

## 4.9 Geology, Soils, and Seismicity

### 4.9.1 Regulatory Framework and Methodology

#### 4.9.1.1 Regulatory Framework

The applicable federal, state, and local regulations that are relevant to an analysis of the proposed project's geological impacts are listed below. For additional information regarding these regulations, please see the Geotechnical Report in Appendix O of this Draft EIS/EIR.

##### **Federal**

- The National Flood Insurance Program (NFIP)

##### **State**

- The Alquist-Priolo Geologic Hazards Zone (APEFZ) Act<sup>1</sup>
- The Seismic Hazards Mapping Act of 1990

##### **Local**

- Metro Design Criteria (Metro, 2012)

#### 4.9.1.2 Methodology

Impacts associated with the geotechnical considerations have been identified from a review of available published and unpublished literature that includes, but is not limited to, the Safety Element of the Los Angeles City General Plan; official APEFZ maps; official seismic hazard zone maps; and geologic and topographic maps and other publications of the California Geological Survey (CGS), U.S. Geological Survey (USGS), and the California Division of Oil and Gas.

#### 4.9.1.3 Significance Thresholds

##### **NEPA**

NEPA does not include specific significance thresholds. According to the Council on Environmental Quality (CEQ) Regulations for Implementing NEPA, the determination of significance under NEPA is based on context and intensity.<sup>2</sup>

Context relates to the various levels of society where effects could result, such as society as a whole, the affected region, the affected interests, and the locality. The intensity of an effect relates to several factors, including the degree to which public health and safety would be affected; the proximity of a project to sensitive resources; and the degree to which effects on the quality of the human environment are likely to be highly controversial or involve unique or unknown risks.

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<sup>1</sup> Bryant, W. A. and E.W. Hart, 2007, Fault Rupture Hazard Zones in California, Alquist-Priolo Earthquake Fault Zoning Act with Index to Earthquake Fault Zone Maps, California Division of Mines and Geology Special Publication 42, Interim Revision 2007.

<sup>2</sup> Code of Federal Regulations. *CEQ – Regulations for Implementing NEPA, 40 CFR Part 1508, Terminology and Index*. Available: <<http://ceq.hss.doe.gov/nepa/regs/ceq/1508.htm>>. Accessed: February 15, 2013.

## CEQA

CEQA requires state and local government agencies to identify the significant environmental effects of proposed actions; however, CEQA does not describe specific significance thresholds. According to the Governor's Office of Planning and Research, significance thresholds for a given environmental effect are at the discretion of the Lead Agency and are at the levels at which the Lead Agency finds the effects of the project to be significant.<sup>3</sup>

### State CEQA Guidelines

The State CEQA Guidelines define a significant effect on the environment as: "a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance" (State CEQA Guidelines, Section 15382).<sup>4</sup>

The State CEQA Guidelines do not describe specific significance thresholds. However, Appendix G of the State CEQA Guidelines lists a variety of potentially significant effects, which are often used as thresholds or guidance in developing thresholds for determining impact significance. Accordingly, for the purposes of this EIS/EIR, a project would normally have a significant geology/soils impact, under CEQA, if it would:

- Expose people or structures to 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 APEFZ Map for the area or based on other substantial evidence of a known fault,
  - 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 project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse;
- Be located on expansive soil creating substantial risks to life or property; or
- Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems in areas where sewers are not available for the disposal of wastewater.

### L.A. CEQA Thresholds

The *L.A. CEQA Thresholds Guide*<sup>5</sup> states that a project would normally have a significant geologic hazard, landform, or soil sedimentation and erosion impact if it would:

- Cause or accelerate geologic hazards, which would result in substantial damage to structures or infrastructure, or expose people to substantial risk of injury;

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<sup>3</sup> OPR (State of California, Governor's Office of Planning and Research). 1994. *Thresholds of Significance: Criteria for Defining Environmental Significance*. September.

<sup>4</sup> AEP. 2012. *California Environmental Quality Act (CEQA) Statute and Guidelines*. Reproduced with permission from the California Resources Agency.

<sup>5</sup> City of Los Angeles. 2006. *L.A. CEQA Thresholds Guide*, E. Geology.

- Constitute a geologic hazard to other properties by causing or accelerating instability or erosion;
- Accelerate natural processes of wind and water erosion and sedimentation, resulting in sediment runoff or deposition, which would not be contained or controlled on-site; or
- Destroy, permanently cover, or materially and adversely modify one or more distinct and prominent geologic or topographic features; such features may include, but are not limited to, hilltops, ridges, hill slopes, canyons, ravines, rock outcrops, water bodies, streambeds, and wetlands.

## 4.9.2 Affected Environment/Existing Conditions

The following description of geologic and soil conditions in the study area is based on information provided in the Geotechnical Report, which is included in Appendix O to this EIS/EIR.

### 4.9.2.1 Geologic Units and Structure in the Eastern San Fernando Valley

The project area along Van Nuys Boulevard is located in the eastern portion of the San Fernando Valley, north of the Santa Monica Mountains, south of the San Gabriel Mountains, southeast of the foothills of the Santa Susana Mountains, and west of the Verdugo Hills. This portion of the San Fernando Valley ranges in elevation from approximately 1,100 feet above mean sea level (MSL) at the northeast end to 640 feet MSL at the Los Angeles River, a drop of 460 feet over the length of the study area. Ground surface generally slopes to the south and southwest because of a merger of alluvial fan surfaces, except at the far southern end, where slopes adjacent to the Santa Monica Mountains are to the north and northeast.

The San Fernando Valley is a geologic area underlain by a thick (several thousand feet) sequence of Tertiary age<sup>6</sup> sedimentary bedrock overlain by younger alluvial deposits. Older and younger Quaternary (Holocene<sup>7</sup> through early Pleistocene<sup>8</sup>) alluvial fan deposits consist predominantly of sand, silt, and gravel/boulders, along with smaller amounts of clay-rich materials. Descriptions of materials encountered in most borings drilled into these deposits for unrelated previous projects at various locations along the project area consist of loose to moderately dense sand. These deposits have been historically saturated to within 10 feet below the ground surface (bgs) near the south end of the project area to approximately 35 feet bgs at the northeast end and deeper within approximately 220 feet in the area of San Fernando Road and Van Nuys Boulevard. Deposits along the alignment south of approximately Vanowen Street are considered susceptible to liquefaction, as are deposits at/near the intersection of San Fernando Road and Hubbard Street at the northeast end of the project area.

Most soils within the project area have been modified and disturbed by grading and earthmoving associated with development, which includes the placement of artificial fill. Therefore, it is unlikely that significant areas of undisturbed native soils are present along the surface of the proposed alignment. Project area soil types are described below:

**Af – Artificial Fill:** artificial fill is located along the freeways in the study area (U.S. 101, I-210, SR-118, and I-5) and at Hanson Dam; this is noted by the CGS (1997, 1998). Other fill materials likely exist in areas scattered across the San Fernando Valley and, therefore, even though not shown on published maps, potentially exist to some extent in the project area. These fills may be engineered and compacted to modern standards or may be undocumented with unknown properties. In general, it

<sup>6</sup> The Tertiary age occurred from 65 to 2 million years ago.

<sup>7</sup> The Holocene epoch began 10,000 years ago.

<sup>8</sup> The Pleistocene epoch began about 2 million years ago and ended 10,000 years ago.

can be expected that the engineered fill materials will be predominantly sand, silt, and fine gravel due to the ease of compaction. Locally present undocumented fills may contain larger materials (cobble, boulders) and trash (e.g., organic matter, metal, concrete, wood).

**Qf – Alluvial Fan Deposits (Holocene):** The Qf deposits extend into the San Fernando Valley from the larger canyons to the north and east of the project area (e.g., Pacoima and Tujunga Canyons, respectively). The map view of these deposits is typically an irregular linear ribbon, some of which passes beneath portions of the proposed alignment. Qf deposits generally consist of unconsolidated gravelly, sandy, or silty alluvial deposits with cobbles and boulders on active and recently active alluvial fans.

**Qyf – Young Alluvial Fan Deposits (Holocene-Late Pleistocene):** Young alluvial fans cover a slightly greater percentage of the proposed alignment area than the alluvial fan deposits. As described by Yerkes and Campbell (2005),<sup>9</sup> Qyf consists of unconsolidated gravel, sand, and silt, coarser-grained closer to the mountains deposited from flooding streams and debris flows. The alluvial fan surfaces can show slight to moderate pedogenic soil development including clay development and cementation.

**Qof – Old Alluvial Fan Deposits (Late-Middle Pleistocene):** Qof is the undifferentiated older alluvial fan deposits (Yerkes and Campbell, 2005). Qof is found along San Fernando Road as it approaches Hubbard Street from the southeast. Qof consists of slightly to moderately consolidated silt, sand, and gravel deposits on incised alluvial fans; surfaces can show moderately to well-developed pedogenic soils.

#### 4.9.2.2 Groundwater

Groundwater levels are shallow at the southern end of the project area near the Los Angeles River and become deeper at the northern end of the project area near the foothills. Based on the review of the Caltrans logs of test borings and California Geological Survey LOTBs and CGS data, groundwater was detected in the previous borings near elevation 635 feet MSL, approximately 25 bgs at the southern end. Borings at the northern end did not encounter groundwater. Historically, groundwater has been as high as the ground surface at the southern end of the project area near the Los Angeles River (CGS, 1997).<sup>10</sup> The historically high groundwater levels specified by the CGS are shown on Figure 3-3 in the Geotechnical Report included in Appendix O.

#### 4.9.2.3 Faulting and Earthquake Potential

Plate tectonics and the forces that affect the earth's crust affect all of Southern California geology and seismicity. Faults are formed at the plate boundaries and other stress points within tectonic plates. Faults adjacent to, within, and beneath the City of Los Angeles and San Fernando Valley areas may be classified as inactive, potentially active, or active. Figure 4.9-1 identifies known faults in the region (CGS, 2010).<sup>11</sup> Regional faults of concern are strike slip faults (e.g., San Andreas, San Jacinto, Elsinore, Newport-Inglewood), normal, reverse, and thrust faults (e.g., Santa Monica-Hollywood, Sierra Madre-San Fernando, Palos Verdes, Raymond, and Verdugo), and buried (blind) thrust faults (e.g., Puente Hills, Northridge, and Elysian Park). This seismotectonic setting has been a part of the evolution of the Los Angeles County landscape for the past 5 million years.

<sup>9</sup> Yerkes, R. F. and Campbell, R. H., 2005, Preliminary Geologic Map of the Los Angeles 30' x 60' Quadrangle, Southern California U.S. Department of the Interior U.S. Geological Survey Open File Report 2005-1019, Scale 1:100000.

<sup>10</sup> California Geological Survey, 1997 (Revised 2001), Seismic Hazard Zone Report 008, Seismic Hazard Zone Report for the Van Nuys 7.5-Minute Quadrangle, Los Angeles County, California, 1997 (Revised 2001).

<sup>11</sup> California Geological Survey, 2010, Fault Activity Map of California, Geologic Data Map No. 6, Compilation and Interpretation by Charles W. Jennings and William A. Bryant.

Figure 4.9-1: Fault Map



The surface faults of most concern for the project area with respect to strong ground shaking are the Verdugo, San Fernando, Santa Monica-Hollywood, Oak Ridge, Newport-Inglewood, and San Andreas faults. Other smaller faults, such as the Mission Hills and Northridge Hills north and west of the project area, and the possible North Hollywood fault south and east of the project area, are of lesser concern due to their lower likelihood of independently generating moderate to large earthquakes. There remains uncertainty with regard to the earthquake characteristics of blind thrust faults (e.g., Elysian Park, Puente Hills, and Northridge) because they are buried; the Northridge blind thrust (source of the 1994 Northridge earthquake) underlies the northeastern San Fernando Valley at a depth of several thousand feet. Additional descriptions of the San Fernando, Verdugo and Northridge Hills, and possible North Hollywood faults are included below because each fault crosses or projects toward the project area, and each could produce ground rupture or ground deformation in a significant earthquake centered in this portion of the San Fernando Valley.

**San Fernando Fault:** The active Sierra Madre fault zone marks the southern margin of uplift of the western San Gabriel Mountains; the fault within the zone affecting the project area is the north-dipping San Fernando. Mapped San Fernando faults are within the APEFZ and the City of Los Angeles Fault Rupture Study Area (FRSA) at the intersection of San Fernando Road and Hubbard Street. The San Fernando fault (also divided by some into the San Fernando, Mission Wells, and Reservoir fault segments) ruptured most significantly in the 1971 San Fernando earthquake. Ground rupture occurred approximately 1,000 feet northeast of the above-named intersection. Offsets measure approximately 3 inches of left lateral and 10 inches of vertical displacement. The overall ratio of horizontal to vertical movement across the San Fernando fault zone in the 1971 earthquake was 1.9:1.39 (horizontal:vertical), and the maximum oblique displacement was 7.9 feet. Vertical movement within limited areas appears to have been greater in magnitude for bedrock sites 3.3 feet, less for older alluvium sites (1.6 feet), and substantially less for younger alluvium sites (2+ inches).

**Verdugo Fault:** The northwest-southeast trending Verdugo fault is the major bounding structure of the eastern San Fernando Valley and is considered active, although not within an APEFZ. Within the project area, the Verdugo fault is less well studied, but at a minimum, data from the neighboring cities of Glendale and Burbank indicate the fault would be considered potentially active.

**Northridge Hills Fault:** The 2010 State Fault Map shows the eastern end of the Northridge Hills fault stopping just west of the proposed alignment. A paleoseismic evaluation of the Northridge Hills fault has been conducted nearer the center of the fault's trend in the community of Northridge. The Northridge Hills fault has been described as a fault-propagation fold above an underlying blind thrust fault dipping northward at about 45 degrees; the fault is considered potentially active. This means that the fault has not yet broken the ground to the surface, but could cause local uplift, tilting, and ground deformation.

**Possible Fault in North Hollywood (Unnamed Fault L 66a):** The CSG shows this fault projecting from approximately 1/4 mile on the east toward the southern portion of the project area south of U.S. 101. The fullest description of this fault indicates it is defined on the 1901 and 1928 USGS topographic maps as an elevation change across a possible low, south-facing break in slope in younger Holocene alluvial deposits. This feature is also associated with an area of subsidence north of the Benedict Canyon fault and is suggestive of down-on-the-south movement affecting Holocene deposits. The fault lies outside any City of Los Angeles FRSA.

#### 4.9.2.4 Surface Faulting/Ground Rupture Hazard

The anticipated (average) amount of surface fault rupture on any given fault trace for the maximum earthquake can be inferred from measurements of offsets caused by past earthquakes. In general, these estimates range from zero to about 1 foot for magnitudes under M6.0, and from 1 foot to 10 feet or more for magnitudes between M6.0 and 7.5. Many variables affect the amount of surface rupture, including the depth of the earthquake hypocenter where the strain energy is released. Site-specific study is typically conducted to refine such estimates for a fault segment at a given project site.

A portion of the project area on San Fernando Road near the existing Sylmar/San Fernando Metrolink Station is within an APEFZ for the San Fernando fault. Additionally, the Verdugo fault is located within the project area and is considered to have potential ground rupture and differential uplift. The potential for earthquake activity and ground rupture is known for the San Fernando fault and not well understood for the Verdugo fault.

#### 4.9.2.5 Seismic Ground Motion

The site is located within a seismically active region. The characteristics of nearby known faults are summarized in Table 4.9-1.

**Table 4.9-1: Major Fault Characterization in the Project Vicinity**

Fault	Approximate Distance <sup>1</sup> (miles)	Type of Fault	Maximum Earthquake Magnitude <sup>2</sup> (Mw)
Verdugo	3.1	Reverse	6.9
Sierra Madre (San Fernando)	5.0	Reverse	6.7
Sierra Madre Connected	5.0	Reverse	7.3
Northridge	7.2	Thrust	6.9
Santa Susana, Alt 1	7.2	Reverse	6.9
Hollywood	9.5	Strike Slip	6.7
Sierra Madre	9.7	Reverse	7.2
San Gabriel	10	Strike Slip	7.3
Santa Monica Connected, Alt 1	11	Strike Slip	7.3
Santa Monica, Alt 1	11	Strike Slip	6.6
Santa Monica Connected, Alt 2	11	Strike Slip	7.4
Elysian Park (Upper)	11	Reverse	6.7
Newport-Inglewood, Alt 1	13	Strike Slip	7.2
Newport-Inglewood Connected, Alt 1	13	Strike Slip	7.5
Newport-Inglewood Connected, Alt 2	13	Strike Slip	7.5
Notes:			
1. Distances measured from intersection of Roscoe Boulevard and Van Nuys Boulevard.			
2. The maximum earthquake magnitude values are based on the Ellsworth relation.			
Source: USGS National Seismic Hazard Maps 2008.			

#### 4.9.2.6 Liquefaction Potential and Seismic Settlement

Liquefaction occurs when saturated, low relative density, low plastic materials are transformed from a solid to a near-liquid state. This phenomenon occurs when moderate to severe ground shaking causes pore-water pressure to increase. Site susceptibility to liquefaction is a function of the depth, density, soil type, and water content of granular sediments, along with the magnitude and frequency of earthquakes in the surrounding region. Saturated sands, silty sands, and unconsolidated silts within 50 feet of the ground surface are most susceptible to liquefaction. Liquefaction-related phenomena include lateral spreading, ground oscillation, flow failures, loss of bearing strength, subsidence, and buoyancy effects.

The expected level of ground shaking in the project area is high. However, for liquefaction to take place, groundwater must be present. According to CGS historical high groundwater maps, there is shallow groundwater (less than 50 feet bgs) at the southern end of the project alignment from approximately Vanowen Street to the southern limit of the project area and near the northeast end of the project area along Hubbard Street. These portions of the project area are potentially susceptible to liquefaction. A seismic hazard zone map, based on data produced by the CGS, is presented in Figure 4.9-2.

#### 4.9.2.7 Landslide and Slope Instability

The project site is not located within a landslide potential zone designated on a CGS seismic hazard map or areas designated by the City of Los Angeles Hillside Ordinance (City of Los Angeles, 2004). Based on the level topography of the site, the landslide potential at the site is judged to be low.

#### 4.9.2.8 Scour Potential

Scour is not a design concern at this time because the drainage channels within the project site are concrete-lined.

#### 4.9.2.9 Corrosion Potential

No corrosion test results from subsurface soils were available for the project site. Sands, silty sands, and silts are expected at the site. Generally, sands and silty sands do not present a corrosive environment.

#### 4.9.2.10 Flooding and Inundation

FEMA's NFIP maps the flooding potential of Los Angeles County and associated areas. Figure 4.9-3 depicts those flood zones as presented by the City of Los Angeles Safety Element (1996).<sup>12</sup> The project area crosses a 100-year floodplain at the Los Angeles River and a 500-year floodplain at the Pacoima Wash and Pacoima Diversion Channel. The City of Los Angeles Safety Element (1996) also summarizes inundation potential from dam failures and water storage facility failures. These areas are shown on Figure 4.9-4. The project area is located within a potential inundation zone.

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<sup>12</sup> City of Los Angeles, 1996, Safety Element of the Los Angeles City General Plan, Department of City Planning, Los Angeles, California, City Plan Case No. 95-0371, Adopted November 26, 1996.



Figure 4.9-2: Seismic Hazard Zones

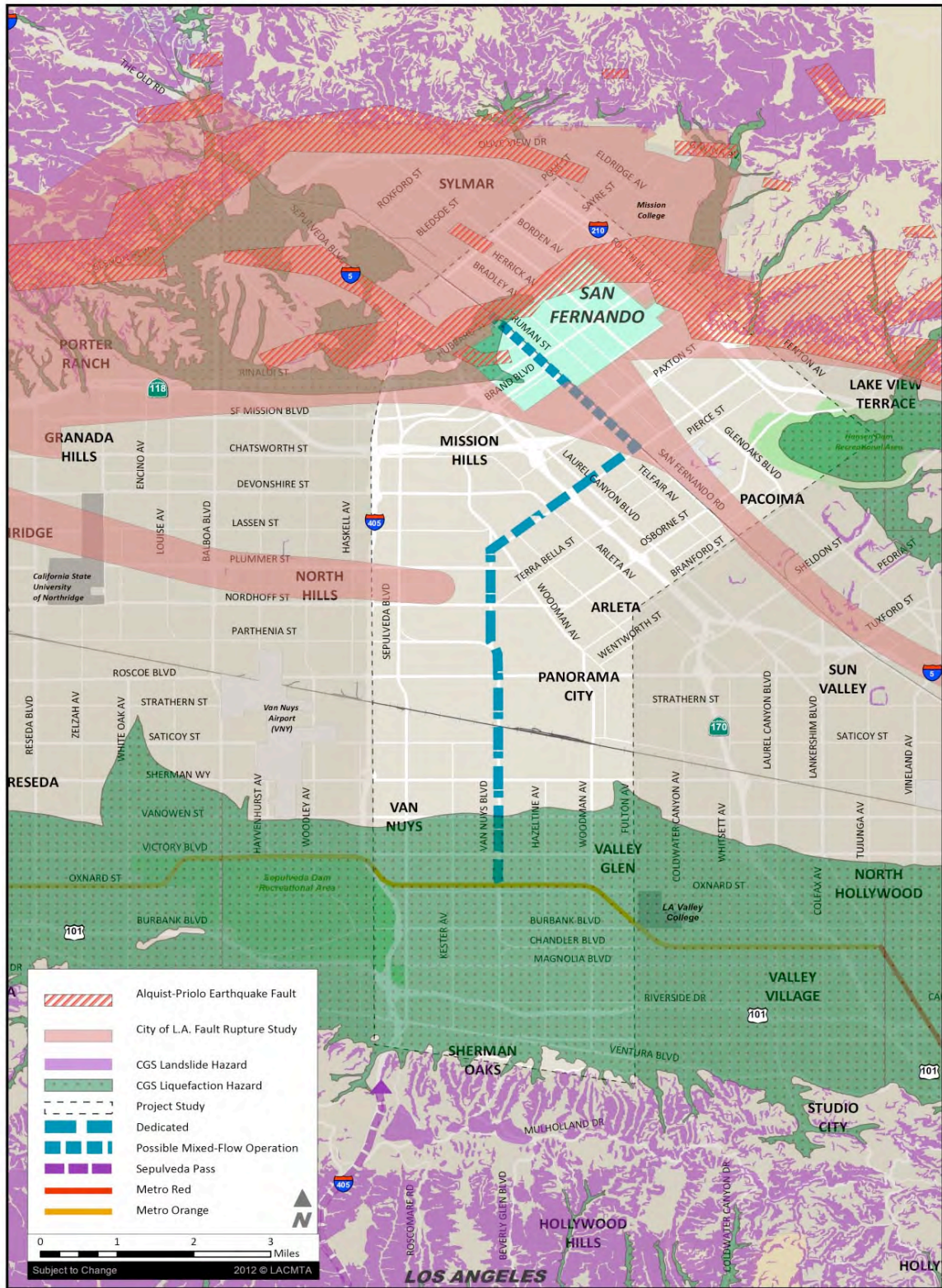


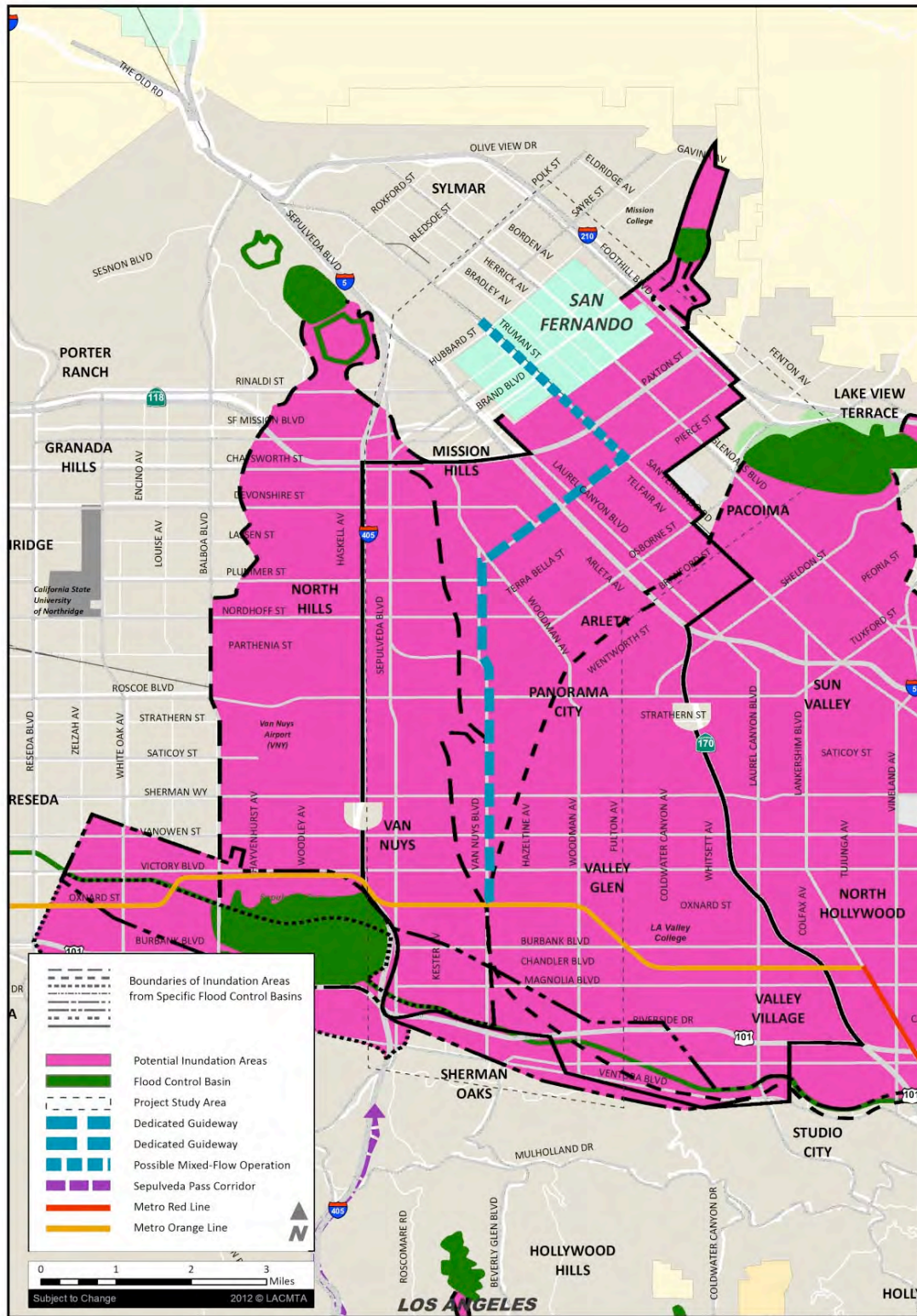
Figure 4.9-3: Flood Plain Area



Source: City of Los Angeles 1996.



Figure 4.9-4: Inundation Areas



Source: City of Los Angeles 1996.



### 4.9.2.11 Methane

In 2004, the City of Los Angeles identified methane gas intrusion into buildings as a potential hazard in some areas of the city and incorporated construction standards to mitigate the potential hazard into the Los Angeles Municipal Code (LAMC). All new buildings and paved areas located in a methane zone or methane buffer zone are required to comply with the requirements of the Methane Mitigation Standards established by the Superintendent of Buildings.

The City of Los Angeles Department of Building and Safety (LADBS) has defined the following areas as a Methane Hazard Site because a portion of the parcel is located within a Methane Zone/Methane Buffer Zone.

- Van Nuys Boulevard between Saticoy Street and Sherman Way.
- Van Nuys Boulevard between approximately 500 feet north of Plummer Street to San Fernando Road.
- San Fernando Road between Van Nuys Boulevard and the City of San Fernando eastern city limits.

According to the LADBS, “... if any portion of a parcel fell within the methane impact area or its buffer zone, the entire parcel was subject to investigation.” The site investigation shall be conducted under the supervision of a licensed Architect or registered Engineer or Geologist and shall be performed by a testing agency approved by LADBS. The licensed Architect, registered Engineer or Geologist shall indicate in a report to LADBS, the testing procedure, the testing instruments used to measure the concentration and pressure of the methane gas. The measurements of the concentration and pressure of the methane gas shall be used to determine the Design Methane Concentration and the Design Methane Pressure.

### 4.9.2.12 Mineral Resources

Although limited oil and gas exploration and pumping from proven reserves have occurred in the areas surrounding the project site, the proposed alignment passes through the Pacoima Oil field (Hesson, 1993). According to the Wildcat Maps and the California Department of Conservation Division of Gas and Geothermal Resources digital wells database, the wells within the project study area and vicinity are idle or abandoned dry wells. Several plugged and abandoned dry holes are located within approximately a block of the project alignment. The locations of these wells are shown on Figure 3-8 in the Geotechnical Report contained in Appendix O.

Abandoned wells and dry holes represent potential vertical migration pathways for crude oil, methane, H<sub>2</sub>S, and other compounds, and can represent potential hazards for nearby buildings and occupants. The California Department of Conservation/Division of Oil, Gas, and Geothermal Resources (DOGGR) regulates drilling and abandonment of wells and dry holes. DOGGR regulations evolved over time to address problems and hazards identified in older wells. As a result, there are fewer problems associated with recently plugged wells and dry holes. Nevertheless, even when a well is plugged in accordance with DOGGR regulations, leaks can occur later.

## 4.9.3 Environmental Consequences, Impacts and Mitigation Measures

### 4.9.3.1 No-Build Alternative

#### Construction Impacts

The No-Build Alternative would not result in any project-related construction activities along the project alignment. Therefore, there would be no geological construction impacts as a result of the No-Build Alternative.

#### Operational Impacts

Under this alternative, no new project facilities would be constructed; therefore, the No-Build Alternative would not result in any new operational impacts.

#### Cumulative Impacts

The No-Build Alternative would not contribute to any cumulative impacts.

#### Mitigation Measures

##### Construction Mitigation Measures

No construction mitigation measures are required.

##### Operational Mitigation Measures

No operational mitigation measures are required.

#### Impacts Remaining After Mitigation

##### NEPA Finding

No adverse effect under NEPA would occur.

##### CEQA Determination

No impact under CEQA would occur.

### 4.9.3.2 TSM Alternative

#### Construction Impacts

The TSM Alternative would consist of cost-efficient service improvements and could include minor physical improvements to the roadway network and to bus stops. Given the very limited amount of construction that could occur under this alternative, geological and flooding hazards in the project area are not likely to affect or be affected by construction activities. Therefore, no impacts/effects would occur during construction.

## **Operational Impacts**

The TSM Alternative proposes minor improvements to transit service such as increased bus frequencies and bus schedule restructuring and could include minor physical improvements to the roadway network (e.g., signalization improvements) and bus facilities (bus stop amenities/improvements).

The East San Fernando Valley Transit Corridor, like other sites in Southern California, would be subjected to strong ground shaking during a seismic event. Although new structures would be small in scale and limited to bus stop amenities such as new canopies or signage, those improvements could experience strong seismic ground shaking and pose a hazard to bus patrons and passers-by. However, given the small size of the bus stop structures and the fact they would be constructed in accordance with current building codes, the potential risks would be minimal. Operation of this alternative would also not cause or accelerate geologic hazards or increase soil instability because the physical improvements would be minor and constructed on flat terrain in a developed urban area. Potential geological impacts and effects would be less than significant under CEQA and non-adverse under NEPA.

## **Cumulative Impacts**

The cumulative impacts analysis for geology, soils, and seismicity is based on the cumulative projects list method of cumulative analysis, as described by CEQA Guidelines, Section 15130, subd. (b)(1)(A), and for the TSM and build alternatives, refers to the projects listed in Table 2-3. These projects are located within or in the neighborhoods and communities surrounding the proposed project alignment. Even though geology and seismicity are regional issues, in general, geologic hazards are site specific, so a more localized study area is appropriate for the analysis of geology, soils, and seismicity. Consequently, it's unlikely that related and proposed projects would contribute to cumulative geological hazards impacts, due to the site-specific nature of geologic hazards. One exception would be when subsurface excavations result in ground and differential settlement that could affect adjacent properties. Other nearby projects, including the cumulative projects listed in Table 2-3, would also include excavation activities that could result in the potential settlement of soils and settlement impacts on nearby properties. However, given the limited amount of construction that is anticipated to occur under the TSM Alternative, including minimal excavation, this alternative would not result in a cumulatively considerable contribution to a significant cumulative impact on ground and differential settlement.

## **Mitigation Measures**

### **Construction Mitigation Measures**

No construction mitigation measures would be required.

### **Operational Mitigation Measures**

No operational mitigation measures would be required.

## **Impacts Remaining After Mitigation**

### **NEPA Finding**

Effects under NEPA would not be be adverse.

### **CEQA Determination**

Impacts under CEQA would be less than significant.

### 4.9.3.3 BRT Alternatives (Alternatives 1 and 2)

#### Alternative 1 – Curb-Running BRT

##### Construction Impacts

Potential impacts due to construction of Alternative 1 would be similar to those that would occur as result of a typical construction project and would require avoiding damage to existing utilities and taking measures to prevent undermining of existing structures and reducing potential geologic/soils hazards to construction workers. Compliance with best construction practices and adherence to regulatory requirements would reduce potential risks to existing structures, the public, and construction workers. Therefore, the construction impacts/effects under this alternative would be less than significant under CEQA and non-adverse under NEPA.

##### Operational Impacts

As discussed above, the East San Fernando Valley Transit Corridor would be subjected to strong ground shaking during a seismic event. As a consequence, structures constructed under the Curb-Running BRT Alternative, which would include new traffic and pedestrian signs and bus stop canopies, could experience strong seismic ground shaking and pose a hazard to riders and passers-by.

On the north end of the alternative alignment, the Sylmar/San Fernando Metrolink Station is located with an APEFZ as previously discussed. The Curb-Running BRT Alternative would include the following project components subject to faulting on the northern end of the alignment: new paving and rehabilitation or resurfacing of existing pavement along San Fernando Road, a new bus stop with canopy, and new traffic and pedestrian signs.

The portion of the alternative alignment south of Vanowen Street is located in a liquefaction zone, as previously discussed. The proposed traffic and pedestrian signs, and bus stop canopies south of Vanowen Street would be subject to liquefaction.

The project site is located outside a landslide hazard zone. No steep slopes were observed within the project area and no significant fill slopes are proposed.

Since, the project would be designed and constructed in compliance with regulatory requirements and current building codes, the operational geological impacts and effects of the Curb-Running BRT Alternative would be less than significant under CEQA and non-adverse under NEPA.

The Curb-Running BRT alignment is not located within a designated 100-year floodplain. The BRT alignment would, however, cross 500-year flood plain areas at three locations as shown on Figure 4.9-3. The BRT alignment is also located in a dam failure inundation zone. Although flooding could cause damage to proposed BRT facilities, the risk of substantial flooding would be low and the proposed project would not cause or exacerbate existing flooding risks. Therefore, the impacts would be less than significant under CEQA and the effects would be non- adverse under NEPA.

##### Cumulative Impacts

See discussion above for the TSM Alternative.

##### *Compliance Requirements and Design Features*

Construction and design would be performed in accordance with Metro's Design Criteria, the latest federal and state seismic and environmental requirements, and state and local building codes.

## **Mitigation Measures**

### ***Construction Mitigation Measures***

No mitigation measures are required.

### ***Operational Mitigation Measures***

No operational mitigation measures are required.

## **Impacts Remaining After Mitigation**

### ***NEPA Finding***

Effects under NEPA would not be adverse.

### ***CEQA Determination***

Impacts under CEQA would be less than significant.

## **Alternative 2 – Median-Running BRT**

### **Construction Impacts**

The Median-Running BRT Alternative would result in the same impacts as the Curb-Running BRT Alternative.

### **Operational Impacts**

The Median-Running BRT Alternative would result in operational impacts that would be the same as those described above for the Curb-Running BRT Alternative. Consequently, the operational geological impacts of this alternative would be less than significant under CEQA and the effects under NEPA would not be adverse.

### **Cumulative Impacts**

See discussion above for the TSM Alternative.

### ***Compliance Requirements and Design Features***

Compliance requirements and design features described under Alternative 1 would also be included under Alternative 2.

## **Mitigation Measures**

### ***Construction Mitigation Measures***

No construction mitigation measures would be required.

### ***Operational Mitigation Measures***

No operational mitigation measures would be required.



## **Impacts Remaining After Mitigation**

### ***NEPA Finding***

Effects under NEPA would not be adverse.

### ***CEQA Determination***

Impacts under CEQA would be less than significant.

## **4.9.3.4 Rail Alternatives (Build Alternatives 3 and 4)**

### **Alternative 3 – Low-Floor LRT/Tram**

#### **Construction Impacts**

The Low-Floor LRT/Tram alternative would result in the same geological construction impacts as the BRT alternatives.

#### **Operational Impacts**

On the north end of the alignment for Low-Floor LRT/Tram Alternative, the proposed pedestrian bridge for the Sylmar/San Fernando Metrolink Station is located with an APEFZ (see Figure 4.9-1). In addition, the Pacoima Wash Bridge on San Fernando Road is located in the City of Los Angeles FRSA (see Figure 4.9-1). If further studies indicate that there is a potential for fault rupture at the proposed Sylmar/San Fernando Metrolink Station pedestrian crossing and/or the Pacoima Wash Bridge on San Fernando Road, the fault rupture hazards to these project facilities could be significant.

Other project structures along the alignment including the Pacoima Channel Bridge, traffic and pedestrian signs, and train stop canopies would be subject to strong seismic ground shaking and could pose a hazard to riders and passers-by. In addition, the proposed catenary wires, traffic and pedestrian signs, and train stop canopies south of Vanowen Street would be subject to potential liquefaction hazards. The catenary wires would move during a seismic event and the system, like other light rail systems currently operated by Metro, would need to be inspected prior to continuing service.

Since the project would be designed in compliance with current building codes and regulatory requirements, the impacts/effects during operation of the Low-Floor LRT/Tram Alternative would be less than significant under CEQA and non-adverse under NEPA.

The flooding risks that could affect or be affected by the Low-Floor LRT/Tram Alternative would be the same as those described above for the BRT alternatives.

#### **Cumulative Impacts**

See discussion above for the TSM Alternative. The only difference for Alternative 3 is that this alternative would require construction of an MSF site, though excavation would be limited to an above-ground habitable building that would not be substantially tall or include deep excavation needs, such as for footings. As a result, this alternative would not result in a cumulatively considerable contribution to a significant cumulative impact on ground and differential settlement.

### ***Compliance Requirements and Design Features***

Compliance requirements and design features described above under Alternative 1 would also be included under Alternative 3.

### **Mitigation Measures**

#### ***Construction Mitigation Measures***

No construction mitigation measures are required.

#### ***Operational Mitigation Measures***

To reduce and minimize potential geologic hazards to project facilities and operations, the following measures shall be implemented.

**MM-GEO-1:** Metro design criteria require probabilistic seismic hazard analyses (PSHA) to estimate earthquake loads on structures. These analyses take into account the combined effects of all nearby faults to estimate ground shaking. During Final Design, site-specific PSHAs shall be used as the basis for evaluating the ground motion levels along the project corridor. The structural elements of the proposed project shall be designed and constructed to resist or accommodate appropriate site-specific estimates of ground loads and distortions imposed by the design earthquakes and conform to Metro's *Design Standards for the Operating and Maximum Design Earthquakes*. The concrete structures are designed according to the *Building Code Requirements for Structural Concrete* (ACI 318) by the American Concrete Institute.

**MM-GEO-2:** At liquefaction or seismic settlement prone areas, evaluations by geotechnical engineers shall be performed during Final Design to provide estimates of the magnitude of the anticipated liquefaction or settlement. Based on the magnitude of evaluated liquefaction, either structural design, or ground improvement (such as deep soil mixing) or deep foundations to non-liquefiable soil (such as drilled piles) measures shall be selected. Site-specific design shall be selected based on State of California guidelines and design criteria set forth in the *Metro Seismic Design Criteria*.

### **Impacts Remaining After Mitigation**

NEPA Finding

Effects would not be adverse.

#### ***CEQA Determination***

Impacts would be less than significant.

## **Alternative 4 – LRT**

### **Construction Impacts**

The LRT Alternative would result in construction impacts that would be the same as those of the Low-Floor LRT/Tram Alternative, the exception being that under this alternative, the tunneling and deep excavations during construction could cause vertical and lateral movement of the existing soils adjacent to the improvements. Therefore, tunneling required to construct the LRT Alternative could result in the potentially significant adverse impacts/effects due to ground settlement and differential settlement immediately above the alignment and on adjacent buildings and structures.

The LRT Alternative could also be affected by groundwater hazards during construction. Groundwater levels are shallow at the southern end of the LRT Alternative alignment near the Los Angeles River and become deeper at the northern end of the project area. The southern end of the proposed tunnel structure would potentially be located below historical high groundwater levels, and consequently groundwater may be encountered during construction of the tunnel, a potentially significant hazard.

However, because the LRT Alternative would be designed and constructed in compliance with current building codes and regulatory requirements, as previously discussed, which would reduce the potential risks posed by the hazards above. Additionally, the potential for settlement during construction of the LRT tunnel, which could be a significant hazard, would be further reduced as a result of implementation of the design measures described below.

### **Operational Impacts**

The operational impacts of the LRT Alternative would be the same as those for the Low-Floor LRT/Tram Alternative, except that unlike the Low-Floor Tram/LRT Alternative, this alternative would include a tunnel. Because of the presence of alluvial soils, the tunnel segment of the alignment could be susceptible to seismic-induced settlement and ground loss, a potentially significant hazard. Experience in California and worldwide shows that tunnels perform well during earthquake ground shaking, exhibiting no significant damage or collapse. Since they are embedded in the ground, they move with the ground, and thus, their motion is not magnified by the pendulum effect that occurs when an aboveground structure is shaken by an earthquake. As an example, during the Northridge Earthquake in 1994, Metro's Segment 1 Red Line tunnels received ground motions at the level of the Operating Design Earthquake without damage. Inspection was performed and the system was reopened for service the following day, with greatly increased ridership because highways were closed due to earthquake damage to bridges. Another example is the 1989 Loma Prieta earthquake that shook San Francisco, collapsing key elevated highways but leaving the Bay Area Rapid Transit tunnel system unaffected. Following an inspection of the tunnels, the system was quickly reopened.

The structural elements of Alternative 4 would be designed and constructed to resist or accommodate the appropriate site-specific estimates of ground loads and distortions imposed by the design earthquakes and conform to Metro's Design Standards for the Operating and Maximum Design Earthquakes. The concrete structures would be designed according to the Building Code Requirements for Structural Concrete by the American Concrete Institute (ACI 318).

Metro will implement Standard Operating Procedures in seismic areas to detect earthquakes and will provide back-up power, lighting, and ventilation systems to increase safety during tunnel or station evacuations in the event of loss of power due to an earthquake. For example, seismographs are located in 11 of the existing Metro Red/Purple Line stations to detect ground motions and trigger Standard Operating Procedures (SOP #8 – Earthquakes) by the train operators and controllers. Operating procedures are dependent on the level of earthquake and include stopping or holding trains, gas monitoring, informing passengers, communications with Metro's Central Control, and inspecting for damage. With the incorporation of these techniques and mitigation Measures MM-GEO-3 through MM-GEO-5, ground shaking does not present a significant impact to this alternative, including all stations and station entrances.

Portions of the alternative alignment are located adjacent to a City of Los Angeles Methane Zone. The proposed tunnel could be affected by hazardous subsurface gases in the area adjacent to the City of Los Angeles Methane Zone along Van Nuys Boulevard between Saticoy Street and Sherman Way. Tunnels and stations would be designed to provide a redundant protection system against gas intrusion hazard, such as those described in the City of Los Angeles Municipal Code, Chapter IX, Building Regulations, Article 1, Division 71, Methane Seepage Regulations. In compliance with these

regulations, specific requirements are determined according to the actual methane levels and pressures detected on a site, and the identified specific requirements would be incorporated into the design and construction. Therefore, hazardous subsurface gas (methane) impacts would be minimized.

Most gases, if present, are purged from the tunnels simply by the action of trains running through the tunnels. During non-revenue operations, air velocity must be maintained at a minimum of 100 feet per minute. This air velocity is the minimum that the ventilation system must achieve to direct hazardous gases toward the nearest point of extraction and prevent gases from accumulating during the hours when the trains are not operating. Additional measures would be incorporated into the design of this alternative to further minimize impacts as described in mitigation measures MM-GEO-3 through MM-GEO-5. With incorporation of these mitigation measures the risks associated with subsurface methane gas would be minimized.

The flooding risks that could affect or be affected by the LRT Alternative would be the same as those described above for the other build alternatives, except that unlike the other build alternatives, portions of the LRT Alternative would be below grade and could be a conduit for the flow of water if precautions are not taken, a potentially significant hazard. However, the portals for stations would be designed to ensure their protection from floodwaters. By complying with Metro's Design Standards, the impacts would not be adverse under NEPA and would be less than significant under CEQA.

Because the LRT Alternative would be designed in compliance with current building codes and regulatory requirements, the risks posed by the geological hazards identified above would be reduced and therefore, the resulting impacts would be less than significant under CEQA and non-adverse under NEPA.

### **Cumulative Impacts**

See discussion above for the TSM Alternative. However, the LRT Alternative, unlike the other alternatives, could result in substantial settlement impacts due to tunneling and the construction of the proposed underground stations. However, the underground portion of the alignment under Alternative 4 is not located in an area identified as having a high risk of liquefaction or seismic settlement. The only component of Alternative 4 that would involve deeper excavation and is located within an area of increased risk for liquefaction or settlement is MSF site Option A. However, as mentioned under the discussion for Alternative 3, excavation for the MSF site would be limited to an above-ground habitable building that would not be substantially tall or include deep excavation needs, such as for footings that would increase the risk of settlement impacts on adjacent properties. Furthermore, mitigation measures MM-GEO-2, and compliance with regulatory requirements and design features would further minimize this impact so as to not result in a cumulatively considerable contribution to a significant cumulative impact on ground and differential settlement. Although the project and cumulative impacts could be significant, compliance with proposed design and mitigation measures would reduce potential impacts to a less-than-significant level.

### ***Compliance Requirements and Design Features***

Compliance requirements and design features described above under Alternative 1 would also be included under Alternative 4.

### **Mitigation Measures**

#### ***Construction Mitigation Measures***

No construction mitigation measures are required.

### ***Operational Mitigation Measures***

Operational mitigation measures included under Alternative 3 would also be included under Alternative 4. In addition, the following measures would also apply to Alternative 4, with regards to potential geologic or seismic impacts occurring with operation of the subway segment of the alignment.

**MM-GEO-3:** In addition to design measures, as Metro has implemented on the existing Red Line, it shall implement standard operating procedures (SOP) in seismic areas to detect earthquakes and shall provide back-up power, lighting, and ventilation systems to increase safety during tunnel or station evacuations in the event of loss of power due to an earthquake. For example, seismographs are located in 11 of the existing Metro Red/Purple Line stations to detect ground motions and trigger SOPs (SOP#8 –Earthquake) by the train operators and controllers. Operating procedures are dependent on the level of earthquake and include stopping or holding trains, gas monitoring, informing passengers, communications with Metro’s Central Control, and inspecting for damage.

**MM-GEO-4:** As with the existing Red or Purple Lines and the Metro Gold Line Eastside Extension, Metro shall install gas monitoring and detection systems with alarms, as well as ventilation equipment to dissipate gas to safe levels according to Metro’s current design criteria and Cal/OSHA standards for a safe work environment. Measures shall include, but are not limited to, the following for both tunnel and station operation:

- High volume ventilation systems with back-up power sources
- Gas detection systems with alarms
- Emergency ventilation triggered by the gas detection systems
- Automatic equipment shut-off
- Maintenance and operations personnel training
- Gas detection instrumentation is set to send alarms to activate ventilation systems and evacuate the structures as follows: methane gas – minor alarm at 10 percent of the lower explosive limit (LEL) (activate ventilation) and major alarms at 20 percent of LEL (evacuation of area)
- Hydrogen sulfide – minor alarm at 8 parts per million (ppm) and major alarm at 10 ppm.

**MM-GEO-5:** Tunnels and stations shall be designed to provide a redundant protection system against gas intrusion hazard. The primary protection from hazardous gases during operations is provided by the physical barriers (tunnel and station liner membranes) that keep gas out of tunnels and stations. As with the existing Metro Red and Purple Lines and the Metro Gold Line Eastside Extension, tunnels and stations shall be designed to exclude gas to below alarm levels (GEO-4) and include gas monitoring and detection systems with alarms, as well as ventilation equipment to dissipate gas.

- At stations in elevated gassy ground (e.g., Van Nuys Metrolink Station and Sherman Way Station), construction shall be accomplished using slurry walls – or similar methods such as continuous drilled piles – to provide a reduction of gas inflow both during and after construction than would occur with conventional soldier piles and lagging.
- Other station design concepts to reduce gas and water leakage are the use of additional barriers; compartmentalized barriers to facilitate leak sealing; and flexible sealants, such as poly-rubber gels, along with high-density polyethylene-type materials used on Metro’s underground stations.

- Consideration of secondary station walls to provide additional barriers or an active system (low or high pressure barrier) shall also be studied during Final Design to further to determine if they will be incorporated into the Final design of the tunnel and stations.
- The evaluations for station and tunnel construction materials shall include laboratory testing programs such as those conducted for the Metro Gold Line Eastside Extension during development of the double gasket system and material testing for long-term exposure to the ground conditions for materials such as rubber gaskets used for tunnel segment linings. Testing programs shall examine:
  - Segment leakage – gasket seal under pressure before, during, and after seismic movements. This will include various gasket materials and profiles (height and width).
  - Gasket material properties – effective life and resistance to deterioration when subjected to man-made and natural contaminants, including methane, asphaltic materials, and hydrogen sulfide.
  - Alternative products to high-density polyethylene products such as poly-rubber gels, now in use in ground containing methane in other cities. Methods for field testing high-density polyethylene joints. These are now being used for landfill liners and water tunnels under internal water pressure.

### **Impacts Remaining After Mitigation**

#### ***NEPA Finding***

Effects would not be adverse under NEPA.

#### ***CEQA Determination***

Impacts would be less than significant under CEQA.