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4.6 GEOLOGY, SOILS, AND SEISMICITY

Would the Proposed Project:	Potentially Significant Impact	Less-than-Significant Impact with Mitigation Incorporated	Less-than-Significant Impact	No Impact
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault?[1]			✓	
ii) Strong seismic ground shaking?			✓	
iii) Seismic-related ground failure, including liquefaction?			✓	
iv) Landslides?			✓	
b) Result in substantial soil erosion or the loss of topsoil?			✓	
c) 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 off-site landslide, lateral spreading, subsidence, liquefaction or collapse?			✓	
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?			✓	
e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?				✓

[1] This question refers to the fault rupture hazard zones described in the California Geological Survey (CGS) Special Publication 42.

4.6.0 Introduction

This section describes the existing geologic and pedogenic soil conditions related to the proposed San Diego Gas & Electric Company (SDG&E) and Southern California Gas Company—hereinafter referred to as “the Applicants”—Pipeline Safety & Reliability Project (Proposed Project). The Proposed Project involves construction, operation, and maintenance of an approximately 47-mile-long, 36-inch-diameter natural gas transmission pipeline that will carry natural gas from SDG&E’s existing Rainbow Metering Station to the pipeline’s terminus on Marine Corps Air Station Miramar. This section analyzes the exposure of people and structures to any potential substantial adverse effects involving strong seismic ground shaking, fault rupture, liquefaction, unstable soils, landslides, expansive soil, substantial soil erosion, or the loss of topsoil. By adhering to the Applicants’ Proposed Project design and the recommendations provided in the Proposed Project-specific geotechnical investigations in the final design, construction of the Proposed Project will result in less-than-significant impacts with Applicants-Proposed Measures (APMs) incorporated to geology and soils.

4.6.1 Methodology

The existing conditions and potential impacts associated with geologic hazards were primarily obtained from the Geologic Hazard Assessment prepared by URS Corporation (URS) for the Proposed Project, which is included as Attachment 4.6–A: Geologic Hazard Assessment. To obtain geologic information in the vicinity of the Proposed Project, URS reviewed and compiled previous geotechnical and geological information for the Proposed Project routes and general area; performed a terrain analysis using digital imagery and terrain modeling software, and a stereoscopic analysis of historic aerial photography in areas of suspected hazardous terrain; and performed a preliminary reconnaissance-level survey to identify geologic hazards. In addition to the research and analyses provided in Attachment 4.6–A: Geologic Hazard Assessment, a thorough review of available geologic resource literature that is relevant to the Proposed Project area was conducted to supplement or confirm the research performed by URS. The materials reviewed include publications and/or data from the United States (U.S.) Geological Survey (USGS), the CGS, and other publicly available technical reports and resources.

4.6.2 Existing Conditions

The regulatory requirements and existing geologic resources in the vicinity of the Proposed Project are described in the following subsections.

Regulatory Background

Pursuant to Article XII, Section 8 of the California Constitution, the California Public Utilities Commission (CPUC) has exclusive jurisdiction in relation to local government to regulate the design, siting, installation, operation, maintenance, and repair of natural gas pipeline transmission facilities. Other state agencies have concurrent jurisdiction with the CPUC. Although local governments do not have the power to regulate such activities, the CPUC encourages, and the Applicants participate in, cooperative discussions with affected local governments to address their concerns where feasible. As part of the environmental review process, the Applicants have considered relevant regional and county, policies, and issues, and have prepared this evaluation of the Proposed Project’s potential impacts to geology, soils, and seismicity. The following subsections describe federal, state, and local regulations that are relevant to the Proposed Project.

Federal

Uniform Building Code

Published by the International Conference of Building Officials, the Uniform Building Code (UBC) provides complete regulations covering all major aspects of building design and construction relating to fire and life safety and structural safety. This is the code that has been adopted by most western states. Volume 1 of the 1997 UBC contains the administrative, fire and life safety, and field inspection provisions, including all nonstructural provisions and those structural provisions necessary for field inspections. Volume 2 contains provisions for structural engineering design, including the design provisions formerly in the UBC Standards. Volume 3 contains the remaining material testing and installation standards previously published in the UBC Standards.

Title 49, Part 192 of the Code of Federal Regulations

Title 49, Part 192 of the Code of Federal Regulations (CFR) outlines the minimum federal safety standards for the transportation of natural gas and other gas by pipeline, including pipeline facilities and the transportation of gas within the limits of the outer continental shelf. Subparts A through P summarize the minimum requirements for the selection and qualification of pipe components, corrosion control regulations, pipeline testing, pipeline integrity management, and additional pipeline design specifications. Section 192.917 (b) requires pipeline operators to incorporate topographic data, soil conditions, and earthquake fault data into evaluations regarding outside force threats. Specific data requirements are described in Appendix A of American Society of Mechanical Engineers (ASME) document B31.8S: Managing System Integrity of Gas Pipelines.

Pipeline Safety Regulations

The Natural Gas Pipeline Safety Act of 1968 and additional federal pipeline safety regulations are discussed in Section 4.8 Hazards and Hazardous Materials.

State

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 of 1972. Formerly known as the Special Studies Zoning Act, the Alquist-Priolo Earthquake Fault Zoning Act regulates construction and development of buildings intended for human occupancy to avoid rupture hazards from surface faults.

In accordance with the law, the CGS establishes regulatory zones around the surface traces of active faults and issues corresponding maps for affected areas. Any project that involves the construction of buildings or structures for human occupancy 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, additional ground failures, or other hazards caused by earthquakes. The Seismic Hazards Mapping Act requires site-specific geotechnical investigations to identify the hazard and to formulate mitigation measures before permitting most developments designed for human occupancy. In addition to the information provided through the Probabilistic Seismic Hazards Mapping program, Special Publication 117 (Guidelines for Evaluating and Mitigating Seismic Hazards in California) provides additional guidelines for evaluating seismic hazards other than surface fault rupture; and for recommending mitigation measures, as required by Section 2695(a) of the California Public Resources Code.

Pipeline Safety Regulations

State pipeline safety regulations are discussed in Section 4.8 Hazards and Hazardous Materials.

Local

County of San Diego

Chapter 7 in the Safety Element of the County of San Diego General Plan provides information related to geologic hazards in the county. The following geologic hazards policy is relevant to the Proposed Project:

- Policy S-7.3: Land Use Location. Prohibit high occupancy uses, essential public facilities, and uses that permit significant amounts of hazardous materials within Alquist-Priolo and County special studies zones.

City of San Diego

The Public Facilities, Services, and Safety Element of the City of San Diego General Plan provides information related to seismic and geologic hazards. The following geologic hazards policy is relevant to the Proposed Project:

- PF-Q.1: Protect public health and safety through the application of effective seismic, geologic, and structural considerations.

Chapter 14, Article 2 of the City of San Diego Land Development Code provides regulations related to grading, storm water runoff, and drainage. This chapter also establishes minimum standards for controlling soil erosion, sedimentation, and increased rates of water runoff and related environmental damage.

City of Escondido

The Community Protection of the City of Escondido General Plan includes the following goal and policy that are relevant to the Proposed Project:

- Goal 7: Minimization of adverse effects to residents, property, and critical facilities caused by geologic and seismic hazards.

- Soils and Seismicity Policy 7.2: Minimize development of public utilities in areas where geologic and seismic hazards exist to avoid additional costs associated with installation, maintenance, and replacement.

City of Poway

The Public Safety Element of the City of Poway General Plan includes the following goals that are relevant to the Proposed Project:

- Goal 8: Minimization of injuries, loss of life, and property damage resulting from natural and man-made hazards.

- Goal 8, Policy B – Geologic Hazards: The community should be protected against the hazards associated with geologic formations, particularly landslides, through proper land use policies and mitigation.

- Goal 8, Policy C – Seismic Safety: Seismic hazards should be controlled to a level of acceptable risk through identification and recognition of potentially hazardous conditions and areas.

Geologic Setting

The Proposed Project lies within the Peninsular Ranges geomorphic province. Mountains of the Peninsular Ranges are predominantly north-south trending and extend approximately 900 miles from Southern California to the southern tip of Mexico's Baja California peninsula. These mountains are part of the North American Coast Ranges that run along the Pacific coast from Alaska to Mexico. Elevations range from 500 to 11,500 feet above mean sea level. Mountains of the Peninsular Ranges are mainly composed of extensive Mesozoic (from approximately 251 million years ago to the beginning of the Cenozoic era 65 million years ago) granitic plutons, overlain in areas by metasedimentary rocks, such as marbles, slates, schist, quartzites, and gneiss. The Proposed Project area is underlain by Mesozoic metamorphic and granitic rocks, as well as Tertiary and Quaternary sedimentary rocks. A detailed list of geological formations in the vicinity of the Proposed Project is provided in Table 4.6-1: Geological Formations within the Proposed Project Area.

The majority of the Proposed Project crosses Tertiary sedimentary rocks and Quaternary sedimentary rocks. These sedimentary deposits consist of non-marine, marine, fluvial, and lacustrine strata; and overlie metamorphic and batholithic rocks in the Peninsular Ranges.

The Tertiary sedimentary rock formation, consisting of the Poway and La Jolla groups, is located along the southern portion of the Proposed Project. These groups are characterized by a coarse-grained sandstone matrix, gravels, cobbles, occasional boulders, sandstone, claystone, and volcanic and volcaniclastic rocks with lesser quartzite and granitic rock.

Table 4.6-1: Geological Formations within the Proposed Project Area

Geological Formation	Geologic Age	Length of Proposed Project Crossed by Geological Formation (miles)
Artificial fill	Late Holocene	0.16
Crystalline bedrock: Gabbro, undivided	Mid-Cretaceous	1.63
Crystalline bedrock: Granodiorite, undivided	Mid-Cretaceous	1.58
Crystalline bedrock: Granodiorite of Indian Mountain	Mid-Cretaceous	1.03
Crystalline bedrock: Granite of Indian Springs	Mid-Cretaceous	0.08
Crystalline bedrock: Granodiorite of Jesmond Dean	Mid-Cretaceous	4.20
Crystalline bedrock: Monzogranite of Merriam Mountain	Mid-Cretaceous	2.24
Crystalline bedrock: Granodiorite of Rainbow	Mid-Cretaceous	1.77
Crystalline bedrock: Tonalite, undivided	Mid-Cretaceous	5.38
Crystalline bedrock: Granodiorite of Woodson Mountain	Mid-Cretaceous	1.87
Crystalline bedrock: Metasedimentary and metavolcanic rocks, undivided	Mesozoic	1.15
Quaternary surficial deposits, landslide deposits, undivided	Holocene and Pleistocene	0.28
Old alluvial floodplain deposits, undivided	Late to middle Pleistocene	7.34
Very old paralic deposits, Unit 2	Middle to early Pleistocene	0.53
Very old paralic deposits, Unit 3	Middle to early Pleistocene	0.05
Very old paralic deposits, Unit 4	Middle to early Pleistocene	0.14
River channel, wash deposits	Late Holocene	0.07
Young alluvial floodplain deposits	Holocene and late Pleistocene	8.30
Young colluvial deposits	Holocene and late Pleistocene	1.47
Sedimentary deposits: Claystones, siltstone, Friars Formation, nonmarine and lagoonal sandstone and claystone	Middle Eocene	1.94

Geological Formation	Geologic Age	Length of Proposed Project Crossed by Geological Formation (miles)
Sedimentary deposits: Sandstones, Mission Valley Formation, marine and nonmarine sandstone	Middle Eocene	1.07
Sedimentary deposits: Conglomerates, Stadium Conglomerate	Middle Eocene	4.38
Torrey sandstone	Middle Eocene	0.29

Source: USGS 2014b

Quaternary surficial deposits formed during the Holocene and Pleistocene epochs are present in drainages along the Proposed Project alignment. These deposits are characterized primarily by young alluvial materials consisting of poorly consolidated, poorly sorted, permeable floodplain deposits. Additional surficial materials along the alignment include colluvial deposits, as well as non-engineered and engineered fill materials, particularly in urban areas. Older Quaternary deposits are present in incised canyons along the southern portion of the Proposed Project alignment and consist of paralic deposits containing poorly sorted, moderately permeable, reddish-brown, interfingered strandline, beach, estuarine, and colluvial deposits. The remainder of the Proposed Project alignment crosses Mesozoic metamorphic and crystalline granitic rocks of the Peninsular Ranges batholith of Southern California. The most abundant types of granitic rock encountered along the alignment include tonalite and granodiorite.

The metamorphic rocks present within the vicinity of the Proposed Project include a wide variety of low to high metamorphic-grade metavolcanic and metasedimentary rocks that are mostly volcaniclastic breccia and meta-andesitic flows, tuffs, and tuff-breccia. These deposits exist primarily along the margins of younger mid-Cretaceous crystalline batholithic rocks. Colluvial deposits within this formation primarily consist of siltstone, sandstone, and conglomerate.

Faults, Seismicity, and Related Hazards

Faults

According to the Alquist-Priolo fault zone maps, the Proposed Project does not cross any active or potentially active faults. Active faults located within the vicinity of the Proposed Project include the Temecula section of the Elsinore fault zone, which is located approximately two miles north of the northern portion of the Proposed Project alignment, and the Newport-Inglewood-Rose Canyon fault zone, which is located approximately eight miles west of the southern portion of the Proposed Project alignment.

The Elsinore fault zone is classified as an active earthquake fault zone over a majority of its length and is a significant element of the San Andreas Fault system. The fault strands within the Elsinore fault zone are capable of generating maximum magnitude earthquakes ranging from Moment Magnitude 6.5 to 7.5. Within the Elsinore fault zone, the Willard and Wildomar faults in the City of Temecula are located approximately 1.9 and 3.1 miles north of the Proposed Project, respectively.

The Newport-Inglewood-Rose Canyon fault zone is the predominant fault along the coast of San Diego County. The onshore portion of this fault zone extends along the northeast flank of Mount Soledad in La Jolla and continues southward along the eastern margins of Mission Bay. Between Mission Bay and San Diego Bay, the zone widens and diverges. Although portions of this fault zone in the Mount Soledad, Rose Canyon, and downtown San Diego areas have been designated as Alquist-Priolo fault zones, the Proposed Project is not located within an Alquist-Priolo fault zone. Figure 4.6-1: Active Fault Zone Map depicts the Alquist-Priolo fault zones in the vicinity of the Proposed Project, and Table 4.6-2: Active Faults in the Vicinity of the Proposed Project lists potentially active faults within 50 miles of the Proposed Project alignment.

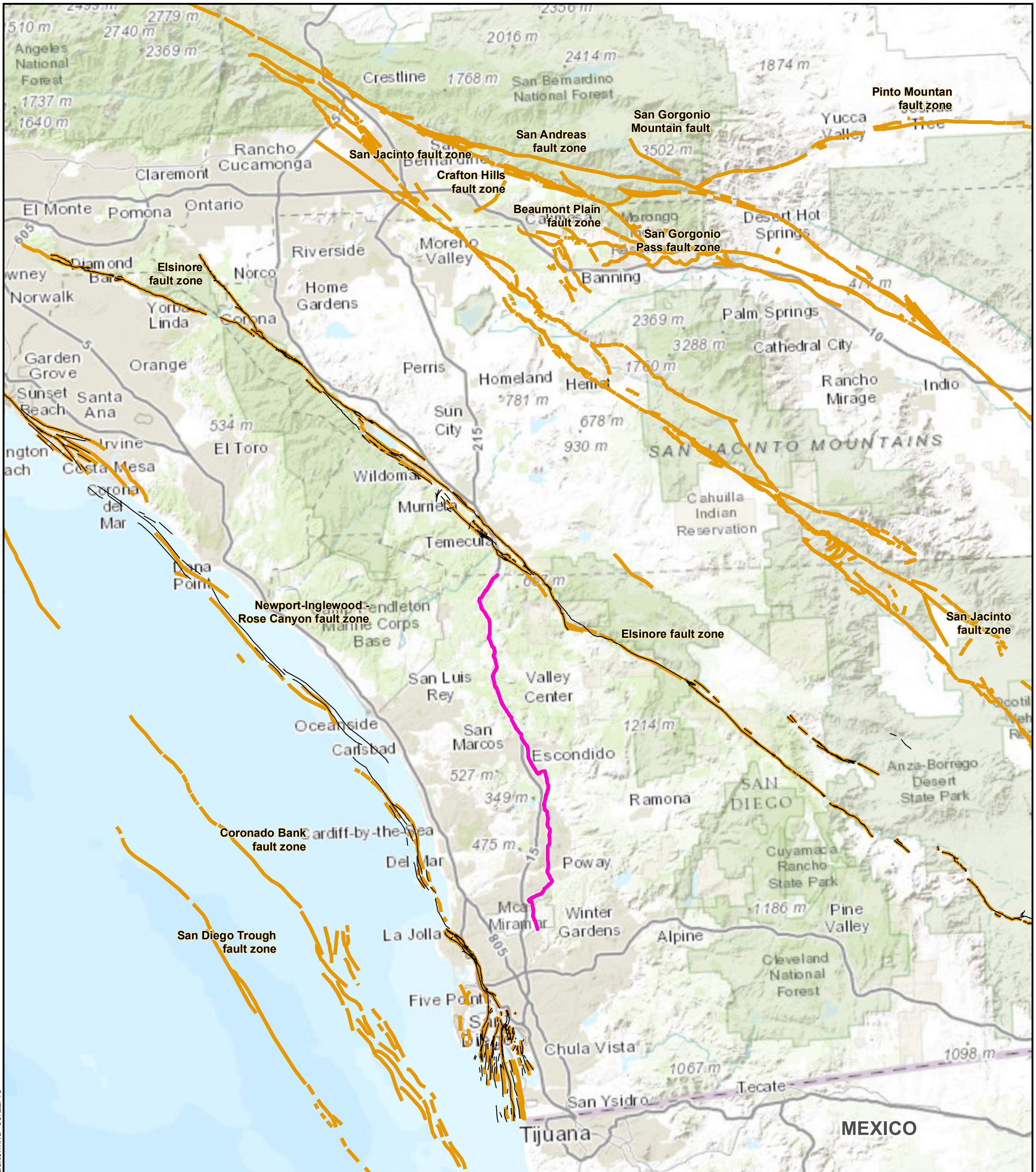

Figure 4.6-1: Active Fault Zone Map

Pipeline Safety & Reliability Project

- Proposed Project Route
- Alquist-Priolo Fault Zones
- Active Fault

1:1,000,000

0 10 20 Miles

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Table 4.6-2: Active Faults in the Vicinity of the Proposed Project

Fault/ Fault Zone	Fault Section	Approximate Distance to Proposed Project	Approximate Fault Length (miles)	Maximum Magnitude Events		
				Maximum Estimated Earthquake Magnitude	Slip Rate (mm/yr)	Pga (g)
Beaumont Plain	Not Applicable (NA)	32 miles northeast	6.5	Information not available (INA)	INA	0.592
Coronado Bank	NA	18 miles southwest	185	7.6	3	0.262
Crafton Hills	NA	41 miles north	5	INA	INA	0.628
Elsinore	Chino	37 miles northwest	28	6.7	1	0.543
	Coyote Mountain	50 miles east	39	6.8	4	0.453
	Glen Ivy	50 miles northwest	36	6.8	5	0.488
	Julian	9 miles east	76	7.1	5	0.402
	Temecula	2 miles north	43	6.8	5	0.4
	Whittier	45 miles northwest	38	6.8	2.5	0.493
Newport-Inglewood-Rose Canyon	Oceanside	17 miles west	136	7.1 to 7.2	1.5	0.285
	San Diego	8 miles west				0.260
	Silver Strand	10 miles south				0.255
	South Los Angeles Basin	40 miles northwest				0.366
Pinto Mountain	NA	49 miles northeast	44	INA	INA	0.539
San Andreas	San Bernardino Mountains	44 miles north	103	7.5	24	0.576
San Diego Trough	NA	28 miles southwest	93	INA	1.5	0.241
San Gorgonio Pass	NA	37 miles northeast	12	INA	INA	0.569

Fault/ Fault Zone	Fault Section	Approximate Distance to Proposed Project	Approximate Fault Length (miles)	Maximum Magnitude Events		
				Maximum Estimated Earthquake Magnitude	Slip Rate (mm/yr)	Pga (g)
San Jacinto	Anza	32 miles northeast	91	7.2	12	0.620
	Coyote Creek	42 miles east	41	6.8	4	0.607
	San Bernardino	37 miles north	36	6.7	12	0.641
	San Jacinto Valley	26 miles north, northeast	43	6.9	12	0.634

Sources: CGS 2014; California Department of Conservation (DOC) 2008, 2014a, and 2014d; San Diego Natural History Museum 2014; Southern California Earthquake Data Center 2013; USGS 2014b and 2014c

Table 4.6-2: Active Faults in the Vicinity of the Proposed Project lists the nearest active fault to the Proposed Project area, the known maximum value of magnitude, the slip rate measured in millimeters per year (mm/yr), and the peak ground acceleration (Pga) expressed as a fraction of the acceleration of gravity (g).

Fault Rupture

Ground surface rupture is typically associated with earthquakes of magnitude 6.0 or greater, which are more likely to produce a noticeable or damaging surface fault rupture and slip. According to the USGS, surface faulting is displacement that reaches the earth's surface during slip along a fault and commonly occurs with shallow earthquakes (i.e., those with an epicenter less than 12.4 miles below the ground surface). Surface faulting also may accompany aseismic creep or natural or man-induced subsidence.

Projects within earthquake fault zones require geologic evaluation to determine if a potential hazard from any fault—whether previously recognized or not—exists. As previously described, the Proposed Project does not cross any active or potentially active faults. The nearest active fault to the Proposed Project is the Elsinore fault, which has exhibited a relatively low rate of activity. The last major rupture event produced by the Elsinore fault occurred in 1910 with a magnitude of 6.0 and the epicenter of the earthquake was located in Elsinore Valley, which is over 20 miles north of the northern portion of the Proposed Project alignment.

Other active faults in the general vicinity of the Proposed Project include the southern San Andreas, Imperial, and San Jacinto faults. The San Jacinto fault zone, which has exhibited the highest activity level of any fault in California, most recently produced earthquakes with magnitudes of 5.4 in 2010 and 6.6 in 1987. In addition, at least two significant surface rupture events have occurred along the Imperial fault in the past century; a magnitude 6.9 earthquake occurred within the San Andreas Fault zone in 1940, and a magnitude 6.5 earthquake occurred in 1979. The earthquake that occurred along the San Andreas Fault in 1906, which affected most of California and parts of western Nevada and southern Oregon, was a magnitude 7.8 earthquake and is considered the most devastating earthquake in California history.

The Newport-Inglewood-Rose Canyon fault zone to the west of the Proposed Project has displayed a historically low level of seismic activity. With the exception of a major event that may have occurred 300 years ago within the Newport-Inglewood-Rose Canyon fault zone, recently recorded seismic activity consists only of microseismicity that was reported during the 1980s in San Diego Bay.

Strong Ground Motion

Strong ground motion or intensity of seismic shaking during an earthquake is dependent on the distance from the epicenter of the earthquake, the magnitude of the earthquake, and the geologic conditions underlying and surrounding the area. Structures built on thick, soft soil deposits are more likely to experience more destructive shaking, with higher amplitude and lower frequency than structures founded on bedrock.

An earthquake is commonly described by the amount of energy released, which has traditionally been quantified using the Richter scale. However, seismologists have recently begun using a

Moment Magnitude scale because it provides a more accurate measurement of a major earthquake's size. The Moment Magnitude and Richter scales are almost identical for earthquakes with magnitudes of 7.0 or less. Moment Magnitude scale readings are slightly greater than a corresponding Richter scale reading for earthquakes with magnitudes greater than 7.0. The maximum magnitude earthquake is defined by the CGS as the maximum earthquake that appears capable of occurring under the presently known tectonic framework. As previously referenced, the earthquake with the greatest recorded magnitude in the vicinity of the Proposed Project occurred in 1910 with a magnitude of 6.0 in Elsinore Valley, which is over 20 miles north of the northern portion of the Proposed Project alignment and is listed in Table 4.6-2: Active Faults in the Vicinity of the Proposed Project.

The probabilistic seismic hazard assessment (PSHA) for the state of California considers a range of possible earthquake sources and estimates their characteristic magnitudes to generate a probability map for ground shaking. The PSHA maps depict values of Pga that have a 10-percent probability of being exceeded in 50 years.

The Modified Mercalli scale is another common measure of earthquake intensity, subjective measures of earthquake strength at a particular place, as determined by its effects on people, structures, and earth materials. Table 4.6-3: Earthquake Intensity Scale presents the Modified Mercalli scale for earthquake intensity, including a range of approximate average Pgas associated with each intensity value.

Based on the CGS Probabilistic Seismic Hazards Ground Motion Interpolator, the Pga in the vicinity of the northern portion of the Proposed Project is approximately 0.3 g, which is within Intensity Value VII of the Modified Mercalli scale, as shown in Table 4.6-3: Earthquake Intensity Scale. This Pga value typically indicates a very strong earthquake capable of causing negligible damage in buildings of good design and construction, slight to moderate damage in well-built ordinary structures, considerable damage in poorly built or badly designed structures, and breaking of some chimneys. The northern portion of the Proposed Project alignment is located within an area that could potentially be exposed to stronger ground motions.

Liquefaction

Liquefaction occurs when loose sands and silts are saturated with water and behave like liquids when strong ground shaking occurs. Seismic waves can cause the pore pressure in the soils to build until the soil grains lose contact, thereby causing the soil to lose tensile strength and behave like a liquid. Higher pore pressure occurs as the soil attempts to compact in response to the shaking, resulting in less grain-to-grain soil contact and, therefore, a loss of strength.

Typically, loose, fine-grained sands and silts below the water table are the most susceptible to liquefaction. Medium dense sands and silts below the water table may also liquefy if the shaking is of sufficient severity and duration. Potential hazards associated with liquefaction in the vicinity of buried pipeline include the loss of support around the pipe, which may subsequently result in the pipe floating to ground surface.

Table 4.6-3: Earthquake Intensity Scale

Intensity Value	Intensity Description	Average Pga Range (g)
I	Not felt except by very few people under especially favorable circumstances.	<0.0017
II	Felt only by a few people at rest, especially on upper floors of buildings. Delicately suspended objects may swing.	0.0017 to 0.014
III	Felt noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing cars may rock slightly, and vibrations are similar to a passing truck. Duration estimated.	
IV	During the day, felt indoors by many, and outdoors by few. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation is like a heavy truck striking building. Standing cars rock noticeably.	0.014 to 0.039
V	Felt by nearly everyone, and many awakened. Some dishes and windows broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees and poles may be noticed. Pendulum clocks may stop.	0.039 to 0.092
VI	Felt by all, and many frightened and run outdoors. Some heavy furniture moves and plaster falls or chimneys are damaged. Damage slight.	0.092 to 0.18
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; damage slight to moderate in well-built ordinary structures; damage considerable in poorly built or badly designed structures; some chimneys broken. Noticed by people driving cars.	0.18 to 0.34
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, and walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. People driving cars disturbed.	0.34 to 0.65
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.	0.65 to 1.24
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.	>1.24
XI	Few, if any, masonry structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.	>1.24

Intensity Value	Intensity Description	Average Pga Range (g)
XII	Damage total. Practically all works of construction are damaged greatly or destroyed. Waves seen on ground surface. Lines of sight and level are distorted. Objects are thrown upward into the air.	>1.24

Sources: Bolt 1998; Wald 1999

According to the Geologic Hazard Assessment conducted for areas within the vicinity of the Proposed Project, the potential for liquefaction and seismic settlement is considered to be low along a majority of the alignment. Although minor drainages comprised of young alluvium are crossed in portions of the alignment, shallow groundwater with vast sections of liquefying materials is not anticipated to occur within these drainages.

Several locations were identified within the Proposed Project area in which relatively thick sequences of loose to medium dense alluvial soils, as well as shallow groundwater, may be present. These locations include the San Luis Rey River at Milepost (MP) 8.7 and Lake Hodges at MP 29.

Slope Instability

Strong ground motion can result in rockfall hazards and/or slope instability. The slopes most susceptible to earthquake-induced failure include those with highly weathered and unconsolidated materials on moderately steep to steep slopes (especially in areas of previously existing landslides). Steep slopes are typically considered those that are greater than 15 percent. The steepest slopes in the vicinity of the Proposed Project range from 30 to 75 percent. In addition, an approximately 0.5-mile segment of the alignment is located in the vicinity of steep slopes between MP 3.3 and MP 3.8.

Landslides occur when masses of rock, earth, or debris move down a slope, including rock falls, deep failure of slopes, and shallow debris flows. The actuators of landslides can be both natural events (e.g., earthquakes, rainfall, and erosion) and human activities. Those induced by man are most commonly related to large grading activities that can potentially cause new slides or reactivate old ones when compacted fill is placed on potentially unstable slopes.

Excavation operations can contribute to landslides when lateral support near the base of unstable hillside areas is removed. Conditions to be considered with regard to slope instability include slope inclination, soil characteristics, the presence of groundwater, and the degree of soil saturation. The Friars Formation, a landslide-prone geologic unit, is located near MP 33 and extends southward to the end of the alignment. The Friars Formation is characterized by Tertiary-age sedimentary deposits, which consist of weak clay layers and localized occurrences of substantially weak bedding plane shears. In addition, hill slopes underlying the Friars Formation are susceptible to landslides. However, active landslides were not identified within the Proposed Project area. In addition, the suspected landslides identified in the vicinity of the Proposed Project alignment are considered to be ancient features and are located primarily in areas that are currently developed.

Wildfires can also increase the potential for landslides and post-fire debris flows, which are fast-moving, destructible flows of material that are generally triggered by intense rainfall and the erosion of burned slopes. Debris flows occur in areas burned by wildfire because the rainfall that is normally absorbed into hillslope soils can run off almost instantly and cause surface erosion after vegetation has been removed by wildfire. As a result, creeks and drainage areas can experience runoff that is much greater and more rapid than normal. Highly erodible soils in a burn scar allow flood waters to accumulate large amounts of ash, mud, boulders, and unburned vegetation. Although post-fire debris can occur in areas underlain by a variety of rock types, debris flows typically occur in areas underlain by sedimentary or metamorphic rock on slopes greater than 20 degrees. In addition, debris flows are more common where more than 65 percent of an area has been burned at moderate to high fire severities. According to information provided by the USGS, the Proposed Project is not located in potential debris flow areas.

Differential Settlement

If the soil beneath a structure settles non-uniformly, the structure can be damaged. The reasons for differential settlement are usually traced to differences in bearing characteristics of the soils. Alternatively, a portion of the soil beneath a structure may lose strength during an earthquake due to liquefaction. If liquefaction occurs non-uniformly, differential compaction can occur. Unconsolidated or weakened geologic units in the Proposed Project area may be subject to differential settlement. These include areas underlain by alluvium and highly weathered rock. As shown in Table 4.6-1: Geological Formations within the Proposed Project Area, approximately 16 miles (35 percent) of the Proposed Project is located within old alluvial deposits, young alluvial valley deposits, or young colluvial deposits. However, this percentage does not account for the unconsolidated or weakened geological units that are stabilized underneath existing structures.

Subsidence

Subsidence occurs most often when fluids are withdrawn from the ground, removing partial support for previously saturated soils. More rarely, subsidence occurs due to tectonic down-warping during earthquakes. The majority of soil units within the Proposed Project area have a low capacity to hold water; therefore, the potential for subsidence is low.

Soils

Approximately 62 distinct soil units are crossed by the Proposed Project, including temporary work areas, although several of these units are grouped within the same soil types. The soil characteristics along the Proposed Project alignment are summarized in Table 4.6-4: Soils in the Proposed Project Area.

Expansive or Collapsible Soils

Expansive soils are characterized by the ability to undergo significant volume change (i.e., shrink and swell) as a result of variation in soil moisture content. Soil moisture content can change due to many factors, including perched groundwater, landscape irrigation, rainfall, and utility leakage. Expansive soils are commonly very fine-grained with a high to very high percentage of clay.

Soil composition along the alignment consists primarily of granular deposits and variably weathered rock, and a majority of the Proposed Project area is not underlain by potentially collapsible soils. However, potentially expansive soils may be encountered in shallow clayey soils (in the upper two to five feet) and in areas underlain by the Friars Formation between MP 33.0 and MP 38.0.

Table 4.6-4: Soils in the Proposed Project Area

Soil Type	Soil Map Unit[2]	Slope (percent)	Permeability	Erosion Potential	Length of Soil Type Crossed by Proposed Project (miles)
Arlington coarse sandy loam	AvC	2 to 9	Slow	Moderate	0.98
Bonsall Sandy Loam	BlC	2 to 9	Very slow	Moderate	0.61
	BmC	2 to 9			
Bosanko clay	BsD	9 to 15	Slow	Moderate	0.58
Chino silt loam, saline	CkA	0 to 2	Moderately Slow	Slight	0.62
Cieneba coarse sandy loam	ClD2	5 to 15	Moderately Rapid	Moderate	0.45
	ClG2	30 to 65		Severe	
Cieneba rocky coarse sandy loam	CmE2	9 to 30		Severe	0.62
Cieneba very rocky coarse sandy loam	CmrG	30 to 75		Severe	2.07
Cieneba-Fallbrook rocky sandy loam	CnE2	9 to 30		Severe	2.40
	CnG2	30 to 65			
Diablo-Olivenhain complex	DoE	9 to 30	Medium to Rapid	Severe	0.79
Escondido very fine sandy loam	EsC	5 to 9	Moderate	Moderate	0.87
	EsD2	9 to 15		Severe	
	EsE2	15 to 30			

[2] Soil map units are utilized by the National Resources Conservation Service (NRCS) to identify and display specific soils and/or groups of soils on a map based on their soil profile, soil type, relationship to other soils, or suitability for various uses.

Soil Type	Soil Map Unit[2]	Slope (percent)	Permeability	Erosion Potential	Length of Soil Type Crossed by Proposed Project (miles)
Fallbrook sandy loam	FaB	2 to 5	Moderately Slow	Slight	3.51
	FaC	5 to 9		Moderate	
	FaC2	5 to 9			
	FaD2	9 to 15		Severe	
	FaE2	15 to 30			
	FaE3	9 to 30			
Fallbrook rocky sandy loam	FeC	5 to 9		Moderate	0.43
Fallbrook-Vista sandy loam	FvD	9 to 15		Moderate	0.82
Friant fine sandy loam	FwF	30 to 50	Moderately Rapid	Severe	0.14
Grangeville fine sandy loam	GoA	0 to 2	Moderate to Moderately Rapid	Slight	0.48
Greenfield sandy loam	GrC	5 to 9	Moderately Rapid	Moderate	0.04
Huerhuero loam	HrC	2 to 9	Very Slow	Moderate	0.13
Las Posas fine sandy loam	LpC	5 to 9	Slow	Moderate	0.94
	LpD2	9 to 15		Severe	
Las Posas stony fine sandy loam	LrG	30 to 65	Slow	Severe	0.47
Olivenhain cobbly loam	OhC	2 to 9	Very Slow	Slight	1.33
	OhE	9 to 30		Moderate	
Olivehain-Urban land complex	OkC	2 to 9		Slight	1.13

<table>
<tr><th>Soil Type</th><th>Soil Map Unit[2]</th><th>Slope (percent)</th><th>Permeability</th><th>Erosion Potential</th><th>Length of Soil Type Crossed by Proposed Project (miles)</th></tr>
<tr><td rowspan="3">Placentia sandy loam</td><td>PeC</td><td>2 to 9</td><td rowspan="4">Very Slow</td><td rowspan="2">Moderate</td><td rowspan="3">3.26</td></tr>
<tr><td>PeC2</td><td>5 to 9</td></tr>
<tr><td>PeD2</td><td>9 to 15</td><td>Severe</td></tr>
<tr><td>Placentia sandy loam, thick surface</td><td>PfC</td><td>2 to 9</td><td>Moderate</td><td>1.26</td></tr>
<tr><td rowspan="4">Ramona sandy loam</td><td>RaB</td><td>2 to 5</td><td rowspan="4">Moderately Slow</td><td rowspan="3">Moderate</td><td rowspan="4">6.43</td></tr>
<tr><td>RaC</td><td>5 to 9</td></tr>
<tr><td>RaC2</td><td>5 to 9</td></tr>
<tr><td>RaD2</td><td>9 to 15</td><td>Severe</td></tr>
<tr><td>Redding gravelly loam</td><td>RdC</td><td>2 to 9</td><td rowspan="3">Slow to Very Slow</td><td>Moderate</td><td>3.27</td></tr>
<tr><td>Redding cobbly loam</td><td>ReE</td><td>9 to 30</td><td>Severe</td><td>2.29</td></tr>
<tr><td>Redding cobbly loam, dissected</td><td>RfF</td><td>15 to 50</td><td>Severe</td><td>1.03</td></tr>
<tr><td>Riverwash</td><td>Rm</td><td>15 to 50</td><td>Moderately Rapid to Very Rapid</td><td>Slight</td><td>1.6</td></tr>
<tr><td>San Miguel rocky silt loam</td><td>SmE</td><td>9 to 30</td><td>Very Slow</td><td>Severe</td><td>0.11</td></tr>
<tr><td>Steep gullied land</td><td>StG</td><td>INA</td><td>INA</td><td>Severe</td><td>0.29</td></tr>
<tr><td>Terrace escarpments</td><td>TeF</td><td>INA</td><td>INA</td><td>Severe</td><td>0.03</td></tr>
<tr><td>Tujunga sand</td><td>TuB</td><td>0 to 5</td><td>Rapid</td><td>Slight</td><td>0.48</td></tr>
<tr><td rowspan="3">Visalia sandy loam</td><td>VaA</td><td>0 to 2</td><td rowspan="3">Rapid</td><td rowspan="2">Slight</td><td rowspan="3">3.8</td></tr>
<tr><td>VaB</td><td>2 to 5</td></tr>
<tr><td>VaC</td><td>5 to 9</td><td>Moderate</td></tr>
</table>

Soil Type	Soil Map Unit[2]	Slope (percent)	Permeability	Erosion Potential	Length of Soil Type Crossed by Proposed Project (miles)
Vista coarse sandy loam	VsD	9 to 15	Moderately Rapid	Severe	2.32
	VsE	15 to 30			
	VsE2	15 to 30			
	VsG	30 to 65			
Vista rocky coarse sandy loam	VvD	5 to 15		Severe	0.84
	VvG	30 to 65			
Water	W	NA	NA	Not Rated	0.32
Wyman loam	WmC	5 to 9	Moderately Slow	Moderate	0.23
	WmD	9 to 15		Severe	

Sources: U.S. Department of Agriculture (USDA) 2014a and 2014b

4.6.3 Impacts

Significance Criteria

Standards of significance were derived from Appendix G of the California Environmental Quality Act Guidelines. Impacts to geology, soils, and seismicity will be considered significant if the Proposed Project:

- Exposes people or structures to potential substantial adverse effects involving strong seismic ground shaking, fault rupture, liquefaction, or landslides
- Results in substantial soil erosion or the loss of topsoil
- Is located on a geologic unit or soil that is unstable, or that will become unstable as a result of the Proposed Project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse
- Is located on expansive soil, as defined in Table 18-1-B of the UBC (1994), creating substantial risks to life or property
- Is located on soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater

Question 4.6a – Human Safety and Structural Integrity

i. Earthquake Fault Rupture – Less-than-Significant Impact

The Proposed Project alignment does not cross any active or potentially active faults. The closest active fault is the Temecula section of the Elsinore fault zone, which is located approximately two miles north of the alignment and is capable of producing a magnitude 6.8 earthquake. Damage to gas pipeline systems from earthquake ground shaking generally occurs to older pipelines. In past earthquakes, transmission pipelines constructed after the 1930s have proven to be resilient to ground-shaking effects due to improved materials and construction methods. Modern pipelines are constructed with welded ductile steel and corrosion protection, which increase pipeline stability and resistance to earthquake hazards. In addition, because the entirety of the pipeline will be buried, the potential effects of seismic shaking will be further reduced. Therefore, the likelihood that ground shaking will cause damage to the proposed pipeline is expected to be low.

Though damage to the pipeline as a result of fault rupture is possible, it is unlikely because fault crossings have been avoided, and the pipeline will be designed to withstand the anticipated earthquake loads. The Applicants will comply with all applicable codes, including the UBC earthwork standards and recommendations. Furthermore, the Applicants have conducted a site-specific Geologic Hazard Assessment for the pipeline and determined that fault rupture is not considered a significant hazard. Because the Proposed Project does not cross active faults and will be designed to minimize potential adverse effects, impacts to people or structures due to fault rupture are expected to be less than significant.

ii. Strong Seismic Shaking – Less-than-Significant Impact

As discussed previously, the Proposed Project is not anticipated to be adversely impacted by strong seismic ground shaking. Although the Pga in the vicinity of the northern portion of the Proposed Project alignment is 0.3 g, a majority of the Proposed Project is located within geologic units that are subject to ground motions less than 0.3 g. To ensure the stability of the proposed pipeline, the Applicants will comply with applicable codes and earthwork standards during construction, which were previously provided in Section 4.6.2 Existing Conditions. In addition, modern pipelines are constructed with welded ductile steel and corrosion protection to prevent potential damage from unstable soils. Therefore, the pipeline will have a low likelihood of failure due to the implementation of standard practices associated with pipeline construction. Additional detail regarding pipeline safety can be found in Section 4.8 Hazards and Hazardous Materials. As previously described, the potential for damage to the pipeline resulting from exposure to seismic shaking is low. As a result, impacts are anticipated to be less than significant.

iii. Ground Failure – Less-than-Significant Impact

The potential for liquefaction and seismic settlement along the majority of the Proposed Project alignment is considered to be low. As described previously, potential liquefaction and seismic settlement may occur at the major river crossings. However, the Applicants will implement APM-GEO-01, which includes the completion of additional geotechnical evaluations to ensure that the Proposed Project is constructed in accordance with applicable codes, seismic standards, and requirements set forth by state, county, and city agencies.

Ground failure and liquefaction are unlikely to result in impacts to new pipelines that will be installed. In the unlikely event that a leak or rupture occurs, the Applicants' operational safety protocols—including remote, automatic, and manual gas shut-off valves—are part of the design to minimize impacts during a catastrophic event. Because the pipeline will be designed to be less vulnerable to liquefaction if a hazard exists, and because the potential for ground failure or liquefaction to damage the pipeline is low, impacts will be less than significant.

iv. Landslides – Less than-Significant Impact

The majority of the pipeline is located in existing roadways, relatively flat topography, or rolling terrain, where landslides are less likely to occur. However, in areas where slopes are steep, landslide hazards could potentially exist. In addition, slopes could become unstable adjacent to or within the Proposed Project right-of-way (ROW) from future urban development or other human-induced activities that alter runoff or existing vegetation. Because pipelines are ductile, some slope movement will not likely cause severe pipeline damage. However, during routine patrols, the Applicants inspect for indications of imminent slope failure and, if present, attempt to stabilize the slope.

No active landslides were identified within the Proposed Project area; however, ancient landslides and landslide-susceptible zones will be traversed by the alignment. Two of these areas are along Pomerado Road between MP 33.0 and MP 35.2 and between MP 37.0 and MP 38.1. Steep slopes were also identified between MP 3.3 and MP 3.8. However, pipeline installation will occur along existing roadways in these locations and will not destabilize adjacent slopes. In addition, none of the areas show evidence of movement in the recent geologic past and do not appear to represent a high level of risk to the proposed pipeline based on the Geologic Hazard Assessment. The Applicants will further evaluate these areas during design-level geotechnical and geologic hazard investigations. Therefore, the risk of landslide damage to new or existing facilities will be reduced to the extent feasible. Furthermore, the Applicants will comply with all applicable codes, including the UBC earthwork standards and recommendations. In addition, the Applicants will implement APM-GEO-01 and APM-GEO-03, which include additional geotechnical evaluations prior to completing the final design and the development of site-specific erosion control drawings for slopes exceeding 33 percent. Therefore, impacts due to landslides will be less than significant.

Question 4.6b – Soil Erosion or Topsoil Loss – ***Less-than-Significant Impact***

Proposed Project activities (e.g., vegetation removal, excavation, and grading) have the potential to cause soil erosion or result in a loss of topsoil, especially in areas with steep slopes. Approximately 40.2 miles of the Proposed Project will be installed in existing roadways where topsoil does not exist. An additional 1.7 miles of the alignment will be installed utilizing trenchless technologies that will avoid the removal of topsoil. For the remaining five miles of cross-country or temporary workspaces where topsoil will be removed, the Applicants will salvage topsoil during the grading phase of the Proposed Project per APM-GEO-02. In addition, as described in APM-GEO-02, the Applicants will implement SDG&E’s Water Quality Construction Best Management Practices (BMPs) Manual, which prescribes an array of erosion and sediment control measures to eliminate or reduce soil erosion and loss of topsoil. Due to the erosion and sediment control measures that will be implemented as part of the Proposed Project, impacts due to potential soil erosion or the loss of topsoil will be less than significant.

Question 4.6c – Geologic Unit Instability – ***Less-than-Significant Impact***

The Proposed Project alignment is located approximately two miles south of the Temecula section of the Elsinore fault zone, which has exhibited a relatively low rate of activity. However, Proposed Project activities could be exposed to lateral spreading, subsidence, or liquefaction from a strong seismic event if the soil conditions associated with these phenomena coincide with long-duration ground shaking. As previously described, portions of the Proposed Project are located within geologic units characterized by severe erosion potential, steep slopes, and liquefaction-prone alluvial soils.

Therefore, the Proposed Project will be engineered to withstand ground movement and will comply with all applicable codes, including the UBC earthwork standards and recommendations. As previously described, the Applicants will implement APM-GEO-01 and conduct design-level geotechnical and geologic hazard investigations for the Proposed Project. Because all Proposed Project activities will be conducted in accordance with all applicable regulations and standards, impacts due to geological instability will be less than significant.

The Proposed Project will meet the U.S. Department of Transportation (DOT) and the California Public Utilities Commission (CPUC) regulations for weather-related and outside force threats. All maintenance activities will be conducted in accordance with CPUC General Order 112-E, which incorporates the DOT regulations in Title 49, Part 192 of the CFR, which is summarized in Section 4.6.2 Existing Conditions. Portions of the operation and maintenance activities will be located on unstable geologic units or soils, but will comply with all applicable codes and UBC earthwork standards and recommendations to prevent landslides. The operation and maintenance activities will not change the potential for lateral spreading, subsidence, liquefaction, or collapse. Therefore, impacts from geological instability will be less than significant.

Question 4.6d – Expansive Soils – *Less-than-Significant Impact*

Potentially expansive soils are not commonly encountered within the majority of geologic units traversed by the pipeline route. However, potentially expansive, clayey soils may be encountered in relatively shallow residual soil layers (i.e., the upper two to five feet) along the Proposed Project alignment, and in areas underlain by the Friars Formation between MP 33.0 and MP 38.0. If improperly designed or installed, new and upgraded facilities in these areas could be subject to damage by expansive soils. However, because the pipeline is flexible, expansive soil will not likely affect its integrity or operability. Further, the pipeline will be installed with select padding and backfill material that will buffer the pipeline from these soils. The Applicants will also comply with all applicable codes and UBC earthwork standards and recommendations. Given the depth of the buried pipeline and the general resilience of large-diameter steel pipelines to minor settlement of the soil, expansive soils are not a significant hazard with respect to pipeline performance. Because the pipeline and its associated facilities will be designed and installed to minimize damage from expansive soils, impacts due to expansive soils will be less than significant.

Question 4.6e – Septic Suitability – *No Impact*

Soil permeability is a consideration for projects that require septic system installation. Because the Proposed Project will not involve the installation of a septic tank or an alternative wastewater disposal system, no impacts will occur.

4.6.4 Applicants-Proposed Measures

The following APMs will be implemented to reduce potential impacts resulting from geologic hazards in the vicinity of the Proposed Project:

- **APM-GEO-01:** Prior to construction, additional geotechnical evaluations will be conducted by a California-licensed geotechnical engineer and California-certified engineering geologist based on the final alignment. The Applicants will consider the recommendations and findings of the final geotechnical evaluations in the final design of all Proposed Project components to ensure that the potential for expansive soils and differential settling is incorporated into the final design and construction techniques. In addition, the Proposed Project will be constructed in accordance with applicable codes, seismic standards, and requirements set forth by state, county, and city agencies.

- **APM-GEO-02:** To ensure the stabilization of topsoil during grading and excavation activities, the Applicants will implement their best management practices for water quality construction. These best management practices include erosion and sediment control measures to reduce the loss of topsoil and ensure that topsoil is salvaged during grading. Following the completion of construction activities, the Applicants will further stabilize disturbed soils by seeding and implementing additional measures outlined in the Storm Water Pollution Prevention Plan, which will be prepared for the Proposed Project.

- **APM-GEO-03**: The Applicants will develop site-specific erosion control drawings in areas where cross-country construction occurs on slopes exceeding 33 percent, including between Milepost 3.3 and Milepost 3.8. The drawings will show the approximate location of trench plugs, waterbars, and outlets. Trench plugs will consist of sakrete, foam, or functional equivalent and will be spaced at regular intervals. Waterbars will be installed below the trench plugs and extend to the edge of the right-of-way or beyond to a stabilized area that will convey flow away from disturbed areas. In addition, the drawings will include stabilization measures, such as rolled erosion control products and seed, as needed. The spacing of the trench plugs and waterbars, as well as the need for additional stabilization measures, will be confirmed in the field by an erosion control specialist.

4.6.5 References

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ATTACHMENT 4.6–A: GEOLOGIC HAZARD ASSESSMENT