4.8 Geology, Soils, and Seismicity

4.8.1 Introduction

This section describes the affected environment and environmental consequences related to geology, soils, and seismicity from operations of the NEPA Alternatives. The analysis in this section is based on *VTA's BART Silicon Valley Phase II Extension Project Geotechnical Memorandum* prepared by PARIKH Consultants, Inc. in February 2014.

4.8.2 Environmental and Regulatory Setting

4.8.2.1 Environmental Setting

This section discusses the existing conditions related to geology, soils, and seismicity within the BART Extension, including staging areas.

Geologic Setting

Topography

Santa Clara County is primarily in a flat alluvial plain that lies between the Santa Cruz Mountains and the Diablo Range. Most of the area consists of level terrain, which gives way to rolling foothills toward the east and west. These foothill areas become steeper and graduate into mountain ranges. The Salinas Valley lies to the south, and San Francisco Bay is located to the north. The elevations in the county range from approximately 0 feet to 4,370 feet above mean sea level, and the slope of the land is toward the bay. The mountains and foothills in the western and southern portions of the county are the sources of the watercourses that flow through the northern county (Santa Clara County 1994).

The alignment is located on relatively flat terrain within Santa Clara County.

Geology

The BART Extension would be located in the Santa Clara Valley, which extends southeastward from San Francisco Bay and is a northwest/southeast trending valley within the Coast Ranges Geomorphic Province of Northern California. The Santa Clara Valley is an alluvium-filled basin located between the Santa Cruz Mountains to the southwest and the Diablo Range to the northeast. The valley is covered by alluvial fan, levee, and active stream channel deposits with marine estuary deposits located along the bay margins. These unconsolidated deposits cover Tertiary through Cretaceous age bedrock. The BART Extension would be located in an area of the valley where the ground surface has no steep slopes.

The BART Extension is underlain by a variety of alluvial deposits. The alluvium has been identified as Holocene age alluvial fan deposits (Qf & Qhf), fine-grained Holocene alluvial

fan deposits (Qhff), Holocene alluvial fan levee deposits (Qhl), Holocene stream channel deposits (Qhc), and historic artificial channel deposits (ac). Fine-grained Holocene alluvial fan deposits (Qhff) occur on the flatter distal portions of fans and consist primarily of silt and clay-rich sediments with interbedded layers of coarser sand and occasional gravel. The Holocene alluvial fan levee deposits (Qhl) consist of silt, sand, and clay. Artificial fill may be present over any of the Holocene age deposits along the BART Extension.

Bedrock buried at great depth beneath the BART Extension is presumed to be the Franciscan Complex of the upper Jurassic to Cretaceous age. The Franciscan Complex bedrock is overlain by a thick (over 1,000 feet) deposit of Tertiary marine/non-marine sediments and by Pleistocene to Recent deposits.

Geologic Hazards

Fault Rupture

The BART Extension lies between the San Andreas Fault to the west and the Hayward and Calaveras Faults to the east. Both the Hayward Fault and Calaveras Fault are known active faults. The Hayward fault is located approximately 12 miles north of the Alum Rock/28th Street Station and extends from San Jose about 74 miles northward along the base of the East Bay Hills to San Pablo Bay. The Silver Creek Fault crosses the alignment perpendicularly between the Downtown San Jose and Alum Rock/28th Street Station locations. Based on geomorphic and preliminary paleoseismic evidence, Silver Creek fault is considered to be potentially active. The Silver Creek Fault is also characterized as potentially active in the *Envision San Jose 2040 General Plan*. The following provides additional detail on the aforementioned faults:

- **Hayward Fault** – Last major earthquake occurred in October 1868 and had a Richter magnitude of 7. Capable of generating a maximum credible earthquake[1] of moment magnitude (Mw) 7.1.
- **San Andreas Fault** –Largest active California fault, responsible for the largest earthquake in California: the 1906 Mw 7.9 San Francisco earthquake.
- **Silver Creek Fault** – Maximum magnitude distribution for this fault ranges from 6.3 to 6.9.

Other faults in the region that are capable of producing large magnitude earthquakes are the San Gregorio, Rodgers Creek, Hayward Southeast Extension, Sargent, Concord-Green Valley, Ortigalita, and Greenville Faults, along with the faults of the Foothills thrust belt. All of these faults are located within 40 miles of the BART Extension.

[1] Maximum credible earthquake is the largest earthquake that can be expected to occur on a fault over a particular period of time.

Liquefaction

Liquefaction occurs when saturated, low-density, loose materials (e.g., sand or silty sand) are weakened and transformed from a solid to a near-liquid state as a result of increased pore water pressure. The increase in pressure is caused by strong ground motion from an earthquake. Liquefaction most often occurs in areas underlain by silts and fine sands and where shallow groundwater exists. Liquefaction can cause structures built on or above liquefiable soils to experience bearing capacity failure and collapse. Flow failure, lateral spreading, differential settlement, loss of bearing capacity, ground fissures, and sand boils are evidence of generation of excess pore pressure and liquefaction. In areas susceptible to liquefaction, one of the primary liquefaction hazards is seismically-induced settlement and temporary increase in lateral earth pressures on below-grade structures. Although a soil layer may or may not fully liquefy during an earthquake, it can still experience settlement.

All of the stations and the Newhall Maintenance Facility would be located on Holocene alluvial fan deposits, which are identified as having a moderate liquefaction potential. Post-liquefaction settlements of less than 1 inch to 2 inches are anticipated near Alum Rock/28th Street, Diridon (South and North Options), and Santa Clara Stations (PARIKH Consultants 2014). A portion of the alignment near the Alum Rock/28th Street Station location crosses a narrow historic artificial channel that is also rated with a moderate liquefaction potential.

Approximately 100 and 700 feet northeast of Diridon Station (South and North Options) the alignment crosses the two (approximately 100-foot-wide) stream channels (Los Gatos Creek and Guadalupe River, respectively), where the liquefaction potential is characterized as being very high. The approximately 500-foot-long segment of the alignment near the Diridon Station (South and North Options) location between the two stream channels is rated as having moderate liquefaction potential.

Landslides

The BART Extension is located on nearly flat terrain and is not identified as being susceptible to earthquake-induced landslides.

4.8.2.2 Regulatory Setting

There are no specific federal regulations related to geologic conditions. The BART Extension must be in compliance with state laws. The state regulations relevant to the BART Extension are provided in Chapter 6, Section 6.8, *Geology, Soils, and Seismicity*.

4.8.3 Methodology

The following section identifies impacts and evaluates whether they would be adverse according to NEPA, using the criteria (i.e., context and intensity) identified in Section 4.1, *Introduction*. An *adverse effect* would pose an increased risk of personal injury, loss of life,

and damage to property on a regional scale. The section also identifies design commitments, best management practices, and other measures to avoid, minimize, or mitigate impacts.

4.8.4 Environmental Consequences and Mitigation Measures

4.8.4.1 No Build Alternative

The No Build Alternative consists of the existing transit and roadway networks and planned and programmed improvements in the study area(see Chapter 2, Section 2.2.1, *NEPA No Build Alternative*, for a list of these projects). The No Build Alternative projects would likely result in geologic and seismic effects typically associated with transit, highway, bicycle, and pedestrian, facilities, and roadway projects. Structures associated with the projects would be designed in accordance with applicable seismic design standards in the California Building Code. Additionally, it could be anticipated that engineering studies would be performed to identify the appropriate design measures needed for the geologic and seismic conditions of any project sites. Projects planned under the No Build Alternative would undergo separate environmental review to determine geologic effects. Review would include an analysis of impacts and identification of mitigation measures to mitigate potential project impacts.

4.8.4.2 BART Extension Alternative

Potential seismic hazard sources in the study area are surface fault rupture, ground shaking, and liquefaction. Potential expansive soils and erosion impacts are also discussed because they have the potential to negatively affect the BART Extension.

Surface Fault Rupture

The BART Extension is not located within an Earthquake Fault Zone as defined and mapped under the Alquist-Priolo Act. The Silver Creek Fault, which is a potentially active fault, runs northwest to southeast and crosses the alignment between the Downtown San Jose and Alum Rock/28th Street Stations. Although there may be potential for fault rupture impacts along the Silver Creek Fault near Alum Rock/28th Street Station, the BART Extension would comply with requirements set forth in the California Building Code and the pertinent BART Facilities Standards to withstand forces associated with the maximum credible earthquake. The California Building Code and the pertinent BART Facilities Standards provide standards intended to permit structures to withstand seismic hazards. The code sets standards for excavation, grading, construction earthwork, fill embankments, expansive soils, foundation investigations, liquefaction potential, and soil strength loss. Adherence to the requirements in the California Building Code and the pertinent BART Facilities Standards would reduce the potential of fault rupture impacts to *no adverse effect*, and no mitigation is required.

Ground Shaking

The San Andreas, Hayward, and Calaveras Faults are capable of generating large magnitude earthquakes that can result in strong ground shaking. Additionally, the Silver Creek Fault is considered a potentially significant seismic source. Seismically induced ground shaking within the BART Extension would depend on the magnitude of the earthquake, distance from the BART Extension to the fault source, directivity (focusing of earthquake energy along the fault in the direction of the rupture), and subsurface conditions. Therefore, the potential for strong ground shaking to occur within the BART Extension is considered moderate to high. The proximity of these faults and other nearby active faults means that strong ground shaking would eventually subject the alignment and structures to strong seismic shaking. Structures could be damaged or destroyed and people could be harmed during a major seismic event originating on any of the nearby faults.

The BART Extension would be designed and constructed to meet or exceed the current seismic design standards set forth by the California Building Code, as well as the pertinent BART Facilities Standards, Release 1.2. These codes and standards are designed to reduce major structural damage and avoid major injury and loss of life in the event of an earthquake. The seismic performance goals generally expect that some property damage would result from a moderate to large earthquake, but that damage would generally be reparable and not life threatening. With adherence to the standards mentioned above, potential exposure of people to harm from geologic or seismic hazards would result in *no adverse effect*, and no mitigation is required.

Liquefaction

As described in Section 4.8.2.2, *Environmental Setting*, the majority of the BART Extension is located in an area with moderate liquefaction potential, and a portion of the alignment is located in an area with very high liquefaction potential. Settlement after liquefaction could range from 1 to 2 inches at the Alum Rock/28th Street, Diridon (South and North Options), and Santa Clara Stations. BART Facilities Standards Design Criteria limit the total settlements for structure foundations to 1 inch or less; therefore, there would be a need to reduce liquefaction-related settlement hazards along some portions of the alignment. The exact methodologies to reduce these hazards to be used will be determined during final engineering, but examples are included in Mitigation Measure GEO-CNST-A (see Chapter 5, Section 5.5.9, *Geology, Soils, and Seismicity*). These design requirements would reduce the potential exposure of people to hazard from seismic risk associated with liquefaction.

Liquefaction could also affect underground structures if the structures are buoyant. The liquefied soil could uplift the underground structures resulting in the deformation of ground surface, buildings, and utilities located above an uplifted structure. This would be a potentially adverse effect.

The BART Extension would be designed and constructed to meet or exceed standards set forth by the California Building Code and the pertinent BART Facilities Standards. Because

the BART Extension would be constructed with adherence to the aforementioned standards, requirements, and mitigation measure, potential operational impacts would result in *no adverse effect*, and no mitigation is required.

Because the ground surface is relatively flat along the alignment, the impacts from lateral spreading would be *no adverse effect*, and no mitigation is required.

Landslides

The BART Extension is located on nearly flat terrain and is not identified on any California Geological Survey Seismic Hazard Zone maps as being susceptible to earthquake-induced landslides. Therefore, impacts from landslides would result in *no adverse effect*, and no mitigation is required.

Expansive Soils

Expansive soils are fine-grained soils (generally high-plasticity clays) that can undergo a significant increase in volume with an increase in water content as well as a significant decrease in volume with a decrease in water content. Changes in the water content of highly expansive soils can result in severe distress for structures constructed on or against the soils.

Expansive soils are a concern for the structures for system facilities, parking garages, and vehicular and pedestrian access at the stations. Some of the soils at station locations and the Newhall Maintenance Facility have high Plasticity Indices of between 21 and 40 meaning that they have moderate to high expansion potential.

The BART Extension would be designed and constructed to meet or exceed standards set forth by the California Building Code and the pertinent BART Facilities Standards.

Because the BART Extension would be constructed with adherence to the aforementioned standards, requirements and mitigation measures, operational impacts result in *no adverse effect*, and no mitigation would be required.

4.8.5 NEPA Conclusion

For the BART Extension Alternative, adherence to California Building Code requirements and pertinent BART Facilities Standards would ensure that impacts related to liquefaction would result in *no adverse effect* under NEPA. Impacts related to fault rupture, ground shaking, liquefaction, landslides, erosion, and expansive soils would result in *no adverse effect* for the BART Extension Alternative, and no mitigation would be required.