California High-Speed Rail Authority

San Jose to Merced Project Section

Draft Environmental Impact Report/ Environmental Impact Statement

Section 3.9
Geology, Soils, Seismicity and Paleontological Resources

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CALIFORNIA
High-Speed Rail Authority

The environmental review, consultation, and other actions required by applicable federal environmental laws for this project are being or have been carried out by the State of California pursuant to 23 U.S.C. 327 and a Memorandum of Understanding dated July 23, 2019, and executed by the Federal Railroad Administration and the State of California.

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ACRONYMS AND ABBREVIATIONS

AREMA	American Railway Engineering and Maintenance-of-Way Association
ATC	automatic train control
Authority	California High-Speed Rail Authority
BMP	best management practice
C.F.R.	Code of Federal Regulations
Cal. Code Regs.	California Code of Regulations
Cal. Public Res. Code	California Public Resources Code
Caltrans	California Department of Transportation
CARB	California Air Resources Board
CBC	California Building Standards Code
CDMG	California Division of Mines and Geology
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
CGP	Construction General Permit
CGS	California Geological Survey
CMP	construction management plan
DOGGR	Division of Oil, Gas, and Geothermal Resources
EEDS	earthquake early detection system
EIR	environmental impact report
EIS	environmental impact statement
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
GHAD	Geologic Hazard Abatement District
HSR	high-speed rail
IAMF	impact avoidance and minimization feature
LDBE	lower-level design basis earthquake
MCE	maximum considered earthquake
NEPA	National Environmental Policy Act
NOA	naturally occurring asbestos
NRCS	Natural Resources Conservation Service
O&M	operations and maintenance
OSHA	Occupational Safety and Health Administration
PBDB	Paleobiology Database
PG&E	Pacific Gas and Electric Company

PMT	program management team
PRMMP	paleontological resources monitoring and mitigation plan
PRM	paleontological resources monitor
PRPA	Paleontological Resources Preservation Act
PRS	paleontological resources specialist
RSA	resource study area
SGMA	Sustainable Groundwater Management Act
SST-FD	Seismic Specialists Team-Fault Displacement
SVP	Society of Vertebrate Paleontology
SWPPP	stormwater pollution prevention plan
TBM	tunnel boring machine
UCERF3	Third Uniform California Earthquake Rupture Forecast
UCMP	University of California Museum of Paleontology
U.S.C.	United States Code
USCS	United Soil Classification System
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WEAP	worker environmental awareness program

3.9 Geology, Soils, Seismicity and Paleontological Resources

3.9.1 Introduction

Geology, Soils, and Seismicity—Key Issues

Geologic hazards resulting in damage to structure or loss of life

Exposure of people or structures to loss of life, injuries, or destruction due to primary and secondary seismic activity

Paleontology—Key Issue

Ground disturbance resulting in loss of paleontological resources (fossils) contained within substrate materials.

This section describes geology, soils, seismicity, and paleontological resources in the San Jose to Central Valley Wye Project Extent (project or project extent) resource study area (RSA) where geology, soils, seismicity, and paleontological resources are most susceptible to change as a result of construction and operations of the project. Geology, soils, and seismicity include the Earth's physical structure, materials, history, and processes. Paleontological resources (fossils) are the preserved remains or traces of animals, plants, protozoans, fungi, and bacteria that can provide important information about the evolution of life on Earth over the past billion years or more. Fossils can also provide information on the age of the rocks in which they are found and shed light on environmental change over time. Fossils are typically found in sedimentary and certain types of metamorphic and extrusive volcanic geologic units.

The *San Jose to Merced Project Section Geology, Soils, and Seismicity Technical Report* (Geology, Soils, and Seismicity Technical Report) (Authority 2019a) provides additional technical details on geologic resources and geologic hazards. This impact analysis considers the California High-Speed Rail Authority's (Authority) project design guideline technical memoranda (Authority 2010a, 2010b, 2010c, 2011a, 2011b, 2011c, 2011d, 2011e, 2014). The *San Jose to Merced Project Section Paleontological Resources Technical Report* (Paleontological Resources Technical Report) (Authority 2019b) provides additional technical details on paleontological resources.

The following appendices in Volume 2 of this Draft environmental impact report (EIR)/environmental impact statement (EIS) provide additional details on geology, soils, seismicity, and paleontological resources:

- Appendix 2-D, Applicable Design Standards, describes the relevant design standards for the project.
- Appendix 2-E, Project Impact Avoidance and Minimization Features, provides the list of all impact avoidance and minimization features (IAMF) incorporated into this project.
- Appendix 2-J, Regional and Local Plans and Policies, provides a list by resource of all applicable regional and local plans and policies.

Geology, soils, and seismicity are important factors for designing and constructing a safe, cost-effective, and environmentally sound project. The geologic setting also plays a key role in determining the potential for paleontological resources to be present. The following three Draft EIR/EIS resource sections provide additional information related to geologic resources:

- Section 3.8, Hydrology and Water Resources, evaluates impacts of the project alternatives on surface water hydrology, water quality, groundwater, floodplains, and soil erosion.
- Section 3.10, Hazardous Materials and Wastes, evaluates impacts of the project alternatives on hazardous materials and waste sites.
- Section 3.11, Safety and Security, evaluates impacts of the project alternatives on the earthquake safety of the high-speed rail (HSR) system.

Volcanic hazards are not included this Draft EIR/EIS because the nearest volcanic sources (Long Valley Caldera and Clear Lake) are more than 100 miles north and east from the project. The project is not in proximity of the limits of the anticipated volcanic hazards from these sources including tephra ash fall (Miller 1989).

3.9.2 Laws, Regulations, and Orders

This section presents federal, state, and local laws, regulations, orders, and plans applicable to geology, soils, seismicity, and paleontology. The Authority would implement the HSR system, including this project, in compliance with all federal and state regulations. Regional and local plans and policies relevant to geology, soils, seismicity, and paleontological resources considered in the preparation of this analysis are provided in Volume 2, Appendix 2-J.

3.9.2.1 Geology, Soils, and Seismicity

Federal

Procedures for Considering Environmental Impacts (64 Federal Register 28545)

The Federal Railroad Administration (FRA) procedures state that an EIS should consider possible impacts on energy and mineral resources.

State

Alquist-Priolo Earthquake Fault Zoning Act (Cal. Public Res. Code, § 2621 et seq.)

The Alquist-Priolo Earthquake Fault Zoning Act was signed into law on December 22, 1972, and went into effect March 7, 1973. The purpose of the Act was to regulate development near active faults in order to mitigate the hazard of surface fault rupture. In general, the Act has two requirements: prohibiting the location of “developments and structures for human occupancy” across the trace of active faults, and establishing Earthquake Fault Zones as defined by the State Geologist, within which affected cities and counties must establish special procedures for reviewing and approving applications for new building permits.

Seismic Hazards Mapping Act (Cal. Public Res. Code, §§ 2690–2699.6)

The State Legislature passed the Seismic Hazards Mapping Act in 1990, which was codified in the California Public Resources Code (Cal. Public Res. Code) as Division 2, Chapter 7.8, which became operative on April 1, 1991. The purpose of the act is to identify areas where earthquakes are likely to cause shaking, liquefaction, landslides, or other ground failure, and to regulate development to reduce future earthquake losses. The California Geological Survey (CGS) has responsibility for developing the hazard maps, and has incrementally focused their efforts on the highest risk areas and areas undergoing significant development. This act requires that site-specific hazard investigations be conducted by licensed professionals, within the zones of required investigation, to identify and evaluate seismic hazards and formulate mitigation measures prior to permitting most developments designed for human occupancy.

Geologic Hazard Abatement Districts (Cal. Public Res. Code, Division 17, §§ 26500–26654)

The Beverly Act of 1979 (Senate Bill 1195) established Geologic Hazard Abatement Districts (GHAD) and allowed local residents to collectively mitigate geological hazards that pose a threat to their properties. GHADs may be formed for the following purposes: prevention, mitigation, abatement, or control of a geologic hazard; and mitigation or abatement of structural hazards that are partly or wholly caused by geologic hazards. Cal. Public Res. Code defines a geologic hazard as “an actual or threatened landslide, land subsidence, soil erosion, earthquake, fault movement, or any other natural or unnatural movement of land or earth.”

Surface Mining and Reclamation Act (Cal. Public Res. Code, § 2710 et seq.)

This act addresses the need for a continuing supply of mineral resources and is intended to prevent or minimize the adverse effects of surface mining on public health, property, and the environment. The act also assigns specific responsibilities to local jurisdictions in permitting and oversight of mineral resources extraction activities.

California Building Standards Code (Cal. Public Res. Code, tit. 24)

The California Building Standards Code (CBC) governs the design and construction of buildings, associated facilities, and equipment and applies to buildings in California.

Oil and Gas Conservation (Cal. Public Res. Code, §§ 3000–3473)

The Division of Oil, Gas, and Geothermal Resources (DOGGR) within the Department of Conservation oversees the drilling, operation, maintenance, and plugging and abandonment of oil, natural gas, and geothermal wells. DOGGR's regulatory program emphasizes the wise development of oil, natural gas, and geothermal resources in the state through sound engineering practices that protect the environment and public safety, and prevent pollution.

Construction General Permit (California State Water Resources Control Board Order No. 2009-0009-DWQ; NPDES No. CAS000002)

Stormwater from construction projects that disturb 1 or more acres of soil, or that disturb less than 1 acre but are part of a larger common plan of development, are required to obtain coverage under the statewide General Permit for Discharges of Storm Water Associated with Construction Activity (also referred to as the Construction General Permit, or CGP). The CGP requires temporary and post-construction best management practices (BMP) and measures to prevent erosion and reduce sediment and pollutants in discharges from construction sites, such as the development of a stormwater pollution prevention plan (SWPPP) by a certified qualified SWPPP developer. A SWPPP is a written document that identifies potential sources of stormwater pollution, describes practices to reduce pollutants in stormwater, and identifies procedures to comply with the permit.

Sustainable Groundwater Management Act

The Sustainable Groundwater Management Act (SGMA) requires California governments and water agencies of high- and medium-priority groundwater basins to halt aquifer overdraft by balancing pumping and recharge levels. Balancing levels of aquifer pumping and recharge would significantly reduce or eliminate regional ground subsidence within a basin. Under the SGMA, these basins should reach sustainability by 2042 (DWR 2018a).

3.9.2.2 Paleontological Resources

Federal

American Antiquities Act of 1906 (16 U.S.C. §§ 431–433)

The American Antiquities Act was enacted with the primary goal of protecting cultural resources in the United States. As such, it prohibits appropriation, excavation, injury, or destruction of "any historic or prehistoric ruin or monument, or any object of antiquity" located on lands owned or controlled by the federal government. The act also establishes penalties for such actions and sets forth a permit requirement for collection of antiquities on federally owned lands.

Although neither the American Antiquities Act itself nor its implementing regulations (43 Code of Federal Regulations [C.F.R.] Part 3) specifically mentions paleontological resources, many federal agencies have interpreted objects of antiquity as including fossils. Consequently, the American Antiquities Act represents an early cornerstone of efforts to protect the nation's paleontological resources.

Paleontological Resources Preservation Act (16 U.S.C. § 470aaa)

Enacted as part of the Omnibus Public Land Management Act (2009), the Paleontological Resources Preservation Act (PRPA) requires the Secretaries of the Interior and Agriculture to manage and protect paleontological resources on federal land using scientific principles and expertise. The PRPA includes specific provisions addressing management of these resources by the Bureau of Land Management, the National Park Service, the U.S. Bureau of Reclamation, the U.S. Fish and Wildlife Service, and the U.S. Forest Service of the Department of Agriculture. The PRPA affirms the authority for many of the policies the federal land-managing agencies already have in place for the management of paleontological resources, such as issuing permits for collecting paleontological resources, curation of paleontological resources, and confidentiality of locality data (Bureau of Land Management 2016).

State

CEQA (Cal. Public Res. Code, § 21000 et seq.) and CEQA Guidelines for Protection for Paleontological Resources

The California Environmental Quality Act (CEQA) statute includes “objects of historic … significance” in its definition of the environment (Cal. Public Res. Code, § 21060.5), and Section 15064.5 of the CEQA Guidelines further defines historical resources as including “any object…site, area, [or] place… that has yielded, or may be likely to yield, information important in prehistory.” This has been widely interpreted as extending CEQA consideration to paleontological resources. The cultural resources section of the CEQA Guidelines Appendix G sample environmental checklist reflects this perspective, and includes a question asking whether the proposed project would “directly or indirectly destroy a unique paleontological resource or site.” However, neither the CEQA statute nor the CEQA Guidelines define what constitutes a “unique paleontological resource” or a “unique paleontological site” and thus merits consideration under this checklist item. Neither the CEQA statute nor the CEQA Guidelines gives direction regarding the treatment of paleontological resources in general (unique and non-unique). Because of the breadth of the CEQA definition of “historical resources,” the general guidance regarding significance determinations in Section 15064.5(b) of the CEQA Guidelines may be interpreted as applying to impacts on paleontological resources, but this chapter focuses for the most part on factors specifically related to eligibility for state and local register listing; it does not address the essence of “[yielding] information important in prehistory” from a paleontological perspective. The most relevant guidance appears in CEQA Guidelines Section 15064.5(b)(1), which defines a “[s]ubstantial adverse change in the significance of an historical resource”—and by extension, a significant impact on such resources, including paleontological resources—as the “physical demolition, destruction, relocation, or alteration of the resource or its immediate surroundings such that … [its] significance … would be materially impaired.”

California Public Resources Code

The Cal. Public Res. Code protects paleontological resources in specific contexts. In particular, Cal. Public Res. Code Section 5097.5 prohibits “knowing and willful” excavation, removal, destruction, injury, and defacement of any vertebrate paleontological feature on public lands without express authorization from the agency with jurisdiction. Violation of this prohibition is a misdemeanor and is subject to a fine, imprisonment, or both (Cal. Public Res. Code, § 5097.5(c)), and persons convicted of such a violation may also be required to provide restitution (Cal. Public Res. Code, § 5097.5(d)(1)). Additionally, Cal. Public Res. Code Section 30244 requires “reasonable mitigation measures” to address impacts on paleontological resources on public lands identified by the State Historic Preservation Officer.

3.9.2.3 Regional and Local

Appendix 2-J in Volume 2 lists all regional and local policies that are applicable to the project. The geology, soils, seismicity, and paleontology standards included in regional and local policies restate, or incorporate by reference, federal and state geologic and seismic hazard and paleontological resources policies described in Section 3.9.2.1, Geology, Soils, and Seismicity, and Section 3.9.2.2, Paleontological Resources.

3.9.3 Consistency with Plans and Laws

As indicated in Section 3.1.5.3, Consistency with Plans and Laws, CEQA and National Environmental Policy Act (NEPA) regulations[1] require a discussion of inconsistencies or conflicts between a proposed undertaking and federal, state, regional, or local plans and laws. As such, this Draft EIR/EIS describes the inconsistency of the project alternatives with federal, state, regional, and local plans and laws to provide planning context.

3.9.3.1 Geology, Soils, and Seismicity

There are a number of federal and state laws and implementing regulations, listed in Section 3.9.2.1 under subsections Federal and State, that govern compliance with construction and operations standards relating to geology, soils, and seismicity for construction projects and transportation facilities. A summary of the federal and state requirements considered in this analysis follows:

- FRA guidelines for consideration of possible effects on energy and mineral resources
- State laws that govern construction in areas of known seismic activity
- State laws that address construction in or near areas of energy and mineral extraction activity
- State guidelines governing construction with respect to geologic and soils hazards

The Authority, as the lead agency proposing to construct and operate the HSR system, must comply with all federal and state laws and regulations and secure all applicable federal and state permits prior to initiating construction on the selected alternative. Therefore, there would be no inconsistencies between the project alternatives and these federal and state laws and regulations.

The Authority is a state agency and therefore is not required to comply with local land use and zoning regulations; however, it has endeavored to design and construct the HSR project to be consistent with land use and zoning regulations. For example, the project alternatives would incorporate an IAMF that requires the contractor to evaluate and take into account soil vulnerabilities, as local ordinances also require. The Authority would also adopt a monitoring program to track any subsidence during operations. Analysts reviewed a total of 7 plans and 33 policies, goals, objectives, implementation actions, implementation programs, and implementation measures. The project alternatives are consistent with all plans, codes, policies, and goals for geology, soils, and seismicity because construction practices, infrastructure design, and operations would be consistent with established building standards relevant to geotechnical issues.

3.9.3.2 Paleontological Resources

Federal and State Laws and Regulations

Section 3.9.2.2 lists a number of federal and state laws and implementing regulations that protect paleontological resources. These federal and state requirements include:

- Federal regulations that address paleontological resources on federally owned or controlled lands.
- State regulations that address paleontological resources on state and public (i.e., state, county, city, special district, public authority, and public corporation) lands.

The Authority, as the lead agency proposing to construct and operate the HSR system, must comply with all federal and state laws and regulations and secure all applicable federal and state permits prior to initiating construction on the selected alternative. Therefore, there would be no inconsistencies between the project alternatives and these federal and state laws and regulations.

The IAMFs for paleontological resources incorporate specific actions to protect scientifically important paleontological resources and avoid the loss of scientific information, consistent with prevailing Society of Vertebrate Paleontology (SVP) guidance (the SVP Standard Guidelines,

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[1] NEPA regulations refer to the regulations issued by the Council on Environmental Quality located at 40 C.F.R. Part 1500.

Conditions of Receivership, and Standard Procedures) and the overall objectives of federal laws protecting paleontological resources. Moreover, with the IAMFs in place, any collection of paleontological resources during construction of the project alternatives would occur with the authorization and oversight of the Authority and would be conducted by a qualified paleontological resources specialist (PRS) in a manner consistent with the prevailing discipline standard for paleontological resources recovery and curation. Consequently, the project alternatives are considered consistent with the objectives of federal and state regulations that require science-based management of paleontological resources and prohibit unauthorized destruction of such resources.

Local Plans and Policies

The Authority is a state agency and therefore is not required to comply with local land use and zoning regulations; however, it has endeavored to design and construct the HSR project so that it is consistent with land use and zoning regulations, including goals and policies protecting paleontological resources. Analysts reviewed a total of 8 plans and 52 policies, goals, objectives, implementation actions, implementation programs, and implementation measures.

The Authority's standard paleontological resources methodology guidelines (Authority 2014) guided the development and content of the paleontological resources IAMFs incorporated into the project alternatives. As the project requires review of 90 percent design and development of specific language detailing paleontological monitoring and other requirements to protect paleontological resources (GEO-IAMF#11: Engage a Qualified Paleontological Resource Specialist), the project alternatives are consistent with all plans, codes, policies, and goals for paleontological resources because the design is consistent with standards of professional practice.

3.9.4 Methods for Evaluating Impacts

3.9.4.1 Impact Avoidance and Minimization Features

IAMFs are project features that are considered to be part of the project and are included as applicable in each of the alternatives for purposes of the environmental impact analysis. The full text of the IAMFs that are applicable to the project is provided in Appendix 2-E. The following IAMFs are applicable to the geology, soils, seismicity, and paleontological resources analysis:

- GEO-IAMF#1: Geologic Hazards
- GEO-IAMF#2: Slope Monitoring
- GEO-IAMF#3: Gas Monitoring
- GEO-IAMF#4: Historic or Abandoned Mines
- GEO-IAMF#5: Hazardous Minerals
- GEO-IAMF#6: Ground Rupture Early Warning Systems
- GEO-IAMF#7: Evaluate and Design for Large Seismic Ground Shaking
- GEO-IAMF#8: Suspension of Operations during an Earthquake
- GEO-IAMF#9: Subsidence Monitoring
- GEO-IAMF#10: Geology and Soils
- GEO-IAMF#11: Engage a Qualified Paleontological Resources Specialist
- GEO-IAMF#12: Perform Final Design Review and Triggers Evaluation
- GEO-IAMF#13: Prepare and Implement Paleontological Resources Monitoring and Mitigation Plan (PRMMP)
- GEO-IAMF#14: Provide WEAP Training for Paleontological Resources
- GEO-IAMF#15: Halt Construction, Evaluate, and Treat if Paleontological Resources are Found

- HYD-IAMF#3: Prepare and Implement a Construction Stormwater Pollution Prevention Plan

This environmental impact analysis considers these IAMFs as part of the project design. In Section 3.9.6, Environmental Consequences, each impact narrative describes how these project features are applicable and, where appropriate, effective at avoiding or minimizing potential impacts to less than significant under CEQA.

3.9.4.2 Geology, Soils, and Seismicity

The following discussion describes the methods used to establish the geological setting in the RSAs, and to determine the impacts of construction and operations on geology, soils, and seismicity. The methods involved the review and assessment of publicly available data when establishing potential impacts. The RSAs were developed to represent the localized (within project footprint) and regional areas of impact.

Definition of Resource Study Areas

Table 3.9-1 describes the RSAs for geology, soils, and seismicity. The RSAs extend beyond the project footprint and into the subsurface beneath the project, such that the RSAs are three-dimensional.

Table 3.9-1 Definition of Geology, Soils, and Seismicity Resource Study Areas

Type	Boundary Definition
Geology, Soils, and Seismicity RSA	
Construction and operations	The RSA for geology, soils, and seismicity is defined as 150 feet on either side of the project footprints for all resources and conditions other than those covered under the separate geologic hazards and seismicity, faulting, and dam failure inundation RSAs.
Geologic Hazards RSA	
Construction and operations	The geologic hazards (soil failures [e.g., adequacy of load-bearing soils], settlement, corrosivity, expansion, erosion, earthquake-induced liquefaction risks, subsidence, and subsurface gas hazards, mineral resource extraction and oil and gas wells) RSA is 0.5 mile on either side of the project alternatives' footprints. The buffer is increased to 2 miles around maintenance facility sites and station sites.
Seismicity, Faulting, and Dam Failure Inundation RSA	
Construction and operations	The seismicity, faulting, and dam failure inundation RSA is defined as a 50-mile radius on either side of the project alternatives' footprints.

RSA = resource study area

Methods for Impact Analysis

The methods used for performing impact analysis included review of information from published maps, professional publications, and reports pertaining to the geology, soils, and seismicity in the geology, soils, and seismicity RSA, the geologic hazards RSA, and the seismicity, faulting, and dam failure inundation RSA. Analysts studied the relevant information and assessed the effects of the project related to geology, soils, and seismicity. Chapter 4, Methods for Evaluating Effects, of the Geology, Soils, and Seismicity Technical Report describes the information used for the analysis (Authority 2019a).

Primary Data Sources for Impact Analysis

- Geologic maps
- Geohazard maps (e.g., landslides and liquefaction)
- Soil maps
- Topographic maps
- Aerial photographs
- Reports by the Authority and others

The impacts analysis evaluates the potential of the project to directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death as a result of geologic hazards, primary seismic hazards, and secondary seismic hazards. The analysis also evaluates the potential for the project to cause soil erosion or reduce the availability of mineral, fossil fuel, and geothermal resources.

Method for Evaluating Impacts under NEPA

Council on Environmental Quality (CEQ) NEPA regulations (40 C.F.R. Parts 1500–1508) provide the basis for evaluating project effects (as described in Section 3.1.5.4, Methods for Evaluating Impacts). As described in Section 1508.27 of these regulations, the criteria of context and intensity are considered together when determining whether a project action would affect a resource.

- **Context**—For this analysis, the *context* would include the type, quality, and sensitivity of the resource involved, the location, or the geographical extent of the effect (national, regional, or local). For the analysis of geology, soils, and seismicity, the context would include the proximity to geologic, soil, and seismic hazards of concern, such as active faults and mapped landslide areas; the relative risk levels (i.e., low, moderate, high) of these hazards in proximity to the project; and the potential for occurrence of energy and mineral resources.
- **Intensity**—For this analysis, *intensity* is determined by the potential duration of exposure to geologic, soil, and seismic hazards (e.g., during excavation activity, duration of project operations); the potential for geologic, soil, and seismic hazards to occur during construction and operations (e.g., frequency of large earthquakes); the degree or severity to which the project could affect public safety and property associated with geologic, soil, and seismic hazards; and the volume of mineral or energy resources that would be unavailable for extraction or number and size of mineral operations that would have restricted access. To inform the severity of effect, analysis focuses on direct impacts, in comparison to No Project effects.

Method for Determining Significance under CEQA

CEQA requires an EIR to identify the significant environmental impacts of a project (CEQA Guidelines § 15126). Accordingly, Section 3.9.9, CEQA Significance Conclusions, summarizes the significance of the resource (as presented in Section 3.1.5.4). One of the primary differences between NEPA and CEQA is that CEQA requires a threshold-based impact analysis. For the purposes of this analysis, the project would result in a significant impact on geology, soils, or seismicity if it would:

- Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death, beyond what people are exposed to currently in the area’s environment due to: seismic activity or its related hazards; fault rupture; strong seismic ground shaking; ground failure including liquefaction; dam failure, seiche or tsunami, or, landslides
- Result in substantial soil erosion or the loss of topsoil in a large area that adversely affects the viability of the ecosystem or productivity of farming present in the area
- Is located on a geologic unit or soil that is unstable or that renders a currently stable geologic unit or soil unstable to a degree that it would result in increased exposure of people to loss of life or structures to destruction due to geologic hazards, such as primary and secondary seismic hazards
- Be constructed on expansive soil or corrosive soils as defined in Table 18-1-B of the Uniform Building Code (1994, or most recent applicable Uniform Building Code, International Building Code, or CBC), creating substantial direct or indirect risks to life or property as a result of the soils’ nature, for instance causing the collapse of the structure
- Make a known petroleum or natural gas resource of regional or statewide value unavailable to extraction through the physical presence of the project either at the ground surface or subsurface
- Result in the loss of availability of a locally important mineral resource recovery site
- Be located in an area of subsurface gas hazard, including landfill gas, and provide a route of exposure to that hazard that results in a substantial risk of loss of life or destruction of property

The analysis of risks to the project from existing geological conditions is for information purposes only and no CEQA significance finding is required.

3.9.4.3 Paleontological Resources

Professional Standards and Authority's Environmental Methodology Guidelines

Although federal and state regulations establish protection for paleontological resources, the legal framework is nonspecific regarding some critical details:

- What resources merit protection?
- What constitutes a significant adverse effect on those resources?
- What level of protection is adequate?

This gap has been filled in two ways: through processes and protocols developed by individual practitioners and professional societies and through guidelines developed by federal, state, and local lead agencies under NEPA and CEQA, respectively.

To comply with applicable laws, the SVP, a scientific organization of professional vertebrate paleontologists, has established standard guidelines (SVP 1996, 2010) that outline acceptable professional practices in the conduct of paleontological resource assessments and surveys, monitoring and mitigation, data and fossil recovery, sampling procedures, museum curation, and specimen preparation, identification, and analysis. A consensus of professional paleontologists approved the SVP's standard guidelines, and they are the standard against which many paleontological monitoring and mitigation programs are judged. Most professional paleontologists in California adhere closely to the SVP's assessment, mitigation, and monitoring requirements as specified in these standard guidelines. Many regulatory agencies as well as many county and city agencies have either formally or informally adopted the SVP's standard guidelines for the mitigation of construction-related impacts on paleontological resources. In addition, the SVP standard procedures (SVP 2010) are the basis of the specific reporting and monitoring requirements set forth in the California Department of Transportation (Caltrans) *Standard Environmental Reference* (Caltrans 2017). Briefly, SVP standard guidelines require literature and museum archival reviews for each project, as well as a field survey and, if there is a high potential for disturbing significant fossils during project construction, a mitigation plan that includes monitoring by a qualified paleontologist to salvage fossils encountered, identify salvaged fossils, determine their significance, and place curated fossil specimens into a permanent paleontological repository (e.g., public museum or other institution with a permanent curator on staff).

The portion of the Version 5 Environmental Methods (Authority and FRA 2017) that addresses paleontological resources was based largely on the methodology laid out in Chapter 8, Paleontology, of the Caltrans *Standard Environmental Reference* (Caltrans 2017). The Caltrans methodology is a good model for Authority needs because it is not only consistent with the discipline's SVP standard guidelines but was also developed to meet Caltrans' responsibilities under both NEPA and CEQA. The key difference between the Caltrans approach and the Authority's Version 5 Environmental Methods is that the latter replaced Caltrans' multiple sequential technical reports with a single project-specific technical report that meets the requirements of both the Caltrans Paleontological Identification Report and Paleontological Evaluation Report. This approach streamlines the technical report preparation process without losing scientific substance.

NEPA and CEQA require the evaluation of impacts on paleontological resources. The following sections describe the paleontological resources RSA and the methods used to analyze paleontological resources.

Definition of Resource Study Area

Table 3.9-2 describes the RSA for paleontological resources, which encompasses the areas directly or indirectly affected by construction and operations. The paleontological resources RSAs for direct and indirect impacts are identical. Where ground disturbance extends into the subsurface, as is typical for excavation, grading, tunneling, and foundation drilling, the paleontological resources RSA becomes a three-dimensional extent of potential disturbance. The maximum subsurface depth of the paleontological resources RSA for the proposed station upgrades, and at-grade, tunnel, and elevated areas of the track alignment is yet to be determined. Activities such as clearing are generally shallow and restricted to the top few inches of surface sediments.

Table 3.9-2 Definition of Paleontological Resources Study Area

Source	RSA Boundary Definition
Paleontological Resources	
Construction and operations	Affected geologic units throughout their geographic extent; includes units exposed at the surface within the project footprint and a surrounding 150-foot-wide buffer, as well as those present in the subsurface below this area, to the depth potentially encountered by construction or operations.

RSA = resource study area

Methods for Impact Analysis

The methods used for performing the paleontological impact analysis included a resource inventory consisting of review of information from published geologic maps, cross sections, records searches of pertinent local and regional museum repositories, scientific literature, and reports pertaining to the geology and paleontology in the vicinity of the project alignment. Using baseline information gathered during the paleontological resources inventory, analysts determined the paleontological resources potential ranking of each geologic unit within the paleontological resources RSA using the criteria outlined in the SVP standard procedures (SVP 2010). Because the Version 5 Environmental Methods are based on a combination of SVP and Caltrans guidelines, Table 3.9-3 describes the SVP (2010) rankings, and compares it to the Caltrans tripartite scale.

Primary Data Sources for Paleontological Impact Analysis

- Geologic maps
- Geologic cross sections
- Paleontological records searches
- Scientific literature
- Reports by the Authority and others
- Criteria outlined in the SVP standard guidelines

Table 3.9-3 Evaluation of Paleontological Sensitivity/Paleontological Potential

SVP Resource Potential	Caltrans Tripartite Scale	Sensitivity Criteria
No Potential	No Potential	Geologic units of intrusive igneous origin, most extrusive igneous rocks, and medium- to high-grade metamorphic rocks are classified as having no potential for containing significant paleontological resources.
Low Potential	Low Potential	This category includes geologic units that are potentially fossiliferous, based upon review of available literature and museum collections records, but have yielded few, if any, significant fossils in the past; or have not yielded fossils, but possess a potential for containing fossil remains; or contain common and/or widespread invertebrate fossils (if the taxonomy, phylogeny, and ecology of the species are well understood). Geologic units of low potential also include those that yield fossils only on rare occasions or under unusual circumstances, eolian deposits, geologic units younger than 10,000 years before present, and deposits that exhibit a high degree of diagenetic alteration.
Undetermined Potential	N/A	In some cases, available literature on a particular geologic unit is scarce and a determination of whether or not it is fossiliferous or potentially fossiliferous would be difficult to make. Under these circumstances, the sensitivity is unknown and further study is needed to determine the unit's paleontological resources potential.
High Potential	High Potential	Geologic units with high potential for paleontological resources are those that, based on previous studies, have proven to yield vertebrate or significant invertebrate, plant, or trace fossils in the past or are likely to contain new vertebrate materials, traces, or trackways. Geologic units with high potential also may include those that contain datable organic remains older than late Holocene (e.g., animal nests, middens). These units include sedimentary deposits that contain significant nonrenewable paleontological resources anywhere within their geographical extent, and sedimentary deposits temporally or lithologically suitable for the preservation of fossils. These units may also include some volcanic and low-grade metamorphic rock units. Fossiliferous deposits with very limited geographic extent or an uncommon origin (e.g., tar pits and caves) are given special consideration and ranked as highly sensitive. A geologic unit with high sensitivity is susceptible to surface-disturbing activities and includes fossiliferous sedimentary deposits that are well exposed with little vegetative cover as well as those shallowly covered by soil, alluvium, or vegetation.

Sources: Caltrans 2017; SVP 2010
Caltrans = California Department of Transportation
N/A = not applicable
SVP = Society of Vertebrate Paleontology

The HSR program defines significant fossils as those that provide taxonomic, taphonomic, phylogenetic, stratigraphic, ecologic, or climatic information. Significant fossils may include body fossils, traces, tracks, and trackways (Authority 2019b). This usage is consistent with both the Caltrans and SVP approaches (Caltrans 2017; SVP 2010). Analysts evaluated the risk to paleontological resources based on the anticipated three-dimensional extent of ground disturbance and the paleontological potential (potential to contain scientifically important fossils) of the geologic units present. This analysis was qualitative, but did take into account the proportionality between the extent of disturbance (based on the project description and the proposed proportion of tunnel, at-grade, and elevated tracks for each alternative), and the extent of potential paleontological resource destruction and loss of information. The Paleontological Resources Technical Report (Authority 2019b) describes the information used for the analysis in detail.

Geology, soils, and seismicity studies and paleontological resources studies differ in the types of geologic maps that are required for complete analyses in accordance with industry standards. Geological studies for the project required review of small-scale maps that cover large areas of the project footprint, whereas the paleontological studies required review of large-scale maps of surficial sediments and the sedimentary bedrock in greater detail. Therefore, the geology, soils, and seismicity analysis used geologic unit descriptions based on mapping at a 1:100,000 scale by Wentworth et al. (1999) and Wagner et al. (2002), and a 1:125,000 scale by Clinkenbeard (1999). The paleontological resources analysis used the largest-scale (i.e., highest-resolution) geologic maps available, which included mapping at a scale of 1:24,000 by Dibblee and Minch (2005a–e, 2006a, 2006b, 2007a–g) and McLaughlin et al. (2001). Where mapping at a scale of 1:24,000 was not available, the paleontological resources analysis used mapping at a scale of 1:250,000 by Wagner et al. (1991). The paleontological resources analysis also grouped together descriptions of geologic units not assigned to a named formation (e.g., Quaternary surface deposits) that are of similar age, depositional environment, and paleontological potential for ease of reference. Table 3.9-4 shows a comparison of the geologic unit terminology used for the two studies. It is important to emphasize that in cases where different geologic unit terminologies are used, the actual physical deposits are the same (only the names used are different). For example, the physical deposits mapped as Knoxville Formation on large-scale maps are lumped in with and referred to as Panoche Formation on small-scale maps. References to the maps used in the geology, soils, and seismicity study are provided in the Geology, Soils, and Seismicity Technical Report (Authority 2019a). The geology and paleontological potential maps used for the paleontological resources study are available in Appendix A, Geologic Maps, of the Paleontological Resources Technical Report (Authority 2019b).

Method for Evaluating Impacts under NEPA

CEQ NEPA regulations (40 C.F.R. Parts 1500–1508) provide the basis for evaluating project effects (as described in Section 3.1.5.4). As described in Section 1508.27 of these regulations, the criteria of context and intensity are considered together when determining if a project action would affect a resource.

- **Context**—For this analysis, the *context* would be the likelihood that fossils would be encountered during ground disturbance, in combination with the probability that the affected fossils are scientifically important. For example, destruction as the result of surface and subsurface disturbance, as well as loss to the scientific community through vandalism or unauthorized collection, of a scientifically important fossil or fossils would be an impact.
- **Intensity**—Paleontological resources are nonrenewable and any loss because of direct or indirect impacts results in the permanent unavailability of the fossil specimen and associated data to scientific research and education, as well as the loss of the information about Earth’s history that it could have potentially provided.

Table 3.9-4 Comparison of Geologic Unit Terminology Used for the Geology, Soils, and Seismicity Analysis and Paleontological Resources Analysis

Geologic Units used for Geology, Soils, and Seismicity	Geologic Units used for Paleontological Resources
Jurassic Serpentinized Ultramafic Rocks (Jsp) Cretaceous Basaltic Volcanic Rocks (Fpv) Jurassic/Cretaceous Franciscan Assemblage (fm, fy1, fy3, gs)	Franciscan Assemblage (fc, fg, fl, fm, fms, fmv, fpl, fpv, fs, fss, gl, v)
Jurassic Serpentinized Ultramafic Rocks (Jsp)	Coast Range Ophiolite Complex (db, sc, sp, Jos)
The name Knoxville Formation is not used in geology analysis, instead these deposits are attributed to the Panoche Formation	Knoxville Formation (JKk)
Jurassic/Cretaceous Panoche Formation (Kp, KJm, Klc, Kmm, Kms, Kpc, Kpm, Kps, Kcu, Ku)	Panoche Formation (Kp, Kpc, Kps, Ku)
The name Moreno Formation is not used in the geology analysis; instead these deposits are attributed to the Panoche Formation	Moreno Formation (Km, Kms)
Jurassic/Cretaceous Panoche Formation (Kcu, Ku)	Unnamed clay shale and claystone (Tsh)
Pliocene Silver Creek Gravels (Tsg)	The name Silver Creek Gravels is not used in the paleontological analysis; instead these deposits are attributed to the Santa Clara Formation (QTs)
Monterey Shale (Tms)	Monterey Formation[1] (Tm, Tms)
Santa Clara Formation (QTsc)	Santa Clara Formation (QTs, QTs, QTsc)
Pleistocene Modesto Formation (Qm, m1, m2)	Modesto Formation (Qm)
Quaternary Landslide Deposits (Qls) Pleistocene Older Alluvium (Qoa) Upper Pleistocene Alluvial Fan (Qpf) Holocene and Upper Pleistocene Alluvial Fan Complex (Qfc)	Older Quaternary Deposits (Qg, Qls, Qsc, Qsp, Qoa, Qoa1, Qoa2, Qpf)
Quaternary Alluvium of San Luis Ranch, Lower Member (Qsl) Holocene to Pleistocene San Luis Ranch alluvium (Qs)	San Luis Ranch Alluvium (Qsl)

Geologic Units used for Geology, Soils, and Seismicity	Geologic Units used for Paleontological Resources
Holocene Levee Deposits (Qhl) Holocene Alluvial Fan Deposits (Qhf2) Holocene Stream Terrace Deposit (Qht) Holocene Basin Deposits (Qhb) Holocene Flood Plain Deposits (Qhfp) Holocene Alluvium (Qha) Holocene Alluvium of Patterson (Qap) Holocene and Upper Pleistocene Alluvial Fan Complex (Qfc) Holocene Alluvium (Qh) Holocene to Pleistocene San Luis Ranch Alluvium (Qs) Holocene Patterson Deposits (Qp, Qpf) Holocene Dos Palos Alluvium (Qd)	Younger Quaternary Deposits, Patterson Alluvium, Dos Palos Alluvium (gp, Qac, Qdp, Qa, Qa.1, Qa.2, Qhb, Qhc, Qhf, Qhfp, Qhl, Qp, Qya)
Not included in analysis	Artificial Fill, gravel quarry, percolation pond[2] (af, pp)

Sources: Wentworth et al. 1999; Wagner et al. 2002; Clinkenbeard 1999; McLaughlin et al. 2001; Wagner et al. 1991; Dibblee and Minch 2005a–e, 2006a, 2006b, 2007a–g

[1] Sensitive geologic unit not mapped at the surface within the alignment, but potentially present at depth

[2] Mapped in the vicinity of the paleontological resources RSA and was observed in aerial photographs in all subsections

Method for Determining Significance under CEQA

CEQA requires an EIR to identify the significant environmental impacts of a project (CEQA Guidelines § 15126). One of the primary differences between NEPA and CEQA is that CEQA requires a threshold-based impact analysis. Significant impacts are determined by evaluating whether project impacts would exceed the significance threshold established for the resources (as presented in Section 3.1.5.4). For this analysis, the project would result in a significant impact on paleontological resources if it would directly or indirectly destroy a unique paleontological resource or site or unique geologic feature.

3.9.5 Affected Environment

This section describes the affected environment for geology, soils, seismicity, and paleontological resources in the respective RSAs. This information provides the context for the environmental analysis and the evaluation of impacts.

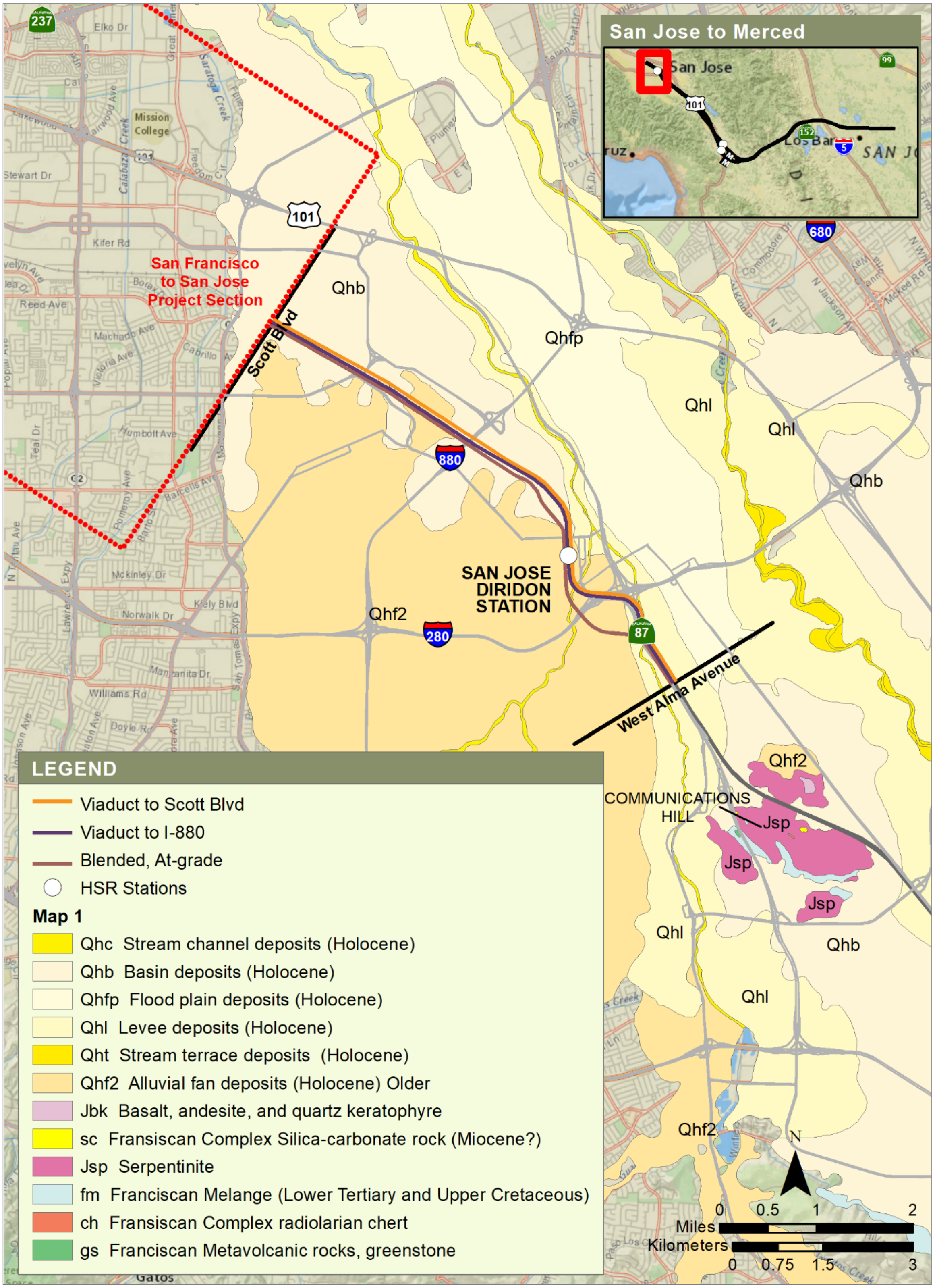
3.9.5.1 Physiography and Regional Geologic Setting, Geologic Conditions, and Soils

The western portion of the geology, soils, and seismicity RSA is situated in the Coast Ranges Geomorphic Province and crosses into the Great Valley Geomorphic Province in its eastern portion in the San Joaquin Valley (Oakeshott 1966). A geomorphic province is a region of unique topography and geology that is readily distinguished from other regions based on its landforms and tectonic history. The San Jose Diridon Station Approach, Monterey Corridor, Morgan Hill and Gilroy, and Pacheco Pass Subsections are all located in the Coast Ranges Geomorphic Province. The San Joaquin Valley Subsection is located in the Great Valley Geomorphic Province. The project and underlying geologic deposits are illustrated on Figure 3.9-1a through Figure 3.9-1e.

The Coast Ranges Geomorphic Province is characterized by a complex geological history of folding and faulting that has resulted in a series of northwest-trending mountain ranges and intervening valleys. The structure reflects uplift and folding associated with the active Pacific-North American plate boundary system (e.g., the San Andreas Fault Zone). The project alignment traverses the Santa Clara Valley in the west, the Diablo Range, and the San Joaquin Valley in the east. The bedrock of the Diablo Range includes three major litho-tectonic units that represent deformed remnants of the ancestral western California convergent margin. These units include: (1) the Franciscan Complex, derived from the late Mesozoic accretionary prism above an east-dipping subduction zone; (2) the Coast Ranges ophiolite, which structurally overlies the Franciscan Complex and represents highly attenuated and metamorphosed remnants of the ancestral forearc basement and upper mantle; and (3) Cretaceous to Tertiary marine sediments of the ancestral forearc basin, collectively referred to as the Great Valley Group (Authority 2017).

West of the Diablo Range, the Santa Clara Valley underlies the geology, soils, and seismicity RSA, and is part of a structural trough bounded by the Santa Cruz Mountains to the west and the Diablo Range to the east and extending approximately 90 miles southeast from San Francisco (Wallace 1990). The Santa Clara Valley has been filled by Quaternary-age sediments derived from the surrounding mountains, resulting in broad coalescing alluvial fans, fan levees, and inter-levee basins (Wentworth et al. 1997).

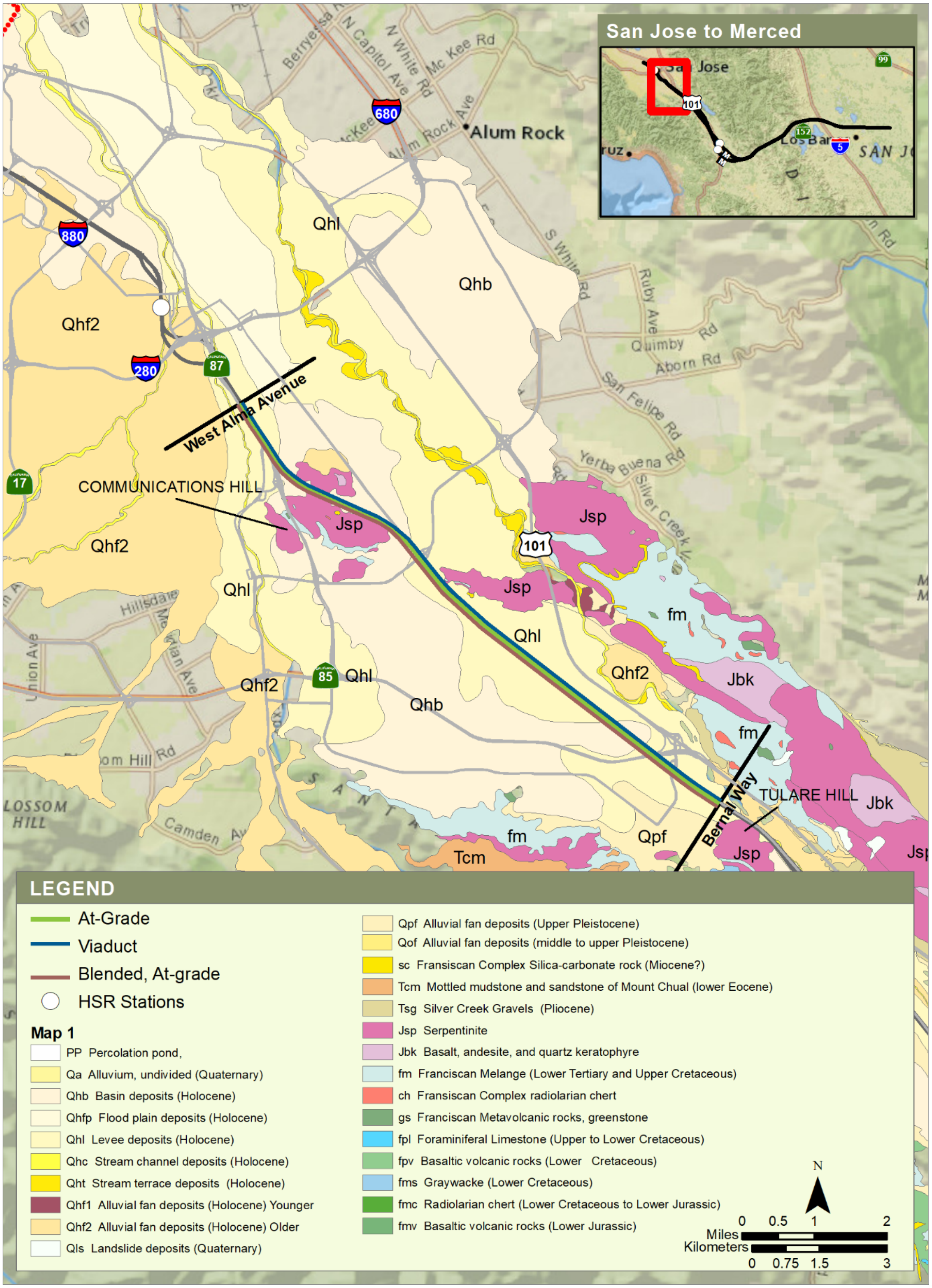
The Great Valley Geomorphic Province is an elongated northwest trending down warped structural trough that has been filled with a great thickness of unconsolidated alluvial deposits (up to 3,500 feet thick) (Poland and Evenson 1966). These alluvial deposits are Pliocene to Holocene in age and are derived from the Sierra Nevada and Coast Ranges. Below the alluvial deposits are late Mesozoic through late Cenozoic marine and non-marine sedimentary rocks.



Source: Wentworth et al. 1997

MARCH 2019

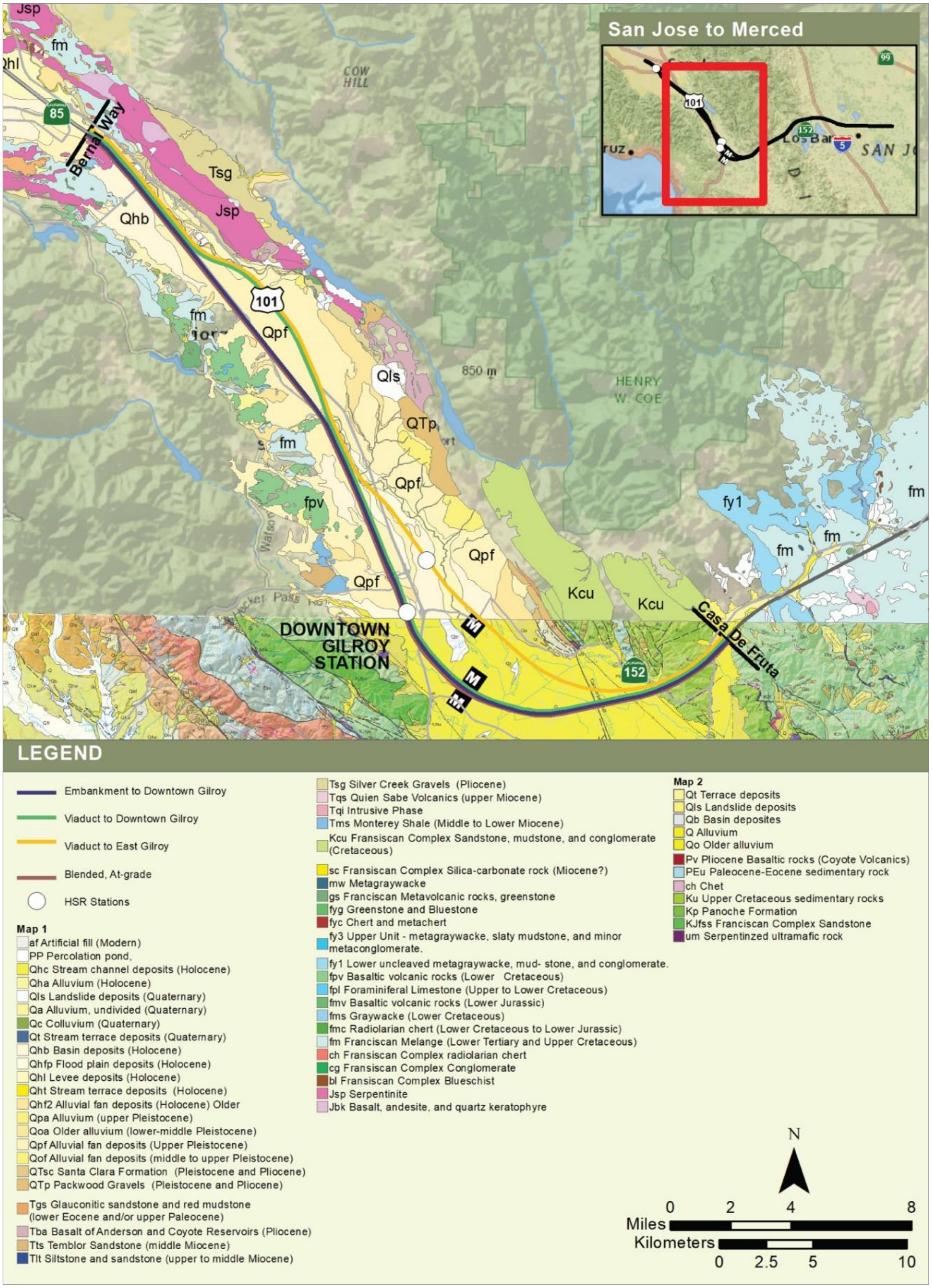
Figure 3.9-1a San Jose Diridon Station Approach Subsection—Geologic Map



Source: Wentworth et al. 1997

MARCH 2019

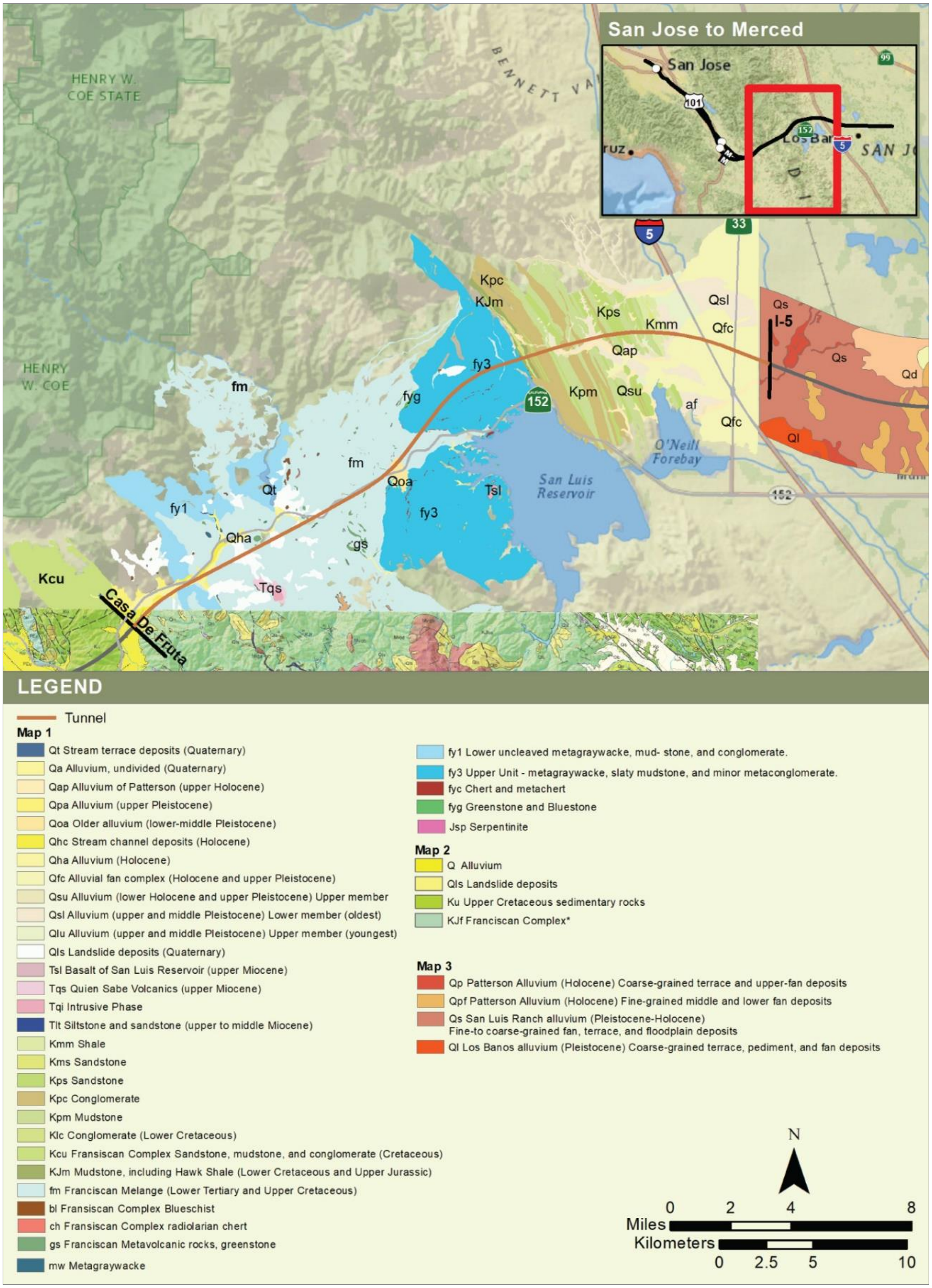
Figure 3.9-1b Monterey Corridor Subsection—Geologic Map



Sources: Wentworth et al. 1997; Wagner et al. 2002

JANUARY 2019

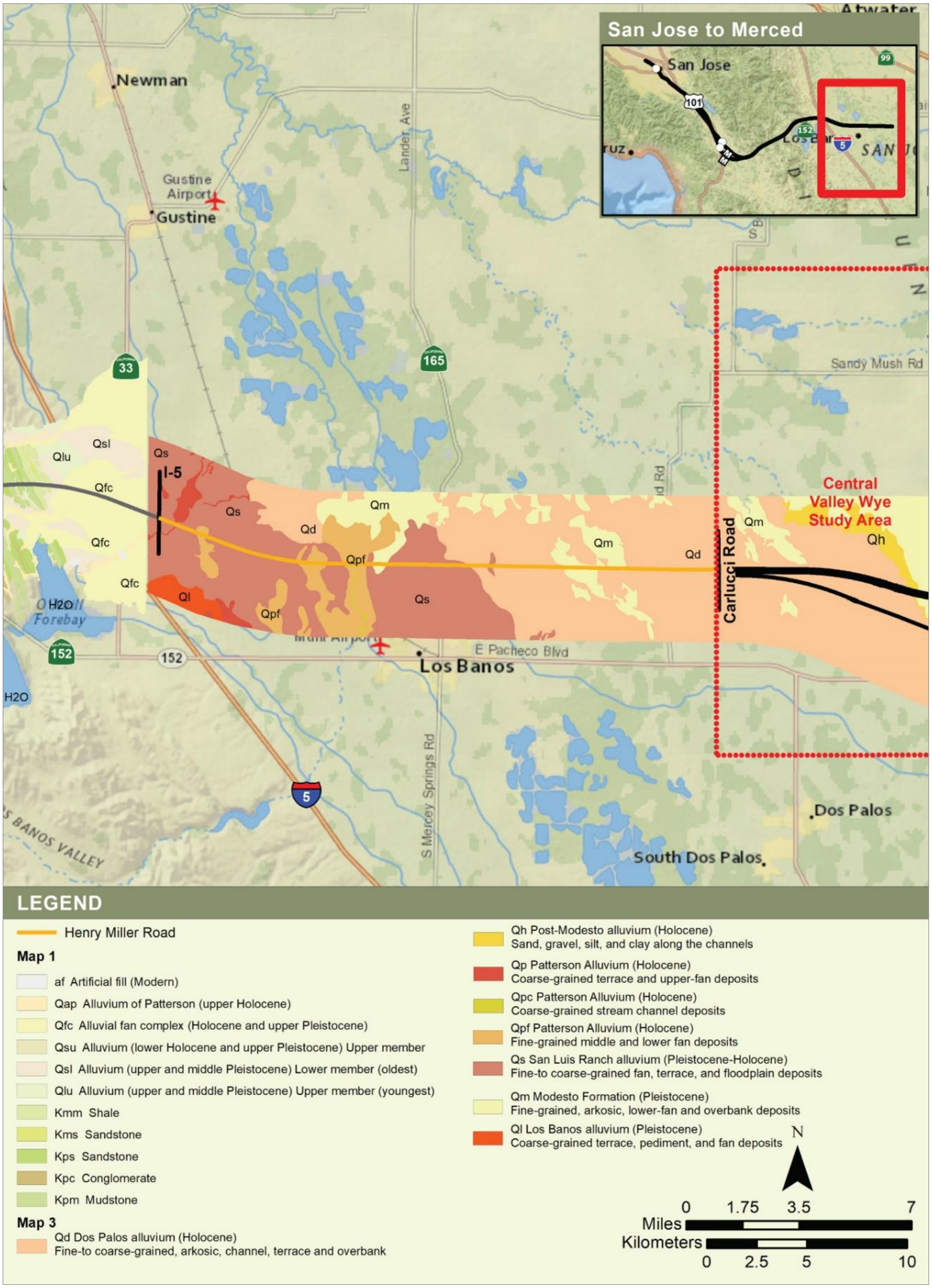
Figure 3.9-1c Morgan Hill and Gilroy Subsection—Geologic Map



Sources: Wentworth et al. 1997; Wagner et al. 2002; Clinkenbeard 1999

JANUARY 2019

Figure 3.9-1d Pacheco Pass Subsection—Geologic Map



Sources: Wentworth et al. 1999; Clinkenbeard 1999

JANUARY 2019

Figure 3.9-1e San Joaquin Valley Subsection—Geologic Map

The underlying geology generally controls the topography in the geology, soils, and seismicity RSA, with gentle topographic relief generally in areas with easily eroded bedrock and steep topography generally within mountainous regions with resistant bedrock. Faulting and folding of bedrock also contributes to topographic relief in the geology, soils, and seismicity RSA. The Santa Clara and South Santa Clara Valleys in the San Jose Diridon Station Approach, Monterey Corridor, and Morgan Hill and Gilroy Subsections range from approximately 110 to 370 feet in elevation. The San Joaquin Valley in the San Joaquin Valley Subsection ranges from approximately 110 to 170 feet in elevation. The Diablo Range, located between the South Santa Clara Valley and the San Joaquin Valley, consists of shallow bedrock and steep topography with some low-lying alluvium-filled valleys with gentle topographic relief. The Diablo Range in the Morgan Hill and Gilroy and Pacheco Pass Subsections varies from approximately 260 feet in elevation at its margins to 1,400 feet at Pacheco Pass. Elevations are based on U.S. Geological Survey (USGS) topographic maps and Google Earth (Datum = Mean Sea Level, WGS84). Depth to groundwater in the geology, soils, and seismicity RSA is variable within the various geologic and topographic terrains and is discussed further in Shallow Groundwater in Section 3.9.5.2, Geologic Hazards.

The geology, soils, and seismicity; geologic hazards; and seismicity, faulting, and dam failure inundation RSAs are located within a seismically active region of California with known active surface faulting and historic earthquakes. This seismicity is a result of the progressive southeastern movement of the North American tectonic plate relative to the Pacific tectonic plate. At the approximate latitude of the geology, soils, and seismicity; geologic hazards; and seismicity, faulting, and dam failure inundation RSAs, the Pacific plate moves about 38 millimeters (1.5 inches) per year relative to the North American tectonic plate (Authority 2017).

Geologic Conditions

The geology underlying the project has been mapped by Wentworth et al. (1999), Clinkenbeard (1999), Marchand and Allwardt (1981), and Jennings et al. (1977). In general, Holocene (present to 11,000 years ago) and Pleistocene (11,000 to 2.6 million years ago) alluvial deposits are mapped throughout the flatlands of the Santa Clara Valley and the Central Valley. Tertiary (2.6 to 66 million years ago) and Mesozoic (66 to 252 million years ago) bedrock is mapped along the margins of the valley and in the adjacent Diablo Range, which encompasses the Pacheco Pass Subsection. Bedrock also underlays the Santa Clara Valley and the Central Valley alluvium at depth. The mapped geologic conditions within each subsection are described as follows:

- **San Jose Diridon Station Approach Subsection**—Holocene alluvium (Wentworth et al. 1999).
- **Monterey Corridor Subsection**—Holocene and Pleistocene alluvium with the exception of a small portion of the alignment near Communications Hill that is mapped as Jurassic bedrock (Wentworth et al. 1999).
- **Morgan Hill and Gilroy Subsection**—Holocene and Pleistocene alluvium within the low-lying valley areas and Cretaceous bedrock where the alignment enters the Diablo Range near Gilroy (Wagner et al. 2002). The alignment also crosses a small section of Jurassic serpentinite bedrock at Tulare Hill near South San Jose and at Llagas Creek near San Martin (Wentworth et al. 1999; Dibblee and Minch 2005a–e). Additionally, the Pacific Gas and Electric Company (PG&E) network upgrades are located in areas mapped as Jurassic bedrock east of the alignment near Coyote and west of the alignment near Morgan Hill and San Martin.
- **Pacheco Pass Subsection**—The majority of the subsection is within the Diablo Range and is underlain by Franciscan Assemblage and Great Valley Sequence rocks. The Great Valley Sequence is locally referred to as the Panoche Formation and is located in the eastern portion of the subsection. The Franciscan Assemblage rocks are separated from adjacent Great Valley Sequence on the west by the Moreno Spring fault (inactive) and on the east by the active Ortigalita fault. Both bounding faults are associated with sheared and altered serpentinites of the Coast Range ophiolite. The Franciscan Assemblage rocks are intensely folded and faulted and exhibit a wide range of bedding orientations, as well as shallow to very large deep-seated landslides. In some areas, alluvial sediments deposited by local creeks

overly the Diablo Range bedrock in low areas. At the eastern limits of the subsection, the Pacheco Pass Subsection extends into the San Joaquin Valley and is underlain by alluvium (Wentworth et al. 1999).

- **San Joaquin Valley Subsection**—This subsection is underlain by alluvium of the Great Valley. These alluvial deposits are mainly of fluvial (river or stream) origin but contain several extensive interbeds of lacustrine (lake) origin. These deposits consist of sand, gravel, and silt as well as extensive overbank deposits of finer-grained sediments of clay and silt. Sediments underlying the valley are derived from the Diablo Range to the west and the Sierra Nevada to the east (Clinkenbeard 1999; Lettis 1982).

Geologic deposits underlying each project subsection are illustrated on Figure 3.9-1a, through Figure 3.9-1e and described in this section.

A summary of the geologic units underlying the project, from north to south, follows. These units are mapped as exposed at the ground surface, so geologic conditions vary with depth. Table 3.9-5 depicts these deposits distributed among the project subsections.

- **Holocene Levee Deposits (Qhl)**—Alluvial deposits that consist of sandy and clayey silt ranging to sandy and silty clay, loose and moderately to well sorted. These deposits are associated with the Guadalupe River and Coyote Creek and other present-day drainages.
- **Holocene Alluvial Fan Deposits (Qhf2)**—Alluvial deposits derived from the Santa Cruz Mountains to the west that consist of sandy and clayey silt ranging to sandy and silty clay, loose and moderately to well sorted.
- **Holocene Stream Terrace Deposits (Qht)**—Alluvial deposits located low in the local topography along the Guadalupe River and Los Gatos Creek channels consisting of unconsolidated moderately to poorly sorted sand, gravel, silt, and clay.
- **Holocene Basin Deposits (Qhb)**—Alluvial deposits that consist of sandy and clayey silt ranging to sandy and silty clay, loose and moderately to well sorted.
- **Jurassic Serpentinized Ultramafic Rocks (Jsp)**—Serpentinized harzburgite, dunite, and peridotite near Communications Hill (approximate stations 230+00 to 250+00, 270+00 to 290+00, and 725+00+00 to 740+00).
- **Holocene Floodplain Deposits (Qhfp)**—Gray, dense, sandy to silty clay, may locally contain lenses of silt and fine gravel.
- **Upper Pleistocene Alluvial Fan (Qpf)**—Tan to reddish-brown gravelly and clayey sand, dense, typically little or no relation to modern drainages.
- **Pliocene Silver Creek Gravels (Tsg)**—Interbedded conglomerate, sandstone, siltstone, tuffaceous sediment, tuff, and basalt. This formation is encountered only in the eastern portion of the geology, soils, and seismicity RSA.
- **Cretaceous Basaltic Volcanic Rocks (fpv)**—Pillowed basalt flows and flow breccias, locally with siliceous tuff near top of sequence (approximate stations 1345+00 to 1360+00).
- **Panoche Formation “Great Valley Sequence” (Kp)**—Late Cretaceous clay shale or claystone, gray, micaceous, crumbly, includes sandstone layers.
- **Holocene Alluvium (Qha)**—Unconsolidated, moderately sorted sand, gravel, and some silt and clay; located largely on low terraces along mountain stream courses.
- **Pleistocene Older Alluvium (Qoa)**—Partially consolidated sand, gravel, and clay; located relatively high in the local topography and considerably dissected.
- **Quaternary Landslide Deposits (Qls)**—Locally derived bedrock materials that range from rubble to nearly intact rock displaced downslope by slumping and sliding (only larger landslides are shown).

- **Quaternary Alluvium of San Luis Ranch, Lower Member (Qsl)**—Undeformed, generally unweathered, and unconsolidated; poorly to moderately sorted and bedded coarse sandy gravel and gravelly coarse sand as stream terraces and valley fills and at fan heads, grading downstream to well-sorted and bedded silt and fine sand on lower fan. Clasts are of chert, greywacke, sandstone, and other rock types from the Diablo Range.
- **Holocene and Upper Pleistocene Alluvial Fan Complex (Qfc)**—Undeformed, generally unweathered and unconsolidated; poorly to moderately sorted and bedded coarse sandy gravel and gravelly coarse sand as stream terraces and valley fills and at fan heads, grading downstream to well-sorted and bedded silt, clay, and fine sand on lower fans. Forms much of the main alluvial fan surface along the east front of the Diablo Range.

Table 3.9-5 Distribution of Geologic Units throughout the Geology, Soils, and Seismicity RSA

Geologic Unit (Map Symbol)	San Jose Diridon Station Approach	Monterey Corridor	Morgan Hill and Gilroy	Pacheco Pass	San Joaquin Valley
Holocene Levee Deposits (Qhl)	X	X	X		
Holocene Alluvial Fan Deposits (Qhf2)	X		X		
Holocene Stream Terrace Deposits (Qht)	X				
Holocene Basin Deposits (Qhb)	X	X	X		
Jurassic Serpentinized Ultramafic Rocks (Jsp)		X	X		
Holocene Floodplain Deposits (Qhfp)			X		
Upper Pleistocene Alluvial Fan (Qpf)			X		
Pliocene Silver Creek Gravels (Tsq)			X		
Cretaceous Basaltic Volcanic Rocks (Fpv)			X		
Holocene Alluvium (Qha)				X	
Holocene Alluvium of Patterson (Qap)				X	
Pleistocene Older Alluvium (Qoa)				X	
Quaternary Landslide Deposits (Qls)				X	
Quaternary Alluvium of San Luis Ranch, Lower Member (Qsl)				X	
Holocene and upper Pleistocene Alluvial Fan Complex (Qfc)				X	
Jurassic/Cretaceous Franciscan Assemblage (fm, fy1, fy3, gs)				X	
Jurassic/Cretaceous Panoche Formation (KJm, Kmm, Kpc, Kpm, Kps)			X	X	
Holocene Alluvium (Qh, Hal)					X
Holocene to Pleistocene San Luis Ranch Alluvium (Qs)					X
Holocene Patterson Deposits (coarse grain) (Qp)					X

Geologic Unit (Map Symbol)	San Jose Diridon Station Approach	Monterey Corridor	Morgan Hill and Gilroy	Pacheco Pass	San Joaquin Valley
Holocene Patterson Deposits (fine grain) (Qpf)					X
Holocene Dos Palos Alluvium (Qd)					X
Pleistocene Modesto Formation (Qm, m1, m2)					X

Sources: Wentworth et al. 1997; Wagner et al. 2002; Clinkenbeard 1999

- **Jurassic and Cretaceous Franciscan Assemblage**
  - **Melange (fm)**—A mixture of coherent fragments of sandstone, chert, and greenstone in a pervasively sheared matrix of dark gray shale and greywacke, often with gouges in seams along surfaces of previous shearing. The Franciscan Assemblage is complexly faulted, deformed, and slightly metamorphosed.
  - **Yolla Bolly Terrane Lower Unit (fy1)**—Uncleaved lithic quartzofeldspathic metagraywacke, mudstone, and conglomerate. Includes scarce basal, basaltic greenstone (fyg), and Middle-Upper Jurassic radiolarian ribbon chert (fyc).
  - **Yolla Bolly Terrane Upper Unit (fy3)**—Metagraywacke, slaty mudstone, and minor metaconglomerate. Distinguished from other Yolla Bolly units by stronger metamorphic fabric, jadeite sprays (fine-grained but usually visible under the hand lens), and abundant quartz-aragonite or quartz-albite veins.
  - **Greenstone (gs)**—Blocks or slabs of greenstone within the Melange.
- **Jurassic and Cretaceous Panoche Formation (Great Valley Sequence)**
  - **Conglomerate (Kpc)**—Cobble and pebble conglomerate with interbedded fine- to coarse-grained pebbly sandstone; clasts mostly rounded and less than about a half meter (1.5 feet) in diameter (locally angular and up to 13.1 feet) and composed mainly of felsic, intermediate, and mafic volcanic rocks, but including various felsic to mafic plutonic rocks.
  - **Mudstone (Kpm)**—Silty, olive-gray mudstone and siltstone with thin, interbedded fine-grained sandstone; contains sparse calcareous concretions.
  - **Sandstone (Kps)**—Interbedded fine- to medium-grained sandstone and siltstone containing prominent lenses of gray, massive, concretionary sandstone; many beds are graded and contain rip-up clasts.
  - **Shale (Kmm)**—Dark gray to brown shale and silty shale containing limestone concretions and thin sandstone interbeds; locally abundant microfossils.
  - **Mudstone (KJm)**—Dark mudstone (locally fissile) containing some thin sandstone and conglomerate interbeds and locally abundant calcareous concretions.
- **Holocene Alluvium (Qh)**—Gravel, sand, silt, and clay along the channels of the present-day waterways.
- **Holocene to Pleistocene San Luis Ranch Alluvium (Qs)**—Fine- to coarse-grained fan, terrace, and floodplain deposits.
- **Holocene Patterson Deposits (Qp)**—Coarse-grained terrace and upper-fan deposits.
- **Holocene Patterson Deposits (Qpf)**—Fine-grained middle and lower alluvial fan deposits.

- **Holocene Dos Palos Alluvium (Qd)**—Fine- to coarse-grained arkosic channel, terrace, and overbank deposits along the San Joaquin River and associated sloughs.
- **Pleistocene Modesto Formation (Qm, m1, m2)**—Gravel, sand, silt, and clay within channels, terraces, fans and overbank deposits. These older soils commonly include a cemented hardpan layer.

Soils

Soils are composed of mineral grains, organic matter, or both that have accumulated on the Earth's surface. It is important to characterize the engineering properties of soil because structures can transmit forces to soil, and the soil can transmit forces to structures. The engineering properties of soils are also important because soil can be used as a material for construction, such as for an earthen embankment. Typical engineering properties considered for design and construction of structures include shrink-swell potential, density/consistency, moisture content, shear strength, erosion potential, cementation, and corrosion potential. Engineering properties and behavior differ between soil types; for example, some soils are hard and strong, while others are soft and weak. The United Soil Classification System (USCS) is a commonly used geotechnical engineering standard (ASTM D2487) for classifying soils based on the results of prescribed laboratory tests to determine properties such as the particle-size characteristics, the liquid limit, and the plasticity index.

Since the 1930s, various government agencies and universities have conducted soil mapping, emphasizing a soil's agricultural and engineering properties. The U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) soil surveys (NRCS n.d.) describe soil units present along the project alignment, including basic engineering properties and USCS soil classifications. A soil association mapped by the NRCS is made up of two or more geographically associated soils that are grouped together for the practicality of mapping (NRCS n.d.). This information is based on conditions within 4–5 feet of the ground surface. In urban areas, NRCS was not able to map the surficial soil because of human development and classified these areas as Urban or NR-NA (not rated or not available). The Geology, Soils, and Seismicity Technical Report illustrates the soil associations and USCS soil types by subsection within the geology, soils, and seismicity RSA (Authority 2019a). Table 3.9-6 shows a summary of the physiographic features, soil associations, and soil hazards for each subsection. Soil hazards characterized during NRCS soils mapping are listed in Table 3.9-6 and include shrink-swell potential, corrosion potential, and erosion potential. Other soil hazards, such as soft soil and collapsible soil, are not mapped by NRCS and therefore are not included in Table 3.9-6. However, soft soil, collapsible soil, and other soil-related hazards are considered geologic hazards; the effects of these hazards on construction and operations activities are addressed in Section 3.9.5.2 and Section 3.9.6.

The effects of soils on construction and operations activities are considered geologic hazards and are discussed in Section 3.9.5.2.

Table 3.9-6 Soil Association Characteristics throughout the Geology, Soils and Seismicity RSA

Soil Association (Map Symbol)	Soil Textures	Subsection	Landform Groups[1]	Soil Hazards
Pacheco-Clear Lake-Campbell (PC)	silt loam, clay loam, silty clay	Morgan Hill and Gilroy	Recent alluvial fans and flood plains	▪ Low to moderate shrink-swell potential ▪ Moderately to highly corrosive to uncoated steel ▪ Slightly corrosive to concrete ▪ Medium to coarse texture soils susceptible to erosion ▪ Moderate potential for water erosion ▪ High potential for wind erosion
Xerorthents-Urban Land-Botella (XU)	clay loam, sandy clay loam	San Jose Diridon Station Approach, Monterey Corridor, Morgan Hill and Gilroy, Pacheco Pass		
Dosamigos-Deldota-Chateau (DD)	clay loam, clay, silty clay	San Joaquin Valley		
Temple-Merced-Grangeville (TM)	clay loam, clay, sandy clay, sandy clay loam, fine sandy loam	San Joaquin Valley		
Woo-Stanislaus (WS)	clay loam, clay	Pacheco Pass, San Joaquin Valley		
Lewis-Fresno-Dinuba (LF)	clay, clay loam, loam, duripan - sandy loam, sandy clay loam - sandy loam, silt, and sand	San Joaquin Valley		
Tujunga-Traver-Pachappa-Grangeville (TT)	loam, sand, sandy loam, loamy sand	San Joaquin Valley		
San Ysidro-Pleasanton-Arbuckle (SPA)	sandy loam, sandy clay loam, clay loam, gravelly fine sandy loam, gravelly sandy clay loam, gravelly loam	Morgan Hill and Gilroy	Older, low alluvial terraces	▪ High shrink-swell potential ▪ Highly corrosive to uncoated steel ▪ Moderately corrosive to concrete ▪ Moderate potential for water erosion ▪ High potential for wind erosion
San Ysidro-Pleasanton-Hillgate (SPH)	sandy loam, clay, sandy clay loam, gravelly fine sandy loam, gravelly sandy clay loam, gravelly loam, loam	Morgan Hill and Gilroy		
Salinas-Mocho-Metz-Cropley (SM)	clay loam, loam, sandy loam-clay, sandy clay loam, silty clay loam	Morgan Hill and Gilroy, Pacheco Pass		

Soil Association (Map Symbol)	Soil Textures	Subsection	Landform Groups[1]	Soil Hazards
Los Banos-Damlius-Bapos (LB)	clay, clay loam	Pacheco Pass		
San Joaquin-Madera-Cometa (SM)	duripan, loam, clay, sandy clay loam, sandy clay, sandy loam	San Joaquin Valley		
Elnido-Dospalos-Bolfar-Alros (ED)	sandy loam, clay loam, clay, sandy clay loam, loam	San Joaquin Valley	Basin areas (including saline-alkali basins)	▪ Moderate shrink-swell potential ▪ Highly corrosive to uncoated steel ▪ Moderately corrosive to concrete ▪ High potential for water erosion ▪ Moderate to high potential for wind erosion
Turlock-Triangle-Britto (TTB)	sandy loam, loam, clay loam, clay	San Joaquin Valley		
Volta-Pedcat-Marcuse (VP)	clay loam, loam, silty clay, silty clay loam, clay	San Joaquin Valley		
Willows-Pacheco-Clear Lake (WPC)	clay, silt loam, clay loam	Morgan Hill and Gilroy		
Waukena-Pescadero (WP)	silty clay loam, silty clay, sandy loam, sandy clay loam	San Joaquin Valley		
Kesterson-Edminster-Dospalos-Bolfar (KE)	sandy loam, loam, clay loam, sandy clay loam	Morgan Hill and Gilroy		
Montara-Henneke (HM)	gravelly loam, very gravelly clay loam	Morgan Hill and Gilroy	Foothills/mountains	▪ 30%–75% steep slopes ▪ Moderate to high shrink-swell potential ▪ Highly corrosive to uncoated steel ▪ Moderately corrosive to concrete ▪ Moderate potential for water erosion ▪ Low to high potential for wind erosion
Sheridan-San Benito-Diablo (SS)	sandy loam, clay loam, silty clay	Morgan Hill and Gilroy		
Inks-Climara-Azule-Altamont (IC)	cobbly loam-clay, gravelly clay, silty clay	Monterey Corridor, Morgan Hill and Gilroy		
Vallecitos-Parrish-Los Gatos-Gaviota (VP)	gravelly loam, clay loam, gravelly clay loam	Morgan Hill and Gilroy, Pacheco Pass		
Vallecitos-Honker-Gonzaga-Franciscan (VH)	gravelly loam, clay loam, sandy loam, sandy clay loam, loam, gravelly sandy clay loam, gravelly sandy clay, sandy clay	Pacheco Pass		

Soil Association (Map Symbol)	Soil Textures	Subsection	Landform Groups[1]	Soil Hazards
Millsholm-Honker-Gonzaga-Fifield (MH)	clay loam, sandy loam, sandy clay loam, clay, loam, gravelly sandy clay loam, gravelly sandy clay	Pacheco Pass		
Oniel-Apollo (OP)	silt loam, clay loam	Pacheco Pass		
Rock outcrop-Peckham-Laveaga-Ararat (RO)	cobbly loam, cobbly clay, sandy clay loam, sandy clay, sandy loam, stony loam, stony sandy clay loam	Pacheco Pass		
Shimmon-Diablo-Cotai (SD)	loam, clay loam, silty clay	Morgan Hill and Gilroy		

Source: NRCS n.d.

[1] As mapped by NRCS, not necessarily observed in the geology, soils, and seismicity RSA.

RSA = resource study area

3.9.5.2 Geologic Hazards

Geologic hazards (also called geohazards) are hazards resulting from adverse rock and soil conditions that are capable of causing damage or loss of life. Geologic hazards include ground subsidence, collapsible soil, landslides, soft soil, naturally occurring asbestos (NOA), in-situ gas, sheared or weak bedrock, corrosive soil, erosion, and shallow groundwater. These geologic hazards are discussed in the following subsections in terms of their existing conditions within the geologic hazards RSA and their potential effects on the project. Seismic hazards are a subset of geologic hazards and are discussed separately in Section 3.9.5.3, Primary Seismic Hazards, and Section 3.9.5.4, Secondary Seismic Hazards.

Ground Subsidence

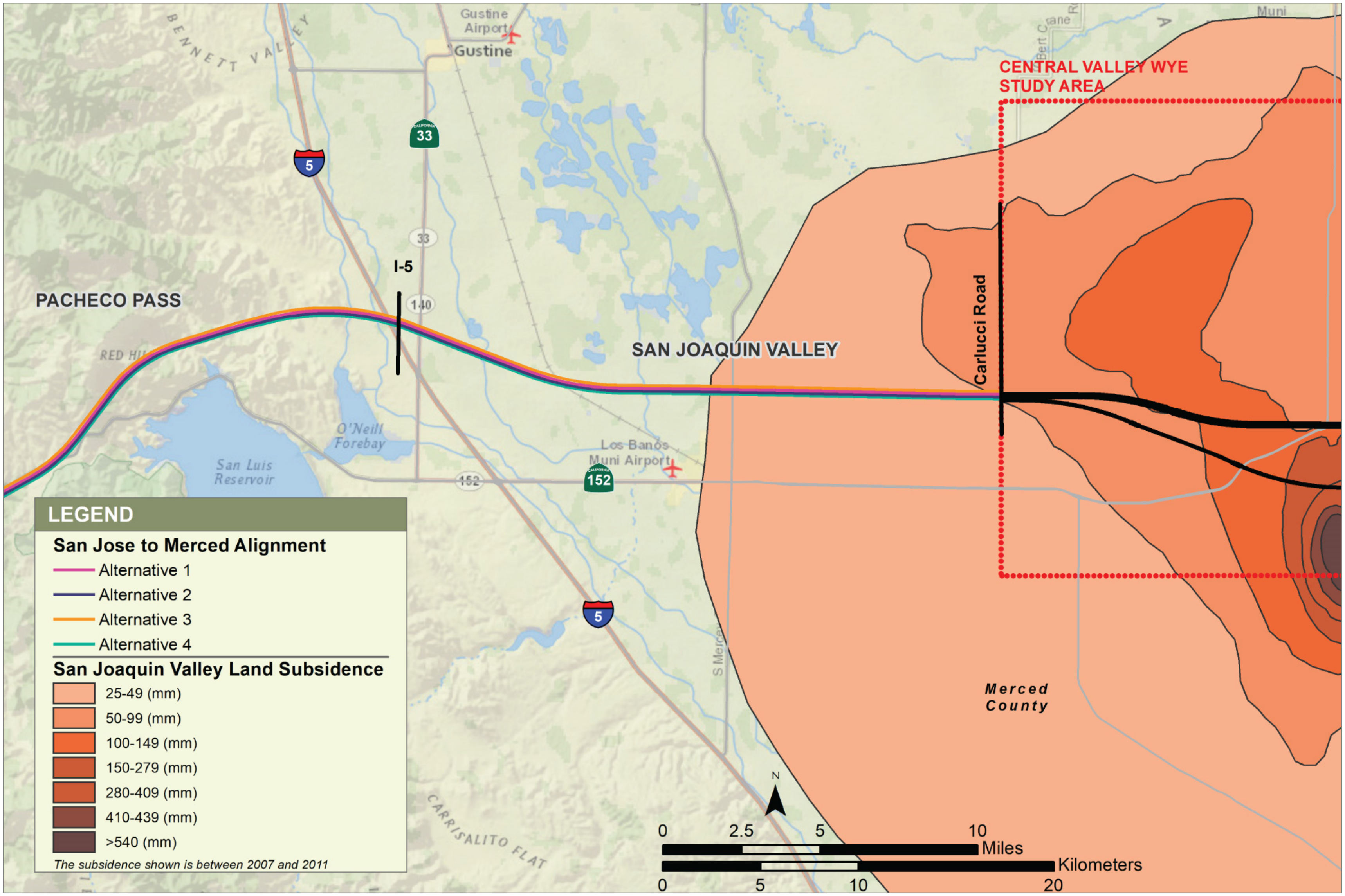
Ground subsidence is the settling or sinking of the land surface caused by groundwater extraction from alluvial geologic formations. Subsidence can happen over large areas when it results from regional groundwater extraction (regional subsidence) or over small areas when it results from localized dewatering (localized subsidence). The resulting ground deformation from ground subsidence can cause damage to structures.

The SGMA was signed into California law in 2014 and requires California governments and water agencies of high- and medium-priority groundwater basins to halt aquifer overdraft by balancing pumping and recharge levels. Balancing levels of aquifer pumping and recharge would significantly reduce or eliminate regional ground subsidence within a basin. All of the groundwater basins that the project crosses are considered medium- or high-priority basins. These basins and their subbasins include: Santa Clara Valley Basin (Santa Clara Subbasin); Gilroy-Hollister Valley Basin (Llagas Area, Hollister Area, and Bolsa Area Subbasins); and San Joaquin Valley Basin (Delta-Mendota Subbasin) (DWR 2018b). Under SGMA, these basins should reach sustainability by 2042 (DWR 2018a).

Within the Santa Clara Valley, including San Jose Diridon Station Approach and Monterey Corridor Subsections, historic subsidence on a regional scale due to groundwater pumping resulted in up to approximately 14 feet of settlement from 1915 to 1970 (Luhdorff & Scalmanini 2014). Since 1970, a reduction of groundwater pumping combined with a groundwater recharge program using imported surface water has reduced groundwater pumping and allowed an effective program of groundwater recharge that prevents groundwater levels from approaching the historic lows of the 1960s. Artificial recharge rates in the 1970s were sufficient to reverse groundwater level declines and arrest subsidence (USGS 1999).

The areas crossed by the Morgan Hill and Gilroy and Pacheco Pass Subsections have not exhibited historical regional subsidence; however, historic and ongoing subsidence has resulted in settlement in the San Joaquin Valley Subsection.

Historical and ongoing subsidence because of regional groundwater pumping has resulted in settlement in the San Joaquin Valley of up to 28 feet in some locations beginning in the 1920s (USGS 1999). The area of historic regional subsidence in the San Joaquin Valley near the project alignment is illustrated on Figure 3.9-2; up to 49 mm (1.9 inches) of subsidence occurred between 2007 and 2011 in the San Joaquin Valley Subsection. From 2007 to 2011, subsidence east of the project alignment in the San Joaquin Valley resulted in settlement of more than 540 mm (21 inches) in the El Nido area in Merced County. Recent surveying campaigns by the California Department of Water Resources and the U.S. Bureau of Reclamation indicate that subsidence continues at approximately 0.9 foot per year near the Eastside Bypass near El Nido (Sneed et al. 2013). The U.S. Army Corps of Engineers has predicted that 17 feet of subsidence will occur between 2000 and 2060 where State Route 152 crosses the San Joaquin River and the East Side Bypass (Luhdorff & Scalmanini 2014).



Source: USGS 2016

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Figure 3.9-2 San Joaquin Valley Land Subsidence

Different from regional ground subsidence, localized subsidence is caused by small-scale dewatering associated with construction of below-grade facilities in areas with shallow groundwater. With the exception of the Pacheco Pass Subsection, groundwater is mapped at less than 20 feet below land surface elevations for more than 50 percent of the remaining subsections within the geologic hazards RSA (Pacheco Pass is not mapped) (SCVWD 2016; SBCWD 2017; DWR 2017). Additional information regarding ground subsidence is provided in the Geology, Soils, and Seismicity Technical Report, Section 5.2.1 (Authority 2019a).

Collapsible Soils

Collapsible soils are deposited in a loose, highly porous state, then weak cementation develops and remains dry after deposition. Upon contact with moisture, the weak cementation between the loose soil particles softens and can result in collapse and settlement. The resulting ground deformation can cause damage to structures founded on collapsible soil. Collapsible soils are known to exist on the west side of the San Joaquin Valley, in the San Joaquin Valley Subsection, and could be encountered in alluvial soils within the Diablo Range in the Pacheco Pass Subsection (Knodel 1981; Prokopovich and Marriott 1983). Portions of the California Aqueduct within the San Joaquin Valley experienced damage due to collapsible soils. The U.S. Bureau of Reclamation conducted research on these collapsible soils in the 1970s by filling ponds over collapsible soils and observing settlement up to approximately 10 feet (Bara 1977). Additional details regarding collapsible soils are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.2.2 (Authority 2019a).

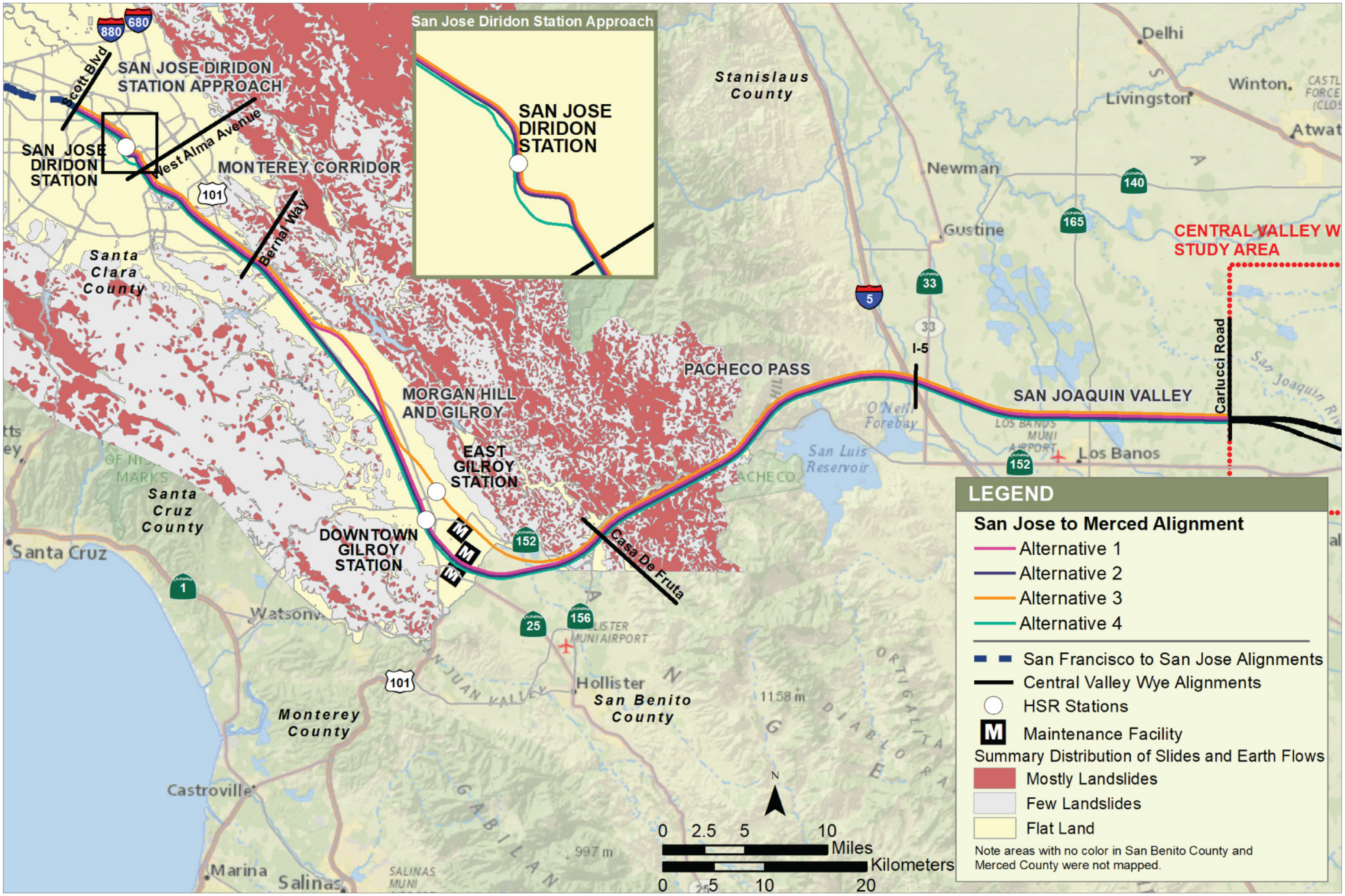
Landslides

Landslides are the downhill movements of soil or rock along a shear surface. Landslides can lead to differential lateral and vertical movements of track, embankments, or structures situated on or in the path of a landslide. Slide debris may collide with vehicles, structures, or persons. The best available predictor of where movement of landslides might occur is the distribution of past movements (Nilsen and Turner 1975).

Landslides have the potential to affect the project in the mountainous Pacheco Pass Subsection at or near the Tunnel 2 western and eastern portal locations, because within this portion of the subsection, the alignment crosses young alluvial fans at the mouths of steep canyons; these areas have the potential to be inundated by debris flows. Landslides could also be encountered in small portions of the Monterey Corridor and Morgan Hill and Gilroy Subsections including at PG&E network upgrade locations. Landslides are not a hazard within the San Joaquin Valley Subsection due to the relatively flat topography. Figure 3.9-3 illustrates mapped landslides in Santa Clara County and Figure 3.9-4 illustrates significant landslides in the Pacheco Pass Subsection. Additional details regarding landslides are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.2.3 (Authority 2019a).

Soft Soil Conditions

Soft soil generally consists of relatively young, fine-grained soil (clay and silt) layers that are compressible and weak (low shear strength). Soft soil can compress under new loads resulting in ground settlement that can damage structures. The settlement could extend beyond the footprint of the new load, which could cause damage to adjacent structures. The magnitude of compression of soft soil is related to the thickness of the soft soil layer, the new load, the distance between the application of the load and the soft soil layer, and other characteristics of the soil itself. Because soft soil has a low shear strength, it can exhibit slope instability, impede earthwork operations, and make soil compaction difficult. Soft soils could be encountered in all subsections. Additional details regarding soft soils are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.2.4 (Authority 2019a).



Source: Wentworth et al. 1997

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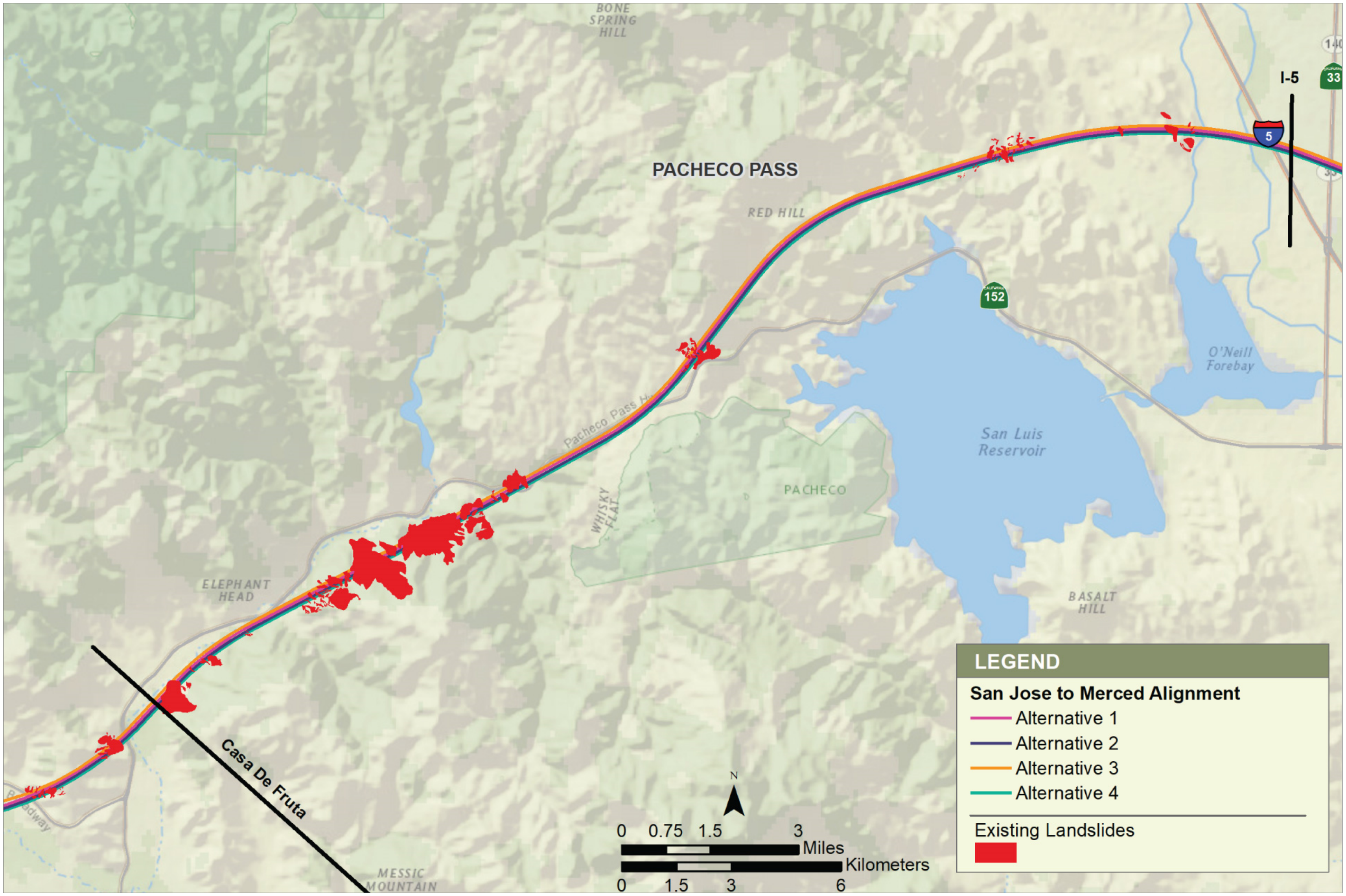
Figure 3.9-3 Summary Distribution of Slides and Earth Flows in Santa Clara County



Source: Authority 2016

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Figure 3.9-4 Significant Landslides in Morgan Hill and Gilroy and Pacheco Pass Subsections

Naturally Occurring Asbestos

Asbestos is the generic term for the naturally occurring fibrous varieties of six silicate minerals—chrysotile, tremolite, actinolite, crocidolite, anthophyllite, and amosite. These six minerals belong to the serpentinite and amphibole mineral groups. These minerals occur naturally in parts of California and are most commonly associated with ultramafic rock. NOA is considered a health risk when it becomes airborne, which can happen when the rock is crushed or pulverized. Inhalation of asbestos fibers can cause respiratory diseases including lung cancer and mesothelioma (CGS 2002, 2011). The California Air Resources Board (CARB) adopted Airborne Toxic Control Measures to control dust emissions from construction, grading, and surface mining in areas with NOA.

The CGS map, *Reported Historic Asbestos Mines, Historic Asbestos Prospects, and Other Natural Occurrences of Asbestos in California*, shows ultramafic rock outcrops in Santa Clara and Merced Counties near the project alignment (CGS 2011). More detailed regional geologic mapping (Dibblee 2005a, 2005b; Wentworth et al. 1999) shows ultramafic rock as Jurassic-age serpentinite. No ultramafic rock is mapped in the San Jose Diridon Station Approach Subsection; therefore, the presence of NOA is unlikely. Communications Hill in the Monterey Corridor Subsection and Tulare Hill in the Morgan Hill and Gilroy Subsection are mapped as ultramafic rocks (Jurassic serpentinite). Additionally, in some locations, PG&E network upgrades within the Morgan Hill and Gilroy Subsection are located in areas mapped as ultramafic rock. The Franciscan Formation bedrock mapped in the Pacheco Pass Subsection locally contains ultramafic bedrock that can contain NOA; these rocks can occur as localized blocks within the metasedimentary rocks, and are likely to be encountered along the Ortigalita fault. No ultramafic bedrock is mapped in the San Joaquin Valley Subsection. Additional details regarding NOA are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.2.5 (Authority 2019a).

In-Situ Gas

In-situ gases that occur naturally within rock formations can be hazardous when encountered in deep excavations and tunnels. These gases could include hydrogen sulfide and methane. If in-situ gases containing hydrogen sulfide and methane are encountered in a tunnel or excavation, people within the tunnel or excavation may be exposed to health hazards. In-situ gas may be encountered in the tunnel portions of the alignment through Panoche Formation (part of the Great Valley Sequence) in the Morgan Hill and Gilroy Subsection and through Franciscan Formation in the Pacheco Pass Subsection (see Figure 3.9-1a through Figure 3.9-1e for depictions of geologic formations). The buildup of in-situ gases within a tunnel or excavation could also create an explosion hazard. In-situ gases can also be encountered in current or historical landfills, however no known landfills are located within the geologic hazards RSA. Refer to the *San Jose to Merced Project Section: Hazardous Materials and Waste Technical Report* (Authority 2019c). Additional details regarding in-situ gas are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.2.6 (Authority 2019a).

Sheared or Weak Bedrock

In seismically active regions, such as California, tectonic movement can create zones of sheared or weak bedrock. The shear zones can range in thickness from less than 1 inch to hundreds of feet. Sheared or weak bedrock can be a hazard during tunneling because the sheared or weak rock mass could move within the tunnel zone and cause crushing and squeezing conditions. The sheared and weak rock zones within the Franciscan Assemblage and Panoche Formation may result in localized crushing and squeezing conditions during construction of the tunnels. This may affect the tunnel portions of Morgan Hill and Gilroy and Pacheco Pass Subsections. Refer to Figure 3.9-1a through Figure 3.9-1e for depictions of geologic formations. Additional details regarding sheared or weak bedrock are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.2.7 (Authority 2019a).

Expansive Soil

Expansive soil changes in volume with changes in moisture content. Expansive soil can shrink and swell, potentially causing differential movement and damage to surface improvements. Soils are generally categorized as having low, moderate, or high expansive potentials; the type and percentage of clay particles in the soil influence the soil's expansion potential. Generally, predominantly fine-grained soils containing a high percentage of clay are expansive, whereas predominantly coarse-grained soils such as sands and gravels are generally non-expansive. The NRCS maps soil types based on the USCS. Clay soils, classified as CL, CH, or CL-ML in accordance with USCS, are shown together on Figure 3.9-5 as “Clay Soil.” These soils are likely to be expansive and are mapped along significant portions of the alignment in all subsections except the San Jose Diridon Station Approach and Monterey Corridor Subsections. Along these two subsections, the maps do not have USCS soil classifications because NRCS was not able to map the surficial soil because of human development and classified these areas as not rated or not available. Geotechnical borings in the geologic hazards RSA in these subsections encountered near-surface clay soils that are potentially expansive (Authority 2016). Additional details regarding expansive soils are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.2.8 (Authority 2019a).

Shallow Bedrock

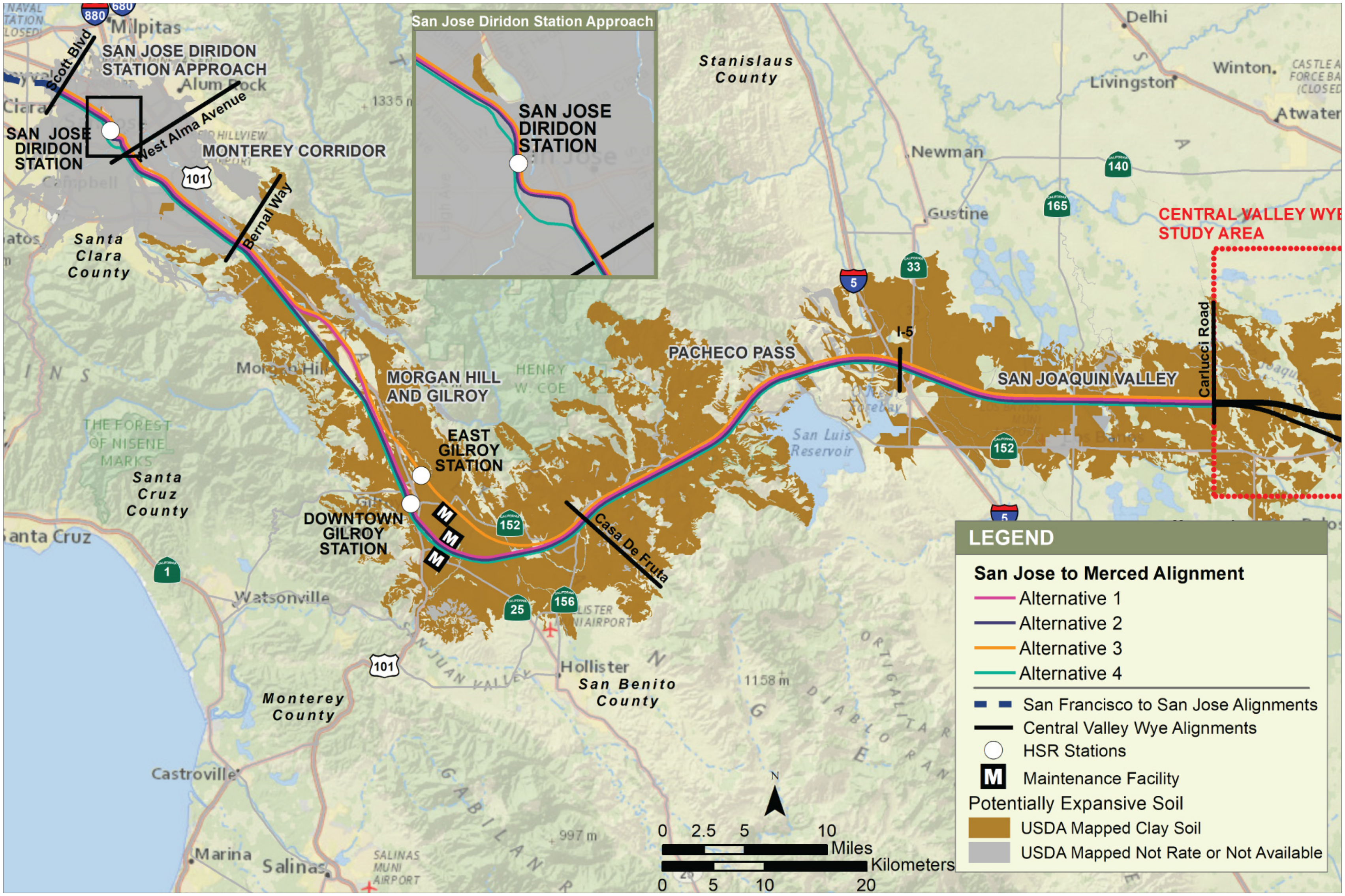
Shallow bedrock can make construction more difficult, depending on the properties of the rock encountered. If shallow bedrock is difficult to excavate with conventional machinery, then costlier and potentially more dangerous methods may be required. Deeper excavations are more likely to encounter harder rock that requires costlier and potentially more dangerous methods because the degree of weathering typically decreases with depth and the strength typically increases with depth. In some cases, explosives may be required to blast bedrock that cannot be excavated with machinery. The use of heavy-duty excavation equipment or blasting techniques could increase the risk of personal injury or death of workers during construction.

Bedrock units are illustrated and described in Section 3.9.5.1, Physiography and Regional Geologic Setting, Geologic Conditions, and Soils. Bedrock is mapped by Wentworth et al. (1999) and Wagner et al. (2002) in portions of the Monterey Corridor, Morgan Hill and Gilroy, and Pacheco Pass Subsections. While the majority of the Monterey Corridor Subsection is alluvium with no shallow bedrock, the portion of the alignment that traverses the base of Communications Hill is mapped as Jurassic-age serpentinite ultramafic rocks and would generally require greater excavation efforts than alluvium.

Similarly, the majority of the Morgan Hill and Gilroy Subsection is mapped as alluvium with no shallow bedrock, except in a few locations. The portion of the alignment near the base of Tulare Hill is serpentinite rocks. The alignment also traverses Cretaceous basaltic volcanic rocks adjacent to Llagas Creek. In some locations, PG&E network upgrades within the Morgan Hill and Gilroy Subsection are located in areas mapped as serpentinite or metasedimentary rock. Additionally, the alignment enters the Diablo Range where tunneling is planned through shale and sandstone of the Cretaceous Panoche Formation.

The majority of the Pacheco Pass Subsection is located in the Diablo Range, which is composed of Jurassic and Cretaceous Franciscan Assemblage and Panoche Formation. The majority of this subsection would include tunnels through bedrock.

The San Jose Diridon Station Approach and San Joaquin Valley Subsections are mapped as alluvium. No shallow bedrock is anticipated. Additional details regarding shallow bedrock are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.2.9 (Authority 2019a).



Source: NRCS n.d.

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Figure 3.9-5 Potentially Expansive Soil

Soil Corrosion

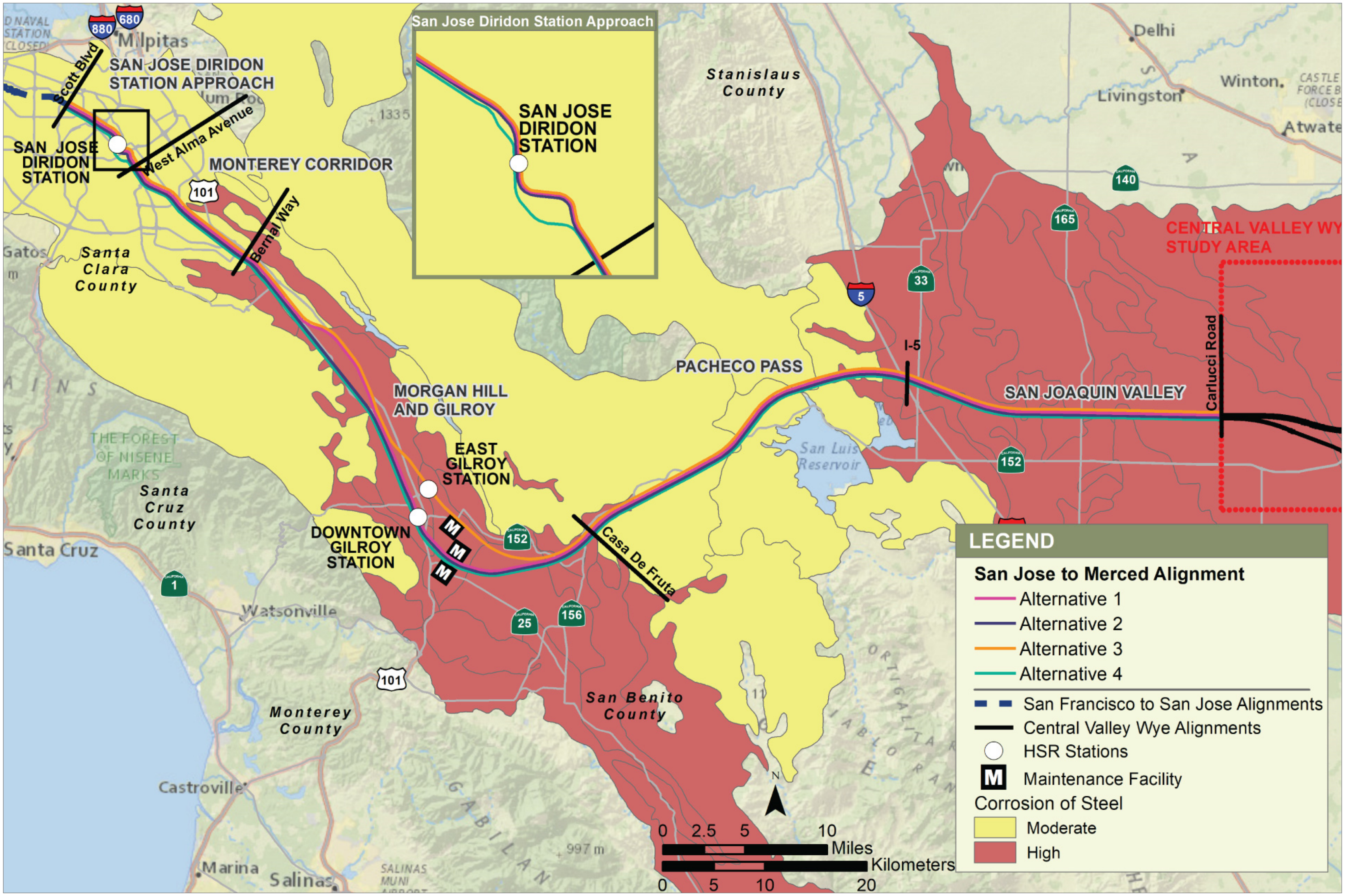
Soils can be corrosive to buried concrete or steel, and can lead to premature weathering and failure of concrete or steel structures. The impacts of corrosion could include eventual loss of structural capacity of the track connections or culvert drainage systems below the track, or damage to switches or other moving parts of the track system. Moderate to highly corrosive soil would likely be encountered in all subsections as depicted on Figure 3.9-6 and Figure 3.9-7. Additional details regarding soil corrosion are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.2.10 (Authority 2019a).

Soil Erosion

Soil erosion is the action of surface processes, such as water flow and wind, that transport soil from one location to another. Factors that affect soil erosion potential include soil type, soil cover, soil moisture, rainfall, surface water flow, wind speed, vegetation, and topography. Soil erosion is possible in the geologic hazards RSA, except for the tunnels, because all soil type characterizations have moderate to high potential for wind or water erosion. Potential for erosion is greater for at-grade, embankment, and trench construction than aerial construction because these methods expose potentially erosive material to surface processes such as wind and rain. In addition, some PG&E network upgrades within the Morgan Hill and Gilroy Subsection are located in hillside terrain that may be susceptible to erosion. Additional details regarding soil erosion are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.2.11 (Authority 2019a).

Shallow Groundwater

Shallow groundwater can make excavations difficult and unstable, and necessitate dewatering during construction. Shallow groundwater is typically encountered in low-lying valleys and basins where the groundwater elevation is similar to the ground surface elevation. Based on review of available data, groundwater within 20 feet of the ground surface is expected within portions of the San Jose Diridon Station Approach, Monterey Corridor, and Morgan Hill and Gilroy Subsections (SCVWD 2016; SBCWD 2017; DWR 2017). Additionally, the entire extent of the San Joaquin Valley Subsection is anticipated to have shallow groundwater conditions (DWR 2016). Groundwater within the Pacheco Pass Subsection is not well defined because of the complex bedrock and mountainous topography. The DWR online Water Data Library shows no monitoring stations within the mountainous portion of the Pacheco Pass Subsection. Groundwater levels in three locations within the Pacheco Pass Subsection have been monitored for HSR beginning in 2016; the groundwater level in these locations has been between 25 and 55 feet below the ground surface (ENGEO 2016). In general, the depth of groundwater is not constant and varies with time because of changes in geology, topography, weather, and human activities. Additional details regarding shallow groundwater are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.2.12 (Authority 2019a).



Source: NRCS n.d.

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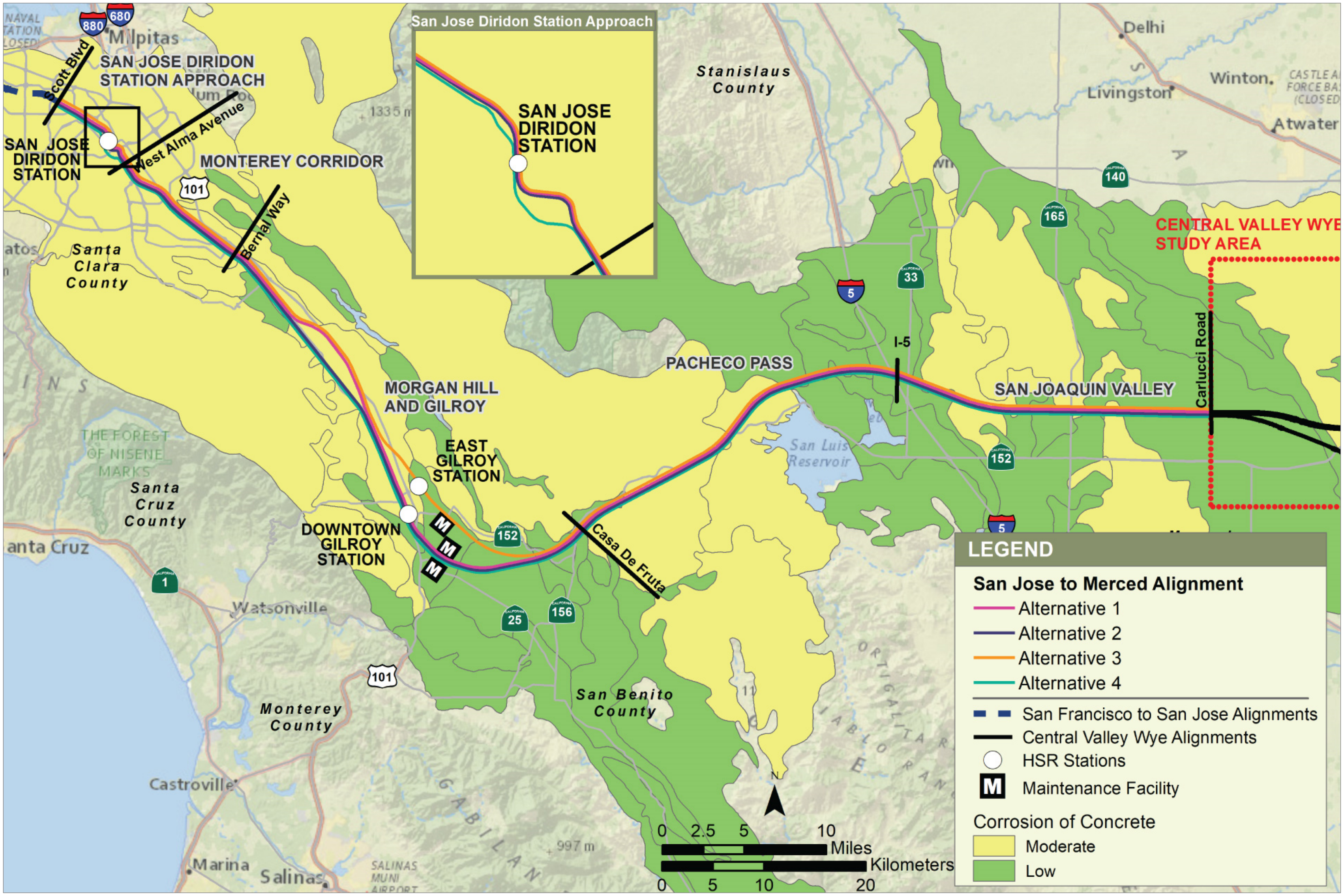
Figure 3.9-6 U.S. Department of Agriculture Mapped Soil Corrosion of Steel



Source: NRCS n.d.

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Figure 3.9-7 U.S. Department of Agriculture Mapped Soil Corrosion of Concrete

3.9.5.3 Primary Seismic Hazards

Primary seismic hazards are hazards directly associated with earthquakes. The primary seismic hazards assessed within this analysis are surface fault ruptures transecting the alignment and ground shaking. The project is located in a seismically active region of California where numerous small and large earthquakes have occurred in the past in association with active seismic faults. A seismic event, depending on the type of fault motion and exposure, can result in surface fault rupture, a permanent offset at the ground surface, and strong ground shaking.

The seismic activity in the region is dominated by the right-lateral strike-slip, thrust, and reverse faults resulting from transpressional (strike-slip with a compressional component) plate motion of the North American tectonic plate relative to the Pacific tectonic plate (Authority 2017). The most prominent feature of this plate boundary is the right-lateral strike-slip San Andreas fault system that trends north-northwest across the majority of California (Wallace 1990). The San Andreas fault is located as close as 6.6 miles west of the project (USGS 2006). East of the San Andreas fault, several other faults trending north-northwest exhibit right lateral movement and accommodate distributive slip from the tectonic plate boundary motion (Wallace 1990). The more prominent of these faults in the seismicity, faulting and dam failure inundation RSA are the Calaveras and the Ortigalita faults. Additionally, because of the complexities of the plate margin boundaries and right-lateral movement, thrust or reverse faults produce folding and uplift within the Coast Ranges (Wallace 1990); these faults include the east-dipping O’Neill fault system, and the blind, west-dipping San Joaquin fault system (Authority 2017).

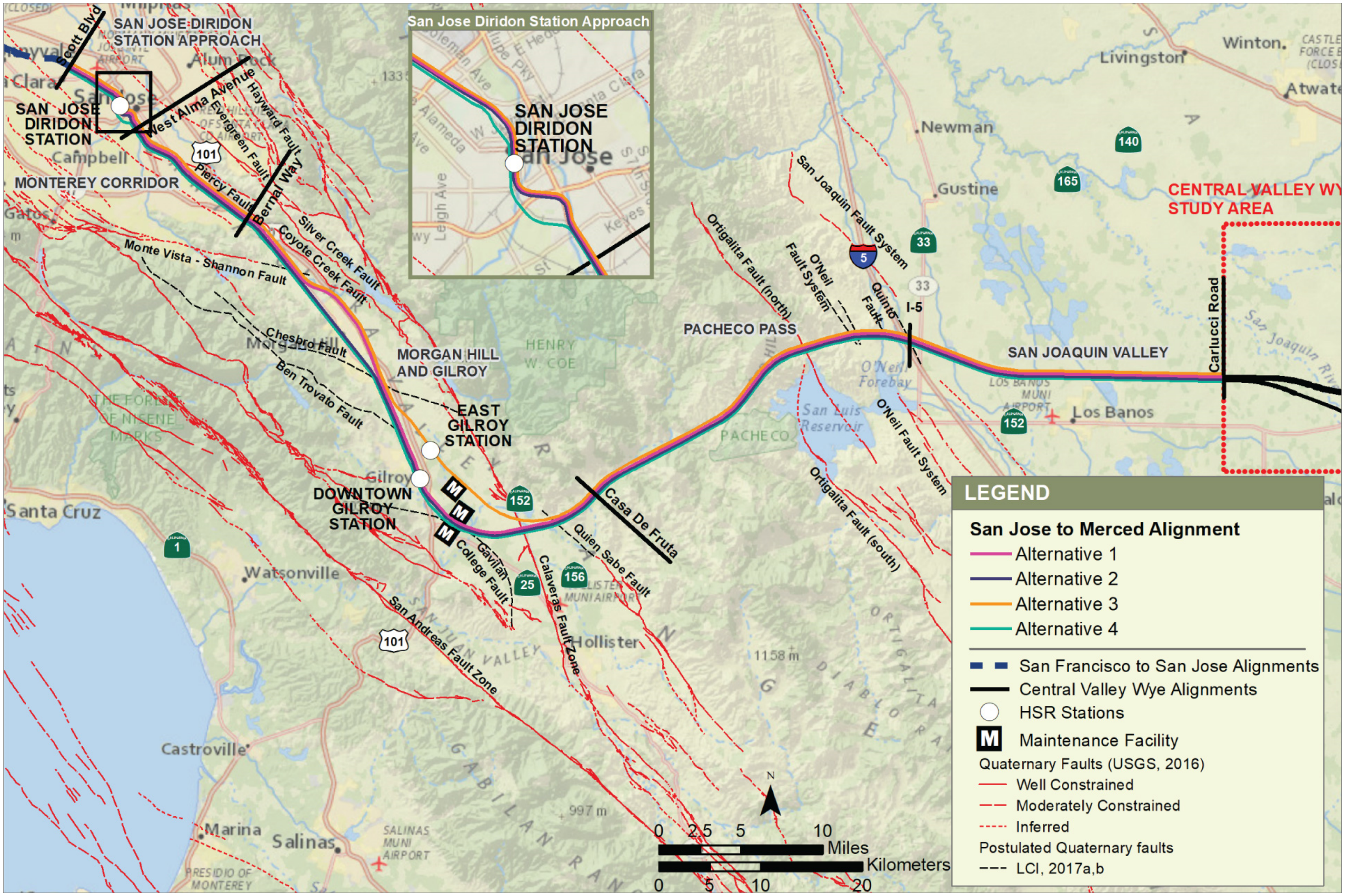
Figure 3.9-8 illustrates regional faulting in proximity to the project. A seismic event along any of these faults, depending on type and exposure, could result in permanent offsets at the ground surface along the fault line and, depending on proximity to the event epicenter, varying degrees of ground shaking. Additional details regarding seismic setting are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.3.1 (Authority 2019a).

Surface Fault Rupture

Faults are planes of weakness in the Earth’s crust where one side has moved relative to the other. When faults rupture the energy released creates ground shaking known as earthquakes. Faults are recognized and mapped by sheared and displaced rock or soil units and by the distinctive landforms created by repeated rupture of the Earth’s surface. Surface fault rupture refers to the extension of a fault to the ground surface in which the ground breaks, resulting in an abrupt relative ground displacement (e.g., vertical or horizontal offset). Surface fault ruptures can cause damage to structures within the rupture zone. Faults that intersect the alignment at known or postulated locations were screened by the project’s Seismic Specialists Team-Fault Displacement (SST-FD) and determined to be Class A Hazardous, Class B Hazardous, or Non-Hazardous faults (SST-FD 2017). The project crosses Class A Hazardous faults such as the Calaveras and Ortigalita in the Morgan Hill and Gilroy and Pacheco Pass Subsections, respectively (Figure 3.9-8). Additional details regarding surface fault rupture are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.3.2 (Authority 2019a).

Ground Shaking

The entire seismicity, faulting, and dam failure inundation RSA would be susceptible to ground shaking from nearby earthquakes. Ground shaking results from the sudden release of energy during an earthquake that creates seismic waves. These waves propagate through the Earth’s crust and can damage engineered structures and potentially result in injury or loss of life. The USGS Earthquake Scenario Map based on the 2014 Building Seismic Safety Council catalog shows earthquake scenarios near the Project Section as very strong to severe based on the Mercalli intensity scale (USGS 2017). Scientists have developed an earthquake forecast model for California referred to as the third Uniform California Earthquake Rupture Forecast (UCERF3). In the San Francisco region, the UCERF3 model predicts a 98 percent probability that one or more events with a magnitude greater than or equal to 6.0 will occur within the next 30 years (Field et al. 2015). Additional details regarding seismic ground motion are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.3.3 (Authority 2019a).



Source: USGS 2006

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Figure 3.9-8 Regional Faulting

3.9.5.4 Secondary Seismic Hazards

Secondary seismic hazards are caused by primary seismic hazards. These seismic hazards include liquefaction, lateral spreading, earthquake-induced landslides, earthquake-induced flooding, and inundation because of earthquake-induced dam failure.

Liquefaction

Soil liquefaction results from loss of strength during cyclic loading, such as that imposed by earthquakes. Soils most susceptible to liquefaction are clean, loose, saturated, uniformly graded fine sands below the groundwater table. When ground shaking occurs, the soil is subjected to cyclic shear stresses that can cause excess hydrostatic pressures to develop. If excess hydrostatic pressures exceed the effective confining stress from the overlying soil, the soil may undergo deformation. If the soil undergoes virtually unlimited deformation without developing significant resistance, it becomes liquefied, and if the soil consolidates or vents to the surface during and following liquefaction, ground settlement and surface deformation may occur. Liquefaction can cause ground settlement that may result in differential movement of structures including tracks, stations, bridges, and other facilities. Differential movement could lead to structural damage or failure.

Soil deposits are susceptible to liquefaction in high groundwater areas that are underlain by poorly compacted granular fills or geologically young, loose, alluvial deposits. The potential for liquefaction exists within all project subsections; the mapped liquefaction susceptibility for the project alternatives is depicted on Figure 3.9-9. Additional details regarding liquefaction are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.4.1 (Authority 2019a).

Lateral Spreading

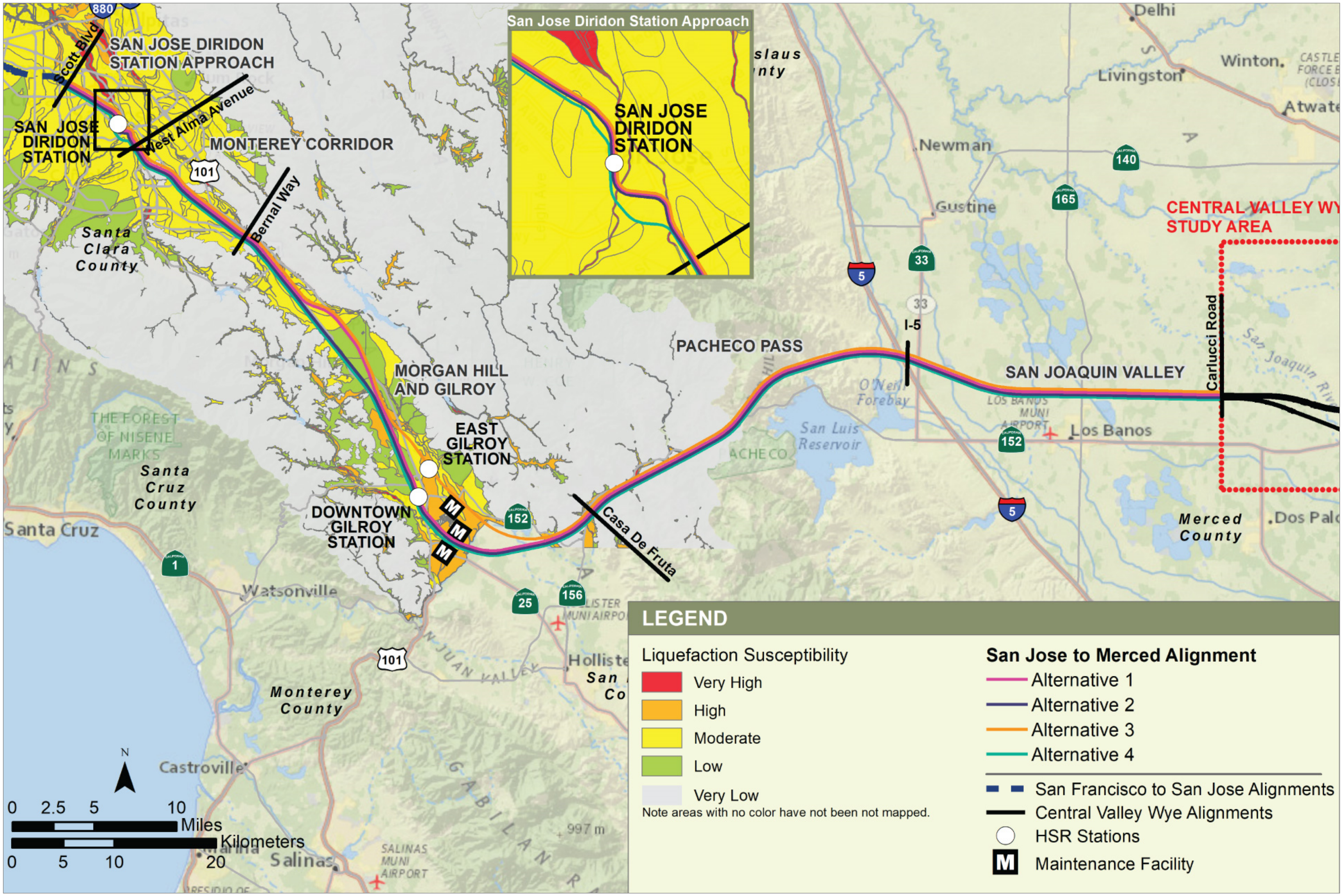
Lateral spreading occurs when sloping ground is underlain by liquefiable soil deposits. When an earthquake causes strong ground shaking, the areas of sloping ground can translate laterally because of the loss of soil strength from liquefaction. For this movement to occur, the area must be near a free face or slope such as a road cut or stream bank. Therefore, the risk of lateral spreading is affected by the likelihood of liquefaction, the ground slope, and the existence of free faces on the downhill side of the area in question. Lateral spreading is possible in deposits susceptible to liquefaction near free faces or slopes in limited locations within all subsections. Lateral spreading can cause ground rupture or movement that may result in differential settlement of structures including tracks, stations, bridges, and other facilities. Differential settlement could lead to structural damage or failure. Lateral spreading can also cause underground utility damage.

Within the Monterey Corridor Subsection, lateral spreading potential is generally limited to the northern end of the subsection where the alignment is near the banks of the Guadalupe River, and the southern end of the subsection, where the alignment is near the banks of Coyote Creek. Other portions of this subsection would have low risk of lateral spreading, either in areas of very low liquefaction susceptibility or at sufficient distances from slope faces.

At the northern end of the Morgan Hill and Gilroy Subsection, the alignment is adjacent to Parkway Lake and crosses Coyote Creek in several locations. The liquefaction susceptibility in this area is generally mapped as high to very high, with multiple free slope faces around stream channels and the lake. The potential for lateral spreading in these areas is considered high.

From Morgan Hill southward, liquefaction susceptibility generally reduces and fewer free faces are available to mobilize lateral spreading. Areas of potential lateral spreading in the Morgan Hill and Gilroy Subsection are localized at the crossings of Llagas Creek, the Pajaro River, and Pacheco Creek, and near detention basins in the San Martin and Gilroy areas.

The Pacheco Pass Subsection is generally within areas of bedrock where liquefaction susceptibility is very low. The potential for lateral spreading in the Pacheco Pass Subsection is, therefore, localized to the vicinity of Pacheco Creek stream banks within the Casa De Fruta valley and in the vicinity of the California Aqueduct and Delta-Mendota Canal along the western margin of the San Joaquin Valley.



Sources: *Witter et al. 2006; Knudsen et al. 2000*

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Figure 3.9-9 Liquefaction Susceptibility in Santa Clara County

Published maps are not available for liquefaction susceptibility in the San Joaquin Valley Subsection; however, based on the mapped geology and high groundwater, the potential for liquefaction exists (County of Merced 2013). Within this subsection, lateral spreading may be possible in the vicinity of free slope faces, such as at streams, canals, and drainage channels that are underlain by liquefiable soil. Additional details regarding lateral spreading are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.4.2 (Authority 2019a).

Earthquake-Induced Landslides

Landslides and debris flows can be activated by ground shaking associated with earthquakes. Earthquake-induced landslides are most likely to occur in areas of steep slopes in poorly cemented or highly fractured rocks, areas underlain by weak soils, and areas on or adjacent to existing landslide deposits. Landslides can lead to ground deformation and debris flows that can cause damage to structures and be hazardous to people.

Because of the relatively flat topography in the San Jose Diridon Station Approach Subsection, earthquake-induced landslides are not anticipated. The Monterey Corridor Subsection includes portions of Communications Hill, a bedrock area within the southern Santa Clara Valley that has been mapped as serpentinite with multiple landslides that could be triggered by an earthquake.

Portions of the Morgan Hill and Gilroy Subsection likely to be affected by earthquake-induced landslides are limited to the slopes of Tulare Hill at the northern end of the subsection and the Tunnel 1 portals and approaches at the southern end of the subsection in the Diablo Range. The Tunnel 1 area is underlain by the Panoche Formation, consisting of steep terrain and landslides. The tunnel in this area would avoid the potential hazard, except at portal locations and approach improvements. Additionally, PG&E network upgrades located in the hills east of the alignment near Coyote and west of the alignment near Morgan Hill and San Martin could be affected by earthquake-induced landslides. The remainder of this subsection is located outside areas of steeper topography that could generate landslides.

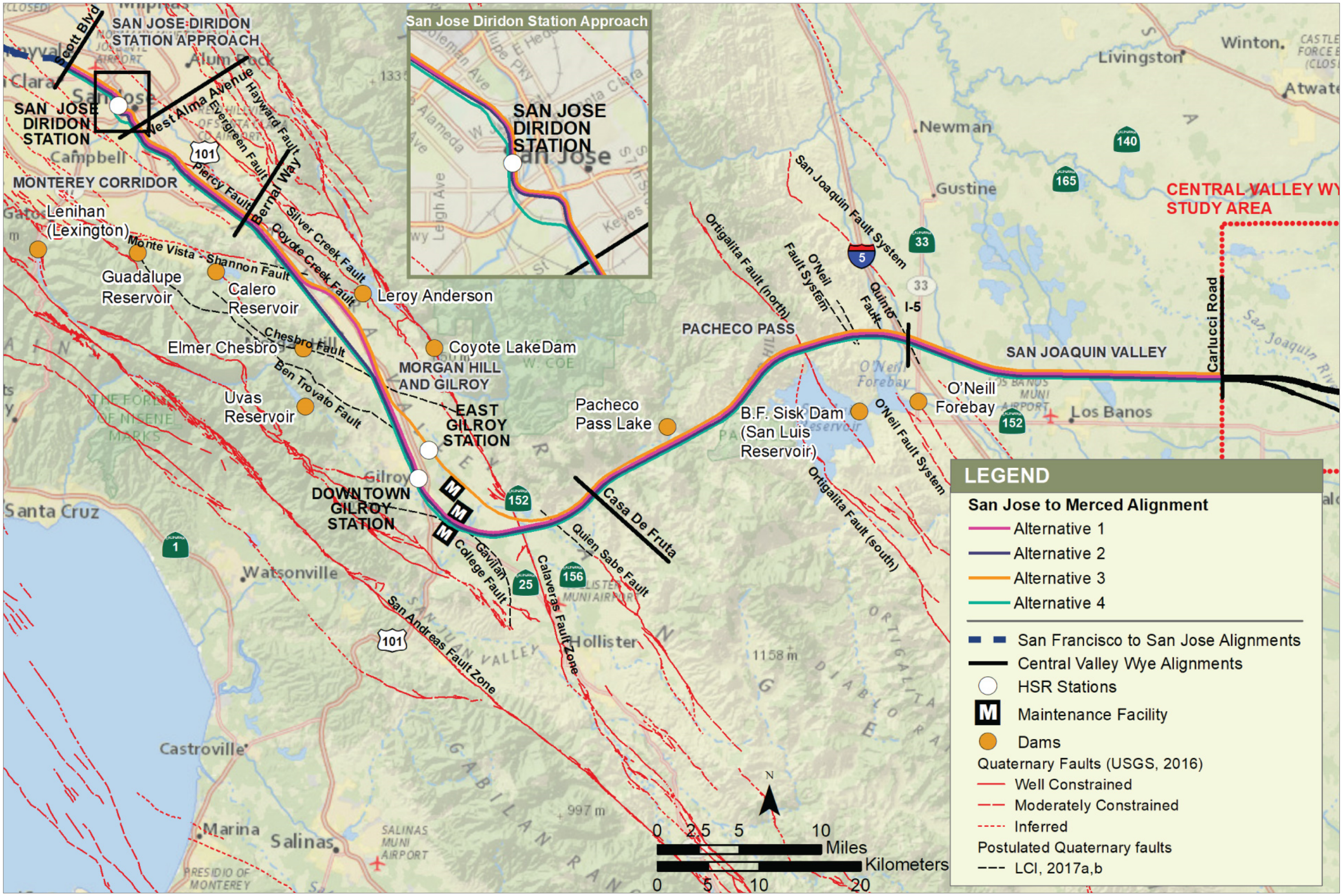
The majority of the Pacheco Pass Subsection is within an area of extensive, deep-seated landslides and high, steep topography. Much of the Pacheco Pass Subsection is underlain by moderately to heavily fractured rock of the Franciscan Melange. The risk of earthquake-induced landslides within this subsection is generally very high. Tunnel 2 through much of this subsection would avoid the potential hazard, except at portal locations and other areas of surface improvements.

Because of the relatively flat topography in the San Joaquin Valley Subsection, earthquake-induced landslides are not anticipated in this area.

Earthquake-Induced Flooding

Earthquake-induced flooding can occur in multiple ways: seiches, tsunamis, or the failure of water-retaining structures (such as dams) during an earthquake. The seismicity, faulting, and dam failure inundation RSA is not within a mapped tsunami inundation zone. However, a seiche or significant ground shaking could cause dam failure that could trigger flooding. Earthquake-induced flooding from dam failure can result in rapidly moving waters that could potentially erode embankments and bridge foundations, or submerge parts of the alignment. Floodwaters could also inundate train stations or other supporting structures.

Within all subsections, the seismicity, faulting, and dam failure inundation RSA includes areas of potential inundation due to dam failure because several dams of regional significance are present uphill of the project. The highest projected floodwaters caused by dam failure would be at the narrow valley between Tulare Hill and the Diablo Range at the southern end of the Monterey Corridor Subsection, where floodwaters are projected to be 30 feet or more in the event of a failure of Leroy Anderson Dam (SCVWD 2009). Figure 3.9-10 illustrates dam locations in the project vicinity. Additional details regarding earthquake-induced flooding are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.4.4 (Authority 2019a).



Sources: SCVWD 1973, 1995, 1997, 2009, 2014

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Figure 3.9-10 Dams Located near Proposed Alignments

3.9.5.5 Geologic Resources

Geologic resources evaluated include mineral, fossil fuel (oil and gas), and geothermal resources. As described in this section, further analysis of these geologic resources has been dismissed. Additional details regarding geologic resources are discussed in the Geology, Soils, and Seismicity Technical Report, Section 5.5 (Authority 2019a).

Mineral Resources

Mineral resources include minerals, aggregates, and building materials extracted from the Earth by mining. Alternatives 2 and 4 would require importing soils for embankment and at-grade construction, approximately 900,000 cubic yards and 2.3 million cubic yards respectively. Alternatives 1 and 3 would require exporting 160,000–163,000 cubic yards of soil. According to the National Minerals Information Center of the USGS, there are no active mines or mineral plants within the geologic hazards RSA for any of the project alternatives but project construction could reduce availability of mineral resources mapped within the Morgan Hill and Gilroy Subsection by reducing access to potential future mining sites. However, because there are no active mineral resource recovery sites mapped within the geologic hazards RSA, project construction would not result in the loss of availability of a locally important mineral resource recovery site. As a result, this resource was dismissed from further consideration.

Fossil Fuel Resources (Oil and Natural Gas)

The California Department of Conservation DOGGR maintains a database of oil, gas, and geothermal resources, which indicates no active gas or oil wells are located within 0.5 mile of the geologic hazards RSA for any of the project alternatives (DOGGR 2017). As a result, this resource was dismissed from further consideration.

Geothermal Resources

The California Department of Conservation DOGGR mapped no geothermal resources within the geologic hazards RSA for any of the project alternatives (DOGGR 2017). As a result, this resource was dismissed from further consideration.

3.9.5.6 Paleontological Resources

Geologic Conditions

Much of the paleontological resources RSA has been mapped at a scale of 1:24,000 by Dibblee and Minch (2005a–e, 2006a, 2006b, 2007a–g) and McLaughlin et al. (2001), while other portions of the paleontological resources RSA have only been mapped at a scale of 1:250,000 by Wagner et al. (1991). According to these published maps, the paleontological resources RSA is underlain by the Jurassic and Cretaceous–aged Franciscan Complex and Coast Ranges Ophiolite Complex, the Jurassic to Cretaceous–aged Knoxville Formation, the late Cretaceous–aged Panoche and Moreno Formations, an Eocene to possibly Late Cretaceous unnamed clay shale and claystone unit, the Miocene-aged Monterey Formation, the Pleistocene to Pliocene–aged Santa Clara Formation, the Pleistocene-aged Modesto Formation, the Pleistocene to Holocene–aged San Luis Ranch Alluvium, various unnamed Pleistocene-aged sedimentary deposits, and various unnamed Holocene-aged sedimentary deposits. Geologic units not assigned to a named formation (e.g., Quaternary surface deposits) that are of similar age, depositional environment, and paleontological potential have been grouped together for ease of reference. Although Miocene-aged hydrothermally altered rocks and volcanic rocks are present within a 1-mile buffer of the paleontological resources RSA, these geologic units do not occur within the actual paleontological resources RSA and are therefore not included in the paleontological analysis. Appendix A of the Paleontological Resources Technical Report provides maps depicting the distribution of geologic units within the paleontological resources RSA and their paleontological potential (Authority 2019b).

Based on the literature review and museum records search results, the geologic units underlying the paleontological resources RSA have paleontological potential rankings that range from no potential to high potential in accordance with SVP guidelines. The strata of the Knoxville, Panoche, Moreno, Monterey, Santa Clara, and Modesto Formations, and (depending on lithology) older Quaternary alluvium deposits mapped within the paleontological resources RSA are considered to have a high paleontological potential because they are known to have produced numerous significant vertebrate fossils in the vicinity of the paleontological resources RSA and elsewhere. The strata of the unnamed clay shale and claystone unit (Tsh) are considered to have an undetermined paleontological potential because little is known about the age or fossil content of these deposits. Certain areas of older Quaternary alluvium are also considered to have an undetermined paleontological potential. Identifiable fossil remains discovered and salvaged from these geologic units during project construction would be scientifically important and significant. The Franciscan Complex, San Luis Ranch Alluvium, Holocene-aged Quaternary deposits, and artificial fill are considered to have low potential for producing significant fossils. The remaining igneous and metamorphic geologic units are assigned no potential because of their origin in environments that are not conducive to fossil preservation (e.g., the high heat and pressure of magma crystallization and high-grade metamorphism). Table 3.9-7 shows the geologic units underlying the paleontological resources RSA, from oldest to youngest, and their assigned paleontological resource potential ratings. See the Paleontological Resources Technical Report for a more detailed discussion (Authority 2019b).

Table 3.9-7 Paleontological Potential of Geologic Units within the Paleontological Resources RSA

Map Symbol	Age & Legend ID	Formation	Location	Lithology	Paleontological Potential (SVP 2010[1])
fc, fg, fl, fm, fms, fmv, fpl, fpv, fs, fss, gl, v	Jurassic and Cretaceous	Franciscan Assemblage	▪ Monterey Corridor ▪ Morgan Hill and Gilroy ▪ Pacheco Pass	Intermediate to high-grade metamorphic and igneous	Low
db, sc, sp, Jos	Jurassic and Cretaceous	Coast Range Ophiolite Complex	▪ Monterey Corridor ▪ Morgan Hill and Gilroy ▪ Pacheco Pass	Plutonic igneous, metamorphic	No
JKk	Late Jurassic and Early Cretaceous	Knoxville Formation	▪ Morgan Hill and Gilroy	Marine shale and sandstone	High
Kp, Kpc, Kps, Ku	Late Cretaceous	Panoche Formation	▪ Morgan Hill and Gilroy ▪ Pacheco Pass	Marine shale, sandstone, conglomerate	High
Km, Kms	Late Cretaceous	Moreno Formation	▪ Pacheco Pass	Marine shale	High
Tsh	Eocene to possibly Late Cretaceous	Unnamed clay shale and claystone	▪ Morgan Hill and Gilroy	Marine shale and claystone	Undetermined
Tm, Tms	Middle Miocene	Monterey Formation	▪ Outside alignment—proximal to Morgan Hill and Gilroy	Marine shale and chert	High
QTs, QTs, QTsc	Pleistocene to Pliocene	Santa Clara Formation	▪ Morgan Hill and Gilroy	Gravel conglomerate, pebbly sandstone	High
Qm	Pleistocene	Modesto Formation	▪ San Joaquin Valley	Non-marine and fluvial sandstone	High

Map Symbol	Age & Legend ID	Formation	Location	Lithology	Paleontological Potential (SVP 2010[1])
Qg, Qls, Qsc, Qsp, Qoa, Qoa1, Qoa2, Qpf	Pleistocene	Older Quaternary Deposits	▪ Throughout the paleontological resources RSA	Unconsolidated silt, sand, gravel	High to Undetermined
Qsl	Pleistocene to Holocene	San Luis Ranch Alluvium	▪ San Joaquin Valley	Unconsolidated silt, sand, gravel	Low
gp, Qac, Qdp, Qa, Qa.1, Qa.2, Qhb, Qhc, Qhf, Qhfp, Qhl, Qp, Qya	Holocene	Younger Quaternary Deposits, Patterson Alluvium, Dos Palos Alluvium	▪ Throughout the paleontological resources RSA	Unconsolidated silt, sand, gravel, rubble	Low
af, pp	Late Holocene	Artificial Fill, Gravel Quarry, Percolation Pond	▪ Morgan Hill and Gilroy ▪ San Joaquin Valley	Undefined and unconsolidated sediments derived from a variety of geologic formations, constructed gravel pit, constructed recharge ponds	Low

Sources: McLaughlin et al. 2001; Wagner et al. 1991; Dibblee and Minch 2005a–e, 2006a, 2006b, 2007a–g

[1] For this analysis, SVP classification of high paleontological sensitivity corresponds to Caltrans High; undetermined paleontological sensitivity corresponds to Caltrans Low; low paleontological sensitivity corresponds to Caltrans Low; and no paleontological sensitivity corresponds to Caltrans No.

SVP = Society of Vertebrate Paleontology

RSA = resource study area

Caltrans = California Department of Transportation

Paleontological Resources Existing Conditions

University of California Museum of Paleontology (UCMP) staff conducted an institutional records search for previously recorded fossil localities within the paleontological resources RSA (Finger 2016). The search results (shown in Table 3.9-8) reported four previously recorded vertebrate fossil localities within the paleontological resources RSA from unnamed Pleistocene deposits and the Santa Clara Formation. These localities produced fossil remains of Ice Age land mammals including *Mammuthus columbi* (mammoth)*, Camelidae* (undetermined camel), *Platygonus* sp. (peccary)*,* and *Proboscidea* (mammoth or mastodon) (Finger 2016). In addition, the UCMP online database has other Pleistocene fossil vertebrate localities from several geologic units outside the paleontological resources RSA but within Santa Clara, Merced, and San Benito Counties. *Equus* sp. (horse), *Mammuthus columbi* (mammoth), and *Platygonus* sp. (peccary), among other mammals, are documented from the Santa Clara Formation and other Pleistocene-aged deposits within Santa Clara County. Vertebrate fossil localities documented in Pleistocene deposits from Merced County have produced remains of *Bison* sp. (bison), *Equus* sp. (horse), and *Mammuthus columbi* (mammoth). Pleistocene deposits in San Benito County have produced multiple vertebrate fossil localities from which remains of *Equus* sp. (horse), and *Mammut americanum* (mastodon) have been collected. There are more than 50 localities documented within the Panoche Formation in Merced and San Benito Counties that have produced fossils of bivalves and foraminiferans. There are more than 80 recorded localities from the Moreno Formation in Merced County that have produced fossils of bivalves, gastropods, foraminiferans, and plants (UCMP 2016).

Table 3.9-8 Previously Recorded UCMP Fossil Vertebrate Localities in the Vicinity (1 mile) of the Paleontological Resources RSA

Locality No.	Geologic Unit	Age	Resource Location	Relevant to Analysis of Subsections	Taxa
V99597	Unnamed Pleistocene Deposits	Pleistocene	City of Santa Clara	San Jose Diridon Station Approach	*Mammuthus columbi*
V99893	Unnamed Pleistocene Deposits	Pleistocene	City of Santa Clara	San Jose Diridon Station Approach	Proboscidea
V93037	Santa Clara Formation	Pleistocene	City of Morgan Hill	Monterey Corridor	Camelidae
V6561	Unnamed Pleistocene Deposits	Late Pleistocene	San Felipe Road, Santa Clara County	Morgan Hill and Gilroy	*Platygonus* sp.

Sources: Finger 2016; UCMP 2016
No. = number
RSA = resource study area

A search of the Paleobiology Database (PBDB) revealed an additional 14 fossil invertebrate and plant localities in Santa Clara and Merced Counties in the Santa Clara, Panoche and Moreno Formations. There is one additional vertebrate fossil locality record in the PBDB that documents the occurrence of a fossil horse from the Santa Clara Formation in Santa Clara County (PBDB 2016). The Paleontology Portal online database does not contain any previously recorded vertebrate fossil localities directly within the paleontological resources RSA, or from the same geologic units exposed elsewhere in Santa Clara, Merced, or San Benito Counties (Paleontology Portal 2016).

Paleontological Resource Sensitivity/Potential Evaluation by Geologic Unit

In total, construction activities associated with the project alternatives may affect six geologic units with high potential to produce significant paleontological resources, one geologic unit with high to undetermined paleontological potential (depending on lithology), and one geologic unit with undetermined paleontological potential. Table 3.9-9 shows the geologic units potentially affected in each subsection. The geologic units in these subsections are the same for all four project alternatives.

Table 3.9-9 Distribution of Geologic Units by Subsection within the Paleontological Resources RSA

Deposit	San Jose Diridon Station Approach	Monterey Corridor	Morgan Hill and Gilroy	Pacheco Pass	San Joaquin Valley
Franciscan Complex (Low Potential)	X[1]	X	X	X	
Coast Range Ophiolite Complex (No Potential)	X[1]	X	X	X	
Knoxville Formation (High Potential)			X		
Panoche Formation (High Potential)			X	X	
Moreno Formation (High Potential)				X	
Unnamed clay shale and claystone (Undetermined Potential)			X		
Monterey Formation (High Potential)			X[2]		
Santa Clara Formation (High Potential)		X[2]	X		
Modesto Formation (High Potential)					X
Older Quaternary Deposits (High to Undetermined Potential)	X[2]	X[2]	X	X	X[2]
San Luis Ranch Alluvium (Low Potential)					X
Younger Quaternary Deposits (Low Potential at the surface/Undetermined Potential subsurface)	X	X	X	X	X
Artificial Fill (Low Potential) [3]	X	X	X	X	X

Sources: McLaughlin et al. 2001; Wagner et al. 1991; Dibblee and Minch 2005a–e, 2006a, 2006b, 2007a–g

[1] No to low sensitivity unit not mapped at the surface within the alignment, but potentially present at depth.

[2] Sensitive geologic unit not mapped at the surface within the alignment, but potentially present at depth.

[3] Artificial fill is mapped in the vicinity of the paleontological resources RSA, and was observed in aerial photographs in all subsections.

3.9.6 Environmental Consequences

3.9.6.1 Overview

This section discusses the impacts on geology, soils, seismicity, and paleontological resources that would result from implementing the project alternatives during both construction and operations.

Project features, including IAMFs, design standards, and compliance with the Authority's project design guidelines and technical memoranda, would avoid or minimize direct and indirect project effects resulting from geologic, soils, and seismic hazards. The Authority would prepare a construction management plan (CMP) to manage geologic hazards during design and construction. They would also monitor for slope instability, monitor for subsurface gas (in-situ gas), install seismic early warning systems, design for earthquake loads, use motion sensors to shut down operations during or after an earthquake, implement track inspection systems, and apply appropriate guidelines and codes for design. These project features reduce exposure of people or structures to effects, including the risk of loss, injury, or death.

The project alternatives would also result in direct impacts on paleontological resources, including the potential to destroy scientifically important fossils during ground disturbance in geologic units identified as having high or undetermined paleontological potential. The Authority would engage a qualified PRS to review final design for the construction package and evaluate portions that would involve work in paleontologically sensitive units (either at the surface or in the subsurface). The PRS would also prepare and implement a paleontological resources monitoring and mitigation plan (PRMMP) that describes when and where construction monitoring would be required, emergency discovery procedures, sampling and data recovery procedures, procedures for the preparation, identification, analysis, and curation of fossil specimens and data recovered, and procedures for reporting. The Authority would provide worker environmental awareness program (WEAP) training for project personnel. The Authority would establish procedures to monitor and halt construction when paleontological resources are found.

3.9.6.2 Geology, Soils, and Seismicity

Construction and operations of the project would result in temporary (short-term) or permanent (long-term) direct impacts from or on geology, soils, and seismicity. Impacts include increased risk of property damage, loss of life or injury from geologic and seismic hazards.

No Project Impacts

As discussed in Section 3.18, Regional Growth, the population along the length of the project is expected to grow through 2040. Development in the region to accommodate the population and employment increase would continue under the No Project Alternative. Section 3.19, Cumulative Impacts, identifies planned and other reasonably foreseeable future projects anticipated to be constructed in the region to accommodate projected growth, including shopping centers, industrial parks, transportation projects, and residential developments.

The No Project Alternative considers the effects of conditions forecast by current plans for land use and transportation in the vicinity of the project, including planned improvements to the highway, aviation, conventional passenger rail, freight rail, and port systems through the 2040 planning horizon for the environmental analysis if the project is not built. Under the No Project Alternative, there would be more vehicles miles traveled, resulting in increased pressure to improve capacity for all transportation modes throughout the area. The Authority estimates that additional highway and airport projects (up to 4,300 highway lane miles, 115 airport gates, and 4 airport runways) would be planned and constructed to achieve equivalent capacity and relieve this increased pressure (Authority 2012).

Development in some areas of the project vicinity would likely continue creating demand for infrastructure projects. These development and infrastructure projects carry risks to public safety and create the potential for property damage caused by geologic hazards. The infrastructure and development projects would at a minimum be subject to the Building Code requirements that require application of engineering design features to address and minimize these risks. Conversely, infrastructure and development projects would affect geology and soils. Changes in local conditions from infrastructure project implementation include water erosion, wind erosion, and loss of valuable topsoil. Future developments planned under the No Project Alternative would require individual environmental review, such as permits, regulatory requirements, and design standards. Future projects would need to comply with Title 24 CBC requirements with adherence to geotechnical and stability regulations and would be designed to avoid or minimize impacts.

Project Impacts

Construction Impacts

Construction of the project would involve demolition of existing structures; clearing and grubbing; handling, storing, hauling, excavating, tunneling, and placing fill and spoils; possible pile driving; and construction of aerial structures, bridges, road modifications, utility upgrades and relocations, HSR electrical systems, and railbeds. Chapter 2, Alternatives, describes construction activities in further detail.

Impact GEO#1: Construction in Unstable Soils

This section discusses the impacts of project construction for unstable soils, including ground subsidence, collapsible soil, landslides, and soft soil.

Ground Subsidence

Regional subsidence has been documented and could occur along portions of the San Joaquin Valley Subsection. In addition, substantial portions of the project alignments have groundwater resources present within 20 feet of the ground surface, which may require construction dewatering that could induce localized subsidence. The project would minimize impacts associated with ground subsidence through implementation of conventional engineering methods to maintain the integrity of the project if regional or localized ground subsidence causes ground settlement. Site conditions would be assessed to determine the most appropriate engineering solutions prior to construction, in accordance with relevant design guidelines and standards such as American Railway Engineering and Maintenance-of-Way Association (AREMA), Federal Highway Administration (FHWA), and Caltrans (GEO-IAMF#10). Additionally, prior to construction, the design-build contractor would prepare a CMP that would include design measures to minimize or avoid exposure of people or structures to impacts from regional or localized ground subsidence (GEO-IAMF#1). The CMP would include topographic surveying prior to, during, and after railbed preparation to determine whether regional ground subsidence has occurred or if ongoing regional ground subsidence is expected and to what degree. The results of the survey would be used to determine the need for initial overbuilding of the railbed to compensate for anticipated future regional ground subsidence or alternate foundation systems to reduce differential settlement as regional ground subsidence continues.

The CMP would also include measures to minimize localized ground subsidence due to groundwater dewatering during construction. The impacts of settlement due to temporary construction dewatering would be minimized or avoided by monitoring and controlling the amount of groundwater withdrawal from the project, by reinjecting groundwater at specific locations if necessary, or by using alternate foundation designs to negate the potential for settlement.

Implementing these project features before and during project construction would avoid increasing exposure of people to loss of life or structures to destruction due to ground subsidence. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

Collapsible Soil

The project would cross known areas of collapsible soils in portions of the Pacheco Pass and San Joaquin Valley Subsections along the west side of the San Joaquin Valley. Project construction would include assessing geotechnical conditions and, if necessary, employ ground improvement methods such as pre-wetting or deep cement-soil mixing, or excavating and replacing collapsible soil with engineered fill. Prior to construction, the design-build contractor would prepare a CMP that would specify the details of how and where these techniques would minimize or avoid exposure of people or structures to impacts from collapsible soil (GEO-IAMF#1). Geotechnical conditions would be assessed to determine the extent of the hazard and the most appropriate engineering solutions prior to construction, in accordance with relevant design guidelines and standards such as AREMA, FHWA, and Caltrans (GEO-IAMF#10). Implementing these project features before and during construction activities would avoid rendering soil unstable to a degree that it would increase exposure of people to loss of life or structures to destruction as a result of settlement caused by collapsible soil.

The project features that include geotechnical characterization and ground improvement or removal of collapsible soil apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

Landslides

The risk of landslides is limited to areas where the alignment passes on or near steep slopes, such as Communications Hill, Tulare Hill, and mountainous areas near tunnel portions within the Morgan Hill and Gilroy and Pacheco Pass Subsections. The project would minimize the potential increased exposure of people to loss of life or structures to destruction associated with landslides through implementation of conventional engineering methods to stabilize existing landslides and stabilize slopes. The Authority would assess site conditions to determine appropriate engineering solutions prior to construction, in accordance with relevant design guidelines and standards such as AREMA, FHWA, and Caltrans (GEO-IAMF#10). The design-build contractor would prepare a CMP that would include design measures, such as structural solutions (e.g., tie backs, soil nails, retaining walls, debris barriers) or earthwork solutions (e.g., ground improvement, regrading/rebuilding of slopes), to stabilize existing landslides and stabilize slopes. In the case of elevated structures, the location of the foundation would be sited during final design to avoid landslides or landslide/debris flow paths to minimize or avoid exposure of people or structures to impacts from landslides (GEO-IAMF#1). Implementing these project features before and during construction would avoid rendering landslides unstable to a degree that it would increase exposure of people to loss of life or structures to destruction. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

Soft Soil

The project traverses areas underlain by alluvial deposits and residual soil over bedrock in all subsections, which in some areas may exhibit soft soil conditions. The project during construction would assess geotechnical conditions and, if necessary, employ ground improvement methods such as stone columns, cement deep-soil mixing, or jet grouting, or excavating and replacing soft soil with engineered fill. Heavily loaded structures, such as bridges, would be constructed with deep foundations that would transfer the structural loads to non-compressible soil layers. Site conditions would be assessed to determine the most appropriate engineering solutions prior to construction, in accordance with relevant design guidelines and standards such as AREMA, FHWA, and Caltrans (GEO-IAMF#10). Additionally, prior to construction, the design-build contractor would prepare a CMP that would specify the details of how and where these techniques would minimize or avoid exposure of people or structures to impacts from soft soil (GEO-IAMF#1). Implementing these project features before and during construction activities would avoid increasing exposure of people to loss of life or structures to destruction as a result of differential settlement or ground failure caused by soft soil.

The project features that include ground improvement or removal of soft soil apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

CEQA Conclusion

The impact under CEQA would be less than significant for all project alternatives because project features would minimize direct and indirect risks to life and property from increased exposure to hazardous ground subsidence, collapsible soil, landslides, and soft soil, beyond the level people currently experience in the RSA. These project features would include assessing soil conditions prior to construction and employing appropriate engineering methods as well as conducting surveys to monitor subsidence (GEO-IAMF#1 and GEO-IAMF#10). Project features would also include controlling groundwater withdrawal during construction dewatering or offsetting potential settlement with alternate foundation systems designed in accordance with relevant design guidelines and standards such as AREMA, FHWA, and Caltrans (GEO-IAMF#1 and GEO-IAMF#10). Therefore, CEQA does not require mitigation.

Impact GEO#2: Inadvertent Disturbance of Naturally Occurring Asbestos during Construction

The project traverses areas with NOA primarily in the Pacheco Pass Subsection because more than half of the profile in this subsection, for all four project alternatives, involves tunneling through bedrock that may contain zones of ultramafic or metavolcanic bedrock. The project would minimize the impacts caused by exposure of construction workers to NOA by employing dust control to reduce the potential for NOA to become airborne during ground-disturbing activities and by proper testing and disposal of excavated material that may contain NOA. Prior to construction, the design-build contractor would prepare a CMP that would specify the details of how and where these techniques would minimize or avoid exposure of people to impacts from NOA (GEO-IAMF#5). The potential for workers to encounter NOA would be reduced or eliminated by following CARB regulatory requirements that limit dust exposure during construction and grading operations in areas with NOA. Implementing these project features before and during construction activities would avoid increasing exposure of people to loss of life as a result of inhalation of NOA.

The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

CEQA Conclusion

The impact under CEQA would be less than significant because project features would minimize direct and indirect risks of injury and loss of life from increased exposure to NOA during construction by following state regulatory requirements, employing dust control, and by proper testing and disposal of excavated material (GEO-IAMF#5). Therefore, CEQA does not require mitigation.

Impact GEO#3: Exposure to In-Situ Gas

The project includes tunneling through bedrock, where in-situ gas occurs, in portions of the Morgan Hill and Gilroy and Pacheco Pass Subsections. Project features minimize the risk of exposure to in-situ gas by using safe and explosion-proof equipment during construction, testing and monitoring for gases on a regular basis, and installing passive or active gas venting systems where subsurface gases are present. Prior to construction, the design-build contractor would prepare a CMP that would specify the details of how and where these techniques would minimize or avoid exposure of people or property to impacts from in-situ gas (GEO-IAMF#1). The potential for workers to encounter hazardous in-situ gas would be reduced or eliminated by following strict federal and state Occupational Safety and Health Administration (OSHA) regulatory requirements and by consulting with other agencies as appropriate, such as the Department of Conservation (DOGGR), California Environmental Protection Agency, and Department of Toxic Substances Control, regarding known areas of concern (GEO-IAMF#3). OSHA regulatory requirements include providing adequate ventilation and frequent air testing for oxygen, methane, and hydrogen sulfide. Implementing these features before and during project construction would avoid increasing exposure of people to loss of life or property to destruction as a result of inhalation or detonation of in-situ gas. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

CEQA Conclusion

The impact under CEQA would be less than significant because project features would minimize direct and indirect risks to life and property from increased exposure to in-situ gas by conforming with regulatory requirements for excavations; installing gas monitoring, collecting, and ventilating systems; and using explosion-proof equipment (GEO-IAMF#1 and GEO-IAMF#3). Therefore, CEQA does not require mitigation.

Impact GEO#4: Tunneling in Areas with Sheared or Weak Bedrock

The project requires tunneling through bedrock that is likely sheared or weak in portions of the Morgan Hill and Gilroy and Pacheco Pass Subsections. The project features would minimize the impacts of sheared or weak bedrock when encountered during tunneling with standard tunnel engineering and construction practices. The design-build contractor would prepare a CMP that would include design measures to minimize or avoid exposure of people or structures to impacts from sheared or weak bedrock (GEO-IAMF#1). This would include planning to use techniques appropriate for tunneling in crushing and squeezing conditions. Conforming to guidelines specified by relevant transportation and building agencies and codes would require Authority contractors to account for sheared or weak bedrock during design and construction (GEO-IAMF#10). The contractor would have site-specific geotechnical data prior to construction that would permit the contractor to anticipate the location of sheared or weak bedrock prior to tunneling and have the appropriate equipment and procedures in place to safely address these conditions. Implementing these project features before and during construction would avoid increasing exposure of people to loss of life or property to destruction as a result of sheared or weak bedrock. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

CEQA Conclusion

The impact under CEQA would be less than significant because project features would minimize direct and indirect risks to life and property from increased exposure to sheared or weak bedrock by assessing geotechnical conditions prior to construction, using tunneling techniques to safely tunnel when crushing and squeezing conditions are expected, and reinforcing tunnels to handle external stresses (GEO-IAMF#1 and GEO-IAMF#10). Therefore, CEQA does not require mitigation.

Impact GEO#5: Construction on Expansive Soil

The project would be constructed in areas with expansive soils in all subsections. Viaduct constructed on deep foundations and tunnel portions in bedrock would not be affected by expansive soils. The project would minimize or avoid the potential for expansive soil to cause differential movement of the track system by treating expansive soils with additives, such as cement or lime, to reduce the shrink-swell potential or excavating and replacing expansive soil with non-expansive soil. Prior to construction, the design-build contractor would prepare a CMP that would specify the details of how and where these techniques would be implemented to minimize or avoid exposure of people or structures to impacts from expansive soil (GEO-IAMF#1). Implementing these features before and during construction activities would avoid increasing exposure of people to loss of life or structures to destruction as a result of expansive soil. The project features that include the treatment or removal of expansive soil apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

CEQA Conclusion

The impact under CEQA would be less than significant for all project alternatives because prior to construction, the design-build contractor would assess soil conditions and treat expansive soils through appropriate engineering measures, thereby minimizing direct and indirect risks to life and property from expansive soil. Engineering measures would include treatment with soil additives to reduce shrink-swell potential or excavation and replacement in accordance with relevant guidelines and standards such as AREMA, FHWA, and Caltrans (GEO-IAMF#1 and GEO-IAMF#10). Therefore, CEQA does not require mitigation.

Impact GEO#6: Excavating in Areas with Shallow Bedrock or Shallow Groundwater

Excavating in Areas of Shallow Bedrock

The project would construct portions of the alignment at grade, on embankment, or aerially in the Monterey Corridor and Morgan Hill and Gilroy Subsections as well as tunnel portals in the Morgan Hill and Gilroy Subsection and Pacheco Pass Subsection, all of which have mapped areas of shallow bedrock. The impacts resulting from excavation in shallow bedrock would be minimized with conventional construction safety measures. The design-build contractor would prepare a CMP that would include design measures to minimize or avoid exposure of people or structures to impacts from shallow bedrock (GEO-IAMF#1). The contractor would develop safety procedures and guidelines for the use of potentially dangerous excavation methods and equipment. Conforming to guidelines specified by relevant transportation and building agencies and codes would require

Authority contractors to account for soil and geotechnical properties during design and construction and thus minimize or avoid risks associated with shallow bedrock (GEO-IAMF#10). Geotechnical investigations would help to identify the areas where potentially difficult-to-excavate rock would be encountered so that contractor would use safe equipment and methods. These project features would reduce the potential for excavation in shallow bedrock to cause loss of life or property damage during construction. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

Excavating in Areas of Shallow Groundwater

The project would be constructed in areas with potential for shallow groundwater (less than 20 feet deep) in all subsections. Project features would minimize the impacts from excavation in shallow groundwater by implementing commonly used construction methods. The design-build contractor would prepare a CMP that would include design measures to minimize or avoid exposure of people or structures to impacts from shallow groundwater (GEO-IAMF#1). Conforming to guidelines specified by relevant transportation agencies and codes would require Authority contractors to account for geotechnical properties during design and construction to minimize hazardous impacts of shallow groundwater (GEO-IAMF#10). The contractors may use temporary dewatering with deep groundwater wells and well points that lower the water level; sheet pile wall systems to stabilize the soil; or techniques such as jet grouting and cement deep-soil mixing techniques that add cement to the soil, thereby providing a cement-soil mix that resists hydrostatic forces. Implementing these features before and during construction activities would avoid increasing exposure of people to loss of life or structures to destruction as a result of excavation in shallow groundwater. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

CEQA Conclusion

The impact of excavating in areas of shallow bedrock or shallow groundwater would be less than significant under CEQA because project features would utilize engineering techniques and construction safety procedures to minimize direct and indirect risks to life and property by conforming with geotechnical guidelines and standards such as AREMA, FHWA, and Caltrans as well as developing a CMP pertaining to excavations, shallow bedrock, and groundwater conditions (GEO-IAMF#1 and GEO-IAMF#10). Therefore, CEQA does not require mitigation.

Impact GEO#7: Exposure of Concrete and Steel to Corrosive Soils

Moderate to highly corrosive soil and rock would likely be encountered in all subsections. The project would conform to guidelines specified by relevant transportation and building agencies and codes, which would require contractors to assess and account for soil properties, including corrosion potential, during design and construction (GEO-IAMF#10). The design-build contractor would prepare a CMP that would include standard engineering/construction methods to avoid or minimize the impacts of exposure of concrete to corrosive soil during construction (GEO-IAMF#1). The CMP would include methods such as replacing the upper portions of soils that exhibit high corrosion potential with soils that do not and using coated or corrosion-resistant steel or concrete materials during construction. Implementing these features before and during construction activities would avoid increasing exposure of people to loss of life or structures to destruction as a result of corrosive soil. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

CEQA Conclusion

The impact under CEQA would be less than significant because project features would minimize direct and indirect risks to life and property from by limiting exposure to or designing structures for corrosive soils by conforming to guidelines specified by relevant transportation and building agencies and codes such as AREMA, FHWA, Caltrans, and CBC (GEO-IAMF#1 and GEO-IAMF#10). Therefore, CEQA does not require mitigation.

Impact GEO#8: Soil Erosion Impacts from Excavation and Grading

The project would be constructed in areas with potential for soil erosion in all subsections. Potential for erosion is greater for at-grade, embankment, and trench construction than aerial construction because these methods expose potentially erosive material to surface processes.

Some PG&E network upgrades within the Morgan Hill and Gilroy Subsection are located in hillside terrain that may be susceptible to erosion. Soil erosion, including the loss of topsoil, resulting from construction of the project would be minimized through the adoption of BMPs that protect exposed soil. The BMPs would be documented in a CMP and a construction SWPPP (HYD-IAMF#3). Project design includes additional erosion control methods documented in the Caltrans Construction Manuals, and the construction technical memorandum (GEO-IAMF#10). These erosion control methods include soil stabilization through the use of stabilizers, mulches, revegetation, and covering exposed work areas with biodegradable geotextiles (GEO-IAMF#1), watering for dust control; perimeter silt fences; sediment basins, and other site-specific BMPs. Project design also requires the preparation of a technical memorandum describing appropriate design guidelines and standards such as AREMA, FHWA, and Caltrans to be incorporated into facility design and construction (GEO-IAMF#10) to address soil erosion.

Standard construction practices and BMPs would be effective in reducing wind and water erosion potential because they would provide a barrier between exposed soils and erosive forces or lessen the degree of erosive forces. Collectively, these practices require construction contractors to take soil properties into account during construction and reduce the impacts associated with soil erosion by implementing erosion control and sediment containment measures. Implementing these project features before and during construction would avoid substantial soil erosion or the loss to topsoil in a large area that adversely affects the viability of the ecosystem or productivity of farming present in the area. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

CEQA Conclusion

The impact under CEQA would be less than significant because project features involving erosion control would minimize substantial soil erosion or the loss of topsoil that would adversely affect the viability of the ecosystem or productivity of farming (GEO-IAMF#1, GEO-IAMF#10, HYD-IAMF#3). Therefore, CEQA does not require mitigation.

Impact GEO#9: Primary Seismic Hazards during Construction

Surface Fault Rupture

The project intersects five hazardous faults, identified by the SST-FD, in the Morgan Hill and Gilroy, Pacheco Pass, and San Joaquin Valley Subsections (SST-FD 2017). All HSR components including tunnels would be designed for the impacts of earthquakes, including bending moments, shear forces, and displacements resulting from surface fault rupture (GEO-IAMF#7). Prior to construction, the design-build contractor would prepare a CMP that would include design measures and actions to minimize or avoid exposure of people or structures to impacts from surface fault rupture, including worker safety protocols for seismic events that could occur during construction (GEO-IAMF#1). The design measures and actions would conform to relevant guidelines specified by transportation and building agencies and codes (GEO-IAMF#10) requiring contractors to account for seismic hazards during design and construction. Implementation of these design measures and actions during project construction would avoid significantly increasing exposure of people or structures to potential loss of life, injuries, or destruction beyond current exposure to surface fault rupture in the area. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

Seismic Ground Shaking

The project traverses areas with nearby active and potentially active faults (seismic sources) that are considered capable of causing strong ground shaking along the proposed alignment. All HSR components would be designed for the impacts of seismic ground shaking, including bending moments, shear forces, and displacements. The Authority would conduct seismic studies to establish up-to-date seismic ground motions that the contractor would use for design (GEO-IAMF#7). Prior to construction, the design-build contractor would prepare a CMP that would include design measures and actions to minimize or avoid exposure of people or structures to impacts from seismic ground shaking, including worker safety protocols for seismic events that could occur during construction (GEO-IAMF#1). The design measures and actions would conform to relevant guidelines and standards such as AREMA, FHWA, and Caltrans (GEO-IAMF#10). Implementation of design measures and actions during project construction would avoid increasing exposure of people or structures to potential loss of life, injuries, or destruction beyond what they are exposed to currently due to seismic ground shaking. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

CEQA Conclusion

The impact under CEQA would be less than significant because seismic design project features would minimize direct and indirect risks to life and property from surface fault rupture and ground shaking during construction, beyond the level people currently experience in the RSA. These project features include the implementation of a CMP (GEO-IAMF#1), evaluation and design for seismic ground shaking (GEO-IAMF#7) in accordance with guidelines and standards specified by relevant transportation and building agencies such as AREMA, FHWA, and Caltrans (GEO-IAMF#10). Therefore, CEQA does not require mitigation.

Impact GEO#10: Secondary Seismic Hazards during Construction

Exposure to Earthquake-Induced Liquefaction during Construction

The project crosses areas of potential liquefaction in portions of all subsections. This potential exists in areas of high groundwater that are underlain by poorly compacted granular fills or geologically young, loose, alluvial deposits. Project features during construction would include assessing geotechnical conditions and, where necessary, employing ground improvement methods, such as stone columns, deep dynamic compaction, cement deep-soil mixing, jet grouting, or excavating and replacing liquefiable soil with engineered fill. Prior to construction, the design-build contractor would prepare a CMP that would specify the details of how and where these techniques would minimize or avoid exposure of people or structures to impacts from liquefaction (GEO-IAMF#1). Geotechnical conditions would be assessed to determine the extent of the hazard and the most appropriate engineering solutions prior to construction, in accordance with relevant design guidelines and standards such as AREMA, FHWA, and Caltrans (GEO-IAMF#10). Implementation of project features and actions before and during construction would avoid increasing exposure of people or structures to potential loss of life, injuries, or destruction beyond what they are exposed to currently in the area’s environment due to liquefaction. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

Exposure to Lateral Spreading from Earthquake-Induced Liquefaction during Construction

The project crosses limited areas classified as being susceptible to lateral spreading from earthquake-induced liquefaction. Project construction would include assessing geotechnical conditions and, if necessary, employing ground improvement methods, such as stone columns, deep dynamic compaction, cement deep-soil mixing, jet grouting, or excavating and replacing liquefiable soil with engineered fill. Prior to construction, the design-build contractor would prepare a CMP that would specify the details of how and where these techniques would minimize or avoid exposure of people or structures to impacts from lateral spreading (GEO-IAMF#1). Geotechnical conditions would be assessed to determine the extent of the hazard and the most appropriate engineering solutions prior to construction, in accordance with relevant design guidelines and standards such as AREMA, FHWA, and Caltrans (GEO-IAMF#10). Implementation of project features and actions before and during construction would avoid increasing exposure of people or structures to potential loss of life, injuries, or destruction beyond what they are exposed to currently in the area’s environment due to lateral spreading. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

Exposure to Earthquake-Induced Landslides during Construction

The project crosses areas where the risk of earthquake-induced landslides exists. This risk of landslides is limited to areas where the alignment passes on or near steep slopes, such as Communications Hill, Tulare Hill, and mountainous areas near tunnel portions within the Morgan Hill and Gilroy and Pacheco Pass Subsections. Project features would minimize the potential increased risks associated with landslides through implementation of conventional engineering methods to remove or stabilize landslides. Detailed landslide evaluations would be conducted in landslide-prone areas (such as tunnel portal locations) to determine appropriate engineering solutions prior to construction, in accordance with relevant design guidelines and standards such as AREMA, FHWA, and Caltrans (GEO-IAMF#10). Landslide stability would be assessed using the most recently updated Authority seismic design criteria (GEO-IAMF#7). Prior to construction, the design-build contractor would prepare a CMP that would include design measures such as structural solutions (e.g., tie backs, soil nails, retaining walls, debris barriers) or earthwork solutions (e.g., ground improvement, regrading/rebuilding of slopes) to reduce or avoid the hazards associated with earthquake-induced landslides. In the case of elevated structures, the location of the foundation would be sited during final design to avoid future landslides or landslide/debris flow paths to minimize or avoid exposure of people or structures to impacts from earthquake-induced landslides (GEO-IAMF#1). Implementation of project features and actions before and during construction would avoid increasing exposure of people or structures to potential loss of life, injuries, or destruction beyond what they are exposed to currently in the area’s environment due to earthquake-induced landslides**.** The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

Exposure to Earthquake-Induced Flooding during Construction

The project crosses areas with numerous dams located near the alignment, resulting in potential for earthquake-induced flooding from dam failure in all subsections. The earthquake-induced flooding impacts would be addressed with conventional construction safety measures. The design-build contractor would prepare a CMP that would include features to reduce the potential for earthquake-induced flood hazards to cause personal injury, loss of life, and property damage during construction (GEO-IAMF#1). This may include evacuation plans as well as earthquake response training for workers. Conforming to guidelines specified by relevant transportation such as AREMA, FHWA, and Caltrans and building agencies and codes would require contractors to account for drainage patterns and topography during design and construction and thus be able to establish safe evacuation areas for construction workers (GEO-IAMF#10). Implementation of project features and actions before and during construction would avoid increasing exposure of people or structures to potential loss of life, injuries, or destruction beyond what they are exposed to currently in the area’s environment due to earthquake-induced flooding**.** The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives.

CEQA Conclusion

The impact under CEQA would be less than significant because project safety and engineering features would minimize direct and indirect risks to life and property from secondary seismic hazards during construction, beyond the level people currently experience in the RSA. These project features include conforming to guidelines specified by relevant transportation and building agencies, such as AREMA, FHWA, and Caltrans, as well as assessing landslides using the most recently updated Authority seismic design criteria (GEO-IAMF#1, GEO-IAMF#7, and GEO-IAMF#10) including applying geotechnical engineering practices to design and construction. Therefore, CEQA does not require mitigation.

Operations Impacts

Operation of the project would involve scheduled train travel along the HSR line through the Santa Clara Valley to the Central Valley, as well as inspection and maintenance along the track and railroad right-of-way and at stations, and on structures, fencing, power systems, positive train control, and communications. Chapter 2 describes operations and maintenance (O&M) activities in further detail.

Geologic hazard impacts that are minimized during construction and would not change during operations are not discussed under operations impacts.

Impact GEO#11: Regional Ground Subsidence during Operations

Regional subsidence has been documented and could occur along portions of the San Joaquin Valley Subsection during operations. Monitoring and maintenance practices would be used to maintain the integrity of the project if regional subsidence causes ground settlement during project operations. HSR trains would be equipped with autonomous equipment for daily track surveys to monitor for structural deformations caused by ground subsidence. If monitoring indicates that deformations exceed tolerable levels, trains would operate at reduced speed until the track tolerances are restored through maintenance (GEO-IAMF#9). The maintenance measures would conform to engineering guidelines and standards and would include releveling structures by reballasting, hydraulic jacking, resin injection, and various other engineering solutions (GEO-IAMF#10). Implementation of these features would reduce risks to HSR infrastructure, people, and property by ensuring that the HSR guideway is maintained within safe tolerances. As a result of the project features, project operations would not increase exposure of people to loss of life or structures to destruction due to regional ground subsidence. In portions of the project constructed below grade, such as stations, tunnels, trenches, or other facilities, ongoing groundwater management may be necessary. Project features would include conforming to O&M guidelines for groundwater management resulting from design specified by relevant transportation agencies and codes (GEO-IAMF#10). As a result of these features, operations activities would not increase exposure of people to loss of life or structures to destruction as a result of localized dewatering settlement. The project features apply to all project alternatives; there would be no substantial difference in operations impacts between project alternatives.

CEQA Conclusion

The impact under CEQA would be less than significant because project features would minimize direct and indirect risks to life and property from ground subsidence by monitoring and maintaining the integrity of the track during operations (GEO-IAMF#9 and GEO-IAMF#10). Therefore, CEQA does not require mitigation.

Impact GEO#12: Primary Seismic Hazards during Operations

Surface Fault Rupture

The project intersects five hazardous faults, identified by the SST-FD, in the Morgan Hill and Gilroy, Pacheco Pass, and San Joaquin Valley Subsections (SST-FD 2017). HSR components including tunnels would be designed to safely withstand or adapt to earthquakes, including bending moments, shear forces, and displacements resulting from surface fault rupture (GEO-IAMF#7). An earthquake early detection system (EEDS) or similar warning system consisting of a network of instruments in communication with the automatic train control (ATC) system would detect and provide real-time warning of seismic activity (GEO-IAMF#6). During or after an earthquake, the ATC would automatically stop or reduce train speeds. The train system would then be inspected for damage and then returned to service or repaired, if necessary (GEO-IAMF#8). Implementation of these features before and during project operations would avoid significantly increasing exposure of people or structures to potential loss of life, injuries, or destruction beyond current exposure to surface fault rupture in the area. The project features apply to all project alternatives; there would be no substantial difference in operations impacts between project alternatives.

Seismic Ground Shaking

The project traverses areas with nearby active and potentially active faults (seismic sources) that are considered capable of causing strong ground shaking along the proposed alignment. Project components would be designed to safely withstand or adapt to shear forces and displacements caused by seismic ground shaking during project operations (GEO-IAMF#7). The train cars, the spring system for the train cars, and the track design would be configured to resist the resulting inertial response of the train while it is traveling at a high speed. The project would incorporate a ground rupture early warning system, motion sensing instruments, and a train control system to shut down operations during or after a significant earthquake (GEO-IAMF#6 and GEO-IAMF#8). The train system would be inspected for damage and then returned to service or repaired, if necessary (GEO-IAMF#8). Implementation of these features before and during project operations would avoid increasing exposure of people or structures to potential loss of life, injuries, or destruction beyond what they are exposed to currently due to seismic ground shaking. The project features apply to all project alternatives; there would be no substantial difference in operations impacts between project alternatives.

CEQA Conclusion

The impact under CEQA would be less than significant because project engineering design features would minimize direct and indirect risks to life and property from surface fault rupture and ground shaking during operations, beyond the level people currently experience in the RSA.

These project engineering features include using seismic design standards in the structural design (GEO-IAMF#7), use of early warning systems that would be triggered by strong ground motion (GEO-IAMF#6), and shutting down train operations during or after an earthquake (GEO-IAMF#8). Therefore, CEQA does not require mitigation.

Secondary Seismic Hazards

Impact GEO#13: Secondary Seismic Hazards during Operations

Exposure to Earthquake-Induced Liquefaction during Operations

The project crosses areas of potential liquefaction in portions of all subsections. This potential exists in areas of high groundwater that are underlain by poorly compacted granular fills or geologically young, loose, alluvial deposits. Liquefiable soils would be characterized, and if necessary improved or removed during construction, avoiding the likelihood of differential movement of the tracks during operations (GEO-IAMF#1). This characterization and design would minimize ground deformation caused by liquefaction. As a result of the project features implemented during construction, operations would not increase exposure of people or structures to potential loss of life, injuries, or destruction beyond what they are exposed to currently in the area’s environment due to liquefaction. The project features apply to all project alternatives; there would be no substantial difference in operations impacts between project alternatives.

Exposure to Lateral Spreading from Earthquake-Induced Liquefaction during Operations

The project crosses limited areas classified as being susceptible to lateral spreading from liquefaction. Liquefiable soils would be characterized, and if necessary improved or removed during construction, minimizing exposure to ground deformation caused by lateral spreading (GEO-IAMF#1). As a result of the characterization and project features implemented during construction, operations would not increase exposure of people or structures to potential loss of life, injuries, or destruction beyond what they are exposed to currently in the area’s environment due to lateral spreading. The project features apply to all project alternatives; there would be no substantial difference in operations impacts between project alternatives.

Exposure to Earthquake-Induced Landslides during Operations

The project crosses areas where the risk of earthquake-induced landslides exists. This risk of landslides is limited to areas where the alignment passes on or near steep slopes, such as Communications Hill, Tulare Hill, and mountainous areas near tunnel portions within the Morgan Hill and Gilroy and Pacheco Pass Subsections. Project features to stabilize landslides during construction would also minimize exposure to potential risks from earthquake-induced landslides during project operations. In addition, the Authority would incorporate slope monitoring by a state-registered engineering geologist into the O&M procedures to promote the long-term stability of slopes near the project (GEO-IAMF#2). Implementing these project features before and during operations would avoid increasing exposure of people or structures to potential loss of life, injuries, or destruction beyond what they are exposed to currently in the area’s environment due to earthquake-induced landslides. The project features apply to all project alternatives; there would be no substantial difference in operations impacts between project alternatives.

Exposure to Earthquake-Induced Flooding during Operations

The project crosses areas with numerous dams located near the alignment, resulting in potential for earthquake-induced flooding from dam failure in all subsections. The impacts resulting from earthquake-induced flood inundation would be addressed with conventional construction safety measures such as developing evacuation routes during construction. An EEDS or similar warning system that detects ground motion would be integrated with the ATC system such that all trains in an area would be autonomously brought to an emergency stop or train speeds would be reduced during or after significant ground shaking. The train system would then be inspected for damage and then returned to service or repaired, if necessary (GEO-IAMF#6). Implementing these project features before and during operation would avoid increasing exposure of people or structures to potential loss of life, injuries, or destruction beyond what they are exposed to currently due to earthquake-induced flooding. The project features apply to all project alternatives; there would be no substantial difference in operations impacts between project alternatives.

CEQA Conclusion

The impact under CEQA would be less than significant because project safety and engineering features would minimize direct and indirect risks to life and property from secondary seismic hazards , beyond the level people currently experience in the RSA, during operations (GEO-IAMF#1), as well as requiring long-term monitoring and maintenance (GEO-IAMF#2 and GEO-IAMF#6). Therefore, CEQA does not require mitigation.

3.9.6.3 Paleontological Resources

Construction of the project alternatives would result in impacts on paleontological resources. The primary mechanism for adverse impacts on paleontological resources is ground disturbance (earthwork), which would result in destruction of paleontological resources contained within geologic units. Table 3.9-9 shows the distribution of geologic units by subsection within the paleontological resources RSA, and Appendix A of the Paleontological Resources Technical Report includes geologic and paleontological sensitivity maps (Authority 2019b). This section describes the potential direct impacts of project construction on paleontologically sensitive geologic units and on paleontological resources for each alternative. Earthwork affecting these geologic units would thus have the potential to destroy significant (i.e., scientifically important) paleontological resources. Once lost, such resources cannot be recovered; impacts are therefore considered permanent. No indirect impacts (i.e., loss of resources to theft and vandalism resulting from increased public access to paleontologically sensitive areas) on paleontological resources are anticipated because increased public access would be greatest near the stations, which are located in existing populated and developed areas where paleontological sensitivity is generally restricted to the subsurface sediments at varying depths beneath the previously disturbed surface sediments. In addition, all of the paleontologically sensitive geologic units exposed at the surface elsewhere within the project footprints are currently accessible to the public by existing interstates, highways, and local roads. Therefore, indirect impacts are not discussed in this section.

HSR construction activities in the western portion of the alignment (i.e., portions of the San Jose Diridon Station Approach Subsection) that use existing railroad right-of-way (see Chapter 2) and would not require modifications involving ground disturbance (e.g., trenching, tunneling, drilling, grading) have no potential to affect paleontological resources. Additionally, much of the existing ground surface in the San Jose portion of the alignment has been disturbed by previous development to varying depths. Therefore, shallow excavations in these areas, particularly within the San Jose Diridon Station Approach, Monterey Corridor, and westernmost Morgan Hill and Gilroy Subsections are also not anticipated to affect previously undisturbed paleontological resources.

In general, deeper excavations have the potential to affect paleontological resources if native sediments belonging to the Knoxville Formation, Panoche Formation, Moreno Formation, unnamed clay shale and claystone unit, Monterey Formation, Santa Clara Formation, Modesto Formation, or older Quaternary deposits are encountered at the surface or in the subsurface. Excavation activities that may result in direct impacts on paleontologically sensitive geologic units include earthwork related to road modifications, utility installation/relocation, PG&E electrical interconnections and network upgrades, track construction and modifications, station construction and modifications, grade separations, tunnels, viaducts, and new structure construction.

No Project Impacts

As discussed in Section 3.18, the human population in the paleontological resources RSA is expected to grow through 2040. Development in the region to accommodate the population and employment increase would continue under the No Project Alternative. Section 3.19 identifies planned and other reasonably foreseeable future projects anticipated to be constructed in the region to accommodate projected growth, including shopping centers, industrial parks, transportation projects, and residential developments.

The No Project Alternative considers the impacts of conditions forecast by current plans for land use and transportation in the vicinity of the project, including planned improvements to the highway, aviation, conventional passenger rail, freight rail, and port systems through the 2040 planning horizon for the environmental analysis if the project is not built. With no project, there would be a greater number of vehicles miles traveled, resulting in increased pressure to improve capacity for all transportation modes throughout the area. The Authority estimates that additional highway and airport projects (up to 4,300 highway lane miles, 115 airport gates, and 4 airport runways) would be planned and constructed to achieve equivalent capacity and relieve this increased pressure (Authority 2012).

Under the No Project Alternative, recent development trends are anticipated to continue. Existing land would be converted for residential, commercial, and industrial development, as well as transportation infrastructure, to accommodate growth. Where future projects involve paleontologically sensitive geologic units, ground disturbance could result in the loss of significant paleontological resources and associated loss of scientific information. To the extent that ongoing infrastructure and other operations would involve ground disturbance, such operations would also have the potential to result in the loss of significant paleontological resources and the loss of scientific information. Depending on the extent of the loss, impacts could be significant. However, these projects would be subject to review under CEQA, NEPA, or both, and subsequent paleontological mitigation to reduce impacts.

Project Impacts

Construction Impacts

Construction of the project alternatives would include road modifications, utility installation/relocation, PG&E electrical interconnections and network upgrades, track construction and modifications, station construction and modifications, grade separations, tunnels, viaducts, and new structure construction. Chapter 2 describes construction activities in more detail.

Impact GEO#14: Destruction of Paleontological Resources during Construction

Ground-disturbing activities conducted during construction of the project could affect geologic units identified as having high or undetermined paleontological potential including:

- Older Quaternary alluvium at depth within the San Jose Diridon Station Approach Subsection
- Santa Clara Formation and older Quaternary alluvium at depth within the Monterey Corridor Subsection
- Knoxville Formation, Panoche Formation, unnamed clay shale and claystone unit, Santa Clara Formation, and older Quaternary alluvium at the surface and Knoxville Formation, Panoche Formation, unnamed clay shale and claystone unit, Monterey Formation, Santa Clara Formation and older Quaternary alluvium at depth within the Morgan Hill and Gilroy Subsection
- Panoche Formation, Moreno Formation, and older Quaternary alluvium at the surface and at depth within the Pacheco Pass Subsection
- Modesto Formation at the surface and Modesto Formation and older Quaternary alluvium at depth within the San Joaquin Valley Subsection

Portions of the alignments that use existing tracks and would not require modifications involving ground disturbance (e.g., trenching, tunneling, drilling, grading) have no potential to affect paleontological resources. Additionally, much of the existing ground surface in the San Jose portion of the alignment has been disturbed by previous development to varying depths. Therefore, shallow excavations in these areas, particularly within the San Jose Diridon Station Approach, Monterey Corridor, and westernmost Morgan Hill and Gilroy Subsections are not anticipated to affect paleontological resources.

Deeper excavations have the potential to affect paleontological resources if native sediments belonging to the Knoxville Formation, Panoche Formation, Moreno Formation, Monterey

Formation, Santa Clara Formation, Modesto Formation, or older Quaternary deposits are encountered in either the surface or subsurface. Excavation activities that may result in direct impacts on paleontologically sensitive geologic units include earthwork related to road modifications, utility installation/relocation, PG&E electrical interconnections and network upgrades, track construction and modifications, station construction and modifications, grade separations, tunnels, viaducts, and new structure construction.

Excavations that extend deep enough to encounter paleontologically sensitive geologic units underlying areas mapped as low-potential younger alluvium have the potential to result in impacts on paleontological resources. Surficial activities such as vegetation removal and staging generally do not extend deep enough to affect paleontologically sensitive geologic units.

To minimize loss of scientifically important paleontological resources during construction, the contractor would designate a PRS to be responsible for determining where and when to conduct paleontological resources monitoring prior to any ground-disturbing activities (GEO-IAMF#11) based on the results of a final design review (GEO-IAMF#12). The PRS would supervise paleontological resources monitors (PRM) who meet or exceed the qualifications for a paleontological monitor as defined in the Caltrans Standard Environmental Reference, Chapter 8 (Caltrans 2017), and would determine the location and duration of their monitoring in accordance with the PRMMP (GEO-IAMF#13). The PRS would be responsible for developing a WEAP training (GEO-IAMF#14), which all management and supervisory personnel and construction workers involved with ground-disturbing activities would be required to take before beginning work on the project. The PRS would be notified immediately if fossil materials are found during construction and would determine the proper treatment (i.e., recovery and documentation of unearthed fossils) (GEO-IAMF#15).

During construction, paleontological resources monitoring would be restricted to those construction-related activities that would result in the disturbance of paleontologically sensitive geologic units, as defined in the PRMMP (GEO-IAMF#13). The PRS would prepare and implement a PRMMP, which would define the location and duration of the monitoring effort. The PRMMP would include pre-construction and construction-period coordination procedures and communications protocol; evaluation as to whether a pre-construction survey is warranted; requirements for paleontological monitoring; provisions for the development and implementation of a paleontological resources WEAP; provisions for in-progress documentation of monitoring; provisions for a “stop work, evaluate, and treat appropriately” response in the event of a paleontological discovery; provisions for sampling and recovery of unearthed fossils; provisions for acquiring a repository agreement from an approved regional repository; provisions for preparation of a final monitoring and mitigation report; and provisions for the preparation, identification, analysis, and curation of fossil specimens and data recovered. The PRMMP would be consistent with SVP guidelines for mitigating construction impacts on paleontological resources. The PRMMP would also be consistent with the SVP (1996) conditions for receivership of paleontological salvage collections (GEO-IAMF#13).

If fossil materials are discovered during construction, regardless of the individual making the discovery (e.g., PRS, PRM, or construction personnel), construction activity in the immediate vicinity of the discovery would halt and the find would be protected from further disturbance. Both the PRMMP and the WEAP training would clearly specify this requirement. Construction activity may continue elsewhere, as long as the find can be adequately protected in the judgment of the PRS. If someone other than a PRM or the PRS makes the discovery, the PRS would immediately be notified to evaluate the find (GEO-IAMF#15).

Alternatives 1, 2, 3, and 4 would affect the same paleontologically sensitive geologic units because the project alternatives follow similar alignments. The overall construction process would be similar under the four project alternatives, resulting in a similar potential for impacts on paleontological resources during ground-disturbance activities. Earthwork affecting these geologic units, classified with a high or undetermined potential to produce significant paleontological resources, would thus have the potential to destroy significant (i.e., scientifically important) paleontological resources. Once lost, such resources cannot be recovered; effects are therefore considered permanent.

Alternative 4 would have the potential to result in fewer effects on paleontological resources than Alternatives 1, 2, or 3 because it would use a blended, at-grade profile in the San Jose Diridon Station Approach, Monterey Corridor, and Morgan Hill and Gilroy Subsections, which would involve substantially less excavation than the viaducts and embankments proposed in these subsections under the other project alternatives. Viaduct elements under Alternatives 1 and 3 would potentially affect a greater number of paleontological resources at depth than the embankment elements under Alternative 2 because of excavation required for viaduct foundations. Viaduct elements under Alternative 1 would result in more ground disturbance in sensitive geologic units in the Morgan Hill and Gilroy Subsection than Alternative 3 as it traverses to east Gilroy. All four project alternatives would be the same in the Pacheco Pass and San Joaquin Valley Subsections. The potential for impacts would increase as the extent of disturbance increases, because fossils are usually found during excavation activities and the chance of finding fossils increases if a large volume of a paleontologically sensitive geologic unit is being exposed. However, even activity that is limited in extent could have the potential to result in the loss of scientifically important paleontological resources. However, project features include provisions for avoiding or minimizing loss of scientifically important paleontological resources in areas of high paleontological potential.

CEQA Conclusion

The impact would be less than significant under CEQA because the project would include design features that would require identification and salvage of fossils prior to and during construction. The contractor would designate a PRS for the project (approved by the Authority) who would be responsible for determining the location and duration of paleontological resources monitoring and developing and implementing a PRMMP (GEO-IAMF#11). The PRS would evaluate the 90 percent design submittal to identify areas that would involve work in paleontologically sensitive geologic units (GEO-IAMF#12). Paleontological resources monitoring would be restricted to those construction-related activities that would result in the disturbance of paleontologically sensitive geologic units (GEO-IAMF#13). Construction activity in the immediate vicinity of a paleontological discovery would halt in order to minimize the potential for impacts (GEO-IAMF#15). The paleontological resources WEAP training would be provided to personnel prior to beginning work on the project (GEO-IAMF#14). These project features would minimize the potential for ground disturbance to directly or indirectly destroy a unique paleontological resource or site or unique geologic feature. Therefore, CEQA does not require mitigation.

Impact GEO#15: Destruction of Paleontological Resources during Operations

Operations would include inspection and maintenance along the track and railroad right-of-way, as well as on the structures, fencing, power system, train control, and communications. Chapter 2 describes O&M activities. Ground disturbance associated with these activities would be minimal and likely would occur within areas of previous disturbance for all four project alternatives.

CEQA Conclusion

During operations there would be no impact under CEQA for any of the four project alternatives. Therefore, CEQA does not require mitigation.

3.9.7 Mitigation Measures

There would be no significant impacts on geology, soils, seismicity, or paleontological resources under CEQA under any of the project alternatives. No mitigation measures are required.

3.9.8 Impact Summary for NEPA Comparison of Alternatives

As described in Section 3.9.4, Methods for Evaluating Impacts, the impacts of project actions under NEPA are compared to the No Project condition when evaluating the impact of the project on the resource. The determination of impact is based on the context and intensity of the change that would be generated by the project alternatives. Table 3.9-10 compares the project impacts by alternative, followed by a summary of the impacts.

Table 3.9-10 Comparison of Project Alternative Impacts for Geology, Soils, Seismicity, and Paleontological Resources

Impacts	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Geology, Soils, and Seismicity				
Impact GEO#1: Construction in Unstable Soils	Project features would minimize direct and indirect risks to life and property from differential ground movement caused by ground subsidence, collapsible soil, landslides, soft soil by conducting site condition assessments, subsidence monitoring, controlling groundwater withdrawal, and implementing geotechnical engineering practices in accordance with relevant design guidelines and standards such as AREMA, FHWA, and Caltrans. A CMP would also be developed to specify how and where these techniques would be implemented.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Impact GEO#2: Inadvertent Disturbance of Naturally Occurring Asbestos during Construction	Project features would minimize direct and indirect risks caused by exposure of construction workers to NOA by conforming with regulatory requirements for construction and grading operations in areas with NOA and employing measures to reduce the potential for NOA to become airborne during ground-disturbing activities and by proper testing and disposal of excavated material that may contain NOA. A CMP would also be developed to specify how and where these techniques would be implemented.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Impacts	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Impact GEO#3: Exposure to In-Situ Gas	Project features would minimize direct and indirect risks to life and property from exposure inhalation or explosion of hazardous in-situ gas by conforming with OSHA regulatory requirements for excavations, installing gas monitoring, collecting, and ventilating systems, and using of explosion-proof equipment. A CMP would also be developed to specify how and where these techniques would be implemented.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Impact GEO#4: Tunneling in Areas with Sheared or Weak Bedrock	Project features would minimize direct and indirect risks to life and property from unstable sheared or weak bedrock by assessing geotechnical conditions prior to construction, using tunneling techniques to safely tunnel when crushing and squeezing conditions are expected, and reinforcing tunnels to handle external stresses. A CMP would also be developed to specify how and where these techniques would be implemented.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Impact GEO#5: Construction on Expansive Soil	Project features would assess soil conditions and treat expansive soils through appropriate engineering measures, thereby minimizing direct and indirect risks to life and property from differential ground movement caused by expansive soil. Engineering measures would include treatment with soil additives to reduce shrink-swell potential or excavation and replacement in accordance with relevant guidelines and standards such as AREMA, FHWA, and Caltrans. A CMP would also be developed to specify how and where these techniques would be implemented.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Impacts	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Impact GEO#6 Excavating in Areas with Shallow Bedrock or Shallow Groundwater	Project features would minimize direct and indirect risks to life and property by conforming with geotechnical guidelines and standards such as AREMA, FHWA, and Caltrans, undertaking geotechnical investigations so that contractor would use safe equipment and techniques, and developing a CMP pertaining to excavations, shallow bedrock, and groundwater conditions.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Impact GEO#7: Exposure of Concrete and Steel to Corrosive Soils	Project features would minimize direct and indirect risks to life and property from corrosive soils by conforming to guidelines specified by relevant transportation and building codes such as AREMA, FHWA, Caltrans, and CBC. and developing a CMP that would include standard engineering and construction methods to avoid or minimize the impacts of corrosive soil during construction.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Impact GEO#8: Excavation and Grading Impacts on Soil Erosion	Project features would minimize substantial soil erosion or the loss of topsoil that would adversely affect the viability of the ecosystem or productivity of farming through the adoption of BMPs that protect exposed soil, include soil stabilization through the use of stabilizers, mulches, revegetation, and covering exposed work areas with biodegradable geotextiles.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Impacts	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Impact GEO#9: Primary Seismic Hazards during Construction	Project features would minimize direct and indirect risks to life and property from surface fault rupture and ground shaking during construction. All HSR components would be designed for the impacts of earthquakes and seismic ground shaking. Project features include seismic studies, the implementation of a CMP that would include design measures to minimize or avoid exposure of people or structures to impacts, including worker safety protocols for seismic events that could occur during construction, and compliance with guidelines and standards such as AREMA, FHWA, Caltrans, and CBC.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Impact GEO#10: Secondary Seismic Hazards during Construction	Project features would minimize direct and indirect risks to life and property resulting from ground deformation from secondary seismic hazards during construction. These project features include conforming to guidelines specified by relevant transportation and building agencies including assessing geotechnical conditions prior to construction and applying geotechnical engineering practices such as ground improvement and foundation design as well as applying construction safety measures like evacuation plans. A CMP would also be developed to specify how and where these practices and measures would be implemented.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Impact GEO#11: Regional Ground Subsidence during Operations	Project features would minimize direct and indirect risks to life and property from differential ground movement resulting from ground subsidence by monitoring and maintaining the integrity of the track during operations.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Impacts	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Impact GEO#12: Primary Seismic Hazards during Operations	Project features would minimize direct and indirect risks to life and property from surface fault rupture and ground shaking during operations. These project features include using seismic design standards in the structural design, use of early warning systems that would be triggered by strong ground motion, and shutting down train operations during or after an earthquake.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1
Impact GEO#13: Secondary Seismic Hazards during Operations	Project features would minimize direct and indirect risks to life and property resulting from ground deformation from secondary seismic hazards during operations. These project features include conforming to design guidelines specified by relevant transportation and building agencies such as AREMA, FHWA, and Caltrans, as well as long-term monitoring and maintenance.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

Impacts	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Paleontological Resources				
Impact GEO#14: Destruction of Paleontological Resources during Construction	Construction of the project could affect eight geologic units identified as having high or undetermined paleontological potential. Excavation that extends deep enough to encounter sensitive geologic units underlying areas mapped as low-potential younger alluvium have the potential to result in impacts on paleontological resources. Alternative 1 would result in more ground disturbance in paleontologically sensitive geologic units in the Morgan Hill and Gilroy Subsection than Alternative 2 and Alternative 3 as it traverses to east Gilroy. Viaduct and embankment elements under Alternative 1 include more ground disturbance in paleontologically sensitive geologic units than Alternative 4 in the San Jose Diridon Station Approach, Monterey Corridor, and Morgan Hill and Gilroy Subsections.	Alternative 2 would have the potential to result in fewer impacts on paleontological resources than Alternatives 1 or 3 because it would use an embankment from Bernal Way to downtown Gilroy, which would involve substantially less excavation than Alternatives 1 and 3. Viaduct and embankment elements under Alternative 2 include more ground disturbance in paleontologically sensitive geologic units than Alternative 4 in the San Jose Diridon Station Approach, Monterey Corridor, and Morgan Hill and Gilroy Subsections.	Viaduct elements in Alternative 3 would result in less ground disturbance in paleontologically sensitive geologic units in the Morgan Hill and Gilroy Subsection than viaduct elements in Alternative 1, but would have more ground disturbance than the embankment under Alternative 2. Viaduct and embankment elements under Alternative 3 also include more ground disturbance in paleontologically sensitive geologic units than Alternative 4 in the San Jose Diridon Station Approach, Monterey Corridor, and Morgan Hill and Gilroy Subsections.	Alternative 4 would result in less ground disturbance in paleontologically sensitive geologic units than Alternatives 1, 2, or 3 because it would use a blended, at-grade profile in the San Jose Diridon Station Approach, Monterey Corridor, and Morgan Hill and Gilroy Subsections, which would involve substantially less excavation than the viaducts and embankments proposed under the other alternatives.
Impact GEO#15: Destruction of Paleontological Resources during Operations	Operation of the project would not affect geologic units identified as having high or undetermined paleontological potential.	Same as Alternative 1	Same as Alternative 1	Same as Alternative 1

AREMA = American Railway Engineering and Maintenance-of-Way Association
FHWA = Federal Highway Administration
Caltrans = California Department of Transportation
CMP = construction management plan
NOA = naturally occurring asbestos
OSHA = Occupational Safety and Health Administration
CBC = California Building Code
BMP = best management practice
HSR = high-speed rail

Prior to construction, the design-build contractor would prepare a CMP that would specify the details of how and where these techniques would minimize or avoid exposure of people or structures to effects from unstable soils (GEO-IAMF#1). Geotechnical conditions would be assessed to determine the extent of the hazard and the most appropriate engineering solutions such as earthwork techniques and foundation design, in accordance with relevant design guidelines and standards such as AREMA, FHWA, and Caltrans (GEO-IAMF#10). As a result of these project features, construction activities would not render soil unstable to a degree that it would increase exposure of people to loss of life or structures to destruction as a result of settlement. The project features include geotechnical characterization, ground improvement (if necessary), subsidence monitoring, and removal of unstable soil; there would be no substantial difference in construction effects between project alternatives. Because project features would address unstable soils during construction, the project would not increase exposure to this geologic hazard during operations under any of the project alternatives.

The Authority would assess site conditions to determine appropriate engineering solutions to landslide-prone areas prior to construction, in accordance with relevant design guidelines and standards such as AREMA, FHWA, and Caltrans (GEO-IAMF#10). The design-build contractor would prepare a CMP that would include design measures, such as structural solutions (e.g., tie backs, soil nails, retaining walls, debris barriers) or earthwork solutions (e.g., ground improvement, regrading/rebuilding of slopes), to stabilize landslides. In the case of elevated structures, the location of the foundation would be sited during final design to avoid landslides or landslide/debris flow paths to minimize or avoid exposure of people or structures to effects from landslides (GEO-IAMF#1). As a result of the project features, construction would not render landslides unstable to a degree that it would increase exposure of people to loss of life or structures to destruction. Because project features would address landslide-prone areas during construction, the project would not increase exposure to this geologic hazard during operations under any of the project alternatives.

Prior to construction, the design-build contractor would prepare a CMP that would minimize or avoid exposure of people to effects from NOA (GEO-IAMF#5). The potential for workers to encounter NOA would be reduced or eliminated by following CARB regulatory requirements for construction and grading operations in areas with NOA. The Authority would employ dust control to reduce the potential for NOA to become airborne during ground-disturbing activities and by proper testing and disposal of excavated material that may contain NOA to reduce the risk of exposure of construction workers. As a result of the project features, construction activities would not increase exposure of people to loss of life as a result of inhalation of NOA. Because project features would address NOA during construction, the project would not increase exposure of riders to this geologic hazard during operations under any of the project alternatives.

Project features would minimize the risk of exposure to in-situ gas by using safe and explosion-proof equipment during construction, testing and monitoring for gases on a regular basis, and installing passive or active gas venting systems where subsurface gases are present. Prior to construction, the design-build contractor would prepare a CMP that would specify the details of how and where these techniques would minimize or avoid exposure of people or property to impacts from in-situ gas (GEO-IAMF#1). The potential for workers to encounter hazardous in-situ gas would be reduced or eliminated by following strict federal and state OSHA regulatory requirements and by consulting with other agencies as appropriate, such as the Department of Conservation (DOGGR), California Environmental Protection Agency, and Department of Toxic Substances Control, regarding known areas of concern (GEO-IAMF#3). As a result of these features, project construction would not increase exposure of people to loss of life or property to destruction as a result of inhalation or detonation of in-situ gas. Because project features would address in-situ gas during construction and the Authority would test and monitor for gases on a regular basis (GEO-IAMF#3), the project would not increase exposure of riders to this geologic hazard during operations under any of the project alternatives.

The design-build contractor would prepare a CMP that would include design measures to minimize or avoid exposure of people or structures to effects from sheared or weak bedrock (GEO-IAMF#1). This would include switching to safer or more efficient tunneling methods when crushing and squeezing conditions are expected. Conforming to guidelines specified by relevant transportation and building agencies and codes such as AREMA, FHWA, Caltrans, and CBC would require Authority contractors to account for sheared or weak bedrock during design and construction (GEO-IAMF#10). The contractor would have site-specific geotechnical data prior to construction that would permit the contractor to anticipate the location of sheared or weak bedrock prior to tunneling and have the appropriate equipment and procedures in place to safely address these conditions. As a result of the project features, construction would not increase exposure of people to loss of life or property to destruction as a result of sheared or weak bedrock. Because project features would address sheared and weak bedrock during construction, the project would not increase exposure of riders to this geologic hazard during operations under any of the project alternatives.

Prior to construction, the design-build contractor would prepare a CMP that would specify the details of how and where these techniques would be implemented to minimize or avoid exposure of people or structures to impacts from expansive soil (GEO-IAMF#1). Implementing these features before and during construction activities would avoid increasing exposure of people to loss of life or structures to destruction as a result of expansive soil. The project features that include the treatment or removal of expansive soil apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives. These features would minimize or avoid the potential for expansive soil to cause differential movement of the track system by treating expansive soils with additives, such as cement or lime, to reduce the shrink-swell potential or excavating and replacing expansive soil with non-expansive soil.

The design-build contractor would prepare a CMP that would include design measures to minimize or avoid exposure of people or structures to effects from shallow bedrock and groundwater (GEO-IAMF#1). The contractor would develop safety procedures and guidelines for the use of potentially dangerous excavation methods and equipment. Conforming to guidelines specified by relevant transportation and building agencies and codes such as AREMA, FHWA, Caltrans, and CBC would require Authority contractors to account for soil and geotechnical properties during design and construction and thus minimize or avoid risks associated with shallow bedrock and shallow groundwater (GEO-IAMF#10). Geotechnical investigations would help to identify the areas where potentially difficult-to-excavate rock would be encountered so that contractor would use safe equipment and methods. The contractors may use temporary dewatering with deep groundwater wells and well points that lower the water level; sheet pile wall systems to stabilize the soil; or techniques such as jet grouting and cement deep-soil mixing techniques that add cement to the soil, thereby providing a cement-soil mix that resists hydrostatic forces. As a result of the project features, construction would not increase exposure of people to loss of life or property to destruction as a result of shallow bedrock or groundwater. Because project features would address shallow bedrock and groundwater during construction, the project would not increase exposure of riders to this geologic hazard during operations under any of the project alternatives. The project features apply to all project alternatives; there would be no substantial difference in impacts between project alternatives.

The Authority would conform to guidelines specified by relevant transportation and building agencies and codes such as AREMA, FHWA, Caltrans, and CBC, which would require contractors to assess and account for soil properties, including corrosion potential, during design and construction (GEO-IAMF#10). The design-build contractor would prepare a CMP that would include standard engineering/construction methods to avoid or minimize the impacts of corrosive soil during construction (GEO-IAMF#1). The CMP would include methods such as, replacing the upper portions of soils that exhibit high corrosion potential with soils that do not and using coated or corrosion-resistant steel or concrete materials during construction. As a result of these features, construction activities would not increase exposure of people to loss of life or structures to destruction as a result of corrosive soil. The project features apply to all project alternatives; there would be no substantial difference in construction impacts between project alternatives. Because project features would address corrosive soil during construction, the project would not increase exposure of riders to this geologic hazard during operations under any of the project alternatives. The project features apply to all project alternatives; there would be no substantial difference in impacts between project alternatives.

Project features would minimize soil erosion, including the loss of topsoil, resulting from construction of the project through the adoption of BMPs that protect exposed soil. The BMPs would be documented in a CMP and a SWPPP (HYD-IAMF#3). Standard construction practices and BMPs would be effective in reducing wind and water erosion potential because they would provide a barrier between exposed soils and erosive forces or lessen the degree of erosive forces. Collectively, these practices require construction contractors to take soil properties into account during construction and reduce the impacts associated with soil erosion by implementing erosion control and sediment containment measures. As a result of these project features, construction would not result in substantial soil erosion or the loss of topsoil that adversely affects the viability of the ecosystem or productivity of farming present in the area. The project features apply to all project alternatives; there would be no substantial difference in impacts between project alternatives.

Prior to construction, the design-build contractor would prepare a CMP that would include design measures to minimize or avoid exposure of people or structures to impacts from surface fault rupture, including where the project crosses the Ortigalita fault (Tunnel 1), including worker safety protocols for seismic events that could occur during construction (GEO-IAMF#1). The design measures would conform to relevant guidelines specified by transportation and building agencies and codes such as AREMA, FHWA, Caltrans, and CBC (GEO-IAMF#10) requiring contractors to account for seismic hazards during design and construction. All HSR components would be designed for the impacts of earthquakes, including bending moments, shear forces, and displacements resulting from surface fault rupture and seismic ground shaking (GEO-IAMF#7). The Authority would install an EEDS and an ATC system would detect and provide real-time warning of seismic activity (GEO-IAMF#6). During or after an earthquake, the ATC would automatically stop or reduce train speeds. The train system would then be inspected for damage and then returned to service or repaired, if necessary (GEO-IAMF#8). Project construction and operations would not increase exposure of people or structures to potential loss of life, injuries, or structural destruction beyond current exposure to surface fault rupture in the area. The project features apply to all project alternatives; there would be no substantial difference in impacts between project alternatives.

The project would assess geotechnical conditions and employ ground improvement methods, such as stone columns, deep dynamic compaction, cement deep-soil mixing, jet grouting, or excavating and replacing liquefiable soil with engineered fill. Prior to construction, the design-build contractor would prepare a CMP that would specify the details of how and where these techniques would minimize or avoid exposure of people or structures to impacts from liquefaction (GEO-IAMF#1). Geotechnical conditions would be assessed to determine the extent of the hazard and the most appropriate engineering solutions prior to construction, in accordance with relevant design guidelines and standards such as AREMA, FHWA, Caltrans, and CBC (GEO-IAMF#10). These project features would reduce exposure to secondary seismic hazards, such as liquefaction and spreading, earthquake-induced landslides or slumps, and earthquake-induced flooding during construction. Because project features would address liquefaction, spreading, and earthquake-induced landslides during construction, the project would not increase exposure of riders to this geologic hazard during operations under any of the project alternatives. Additionally, an EEDS or similar warning system that detects ground motion would be integrated with the ATC system such that all trains in an area would be autonomously brought to an emergency stop or train speeds would be reduced during or after significant ground shaking. The train system would then be inspected for damage and then returned to service or repaired, if necessary (GEO-IAMF#6). Project operation would not increase exposure of people or structures to potential loss of life, injuries, or destruction beyond what they are exposed to currently due to earthquake-induced flooding**.** The project features apply to all project alternatives; there would be no substantial difference in impacts between project alternatives.

Project features would address paleontological resources monitoring and mitigation; discovery procedures; halting construction when paleontological resources are found; and training (GEO-

IAMF#11, GEO-IAMF#12, GEO-IAMF#13, GEO-IAMF#14, and GEO-IAMF#15). Alternatives 1, 2, 3, and 4 would affect the same paleontologically sensitive geologic units and the overall construction process and O&M activities would be very similar under the four project alternatives, resulting in similar potential for impacts on paleontological resources during ground-disturbing activities. Alternative 4 would have the potential to result in fewer impacts on paleontological resources than Alternatives 1, 2, or 3 because it would use a blended, at-grade profile in the San Jose Diridon Station Approach, Monterey Corridor, and Morgan Hill and Gilroy Subsections, which would involve substantially less excavation than the viaducts and embankments proposed in these subsections under the other project alternatives. Alternative 2 would have the potential to result in fewer impacts on paleontological resources than Alternatives 1 or 3 because it would use an embankment from Bernal Way to downtown Gilroy, which would involve substantially less excavation than the viaducts proposed under Alternatives 1 and 3. Alternative 1 would result in more ground disturbance in sensitive geologic units in the Morgan Hill and Gilroy Subsection than Alternative 2 and Alternative 3 as it traverses to east Gilroy.

3.9.9 CEQA Significance Conclusions

As described in Section 3.9.4, the impacts of project actions under CEQA are evaluated against thresholds to determine whether a project action would result in no impact, a less-than-significant impact, or a significant impact. Table 3.9-11 identifies the CEQA significance determinations for each impact discussed in Section 3.9.6. All impacts were determined to be less than significant for all project alternatives.

Table 3.9-11 CEQA Significance Conclusions and Mitigation Measures for Geology, Soils, Seismicity, and Paleontological Resources

Impact	Impact Description and CEQA Level of Significance before Mitigation	Mitigation Measure	CEQA Level of Significance after Mitigation
Geology, Soils, and Seismicity			
Impact GEO#1: Construction in Unstable Soils	Less than significant for all project alternatives: Project features would minimize direct and indirect risks to life and property from ground subsidence, collapsible soil, landslides, and soft soil by assessing soil conditions prior to construction, conducting subsidence monitoring, controlling groundwater withdrawal, and implementing geotechnical engineering practices in accordance with relevant design guidelines and standards such as AREMA, FHWA, and Caltrans.	No mitigation measures are required	N/A
Impact GEO#2: Inadvertent Disturbance of Naturally Occurring Asbestos during Construction	Less than significant for all project alternatives: Project features would minimize the direct and indirect adverse effects caused by exposure to NOA during construction by following state regulatory requirements for employing dust control, and by proper testing and disposal of excavated material.	No mitigation measures are required	N/A

Impact	Impact Description and CEQA Level of Significance before Mitigation	Mitigation Measure	CEQA Level of Significance after Mitigation
Impact GEO#3: Exposure to In-Situ Gas	Less than significant for all project alternatives: Project features would minimize direct and indirect risks to life and property from exposure to in-situ gas by conforming with OSHA regulatory requirements for excavations, such as installing gas monitoring, collecting, and ventilating systems, and using explosion-proof equipment.	No mitigation measures are required	N/A
Impact GEO#4: Tunneling in Areas with Sheared or Weak Bedrock	Less than significant for all project alternatives: Project features would minimize direct and indirect risks to life and property from sheared or weak bedrock by assessing geotechnical conditions prior to construction, using tunneling techniques to safely tunnel when crushing and squeezing conditions are expected, and reinforcing tunnels to handle external stresses.	No mitigation measures are required	N/A
Impact GEO#5: Construction on Expansive Soil	Less than significant for all project alternatives: Project features would assess soil conditions and treat expansive soils through appropriate engineering measures, thereby minimizing direct and indirect risks to life and property from expansive soil. Engineering measures would include treatment with soil additives to reduce shrink-swell potential or excavation and replacement in accordance with relevant guidelines and standards such as AREMA, FHWA, and Caltrans.	No mitigation measures are required	N/A
Impact GEO#6: Excavating in Areas with Shallow Bedrock or Shallow Groundwater	Less than significant for all project alternatives: Project features would utilize engineering techniques and construction safety procedures to minimize direct and indirect risks to life and property by conforming with geotechnical guidelines and standards such as AREMA, FHWA, and Caltrans, as well as developing a CMP pertaining to excavations, shallow bedrock, and groundwater conditions.	No mitigation measures are required	N/A

Impact	Impact Description and CEQA Level of Significance before Mitigation	Mitigation Measure	CEQA Level of Significance after Mitigation
Impact GEO#7: Exposure of Concrete and Steel to Corrosive Soils	Less than significant for all project alternatives: Project features would minimize direct and indirect risks to life and property by limiting exposure to or designing structures for corrosive soils by conforming to guidelines specified by relevant transportation and building agencies and codes such as AREMA, FHWA, Caltrans and CBC.	No mitigation measures are required	N/A
Impact GEO#8: Excavation and Grading Impacts on Soil Erosion	Less than significant for all project alternatives: Project features involving erosion control would minimize substantial soil erosion or the loss of topsoil that would adversely affect the viability of the ecosystem or productivity of farming.	No mitigation measures are required	N/A
Impact GEO#9: Primary Seismic Hazards during Construction	Less than significant for all project alternatives: Project features would minimize direct and indirect risks to life and property from surface fault rupture and ground shaking during construction. These seismic design project features include the implementation of a CMP, evaluation and design for seismic ground shaking in accordance with guidelines and standards specified by relevant transportation and building agencies such as AREMA, FHWA, Caltrans, and CBC.	No mitigation measures are required	N/A
Impact GEO#10: Secondary Seismic Hazards during Construction	Less than significant for all project alternatives: Project safety and engineering features would minimize direct and indirect risks to life and property from secondary seismic hazards during construction. These project features include conforming to guidelines specified by relevant transportation and building agencies such as AREMA, FHWA, Caltrans, and CBC and applying geotechnical engineering practices to design and construction.	No mitigation measures are required	N/A
Impact GEO#11: Regional Ground Subsidence during Operations	Less than significant for all project alternatives: Project features would minimize direct and indirect risks to life and property from ground subsidence by monitoring and maintaining the integrity of the track during operations.	No mitigation measures are required	N/A

Impact	Impact Description and CEQA Level of Significance before Mitigation	Mitigation Measure	CEQA Level of Significance after Mitigation
Impact GEO#12: Primary Seismic Hazards during Operations	Less than significant for all project alternatives: Project features would minimize direct and indirect risks to life and property from surface fault rupture and ground shaking during operations. These project features include using seismic design standards in the structural design, use of early warning systems that would be triggered by strong ground motion, and shutting down train operations during or after an earthquake.	No mitigation measures are required	N/A
Impact GEO#13: Secondary Seismic Hazards during Operations	Less than significant for all project alternatives: Project features would minimize direct and indirect risks to life and property from secondary seismic hazards during operations. These project features include conforming to design guidelines specified by relevant transportation and building agencies such as AREMA, FHWA, Caltrans, and CBC as well as long-term monitoring and maintenance.	No mitigation measures are required	N/A
Paleontological Resources			
Impact GEO#14: Destruction of Paleontological Resources during Construction	Less than significant for all project alternatives: Project features would address paleontological resources monitoring and mitigation; discovery procedures; halting construction when paleontological resources are found; and training.	No mitigation measures are required	N/A
Impact GEO#15: Destruction of Paleontological Resources during Operation	No impact	No mitigation measures are required	N/A

AREMA = American Railway Engineering and Maintenance-of-Way Association
FHWA = Federal Highway Administration
Caltrans = California Department of Transportation
N/A = not applicable
NOA = naturally occurring asbestos
OSHA = Occupational Safety and Health Administration
CMP = construction management plan
CBC = California Building Code