Section 3.6
Geology and Soils

This section discusses the geology and geologic hazards (including seismic hazards), the soil conditions, and the potential for occurrence of mineral resources in the project area.

Environmental Setting

Physical Setting

The Montezuma Hills and adjacent Kirby Hills cover an area of approximately 100 square miles and comprise unique geologic formations just north of the confluence of the Sacramento and San Joaquin Rivers where they discharge to Suisun Bay. These low-lying hills are surrounded by Suisun Marsh and Suisun Bay to the west, the islands and sloughs of the Delta to the south and east, and Central Valley lowlands to the north.

Geology

The project area lies both within the Montezuma Hills and the immediately adjacent Kirby Hills to the west in the *Vacaville assemblage*. The Montezuma Hills are composed of Quaternary-period (early Pleistocene) sediments known as the Montezuma formation. This material is primarily poorly sorted, poorly consolidated clayey sand, silt, and pebble gravel, apparently of nonmarine, fluvial origin. The hills are relatively smooth, rounded, and low lying. The Kirby Hills comprise the Markley marine sandstone (with siltstone) and Neroly sandstone, formed in the Tertiary period (Eocene and Miocene, respectively), which have weathered to a higher terrain than the poorly consolidated Montezuma Hills. Between these two formations, an existing pipeline connecting the meter and compressor stations also crosses the Tehama formation (also from the Tertiary period [Pliocene]) and overlying recent alluvium. This formation is composed of sandstone, siltstone, conglomerate, and volcaniclastic (ash fragments) rocks. (Wagner et al 1987, Graymer et al 2002.)

Soils

Six soil types are found in the project region (Table 3.6-1). All soils have relatively high clay content; none are classified as silty or sandy. As a result, all of the soils have high shrink-swell potential. They swell or expand when wetted and shrink or contract as they dry, threatening the stability of structures without adequately engineered foundations. Also, these clayey soils do not absorb water readily and generate moderately high to high rates of runoff. The hazard of erosion by running water of these soils varies from slight, where gently sloping, to high in steeper parts of the Kirby Hills. The clayey surface texture of these soils renders them relatively nonsusceptible to wind erosion and limits their susceptibility to water erosion.

Table 3.6-1. Soils and Key Soil Characteristics in the Project Region

Mapping Symbol	Soil Name/Slope	Project Elements Affected[2]	Topsoil/Subsoil Texture	Shrink-Swell Potential	Erosion Hazard Rating	Hydrologic Soil Group[a]
AcC	Altamont clay, 0–2%	GP	Clay/silty clay loam	High	Slight	D
AlC	Altamont-San Ysidro-San Benito complex, 2–9%	GP, MS?	Clay/silty clay loam	High	Moderate	D
AlE	Altamont-San Ysidro-San Benito complex, 9–30%	GP	Clay/silty clay loam	High	Moderately high	D
AoA	Antioch-San Ysidro complex, 0–2%	GP	Loam/clay	High	Slight	D
AoC	Antioch-San Ysidro complex, 2–9%	GP, MS?	Loam/clay	High	Slight	D
DlE, DlF[b]	Dibble-Los Osos clay loam, 9–50%	GP (<9% slope), CS	Clay loam/clay	High	Moderate to high	C

[a] Hydrologic soil group: C = slow infiltration rate/moderately high runoff potential; D = Very slow infiltration rate/high runoff potential.

[b] Project elements: CS = compressor station, MS = metering station, GP = gas pipeline. MS= indicates site is near boundary of soil mapping units.

Source: USDA Soil Conservation Service 1977.

Seismic Hazards

The San Francisco Bay Area region, including the Phase II project area, is considered seismically active. The State of California considers a fault segment *historically active* if it has generated earthquakes accompanied by surface rupture during historic time (i.e., approximately the last 200 years). A fault that shows evidence of movement within Holocene time (approximately the last 11,000 years) is defined as *active*. A fault segment is considered *potentially active* if there is evidence of displacement during Quaternary time (approximately the last 2 million years) (Hart and Bryant 1997).

The major active and potentially active faults near the project area are the Kirby Hills-Montezuma Hills-Antioch Faults (historically active), Rio Vista Fault (potentially active), Clayton-Marsh Creek-Greenville Faults (active), Cordelia-Green Valley-Concord Faults (active), Calaveras Fault (active), Hayward Fault (historically active), and San Andreas Fault (historically active), as well as the Diablo Thrust (Jennings 1994) (Table 3.6-2). The Kirby Hills-Montezuma Hills-Antioch Fault passes through an area south of the proposed well field, about 1 mile west of the existing compressor station, and the PG&E interconnect is about 6 miles west of the Rio Vista Fault. Although no evidence exists of surface faulting along the Kirby Hills Fault in the Holocene, many smaller earthquake epicenters have been located at depth along its linear trend. The Marsh Creek-Greenville and Cordelia-Green Valley-Concord Faults are respectively about 9 and 12 miles from the project area. The project area is also located 10–12 miles from the newly identified Diablo Thrust. A major seismic event or earthquake on any of these faults is possible and could cause significant ground shaking in the project area. The project area is not known to have experienced surface rupture from an earthquake, and no fault-rupture hazard zones as defined by the Alquist-Priolo Earthquake Fault Zoning Act are present (Hart and Bryant 1997).

Severe ground shaking can involve forces that damage structures not designed to withstand them. The estimated peak ground acceleration (10% probability of being exceeded in 50 years) in the project area is moderate for California (and high from a national perspective)—in the range of 35–65% of the acceleration of gravity (g) (Petersen et al. 1999). Project elements will be designed to withstand such forces.

Severe ground shaking also can induce liquefaction (induced flow as if a liquid) of certain saturated substrates, which can greatly magnify damage to overlying structures not designed to accommodate this possibility. Sandy substrates below the water table are most susceptible in this regard. The relatively unconsolidated sandy substrates reported for the Montezuma Hills, especially in low-lying areas where the seasonal water table may be relatively shallow, may be susceptible to liquefaction—although the clay content would act to counter the possible susceptibility. Geotechnical evaluation of liquefaction potential, based on subsurface borings, will be used as the basis of design for project elements.

Table 3.6-2. Active Faults in the Project Vicinity

Fault	Historical Seismicity [a]	Maximum Moment Magnitude Earthquake
Kirby Hill-Montezuma Hills	Many <M 4 in the last 35 years	Not available
Midland-Rio Vista	None within the last 700,000 years	Not available
March Creek-Greenville	M 5.6 in 1980	6.9
Cordelia-Concord-Green Valley	Historic active creep	6.9
Diablo Thrust	Newly recognized	6.7
Calaveras	M 5.6-6.4 in 1867	6.8
	M 4-4.5 in 1970 and 1990	
Hayward	M 6.8 in 1868	7.1
	Many <M 4.5	
Rodgers Creek (possible extension of Calaveras Fault)	M 6.7 in 1898	7.0
	M 5.6, 5.7 in 1969	
San Andreas	M 7.1 in 1989	7.9
	M 8.25 in 1906	
	M 7.0 in 1838	
	Many <M6	

[a] A Richter magnitude (M) and year for recent or large events. The Richter magnitude scale reflects the maximum amplitude of a particular type of seismic wave.

Sources: Solano County Department of Environmental Management 2002, Sleeter et al. 2004.

Landslide Hazards

A landslide (also called mass movement) involves the downslope transport of soil, rock, and sometimes vegetative material en masse, primarily under the influence of gravity. Landslides occur when shear stress (primarily weight) exceeds the shear strength of the soil/rock. The shear strength of the soil/rock may be reduced during high rainfall periods when materials become saturated. Landslides also may be induced by ground shaking from earthquakes. Landslides usually involve most or all of the soil profile and often part of the underlying parent material. They may take several forms, including soil creep, earthflow, slump, debris slide, debris flow, and rockfall.

According to the Solano County General Plan, the project area is classified as Category 3, or generally stable lands, and is therefore not at a high risk of landslides. No evidence of mass movement has been observed in areas that could affect project elements. The Montezuma and Kirby Hills, unlike many parts of the Coast Ranges, do not appear to be susceptible to slumping. Some rockfall or debris slide is possible in the steeper portions of the Kirby Hills, but such events would not affect the Phase II project elements.

Soil Erosion Potential

Soil erosion is the process by which soils are abraded, or worn away from the earth's surface, by precipitation and runoff or wind. The rate of erosion depends on many factors, including soil type and geologic parent materials (inherent erodibility), degree of surface disturbance and resulting vegetative cover and degree of compaction, degree and length of slope, rainfall and/or wind amount and intensity, and erosion control practices. Soils that are high in silt and low in clay and organic matter are the most inherently erodible; but, regardless of soil texture, erosion potential may be high in steep, unvegetated areas—especially those disturbed by cut-and-fill or other construction activities. As noted previously, project area soils are relatively nonerodible due to their clay content. However, erosion potential is considered high in the steeper parts of the Kirby Hills. These steeper soils will not be disturbed by project activities, and erosion control APMs will be used to minimize soil erosion (these APMs are described in Chapter 2, *Project Description*).

Regulatory Setting

State Regulations

Alquist-Priolo Earthquake Fault Zoning Act of 1972

In response to the 1971 San Fernando Earthquake, which damaged numerous homes, commercial buildings, and other structures, California passed the Alquist-Priolo Earthquake Fault Zoning Act. The goal of the act is to avoid or reduce damage to structures like that caused by the San Fernando Earthquake, by preventing the construction of buildings on active faults.

In accordance with the law, California Geological Survey (formerly the California Department of Mines and Geology) (CGS) maps active faults and the surrounding earthquake fault zones for all affected areas. Any project that involves the construction of buildings or structures for human occupancy, such as an operation and maintenance building, is subject to review under this law. Structures for human occupancy must be constructed at least 50 feet from any active fault.

California Seismic Hazards Mapping Act of 1990

The Seismic Hazards Mapping Act is designed to protect the public from the effects of strong ground shaking, liquefaction, landslides, other ground failures, or other hazards caused by earthquakes. The act requires site-specific geotechnical investigations to identify the hazard and the formulation of mitigation measures before the permitting of most developments designed for human occupancy.

Special Publication 117, Guidelines for Evaluating and Mitigating Seismic Hazards in California, (CDMG 1997) constitutes the guidelines for evaluating seismic hazards other than surface fault rupture and for recommending mitigation measures as required by Public Resources Code Section 2695(a).

California Uniform Building Code

The Uniform Building Code (UBC) contains requirements related to excavation, grading, and construction. Because the project area is located in Seismic Zone 4, the project is required to consider ground acceleration in structural design to provide earthquake-resistant design.

Solano County Regulations

The Scenic Roadways Element of the Solano County General Plan recommends avoiding locating development on the steeper slopes (15% or greater) of upper hilltops and ridges in areas where such development would be highly visible.

Impact Analysis

Significance Criteria

Criteria for determining the significance of impacts on geology, soils, and paleontological resources were developed based on questions contained in the environmental checklist form in Appendix G of the State CEQA Guidelines. Based on the checklist questions, a project may have a significant effect on the environment if it would:

- Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault,
  - Strong seismic ground shaking,
  - Seismic-related ground failure, including liquefaction, or

  - Landslides;

- Result in substantial soil erosion or the loss of topsoil;
- 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 an onsite or offsite landslide, lateral spreading, subsidence, liquefaction, or collapse; or
- Be located on expansive soil, creating substantial risks to life or property.

These significance criteria are tempered by Section 15064(h) of the State CEQA Guidelines, which states that a change in the environment is not a significant effect if the change complies with a standard that is a quantitative, qualitative, or a performance requirement found in a statute, ordinance, resolution, rule, regulation, order, or other standard of general application.

Impacts

IMPACT 3.6-1: POTENTIAL TO EXPOSE PEOPLE OR STRUCTURES TO DAMAGE FROM EARTHQUAKES

The Kirby Hills Phase II project components are located within 1 mile of the seismically active Kirby Hills-Montezuma Hills Fault, which passes through the Kirby Hills I well field. Other active, including historically active, faults are within 25 miles of the project area; several have a history of surface rupture associated with large earthquakes, as described in the Environmental Setting section. Surface fault rupture in the well field and flow line area is possible. Intense ground shaking (strong ground acceleration) could occur throughout the project area and could damage any or all of the project elements. Liquefaction induced by ground shaking could occur in portions of the Montezuma Hills and increase the potential for damage of the gas pipeline project component near the metering station. Furthermore, facilities could be damaged by earthquake-induced landslide, although the potential is considered to be low. Rupture of project facilities could cause the uncontrolled release of flammable natural gas. Ignition of released gases is also possible, which could further damage facilities and threaten personnel safety.

Buried pipelines, although they may be damaged during a large earthquake, are flexible and generally can resist small fault rupture, strong ground shaking, and ground displacement caused by liquefaction. Aboveground facilities are at greater risk because ground motion can be amplified, depending on the design of the structure and the underlying geologic materials. Failures typically occur at joints connecting the aboveground facilities to the belowground facilities, due to differences in motion. Secondary effects of seismic activity such as liquefaction may damage aboveground and belowground facilities due to lateral or vertical displacement. As part of the proposed project, LGS will design the project to meet the seismic safety standards of the UBC and to comply with the requirements of the federal, state, and local agencies with oversight responsibilities to ensure the safety of the proposed project. The DOT's Office of Pipeline Safety records of natural gas leaks in California show that proper design can effectively mitigate potential seismic hazards. The incident reports show no relationship between leaks and major seismic events that have occurred since 1985: Palm Springs (7/8/86), Whittier (10/4/87), Loma Prieta (10/17/89), Upland (2/28/90), Sierra Madre (6/28/91), Cape Mendocino (4/25/92), Big Bear (6/28/92), Northridge (1/17/94), Eureka (9/1/94), South Lake Tahoe (9/12/94), and Parkfield (12/20/94). No pipeline leaks due to any type of failure (outside forces, corrosion, or operator error) were reported within 60 days in any region affected by a major seismic event. Because the project will be designed in compliance with all safety standards and requirements, this impact is considered less than significant, and no mitigation is required.

IMPACT 3.6-2: POTENTIAL TO CAUSE SUBSTANTIAL DAMAGE TO FACILITIES FROM SOIL EXPANSION/CONTRACTION

As previously noted, all soils in the project area are highly expansive and could therefore damage structures constructed without adequate foundations. Based on geotechnical investigation and engineered design, all project elements will be designed to withstand shrink-swell forces, the magnitudes of which can readily be anticipated. This potential impact is therefore considered less than significant, and no mitigation is required.

IMPACT 3.6-3: POTENTIAL TO CAUSE SUBSTANTIAL WATER EROSION

Construction activities would expose disturbed and loosened soils to erosion from rainfall, surface runoff, and wind. Because of the high clay content of the project area soils, accelerated soil erosion during project construction is not expected to occur.

As described in Chapter 2, *Project Description*, erosion control APMs will be implemented to minimize accelerated erosion and sedimentation. Except for the fenced facilities, the site topography will be reclaimed to preconstruction conditions. A SWPPP has been prepared for the project, which describes site reclamation APMs.. Because the APMs have been incorporated into the project design and most of the project occurs in flat lands, the potential impact related to soil erosion is considered less than significant. No mitigation is required.

Applicant-Proposed Measures and Mitigation Measures

LGS will implement APMs (described in Chapter 2, *Project Description*) as part of the proposed project to avoid and minimize potentially significant impacts related to geology and soils. Therefore, no additional mitigation is required.