## 2.3.2 Geology/Soils/Seismic/Topography

### 2.3.2.1 Regulatory Setting

#### *Federal Regulations*

For geologic and topographic features, the key federal law is the Historic Sites Act of 1935, which establishes a national registry of natural landmarks and protects "outstanding examples of major geological features." Topographic and geologic features are also protected under the California Environmental Quality Act (CEQA).

This section also discusses geology, soils, and seismic concerns as they relate to public safety and project design. Earthquakes are prime considerations in the design and retrofit of structures. Structures are designed using the California Department of Transportation's (Caltrans') Seismic Design Criteria. The Seismic Design Criteria provides the minimum seismic requirements for highway bridges designed in California. A bridge's category and classification will determine its seismic performance level and which methods are used for estimating the seismic demands and structural capabilities.

#### *State Regulations*

**Alquist-Priolo Earthquake Fault Zoning Act**

California's Alquist-Priolo Earthquake Fault Zoning Act (Public Resources Code Section 2621 et seq.), originally enacted in 1972 as the Alquist-Priolo Special Studies Zones Act and renamed in 1994, is intended to reduce the risk to life and property from surface fault rupture during earthquakes. The act prohibits the location of most types of structures intended for human occupancy across the traces of active faults and strictly regulates construction in the corridors along active faults (referred to as earthquake fault zones). It defines criteria for identifying active faults, giving legal weight to terms such as *active*, and it establishes a process for reviewing proposals for building in and adjacent to earthquake fault zones. It also encourages and regulates seismic retrofits of some types of structures.

**Seismic Hazards Mapping Act of 1990**

The Seismic Hazards Mapping Act of 1990 (Public Resources Code Sections 2690–2699.6) is intended to avoid or reduce damage resulting from earthquakes. While the Alquist-Priolo Earthquake Fault Zoning Act addresses surface fault rupture, the Seismic Hazards Mapping Act addresses other earthquake-related hazards, including strong ground shaking, liquefaction,[1] and seismically induced landslides. Its provisions are similar in concept to those of the Alquist-Priolo Earthquake Fault Zoning Act (i.e., the state is charged with identifying and mapping areas at risk of strong ground shaking,

[1] *Liquefaction* is a phenomenon in which the strength and stiffness of a soil are reduced by earthquake shaking or other rapidly applied loading. Liquefaction and related types of ground failure are of greatest concern in areas where well-sorted sandy unconsolidated sediments are present in the subsurface and the water table is comparatively shallow.

liquefaction, landslides, and other corollary hazards, and cities and counties are required to regulate development within mapped seismic hazard zones).

Under the Seismic Hazards Mapping Act, permit review is the primary mechanism for local regulation of development. Specifically, cities and counties are prohibited from issuing development permits for sites within seismic hazard zones until appropriate site-specific geologic and/or geotechnical investigations have been carried out and measures to reduce potential damage have been incorporated into the development plans.

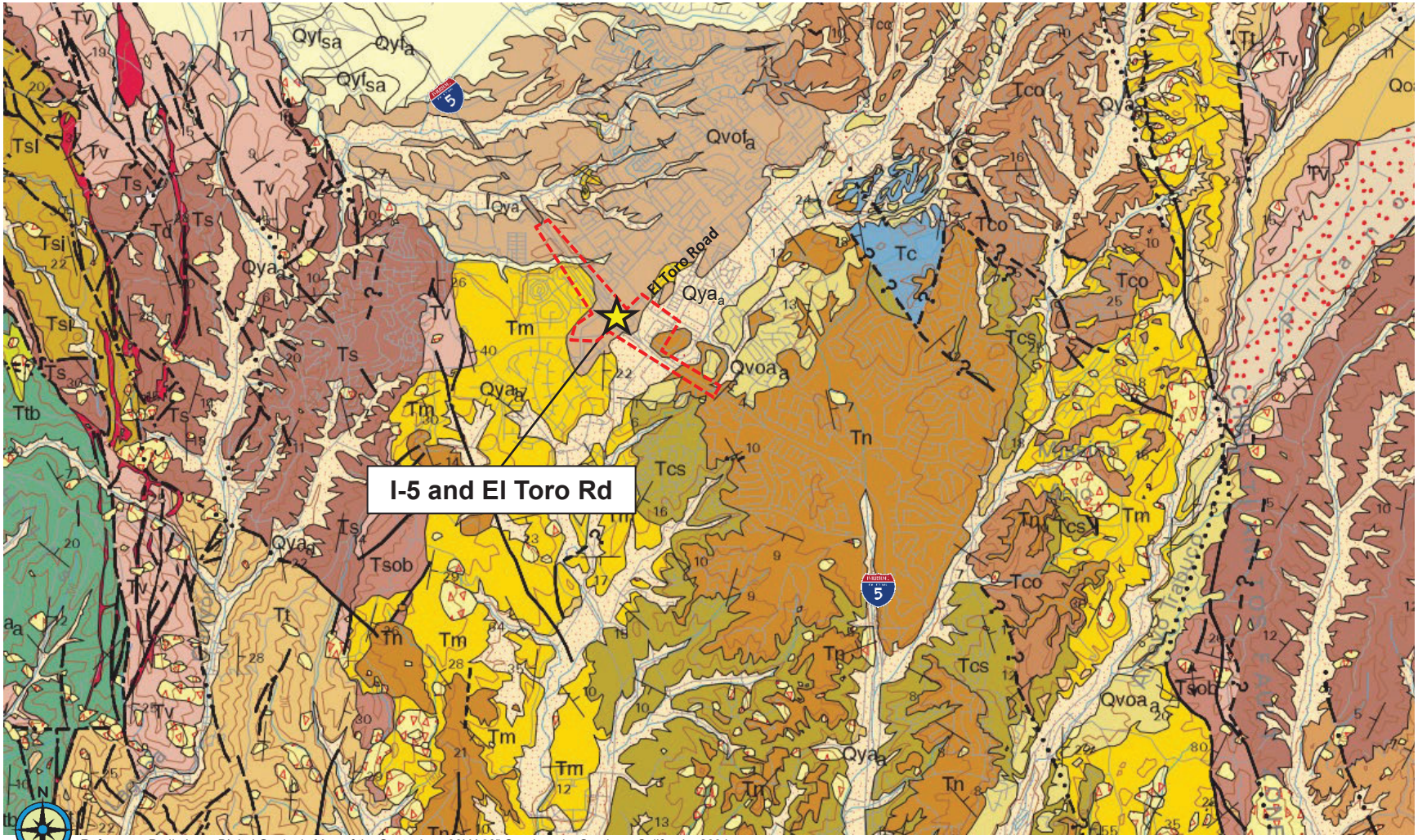
### 2.3.2.2 Affected Environment

The primary sources used in the preparation of this section are the *Technical Memorandum: Geotechnical Review of District Preliminary Geotechnical Report* (Group Delta 2025), *Technical Memorandum: Structure Preliminary Geotechnical Report for El Toro Road Interchange Bridge* (Caltrans 2025), and *District Preliminary Geotechnical Report for Interstate 5/El Toro Interchange* (Caltrans 2018).

#### *Topography, Physiography and Regional Geology*

The Project is within the Peninsular Ranges geomorphic province, a 900-mile-long, 225-mile-wide northwest-to-southwest–trending structural block bounded by faults. It is characterized by a series of mountain ranges and valleys, which trend in a northwest-southeast direction parallel with the San Andreas Fault Zone. It extends from the Transverse Ranges to the north to the tip of Baja California in the south and is bounded by the Colorado Desert in the east and the southern Channel Islands (Santa Barbara, San Nicolas, Santa Catalina, and San Clemente) in the west.

Specifically, the Project is situated at the northeastern edge of the San Joaquin Hills, which are along the southern boundary of the Irvine Basin. A number of streams, including Aliso Creek, Oso Creek, Trabuco Creek, and San Juan Creek, have incised valleys and canyons through the hills toward the Pacific Ocean. Three major active or potentially active faults are within 9 miles of the Project limits: the San Joaquin Hills fault, the Newport-Inglewood Fault Zone (South Los Angeles section – southern), and the Newport-Inglewood fault (offshore). Uplift of the San Joaquin Hills is believed to be a shortening of the crust perpendicular to the southern Newport-Inglewood Fault Zone. The elevation within the Project limits is relatively level, ranging from approximately 300 feet above mean sea level (amsl) near Lake Forest Drive to approximately 380 feet amsl near El Toro Road. Geologic units mapped within the region and Project limits are shown on Figure 2.3.2-1.




Reference: Preliminary Digital Geologic Map of the Santa Ana 30' X 60" Quadrangle, Southern California, 2004

## Geologic Map Units and Legend

$Qvof_a$ – Very old alluvial fan deposits (middle to early Pleistocene)

$Qya_a$ – Young axial channel deposits (Holocene and late Pleistocene)

Tm – Monterey Formation (Miocene)

Tn – Niguel Formation (Pliocene)

----- Approximate Project Boundary

\\PDCCITRDSGIS01\Projects_1\Caltrans\I5_ElToro\Figures\Faults

Figure 2.3.2-1

*I-5 El Toro Road Interchange Project*
Regional Geology

12-ORA-5 PM 17.8/19.7
EA 0M980

### *Site Geology*

Exposed surface deposits north of the El Toro Road Undercrossing are predominantly Pleistocene Very Old Alluvial Fan Deposits ($Qvof_a$) and Miocene-aged Monterey Formation (Tm), with some Holocene to Pleistocene-aged young axial channel deposits (Qya). Surface deposits south of the El Toro Road Undercrossing consist primarily of Qya deposits with some Niguel Formation (Tn). Human-made artificial fills (Qaf) are not mapped in the area but are known to exist from past grading of surrounding properties and construction of embankments along Interstate (I-) 5.

**Subsurface Soil Conditions**

Based on soil samples previously taken from the site, the I-5 embankment at the El Toro Road Undercrossing bridge consists of approximately 15 to 20 feet of fill overlying terrace and alluvial deposits and Monterey Formation. Fill consists of medium dense to dense sands with varying degrees of fines, such as silty sand (SM), clayey sand (SC), and poorly graded sands (SP). Underlying the fill, terrace and alluvial deposits were encountered at an approximate elevation of 360 feet amsl and consist of medium dense to very dense silty sand (SM) and clayey sand (SC) with varying degrees of gravels. During previous geotechnical investigation drilling, the Monterey Formation was encountered between elevation 300 and 350 feet amsl and generally consists of claystone and siltstone.

Further testing previously conducted east of the intersection of El Toro Road and Avenida De La Carlota encountered medium stiff to stiff clayey soils with interbedded silty/clayey sands, except for one testing area to the east that indicated soft to stiff clayey deposits.

The subgrade soils, which are the layers of natural soil upon which the Project would be built, range from granular soils to plastic cohesive soils to soft rock siltstone/claystone materials within the Project limits.

**Surface Water**

The Project limits are within the Aliso Creek and San Diego Creek watersheds. Aliso Creek is a 35-square-mile watershed that includes discharges from Aliso Viejo, Laguna Hills, Laguna Beach, Laguna Niguel, Laguna Woods, Lake Forest, and Mission Viejo. It originates in the Cleveland National Forest and drains into the Pacific Ocean at Aliso Beach.

San Diego Creek watershed covers 112 square miles and includes discharges from Irvine, parts of Aliso Viejo, Laguna Hills, Laguna Woods, Lake Forest, Orange, Santa Ana, and Tustin. It originates in the foothills of the Santa Ana Mountains and ultimately feeds into Upper Newport Bay.

Runoff from the Project limits flows toward Caltrans storm drains within I-5 and the El Toro Road Interchange. The storm drain system connects to the local flood control drainage systems that eventually discharge into Aliso Creek, Veeh Reservoir, and Cañada Channel.

**Groundwater Conditions**

Groundwater flows generally toward the Pacific Ocean. Within the Project limits, groundwater elevation is higher in the northeast, while the gradient flows southwest. However, even though the groundwater elevation is higher to the northeast, the depth to groundwater is shallower in the southwest due to the change in ground surface elevation over the area. The historical depth to groundwater is generally reported to be 15 to 20 feet below ground surface (bgs) in the northeast and 10 to 15 bgs in the southwest. Fluctuations of groundwater level, localized zones of perched water, and variations in soil moisture content should be anticipated during and following the rainy season in late fall to early spring.

The California Geological Survey (CGS) online borehole warehouse and Seismic Hazard Zone report indicate that the historical highest groundwater within the Project limits is between 10 to 20 feet bgs at locations mapped as Qya on Figure 2.3.2-1. Recent groundwater monitoring data from existing wells southeast and west of the El Toro Undercrossing bridge indicate that groundwater was encountered between 11.5 and 20.5 feet bgs. Groundwater at the I-5 embankment, which is at a higher elevation, was encountered at a deeper depth of 44 feet bgs at an approximate elevation of 339.3 feet amsl, based on data obtained during 1992 testing. Testing completed in 2016 for a second bridge widening shows an increase in groundwater level at an elevation of 347.6 feet amsl. Groundwater levels measured in 2024 at monitoring wells within the Project limits indicate that groundwater elevations vary between 350 and 357 feet amsl.

### *Geologic Hazards*

**Regional Faulting, Seismic Hazards, and Surface Rupture**

The Project is in a seismically active region of Southern California that is subject to substantial hazards from moderate to large earthquakes. Ground shaking due to nearby and distant earthquakes should be anticipated during the life of the facilities that are proposed as part of the Project. The three major active or potentially active surface faults nearest the Project are the San Joaquin Hills fault, the Newport-Inglewood Fault Zone (South Los Angeles section – southern), and the Newport-Inglewood fault (offshore). The San Joaquin Hills fault, approximately 0 to 1.3 miles from the Project limits, is a southwest-dipping, low-angle reverse (thrust) fault that is concealed and does not reach ground surface. The San Joaquin Hills fault is capable of generating a magnitude 7.0 earthquake. The Newport-Inglewood Fault Zone (South Los Angeles section – southern) is a right-lateral strike-slip fault approximately 7.2 miles from the Project limits and is capable of generating a magnitude 7.2 earthquake. The Newport-Inglewood fault is a right-lateral strike-slip fault approximately 9 miles from the Project limits, and it is capable of generating a magnitude 6.9 earthquake.

Peak ground acceleration (PGA) is a measurement of maximum ground acceleration in a particular area and is an important factor for structural engineering against earthquake damage for structures such as roads, bridges, and buildings. It can be described as how hard the ground may shake in a given geographic area based on several factors, such as the distance from an active fault, the maximum expected earthquake from that fault, and the underlying geologic units. The PGAs within the Project limits are estimated to

be 0.46g[2] with a shear wave velocity of 250 meters per second,[3] which means that there is potential for moderate to strong ground shaking within the Project limits during a significant earthquake.

The potential for surface rupture is evaluated based on the Project's distance to an active earthquake fault where there is evidence of surface rupture in the last 11,700 years. The locations of potentially active faults are zoned and mapped under the Alquist-Priolo Act. The San Joaquin Hills fault is the closest fault, approximately 1,000 feet east of the Project limits at Rockfield (see Figure 2.3.2-2).

The San Joaquin Hills fault is a blind thrust fault that has not historically ruptured at ground surface and is not anticipated to rupture at ground surface; therefore, it is not included in Alquist-Priolo zones or maps (CGS 2025a). The Newport Inglewood fault (South Los Angeles section – southern), approximately 7.2 miles from the Project limits, is the closest fault that is capable of surface rupture.

**Liquefaction and Seismically Induced Settlement**

Liquefaction is the sudden loss in strength of a saturated, cohesionless soil caused by the buildup of pore water pressure during cyclic loading, such as that produced by an earthquake. The effects of liquefaction can include lateral and vertical ground displacements, slope instability and lateral spreading, and bearing failure.

For liquefaction to occur, all of the following must be present:

- Liquefaction-susceptible soils (loose to medium-dense cohesionless soils)
- Groundwater within 50 feet of the surface
- Strong shaking, such as that caused by an earthquake

According to the CGS *Earthquake Zones of Required Investigation* map, the southern portion of the Project limits underlain by Qya is within a liquefaction zone (see Figure 2.3.2-3) (CGS 2025b). These deposits below groundwater are more prone to liquefaction potential. The other geologic units within the Project limits (mapped as $Qvof_a$, Tm, and Tn) are generally medium-dense to dense sands and clays that are not prone to liquefaction. However, locally, there could be loose saturated sand layers within these units.

[2] "g" is a common value of acceleration equal to 32 feet per second$^2$.
[3] Shear wave velocity was estimated by reviewing published CGS maps and seismic cone penetration testing data; however, it is recommended that the shear wave velocity be verified with site-specific explorations.


Reference: USGS Quaternary Faults, NSHM 2014 Fault Sources https://usgs.maps.arcgis.com/apps/webappviewer/index.html

NSHM 2014 Fault Sources

- Normal
- Strike Slip
- Thrust
- Unassigned

\\PDCCITRDSGIS01\Projects_1\Caltrans\I5_ElToro\Figures\Faults

Figure 2.3.2-2

*I-5 El Toro Road Interchange Project*
Regional Faults

12-ORA-5 PM 17.8/19.7
EA 0M980


**MAP EXPLANATION**

**SEISMIC HAZARD ZONES**

**Liquefaction Zones**
Areas where historical occurrence of liquefaction, or local geological, geotechnical and ground water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

**Earthquake-Induced Landslide Zones**
Areas where previous occurrence of landslide movement, or local topographic, geological, geotechnical and subsurface water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

Approximate Project Boundary

**REFERENCES:**
**Department of Conservation,**
**California Geological Survey,**
**Earthquake Zones of Required Investigation, ArcGIS Web**

\\PDCCITRDSGIS01\Projects_1\Caltrans\I5_ElToro\Figures\Faults

Figure 2.3.2-3

*I-5 El Toro Road Interchange Project*
Earthquake Zones

12-ORA-5 PM 17.8/19.7
EA 0M980

**Landslides**

Landslides commonly occur in connection with other natural disasters such as earthquakes, volcanoes, wildfires, and floods. Steep, bare slopes; deposits of stream or river sediment; clay-rich rock; and heavy rains can also cause landslides. The terrain in the Project area is relatively flat. Based on CGS mapping, the Project is not within an area that is at risk for seismically induced landslides (see Figure 2.3.2-3).

**Other Seismic Hazards**

Subsidence is the sinking of the ground surface in response to geologic or human-induced causes, such as the removal of water, oil, or natural gas. The Project area has no known history of subsidence.

A tsunami is a large ocean wave that is caused by sudden movement on the ocean floor, such as from an earthquake, a volcanic eruption, or an underwater landslide. The nearest mapped Tsunami Inundation Zone is 6.55 miles from the closest point of the Project limits (CGS 2025c).

A seiche is a standing wave that forms in an enclosed or partially enclosed body of water. The effect is caused by resonances in the confined water body. Most often, they are caused by wind and are imperceptible. However, in the event of an earthquake, the ground movement can be enough to create a large standing wave (seiche) that causes the "slosh" of the water body onto its shores at levels higher than expected. There are no major water bodies within or near the Project limits.

There are no active, potentially active, or inactive volcanoes in Orange County.

### 2.3.2.3 Environmental Consequences

Build Alternative 3 only includes technological improvements; no physical or geometric changes would occur. Accordingly, Build Alternative 3 would not result in any permanent changes to geological, soil, seismic, or topographical conditions within the Project area. As such, Build Alternative 3 is not discussed further, as temporary and permanent impacts related to geological, soil, seismic, or topographical conditions on site would not occur.

#### *Temporary Impacts*

**Build Alternatives**

*Build Alternative 1*

Potential temporary impacts on the geological environment are expected to occur as a result of construction of Build Alternative 1 – Southbound I-5 Hook Ramps. Activities such as cut-and-fill operations in the development of embankments would result in the alteration of the existing topography and may increase the risk of soil erosion and siltation. During construction, excavated soil would be exposed, increasing the potential for soil erosion. Additionally, during a storm event, unprotected soils would be subject to erosion. Construction activities may also temporarily disturb soil outside the Project

footprint and within the Project right of way, primarily in work areas, staging areas, and equipment traffic areas.

Temporary impacts due to soil erosion are discussed further in Section 2.3.1, *Water Quality and Stormwater Runoff*. Consistent with all Caltrans projects with a soil disturbance area greater than 1 acre, Build Alternative 1 would be required to conform to the requirements of the Caltrans Statewide National Pollutant Discharge Elimination System (NPDES) Storm Water Permit, Order No. 2022-0033-DWQ, NPDES No. CAS000003, adopted on June 22, 2022, and effective on July 1, 2023; and any subsequent permit in effect at the time of construction. In addition, Build Alternative 1 would be required to comply with the requirements of the NPDES Permit for Construction Activities, Order No. 2022-0057-DWQ, adopted on September 8, 2022, and effective on September 1, 2023; as well as implementation of the best management practices (BMPs) specified in Caltrans' Storm Water Management Plan.

The Project contractor would also be required to develop a Stormwater Pollution Prevention Plan (SWPPP) in accordance with the requirements stated in the NPDES General Permit, Waste Discharge Requirements for Discharges of Storm Water Runoff Associated with Construction Activities (Construction General Permit, Order No. 2022-0057-DWQ), or subsequent permits in effect at the time of construction. The SWPPP will address all construction-related activities, equipment, and materials that have the potential to affect water quality. The SWPPP will include BMPs to control pollutants, sediment from erosion, stormwater runoff, and other construction-related impacts. Refer to Section 2.3.1, *Water Quality and Stormwater Runoff*, for a detailed analysis of short-term construction water quality impacts and a further description of existing regulations and Project features **PF-WQ-1** through **PF-WQ-5** applicable to Build Alternative 1.

Construction activities associated with Build Alternative 1 could expose construction workers and the traveling public to potential impacts associated with seismic shaking, which would be addressed by **PF-GEO-1**, below. In addition, all improvements would be constructed and operated in accordance with Minimization Measure **GEO-1**, listed in Section 2.3.2.4, *Avoidance, Minimization, and/or Mitigation Measures*, below.

Implementation of Project Features **PF-WQ-1** through **PF-WQ-5** (refer to Sections 1.4.1 and 2.3.1)—which stipulate adherence to all requirements set forth in the NPDES permit required for construction activities, including erosion control BMPs that would be part of the SWPPP—would address any potential construction-related erosion and siltation impacts. With implementation of these Project features, no short-term direct or indirect adverse impacts related to soil erosion are expected to occur during Project construction under Build Alternative 1.

*Design Variation: Build Alternative 1a*

As Build Alternative 1a generally occupies a similar footprint to Alternative 1, potential impacts on the geological environment are also expected to occur and would be similar to those described under Build Alternative 1 above. Alteration of existing topography and the exposure of soils (resulting in erosion) could occur during construction for similar reasons (e.g., excavations, weather) as those described above. In addition,

construction personnel and roadway users could be subject to potential impacts associated with seismic shaking under Build Alternative 1a, as it is in the seismically active region of Southern California and is seismically vulnerable based on the calculated PGA data.

Build Alternative 1a would adhere to all regulations and permit requirements described as part of Build Alternative 1 and would also require implementation of the same Project Features (**PF-WQ-1** through **PF-WQ-5**, **PF-GEO-1**) and Minimization Measure (**GEO-1**) mentioned above.

*Build Alternative 3*

Alternative 3 consists of Transportation System Management/Transportation Demand Management strategies and would not involve ground-disturbing activities. As such, no short-term or temporary impacts on geological or soil resources (e.g., erosion, sedimentation, slope instability) would occur because construction is not required.

**No-Build Alternative**

Under the No-Build Alternative, no construction activities would occur; therefore, no short-term or temporary impacts related to geological or soil resources would be expected. Existing conditions, however, would remain unchanged, and minor ongoing processes such as sedimentation and localized erosion of existing embankment slopes could continue.

***Permanent Impacts***

**Build Alternatives**

*Build Alternative 1*

Regional Geology and Topography

Build Alternative 1 is not anticipated to adversely affect geologic or topographic conditions within the Project limits, as improvements such as embankments would generally be constructed at or close to the same grade as the existing facility.

Subsurface Soil Conditions

Due to shallow soil variability and groundwater within the Project limits, it is recommended that special construction methods for retaining walls and soundwalls be considered. As stipulated in Minimization Measure **GEO-2**, a site-specific geotechnical investigation and laboratory testing would be performed for the proposed embankments, roadways, and structures to develop appropriate subsurface profiles for design and address constructability issues.

Faulting, Seismicity, and Surface Fault Rupture

There are no known active or potentially active surface faults within the Project limits, nor is the Project in an Alquist-Priolo Earthquake Fault Zoning Act–mapped area. However, the Project is subject to seismic shaking, as it is in the seismically active region of Southern California and is seismically vulnerable based on the calculated PGAs. As such, Build Alternative 1 would be designed and constructed in accordance

with Caltrans' current highway and structure seismic design standards, as discussed in Project Feature **PF-GEO-1**, which would minimize potential impacts. With implementation of **PF-GEO-1**, no direct or indirect adverse long-term impacts due to seismic shaking would occur as a result of Build Alternative 1.

Liquefaction and Seismically Induced Settlements

As previously discussed, the southern portion of the Project is within an identified liquefaction zone, as it is underlain by soil deposits that are susceptible to liquefaction. Alternative 1 would include some fill along the southbound direction of I-5 to accommodate the widening for a planned off-ramp. As stipulated in Minimization Measure **GEO-2**, a site-specific subsurface investigation and evaluation of liquefaction will be performed during the design phase for the Project, following identification of the preferred alternative, to address potential impacts of liquefaction on bridge, wall, and embankment foundations. If the No-Build Alternative is identified as the preferred alternative for the Project, then no further evaluation of potential liquefaction would be required. The Project will follow Caltrans' latest design requirements to minimize any potential effects related to liquefaction and seismically induced settlement. With implementation of Project Feature **PF-GEO-1** and Minimization Measure **GEO-2**, no direct or indirect adverse long-term impacts are expected to occur as a result of Build Alternative 1.

**PF-GEO-1** **Caltrans Standard Specifications 48.2.02 B and Section 19 Earthwork General:** The Project shall comply with the most current Caltrans procedures and design criteria regarding seismic design to address any adverse effects related to seismic ground shaking. Earthwork shall be performed in accordance with Caltrans Standard Specifications, Section 19, which requires standardized measures related to compacted fill, over-excavation and recompaction, and retaining walls, among other requirements. Moreover, Caltrans Highway Design Manual Topic 113, Geotechnical Design Report, requires that a site-specific, geotechnical field investigation be performed for the Project during the design phase. The findings and recommendations from the investigation shall be incorporated into the final Project design.

Landslides

The terrain within the Project limits is relatively flat and, according to the CGS, is not at risk of seismically induced landslides or rockfall; therefore, there would be no impact on Build Alternative 1 as a result of this hazard.

Other Seismic Hazards

Due to the shallow depth of bedrock and increasing groundwater levels measured over time, and no known history of subsidence, soil subsidence is unlikely to occur within the Project limits.

The area within the Project limits could be subject to liquefaction and seismically induced settlements. Due to the site elevation and distance from the coastline, as well as lack of large water bodies, there is no predicted risk of tsunami or seiche within the

Project limits. There is also no risk of volcanic activity, as there are no active, potentially active, or inactive volcanoes in Orange County.

*Design Variation: Build Alternative 1a*

As mentioned, Build Alternative 1a generally occupies a similar footprint to Alternative 1, and therefore potential permanent impacts associated with seismic phenomena and unstable soils such as those described for Build Alternative 1 above would also apply to Build Alternative 1a. Implementation of a site-specific geotechnical investigation (as part of Minimization Measure **GEO-2**) would be required for applicable Project features. In addition, Build Alternative 1a would be designed and constructed in accordance with Caltrans' current highway and structure seismic design standards (as required under Project Feature **PF-GEO-1**) to minimize potential adverse effects associated with seismic shaking. As mentioned, the southern portion of the Project footprint is within an identified liquefaction zone. As such, a site-specific subsurface investigation (which includes an evaluation of subsurface conditions, including liquefaction) would be performed as part of Minimization Measure **GEO-2** to address potential impacts on bridge, wall, and embankment foundations.

Similar to Build Alternative 1, impacts associated with regional geology and topography, landslides, and other seismic hazards are also considered unlikely for Build Alternative 1a.

With implementation of Project Feature **PF-GEO-1** and Minimization Measure **GEO-2**, no direct or indirect adverse long-term impacts are expected to occur as a result of Build Alternative 1a.

*Build Alternative 3*

Alternative 3 does not include physical improvements or ground disturbance; therefore, no long-term or permanent impacts on geological or soil resources would occur. Existing topography and soil conditions would remain unchanged, and current exposure to geologic hazards, including seismic activity, would remain the same.

**No-Build Alternative**

No construction is proposed under the No-Build Alternative; therefore, no long-term or permanent impacts related to geological or soil resources would occur. The existing topography and soils would not be affected; however, sedimentation, erosion of existing embankment slopes, and exposure to hazards associated with seismic activity would still exist.

### 2.3.2.4 Avoidance, Minimization, and/or Mitigation Measures

With implementation of Project Feature **PF-GEO-1,** as outlined above, the minimization measures listed below, and Project Features **PF-WQ-1** through **PF-WQ-5** outlined in Section 2.3.1, *Water Quality and Stormwater Runoff*, impacts related to geology, soils, seismicity, and topography would not be adverse.

**GEO-1** All improvements under all Build Alternatives would be constructed and operated in accordance with all applicable safety standards, such as the California Occupational Safey and Health Administration's standards related to worker safety during construction and operation in Title 8 Chapter 3.2, California Safety and Health Regulations, California Code of Regulations; and National Fire Protection Association Safety Codes and Standards.

**GEO-2** During the design phase, a detailed geotechnical investigation shall be conducted by qualified geotechnical personnel to assess the geotechnical conditions at the Project area. The geotechnical investigation shall include exploratory borings to investigate site-specific soils and conditions and to collect samples of subsurface soils for laboratory testing. Those soil samples shall be tested to determine liquefaction potential, collapsibility potential, stability, and corrosion potential. The Project-specific findings and recommendations of the geotechnical investigation shall be summarized in Structure Foundation Reports and a Geotechnical Design Report to be submitted to Caltrans for review and approval. Those findings and recommendations shall be incorporated in the final design of the identified preferred alternative. If the No-Build Alternative is identified as the preferred alternative for the Project, then no further geotechnical investigations are required.