3.7 Geology and Soils

3.7.1 Introduction

This section describes the regulatory setting and environmental setting for geology, soils, minerals, and paleontological resources[1] in the vicinity of the Proposed Project [including all track variants, technology variants, and the Greenville and Mountain House initial operating segments (IOS)] and the alternatives analyzed at an equal level of detail (Southfront Road Station Alternative, Stone Cut Alignment Alternative, West Tracy Operation and Maintenance Facility [OMF] Alternative, Mountain House Station Alternative, and Downtown Tracy Station Parking Alternatives 1 and 2). It also describes the impacts on geology, soils, minerals, and paleontological resources that would result and mitigation measures that would reduce significant impacts, where feasible. Appendix N, *Supporting Geology, Soils, Seismicity, and Paleontological Information*, contains the referenced figures and additional technical information for this section.

There would be no differences in the physical impacts on geology, soils, minerals, and paleontological resources due to the diesel multiple unit (DMU), hybrid battery multiple unit (HBMU), battery-electric multiple unit (BEMU), or diesel locomotive (DLH) haul technology variants, so the discussion in this section does not discuss those variants. Potential impacts associated with implementation of the Proposed Project and the alternatives analyzed at an equal level of detail assume the larger environmental footprint at proposed and alternative stations associated with a potential IOS (i.e., Greenville IOS, Mountain House IOS, Southfront Road Station Alternative IOS, and Mountain House Alternative IOS) and/or the expanded parking in 2040. As such, the analysis of the Proposed Project and the alternatives analyzed at an equal level of detail below considers the potential impacts associated with a potential IOS and/or the expanded parking in 2040.

Cumulative impacts from identified projects on geology, soils, minerals, and paleontological resources, in combination with planned, approved, and reasonably foreseeable projects, are discussed in Chapter 4, *Other CEQA-Required Analysis*.

3.7.2 Regulatory Setting

This section summarizes the federal, state, regional, and local regulations related to geology, soils, minerals, and paleontological resources that are applicable to the Proposed Project and alternatives analyzed at an equal level of detail. This section also includes a list of key design standards and guidelines related to geology and soils that will be used during design and construction of the Proposed Project.

[1] *Paleontological resources* include vertebrate, invertebrate, or plant fossils.

3.7.2.1 Federal

Geology, Soils, and Mineral Resources

Track Safety Standards

Section 213.239, Special Inspections, of 49 Code of Federal Regulations (CFR) Part 213 requires that, in the event of a natural disaster, such as an earthquake or flooding, the Federal Railroad Administration and the rail operator will conduct a special inspection of the track involved as soon as possible after the occurrence, and, if possible, before the operation of any train over the track.

Earthquake Hazards Reduction Act

In October 1977, the U.S. Congress passed the Earthquake Hazards Reduction Act to reduce the risks to life and property from future earthquakes in the United States through the establishment and maintenance of an effective earthquake hazards reduction program. To accomplish this goal, the act established the National Earthquake Hazards Reduction Program. This program was substantially amended in November 1990 by the National Earthquake Hazards Reduction Program Act (NEHRPA), which refined the description of agency responsibilities, program goals, and objectives.

The mission of the National Earthquake Hazards Reduction Program includes improved understanding, characterization, and prediction of hazards and vulnerabilities; improved building codes and land use practices; risk reduction through post-earthquake investigations and education; development and improvement of design and construction techniques; improved mitigation capacity; and accelerated application of research results. The NEHRPA designates the Federal Emergency Management Agency as the lead agency of the program and assigns several planning, coordinating, and reporting responsibilities. Other NEHRPA agencies include the National Institute of Standards and Technology, National Science Foundation, and the U.S. Geological Survey (USGS).

Paleontological Resources

Paleontological Resources Preservation Act

The federal Paleontological Resources Preservation Act of 2002 was enacted to codify the generally accepted practice of limiting the collection of vertebrate fossils and other rare and scientifically significant fossils to qualified researchers. These researchers must obtain a permit from the appropriate state or federal agency and agree to donate any materials recovered to recognized public institutions, where they will remain accessible to the public and to other researchers.

3.7.2.2 State

Geology, Soils, and Minerals Resources

Alquist-Priolo Earthquake Fault Zoning Act

The Alquist-Priolo Earthquake Fault Zoning Act (Alquist-Priolo Act) (California Public Resources Code [Public Res. Code] §§ 2621–2630) was enacted in 1972 to reduce the hazard of surface faulting to structures designed for human occupancy. The main purpose of the law is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. The law addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards. The Alquist-Priolo Act requires the State Geologist to establish regulatory zones known as Earthquake Fault Zones around the surface traces of active faults and issue appropriate maps, which are distributed to all affected cities, counties, and state agencies for their use in planning efforts. Before a project can be permitted in a designated Alquist-Priolo Earthquake Fault Zone, the permitting agency must require a geologic investigation to demonstrate that buildings intended for human habitation would not be constructed across active faults.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping Act of 1990 (Public Res. Code §§ 2690–2699.6) addresses earthquake hazards from non-surface fault rupture, including liquefaction and seismically induced landslides. The act established a mapping program for areas that have the potential for liquefaction, landslides, strong ground shaking, or other earthquake and geologic hazards. The act also specifies that the lead agency for a project may withhold development permits until geologic or soils investigations are conducted for specific sites and mitigation measures are incorporated into plans to reduce hazards associated with seismicity and unstable soils.

As required by the act, the California Geological Survey (CGS) has issued official Seismic Hazard Zone Maps that indicate zones of required investigation for earthquake faulting, landslides, and liquefaction.

California Building Standards Code

The California Building Standards Commission is responsible for coordinating, managing, adopting, and approving building codes in California. The State of California provides minimum standards for building design through the California Building Standards Code (CBC) (California Code of Regulations [Cal. Code Regs.] Title 24). The CBC applies to building design and construction in the state and is based on the federal Uniform Building Code used widely throughout the country (generally adopted on a state-by-state or district-by-district basis). The CBC has been modified for California conditions with numerous regulations that are more detailed or stringent.

The state earthquake protection law (California Health and Safety Code § 19100 et seq.) requires that structures be designed to resist stresses produced by lateral forces caused by wind and earthquakes. The CBC requires an evaluation of seismic design that falls into Categories A through F (where F requires the most earthquake-resistant design) for structures designed for a project site. The CBC philosophy focuses on *collapse prevention*, meaning that structures are designed for prevention of collapse for the maximum level of ground shaking that could reasonably be expected to occur at a site. Chapter 16, *Structural Design*, of the CBC specifies exactly how each seismic design category is to be determined on a site-specific basis through the site-specific soil characteristics and proximity to potential seismic hazards.

Chapter 18, *Soils and Foundations*, of the CBC regulates the excavation of foundations and retaining walls, including the preparation of preliminary soil, engineering geologic, geotechnical, and supplemental ground-response reports. Chapter 18 also regulates analysis of expansive soils and the determination of the depth to groundwater table. For Seismic Design Category C, Chapter 18 requires analysis of slope instability, liquefaction, and surface rupture attributable to faulting or lateral spreading. For Seismic Design Categories D, E, and F, Chapter 18 requires these same analyses plus an evaluation of lateral pressures on basement and retaining walls, liquefaction and soil strength loss, and lateral movement or reduction in foundation soil-bearing capacity. It also requires that seismic mitigation measures be considered in structural design. Mitigation measures may include ground stabilization, selection of appropriate foundation type and depths, selection of appropriate structural systems to accommodate anticipated displacements, or any combination of these measures. The potential for liquefaction and soil strength loss must be evaluated for site-specific peak ground acceleration magnitudes and source characteristics consistent with the design earthquake ground motions. Peak ground acceleration must be determined from a site-specific study, the contents of which are specified in CBC Chapter 18.

Finally, Appendix J of the CBC regulates grading activities, including drainage and erosion control and construction on unstable soils, such as expansive soils and areas subject to liquefaction.

National Pollutant Discharge Elimination System and Stormwater Pollution Prevention Plans

As discussed in detail in Section 3.10, *Hydrology and Water Quality*, the Proposed Project lies within the jurisdictions of two Regional Water Quality Control Boards (RWQCB): the San Francisco RWQCB, and the Central Valley RWQCB. Both have adopted specific National Pollutant Discharge Elimination System (NPDES) permits for a variety of activities that have the potential to discharge wastes (including sediment) to waters of the state. The State Water Resources Control Board's (SWRCB) statewide stormwater general permit for construction activity (Order 2009-009-DWQ as amended by Order No. 2012-0006-DWQ) is applicable to all land-disturbing construction activities that would disturb 1 acre or more. Compliance with the NPDES permit requires submittal to the Central Valley RWQCB of notices of intent to discharge and implementation of stormwater pollution prevention plans (SWPPPs) that include best management practices (BMPs) to minimize water quality degradation, including erosion and subsequent sediment transport, during construction activities.

Paleontological Resources

California Environmental Quality Act and California Environmental Quality Act Guidelines for Protection of Paleontological Resources

The California Environmental Quality Act (CEQA) Guidelines (Public Res. Code § 21000 et seq.; 14 Cal. Code Regs. § 15064.7) provide specific guidance for determining the significance of impacts on historic and unique archaeological resources. Under CEQA, these resources are called *historical resources* whether they are of historic or prehistoric age.

Guidelines for implementing CEQA define procedures, types of activities, persons, and public agencies required to comply with CEQA. Section 15064.7(b) prescribes that project effects that would "cause a substantial adverse change in the significance of an historical resource" are significant effects on the environment. Substantial adverse changes include physical changes to both the historical resource and its immediate surroundings.

Appendix G of the CEQA Guidelines provides an environmental checklist of questions that a lead agency should normally address if relevant to a project's environmental impacts. One of the questions to be answered in the environmental checklist (Section 15023, Appendix G, Section VII, part f) is: "Would the project directly or indirectly destroy a unique paleontological resource or site?" Although CEQA does not define what constitutes "a unique paleontological resource or site," Section 21083.2 defines *unique archaeological resources* as "any archaeological artifact, object, or site about which it can be clearly demonstrated that, without merely adding to the current body of knowledge, there is a high probability that it meets any of the following criteria:

- Contains information needed to answer important scientific research questions and show that there is a demonstrable public interest in that information.

- Exhibits a special and particular quality, such as being the oldest of its type or the best available example of its type.
- Is directly associated with a scientifically recognized important prehistoric or historic event or person.

This definition is equally applicable to recognizing "a unique paleontological resource or site." CEQA Guidelines Section 15064.7(a)(3)(D) provides additional guidance, indicating that "generally, a resource shall be considered historically significant if it has yielded, or may be likely to yield, information important in prehistory or history."

The CEQA lead agency having jurisdiction over a project is responsible for ensuring that paleontological resources are protected in compliance with CEQA and other applicable statutes. Public Res. Code Section 21081.6 requires that the CEQA lead agency demonstrate project compliance with mitigation measures developed during the environmental impact review process.

California Public Resources Code (§ 5097.5)

This law protects artifacts at paleontological sites, including fossilized footprints, that are situated on public lands, except with the permission of the public agency with jurisdiction over the lands. *Public lands* are defined as lands owned by the state, any city, county, district, authority, or public corporation.[2] Disturbing paleontological resources on public lands is a misdemeanor.

3.7.2.3 Regional and Local

Appendix I, *Regional Plans and Local General Plans*, provides a list of applicable goals, policies, and objectives from regional and local plans of the jurisdictions in which the Proposed Project is located. Section 15125(d) of the CEQA Guidelines requires an environmental impact report to discuss "any inconsistencies between the proposed project and applicable general plans, specific plans, and regional plans." These plans were considered during the preparation of this analysis and were reviewed to assess whether the Proposed Project would be consistent[3] with the plans of relevant jurisdictions. The Proposed Project would be generally consistent with the applicable goals, policies, and objectives related to geology, soils, and paleontological resources identified in Appendix I.

Design and Construction Standards Related to Geology, Soils, and Mineral Resources

Design and construction of the Proposed Project would conform to industry-wide engineering design guidelines and standards that are intended to protect the users of the facilities. Primary guidelines and standards that would be incorporated as part of project design and construction (in addition to the CBC discussed above) to reduce risks associated with geology, soils, and seismicity are briefly summarized below.

Each component of the Proposed Project would be designed to handle normal operating loads from the weight of the structure or train, as well as loads from environmental conditions such as seismic shaking and wind forces. At locations where geologic conditions present a hazard, the guidelines and

[2] Lands within the existing rail right-of-way (ROW) and acquired for rail ROW fall within the definition of public lands used for this section of the Public Res. Code.

[3] An inconsistency with regional or local plans is not necessarily considered a significant impact under CEQA, unless it is related to a physical impact on the environment that is significant in its own right.

standards discussed below (including the CBC) identify minimum requirements for characterizing the geologic conditions and then addressing the design issue, such as the stability of slopes, the corrosion of materials, and BMPs for water and wind erosion, stream sedimentation, or dust control.

Engineering geologists and geotechnical engineers who will assist in the design of the Proposed Project are obligated to use these guidelines and standards. To meet professional licensing requirements, contract design documents would have to be signed and stamped by engineering geologists, civil engineers, and geotechnical engineers registered in California, certifying that the designs have been completed in a manner that meets minimum standards and is protective of the public.

- **Bridge Design Specifications**. The American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications and the AASHTO Guide Specifications for LRFD Seismic Bridge Design provide guidance for characterization of soils, as wells as methods to be used in the design of bridge foundations and structures, retained cuts and fills, at-grade segments, and buried structures. These design specifications would provide minimum specifications for evaluating the seismic response of soil and structures.
- **Federal Highway Administration (FHWA) Circulars and Reference Manuals**. These FHWA documents provide detailed guidance on the characterization of geotechnical conditions at sites, methods for performing foundation design, and recommendations on foundation construction. These guidance documents include methods for designing retaining walls used for retained cuts and fills, foundations for elevated structures, and at-grade segments. Some of the documents include guidance on methods of design to reduce the risk of geologic hazards that are encountered during design.
- **American Railroad Engineering and Maintenance-of-Way Association (AREMA) Manual**. The AREMA guidelines deal with rail systems. Although these guidelines cover many of the same general topics as the AASHTO, they are more focused on best practices for rail systems. The manual includes principles, data, specifications, plans, and economics pertaining to the engineering, design, and construction of railways.
- **Union Pacific Railroad (UPRR) Design and Construction Standards**. These guidelines are specific to any work that will take place within or affect facilities owned and operated by UPRR. In general, UPRR relies on the current guidance provided by the most recent version of AREMA, while applying their own criteria to be applied to their assets as they deem necessary. Where a conflict between the current UPRR criteria and the AREMA guidelines arises, the UPRR criteria will govern for facilities or resources within their right-of-way (ROW).
- **California Department of Transportation (Caltrans) Design Standards**. Caltrans has specific minimum design and construction standards for all aspects of transportation system design, ranging from geotechnical explorations to construction practices. Caltrans design standards include state-specific amendments to the AASHTO LRFD Bridge Design Specifications and Guide Specifications for LRFD Seismic Bridge Design. These amendments provide specific guidance for the design of deep foundations used to support elevated structures, for design of mechanically stabilized earth walls used for retained fills, and for design of various types of cantilever (e.g., soldier pile, secant pile, and tangent pile) and tie-back walls used for retained cuts.
- **American Society for Testing and Materials (ASTM) International.** This organization has developed standards and guidelines for all types of material testing, from soil classifications to

pile-load testing or compaction testing through concrete-strength testing. The ASTM standards also include minimum performance requirements for materials. Most of the guidelines and standards cited above use ASTM or a corresponding series of standards from AASHTO to assure that the required and intended quality is achieved in the constructed project.

Society of Vertebrate Paleontology

The Society of Vertebrate Paleontology (SVP) has developed standards for mitigating adverse impacts from development (SVP 2010). These standards involve determining whether a geologic unit has high, undetermined, low, or no potential to contain significant paleontological resources. Measures for adequate protection or salvage of significant paleontological resources are applied to areas determined to contain geologic units with high or undetermined potential to contain significant paleontological resources. In areas determined to have high or undetermined potential for significant paleontological resources, an adequate program for mitigating the impact of development must include specific conditions that include surveying, monitoring by a qualified paleontologist, salvage, identification, cataloguing, curation, and provision for repository storage, and reporting. All phases of mitigation must be overseen by a qualified paleontologist.

3.7.3 Environmental Setting

This section describes the environmental setting related to geology, soils, minerals, and paleontological resources by segment for the Proposed Project and alternatives analyzed at an equal level of detail.

For purposes of this analysis, the study area for geology, soils, and mineral resources consists of the Project footprint. The analysis also considers faults, mineral resource zones, and geologic formations at local and regional levels. The geologic, soil, and seismic conditions described in this section have geographic distributions that are depicted in Appendix N, Figures N-1 through N-12, *Geology, Soils, and Seismicity Maps*.

The study area for paleontological resources is defined as the horizontal environmental footprint plus a 150-foot buffer and extending below ground to the maximum depth of disturbance to include all geologic units that could be encountered during construction or operation. Undisturbed land was determined through the use of geographic information systems (GIS). The study area for paleontological conditions is depicted in Appendix N, Figures N-13 through N-15, *Paleontological Resources Study Area Maps*.

The information presented in this section related to paleontological resources was obtained from the following sources.

- Peer-reviewed scientific literature (Marchand and Allwardt 1981; Barlock 1989; Bartow 1985; Schierer and Magoon 2007).
- Geologic mapping (Wagner et al. 1991; Barlock 1989).
- Records searches from the University of California Museum of Paleontology database (University of California Museum of Paleontology 2018a, 2018b, 2018c, 2018d, 2018e).

3.7.3.1 Regional Geologic Setting

The Proposed Project spans two geomorphic provinces: the Coast Ranges and the Great Valley (CGS 2002:2–3).

The western extent of the Proposed Project area is located in the Coast Ranges geomorphic province (CGS 2002:3). The Coast Ranges province is characterized by en échelon (i.e., parallel to subparallel) northwest-trending mountain ranges formed by active uplift related to the complex tectonics of the San Andreas fault/plate boundary system (Norris and Webb 1990:359–380). Lying between the western and eastern Coast Ranges in the Project area is in the Livermore Valley. The Livermore Valley lies within the Livermore Basin, which is defined by an east-west trending trough bounded by the Las Positas fault on the southeast, the Verona Thrust fault on the southwest, and blind and emergent thrust faults that are inferred to be a continuation of the Mount Diablo Thrust fault on the north (CGS 2008a).

The eastern Coast Ranges are broadly antiformal (i.e., fold is convex, with oldest geologic units in the core). At the general latitude of the Project area, they consist of a central core of Mesozoic units—primarily the Cretaceous Panoche Formation—flanked on the east by an upward younging sequence of marine and terrestrial sedimentary units that include the San Pablo Formation, a Miocene fanglomerate, and Quaternary alluvial deposits (Wagner et al. 1991).

The eastern extent of the Project area lies in the Great Valley geomorphic province (CGS 2002:2). The Great Valley, also called the Central Valley, is a nearly level alluvial plain that lies between the Sierra Nevada on the east and the Coast Ranges on the west. Its south end is defined by the Tehachapi Mountains north of Los Angeles and its north end by the Klamath Mountains. Subdivided into the Sacramento Valley to the north and the San Joaquin Valley to the south, the Great Valley has an average width of about 50 miles and is about 400 miles long overall (Norris and Webb 1990:412; Bartow 1991:2).

The Great Valley is floored by a thick sequence of sedimentary deposits that range in age from Jurassic through Quaternary. Under the eastern and central portions of the valley, the base of the sequence likely rests on Mesozoic crystalline rock allied to the plutons of the Sierra Nevada; to the west, basement rocks are believed to be Franciscan metasediments and/or mélange similar to exposures in the Coast Ranges. Mesozoic sedimentary rocks now in the subsurface record marine deposition are overlain by Tertiary strata reflecting marine, estuarine, and terrestrial conditions, which are in turn overlain by Quaternary fluvial and alluvial strata recording uplift and erosion of the Sierra Nevada and Coast Ranges to approximately their present shape (Norris and Webb 1990:417–425; Bartow 1991:2). In the Project area, the Great Valley is characterized by alluvial and basin units of Holocene, Pleistocene, and Pliocene age (Wagner et al. 1991).

Elevations in the Project area range from 97 to 233 feet[4] in the Tri-Valley segment, from 35 to 256 feet in the Altamont segment, and from 1 to 36 feet in the Tracy to Lathrop segment.

Geologic units surficially exposed within the Project area are described in Table 3.7-1.

[4] Elevation relative to the North American Vertical Datum of 1988.

Table 3.7-1. Surficial Geologic Units within the Project Area

Symbol	Geologic Unit	Description [a]
Q	Alluvium	Unconsolidated stream and basin deposits of varying size, from clay to boulder.
Qf	Alluvial fan deposits	Fan deposits of gravel, sand, silt, and clay.
Qdp	Dos Palos alluvium	Floodbasin deposits.
Qm	Modesto Formation	Arkosic alluvium, or alluvium high in feldspar in the San Joaquin Valley, characterized by oxidized and weathered well sorted sand and gravel that transitions to fine sand and silt. [b] The origin of the materials is primarily the Sierra Nevada. Locally derived material, such as andesite or metamorphic rock, also appears in the Modesto Formation. The age of the Modesto Formation is approximately 14,000 to 42,000 years.
Qo	Older alluvium	Older alluvial deposits that have been dissected by geologic processes.
Q_T	Plio-Pleistocene non-marine deposits (sand and gravel); corresponds to Livermore Gravels[c]	Conglomerate, sandstone, stiltstone, and claystone. The Livermore Gravels are subdivided into two members, the Lower Livermore and the Upper Livermore, each of which derives from a different source (Barlock 1989). The Lower Livermore derives from deposition by sandy braided streams and is composed predominantly of clasts of Cenozoic sandstone, greywacke, and fine-grained quartz.[d] The Upper Livermore derives from gravelly braided streams on an alluvial fan and is composed predominantly of clasts of Franciscan greywacke, lithic sandstone, metamorphic rock, volcanic, rock, and traces of fine-grained quartz.
Pta	Tassajara Formation	Nonmarine mudstone with lenses of sandstone and pebble conglomerate.[e]
Msp	San Pablo Group	Sandstone, mudstone, siltstone, and shale with minor tuff. The San Pablo Group comprises the Poverty Flat Sandstone, the Valley Springs Formation, and the Neroly Sandstone.[f] Poverty Flat Sandstone is predominantly sandstone. The Valley Springs Formation consists of sandstone and claystone. The Neroly Sandstone consists of sandstone and conglomeratic sandstone.
Mf	Fanglomerate	Conglomerate, sandstone, and siltstone. The fanglomerate (or type of conglomerate rock deposited in an alluvial fan showing some water weathering) in the paleontology study area has continental origin.
Kp	Panoche Formation	Marine sandstone, shale, siltstone, conglomerate lenses. [g]

[a] Wagner et al. 1991
[b] Marchand and Allwardt 1981
[c] Plio-Pleistocene non-marine deposits (sand and gravel) in Wagner et al. (1991) are mapped to the same geographic extent where Livermore Gravels are mapped (e.g., Barlock 1989).
[d] Barlock 1989
[e] CGS 2008a
[f] Bartow 1985
[g] Schierer and Magoon 2007

3.7.3.2 Tri-Valley Segment

Seismicity

The Tri-Valley segment is located in the San Francisco Bay Area (Bay Area). The Bay Area is seismically active, primarily as a result of friction caused as the Pacific Oceanic Plate and the North American Continental Plate move past one another. Numerous earthquakes have originated on faults in the Bay Area and the Coast Ranges. Potential seismic hazards resulting from a nearby moderate-to-major earthquake can generally be classified as primary and secondary. The primary effect is fault ground rupture, also called surface faulting. Common secondary seismic hazards include ground shaking, liquefaction, landslides, subsidence, and seiches, as described below.

Surface Fault Rupture

Surface rupture is an actual cracking or breaking of the ground along a fault during an earthquake. Active faults—those faults that have exhibited evidence of movement during the Holocene period (i.e., within the last 11,700 years)—are most likely to exhibit surface rupture. Rather than the sudden, larger movements associated with fault rupture during an earthquake, some active faults undergo small, relatively slow, incremental surface displacements over extended periods of time without causing significant earthquakes; such “fault creep” can eventually result in deformation of structures built across such faults. The larger sudden movements from surface fault rupture can result in any structure built on top of or through the fault trace being torn apart, including buildings, roads, bridges, rail lines, and underground utilities. Active faults in California that are at high risk for surface fault rupture have been classified by the CGS and mapped under the Alquist-Priolo Act. Before a project that crosses an Alquist-Priolo Fault Zone can be permitted, site-specific studies are required to determine the amount of risk, ensure appropriate design that is protective of human life, and reduce property loss.

The location of major faults in California has been mapped by CGS, most recently in the *2010 Fault Activity Map of California* (Jennings and Bryant 2010). The future probability of both surface fault rupture and strong seismic ground shaking generally depends on the age of a fault’s last known movement. Active faults are the most likely to result in surface fault rupture and strong seismic ground shaking. Faults are classified as *active* if they have exhibited evidence of movement during the Holocene epoch (i.e., 11,700 years Before Present to Present Day). Faults are classified as *potentially active* if they have exhibited evidence of movement during the Quaternary period (i.e., 2.6 million years Before Present) As shown on Figure N-1, the Tri-Valley segment crosses four known faults, two of which are active. Several other active faults are located in close proximity to the Proposed Project.

In the Tri-Valley segment, the Calaveras, Pleasanton, Las Positas, and Greenville faults are designated under the Alquist-Priolo Act (CGS 2017). The Tri-Valley segment crosses the Pleasanton and Greenville faults. The Alquist-Priolo Earthquake Fault Zones for each of these faults are shown on Figures N-2A and N-2B, respectively.

The Tri-Valley segment crosses through the northernmost Livermore section of the Greenville Fault Zone. As described by Lettis Consultants International, Inc. (LCI 2019), the Livermore section exhibits tectonic-related geomorphology, such as east- and west-facing scarps, linear troughs, deflected creeks, tonal lineaments, and multiple closed depressions. The Livermore earthquake sequence in 1980 produced minor ground rupture along the fault within the Project area, and potentially triggered slip along the Las Positas fault to the southwest. In the Project area, the

Greenville Fault is mapped as a broad zone of multiple northwest-striking fault traces that are complicated, in part, due to a structural left-step in the vicinity of Interstate (I-) 580, as well as a high-angle intersection with the left lateral Las Positas fault approximately 1.5 miles south-southeast of the Proposed Project. Directly north of I-580, the Greenville fault makes a releasing step to form a pull-apart basin that coincides with Frick Lake. Estimated and actual measurements of fault creep along the Livermore section of the Greenville Fault range from approximately 0.67 millimeters per year (mm/yr) to 2 mm/yr.

Seismic Ground Shaking

Seismic ground shaking refers to ground motion that results from the release of stored energy during an earthquake. Strong seismic ground shaking can result in damage to or collapse of buildings, bridges, and other structures. The intensity of ground shaking depends on the distance from the earthquake epicenter to the site, the magnitude and depth of the earthquake, and site-specific geologic conditions.

The 2014 Working Group on California Earthquake Probabilities estimates there is a 72 percent chance that an earthquake with a magnitude equal to or greater than 6.7 will occur within the next 30 years in the San Francisco region (Field and 2014 Working Group on California Earthquake Probabilities 2015).

In January 1980, two earthquakes with magnitudes of 5.8 and 5.2 occurred in the Livermore Valley area. These earthquakes resulted in surface fault rupture along both the Greenville and Las Positas faults, including the area where the Proposed Project crosses the Greenville fault at Greenville Road (Bonilla et al. 1980). As shown on Figure N-3, numerous other earthquakes with magnitudes of 4.0 or greater have occurred in the Project area.

Table 3.7-2 lists the known active faults in the Project area, their approximate distance from the Proposed Project footprint, the projected maximum moment magnitude of a future earthquake, and the slip rate.[5] The Mocho and Livermore faults, which run through the Proposed Project in a northwestern to southeastern direction near Santa Isabel, have shown evidence of activity during the Quaternary period, and therefore are considered potentially active.

[5] Slip rate is defined as the rate at which two sides of a fault are moving past one another. Faults with higher slip rates tend to have more frequent earthquakes.

Table 3.7-2. Active Regional Faults in the Tri-Valley Segment

Fault Name	Approximate Distance from Proposed Project (miles)	Age of Last Known Fault Displacement or Major Earthquake	Projected Maximum Moment Magnitude	Slip Rate (mm/yr)
Pleasanton Fault	Crosses the Tri-Valley Alignment at Dublin	Holocene	N/A	N/A
Greenville Fault Zone	Crosses the Proposed Project at Greenville Station	1980	6.6	2.0
Calaveras Fault	0.75 mile west	1861	6.2	15.0
Las Positas Fault	2.5 miles south	1943, 1980	5–6.2	0.02
Hayward Fault	8 miles west	1868	6.5	9.0
Carnegie Fault	8 miles south	Holocene	6.5	0.06–2.0
Concord Fault	12 miles north	Historic (active creep, minor earthquake 2015) and Holocene	6.2	4.0
San Andreas (Peninsula Section)	28 miles west	Historic	7.2	17.0

Source: Jennings and Bryant 2010; 2007 Working Group on California Earthquake Probabilities 2008; Herd 1977; Shedlock et al. 1980; U.S. Department of Energy and University of California 1992.
Notes: N/A = not available or not known; mm/yr = millimeters per year; Historic = the last 200 years; Holocene = the last 11,700 years.

The intensity of ground shaking depends on the distance from the earthquake epicenter to the site, the magnitude of the earthquake, and site soil conditions. Ground motions from seismic activity can be estimated by the probabilistic method at specified hazard levels and site-specific design calculations using a computer model. The CGS Probabilistic Seismic Hazards Assessment Model (CGS 2008b) shows the projected peak horizontal ground acceleration (PGA), which correlates to the intensity of ground shaking, with a 10 percent probability of being exceeded in 50 years for any given location (also known as the Design Basis Earthquake) for use in earthquake-resistant design). These estimates show there is a 1-in-10 probability that an earthquake within 50 years would result in a PGA ranging from 0.575*g* (where *g* is a percentage of gravity) in the vicinity of Dublin, decreasing gradually toward the east to 0.492*g* at Greenville Road. These calculations indicate that a high level of seismic ground shaking could occur throughout the Proposed Project in the Tri-Valley segment from movement along any of the faults listed in Table 3.7-2 or other active regional faults.

Liquefaction and Lateral Spreading

Liquefaction is a process by which water-saturated materials lose strength and may fail during strong ground shaking, when granular materials are transformed from a solid state into a liquefied state as a result of increased pore-water pressure. Structures on soil that undergoes liquefaction may settle or suffer major structural damage. Liquefaction is most likely to occur in low-lying areas where the substrate consists of poorly consolidated to unconsolidated water-saturated sediments, recent Holocene-age sediments, or deposits of artificial fill. Additional factors that determine the liquefaction potential are the distance to an active seismic source and the depth to groundwater.

Liquefaction-induced lateral spreading is a finite, lateral displacement of gently sloping ground that occurs from liquefaction or pore-pressure build up in a shallow underlying deposit during an earthquake. Lateral spreading generally occurs on mild slopes of 0.3 to 5.0 percent that are underlain by loose soil deposits and a shallow water table.

The potential liquefaction susceptibility in the Tri-Valley segment as mapped by Knudsen et al. (2000) and Witter et al. (2006) is shown on Figure N-4 and is described in Table 3.7-3.

Table 3.7-3. Liquefaction Susceptibility in the Tri-Valley Segment

Project Location	Geologic Units	Liquefaction Susceptibility Rating	PGA Necessary to Trigger Liquefaction[1]
Streambed crossings such as Tassajara Creek, Cottonwood Creek, Canyon Creek, Arroyo Las Positas, and Altamont Creek	Latest Holocene to historic stream channel, natural levee, and beach deposits and historically active stream channels	Very High	0.1*g*
Dublin to Vasco Road in Livermore	Latest Pleistocene to Holocene deposits from a variety of environments	Moderate	> 0.2–0.3*g*
Vasco Road to Greenville Road	Pleistocene marine and Bay terrace deposits, late Pleistocene deposits, Holocene to latest Pleistocene basin deposits, and artificial (historic) fill materials	Low	> 0.5*g*

Source: Witter et al. 2006.
PGA = peak horizontal ground acceleration; *g* = percentage of gravity.
[1] In general, areas that are highly susceptible to liquefaction require only a very low level of ground shaking (low PGA) to trigger liquefaction effects, while areas that are of low liquefaction susceptibility require a high level of ground shaking (high PGA) to trigger liquefaction effects.

As shown on Figure N-5, the official CGS (2019) Seismic Hazard Zones that require a site-specific investigation for liquefaction hazards generally correlate with the Very High, High, and Moderate liquefaction susceptibility ratings established by Witter et al. (2006) and shown in Figure N-4.

Subsidence and Settlement

Subsidence is the gradual settling or sudden sinking of the ground surface resulting from subsurface movement of earth materials. Seismically induced settlement refers to the compaction of soils and alluvium caused by ground shaking. Fine-grained soils are subject to seismic settlement and differential settlement. A potential for differential settlement exists where low-density and unconsolidated material is encountered, such as overbank river deposits (present day and historical) common along the river and streambeds. Subsidence and settlement may also occur from construction (separate from liquefaction or densification), due to both immediate settlements in granular soils and the consolidation of fine-grained soils. Subsidence and settlement can result in damage to building foundations and other structures.

Because the Tri-Valley segment would be constructed in areas of recent (historic) and Holocene-age streambed deposits, there is a potential for subsidence and settlement in these soft, unconsolidated sediments. Subsidence and settlement could also occur in other areas. A geotechnical report is required in order to identify site-specific areas where subsidence and settlement could occur, as well as the amount of anticipated settlement.

Tsunamis and Seiches

A tsunami is a series of water waves caused by the displacement of a large volume of a body of water, typically an ocean or a large lake. Earthquakes, volcanic eruptions, landslides, and other disturbances above or below water all have the potential to generate a tsunami. Since the Tri-Valley segment is at a considerably higher elevation and is several miles inland from the coast and San Francisco Bay, the Proposed Project would not be exposed to seismically induced flooding risks from tsunamis.

A *seiche* is a standing wave in an enclosed or partially enclosed body of water. Seiches and seiche-related phenomena have been observed on lakes, reservoirs, bays, harbors, and seas. The key requirement for formation of a seiche is that the body of water be at least partially bounded, allowing the formation of a standing wave. Seiches of a substantial height can inundate developed areas, threatening public safety and structures.

The wastewater ponds associated with the Pleasanton Quarry operated by Vulcan Materials, south of I-580 between Livermore and Pleasanton, could be subject to seiche activity in the event of a strong earthquake.

Slope Stability

A landslide is the downhill movement of masses of earth material under the force of gravity. The factors contributing to landslide potential are steep slopes, unstable terrain, rainfall, and proximity to earthquake faults. Excavation or erosion of material at the toe of a slope can destabilize the slope above it. Placement of fill on the upper portion of a slope can overload the soil or rock within the slope and cause it to fail. Landslides typically involve the surface soil and an upper portion of the underlying bedrock. Movement may be very rapid or so slow that a change of position can be noted only over a period of weeks or years; this slow change is known as *creep*. The size of a landslide can range from several square feet to several square miles.

Existing landslides in the Tri-Valley segment have been mapped by Roberts et al. (1999) and are shown on Figure N-6A. The Proposed Project would cross through several small existing landslide deposits in the vicinity of Arroyo Las Positas, between Cayetano Creek and the First Street/I-580 interchange in Livermore.

As shown on Figure N-7, the official CGS (2019) Seismic Hazard Zones that require a site-specific investigation for landslide hazards generally correlate with this same area, between Cayetano Creek and the First Street/I-580 interchange in Livermore.

Soils

Figure N-8A shows the locations of the soil types within the Tri-Valley segment, and Table 3.7-4 presents relevant soil characteristics based on U.S. Natural Resources Conservation Service (NRCS) soil survey data (NRCS 2018). Additional detailed discussions related to soil expansion, erosion, and corrosivity are provided below. Classification of soil into hydrologic groups is a measure of the potential for stormwater runoff; this is discussed further in Section 3.10*, Hydrology and Water Quality*.

Table 3.7-4. Soil Characteristics in the Tri-Valley Segment

Soil Map Unit Name	Acreage in Proposed Project[1]	Shrink-Swell Potential[2]	Water Erosion Hazard[3]	Wind Erosion Hazard[4]	Corrosion of Steel	Corrosion of Concrete	Hydrologic Group[5]
Altamont clay, 3 to 15 percent slopes	2.1	High	Moderate	4	High	Low	C
Altamont clay, moderately deep, 30 to 45 percent slopes, eroded	2.7	High	Moderate	4	High	Low	D
Clear Lake clay, 0 to 3 percent slopes	34.8	Very High	Moderate	4	High	Moderate	C/D
Clear Lake clay, drained, 0 to 2 percent slopes	75.8	Very High	Low	4	High	Moderate	D
Clear Lake clay, drained, 3 to 7 percent slopes	0.1	High	Moderate	4	High	Moderate	C
Danville silty clay loam, 0 to 3 percent slopes	54.4	High	Moderate	6	High	Low	C
Diablo clay, very deep, 3 to 15 percent slopes	73.5	High	Moderate	4	High	Moderate	C
Linne clay loam, 3 to 15 percent slopes	54.2	Low	Moderate	4	Moderate	Low	C
Linne clay loam, 15 to 30 percent slopes	28.0	Moderate	Moderate	6	Low	Low	D
Pescadero clay loam, 0 to 6 percent slopes	22.0	High	Moderate	6	High	Moderate	C/D
Pleasanton gravelly loam, 0 to 3 percent slopes	21.2	Low	Low	6	Moderate	Low	C
Rincon clay loam, 0 to 3 percent slopes	79.4	Moderate	Moderate	6	High	Low	C
Rincon clay loam, 3 to 7 percent slopes	1.8	Moderate	Moderate	6	High	Low	C
Riverwash	11.6	NR	NR	1	NR	NR	A
San Ysidro loam, 0 to 2 percent slopes	142.8	Moderate	Moderate	6	Moderate	Low	C

Soil Map Unit Name	Acreage in Proposed Project[1]	Shrink-Swell Potential[2]	Water Erosion Hazard[3]	Wind Erosion Hazard[4]	Corrosion of Steel	Corrosion of Concrete	Hydrologic Group[5]
Solano fine sandy loam	3.9	Low	Moderate	3	Moderate	Moderate	C
Sunnyvale clay loam over clay	81.7	High	Moderate	4	High	Moderate	C
Sycamore silt loam, 0 to 2 percent slopes	38.7	Low	Moderate	6	High	Low	B
Sycamore silt loam over clay	0.5	Low	High	6	Moderate	Low	B
Yolo loam, calcareous substratum, 0 to 6 percent slopes	5.5	Low	High	6	Low	Low	B
Zamora silt loam, 0 to 4 percent slopes	23.8	Low	High	6	Moderate	Low	C

Source: NRCS 2018
NR = not rated
[1] Acreages have been rounded.
[2] Based on the plasticity index; ratings of moderate to very high can result in damage to buildings, roads, bridges, and other structures.
[3] Based on the erosion factor "Kw whole soil," which is a measurement of relative soil susceptibility to sheet and rill erosion by water.
[4] Soils assigned to wind erodibility group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible.
[5] Group A soils = low runoff potential, Group B soils = low to medium runoff potential, Group C soils = medium to high runoff potential, Group D soils = high runoff potential.

Soil Expansion

Expansive soils are composed largely of clays, which greatly increase in volume when saturated with water and shrink when dried (referred to as *shrink-swell potential*). Because of this effect, structural foundations may rise during the rainy season and fall during the dry season. If this expansive movement varies beneath different parts of a structure, the foundation may crack, and portions of the structure may become distorted. Retaining walls and underground utilities may be damaged for the same reasons. Plasticity index is a commonly used method to help determine the expansive properties of soils for engineering purposes.

Figure N-9A illustrates the shrink-swell potential of the Proposed Project in the Tri-Valley segment based on the NRCS (2018) plasticity index ratings. As shown in Figure N-9A and Table 3.7-4, the shrink-swell potential is highly variable along the Tri-Valley segment, ranging from low to very high.

Soil Erosion

The potential for erosion by water or wind is a function of the cohesiveness of the soil particles. NRCS has quantified the potential for water-related soil erosion by a measurement termed *K factor*. NRCS has also classified the soil types according to their potential for wind erosion: soils on steep slopes are often erodible, especially during heavy rain events. Soils and alluvial deposits present in stream channels are susceptible to erosional scour, especially around foundation elements where erosive forces can be concentrated. Soils located in areas where high winds are prevalent, particularly when the soil is dry during the summer and fall months, are particularly susceptible to wind erosion.

Figure N-10A illustrates the potential for water erosion in the Proposed Project in the Tri-Valley segment. As shown in Figure N-10A and Table 3.7-4, the water erosion potential for most of the Tri-Valley segment is rated as moderate. The wind erosion potential is moderate to low (see Table 3.7-4).

Soil Corrosivity

Buried steel and concrete in direct contact with soil can become corroded. Several factors—including soil composition, soil and pore water chemistry, moisture content, and pH—affect the response of steel and concrete to soil corrosion. Soils with high moisture content, high electrical conductivity, high acidity, and high dissolved-salts content are most corrosive. In general, sandy soils have high resistivity and are the least corrosive; soils with a high clay content can be highly corrosive.

As shown in Table 3.7-4, the potential for corrosion of steel is rated as high for most of the Tri-Valley segment, while the potential for corrosion of concrete is rated as low to moderate.

Mineral Resources

Construction Aggregate

The loss of access to regionally important mineral deposits as a result of land uses that preclude mining is one of the problems that the California Surface Mining and Reclamation Act of 1975 (SMARA) was framed to address. SMARA mandates a two-phased mineral resource conservation process called *classification-designation*. Under SMARA, the State Mining and Geology Board may designate certain mineral deposits as regionally significant to satisfy future needs. The Board's decision to designate an area is based on a classification report prepared by CGS and input from agencies and the public.

The Tri-Valley segment lies within the designated South San Francisco Bay Production-Consumption Region for aggregate minerals, which includes all designated lands within the marketing area of the active aggregate operations supplying the South San Francisco Bay urban center.

CGS has established a classification system, shown in Table 3.7-5, to indicate the location and significance of key extractive resources.

Table 3.7-5. California Geological Survey Mineral Land Classification System

Classification	Description
MRZ-1	Areas where adequate information indicates that no significant mineral deposits are present or where it is judged that little likelihood exists for their presence
MRZ-2	Areas where adequate information indicates that significant mineral deposits are present or where it is judged that a high likelihood for their presence exists
MRZ-3	Areas containing mineral deposits, the significance of which cannot be evaluated from existing data
MRZ-4	Areas where available data are inadequate for placement in any other mineral resource zone

Source: Stinson et al. 1987
MRZ = Mineral Resource Zone

Aggregate mineral deposits in the South San Francisco Bay Production-Consumption Region have been classified and mapped by Stinson et al. (1987) and Kohler-Antablin (1996). As shown in Figure N-11A, the Tri-Valley segment is not located in a designated regionally important area of known mineral resources (i.e., MRZ-2). Although most of the Tri-Valley segment is classified as MRZ-1, the Proposed Project is classified as MRZ-3 at Portola Avenue. The Proposed Project would also cross through several areas classified as MRZ-4 between Portola Avenue and Vasco Road.

Oil, Gas, and Geothermal Resources

The Livermore natural gas and oil field is located approximately 0.5 mile south of the Proposed Project at Greenville Road (California Department of Oil, Gas, and Geothermal Resources [DOGGR] 2019). The active and currently idle oil and gas wells in this field are clustered around Patterson Pass Road, approximately 1 mile south of the Proposed Project at Greenville Road. There are no oil or gas wells within the Tri-Valley segment.

There are no mapped geothermal wells within or in the vicinity of the Tri-Valley segment (California Department of Conservation [DOC] 2018).

3.7.3.3 Altamont Segment

Seismicity

Surface Fault Rupture

The Altamont segment is located in the Diablo Range, which is seismically active. Several active and potentially active faults are located in the vicinity of the Altamont segment as shown on Figure N-1. The west end of the Altamont segment crosses through the active Greenville fault, which is classified under the Alquist-Priolo Act (CGS 2017). The Altamont segment also crosses through the Midway fault, which has shown evidence of movement in the last 700,000 years and therefore is considered potentially active. Details related to the Alquist-Priolo Earthquake Fault Zone for the Greenville fault are shown on Figure N-2B.

Strong Seismic Ground Shaking

Several historic earthquakes with a magnitude of 4.0 or greater have occurred in the Diablo Range in the Project vicinity, as shown on Figure N-3.

The known active faults in the vicinity of the Altamont segment are the same faults in proximity to the Tri-Valley segment, which are described in Table 3.7-2. As noted previously, in January 1980, two earthquakes with magnitudes of 5.8 and 5.2, respectively, occurred along the Greenville fault and resulted in surface fault rupture at the western end of the Altamont segment. The Midway fault, which runs through the Altamont segment in a northwest to southeast direction along the east side of the Diablo Range, has shown evidence of activity during the Quaternary period and therefore is considered potentially active. The Corral Hollow and Black Butte faults, approximately 5 and 2.5 miles south of the Altamont segment, respectively, are also considered potentially active.

The CGS Probabilistic Seismic Hazards Assessment Model (CGS 2008b) indicates there is a 1-in-10 probability that an earthquake within 50 years would result in PGAs ranging from 0.479*g* at the west end of the Altamont segment, and decreasing gradually to 0.404*g* at the eastern end of the Altamont segment. These calculations indicate that a moderate level of seismic ground shaking could occur throughout the Proposed Project in the Altamont segment.

Liquefaction and Lateral Spreading

The potential liquefaction susceptibility of the Altamont segment from the western end near Greenville Road east to the San Joaquin County line as mapped by Knudsen et al. (2000) and Witter et al. (2006) is shown on Figure N-4 and is described in Table 3.7-6. Liquefaction susceptibility has not been mapped for the eastern half of the Altamont segment, which is in San Joaquin County, due to the longer distance from active seismic sources and the greater depth to the groundwater table in San Joaquin County. Furthermore, most of the Proposed Project in the Altamont segment would be constructed in bedrock, which is not susceptible to liquefaction hazards.

However, recent (Historic) and Holocene-age streambed deposits are susceptible to liquefaction hazards. Because some of the proposed improvements in the Altamont segment would be constructed across these features, there is a potential for liquefaction in these areas because these deposits are loose and unconsolidated and there is a shallow depth to groundwater immediately adjacent to streambeds.

Table 3.7-6. Liquefaction Susceptibility in the Altamont Segment

Project Location	Geologic Units	Liquefaction Susceptibility Rating	PGA Necessary to Trigger Liquefaction[1]
Streambed crossings from the west end of the Altamont segment to the location where the footprint crosses I-580.	Latest Pleistocene to Holocene deposits from a variety of environments.	Moderate	> 0.2–0.3*g*
Streambed crossings from the location where the Altamont segment crosses I-580 east to the San Joaquin County line.	Latest Holocene to historical alluvial fan, stream, and estuarine deposits and many artificial fills.	High	> 0.1–0.2*g*

Source: Witter et al. 2006
PGA = peak horizontal ground acceleration; *g* = percentage of gravity
[1] In general, areas that are highly susceptible to liquefaction require only a very low level of ground shaking (low PGA) to trigger liquefaction effects, while areas that are of low liquefaction susceptibility require a high level of ground shaking (high PGA) to trigger liquefaction effects.

There are no CGS (2019) Seismic Hazard Zones that require a site-specific investigation for liquefaction hazards in the Altamont segment.

Subsidence and Settlement

Because portions of the Altamont segment would be constructed in areas of recent (Historic) and Holocene-age streambed deposits, there is a potential for subsidence and settlement in these soft, unconsolidated sediments. Subsidence and settlement could also occur in other areas. However, a geotechnical report is required in order to identify site-specific areas and amounts where seismically-induced subsidence and settlement could occur.

Tsunamis and Seiches

Given the long distance of the Altamont segment from the coast and San Francisco Bay, the Proposed Project would not be exposed to seismically-induced flooding risks from tsunamis. The Altamont Alignment (both Owens-Illinois Industrial Lead Variant 1, Single Track and Owens-Illinois Industrial Lead Variant 2, Double Track) would cross over the California Aqueduct and the Delta-Mendota Canal, on the east side of I-580, which could be subject to seismic seiche hazards.

Slope Stability

Existing landslides in the Altamont segment, mapped by Roberts et al. (1999) and Nilsen et al. (1975), are shown on Figure N-6B. As shown, the Altamont Alignment would cross through numerous existing landslide deposits throughout the Altamont segment. Fieldwork performed by AECOM in February 2019 identified four large and several smaller active landslide areas, in addition to areas of active rockfall hazards, along the proposed rail alignment in the Altamont segment. Furthermore, the Stone Cut Alignment Alternative would cross through several known large mapped landslide deposits, as well as areas where landslide deposits may be present (mapped as “uncertain”). The Interim OMF would also be located in a mapped landslide deposit.

As shown on Figure N-7, the official CGS (2019) Seismic Hazard Zones that require a site-specific investigation for landslide hazards correlate with all of the drainages through which the Altamont Alignment would cross, from the western end near Greenville Road eastward to the San Joaquin

County line. Most of the Altamont segment would be located in areas that require site-specific landslide investigations.

There are no CGS (2019) Seismic Hazard Zones that require a site-specific investigation for landslide hazards in the San Joaquin County portion of the Altamont segment.

Soils

Figure N-8B shows the locations of the soil types within the Altamont segment, and Table 3.7-7 presents relevant soil characteristics based on NRCS soil survey data (NRCS 2018). Additional detailed discussions related to soil expansion, erosion, and corrosivity are provided below. Classification of soil into hydrologic groups is a measure of the potential for stormwater runoff; this is discussed further in Section 3.10*, Hydrology and Water Quality*.

Table 3.7-7. Soil Characteristics in the Altamont Segment

Soil Map Unit Name	Acreage in Proposed Project[1]	Shrink-Swell Potential[2]	Water Erosion Hazard[3]	Wind Erosion Hazard[4]	Corrosion of Steel	Corrosion of Concrete	Hydrologic Group[5]
Altamont clay, 3 to 15 percent slopes	2.9	High	Moderate	4	High	Low	C
Altamont clay, 15 to 30 percent slopes	64.1	Very High	Moderate	4	High	Low	C
Altamont clay, moderately deep, 30 to 45 percent slopes, eroded	136.8	High	Moderate	4	High	Low	D
Altamont clay, moderately deep, 45 to 75 percent slopes, eroded	13.8	High	Moderate	4	High	Low	D
Altamont rocky clay, moderately deep, 7 to 30 percent slopes	26.7	High	Moderate	4	High	Low	D
Calla-Carbona complex, 8 to 30 percent slopes	29.4	Low	Moderate	4	Moderate	Low	C
Calla-Carbona complex, 30 to 50 percent slopes	2.1	Low	Moderate	4	Moderate	Low	C
Capay clay, 0 to 2 percent slopes	56.1	Very High	Moderate	4	High	Low	C
Capay clay, 1 to 6 percent slopes	6.3	Very High	Moderate	4	High	Low	D
Carbona clay loam, 2 to 8 percent slopes	78.7	Moderate	Moderate	4	High	Moderate	C
Clear Lake clay, drained, 3 to 7 percent slopes	1.2	High	Moderate	4	High	Moderate	C
Diablo clay, 7 to 15 percent slopes	0.1	High	Low	4	High	Moderate	C
Diablo clay, 15 to 30 percent slopes	2.6	Very High	Low	4	High	Low	C

Soil Map Unit Name	Acreage in Proposed Project[1]	Shrink-Swell Potential[2]	Water Erosion Hazard[3]	Wind Erosion Hazard[4]	Corrosion of Steel	Corrosion of Concrete	Hydrologic Group[5]
Diablo clay, 30 to 45 percent slopes, eroded	0.9	High	Low	4	High	Moderate	C
Linne clay loam, 3 to 15 percent slopes	32.4	Low	Moderate	4	Moderate	Low	C
Linne clay loam, 30 to 45 percent slopes, eroded	15.1	Low	Moderate	4	Moderate	Low	C
Pescadero clay loam, 0 to 6 percent slopes	83.8	High	Moderate	6	High	Moderate	C/D
Rincon Clay loam, 0 to 3 percent slopes	5.3	Moderate	Moderate	6	High	Low	C
Stomar clay loam, 0 to 2 percent slopes	185.2	Moderate	Moderate	6	High	Low	C
Sycamore silt loam, 0 to 2 percent slopes	0.7	Low	Moderate	6	High	Low	B

Source: NRCS 2018

[1] Acreages have been rounded.

[2] Based on the plasticity index; ratings of moderate to very high can result in damage to buildings, roads, bridges, and other structures.

[3] Based on the erosion factor "Kw whole soil," which is a measurement of relative soil susceptibility to sheet and rill erosion by water.

[4] Soils assigned to wind erodibility group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible.

[5] Group A soils = low runoff potential, Group B soils = low to medium runoff potential, Group C soils = medium to high runoff potential, Group D soils = high runoff potential.

Soil Expansion

Figure N-9B illustrates the shrink-swell potential of the Proposed Project in the Altamont segment. As shown in Figure N-9B and Table 3.7-7, the shrink-swell potential along most of the Altamont segment is moderate to very high.

Soil Erosion

Figure N-10B illustrates the potential for water erosion in the Proposed Project in the Altamont segment. As shown in Figure N-10B and Table 3.7-7, the water erosion potential for most of the Altamont segment is rated as moderate. The wind erosion potential is also moderate (see Table 3.7-7).

Soil Corrosivity

As shown in Table 3.7-7, the potential for corrosion of steel is rated as high for most of the Altamont segment, and the potential for corrosion of concrete is rated as low to moderate.

Soil Suitability for Septic Systems

For a septic system to function properly, soils must percolate (or "perc")—that is, a certain volume of wastewater must flow through the soil in a certain time period, as determined by a licensed geotechnical engineer. Wastewater is "treated" as soil bacteria feed on the waste material and in the process, breaking down the material into more basic elements that are dispersed into the lower layers of the soil horizon. If wastewater percolates through the soil too quickly, there is not sufficient time for the bacteria to digest this material. Conversely, if wastewater percolates through the soil too slowly, the bacteria die of oxygen deprivation.

A review of NRCS soil survey data (NRCS 2018) indicates that the Pescadero clay loam soil at the Interim OMF is rated as very limited for use with septic systems because of the shallow depth to a water-saturated zone, the soil's ponding tendency, and a slow rate of water transmission through the soil. The Calla-Carbona complex and Carbona clay loam soils at the West Tracy OMF Alternative are also rated as very limited for use with septic systems because of steep slopes and a slow rate of water transmission.

Mineral Resources

Construction Aggregate

The western third of the Altamont segment lies within the designated South San Francisco Bay Production-Consumption Region for aggregate minerals; however, mineral resources in this area have not been mapped. The eastern two-thirds of the Altamont segment are outside the boundaries of any production-consumption region. As shown in Figures N-11A and N-11B, the Altamont Pass region has not been classified for aggregate mineral resources.

CGS's priority for mineral land classification studies is based on areas that are most likely to urbanize in the future, with the goal of establishing an awareness of the availability of important resources by communicating with the appropriate lead agencies regarding the presence, location, and significance of mineral deposits within a particular region. The Altamont Pass region is in a rural area of Alameda and San Joaquin counties that CGS has not identified as an area likely to urbanize; therefore, CGS has not classified the minerals in this area. However, the absence of mineral land classification does not mean that no important mineral resources are present; rather, it means that CGS has not yet classified the area in question. Although the mineral resources of the Altamont segment have not been classified by CGS, this area consists primarily of Mesozoic-age bedrock of the Diablo Range, which does not serve as a good source material for construction aggregate.

Oil, Gas, and Geothermal Resources

Based on a review of DOGGR (2018) well data, there are no oil or gas fields in the Altamont segment. One plugged and abandoned dry hole is located adjacent to and south of the Altamont segment at the Musco Family Olive Co., on the west side of I-580.[6] There are no mapped geothermal wells within or in the vicinity of the Altamont segment (DOC 2018).

3.7.3.4 Tracy to Lathrop Segment

Seismicity

Surface Fault Rupture

The Tracy to Lathrop segment, located in the San Joaquin Valley, generally has not been seismically active (with the exception of the area around Bakersfield, approximately 200 miles to the south). Active seismic sources are located either in the Coast Ranges to the west or the Sierra Nevada to the east.

The Tracy to Lathrop segment crosses the Vernalis Fault, as shown on Figure N-1. The Vernalis Fault has shown evidence of movement during the Quaternary period, and therefore is considered potentially active. There are no Alquist-Priolo Earthquake Fault Zones in the vicinity of the Tracy to Lathrop segment.

Strong Seismic Ground Shaking

Only one historic earthquake with a magnitude of 4.0 or greater has occurred in the Tracy to Lathrop region, as shown on Figure N-3. This earthquake occurred in 1979 and was located approximately 15 miles northeast of the Tracy to Lathrop segment. There are no active faults in the Tracy to Lathrop region; the nearest active faults are located in the Coast Ranges to the west and are described above in Table 3.7-2.

The CGS Probabilistic Seismic Hazards Assessment Model (CGS 2008b) indicates there is a 1-in-10 probability that an earthquake within 50 years would result in PGAs ranging from 0.379*g* at the southwest end of the Tracy to Lathrop segment, decreasing gradually toward the northeast to 0.237*g* at the north end of the segment. These calculations indicate that a low level of seismic ground shaking is anticipated throughout the Tracy to Lathrop segment.

Liquefaction and Lateral Spreading

Due to the relatively longer distance from active seismic sources and the generally greater depth to the groundwater table in San Joaquin County, as compared to the Bay Area, liquefaction susceptibility has not been mapped for the Tracy to Lathrop segment. There are no CGS (2019)

[6] A *dry hole* means that either the well did not produce any oil or natural gas or the commodity was not produced in paying quantities.

Seismic Hazard Zones that require a site-specific investigation for liquefaction hazards in the Tracy to Lathrop segment. Lateral spreading could represent a hazard where project facilities would be constructed in recent (Historic) and Holocene-age streambeds deposits: these deposits are loose and unconsolidated, and a shallow depth to groundwater is immediately adjacent to the streambeds. However, a geotechnical report would be required to determine the site-specific locations and potential magnitude of effects.

Subsidence and Settlement

Because portions of the Tracy to Lathrop Alignment (including both alignment variants) would be constructed in areas of recent (Historic) and Holocene-age streambed deposits, there is a potential for subsidence and settlement in these soft, unconsolidated sediments. Subsidence and settlement could also occur in other areas. However, a geotechnical report is required in order to identify site-specific areas and magnitudes where subsidence and settlement could occur.

Tsunamis and Seiches

Given the long distance of the Tracy to Lathrop segment from the coast and San Francisco Bay, the Proposed Project would not be exposed to seismically induced flooding risks from tsunamis.

Several large bodies of standing water are present in the vicinity of the Tracy to Lathrop segment, including the San Joaquin River and the Paradise Cut during high-flow conditions, when they are full of water; the wastewater ponds associated with the Brown Sand Mossdale Quarry; and the lakes at River Islands. These waterbodies could be subject to seiche hazards.

Slope Stability

The Tracy to Lathrop segment is located in a generally flat alluvial plain; the Proposed Project would not be constructed in any mapped landslide deposits. There are no CGS (2019) Seismic Hazard Zones that require a site-specific investigation for landslide hazards in the Tracy to Lathrop segment.

Soils

Figure N-8C shows the locations of the soil types within the Tracy to Lathrop segment, and Table 3.7-8 presents relevant soil characteristics based on NRCS soil survey data (NRCS 2018). Additional detailed discussions related to soil expansion, erosion, and corrosivity are provided below. Classification of soil into hydrologic groups is a measure of the potential for stormwater runoff; this is discussed further in Section 3.10, *Hydrology and Water Quality*.

Table 3.7-8. Soil Characteristics in the Tracy to Lathrop Segment

Soil Map Unit Name	Acreage in Proposed Project[1]	Shrink-Swell Potential[2]	Water Erosion Hazard[3]	Wind Erosion Hazard[4]	Corrosion of Steel	Corrosion of Concrete	Hydrologic Group[5]
Bisgani loamy coarse sand, partially drained, 0 to 2 percent slopes	5.2	Low	Low	2	Moderate	Moderate	A
Capay clay, 0 to 1 percent slopes	104.8	Very High	Moderate	4	High	Low	C
Capay-Urban land complex, 0 to 2 percent slopes	52.3	Very High	Moderate	4	High	Low	C
Columbia fine sandy loam, drained, 0 to 2 percent slopes	20.0	Low	Moderate	3	High	Moderate	C
Columbia fine sandy loam, partially drained, 0 to 2 percent slopes, occasionally flooded	0.8	Low	Low	3	High	Low	A
Columbia fine sandy loam, clayey substratum, partially drained, 0 to 2 percent slopes	36.5	Low	Low	3	High	Low	A
Delhi loamy sand, 0 to 2 percent slopes	14.4	Low	Low	2	Moderate	Moderate	A
Egbert silty clay loam, partially drained, 0 to 2 percent slopes	19.3	High	Low	4	High	Moderate	C
Grangeville fine sandy loam, partially drained, 0 to 2 percent slopes	25.6	Low	Low	3	High	Low	A
Manteca fine sandy loam, 0 to 2 percent slopes	9.5	Low	Moderate	3	High	Low	C
Merritt silty clay loam, partially drained, 0 to 2 percent slopes	11.2	Moderate	Moderate	6	High	Low	C
Merritt silty clay loam, partially drained, 0 to 2 percent slopes, occasionally flooded	3.4	Low	Moderate	6	High	Low	C

Soil Map Unit Name	Acreage in Proposed Project[1]	Shrink-Swell Potential[2]	Water Erosion Hazard[3]	Wind Erosion Hazard[4]	Corrosion of Steel	Corrosion of Concrete	Hydrologic Group[5]
Reiff loam, 0 to 2 percent slopes	8.1	Low	Moderate	5	High	Low	A
Stomar clay loam, 0 to 2 percent slopes	7.4	Moderate	Moderate	6	High	Low	C
Timor loamy sand, 0 to 2 percent slopes	22.1	Low	Low	2	Moderate	Low	A
Tinnin loamy coarse sand, 0 to 2 percent slopes	35.4	Low	Low	2	Moderate	Low	A
Urban Land	30.0	NR	NR	NR	NR	NR	NR
Veritas fine sandy loam, 0 to 2 percent slopes	27.0	Low	Moderate	3	Moderate	Moderate	A
Willows clay, partially drained, 0 to 2 percent slopes	13.1	Very High	Moderate	4	High	High	D
Zacharias clay loam, 0 to 2 percent slopes	19.5	Moderate	Moderate	6	Moderate	Low	C

Source: NRCS 2018
NR = not rated
[1] Acreages have been rounded.
[2] Based on the plasticity index; ratings of moderate to very high can result in damage to buildings, roads, bridges, and other structures.
[3] Based on the erosion factor "Kw whole soil," which is a measurement of relative soil susceptibility to sheet and rill erosion by water.
[4] Soils assigned to wind erodibility group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible.
[5] Group A soils = low runoff potential, Group B soils = low to medium runoff potential, Group C soils = medium to high runoff potential, Group D soils = high runoff potential.

Soil Expansion

Figure N-9C illustrates the shrink-swell potential of the Proposed Project in the Tracy to Lathrop segment. As shown in Figure N-9C and Table 3.7-8, the shrink-swell potential along most of the segment is low. However, the shrink-swell potential from Downtown Tracy to just northeast of Banta is very high.

Soil Erosion

Figure N-10C illustrates the potential for water erosion in the Tracy to Lathrop segment. As shown in Figure N-10C and Table 3.7-8, the water erosion potential for most of the segment is rated as low to moderate. The wind erosion potential is moderate to high (see Table 3.7-8).

Soil Corrosivity

As shown in Table 3.7-8, the potential for corrosion of steel is rated as high in the Tracy to Lathrop segment, and the potential for corrosion of concrete is rated as low.

Mineral Resources

Construction Aggregate

The Tracy to Lathrop segment lies within the designated Stockton-Lodi Production-Consumption Region for Portland cement concrete-grade aggregate. The CGS mineral land classifications are defined above in Table 3.7-5. Aggregate resources in this region have been classified and mapped by Jensen and Silva (1988) and Smith and Clinkenbeard (2012). As shown in Figure N-11B, most of the Proposed Project area in the Tracy to Lathrop segment has been classified by CGS as either MRZ-1 (no mineral resources) or MRZ-3 (mineral resources of unknown significance). However, an approximately 1-mile-long segment of the Tracy to Lathrop Alignment near the San Joaquin River would be constructed in an area of regionally important mineral deposits (i.e., areas classified as MRZ-2).

Oil, Gas, and Geothermal Resources

Based on a review of DOGGR (2018) well data, several natural gas fields are located in the vicinity of the Tracy to Lathrop segment, which crosses through the abandoned Tracy Gas Field (all wells have been plugged). Several oil and/or gas wells lie adjacent to the Proposed Project, but all are dry holes that have been plugged and abandoned. There are no active or idle oil or gas wells within or adjacent to the Tracy to Lathrop segment.

There are no mapped geothermal wells within or in the vicinity of the Tracy to Lathrop segment (DOC 2018).

3.7.3.5 Paleontological Resources

This section describes the environmental setting related to paleontological resources. The analysis considers rock formations and recorded fossil sites at local and regional levels.

Paleontological Sensitivity

Paleontological sensitivity, an indicator of the likelihood of a geologic unit to yield fossils, is defined and discussed below. Unlike archaeological sites, which are narrowly defined, paleontological sites are defined by the entire extent (both areal and stratigraphic) of a unit or formation. Once a unit is identified as containing vertebrate fossils or other rare fossils, the entire unit is a paleontological site (SVP 2010). For this reason, the paleontological sensitivity of geologic units is described and analyzed broadly, rather than being limited to county boundaries.

The Impact Mitigation Guidelines Revisions Committee of the SVP has published Standard Guidelines (SVP 2010) that include procedures for the investigation, collection, preservation, and cataloguing of fossil-bearing sites. The Standard Guidelines are widely accepted among paleontologists and followed by most investigators. The Standard Guidelines identify the two key phases of paleontological resource protection as (1) assessment and (2) implementation. Assessment involves identifying the potential for a project site or area to contain significant nonrenewable paleontological resources that could be damaged or destroyed by project excavation or construction. Implementation involves formulating and applying measures to reduce such adverse effects. The SVP defines the level of potential as one of four sensitivity categories for sedimentary rocks: High, Undetermined, Low, and No Potential (SVP 2010).

- **High Potential.** Assigned to geologic units from which vertebrate or significant invertebrate, plant, or trace fossils have been recovered and to sedimentary rock units suitable for the preservation of fossils (e.g., middle Holocene and older, fine-grained fluvial sandstones fine-grained marine sandstones, etc.). Paleontological potential is the area's potential for yielding abundant fossils, a few significant fossils, and/or recovered evidence for new and significant taxonomic, phylogenetic, taphonomic, paleoecologic, biochronologic, or stratigraphic data.
- **Undetermined Potential.** Assigned to geologic units for which little information is available concerning paleontological content, geologic age, and depositional environment. In cases where no subsurface data already exist, paleontological potential can sometimes be assessed by subsurface site investigations.
- **Low Potential.** Field surveys or paleontological research may allow determination that a geologic unit has low potential for yielding significant fossils, e.g., basalt flows. Mitigation is generally not required to protect fossils.
- **No Potential.** Some geologic units have no potential to contain significant paleontological resources, such as high-grade metamorphic rocks (e.g., gneisses and schists) and plutonic igneous rocks (e.g., granites and diorites). Mitigation is not required.

Table 3.7-9 shows the paleontological sensitivity of the geologic units exposed at ground surface in the study area. In many cases, particularly for long, linear rail alignments, multiple types of geologic units are understood to underlie a particular proposed or alternative facility. Appendix N, *Supporting Geology, Soils, Seismicity, and Paleontological Information*, shows the geologic units in the study area.

Table 3.7-9. Geologic Units in the Paleontological Study Area

Symbol	Geologic Unit	Epoch	Paleontological Sensitivity [a]	Proposed or Alternative Facility
Q	Alluvium	Holocene	Low: This unit is likely too young to yield fossils.[b]	**Proposed Project** • Tri-Valley Alignment • Dublin/Pleasanton Station • Isabel Station • Altamont Alignment, including Owens-Illinois Industrial Lead Variant 1, Single Track and the Owens-Illinois Industrial Lead Variant 2, Double Track **Alternatives** • Southfront Road Station Alternative • West Tracy OMF Alternative
Qf	Alluvial fan deposits	Holocene	Low: This unit is likely too young to yield fossils.[b]	**Proposed Project** • Altamont Alignment, including Owens-Illinois Industrial Lead Variant 1, Single Track and Owens-Illinois Industrial Lead Variant 2, Double Track • Tracy OMF • Tracy to Lathrop Alignment Variant 1, Single Track • Tracy to Lathrop Alignment Variant 2, Double Track • Downtown Tracy Station **Alternatives** • Mountain House Station Alternative • Downtown Tracy Station Parking Alternative 1 • Downtown Tracy Station Parking Alternative 2
Qdp	Dos Palos alluvium	Holocene	Low: This unit is likely too young to yield fossils.[b]	**Proposed Project** • Tracy to Lathrop Alignment Variant 1, Single Track • Tracy to Lathrop Alignment Variant 2, Double Track • River Islands Station
Qm	Modesto Formation	Pleistocene	High: This unit has produced vertebrate fossils from multiple localities.[c]	**Proposed Project** • Tracy to Lathrop Alignment Variant 1, Single Track • Tracy to Lathrop Alignment Variant 2, Double Track • North Lathrop Station

Symbol	Geologic Unit	Epoch	Paleontological Sensitivity [a]	Proposed or Alternative Facility
Qo	Older alluvium	Holocene/ Pleistocene	High: Non-marine sedimentary deposits of Pleistocene age have potential to yield fossils.[d]	**Proposed Project** • Altamont Alignment, including Owens-Illinois Industrial Lead Variant 1, Single Track and Owens-Illinois Industrial Lead Variant 2, Double Track • Mountain House Station **Alternatives** • West Tracy OMF Alternative
QT	Plio-Pleistocene non-marine deposits (sand and gravel); corresponds to Livermore Gravels[e]	Pleistocene/ Pliocene	High: Non-marine sedimentary deposits of Pleistocene age have potential to yield fossils. Livermore Gravels have yielded vertebrate fossils.[f]	**Proposed Project** • Tri-Valley Alignment **Alternatives** • Southfront Road Station Alternative
Pta	Tassajara Formation	Pliocene	High: This unit has produced vertebrate fossils from multiple localities.[g]	**Proposed Project** • Tri-Valley Alignment • Isabel Station
Msp	San Pablo Group (marine sandstone)	Miocene	High: This unit has produced vertebrate fossils from multiple localities.[h]	**Proposed Project** • Tri-Valley Alignment • Greenville Station • Altamont Alignment, including Owens-Illinois Industrial Lead Variant 1, Single Track and Owens-Illinois Industrial Lead Variant 2, Double Track • Mountain House Station
Mf	Fanglomerate	Miocene	Undetermined: There are no records indicating potential to yield fossils; however, sedimentary deposits have potential to yield fossils.[i]	**Proposed Project** • Altamont Alignment, including Owens-Illinois Industrial Lead Variant 1, Single Track and Owens-Illinois Industrial Lead Variant 2, Double Track **Alternatives** • West Tracy OMF Alternative
Kp	Panoche Formation	Late Cretaceous	High: This unit has produced vertebrate fossils from a number of localities.[j]	**Proposed Project** • Altamont Alignment, including Owens-Illinois Industrial Lead Variant 1, Single Track and Owens-

Symbol	Geologic Unit	Epoch	Paleontological Sensitivity [a]	Proposed or Alternative Facility
				Illinois Industrial Lead Variant 2, Double Track • Interim OMF **Alternatives** • Stone Cut Alignment Alternative

[a] University of California Museum of Paleontology 2018a–2018f, 2019
[b] Geologic units younger than 5,000 years old are generally not considered old enough to contain fossils (SVP 2010; Wagner et al. 1991)
[c] Marchand and Allwardt 1981; University of California Museum of Paleontology 2018a
[d] University of California Museum of Paleontology 2019
[e] Plio-Pleistocene non-marine deposits (sand and gravel) in Wagner et al. (1991) are mapped to the same geographic extent where Livermore Gravels are mapped (e.g., Barlock 1989).
[f] Barlock 1989; University of California Museum of Paleontology 2018b
[g] CGS 2008a; University of California Museum of Paleontology 2018c
[h] Bartow 198;, University of California Museum of Paleontology 2018e
[i] University of California Museum of Paleontology 2019
[j] Shierer and Magoon 2007; University of California Museum of Paleontology 2018f

3.7.4 Impact Analysis

This section describes the Proposed Project's environmental impacts related to geology, soils, seismicity, and mineral and paleontological resources, as well as the impacts from the alternatives analyzed at an equal level of detail. It describes the methods used to evaluate the impacts and the thresholds used to determine whether an impact would be significant. Measures to mitigate significant impacts are provided, where appropriate.

3.7.4.1 Methods for Analysis

Geology, Soils, Seismicity, and Mineral Resources

The methodology used to evaluate the potential environmental impacts of and on the Proposed Project associated with geology, soils, seismicity, and mineral resources involved a review and assessment of published maps, professional publications, and reports pertaining to the study area. The information included USGS topographic maps; USGS, CGS, and other geologic, landslide, and liquefaction susceptibility maps; NRCS soil survey data; CGS Seismic Hazard Zone maps; USGS and CGS potential ground shaking maps; CGS Alquist-Priolo Earthquake Fault Zoning data; and USGS and State of California mineral land classification studies.

Impacts related to geology, soils, seismicity, and mineral resources have been analyzed qualitatively, based on a review of published geologic, seismic, soils, and minerals information for the study area and on professional judgment, in accordance with the current standard of care for geotechnical engineering and engineering geology. The analysis focuses on the construction and operational potential of the Proposed Project, including new facilities, to increase the risk of personal injury, loss of life, and damage to property as a result of existing geologic conditions in the study area or result in the loss of availability of known, regionally important mineral resource deposits.

Paleontological Resources

The fossil-yielding potential of geologic units in a particular area depends on the geologic age and origin of the units, as well as on the geologic and anthropogenic processes they have undergone. The methods used to analyze potential impacts on paleontological resources and develop mitigation for the identified impacts involved the following steps:

1. Assess the likelihood that the affected sediments contain scientifically important, nonrenewable paleontological resources that could be directly affected.
2. Identify the geologic units in the paleontological study area.
3. Evaluate the potential of the identified geologic units to contain significant fossils (i.e., their paleontological sensitivity).
4. Identify the geologic units that would be affected based on the depth of excavation—either at ground surface or below ground surface (at least 5 feet below ground surface [bgs]).
5. Identify and evaluate impacts on paleontologically sensitive geologic units that may occur as a result of construction and operation that involves ground disturbance.
6. Evaluate impact significance.
7. According to the identified degree of sensitivity, formulate and implement measures to mitigate potential impacts.

The potential of the Proposed Project to affect paleontological resources relates to ground disturbance. Ground disturbance would take place during construction phases; therefore, this impact analysis addresses construction impacts.

To identify the geologic units in the paleontological study area, the Geologic Map of the San Francisco–San Jose Quadrangle (Wagner et al. 1991) was consulted.

To evaluate the paleontological sensitivity of the geologic units, first the University of California Museum of Paleontology database was searched for records of fossils in these geologic units (University of California Museum of Paleontology 2018a, 2018b, 2018c, 2018d, 2018e, 2018f).

After the records search, the paleontological sensitivity of the units was assessed according to the Standard Guidelines published by the SVP (2010) and discussed above in Section 3.7.3.5, *Paleontological Resources*.

Based on data from the University of California Museum of Paleontology database, each geologic unit in the study area was assigned a paleontological sensitivity according to SVP's Standard Guidelines.

To identify and evaluate Project-related impacts on paleontologically sensitive geologic units, GIS was used to identify ground-disturbing activities, including the depth of ground disturbance, with respect to the location of geologic units with high and undetermined potential.

3.7.4.2 Thresholds of Significance

State CEQA Guidelines Appendix G (14 Cal. Code Regs. § 15000 et seq.) has identified significance criteria for consideration in determining whether a project could have significant impacts related to geology, soils, and mineral and paleontological resources. An impact would be considered significant if construction or operation of the Proposed Project and the alternatives analyzed at an equal level of detail would have any of the following consequences:

- Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:
  - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault (refer to Division of Mines and Geology Special Publication 42);
  - Strong seismic ground shaking;
  - Seismic-related ground failure, including liquefaction; or
  - Landslides.
- Result in substantial soil erosion or the loss of topsoil;
- Be located on a geologic unit or soil that is unstable or that would become unstable as a result of the Proposed Project and potentially result in on- or offsite landslide, lateral spreading, subsidence, liquefaction or collapse;
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property;
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater;
- Result in the loss of availability of a known mineral resource that would be a value to the region and the residents of the state;
- Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan; or
- Directly or indirect destroy a unique paleontological resource, site, or unique geologic feature.

3.7.4.3 Impacts and Mitigation Measures

Impact GEO-1: Construction or operation of the Proposed Project would not directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving surface fault rupture, strong seismic ground shaking, liquefaction, seiches, landslides, subsidence and settlement, expansive soils, corrosive soils, and erosion.

Level of Impact	**Less than significant** <u>Proposed Project</u> Tri-Valley Alignment Dublin/Pleasanton Station Isabel Station Greenville Station Altamont Alignment Interim OMF Owens-Illinois Industrial Lead Variant 1, Single Track Owens-Illinois Industrial Lead Variant 2, Double Track Mountain House Station Tracy OMF Tracy to Lathrop Alignment Variant 1, Single Track Tracy to Lathrop Alignment Variant 2, Double Track

	Downtown Tracy Station River Islands Station North Lathrop Station
	<u>Alternatives Analyzed at an Equal Level of Detail</u> Southfront Road Station Alternative Stone Cut Alignment Alternative West Tracy OMF Alternative Mountain House Station Alternative Downtown Tracy Station Parking Alternative 1 Downtown Tracy Station Parking Alternative 2
Mitigation Measures	**None Required**

Impact Characterization

Project-related construction, operation, and maintenance would be subject to hazards from all of the geologic, seismic, and soils effects identified above, including surface fault rupture, strong seismic ground shaking, liquefaction, earthquake-induced landslides, seiches, erosion, expansive and corrosive soils, subsidence and settlement, and landslides, as discussed further below. Table 3.7-10 shows the potential for the Proposed Project (including all track and technology variants), the station alternatives (Southfront Road Station Alternative, Mountain House Station Alternative, Downtown Tracy Station Parking Alternative 1, and Downtown Tracy Station Parking Alternative 2), the Stone Cut Alignment Alternative, and the West Tracy OMF Alternative, by segment, to be affected by specific geologic hazards.

Table 3.7-10. Geologic Hazards

Proposed or Alternative Facility	Surface Fault Rupture	Strong Seismic Ground Shaking	Liquefaction	Earthquake-Induced Landslides	Seiches	Erosion	Expansive Soil	Corrosive Soil	Subsidence and Settlement	Landslides
Tri-Valley Segment										
Tri-Valley Alignment	--	X	X	--	--	X	X	X	X	--
Dublin/Pleasanton Station	X	X	X	--	--	X	X	X	X	--
Greenville Station[1]	X	X	X	X	--	X	X	X	X	X
Southfront Road Station Alternative[1]	--	X	X	--	--	X	X	X	X	--
Altamont Segment										
Altamont Alignment	--	X	X	X	--	X	X	X	X	X
Stone Cut Alignment Alternative	--	X	X	X	--	X	X	X	X	X
Owens-Illinois Industrial Lead Variant 1, Single Track	--	X	X	X	X	X	X	X	X	X
Owens-Illinois Industrial Lead Variant 2, Double Track	--	X	X	X	X	X	X	X	X	X

Proposed or Alternative Facility	Surface Fault Rupture	Strong Seismic Ground Shaking	Liquefaction	Earthquake-Induced Landslides	Seiches	Erosion	Expansive Soil	Corrosive Soil	Subsidence and Settlement	Landslides
Interim OMF	--	X	X	X	--	X	X	X	X	X
Mountain House Station[1]	--	X	X	X	--	X	X	X	X	X
Tracy OMF	--	X	--	--	X	X	X	X	X	--
Mountain House Station Alternative[1]	--	X	--	--	X	X	X	X	X	--
West Tracy OMF Alternative	--	X	X	X	--	X	X	X	X	X
Tracy to Lathrop Segment										
Tracy to Lathrop Alignment Variant 1, Single Track	--	--	X	--	X	X	X	X	X	--
Tracy to Lathrop Alignment Variant 2, Double Track	--	--	X	--	X	X	X	X	X	--
Downtown Tracy Station	--	--	--	--	--	X	X	X	X	--
Downtown Tracy Station Parking Alternative 1	--	--	--	--	--	X	X	X	X	--
Downtown Tracy Station Parking Alternative 2	--	--	--	--	--	X	X	X	X	--
River Islands Station	--	--	X	--	X	X	X	X	X	--
North Lathrop Station	--	--	--	--	--	X	--	X	X	--

Source: Data compiled by AECOM in 2020.

[1] The footprint for the Greenville Station, Southfront Road Station Alternative, Mountain House Station, and Mountain House Station Alternative assumes the station footprints associated with phased implementation of the Proposed Project improvements and maximum station parking associated with an IOS potentially ending at one of the four stations.

Tri-Valley Segment

The Tri-Valley segment is located in a seismically active area. Three faults cross through the segment; two of these faults (i.e., Greenville and Pleasanton) are considered active and are included in the Alquist-Priolo Act (see Figures N-1 and N-2A). The proposed Greenville Station would be located within a designated Alquist-Priolo Earthquake Fault Zone associated with the Greenville fault. If the Greenville Station IOS were implemented, it would also be located within the boundary of this fault zone. As noted by LCI (2019), overall, available geologic and geomorphic mapping by the authors of several studies related to the Greenville Fault Zone have defined a relatively wide zone (up to 1.4–1.5 miles) of fault-related geomorphic features and historic ground rupture on the Livermore section of the Greenville fault. This area includes the Greenville Station (including the relocated Vasco Road Altamont Corridor Express [ACE] Station). The Alquist-Priolo Act regulates structures that are designed for human occupancy, defined as "any structure used or intended for supporting or sheltering any use or occupancy, which is expected to have a human occupancy rate of more than 2,000 person-hours per year" (Cal. Code Regs. Title 14, Division 2 § 3601(e)). The occupancy rate at the Greenville Station and the relocated Vasco Road ACE Station boarding platforms would meet the human occupancy threshold of the Alquist-Priolo Act. Therefore, a site-specific analysis of the Greenville Station (which includes the relocated Vasco Road ACE Station) is required prior to issuance of building permits.

The proposed Dublin/Pleasanton Station would be located adjacent to, but outside of, the boundaries of the Alquist-Priolo Earthquake Fault Zone associated with the Pleasanton fault. The proposed Isabel Station would be located adjacent to the fault trace of the Mocho fault; however, this fault is not classified as active by CGS, and therefore is not designated under the Alquist-Priolo Act.

Several active faults with high slip rates are located in the Tri-Valley region (see Table 3.7-2), and earthquakes with magnitudes of 4.0 or greater have occurred in the Tri-Valley region and the local Tri-Valley segment vicinity (see Figure N-3). The estimated PGAs for the Tri-Valley segment are high (CGS 2008b). These data indicate that there is a high potential for surface fault rupture along the Pleasanton or Greenville faults (which would affect the Proposed Project within the Tri-Valley segment, except the Isabel Station and the Southfront Road Station Alternative), and there is a high potential for strong seismic ground shaking throughout the Tri-Valley segment.

Most of the Tri-Valley segment has a moderate susceptibility to liquefaction, with a high susceptibility where the Proposed Project would cross streambeds, where the soil conditions are loose and unconsolidated and the depth to groundwater is extremely shallow (see Figure N-4 and Table 3.7-3). As a result of the high potential for seismic activity and the nature of the unconsolidated alluvial soils found throughout the Tri-Valley segment, CGS has included most of the Tri-Valley segment in a liquefaction hazard zone (see Figure N-5), which requires a site-specific analysis prior to issuance of building permits.

Only a few mapped landslides are located within the Tri-Valley segment (see Figure N-6A), and the CGS landslide hazard zones (see Figure N-7) correspond to these areas. Construction in a designated earthquake-induced landslide hazard zone requires a site-specific analysis prior to issuance of building permits. Landslide hazards in the Tri-Valley segment, whether induced by seismic hazards or some other form of instability, such as construction-related slope destabilization or heavy rainfall, would only affect the Proposed Project between Cayetano Creek and First Street (Tri-Valley Alignment) and the vicinity of Greenville Road (Greenville Station).

The wastewater ponds associated with the Pleasanton Quarry operated by Vulcan Materials, south of I-580 between Livermore and Pleasanton, could be subject to seiche activity in the event of a strong earthquake, which could affect the Tri-Valley Alignment.

The water erosion hazard throughout most of the Tri-Valley segment is generally moderate, but a high water erosion hazard is present between Tassajara Creek and Fallon Road/El Charro Road (see Figure N-10A and Table 3.7-4). The wind erosion hazard is similar to the water erosion hazard (see Table 3.7-4). Therefore, the Proposed Project including stations and station alternatives in the Tri-Valley segment could result in an erosion hazard.

As shown in Figure N-9A and Table 3.7-4, the shrink-swell potential along most of the Tri-Valley segment ranges from moderate to very high. Only the Isabel Station would not be subject to hazards from shrink-swell potential.

In general, there is a high potential for corrosion of steel and a moderate potential for corrosion of concrete in the Tri-Valley segment (see Table 3.7-4). Therefore, the Proposed Project (including stations and station alternatives) in the Tri-Valley segment could be subject to hazards from soil corrosion.

Because the Tri-Valley segment would be constructed in areas of recent (Historic) and Holocene-age streambed deposits, there is a potential for subsidence and settlement in these soft, unconsolidated sediments. Subsidence and settlement could also occur in other areas. A geotechnical report is required in order to identify site-specific areas where subsidence and settlement could occur as well as the amount of anticipated settlement. Therefore, the Proposed Project (including stations and station alternatives) in the Tri-Valley segment could be subject to hazards from subsidence and settlement.

Altamont Segment

Within the Altamont segment, the Altamont Alignment would be subject to hazards from surface fault rupture along the Greenville Fault Zone (see Figure N-2B). Based on the proximity to known active faults (see Figure N-1 and Table 3.7-2), the number and proximity of historic earthquakes (see Figure N-3), and the estimated PGA, the Proposed Project (including stations and OMFs in the Altamont segment) would be subject to a moderate level of seismic ground shaking.

The Altamont segment has a moderate to high susceptibility to liquefaction where the Proposed Project would cross over streambeds (see Figure N-4 and Table 3.7-6). Only the facilities east of I-580 would be unaffected by liquefaction hazards (Mountain House Station Alternative, and Tracy OMF).

Landslide hazards, whether induced by seismic hazards or some other form of instability, such as construction-related slope destabilization or heavy rainfall, are present throughout the Altamont segment west of I-580 (see Figure N-6B). In particular, fieldwork performed by AECOM in February 2019 identified four large and several smaller active landslide areas, in addition to areas of active rockfall hazards, along the proposed Altamont Alignment. Furthermore, the Stone Cut Alignment Alternative would cross through several known large mapped landslide deposits, as well as areas where landslide deposits may be present (mapped as “uncertain”). The Interim OMF would also be located in a mapped landslide deposit. CGS has included most of the western half of the Altamont segment in an earthquake-induced landslide hazard zone (see Figure N-7), which requires a site-specific analysis prior to issuance of building permits. Only the facilities east of I-580 would be unaffected by landslide hazards (Mountain House Station Alternative and Tracy OMF).

The Altamont Alignment (including both alignment variants) would cross over the California Aqueduct and the Delta-Mendota Canal, on the east side of I-580. Therefore, the Altamont Alignment, inclusive of Owens-Illinois Industrial Lead Variant 1, Single Track and Owens-Illinois Industrial Lead Variant 2, Double Track; Mountain House Station Alternative; and Tracy OMF could be subject to flooding hazards from seismic seiches in the canals.

The water erosion hazard throughout most of the Altamont segment is moderate (see Figure N-10B and Table 3.7-6). The wind erosion hazard is similar to the water erosion hazard (see Table 3.7-6). Therefore, the Proposed Project, including all alignment variants, stations, station alternatives, and OMFs in the Altamont segment, could result in an erosion hazard.

As shown in Figure N-9B and Table 3.7-6, the shrink-swell potential along most of the Altamont segment ranges from moderate to very high. Therefore, the Proposed Project, including stations and OMFs in the Altamont segment, could be subject to hazards from expansive soils.

In general, there is a high potential for corrosion of steel and a moderate potential for corrosion of concrete in the Altamont segment (see Table 3.7-6). Therefore, the Proposed Project, including all alignment variants, stations, station alternatives, and OMFs in the Altamont segment, could be subject to hazards from soil corrosion. Most of the Altamont Alignment would be constructed in Mesozoic-age bedrock, which is not subject to subsidence or settlement. However, portions of the Altamont Alignment would be constructed in areas of recent (Historic) and Holocene-age streambed deposits, and there is a potential for subsidence and settlement in these soft, unconsolidated sediments. Subsidence and settlement could also occur in other areas, such as flatland deposits east of I-580 where the Mountain House Station Alternative and Tracy OMF would be located. A geotechnical report is required in order to identify site-specific areas where subsidence and settlement could occur, as well as the amount of anticipated settlement. Therefore, the Proposed Project, including all alignment variants, stations, station alternatives, and OMFs in the Altamont segment, could be subject to hazards from subsidence and settlement.

Tracy to Lathrop

The Tracy to Lathrop segment is not located in a seismically active area. There are no active earthquake faults in the Project area, and the estimated PGA is low. Therefore, the Proposed Project (including all alignment variants and station alternatives) in the Tracy to Lathrop segment would not be subject to hazards from surface fault rupture or strong seismic ground shaking.

Because of the greater depth to groundwater, longer distance to active seismic sources, and the generally well-consolidated Pleistocene-age rock formations, most areas within the Tracy to Lathrop segment are likely to have a low liquefaction potential. However, a moderate liquefaction hazard may be present in the vicinity of the San Joaquin River, where the groundwater table is shallow, and the sediments are loose and unconsolidated. Therefore, Tracy to Lathrop Alignment Variant 1, Single Track, Tracy to Lathrop Alignment Variant 2, Double Track (near the San Joaquin River), and the River Islands Station could be affected by liquefaction hazards.

The Tracy to Lathrop segment is flat and is not located adjacent to any mountainous areas. Therefore, the Proposed Project (including all alignment variants and station alternatives) in the Tracy to Lathrop Altamont segment would not be subject to hazards from earthquake-induced or other types of landslides.

Several large bodies of standing water are present in the vicinity of the Tracy to Lathrop segment, including the San Joaquin River and Paradise Cut during high-flow conditions when they are full of water, the wastewater ponds associated with the Brown Sand Mossdale Quarry, and the lakes at River Islands. Therefore, Tracy to Lathrop Alignment Variant 1, Single Track, Tracy to Lathrop Alignment Variant 2, Double Track (near Paradise Cut and the San Joaquin River), and the River Islands Station could be subject to flooding from seismic seiches.

The water erosion hazard throughout most of the Tracy to Lathrop segment is moderate (see Figure N-10C and Table 3.7-8). The wind erosion hazard is high from the east side of the San Joaquin River to the northeastern end of the Tracy to Lathrop segment (see Table 3.7-8). Therefore, the Proposed Project (including all alignment variants and station alternatives) in the Tracy to Lathrop segment could result in an erosion hazard.

The shrink-swell potential is very high for the Tracy to Lathrop Alignment Variant 1, Single Track and Tracy to Lathrop Alignment Variant 2, Double Track in the vicinity of the Westside Water District's Upper Main Canal and from downtown Tracy to Banta, along with the Downtown Tracy Station (see Figure N-9C and Table 3.7-8).

In general, there is a high potential for corrosion of steel and a moderate potential for corrosion of concrete in most of the Tracy to Lathrop segment (see Table 3.7-8). Therefore, the Proposed Project (including all alignment variants and station alternatives) in the Tracy to Lathrop segment could be subject to hazards from soil corrosion.

Subsidence and settlement could represent hazards throughout the Tracy to Lathrop segment in areas where loose, unconsolidated deposits are present near streambeds. Therefore, the Proposed Project (including all alignment variants and station alternatives) in the Tracy to Lathrop segment (including all variants and alternatives) could be subject to hazards from subsidence and settlement.

Impact Detail and Conclusions

Proposed Project

Geologically hazardous conditions, including seismic events or ground failure, could occur within the Proposed Project, which could potentially affect the project's design and construction, as well as the operation of trains, causing structural damage and resulting in injury or death. Proposed Project facilities throughout the Tri-Valley and Altamont segments would be subject to seismic hazards, such as surface fault rupture, strong seismic ground shaking, liquefaction, seiches, seismically induced settlement, and landslides. Expansive soils, corrosion of steel, and subsidence and settlement from construction in unconsolidated alluvial deposits also represent hazards in all three segments.

Seismic Hazards

The Alquist-Priolo Act regulates structures that are designed for human occupancy; this act specifically relates to the proposed Greenville Station (which includes two boarding platforms: one for Valley Link rail service and one for ACE rail service associated with the relocated Vasco Road Station). It also applies to the Greenville IOS, if implemented.

A Phase 1 Surface Fault Rupture Hazard Study (LCI 2019) was prepared for the proposed Greenville Station. The Phase 1 Study consisted of a review of scientific literature, unpublished consultant reports, geologic maps, aerial and satellite imagery, and topographic data; consultation with CGS officials; and a reconnaissance-level field visit to assess the likelihood of active faulting and surface rupture at the two sites. The Phase 1 Study did not include subsurface fieldwork. Preliminary conclusions based on the Phase 1 Study are briefly summarized below.

Hart (Hart 1981) mapped a well-defined lineament (interpreted as a fault trace) of the Greenville fault that traverses the proposed Greenville Station boarding platform and the proposed location of the relocated Vasco Road ACE boarding platform (see the solid red line identified as Lineament 1 shown on Figure N-12). Hart indicated that this fault trace displayed evidence of activity during the Historic time period (i.e., the last 200 years), and therefore is considered active. Several subsequent subsurface studies in the project vicinity confirmed the presence of this fault trace that runs through the proposed Greenville Station and the proposed location of the relocated Vasco Road ACE boarding platform. In addition, the most recent mapping of the Greenville fault by USGS (Graymer et al. 2006) indicated the presence of a separate bedrock fault trace that also intersects the Greenville Station and the proposed location of the relocated Vasco Road ACE boarding platform (see the solid black line through the boarding platforms shown on Figure N-12). The results of subsurface trenching conducted during various fault investigation studies in the Project area (shown on Figure N-12) indicated that several of the mapped fault traces, including Lineament 1 mapped by Hart, may not be active. However, LCI concluded that based on the results of previous studies reviewed as part of the Phase 1 Study, coseismic slip (fault motion during earthquakes) is likely being transferred either to the west along poorly assessed fault(s) and/or to the east along the well-defined eastern fault trace (Lineament 1), which traverses the proposed Greenville Station. LCI further indicated that studies of fault creep in the Project area suggest the eastern part of the Greenville Fault Zone is indeed accommodating some of the fault's coseismic slip (Hart 1981; LCI 2019).

The location of Hart's well-defined eastern-most fault strand of the Greenville Fault Zone (Lineament 1) was observed during LCI's field reconnaissance within a bedrock railroad cut along the east side of the Western Pacific Railroad tracks. However, the field reconnaissance was unable to confirm the presence of the fault trace mapped by Graymer et al. (2006); however, LCI suggested that the limited railroad cut exposure near the mapped fault trace may be too poor to resolve the presence and location of the fault trace.

LCI also reviewed the results of studies conducted south of I-580 near Greenville Road in the vicinity of the proposed parking lots associated with the Greenville Station IOS. Trenching conducted for these studies west of the Greenville Station IOS indicated that active faults were not present and that faults and lineaments previously mapped across the parcel west of the Greenville Station IOS by CGS and USGS are inactive and/or may not exist. However, as stated above, LCI concluded that the data collectively support a model in which coseismic slip from the northwest is transferred to the southeast along the eastern part of the Greenville Fault Zone in the Project area.

With regard to facilities that would be located south of I-580, the well-defined easternmost Lineament 1 of the Greenville Fault zone does not intersect the proposed parking at the Greenville Station IOS south of I-580. However, the fault trace mapped by Graymer et al., if indeed it is present, does intersect the proposed parking at the Greenville Station IOS south of I-580. In the absence of subsurface trenching, it is not possible to ascertain whether or not the fault mapped by Graymer et al. is indeed present or whether it is active (i.e., displays evidence of activity during the Holocene epoch) (Graymer et al. 2006).

LCI concluded that given the uncertainties surrounding what is likely a complex step-over structure of the Greenville Fault in the vicinity of the proposed Greenville Station (including the relocated Vasco Road ACE Station) and the parking south of I-580 as part of the Greenville Station IOS, additional studies that include subsurface trenching should be performed to definitively assess the presence or absence of faulting within the footprint of both of the proposed platforms (LCI 2019).

It should be noted that the proposed parking south of I-580 associated with the Greenville Station IOS, if implemented, would not include any structures. This area would only include paved surface parking lots, landscaping, and lighting.

Liquefaction and Landslides

For those portions of the Proposed Project in the Tri-Valley and Altamont segments that would be located in zones of required investigation for liquefaction and landslides, site-specific investigations would be performed and submitted to the appropriate permitting agency as required by law. Standard engineering practices (discussed in greater detail below under the *Geotechnical and Engineering Design Standards* heading) would be employed during the Proposed Project's design, engineering, and construction phase to reduce potential damage from seismic activity and other geologic hazards (e.g., soil expansion) to the maximum extent practicable.

Seiche Hazards

In terms of seiche hazards, the Pleasanton Quarry ponds in the Tri-Valley segment are approximately 0.75 mile south of the Tri-Valley Alignment, surrounded by tall berms, and approximately 65 feet lower in elevation than the Proposed Project at I-580 (at the closest point). The California Aqueduct and the Delta-Mendota Canal (both in the Altamont segment) were constructed using standard engineering practices that include berms on both sides, concrete-lined channels, and extra freeboard, all of which would reduce the hazard from seismic seiches. Paradise Cut and the San Joaquin River (in the Tracy to Lathrop segment) are bounded by levees on both sides, which were constructed in accordance with U.S. Army Corps of Engineers specifications and California Department of Water Resources Urban Levee Design Criteria that are designed to reduce seismic hazards such as seiches. The Brown Sand Mossdale Quarry ponds (also in the Tracy to Lathrop segment) are surrounded by tall earthen berms and are approximately 15 feet lower in elevation than the River Island Station. Therefore, seismic seiches are not likely to represent a hazard to the Proposed Project in any of the three segments.

Geotechnical and Engineering Design Standards

As discussed above, a variety of geotechnical and engineering design standards, specifications, and regulations are specifically intended to reduce geologic and seismic hazards and would be implemented as part of the Proposed Project. These include AASHTO, AREMA, UPRR, Caltrans, and FHWA requirements. Compliance with the CBC is required by law (Cal. Code Regs. Title 24). Design and construction of the Proposed Project would be conducted in accordance with and using these standards, which identify minimum requirements for preparing site-specific design-level geotechnical reports characterizing the geologic conditions, defining seismic loads, evaluating the response of the foundation systems, and addressing potential hazards, such as strong seismic ground shaking, slope stability, shrink-swell potential, and corrosion of materials. Examples of the types of design and construction practices to reduce geologic and seismic hazards, which are required by these standards and regulations, are listed below.

- **Surface fault rupture**. Prepare a site-specific fault investigation report that includes subsurface trenching for traces of the Greenville fault at the Greenville Station (including the relocated Vasco Road ACE Station). If the results of the fault investigation report determine that active fault traces are not present underneath the Greenville Station or the relocated Vasco Road ACE Station, then design and construct facilities to the maximum level of seismic protection (i.e., CBC Site Category F), and incorporate engineering practices such as ground stabilization, selection of appropriate foundation type and depths, and selection of appropriate structural systems to accommodate anticipated displacements as directed in a geotechnical report prepared by a licensed geotechnical engineer. If the results of the site-specific fault investigation report determine that active fault traces are present underneath either the Greenville Station or the relocated Vasco Road ACE Station, then relocate the boarding platform(s) to the southwest of the identified active fault trace(s) at the required distance from the fault(s) as identified in the fault investigation report and include design features that incorporate the potential for secondary and tertiary deformation from fault movement as directed by a licensed geotechnical engineer in the geotechnical report. Preparation of a geotechnical report is required by the CBC. Preparation of a site-specific fault investigation report is required by the Alquist-Priolo Act (Public Res. Code §§ 2621–2630).
- **Strong seismic ground shaking**. Install additional rebar and tie-downs at critical building joints.

- **Liquefaction**. Construct foundations using deep piers and pilings, compact the soil.
- **Expansive soils**. Treat soil with lime to reduce expansive characteristics, or excavate expansive soil and replace with clean fill dirt.
- **Corrosive soils**. Provide cathodic protection and/or increase dimensions of foundation elements, and coat buried steel.
- **Erosion**. Protect sloping embankment fill surfaces, armor stream banks, and control surface runoff in concrete V-ditches.
- **Landslides**. Excavate and/or stabilize (e.g., with retaining walls, tie backs, soil nails, buttress, dewater, and control of surface runoff) unstable materials, and install rockfall fences to further prevent mudflow, debris, and rocks from accessing the tracks.
- **Subsidenc**e. Raise track elevation through re-ballasting.

In addition, UPRR has practices in place for routine track inspections, as required by the Federal Railroad Administration. Inspectors verify the integrity of the track prior to the operation of trains on the track. Routine inspection and special inspections pursuant to 49 CFR § 213.239 would ensure train operators were notified in advance of damage to the tracks associated with natural disasters, such as an earthquake. This procedure would prevent hazards associated with these events as well as any secondary seismic effects, such as surface faulting, earthquake-induced landslides, or liquefaction.

Finally, erosion hazards during construction activities in all three segments would be prevented by standard measures required as part of the NPDES program, as described in Section 3.10, *Hydrology and Water Quality*. These measures include preparation of an SWPPP and implementation of BMPs that are specifically designed to reduce construction-related stormwater and subsequent erosion.

Therefore, for all of the reasons discussed above, impacts from geologic, seismic, and soils hazards, including the risk of loss, injury, or death involving surface fault rupture, strong seismic ground shaking, liquefaction, seiches, landslides, subsidence and settlement, expansive soils, corrosive soils, and erosion, would be less than significant. No mitigation measures are required.

Alternatives Analyzed at an Equal Level of Detail

As indicated in Table 3.7-10, the Southfront Road Station Alternative (in the Tri-Valley segment) would not be subject to hazards from surface fault rupture, earthquake-induced landslides, seiches, or landslides caused by other factors. However, the Southfront Road Station Alternative would be subject to hazards from strong seismic ground shaking, liquefaction, subsidence and settlement, erosion, expansive soils, and corrosive soils.

The Stone Cut Alignment Alternative and the West Tracy OMF Alternative (both in the Altamont segment) would be subject to hazards from earthquake-induced landslides, landslides caused by other factors, strong seismic ground shaking, liquefaction, erosion, expansive soils, and corrosive soils. The Mountain House Station Alternative, also in the Altamont segment, would be subject to strong seismic ground shaking, seiches, subsidence and settlement, erosion, expansive soils, and corrosive soils.

Downtown Tracy Parking Alternative 1 and Downtown Tracy Parking Alternative 2 would both be subject to hazards from subsidence and settlement, erosion, expansive soil, and corrosive soil.

Comparison of Alternatives

As summarized in Table 3.7-10, unlike the Greenville Station and the Greenville Station IOS if implemented (Proposed Project) that would be subject to hazards from surface fault rupture, seismically-induced landslides, landslides caused by other factors, and liquefaction, the Southfront Road Station Alternative would not be subject to any of these hazards. Nonetheless, both stations would result in less-than-significant impacts (after preparation of the required fault zone investigation and before the issuance of construction permits, boarding platform(s) associated with the Greenville Station and/or the relocated Vasco Road ACE Station would be relocated if subsurface fault investigations determine that the Greenville fault traces in these locations are active, as required by law under the Alquist-Priolo Act).

As also summarized in Table 3.7-10, the Stone Cut Alignment Alternative would be subject to the same geologic hazards as the Altamont Alignment; however, both these facilities would result in less-than-significant impacts.

As summarized in Table 3.7-10, the West Tracy OMF Alternative would be affected by more serious geologic hazards than the Tracy OMF (Proposed Project), including strong seismic ground shaking, liquefaction, and earthquake-induced landslides. Nonetheless, both OMFs would result in a less-than-significant impact.

As summarized in Table 3.7-10, the Mountain House Station Alternative would be affected by less geologic hazards than the proposed Mountain House Station (six geologic hazards compared to eight). Thus, the Mountain House Station Alternative would have a slightly less severe impact than the proposed Mountain House Station. Nonetheless, both stations would result in a less-than-significant impact.

Impact GEO-2: Construction or operation of the Proposed Project would occur in soils that are incapable of adequately supporting the use of conventional septic systems, and could also result in degradation of groundwater quality.

Level of Impact	**Less than Significant** <u>Alternatives Analyzed at an Equal Level of Detail</u> West Tracy OMF Alternative **No Impact** <u>Proposed Project</u> Tri-Valley Alignment Dublin/Pleasanton Station Isabel Station Greenville Station Altamont Alignment Owens-Illinois Industrial Lead Variant 1, Single Track Owens-Illinois Industrial Lead Variant 2, Double Track Mountain House Station Tracy OMF Tracy to Lathrop Alignment Variant 1, Single Track Tracy to Lathrop Alignment Variant 2, Double Track Downtown Tracy Station

	River Islands Station North Lathrop Station <u>Alternatives Analyzed at an Equal Level of Detail</u> Southfront Road Station Alternative Stone Cut Alignment Alternative Mountain House Station Alternative Downtown Tracy Station Parking Alternative 1 Downtown Tracy Station Parking Alternative 2
Mitigation Measures	**None Required**

Impact Characterization

Impacts would occur if construction or operation of the Proposed Project or alternatives analyzed at an equal level of detail would require the construction of septic systems that may, due to geologic conditions at the installation site, degrade groundwater quality.

Impact Detail and Conclusions

Proposed Project

The Proposed Project would not require the use of septic systems. Thus, there would be no impact.

Alternatives Analyzed at an Equal Level of Detail

The West Tracy OMF Alternative would require the construction and operation of an on-site septic system for wastewater treatment. NRCS (2018) has rated the soils at the West Tracy OMF Alternative site as very limited for use with conventional septic systems because of the shallow depth to groundwater, low rate of water transmission, ponding of water on the surface, and steep slopes.

Septic systems in San Joaquin County are regulated under the San Joaquin County Local Agency Management Program (LAMP) adopted by the Central Valley RWQCB in 2017 (San Joaquin County Environmental Health Department [SJEHD] 2016), and must also comply with County onsite wastewater treatment system (OWTS) requirements contained in the *Water Quality Control Policy for Siting, Design, Operation, and Maintenance of Onsite Wastewater Treatment Systems* (SJEHD 2017). Therefore, the West Tracy OMF Alternative site is subject to LAMP and OWTS regulations that are enforced by SJEHD.

Before a septic system can be installed, San Joaquin County regulations require that the applicant obtain a septic system permit from SJEHD as part of the SWRCB requirements under the LAMP. During the application process, the County department consults with applicants on a case-by-case basis to determine the specific requirements at any given project site prior to issuance of a permit, which would include a perc test conducted by a registered civil or geotechnical engineer. For the Proposed Project, SJEHD would also require the use of engineered systems since conventional septic systems are inappropriate, and would also include a requirement for groundwater monitoring to ensure that appropriate water quality levels are maintained. The results of these tests would determine what types of wastewater treatment facilities may be constructed. Compliance with LAMP requirements and with conditions included in the permit to protect water quality, including the requirement for groundwater monitoring, would ensure that water quality would not be adversely affected from OWTS operation. Because SJEHD and LAMP regulatory requirements are specifically designed to reduce adverse environmental effects of OWTS systems on the environment, this impact is considered less than significant. No mitigation measures are required.

None of the other alternatives analyzed at an equal level of detail (including the Southfront Road Alternative Station, Stone Cut Alignment Alternative, Mountain House Station Alternative, Downtown Tracy Parking Alternative 1, and Downtown Tracy Parking Alternative 2) would require the use of septic systems. Thus, there would be no impact.

Comparison of Alternatives

Because the West Tracy OMF Alternative would require the construction and operation of OWTS, this facility has a greater potential for adverse impacts as compared to the Tracy OMF (Proposed Project). However, OWTS impacts would be less than significant as a result of compliance with State and local regulatory controls, which is required by law.

Impact GEO-3: Construction or operation of the Proposed Project would not result in a loss of availability of regionally or locally important mineral resources.

Level of Impact	**Less than Significant** Proposed Project Tracy to Lathrop Alignment Variant 1, Single Track Tracy to Lathrop Alignment Variant 2, Double Track **No Impact** Proposed Project Tri-Valley Alignment Dublin/Pleasanton Station Isabel Station Greenville Station Altamont Alignment Interim OMF Owens-Illinois Industrial Lead Variant 1, Single Track Owens-Illinois Industrial Lead Variant 2, Double Track Mountain House Station Tracy OMF Downtown Tracy Station River Islands Station North Lathrop Station Alternatives Analyzed at an Equal Level of Detail: Southfront Road Station Alternative Stone Cut Alignment Alternative West Tracy OMF Alternative Mountain House Station Alternative Downtown Tracy Station Parking Alternative 1 Downtown Tracy Station Parking Alternative 2
Mitigation Measures	**None Required**

Impact Detail and Conclusions

Proposed Project

There are no mapped geothermal resources within or in the vicinity of the Proposed Project in any of the three segments (DOC 2018). Oil and gas wells adjacent to the Proposed Project footprint have all been plugged and abandoned. There are no active or idle oil or gas wells within or adjacent to the Proposed Project in any of the three segments (DOGGR 2018). Construction and operational activities associated with the Proposed Project would have no impact on oil, gas, or geothermal resources, since no active or idle wells are located within or adjacent to the Proposed Project footprint in any of the three segments.

As shown in Figure N-11A, the Tri-Valley segment has been classified by CGS as either MRZ-1 (no mineral resources) or MRZ-4 (no information is known). The Altamont segment has not been classified by CGS; however, this area consists primarily of Mesozoic-age bedrock of the Diablo Range, which does not serve as a good source material for construction aggregate. The Alameda County General Plan (Alameda County 1994) indicates that the only sources of aggregate mineral resources in the vicinity of the Tri-Valley or Altamont segments are the alluvial deposits along the Arroyo Mocho and Arroyo del Valle stream channels. Thus, the Tri-Valley and Altamont segments would not be located in any regionally or locally important mineral deposits (i.e., areas classified as MRZ-2). Thus, facilities associated with the Proposed Project in the Tri-Valley and Altamont segments would have no impact on mineral resources.

As shown in Figure N-11B, most of the Tracy to Lathrop segment has been classified by CGS as either MRZ-1 (no mineral resources) or MRZ-3 (mineral resources of unknown significance). There is, however, an approximately 1-mile-long segment of the Proposed Project, associated with Tracy to Lathrop Alignment Variant 1, Single Track and Tracy to Lathrop Alignment Variant 2, Double Track (near the San Joaquin River), that would be constructed in an area of regionally important mineral deposits (i.e., areas classified as MRZ-2). Much of this area is encompassed by the Brown Sand Mossdale Quarry, which has been and continues to mine sand and aggregate. Remaining portions of this MRZ-2 area are underneath the Del Osso Family Farm (partially paved and open to the public) and the Mossdale County Park north of I-5 (where mining activities are not permitted), and underneath existing agricultural fields south of I-5 and north of Oakwood Lake. The San Joaquin County 2035 General Plan (San Joaquin County 2016) indicates that locally important sources of aggregate mineral resources in the vicinity of the Tracy to Lathrop segment consist of the alluvial deposits located south of Tracy near Carbona and the alluvial deposits in the vicinity of the San Joaquin River. These are the same deposits classified by CGS as MRZ-2 and shown on Figure N-11B. San Joaquin County General Plan Policy NCR-4.2 requires that all new development in areas of significant sand and gravel deposits as identified by the State Division of Mines and Geology (i.e., areas designated MRZ-2), must obtain a discretionary permit that is conditioned to protect the mineral resources (San Joaquin County 2016). Proposed track in this area would be located within the existing UPRR ROW. There are no mining activities adjacent to the UPRR ROW, nor would the new track impede any future mining activities (if such were to occur). Thus, for the reasons stated above, the Proposed Project (including construction of Tracy to Lathrop Alignment Variant 1, Single Track and Tracy to Lathrop Alignment Variant 2, Double Track) would have a less-than-significant impact on mineral resources. No mitigation measures are required.

Alternatives Analyzed at an Equal Level of Detail

Alternatives analyzed at an equal level of detail (Southfront Road Station Alternative, Stone Cut Alignment Alternative, West Tracy OMF Alternative, Mountain House Station Alternative, Downtown Tracy Parking Alternative 1, and Downtown Tracy Parking Alternative 2) would be located in similar areas as the Proposed Project (Greenville Station, Altamont Alignment, Tracy OMF, Mountain House Station, and Downtown Tracy Station). Neither the alternatives nor their corresponding Proposed Project station, alignment, or OMF would be located in areas containing significant mineral deposits; therefore, the impacts among the alternatives and the Proposed Project would be the same (i.e., no impact).

Impact GEO-4: Construction of the Proposed Project could directly or indirectly destroy a unique paleontological resource or site or unique geological feature.

Level of Impact Prior to Mitigation	**Potentially Significant (mitigation required)** Proposed Project Tri-Valley Alignment Isabel Station Greenville Station Southfront Road Station Alternative Altamont Alignment Owens-Illinois Industrial Lead Variant 1, Single Track Owens-Illinois Industrial Lead Variant 2, Double Track Interim OMF Mountain House Station Tracy OMF Tracy to Lathrop Alignment Variant 1, Single Track Tracy to Lathrop Alignment Variant 2, Double Track River Islands Station North Lathrop Station Alternatives Analyzed at an Equal Level of Detail Southfront Road Station Alternative Stone Cut Alignment Alternative Mountain House Station Alternative West Tracy OMF Alternative **Less than Significant** Proposed Project Dublin/Pleasanton Station Downtown Tracy Station Tracy OMF Alternatives Analyzed at an Equal Level of Detail Downtown Tracy Station Parking Alternative 1 Downtown Tracy Station Parking Alternative 2 West Tracy OMF

Mitigation Measure	Mitigation Measure GEO-4.1: Monitor for discovery of paleontological resources, evaluate found resources, and prepare and follow a recovery plan for found resources.
Level of Impact after Mitigation	**Less than Significant**

Impact Characterization

The potential for impacts on paleontological resources depends on whether the Proposed Project would disturb geologic units with undetermined or high paleontological sensitivity. Many proposed alignments, stations, and OMFs would occur on geologic units with undetermined or high paleontological sensitivity. Construction would require ground disturbance, which could affect significant paleontological resources. Likewise, construction of the Southfront Road Station Alternative, Stone Cut Alignment Alternative, West Tracy OMF Alternative, or Mountain House Station Alternative would require ground disturbance that could affect significant paleontological resources.

Operational activities for the Proposed Project are not anticipated to be ground-disturbing and thus are not expected to have any significant impact on paleontological resources. Similarly, operational activities for the alternatives analyzed at an equal level of detail are not expected to have any significant impact on paleontological resources.

Impact Detail and Conclusions

The potential for impacts on paleontological resources relates to the paleontological sensitivity of the geologic units—that is, their potential to produce significant (scientifically important) fossil materials—involved in ground disturbance associated with construction. The Proposed Project (except for the Dublin/Pleasanton station and Downtown Tracy Station), the Southfront Road Station Alternative, Stone Cut Alignment Alternative, West Tracy OMF Alternative, and Mountain House Station Alternative would be located constructed in areas that are underlain by geologic units that have yielded abundant, diverse, and scientifically important fossil finds, including numerous vertebrate remains.

Where geologic units with high paleontological sensitivity are present, excavation-related ground disturbance associated with construction of previously undisturbed units could result in disturbance, damage, or loss affecting other significant (scientifically important but non-unique) paleontological resources. Impacts are possible in two situations:

- Where strata with high paleontological sensitivity are exposed at the ground surface in areas subject to ground-disturbing activities, such as grading; or
- Where highly sensitive units are not surface-exposed, but ground disturbance would extend deep enough to involve underlying highly sensitive materials, such as excavation for foundations.

Ground-disturbing activities associated with construction generally involve grading, excavating, and drilling and placing piles. Of these, grading and excavating can disturb paleontological resources. Drilling and placing piles disturbs a relatively small area and is not considered substantial enough to disturb paleontological resources.

As discussed in Chapter 2, *Project Description*, construction would involve construction of track, relocation of utilities, construction of track-supporting structures and grade separation structures, and construction of stations and maintenance facilities. Construction of track would involve grading for the track subgrade. Construction of bridges (including grade separations) would involve grading for temporary construction access roads, drilling and placing piles, and excavating for foundations. Construction of stations and maintenance facilities would involve grading for parking structures, rough grading for stations and pedestrian overpasses and underpasses, structural excavation for walls, and excavation for installation of utilities. Most of these activities would involve excavation at depths greater than 5 feet bgs.

The text below discusses the geologic unit that would be disturbed, its paleontological sensitivity, depth of disturbance, and the construction activities that could cause the disturbance.

The potential to affect fossils varies with the depth of disturbance, previous disturbance, and the improvement that would be implemented. The logistics of excavation also affect the possibility of recovering scientifically significant fossils because information regarding location, vertical elevation, geologic unit of origin, and other aspects of context is critical to the significance of any paleontological discovery. Disturbance of, damage to, or loss of paleontological resources with undetermined or high sensitivity would constitute a significant impact. Table 3.7-11 summarizes this information in tabular format.

Proposed Project

Tri-Valley Alignment

The Tri-Valley Alignment would be constructed on alluvium (Q), Tassajara Formation (Pta), Livermore Gravels (Q_T), and San Pablo Group (Msp). The Tassajara Formation, Livermore Gravels, and San Pablo Group have high sensitivity for paleontological resources and are exposed at the surface. Construction would involve grading and excavation to depths of up to 5 feet bgs to accommodate the trackbed and widening of I-580 as needed to maintain existing lane and interchange configurations. In addition, there may be drilled shaft pile foundations for supporting traffic signals and crossing gates, and drilled shaft piles and excavations deeper than 5 feet bgs for storm drainage system elements and for proposed bridge foundations, including overcrossing replacements, at Vasco, Las Colinas, and 1st Street, and retaining walls. Therefore, construction of the Tri-Valley Alignment would result in a potentially significant impact.

Dublin/Pleasanton Station

The Dublin/Pleasanton Station would be constructed on alluvium (Q). This geologic unit has low sensitivity for paleontological resources. Construction of the Dublin/Pleasanton Station would involve grading to depths of 5 feet bgs and excavation to depths greater than 5 feet bgs to accommodate access to the Bay Area Rapid Transit station. In addition, there would be drilled pier foundations for station canopy supports and area lights. Because construction of the Dublin/Pleasanton Station would involve excavation on a geologic unit with low sensitivity for paleontological resources, construction is unlikely to unearth significant paleontological resources. Impacts would therefore be less than significant.

Isabel Station

The Isabel Station would be constructed on alluvium (Q) and Tassajara Formation (Pta). The Tassajara Formation has high sensitivity for paleontological resources and is exposed at the surface. Construction of the Isabel Station would involve grading to depths of 5 feet bgs, as well as excavation greater than 5 feet bgs for drainage facilities, pedestrian bridge footings, station canopy supports, and area lights. Therefore, construction of Isabel Station would result in a potentially significant impact.

Greenville Station

The Greenville Station would be constructed on San Pablo Group (Msp). The San Pablo Group has high sensitivity for paleontological resources and is exposed at the surface as well as extending below ground. Construction of the Greenville Station would involve grading to depths of 5 feet bgs as well as excavation to depths greater than 5 feet bgs for drainage facilities, the approach wall and column footings associated with the aerial viaduct, and drilled pier foundations for station canopy supports. The construction of the Greenville Station would therefore result in a potentially significant impact.

Altamont Alignment

The Altamont Alignment, including the Owens-Illinois Industrial Lead, variants 1 and 2, would be constructed on alluvium (Q), alluvial fan deposits (Qf), older alluvium (Qo), San Pablo Group (Msp), fanglomerate (Mf), and Panoche Formation (Kp). Fanglomerate has undetermined sensitivity for paleontological resources, and older alluvium, San Pablo Group, and Panoche Formation have high sensitivity and are exposed at the surface, as well as extending below ground. Alluvium and alluvial fan deposits, where they are immediately adjacent to more sensitive geologic units, are assumed to extend up to 5 feet bgs and be underlain by the adjacent more sensitive units. Construction of the Altamont Alignment, including the Owens-Illinois Industrial Lead, variants 1 and 2, would involve grading and excavation to depths of up to 5 feet bgs on average to accommodate the trackbed, with deeper excavation potentially required in different locations. In addition, there may be drilled shaft pile foundations for supporting traffic signals and crossing gates, and drilled shaft piles and excavations deeper than 5 feet bgs for proposed bridge foundations and retaining walls. Thus, construction of the Altamont Alignment, including the Owens-Illinois Industrial Lead Variant 1, Single Track and the Owens-Illinois Industrial Lead Variant 2, Double Track would result in a potentially significant impact.

The two variants would have approximately the same potentially significant impact on paleontological resources because they would be constructed on the same geologic unit, disturb approximately the same area, and would involve similar depth of excavation.

Interim OMF

The Interim OMF would be constructed on the Panoche Formation (Kp). This geologic unit has high sensitivity, is exposed at the surface, and extends below ground. The Interim OMF would involve activities requiring excavation to depths of 5 feet bgs or greater, and construction would result in a potentially significant impact.

Mountain House Station

The Mountain House Station would be constructed on alluvium (Q). This geologic unit has low sensitivity for paleontological resources but is adjacent to sensitive (San Pablo Group [Msp]) and undetermined (fanglomerate [Mf]) geologic units. As previously discussed, this analysis assumes that where geologic units with low sensitivity for paleontological resources are immediately adjacent to more sensitive units, the more sensitive units are assumed to underlie the less sensitive unit at 5 feet bgs and deeper. Since construction of the Mountain House Station would require excavation greater than 5 feet bgs, the impact would be potentially significant.

Tracy OMF

The Tracy OMF would be constructed on a geologic unit with low paleontological sensitivity (alluvial fan deposits [Qf]) overlying a geologic unit with undetermined sensitivity (fanglomerate [Mf]). These more sensitive geologic units underlie the units with low sensitivity for paleontological resources at an unknown depth. As previously discussed, this analysis assumes that where geologic units with low sensitivity for paleontological resources are immediately adjacent to more sensitive units, the more sensitive units are assumed to underlie the less sensitive unit at 5 feet bgs and deeper. The Tracy OMF would involve activities requiring excavation to depths of 5 feet bgs or greater, and construction would result in a potentially significant impact.

Tracy to Lathrop Alignment

The Tracy to Lathrop Alignment Variant 1, Single Track and Tracy to Lathrop Alignment Variant 2, Double Track, would be constructed on alluvial fan deposits (Qf), Dos Palos alluvium (Qdp), and Modesto Formation (Qm). The Modesto Formation has high sensitivity for paleontological resources, as shown in Table 3.7-11, and is exposed at the surface as well as extending below ground. In addition, while alluvial fan deposits and Dos Palos alluvium have low sensitivity for paleontological resources, where they are immediately adjacent to geologic units with higher sensitivity, this analysis assumes that the unit with higher sensitivity underlies the unit at a depth of 5 feet bgs. The alluvial fan deposits are assumed to overlie fanglomerate (Mf) in the west, and the Dos Palos alluvium is assumed to overlie Modesto Formation (Qm) in the east. Construction of either variant of the Tracy to Lathrop Alignment would involve grading and excavation to depths of up to 5 feet bgs to accommodate the trackbed, and excavation greater than 5 feet bgs to accommodate the trackbed at various locations. In addition, there may be drilled shaft pile foundations for supporting traffic signals and crossing gates and drilled shaft piles and excavations deeper than 5 feet bgs for bridge foundations and retaining walls. The two variants would have approximately the same effect on paleontological resources because they would be constructed on the same geologic unit, disturb approximately the same area, and involve similar depth of excavation. Therefore, construction of the Tracy to Lathrop Alignment Variant 1, Single Track and Tracy to Lathrop Alignment Variant 2, Double Track would result in a potentially significant impact.

Downtown Tracy Station

The Downtown Tracy Station would be constructed on alluvial fan deposits (Qf), which have low sensitivity for paleontological resources. The Downtown Tracy Station not located near the interface of alluvial fan deposits with more sensitive geologic units. Construction of the Downtown Tracy Station would involve grading to depths of 5 feet bgs. Construction of the Downtown Tracy Station would involve excavation to depths greater than 5 feet bgs to accommodate garage foundations and drainage facility excavation. In addition, there would be drilled pier foundations for station canopy supports and area lights. Because construction of the Downtown Tracy Station would involve excavation on a geologic unit with low sensitivity for paleontological resources, construction is unlikely to unearth significant paleontological resources; impacts would be less than significant.

River Islands Station

The River Islands Station would be constructed on Dos Palos alluvium (Qdp). Dos Palos alluvium has low sensitivity for paleontological resources. However, the River Islands Station would be located very near the interface of Dos Palos alluvium and Modesto Formation. Modesto Formation has high sensitivity for paleontological resources. This analysis assumes that where geologic units with low sensitivity for paleontological resources are immediately adjacent to more sensitive units, more sensitive units underlie the less sensitive unit at 5 feet bgs and deeper. Construction of the River Islands Station would involve grading to depths of 5 feet bgs and excavation to depths greater than 5 feet bgs for drainage facilities, a pedestrian bridge, and drilled pier foundations for station area lights. Accordingly, impacts would be potentially significant.

North Lathrop Station

The North Lathrop Station would be constructed on Modesto Formation (Qm). Modesto Formation has high sensitivity for paleontological resources. Construction of the North Lathrop Station would involve grading to depths of 5 feet bgs and excavation to depths greater than 5 feet bgs to accommodate foundations and excavation for the pedestrian bridge, specifically access structure footings. In addition, there would be drilled pier foundations for station canopy supports and area lights. Because construction would involve excavation on geologic units with high sensitivity for paleontological resources and on geologic units overlying units with undetermined and high paleontological sensitivity, construction on such geologic units could unearth significant paleontological resources. If unearthed resources are not identified, construction could damage or destroy the resources. Accordingly, impacts would be potentially significant.

Operation and Maintenance

As discussed in Chapter 2, *Project Description*, operation and maintenance activities include tie replacement, ballast re-contouring, landscaping, maintenance of drainage features and signal infrastructure, and related activities. These activities would not disturb the ground to depths greater than 5 feet bgs. These activities would take place on geologic units that were disturbed during construction, including some areas that could have been disturbed before construction began. Operational effects of the Proposed Project are therefore less than significant, and no mitigation would be required.

Greenville IOS and Mountain House IOS

Implementation of the Greenville IOS would require construction of the Tri-Valley Alignment, Dublin/Pleasanton Station, Isabel Station, Greenville Station, Interim OMF, and a portion of the Altamont Alignment. Implementation of the Mountain House IOS would require construction of the Tri-Valley Alignment; Dublin/Pleasanton Station; Isabel Station; Greenville Station; Altamont Alignment; Owens-Illinois Industrial Lead Variant 1, Single Track; Owens-Illinois Industrial Lead Variant 2, Double Track; Mountain House Station; and Tracy OMF. Either IOS would include modified station designs to accommodate additional ridership associated with being an interim end-line station.

The potential impacts from the proposed alignments, stations, and OMFs, which are identified above, consider a conservative footprint that accounts for the potential design of an interim end-line station. As such, implementation of the Greenville IOS and Mountain House IOS would result in a potentially significant impact on paleontological resources, as described above.

Alternatives Analyzed at an Equal Level of Detail

Southfront Road Station Alternative

The Southfront Road Station Alternative would be constructed on alluvium (Q) potentially overlying Livermore Gravels (Q_T), as well as on Livermore Gravels. While alluvium has low sensitivity for paleontological resources, the Livermore Gravels have a high sensitivity. This analysis assumes that where geologic units with low sensitivity for paleontological resources are immediately adjacent to more sensitive units, more sensitive units underlie the less sensitive unit at 5 feet bgs and deeper. Construction of the Southfront Road Station Alternative would involve grading to depths of 5 feet bgs, as well as excavation greater than 5 feet bgs. Therefore, construction of the Southfront Road Station Alternative would result in a potentially significant impact.

Stone Cut Alignment Alternative

The Stone Cut Alignment Alternative would be constructed on the Panoche Formation (Kp). This geologic unit has high sensitivity, is exposed at the surface, and extends below ground. The Stone Cut Alignment Alternative would involve activities requiring excavation to depths of 5 feet bgs or greater, and construction would result in a potentially significant impact.

West Tracy OMF Alternative

The West Tracy OMF Alternative would be constructed on a geologic unit with low paleontological sensitivity (alluvium [Q]), a geologic unit with high paleontological sensitivity (older alluvium [Qo]) and fanglomerate (Mf), which has undetermined sensitivity for paleontological resources. Construction would involve grading to depths of 5 feet bgs and excavation to depths of greater than 5 feet bgs for the drainage facility excavation, train wash foundation, and building foundation, the latter two of which could consist of drilled piers. In addition, there would be drilled pier foundations for area lights. Accordingly, the impact would be potentially significant.

Mountain House Station Alternative

The Mountain House Station Alternative would be constructed on a geologic unit with low paleontological sensitivity (alluvial fan deposits [Qf]) overlying a geologic unit with undetermined sensitivity (fanglomerate [Mf]). These more sensitive geologic units underlie the units with low sensitivity for paleontological resources at an unknown depth. As previously discussed, this analysis assumes that where geologic units with low sensitivity for paleontological resources are immediately adjacent to more sensitive units, the more sensitive units are assumed to underlie the less sensitive unit at 5 feet bgs and deeper. The Mountain House Station Alternative would involve activities requiring excavation to depths of 5 feet bgs or greater, and construction would result in a potentially significant impact.

Downtown Tracy Station Parking Alternative 1 and Downtown Tracy Station Parking Alternative 2

The Downtown Tracy Station Parking Alternative 1 and Downtown Tracy Station Parking Alternative 2 would be constructed on alluvial fan deposits (Qf), which have low sensitivity for paleontological resources. These alternative stations are not located near the interface of alluvial fan deposits with more sensitive geologic units. Construction of the alternative stations would involve grading to depths of 5 feet bgs and excavation to depths greater than 5 feet bgs to accommodate foundations and drainage facility excavation. In addition, there would be drilled pier foundations for station canopy supports and area lights. Because construction of these alternative stations would involve excavation on a geologic unit with low sensitivity for paleontological resources, construction is unlikely to unearth significant paleontological resources; impacts would be less than significant.

Operation and Maintenance

As with the Proposed Project, operation and maintenance of the Southfront Road Station Alternative, Stone Cut Alignment Alternative, West Tracy OMF Alternative, Mountain House Station Alternative, Downtown Tracy Station Parking Alternative 1, and Downtown Tracy Station Parking Alternative 2 would disturb the ground to depths greater than 5 feet bgs and would take place on geologic units that were disturbed during construction. Thus, operation and maintenance of these alternatives would be less than significant, and no mitigation would be required.

Table 3.7-11. Summary of Impacts on Geologic Units/ Paleontological Resources

Proposed or Alternative Facility	Construction Activities	Depth of Disturbance [a]	Geologic Units and Paleontological Sensitivity [b]	CEQA Conclusion Prior to Mitigation
Proposed Project				
Tri-Valley Alignment	Grading Excavation for storm drainage Foundation elements for overcrossing replacements at Vasco, Las Colinas, and First Street Drilled shaft piles for overcrossing replacements at Vasco, Las Colinas, and First Street and for retaining walls, traffic signals, and crossing gates	Surface Below ground surface	Alluvium (Q) **Tassajara Formation (Pta)** **San Pablo Group (Msp)**	Potentially significant – mitigation required
Dublin/Pleasanton Station	Grading Excavation for access to Bay Area Rapid Transit system Drilled pier foundations for station canopy supports and area lights	Surface Below ground surface	Alluvium (A)	Less-than-significant impact
Isabel Station	Grading Excavation for facility drainage and pedestrian bridge (access structure footings and column footings) Drilled pier foundations for station canopy supports and area lights	Surface Below ground surface	Alluvium (Q) **Tassajara Formation (Pta)**	Potentially significant – mitigation required
Greenville Station	Grading Excavation for facility drainage and aerial viaduct (approach wall footings and column footings) Drilled pier foundations for station canopy supports and area lights	Surface Below ground surface	**San Pablo Group (Msp)**	Potentially significant – mitigation required

Proposed or Alternative Facility	Construction Activities	Depth of Disturbance [a]	Geologic Units and Paleontological Sensitivity [b]	CEQA Conclusion Prior to Mitigation
Altamont Alignment, including the Owens-Illinois Industrial Lead Variant 1, Single Track and the Owens-Illinois Industrial Lead Variant 2, Double Track	Grading Excavation for storm drainage and trackbed at various locations Drilled shaft piles for retaining walls, traffic signals, and crossing gates	Surface Below ground surface	Alluvium (Q) Alluvial fan deposits (Qf) **Older alluvium (Qo)** **San Pablo Group (Msp)** **Fanglomerate (Mf)** **Panoche Formation (Kp)**	Potentially significant – mitigation required
Interim OMF	Grading Excavation for facility as a whole, facility drainage, train wash foundation, and building foundation Drilled pier foundations for area lights and foundations	Surface Below ground surface	**Panoche Formation (Kp)**	Potentially significant – mitigation required
Mountain House Station	Grading Excavation for facility drainage and parking and bus facilities Drilled pier foundations for station canopy supports and area lights	Surface Below ground surface	Alluvium (Q), overlying **San Pablo Group (Msp)** and **fanglomerate (Mf)**	Potentially significant – mitigation required
Tracy OMF	Grading Excavation for facility drainage, train wash foundation, and building foundation Drilled pier foundations for area lights and foundations	Surface Below ground surface	Alluvial fan deposits (Qf) overlying **fanglomerate (Mf)**	Potentially significant – mitigation required
Tracy to Lathrop Alignment Variant 1, Single Track and Tracy to Lathrop Alignment Variant 2, Double Track	Grading Excavation for drainage Drilled shaft piles for retaining walls, traffic signals, and crossing gates	Surface Below ground surface	Alluvial fan deposits (Qf) **Alluvial fan deposits (Qf) overlying fanglomerate (Mf)** Dos Palos alluvium (Qdp) **Dos Palos alluvium (Qdp) overlying Modesto Formation (Qm)**	Potentially significant – mitigation required

Proposed or Alternative Facility	Construction Activities	Depth of Disturbance [a]	Geologic Units and Paleontological Sensitivity [b]	CEQA Conclusion Prior to Mitigation
			Modesto Formation (Qm)	
Downtown Tracy Station	Grading Excavation for facility drainage and foundations Drilled pier foundations for station canopy supports and area lights	Surface Below ground surface	Alluvial fan deposits (Qf)	Less-than-significant impact
River Islands Station	Grading Excavation for facility drainage and pedestrian bridge (access structure footings) Drilled pier foundations for station canopy supports and area lights	Surface Below ground surface	Dos Palos alluvium (Qdp) overlying **Modesto Formation (Qm)**	Potentially significant – mitigation required
North Lathrop Station	Grading Excavation for facility drainage and pedestrian bridge (access structure footings) Drilled pier foundations for station canopy supports and area lights	Surface Below ground surface	**Modesto Formation (Qm)**	Potentially significant – mitigation required
Alternatives Analyzed at an Equal Level of Detail				
Southfront Road Station Alternative	Grading Excavation for facility drainage and foundations Drilled pier foundations for station canopy supports and area lights	Surface Below ground surface	Alluvium (Q) **Livermore Gravels (Q_T)**	Potentially significant – mitigation required
Stone Cut Alignment Alternative	Grading Excavation for storm drainage and trackbed at various locations Retaining walls Single-span bridge over I-580	Surface Below ground surface	**Panoche Formation (Kp)**	Potentially significant – mitigation required

Proposed or Alternative Facility	Construction Activities	Depth of Disturbance [a]	Geologic Units and Paleontological Sensitivity [b]	CEQA Conclusion Prior to Mitigation
West Tracy OMF Alternative	Grading Excavation for facility as a whole, facility drainage, train wash foundation, and building foundation Drilled pier foundations for area lights and foundations	Surface Below ground surface	**Older alluvium (Qo)**, **fanglomerate (Mf)**	Potentially significant – mitigation required
Mountain House Station Alternative	Grading Excavation for facility drainage and parking and bus facilities Drilled pier foundations for station canopy supports and area lights	Surface Below ground surface	Alluvial fan deposits (Qf), overlying **fanglomerate (Mf)**	Potentially significant – mitigation required
Downtown Tracy Station Parking Alternative 1 and Downtown Tracy Station Parking Alternative 2	Grading Excavation for facility drainage and foundations Drilled pier foundations for station canopy supports and area lights	Surface Below ground surface	Alluvial fan deposits (Qf)	Less-than-significant impact

[a] Surface disturbances are defined as disturbances up to 5 feet and below-ground-surface disturbances are defined as disturbances more than 5 feet bgs.
[b] Geologic formations with undetermined or high sensitivity are shown in bold typeface.

Mitigation Measure

Mitigation Measure GEO-4.1, as described below, would apply to construction of the Tri-Valley Alignment; Isabel Station; Greenville Station; Altamont Alignment, including the Owens-Illinois Industrial Lead Variant 1, Single Track and the Owens-Illinois Industrial Lead Variant 2, Double Track; Interim OMF; Mountain House Station; Tracy OMF; Tracy to Lathrop Alignment Variant 1, Single Track; Tracy to Lathrop Alignment Variant 2, Double Track; River Islands Station; and North Lathrop Station. In addition, this mitigation measure would apply to construction of the Southfront Road Station Alternative, Stone Cut Alignment Alternative, West Tracy OMF Alternative, and Mountain House Station Alternative.

Mitigation Measure GEO-4.1: Monitor for discovery of paleontological resources, evaluate found resources, and prepare and follow a recovery plan for found resources.

The following measure will be undertaken during construction of the following proposed and alternative alignments, stations, and OMFs: Tri-Valley Alignment; Isabel Station; Greenville Station; Altamont Alignment, including the Owens-Illinois Industrial Lead Variant 1, Single Track and the Owens-Illinois Industrial Lead Variant 2, Double Track; Interim OMF; Mountain House Station; Tracy OMF; Tracy to Lathrop Alignment Variant 1, Single Track; Tracy to Lathrop Alignment Variant 2, Double Track; River Islands Station; North Lathrop Station; Southfront Road Station Alternative; Stone Cut Alignment Alternative; West Tracy OMF Alternative; and Mountain House Station Alternative.

Before the start of ground-disturbing activities, the Authority will retain a qualified paleontologist, as defined by the SVP, who is experienced in identifying potential for occurrence of significant fossils at construction sites, and who is experienced in teaching non-specialists. The qualified paleontologist will conduct appropriate studies of the construction site before any ground-disturbing activities occur, including onsite investigations, to determine likelihood of significant fossils at the site, in particular small fossils. Particular attention will be given to smaller vertebrate fossils in those areas where the Tassajara Formation or San Pablo Group occur (i.e., geologic units known to contain an abundance of rodent or lagomorph fossils), which includes the Tri-Valley Alignment; Isabel Station; Greenville Station; Altamont Alignment, including the Owens-Illinois Industrial Lead Variant 1, Single Track and the Owens-Illinois Industrial Lead Variant 2, Double Track; and the Mountain House Station.

If vertebrate fossils are determined likely to be discovered at the construction site, the qualified paleontologist or his/her appointee will conduct onsite monitoring during construction activities.

In addition, the qualified paleontologist will train all construction personnel who are involved with earthmoving activities, including the site superintendent, regarding the possibility of encountering fossils, the appearance and types of fossils that are likely to be seen during construction, and proper notification procedures should fossils be encountered. Procedures to be conveyed to workers include halting construction within 50 feet of any potential fossil find and notifying a qualified paleontologist, who will evaluate the significance.

The qualified paleontologist will also make periodic visits during earthmoving in high sensitivity sites to verify that workers are following the established procedures.

If paleontological resources are discovered during earthmoving activities either by the paleontological monitor or the construction personnel, the construction crew will immediately cease work near the find and notify the Authority. Construction work in the affected areas will remain stopped or be diverted to allow recovery of fossil remains in a timely manner. The Authority will retain a qualified paleontologist to evaluate the resource and prepare a recovery plan in accordance with SVP guidelines (SVP 2010). The recovery plan may include a field survey, construction monitoring, sampling and data recovery procedures, museum storage coordination for any specimen recovered, and a report of findings. Recommendations in the recovery plan that are determined by the Authority to be necessary and feasible will be implemented before construction activities can resume at the site where the paleontological resources were discovered. The Authority will be responsible for ensuring that the monitor's recommendations regarding treatment and reporting are implemented.

Significance with Application of Mitigation

Mitigation Measure GEO-4.1 would be implemented to avoid the destruction of paleontological resources during construction. Mitigation Measure GEO-4.1 would require training for construction crews to better recognize paleontological resources, stopping work in case of discovering such resources, evaluating those resources by a qualified paleontologist and, as appropriate, preparing and implementing a recovery plan. With implementation of this mitigation measure, the impact on paleontological resources due to construction of the Proposed Project would be less than significant.

For the same reasons listed above, implementation of Mitigation Measures GEO-4.1 would reduce potential impacts on paleontological resources due to construction of the Southfront Road Station Alternative, Stone Cut Alignment Alternative, West Tracy OMF Alternative, and Mountain House Station Alternative to a less-than-significant level.

Comparison of Alternatives

Implementation of Southfront Road Station Alternative instead of the proposed Greenville Station would not change the impact associated with paleontological resources. Construction of both the Southfront Road Station Alternative and the proposed Greenville Station would result in a less-than-significant impact on paleontological resources after implementation of Mitigation Measure GEO-4.1.

Implementation of Stone Cut Alignment Alternative instead of the portion of the proposed Altamont Alignment that the Stone Cut Alignment Alternative would replace would not change the impact associated with paleontological resources. Construction of both the Stone Cut Alignment Alternative and the proposed Altamont Alignment would result in a less-than-significant impact on paleontological resources after implementation of Mitigation Measure GEO-4.1.

Implementation of the West Tracy OMF Alternative instead of the proposed Tracy OMF would not change the impact associated with paleontological resources. Construction of both the West Tracy OMF Alternative and the proposed Tracy OMF would result in a less-than-significant impact on paleontological resources after implementation of Mitigation Measure GEO-4.1.

Implementation of the Mountain House Station Alternative instead of the proposed Mountain House Station would not change the impact associated with paleontological resources. Construction of both the Mountain House Station Alternative and the proposed Mountain House Station would result in a less-than-significant impact on paleontological resources after implementation of Mitigation Measure GEO-4.1.

Implementation of the Downtown Tracy Station Parking Alternative 1 and Downtown Tracy Station Parking Alternative 2 instead of the proposed Downtown Tracy Station would not change the impact associated with paleontological resources. Construction of both the alternative stations (Downtown Tracy Station Parking Alternative 1 and Downtown Tracy Station Parking Alternative 2) and the proposed Downtown Tracy Station would result in a less-than-significant impact on paleontological resources.