2.8 Geology/Soils/Seismic/Topography

2.8.1 Regulatory Setting

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.

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 Caltrans Seismic Design Criteria (SDC). The SDC 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. For more information, please see Caltrans Division of Engineering Services, Office of Earthquake Engineering, Seismic Design Criteria.

2.8.2 Affected Environment

This section is based on the Preliminary Geotechnical Report (PGR) (July 2018), Paleontological Identification Report and Paleontological Evaluation Report (December 2018); and most current groundwater data.[1]

2.8.2.1 Topography and Regional Geology

The Study Area is within the Peninsular Ranges geomorphic province at the northeast edge of the San Joaquin Hills. The San Joaquin Hills are along the southern boundary of the Irvine Basin and are the expression of a large, broad, faulted anticline (Vedder et al. 1957; Vedder 1975). Several streams (e.g., San Juan Creek, Trabuco Creek, Oso Creek, Aliso Creek) have incised valleys and canyons through the hills toward the coast. Uplift of the San Joaquin Hills is believed to be a result of the shortening of the crust perpendicular to the southern Newport-Inglewood Fault Zone (Grant et al., 1999, 2002 and 2004). The Study Area contains Artificial Fill, Young Axial Channel Deposits, Young Alluvial Fan Deposits, Very Old Axial Channel Deposits, Very Old Alluvial Fan Deposits, the Niguel Formation, and the Monterey Formation. The elevation in the Study Area is relatively level, ranging from roughly 300 feet near Lake Forest Drive to 380 feet near El Toro Road. Information of Groundwater Conditions, Regional Faulting, and Seismic Hazards and Surface Fault Rupture are discussed in Sections 2.8.2.3 and 2.8.2.4, below.

2.8.2.2 Subsurface Soil Conditions

The subsurface conditions within the Study Area was determined by the Log of Test Borings (LOTB) prepared for the original bridge construction and the subsequent widening. The LOTB indicated that the subsurface materials within the Study Area consist of Artificial Fill placed for the construction of the Interstate 5 (I-5) embankment, including approach fills and the underlying native soils. The Artificial

[1] Most current groundwater data from the Structure Preliminary Geotechnical and District Preliminary Geotechnical Reports.

Fill at the bridge approaches is present from an elevation of about 360 feet to the top of the I-5 embankment at an approximate elevation of 380 feet. The fill consists mainly of granular materials with varying amounts of clays and silts. The apparent density of the fill ranges from medium dense to very dense. Terrace Deposits and alluvium underlying the fill also consists of granular soils with clays and silts that are predominantly dense. Terrace Deposits and alluvium are underlain by claystone/ siltstone units of Monterey Formation from elevations of 339 feet and 352 feet downwards. There are no existing expansion index tests for the Study Area. However, due to the fine-grained soils present in the area, the risk is expected to be moderate.

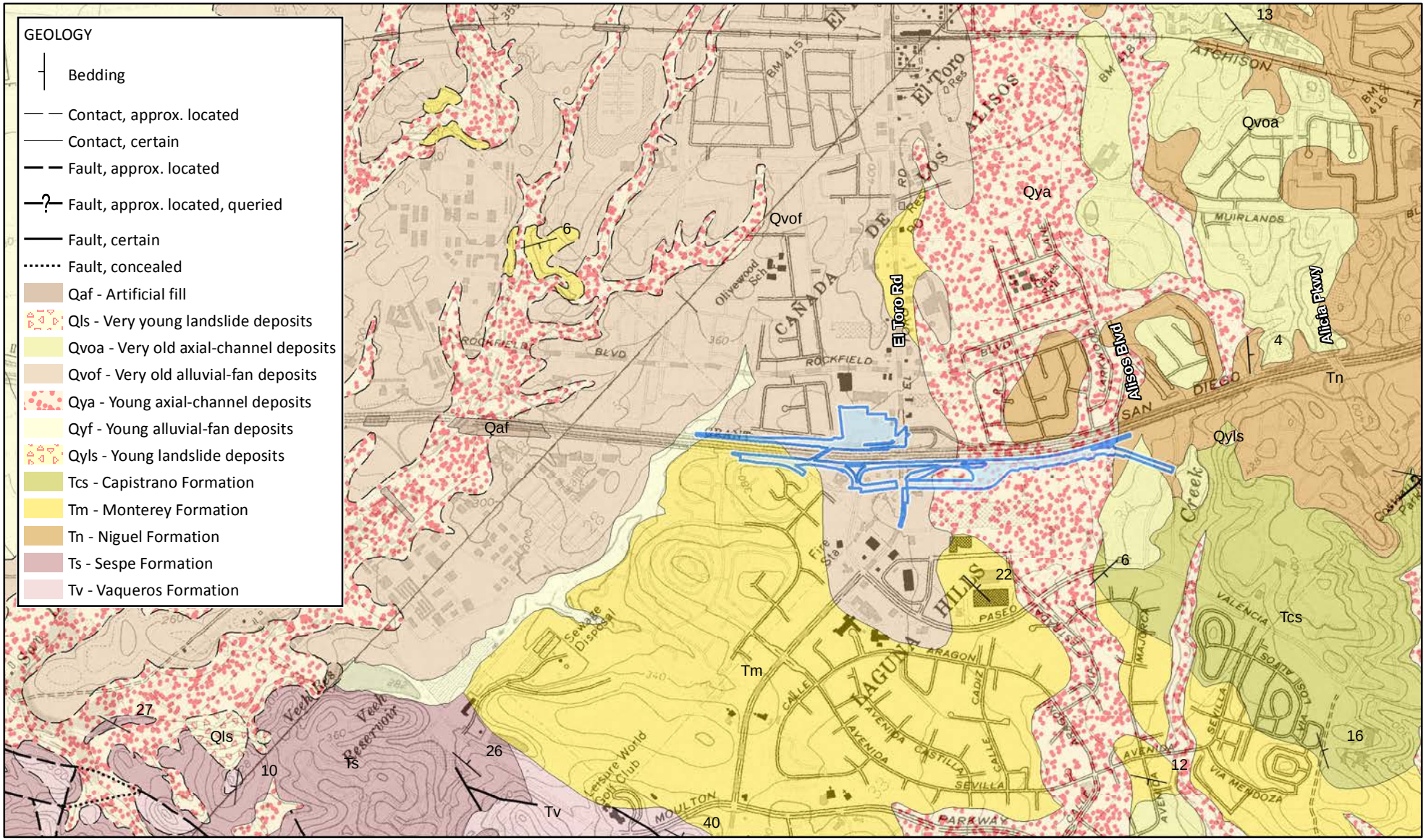
2.8.2.3 Groundwater Conditions

Groundwater flow direction is toward the Pacific Ocean. Within the Study Area, groundwater elevation is higher in the northeast and the gradient flows to the 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 to the northeast, and between 10 to 15 feet in the southwest. Fluctuations of the groundwater level, localized zones of perched water, and variations in soil moisture content should be anticipated during and following the rainy season (late fall to early spring).

2.8.2.4 Regional Faulting, Seismic Hazards and Surface Fault Rupture

The Study Area is in the seismically active Southern California region within the influence areas of three closest major active or potentially active surface faults including the San Joaquin Hills Fault, the Newport-Inglewood Fault Zone (S. Los Angeles section-southern) and the Newport-Inglewood Fault (offshore). These fault systems are considered active and well defined, and are capable of producing potentially damaging seismic ground shaking in the Study Area. The San Joaquin Hills Fault is a southwest-dipping, low-angle reverse (thrust) fault that is concealed and does not reach the ground surface; this fault is 0 to 1.3 miles from the Study Area. The San Joaquin Fault is capable of generating a magnitude 7.0 earthquake. The Newport Inglewood fault zone (S. Los Angeles section-southern) is a right-lateral strike-slip fault and is 7.2 miles to the Study Area. The Newport Inglewood Fault Zone (S. Los Angeles section-southern) is capable of generating a magnitude 7.2 earthquake. The Newport Inglewood Fault is a right-lateral strike-slip fault and is approximately 9 miles from the Study Area; this fault is capable of generating a magnitude 6.9 earthquake. The nearest substantial local sources of earthquakes and associated information are summarized in Table 2.8.1 below. Figure 2.8-1 shows fault systems near the Study Area.

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 things such as roads, bridges, and buildings.



LEGEND

Project Limits

FIGURE 2.8-1

0 1000 2000

FEET

SOURCE: USGS 7.5' QUAD (El Toro (1982), San Juan Capistrano (1981)); Morton (2006)

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I-5/El Toro Road Interchange Project

Regional Geology

12-ORA-5 PM 17.8/19.7

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Table 2.8.1: Local Fault Data

Fault Name	Maximum Earthquake Magnitude	Type	Dip Degrees	Dip Direction	R_{rup} (miles)	R_{JB} (miles)	Rx (miles)
San Joaquin Hills	7.0	Rev	23	W	1.3	0	0.4
Newport Inglewood Fault Zone (S. Los Angeles section-southern)	7.2	SS	90	V	7.2	7.2	7.2
Newport-Inglewood (offshore)	6.9	SS	90	V	9.0	9.0	9.0

Source: *Preliminary Geotechnical Report (July 2018).*
R_{rup} = Closest distance (miles) to the fault rupture plane.
R_{JB} = Joyner-Boore distance - The shortest horizontal distance (mi) to the surface projection of the rupture area.
R_x = Horizontal distance (miles) to the fault trace or surface projection of the top of rupture plane.
Rev = Reverse
SS = Strike-Slip
V = Vertical
W = West

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 Study Area are estimated to be 0.619g[1].

The Study Area is not near any mapped Special Studies Zone[2], or within 1,000 feet of a historically active, unzoned fault.

2.8.2.5 Geological Hazards

Liquefaction and Seismically Induced Landslides

The Study Area is not within a liquefaction or seismically induced landslides zone and is not mapped by the California Geological Survey (CGS) within a zone that is at risk for seismically induced landslide. Combined with the relatively low relief across the project limits, it has been determined that there is no risk of seismically induced landslide and rockfall at the Study Area.

Groundwater in close proximity to the Study Area was encountered at a depth of 10–20 feet below ground surface (elevation 337 feet) in potentially non-liquefiable bedrock materials. In addition, the Study Area is on relatively flat terrain; therefore, the consequences of liquefaction would be mainly limited to seismically induced settlements.

Tsunami and Seiches

Tsunamis are seismically induced sea waves generated by offshore earthquakes, submarine landslides, or volcanic activity. The nearest mapped Tsunami Inundation Zone is 6.55 miles from the closest point of the Study Area, according to the California Geological Survey's Tsunami Inundation Map for the Laguna Beach quadrangle. In addition, there is no large body of enclosed water near the Study Area. Seiches are another type of water-related, seismically induced hazard. Seiches

[1] "g" is a common value of acceleration equal to 32 feet/second^2.
[2] Name of map that shows seismic hazards and fault ruptures.

are extensive wave actions on lakes or reservoirs. Because there is no major water body in the Cites of Laguna Hills, Laguna Woods, or Lake Forest, the potential for a seiche is remote.

Soil Subsidence

Due the shallow depth to bedrock and the increasing groundwater levels measured over time, soil subsidence is unlikely to occur within the Study Area.

Volcanic Hazards

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

Economical Resources/Mineral Hazards

The CGS Mineral Land Classification Map does not identify economical resources/ mineral resources within the Study Area.

2.8.3 Environmental Consequences

2.8.3.1 Temporary Impacts

Build Alternatives (Alternatives 2 and 4 [including Design Option B])

The potential temporary impacts of the two Build Alternatives and Design Option B related to geotechnical issues and resources would be very similar along the project limits and would differ only as a result of improvements provided in slightly different areas under each Build Alternative (including Design Option B). Those impacts are discussed generally in this section and are summarized by alternative in the following sections.

Potential temporary impacts related to the geological environment are expected to occur as a result of earthwork activities associated with the Build Alternatives (including Design Option B), which include soil erosion and siltation. Cut-and-fill operations necessary to provide embankments would result in an alteration to the existing topography and may increase the risk of soil erosion and siltation. The Build Alternatives (including Design Option B) would be required to conform to the requirements of the Caltrans statewide National Pollutant Discharge Elimination System (NPDES) Storm Water Permit, Order No. No. 2012-0011-DWQ, NPDES No. CAS000003, adopted by the State Water Resources Control Board, and any subsequent permit in effect at the time of construction. In addition, the Build Alternatives would be required to comply with the requirements of the NPDES Permit for Construction Activities, Order No. 2009-0009-DWQ, NPDES No. CAS000002, as well as implementation of the best management practices (BMPs) specified in Caltrans' Storm Water Management Plan (Caltrans, 2003).

The project contractor would also be required to develop a Storm Water Pollution Prevention Plan (SWPPP) prepared 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. 2009-0009-DWQ, as amended by Order No. 2010-0014-DWQ, and Order No. 2012-0006-DWQ, NPDES No. CAS000002), or subsequent permits in effect at the time of construction. The SWPPP shall address all construction-related activities, equipment, and materials that have the potential to affect water quality. The SWPPP

shall include BMPs to control pollutants, sediment from erosion, storm water runoff, and other construction-related impacts. Refer to Section 2.7, Water Quality and Storm Water Runoff, for a detailed analysis of short-term construction water quality impacts and a further description of existing regulations and Project Features applicable to the Build Alternatives (including Design Option B).

Construction activities associated with the Build Alternatives (including Design Option B) could expose construction workers and the traveling public to potential impacts associated with seismic shaking. A Project Feature has therefore been recommended, as described in PF-GEO-1, below. Implementation of PF-GEO-1 during construction would avoid and minimize these potential impacts.

No Build Alternative

The No Build Alternative would not result in short-term/temporary impacts to geological or soil resources, because no construction is proposed in this alternative. Under the No Build Alternative, hazards associated with seismic activity would exist as they do today.

2.8.3.2 Permanent Impacts

Build Alternatives (Alternatives 2 and 4 [including Design Option B])

The following geological hazards, including Tsunami and Seiches, Soil Subsidence, Volcanic Hazards and Economical Resources/Mineral Hazards for the Build Alternatives are not discussed further in this section, because risks associated with these hazards within the Study Area are low:

Tsunami and Seiches

Due to a lack of large bodies of enclosed water near the Study Area and because it is far from the Tsunami Inundation Zone, the potential risks to the Build Alternatives related to tsunamis and seiches are considered negligible.

Soil Subsidence

Due to the shallow depth of bedrock and the increasing groundwater levels measured over time, soil subsidence is unlikely to occur within the Study Area.

Volcanic Hazards

As discussed earlier, there are no active, potentially active, or inactive volcanoes in Orange County; therefore, volcanic hazards are unlikely to affect the project limits.

Economical Resources/Mineral Hazards

No economic resources/mineral resources are identified within the Study Area; therefore, economical resources/mineral resources are unlikely to be affected or become hazardous to the project limits.

Topography and Regional Geology

Both Build Alternatives and Design Option B would not result in permanent substantive changes to the topography in the project limits, because the improvements would generally be constructed at or close to the same grade as the existing facility.

Subsurface Soil Conditions

As discussed earlier in Section 2.8.2.1, due to the fine-grained soils present in the area, expansive soils on site represent a moderate risk. During final design, implementation of the minimization measure GEO-2 would ensure that appropriate measures are incorporated into the design phase to address the risk from expansive soils.

Regional Faulting, Seismicity and Surface Fault Rupture

As discussed above, there are no known active or potentially active surface faults within the Study Area. In addition, the Study Area is not located in the vicinity of any mapped Special Studies Zone or within 1,000 feet of a historically active, unzoned fault. Therefore, the potential for ground rupture is considered to be low. The Build Alternatives (including Design Option B) would not result in adverse effects related to ground rupture. In addition, as discussed in Project Feature PF-GEO-1, all structures associated with the Build Alternatives (including Design Option B) would be designed to incorporate appropriate design measures to address potential effects associated with PGA during seismic events.

Liquefaction, and Seismically Induced Landslides

Although the embankments could experience seismically induced lateral deformations depending on depth, areal extent, post-liquefaction, residual strength of the potentially liquefiable layers, it is determined that such deformations would be minor. Implementation of Project Feature PF-GEO-1 and minimization measure GEO-2 (Section 2.8.4), described below, would reduce potential effects associated with liquefaction and seismically induced settlement, and these effects would not be substantial.

PF-GEO-1 **Caltrans Standard Specifications 48-2.02. B and Section 19 Earthwork General:** The project will comply with the most current Caltrans procedures and design criteria regarding seismic design to mitigate any adverse effects related to seismic ground shaking. Earthwork will 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 (HDM) Topic 113, Geotechnical Design Report, would require that a site-specific, geotechnical field investigation be performed for the proposed project during the design phase. The findings and recommendations from the investigation would be incorporated into the final design.

No Build Alternative

The No Build Alternative does not involve any construction activities and would not alter existing geologic or soil conditions; therefore, it would not result in any adverse impacts to geological, mineral, or soil resources. Hazards associated with seismic activity would exist as they do today under the No Build Alternative.

2.8.4 Avoidance, Minimization, and/or Mitigation Measures

With implementation of the Project Feature PF-GEO-1 as outlined above and the minimization measures as listed below, impacts would not be adverse.

GEO-1 All improvements under both Build Alternatives and Design Option B would be constructed and operated in accordance with all applicable safety standards, such as California Occupational Safety and Health Administration (Cal/OSHA) 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 (NFPA) Safety Codes and Standards.

GEO-2 During design phase, a detailed geotechnical investigation will be conducted by qualified geotechnical personnel to assess the geotechnical conditions at the project area. The geotechnical investigation will include exploratory borings to investigate site-specific soils and conditions and to collect samples of subsurface soils for laboratory testing. Those soil samples will be tested to determine liquefaction potential, collapsibility potential, stability, and corrosion potential. The project-specific findings and recommendations of the geotechnical investigation will be summarized in Structure Foundation Reports (SFRs) and a Geotechnical Design Report (GDR) to be submitted to the California Department of Transportation (Caltrans) for review and approval. Those findings and recommendations will be incorporated in the final design of the selected Build Alternative.

In addition, short-term erosion effects during construction would be avoided and/or minimized through Project Features outlined in Section 2.7, Water Quality and Storm Water Runoff.

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