8.15 Geologic Hazards and Resources

8.15.1 Introduction

This subsection evaluates the effect of geologic hazards and resources that might be encountered on the AES Highgrove project site. The objective of this evaluation is to identify site conditions and the potential impacts from the construction or operation of the project. This subsection presents a summary of the relevant laws, ordinances, regulations, and standards (LORS); the existing site conditions; and the expected direct, indirect, and cumulative impacts because of construction, operation, and maintenance of the project. Proposed mitigation measures and the effectiveness and monitoring plans are also described. Permits that are required and permitting agencies are identified.

8.15.2 Laws, Ordinances, Regulations, and Standards

The LORS that apply to geologic hazards and resources are summarized in Table 8.15-1.

TABLE 8.15-1
Laws, Ordinances, Regulations, and Standards Applicable to Geologic Hazards and Resources

Jurisdiction	Authority	Administering Agency	Compliance
State/Local	California Building Code (CBC), 2001.	California Building Standards Commission, State of California, and City of Grand Terrace Building Department	Acceptable design criteria for structures with respect to seismic design and load-bearing capacity.
State/Local	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
State /Local	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
Local	City of Grand General Plan	City of Chula Vista	Compliance with the Safety Element of the General Plan
	City of Riverside	City of Riverside	
	County of Riverside	County of Riverside	

8.15.3 Affected Environment

The proposed AES Highgrove project site is a 9.8-acre parcel in the City of Grand Terrace, San Bernardino County, California, located along the western side of Taylor Street, north of Main Street. The elevation of the site is approximately 940 feet above mean sea level. The project also includes a natural gas pipeline that extends approximately 7 miles (11.5 km) south of the plant site to connection with a regional gas pipeline and will involve the demolition of the existing generating equipment located on the Generating Station Property.

The project area lies in the Inland Empire area of southern California between the San Bernardino and San Jacinto Mountains of the Transverse Ranges to the east, and the Chino Hills and Santa Ana Mountains to the west. Physiographically, it lies on the northwestern portion of the Perris Block, an eroded surface of Mesozoic crystalline rock between the Santa Ana and the San Jacinto Mountains. The Box Springs Mountains lie immediately to the east of the pipeline route. The La Loma Hills lie immediately to the west and northwest of the plant site. Farther to the east, the San Jacinto Fault Zone lies at the eastern base of the Box Springs Mountains and marks the eastern edge of the Perris Block. To the west, the Elsinore and Chino Fault Zones lie along the eastern margin of the Santa Ana Mountains and mark the western limit of the Perris Block.

The project area is considered to be seismically active and is designated as a California UBC Seismic Zone 4.

8.15.3.1 Regional Geology

The geology of the vicinity is complex, largely a result of the interaction of numerous faults that are present in the southern California area. The project area lies in the Inland Empire area of southern California between the San Bernardino and San Jacinto Mountains of the Transverse Ranges to the east, and the Chino Hills and Santa Ana Mountains to the west. Physiographically, it lies on the northwestern portion of the Perris Block, an eroded surface of Mesozoic crystalline rock between the Santa Ana and the San Jacinto Mountains (Woodford et al., 1971). The Box Springs Mountains lie immediately to the east of the pipeline route. The La Loma Hills lie immediately to the west and northwest of the plant site. Father to the east, the San Jacinto Fault Zone lies at the eastern base of the Box Springs Mountains and marks the eastern edge of the Perris Block. To the west, the Elsinore and Chino Fault Zones lie along the eastern margin of the Santa Ana Mountains and mark the western limit of the Perris Block.

8.15.3.2 Local Geology and Stratigraphy

Very limited exposures of metamorphic rocks of probable Paleozoic age are present in the project area. These rocks, originally sedimentary in nature, were subject to high-temperature metamorphism during the emplacement of the Mesozoic igneous batholith in this area. They include biotite schist, impure quartzite, marble, and other calc-silicate rocks (Morton and Cox, 2001).

Igneous rocks emplaced in the crust primarily during the Late Mesozoic dominate the basement geology. In the project area these rocks are of the Peninsular Range Batholith (Morton and Miller, 2003), in most areas overlain by varying depths of Quaternary alluvium and, in some cases, by artificial fill (Morton and Cox, 2001). Rocks of the Peninsular Range Batholith were emplaced during the Cretaceous Epoch, which ended about 64 million years ago. These granitic rocks vary in mineralogical composition and, in the project area, are principally tonalite and granodiorite (Morton and Cox, 2001).

Quaternary (Pleistocene and Holocene) sediments exposed in the project area are primarily alluvial fan deposits issuing from the Box Springs Mountains to the east along the northern 5 miles (8.2 km) of the pipeline route and the plant site. Older alluvium of less certain provenance lies along the southern 2 miles (3.3 km) of the pipeline route on the northwest edge of the Perris Plain, as well as beneath the northern approximately 1 mile (1.6 km) of the

pipeline route and beneath the generating site. Artificial fill and Holocene eolian and sheet wash sediments typically mantle these units. Figure 8.15-1 (figures are located at the end of the subsection) shows the stratigraphic units, strata, and geographic features within a 2-mile radius of the Highgrove project site. Figure 8.15-2 shows the geology within a ¼-mile buffer along the gas pipeline linear.

8.15.3.3 Seismicity

The Highgrove project site lies within a seismically active region. Large earthquakes have occurred in the past and will occur in the future. The region is influenced by the San Andreas Fault system that separates the North American and Pacific plate boundaries. This boundary has been the site of numerous large-scale earthquakes. Numerous active faults are in the vicinity of Grand Terrace although none are known to exist within the city (Bortogno and Spittler, 1986). These include the Rialto-Colton fault (4 miles north of site), San Jacinto fault zone (3 miles east of site),), the San Andreas fault zone (10 miles north of site), Cucamonga fault (13 miles northwest of site), Whittier-Elsinore fault (20 miles southwest of site). The site is not located within a special study zone, as delineated by the Alquist-Priolo Special Studies Zone Act of 1972; and no known fault, active or inactive, reaches the surface within the project area (Jennings, 1994). However, the San Jacinto Fault Zone that is less than 3 miles from the site is state-designated fault with a ground rupture hazard area. The significant faults in the study area are described below and are shown on Figure 8.15-3.

8.15.3.3.1 San Andreas Fault

The nearest major fault is the San Andreas fault, which is approximately 10 miles north of the site. This fault is the largest active fault in California and extends from the Gulf of California to Cape Mendocino in northern California (Jennings, 1994). The fault is divided into numerous segments. The segment nearest the site is the San Bernardino segment and has been assigned individual maximum moment magnitude (Mmax) of 7.5, by the Working Group on California Earthquake Potential (WGCEP, 2002).

8.15.3.3.2 San Jacinto Fault Zone

Northeast of the site is the San Jacinto Fault Zone. This fault is approximately 3 miles from the Highgrove project site and is considered to be an active Holocene fault and is an Alquist-Priolo Special Studies fault zone. It is approximately 160 miles long and runs from southern end of the Imperial Valley south of the Salton Sea to the eastern San Gabriel Mountains at the San Andreas fault (Jennings, 1994). The Mmax from this fault is 6.7 (WGCEP, 2002).

8.15.3.3.3 Whittier-Elsinore Fault Zone

The Whittier-Elsinore Fault Zone lies approximately 20 miles southwest of the site. The fault system essentially parallels the San Jacinto fault zone and extends from Whittier in Los Angeles County to the southern end of Imperial Valley south of the Salton Sea (Jennings, 1994). According to the WGCEP (2002), the Whittier-Elsinore Fault Zone has been assigned a Mmax of 6.8.

8.15.3.4 Geologic Hazards

A site-specific geotechnical investigation is being planned for the Highgrove project site. Results will be provided upon its completion.

The following subsections discuss the potential geologic hazards that might occur in the project area.

8.15.3.4.1 Ground Rupture

Ground rupture is caused when an earthquake event along a fault creates rupture at the surface. Since no known faults exist at the Highgrove project site, the likelihood of ground rupture to occur at the project site is low.

8.15.3.4.2 Seismic Shaking

The Inland Empire of southern California has experienced strong ground motion in the past and will do so in the future. Mualchin (1996) estimated that the ground-shaking of a moment magnitude 7.50 earthquake along the San Jacinto Fault Zone system could produce peak bedrock acceleration of up to 0.55g (where g is gravity) in the vicinity of the Highgrove Project. A preliminary review of the probabilistic peak ground acceleration (PGA) with a return period of 475 years, indicates that the PGA will be on the order of 0.7g at the site (California Geological Survey, 2003).

8.15.3.4.3 Liquefaction

During strong ground-shaking, loose, saturated, cohesionless soils can experience a temporary loss of shear strength. This phenomenon is known as liquefaction. Liquefaction 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. The depth to groundwater at the Highgrove project site is relatively shallow, less than 50 feet, and the soil types generally consist of alluvial sediments. According to the City of Grand Terrace General Plan, the southwestern part of the city is susceptible to liquefaction due to high water table. Therefore, the likelihood that liquefaction will occur is considered high.

8.15.3.4.4 Mass Wasting

Mass wasting 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 mass wasting hazards at the Highgrove project site. Because the Highgrove project site is relatively flat and no significant excavation is planned during site construction, the potential for direct impact from mass wasting at the site is considered low to negligible.

8.15.3.4.5 Subsidence

Subsidence can be a natural or man-made phenomenon resulting from tectonic movement, consolidation, hydrocompaction, or rapid sedimentation. Given that the site is underlain by dense alluvial fan deposits, the potential for subsidence, as a hazard that could affect the project site, is low.

8.15.3.4.6 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 soils have not been identified as a potential hazard in the Grand Terrace area. Based on this, the likelihood of expansive soils to be present at the site is low.

8.15.3.4.7 Geologic Resources of Recreational, Commercial, or Scientific Value

Geologic resources of recreational, commercial, or scientific value in the project vicinity that could be affected include aggregate and gas reserves. Geologic resources of value are discussed in the next paragraph.

8.15.3.4.8 Aggregate Resources

In 1995, the California Division of Mines and Geology performed a mineral land classification of part of the San Bernardino Valley area. According to the published report, the entire Highgrove project site was classified as Mineral Resource Zone (MRZ)-3 that is defined as "areas of undetermined mineral resource significance (State of California, 1995). An area to the west of the site, all along the Santa Ana River flood plain was classified as MRZ-2, "Areas of identified Mineral Resource Significance." This classification is primarily due to the presence of portland cement-grade aggregate and limestone.

8.15.3.4.9 Natural Gas

No oil or gas fields are present in the project vicinity, according to online maps from the California Division of Oil, Gas and Geothermal Resources (CDOGGR, 2004).

There are no known geologic resources that provide a significant scientific or recreational value in the vicinity of the site.

8.15.4 Environmental Impacts

8.15.4.1 Generating Facility and Pipelines

8.15.4.1.1 Geologic Hazards

Ground-shaking and liquefaction present the most significant geologic hazard to the proposed Highgrove project site and project linear. Table 8.15-2 summarizes the geologic hazards associated with the project.

TABLE 8.15-2
Summary of Potential Geologic Hazards

Project Component	Area of Potential Concern	Geologic Hazards of Potential Concern
Proposed generating facility site (up to 9.8 acres)	Entire site	Seismic ground-shaking. Liquefaction
Water pipeline	Entire length of pipeline	Seismic ground-shaking, Liquefaction
Gas pipeline	Entire length of pipeline	Seismic ground-shaking, Liquefaction

8.15.4.1.2 Geologic Conditions and Topography

Construction will require minor grading and excavation, thereby altering the terrain of the Highgrove site. Impacts on the geologic conditions involve changes in drainage, cuts, and fills. Since the site is generally level, site grading is not expected to adversely impact the geologic environment.

8.15.4.2 Geologic Resources of Recreational, Commercial, and Scientific Value

No known natural resources occur in the Highgrove project site area. The MRZ-2 area identified along the Santa Ana River is not being actively developed. No significant impact to geologic resources would occur with the project.

8.15.5 Mitigation Measures

The following subsections describe mitigation measures that could be used to reduce impacts from geologic hazards.

8.15.5.1 Ground Rupture

No active faults cross the Highgrove site or project linear (Jennings, 1994). Therefore, no mitigation measures are required to reduce the hazard from surface faulting rupture.

8.15.5.2 Ground-Shaking

The Highgrove site and pipelines will need to be designed and constructed to withstand strong earthquake-shaking as specified in the 2001 CBC for Seismic Zone 4. A site-specific geotechnical investigation (forthcoming) will aid in the development of the seismic design criteria.

8.15.5.3 Liquefaction

The soil types present at the Highgrove site and along the pipeline routehave been mapped as being conducive to liquefaction. A site-specific geotechnical investigation currently being planned will aid in the full assessment of liquefaction potential and lateral spreading.

8.15.5.4 Subsidence

Based on site-specific data, subsidence is not considered to be a hazard at the site and mitigation would not be required.

8.15.5.5 Expansive Soils

Expansive soils can be mitigated by removing the soil and backfilling with non-expansive soil, instituting chemical stabilization of the soil, or constructing a foundation treatment that resists uplift of the expansive soil. Expansive soils have not been identified as potential hazard at the site. Mitigation measures would likely not be required at the site, however, borings that will be drilled at the site during the geotechnical study will identify any potential soils that would be prone to expansion.

8.15.6 Involved Agencies and Agency Contacts

No permits are required for compliance with geological LORS. However, the City of Grand Terrace, and the County of San Bernardino are responsible for enforcing compliance with building standards.

8.15.7 Permits Required and Permit Schedule

Compliance of building construction with CBC standards is covered under engineering and construction permits for the project. There are no other permit requirements that specifically address geologic resources and hazards. However, excavation/grading and inspection

permits will be required prior to construction and will be included in the overall project construction permit. Borings planned for the geotechnical investigation will require a permit from the County of San Bernardino since they will likely penetrate groundwater (borings that do not encounter groundwater and are immediately grouted up do not require a permit). According to the City of Grand Terrace, no separate drilling permit is required for private property (Glander, 2005). The County of San Bernardino Geologist, may be required to review geotechnical reports and/or design documents as part of land use permitting. Required permits and agency contact information is summarized in Table 8.15-3.

TABLE 8.15-3
Permits and Agency Contact Information

Agency	Contact	Telephone
County of San Bernardino, Dept of Environmental Health	Steve Sassler	(909) 387-4666
County of San Bernardino, Land Use Dept, County Geologist	Wes Reader	(909) 387 4240

8.15.8 References

Bortogno, E.J. and T.E. Spittler. 1986. Geologic Map of the San Bernardino Quadrangle. Regional Geologic Map Series, 1:250000 scale. State of California, Department of Conservation, Division of Mines and Geology.

California, State of. 1995. Mineral Land Classification of a Part of Southwest San Bernardino Valley Area, California, State of California, Department of Conservation, Division of Mines and Geology. Open-File Report 94-08.

California Geological Survey. 2003. Probabilistic Seismic Hazards Mapping Ground Motion Page Based on the USGS/CGS Probabilistic Seismic Hazards Assessment (PSHA) Model, 2002 (revised April 2003).
http://www.consrv.ca.gov/CGS/rghm/pshamap/pshamain.html.

California Division of Oil, Gas, and Geothermal Resources (CDOGGR). 2004. Oil and Gas Field Maps. http://www.consrv.ca.gov/dog.

Glander, Jerry. 2005. Personal communication between CH2M HILL staff and Mr. Jerry Glander, Director of Building and Safety, Public Works and Housing Department, City of Grand Terrace, CA. (909) 430 2250. February 18.

Jennings, C.W. 1994. Fault Activity Map of California and Adjacent Areas. Division of Mines and Geology.

Morton, D.M., and B. Cox. 2001. Geologic Map of the Riverside East 7.5′ Quadrangle, Riverside County, California. U.S. Geological Survey Open-File Report 01-452. Denver Federal Center, Boulder, CO.

Morton, D.M. and F.K. Miller. 2003. Preliminary Digital Geologic Map of the San Bernardino 30′ x 60′ Quadrangle, California, Version 1.0. U.S. Geological Survey Open-File Report 03-293. Denver Federal Center, Boulder, CO.

Mualchin, L. 1996. A Technical Report to Accompany the Caltrans California Seismic Hazard Map. Prepared for Caltrans by the Office of Earthquake Engineering. July.

Norris, R.M. and R.W. Webb. 1990. *Geology of California.* Second Edition. John Wiley and Sons. New York.

U.S. Geological Survey (USGS). 2002. National Seismic Hazard Mapping Project. http://geohazards.cr.usgs.gov/eq/

Working Group On California Earthquake Potential (WGCEP). 2002. Appendix A. California Fault Parameters. Division of Mines and Geology. Update to Open-File Report 96-08.

Qow

Kqd

Qof

Qw

Kgr

LEGEND

- SITE LOCATION
- Kgr — CRETACEOUS GRANITIC ROCKS
- Kqd — JURASSIC QUARTZ DIORITE
- Qof — OLDER QUATERNARY ALLUVIAL FAN DEPOSITS
- Qow — OLDER QUATERNARY WASH DEPOSITS (ALLUVIAL DEPOSITS OF ABANDONED WASHES)
- Qw — QUATERNARY WASH DEPOSITS (ALLUVIAL DEPOSITS OF MODERN WASHES)

SOURCE: BORTUGNO, E.J., AND SPITTLER, T.G., 1986, GEOLOGIC MAP OF THE SAN BERNARDINO QUADRANGLE

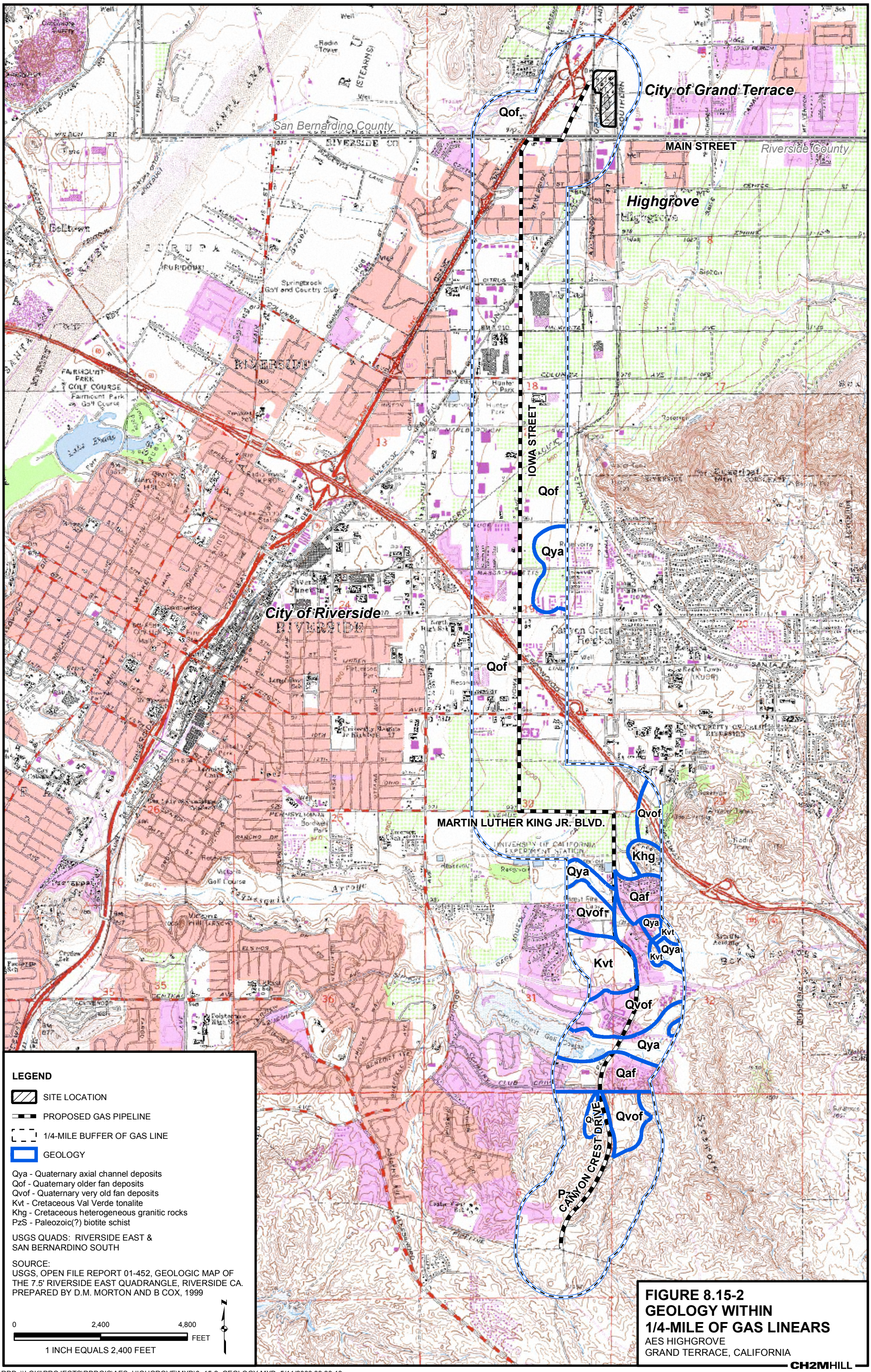
0 2,000 4,000 FEET

1 INCH EQUALS 2,000 FEET

FIGURE 8.15-1
AREA GEOLOGY WITHIN 2 MILES OF AES SITE
AES HIGHGROVE
GRAND TERRACE, CALIFORNIA

CH2MHILL

RDD \\LOKI\PROJECTS\RDDGIS\AES_HIGHGROVE\MXD\8_15-1_GEOLOGY.MXD 4/11/2006 14:34:57



RDD \\LOKI\PROJECTS\RDDGIS\AES_HIGHGROVE\MXD\8_15-2_GEOLOGY.MXD 5/11/2006 09:38:13

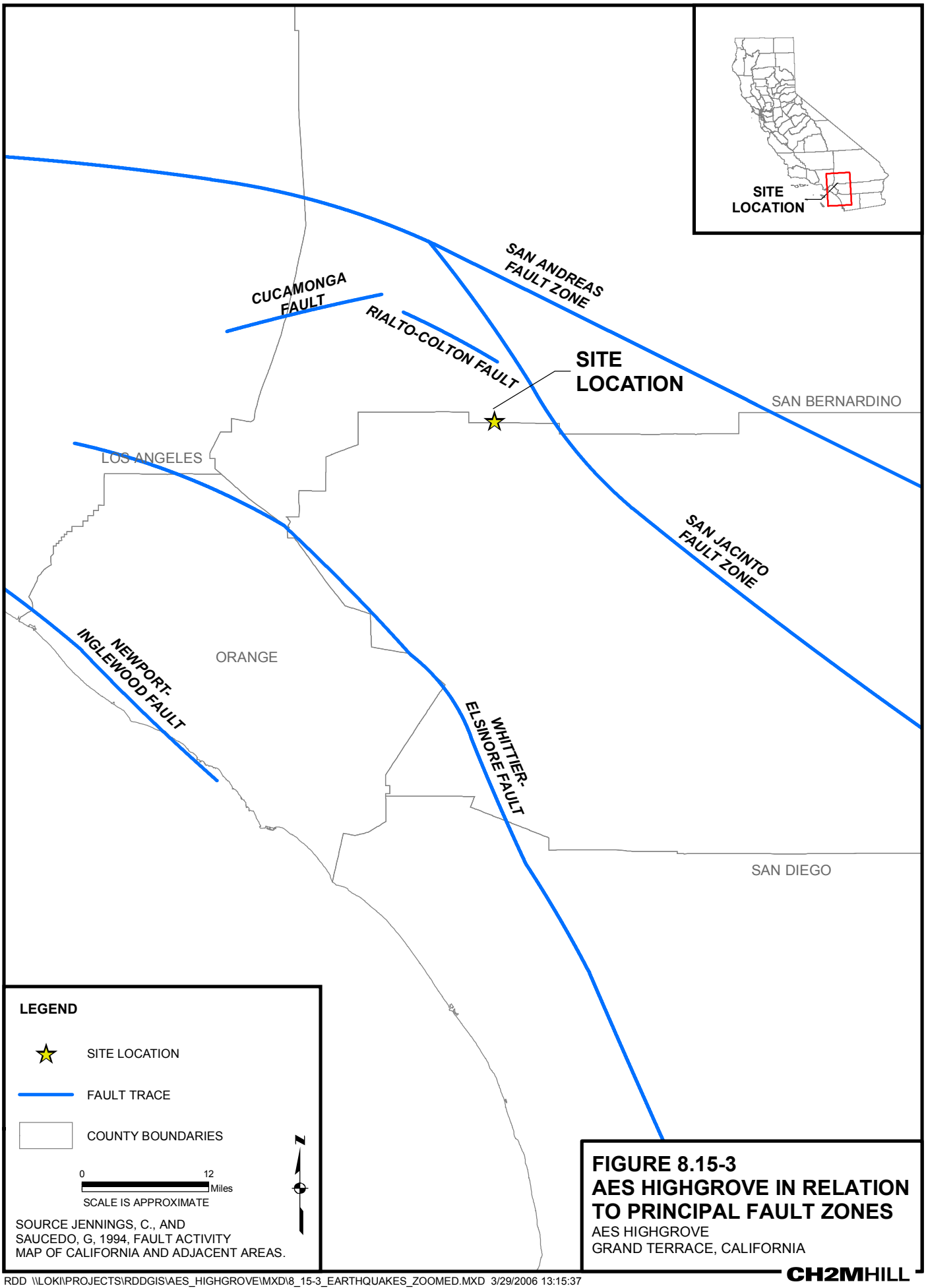


FIGURE 8.15-3
AES HIGHGROVE IN RELATION TO PRINCIPAL FAULT ZONES
AES HIGHGROVE
GRAND TERRACE, CALIFORNIA

CH2MHILL

RDD \\LOKI\PROJECTS\RDDGIS\AES_HIGHGROVE\MXD\8_15-3_EARTHQUAKES_ZOOMED.MXD 3/29/2006 13:15:37