Los Angeles County
Metropolitan Transportation Authority

West Santa Ana Branch Transit Corridor

Draft EIS/EIR Appendix O
Final Geotechnical, Subsurface, and Seismic Impact Analysis Report

Metro

WEST SANTA ANA BRANCH TRANSIT CORRIDOR PROJECT

Draft EIS/EIR Appendix O

Final Geotechnical, Subsurface, and Seismic Impact Analysis Report

Prepared for:

Metro

Los Angeles County
Metropolitan Transportation Authority

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ACRONYMS AND ABBREVIATIONS

AA	Alternatives Analysis
AASHTO	American Association of State Highway and Transportation Officials
ACGIH	American Conference of Governmental Industrial Hygienists
AREMA	American Railway Engineering and Maintenance-of-Way Association
ARP	average return period
ASCE	American Association of Civil Engineers
bgs	below ground surface
BRT	bus rapid transit
Cal/OSHA	California Occupational Safety and Health Administration
Caltrans	California Department of Transportation
CBC	California Building Code
CCR	California Code of Regulations
CEQA	California Environmental Quality Act
CGS	California Geological Survey
DOGGR	California Department of Conservation, Division of Oil, Gas, and Geothermal Resources (California)
ECI	Earth Consultants International
EPBT	Elysian Park Blind Thrust Fault
g	acceleration due to gravity
H_2S	hydrogen sulfide gas
I-	Interstate
LA	Los Angeles
LADBS	Los Angeles Department of Building and Safety
LAUS	Los Angeles Union Station
LAX	Los Angeles International Airport
LEL	lower explosive limit
LRFD	Load and Resistance Factor Design
LRT	light rail transit
LRTP	Long-Range Transportation Plan
LRV	light rail vehicle
MDE	maximum design earthquake
Metro	Los Angeles County Metropolitan Transportation Authority
mm/yr	millimeters per year
M_{max}	maximum moment magnitude

MRDC	Metro Rail Design Criteria
MSF	maintenance and storage facility
msl	above mean sea level
M_W	earthquake moment magnitude
MWD	Metropolitan Water District
NEPA	National Environmental Policy Act
NOP	Notice of Preparation
OCTA	Orange County Transportation Authority
ODE	operating design earthquake
OLDA	Orangeline Development Authority
OSHA	U.S. Occupational Safety and Health Administration
PEROW	Pacific Electric Right-of-Way
PGA	peak ground acceleration
PGAM	peak ground acceleration corrected for site effects
PHBT	Puente Hills Blind Thrust Fault
ppm	parts per million
Project	West Santa Ana Branch Transit Corridor
ROW	right-of-way
RTP/SCS	Regional Transportation Plan/Sustainable Communities Strategy
SCAG	Southern California Association of Governments
SDC	seismic design criteria
SR	State Route
TAP	Tunnel Advisory Panel
TBM	tunnel boring machine
TLV	threshold limit value
TPSS	traction power substation
UBC	Uniform Building Code
UEPBT	Upper Elysian Park Blind Thrust Fault
UPRR	Union Pacific Railroad
US-101	U.S. Highway 101
USGS	United States Geological Survey
VA	Veterans Affairs
WSAB	West Santa Ana Branch

1 INTRODUCTION

1.1 Study Background

The West Santa Ana Branch (WSAB) Transit Corridor (Project) is a proposed light rail transit (LRT) line that would extend from four possible northern termini in southeast Los Angeles (LA) County to a southern terminus in the City of Artesia, traversing densely populated, low-income, and heavily transit-dependent communities. The Project begins in downtown Los Angeles and terminates at Pioneer Boulevard in the City of Artesia. The Project would provide reliable, fixed-guideway transit service that would increase mobility and connectivity for historically underserved, transit-dependent, and environmental justice communities; reduce travel times on local and regional transportation networks; and accommodate substantial future employment and population growth.

1.2 Alternatives Evaluation, Screening, and Selection Process

A wide range of potential alternatives have been considered and screened through the alternatives analysis processes. In March 2010, the Southern California Association of Governments (SCAG) initiated the *Pacific Electric Right-of-Way (PEROW)/West Santa Ana Branch Alternatives Analysis (AA) Report* (SCAG 2013) in coordination with the relevant cities, Orangeline Development Authority (now known as Eco-Rapid Transit), the Gateway Cities Council of Governments, the Los Angeles County Metropolitan Transportation Authority (Metro), the Orange County Transportation Authority, and the owners of the right-of-way (ROW)—Union Pacific Railroad (UPRR), BNSF Railway, and the Ports of Los Angeles and Long Beach. The AA Report evaluated a wide variety of transit connections and modes for a broader 34-mile corridor from Union Station in downtown Los Angeles to the City of Santa Ana in Orange County. In February 2013, SCAG completed the *PEROW/WSAB AA Report*[1] and recommended two LRT alternatives for further study: West Bank 3 and the East Bank.

Following completion of the AA, Metro completed the *West Santa Ana Branch Transit Corridor Technical Refinement Study* in 2015 focusing on the design and feasibility of five key issue areas along the 19-mile portion of the WSAB Transit Corridor within LA County:

- Access to Union Station in downtown Los Angeles
- Northern Section Options
- Huntington Park Alignment and Stations
- New Metro C (Green) Line Station
- Southern Terminus at Pioneer Station in Artesia

In September 2016, Metro initiated the WSAB Transit Corridor Environmental Study with the goal of obtaining environmental clearance of the Project under the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA).

Metro issued a Notice of Preparation (NOP) on May 25, 2017, with a revised NOP issued on June 14, 2017, extending the comment period. In June 2017, Metro held public scoping meetings in the Cities of Bellflower, Los Angeles, South Gate, and Huntington Park. Metro

[1] Initial concepts evaluated in the SCAG report included transit connections and modes for the 34 mile corridor from Union Station in downtown Los Angeles to the City of Santa Ana. Modes included low speed magnetic levitation (maglev) heavy rail, light rail, and bus rapid transit (BRT).

provided project updates and information to stakeholders with the intent to receive comments and questions through a comment period that ended in August 2017. A total of 1,122 comments were received during the public scoping period from May through August 2017. The comments focused on concerns regarding the Northern Alignment options, with specific concerns related to potential impacts to Alameda Street with an aerial alignment. Given potential visual and construction issues raised through public scoping, additional Northern Alignment concepts were evaluated.

In February 2018, the Metro Board of Directors approved further study of the alignment in the Northern Section due to community input during the 2017 scoping meetings. A second alternatives screening process was initiated to evaluate the original four Northern Alignment options and four new Northern Alignment concepts. The *Final Northern Alignment Alternatives and Concepts Updated Screening Report* was completed in May 2018 (Metro 2018). The alternatives were further refined and, based on the findings of the second screening analysis and the input gathered from the public outreach meetings, the Metro Board of Directors approved Build Alternatives E and G for further evaluation (now referred to as Alternatives 1 and 2, respectively, in this report).

On July 11, 2018, Metro issued a revised and recirculated CEQA NOP, thereby initiating a scoping comment period. The purpose of the revised NOP was to inform the public of the Metro Board's decision to carry forward Alternatives 1 and 2 into the Draft Environmental Impact Statement/Environmental Impact Report. During the scoping period, one agency and three public scoping meetings were held in the Cities of Los Angeles, Cudahy, and Bellflower. The meetings provided project updates and information to stakeholders with the intent to receive comments and questions to support the environmental process. The comment period for scoping ended on August 24, 2018; over 250 comments were received.

Following the July 2018 scoping period, a number of project refinements were made to address comments received, including additional grade separations, removing certain stations with low ridership, and removing the Bloomfield extension option. The Metro Board adopted these refinements to the project description at their November 2018 meeting.

1.3 Report Purpose and Structure

The purpose of this Geotechnical, Subsurface, and Seismic Impact Analysis Report is to evaluate the existing geologic, soils and seismic conditions present within the Affected Area, and analyze potential impacts to the Project. The Affected Area for geotechnical, subsurface, and seismic resources is defined as the area within 250 feet of the project alignments. The 250-foot buffer extends out from the alternative alignment anticipated area of work/disturbance, including the maintenance and storage facility (MSF) site options, Design Options 1 (Los Angeles Union Station [LAUS] at the Metropolitan Water District [MWD]) and 2 (Add Little Tokyo Station), temporary (construction) areas, and permanent areas. Considering that the Affected Area for geotechnical, subsurface, and seismic resources is relatively flat, the 250-foot width would cover potential impacts from the project upon the geology and soils of the area.

The study included review and evaluation of previously published and unpublished geologic and hydrogeologic information developed within the Affected Area. The report is organized into nine sections:

- Section 1 – Introduction
- Section 2 – Project Description

- Section 3 – Regulatory Framework
- Section 4 – Affected Environment/Existing Conditions
- Section 5 – Environmental Consequences/Environmental Impacts
- Section 6 – CEQA Determination
- Section 7 – Construction-related Impacts/Consequences
- Section 8 – Project Measures and Mitigation Measures
- Section 9 – References

1.4 Methodology

Existing geologic and geotechnical data were reviewed to assess the Affected Area for known geologic hazards and identify potential impacts. If stations or structures are proposed within or directly adjacent to known geologic hazard areas, the potential for an impact has been identified and assessed. As discussed in Sections 3, 5, and 8, additional geotechnical investigations would be performed during preliminary engineering and final design of the selected alternative.

To satisfy CEQA requirements, geology and soils impacts are analyzed in accordance with Appendix G of the CEQA Guidelines and considered significant if the Project has the potential to result in the following:

a) Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:

    i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault. Refer to Division of Mines and Geology Special Publication 42.
    ii) Strong seismic ground shaking.
    iii) Seismic-related ground failure, including liquefaction.
    iv) Landslides.

b) Result in substantial soil erosion or the loss of topsoil.
c) 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.
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property.
e) Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.
f) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature.

Part “f” of the Geology and Soils portion of the CEQA Appendix G checklist is addressed in the *West Santa Ana Branch Transit Corridor Project Final Paleontological Resource Impacts Analysis Report* (Metro 2021a).

2 PROJECT DESCRIPTION

This section describes the No Build Alternative and the four Build Alternatives studied in the WSAB Transit Corridor Draft Environmental Impact Statement/Environmental Impact Report, including design options, station locations, and MSF site options. The Build Alternatives were developed through a comprehensive alternatives analysis process and meet the purpose and need of the Project.

The No Build Alternative and four Build Alternatives are generally defined as follows:

- **No Build Alternative** - Reflects the transportation network in the 2042 horizon year without the proposed Build Alternatives. The No Build Alternative includes the existing transportation network along with planned transportation improvements that have been committed to and identified in the constrained Metro 2009 *Long-Range Transportation Plan* (LRTP) and SCAG's *2016-2040 Regional Transportation Plan/Sustainable Communities Strategy* (RTP/SCS) (SCAG 2016), as well as additional projects funded by Measure M that would be completed by 2042.
- **Build Alternatives**: The Build Alternatives consist of a new LRT line that would extend from different termini in the north to the same terminus in the City of Artesia in the south. The Build Alternatives are referred to as:
  - Alternative 1: Los Angeles Union Station to Pioneer Station; the northern terminus would be located underground at Los Angeles Union Station (LAUS) Forecourt
  - Alternative 2: 7th Street/Metro Center to Pioneer Station; the northern terminus would be located underground at 8th Street between Figueroa Street and Flower Street near 7th Street/Metro Center Station
  - Alternative 3: Slauson/A (Blue) Line to Pioneer Station; the northern terminus would be located just north of the intersection of Long Beach Avenue and Slauson Avenue in the City of Los Angeles, connecting to the current A (Blue) Line Slauson Station
  - Alternative 4: I-105/C (Green) Line to Pioneer Station; the northern terminus would be located at I-105 in the City of South Gate, connecting to the C (Green) Line along the I-105

Two design options are under consideration for Alternative 1. Design Option 1 would locate the northern terminus station box at the LAUS Metropolitan Water District (MWD) east of LAUS and the MWD building, below the baggage area parking facility. Design Option 2 would add the Little Tokyo Station along the WSAB alignment. The Design Options are further discussed in Section 2.3.6.

Figure 2-1 presents the four Build Alternatives and the design options. In the north, Alternative 1 would terminate at LAUS and primarily follow Alameda Avenue south underground to the proposed Arts/Industrial District Station. Alternative 2 would terminate near the existing 7th Street/Metro Center Station in the Downtown Transit Core and would primarily follow 8th Street east underground to the proposed Arts/Industrial District Station.

Figure 2-1. Project Alternatives

Source: Metro 2020

From the Arts/Industrial District Station to the southern terminus at Pioneer Station, Alternatives 1 and 2 share a common alignment. South of Olympic Boulevard, the Alternatives 1 and 2 would transition from an underground configuration to an aerial configuration, cross over the Interstate (I-) 10 freeway and then parallel the existing Metro A (Blue) Line along the Wilmington Branch ROW as it proceeds south. South of Slauson Avenue, which would serve as the northern terminus for Alternative 3, Alternatives 1, 2, and 3 would turn east and transition to an at-grade configuration to follow the La Habra Branch ROW along Randolph Street. At the San Pedro Subdivision ROW, Alternatives 1, 2, and 3 would turn southeast to follow the San Pedro Subdivision ROW and then transition to the PEROW, south of the I-105 freeway. The northern terminus for Alternative 4 would be located at the I-105/C Line Station. Alternatives 1, 2, 3, and 4 would then follow the PEROW to the southern terminus at the proposed Pioneer Station in Artesia. The Build Alternatives would be grade-separated where warranted, as indicated on Figure 2-2.

Figure 2-2. Project Alignment by Alignment Type

Source: Metro 2020

2.1 Geographic Sections

The approximately 19-mile corridor is divided into two geographic sections—the Northern and Southern Sections. The boundary between the Northern and Southern Sections occurs at Florence Avenue in the City of Huntington Park.

2.1.1 Northern Section

The Northern Section includes approximately 8 miles of Alternatives 1 and 2 and 3.8 miles of Alternative 3. Alternative 4 is not within the Northern Section. The Northern Section covers the geographic area from downtown Los Angeles to Florence Avenue in the City of Huntington Park and would generally traverse the Cities of Los Angeles, Vernon, Huntington Park, and Bell, and the unincorporated Florence-Firestone community of LA County (Figure 2-3). Alternatives 1 and 2 would traverse portions of the Wilmington Branch (between approximately Martin Luther King Jr Boulevard along Long Beach Avenue to Slauson Avenue). Alternatives 1, 2, and 3 would traverse portions of the La Habra Branch ROW (between Slauson Avenue along Randolph Street to Salt Lake Avenue) and San Pedro Subdivision ROW (between Randolph Street to approximately Paramount Boulevard).

Figure 2-3. Northern Section

Source: Metro 2020

2.1.2 Southern Section

The Southern Section includes approximately 11 miles of Alternatives 1, 2, and 3 and includes all 6.6 miles of Alternative 4. The Southern Section covers the geographic area from south of Florence Avenue in the City of Huntington Park to the City of Artesia and would generally traverse the Cities of Huntington Park, Cudahy, South Gate, Downey, Paramount, Bellflower, Cerritos, and Artesia (Figure 2-4). In the Southern Section, all four Build Alternatives would utilize portions of the San Pedro Subdivision and the Metro-owned PEROW (between approximately Paramount Boulevard to South Street).

Figure 2-4. Southern Section

Source: Metro 2020

2.2 No Build Alternative

For the NEPA evaluation, the No Build Alternative is evaluated in the context of the existing transportation facilities in the Transit Corridor (the Transit Corridor extends approximately 2 miles from either side of the proposed alignment) and other capital transportation improvements and/or transit and highway operational enhancements that are reasonably foreseeable. Because the No Build Alternative provides the background transportation network, against which the Build Alternatives' impacts are identified and evaluated, the No Build Alternative does not include the Project.

The No Build Alternative reflects the transportation network in 2042 and includes the existing transportation network along with planned transportation improvements that have been committed to and identified in the constrained Metro 2009 LRTP and the SCAG 2016 RTP/SCS, as well as additional projects funded by Measure M, a sales tax initiative approved by voters in November 2016. The No Build Alternative includes Measure M projects that are scheduled to be completed by 2042.

Table 2.1 lists the existing transportation network and planned improvements included as part of the No Build Alternative.

Table 2.1. No Build Alternative – Existing Transportation Network and Planned Improvements

Project	To / From	Location Relative to Transit Corridor
Rail (Existing)		
Metro Rail System (LRT and Heavy Rail Transit)	Various locations	Within Transit Corridor
Metrolink (Southern California Regional Rail Authority) System	Various locations	Within Transit Corridor
Rail (Under Construction/Planned)[1]		
Metro Westside D (Purple) Line Extension	Wilshire/Western to Westwood/VA Hospital	Outside Transit Corridor
Metro C (Green) Line Extension[2] to Torrance	96th Street Station to Torrance	Outside Transit Corridor
Metro C (Green) Line Extension	Norwalk to Expo/Crenshaw[3]	Outside Transit Corridor
Metro East-West Line/Regional Connector/Eastside Phase 2	Santa Monica to Lambert Santa Monica to Peck Road	Within Transit Corridor
Metro North-South Line/Regional Connector/Foothill Extension to Claremont Phase 2B	Long Beach to Claremont	Within Transit Corridor
Metro Sepulveda Transit Corridor	Metro G (Orange) Line to Metro E (Expo) Line	Outside Transit Corridor
Metro East San Fernando Valley Transit Corridor	Sylmar to Metro G (Orange) Line	Outside Transit Corridor
Los Angeles World Airport Automated People Mover	96th Street Station to LAX Terminals	Outside Transit Corridor
Metrolink Capital Improvement Projects	Various projects	Within Transit Corridor
California High-Speed Rail	Burbank to LA LA to Anaheim	Within Transit Corridor
Link US	LAUS	Within Transit Corridor

Project	To / From	Location Relative to Transit Corridor
Bus (Existing)		
Metro Bus System (including BRT, Express, and local)	Various locations	Within Transit Corridor
Municipality Bus System[4]	Various locations	Within Transit Corridor
Bus (Under Construction/Planned)		
Metro G (Orange) Line (BRT)	Del Mar (Pasadena) to Chatsworth Del Mar (Pasadena) to Canoga Canoga to Chatsworth	Outside Transit Corridor
Vermont Transit Corridor (BRT)	120th Street to Sunset Boulevard	Outside Transit Corridor
North San Fernando Valley BRT	Chatsworth to North Hollywood	Outside Transit Corridor
North Hollywood to Pasadena	North Hollywood to Pasadena	Outside Transit Corridor
Highway (Existing)		
Highway System	Various locations	Within Transit Corridor
Highway (Under Construction/Planned)		
High Desert Multi-Purpose Corridor	SR-14 to SR-18	Outside Transit Corridor
I-5 North Capacity Enhancements	SR-14 to Lake Hughes Rd	Outside Transit Corridor
SR-71 Gap Closure	I-10 to Rio Rancho Rd	Outside Transit Corridor
Sepulveda Pass Express Lane	I-10 to US-101	Outside Transit Corridor
SR-57/SR-60 Interchange Improvements	SR-70/SR-60	Outside Transit Corridor
I-710 South Corridor Project (Phase 1 and 2)	Ports of Long Beach and LA to SR-60	Within Transit Corridor
I-105 Express Lane	I-405 to I-605	Within Transit Corridor
I-5 Corridor Improvements	I-605 to I-710	Outside Transit Corridor

Sources: Metro 2018, WSP 2019

Notes: [1] Where extensions are proposed for existing Metro rail lines, the origin/destination is defined for the operating scheme of the entire rail line following completion of the proposed extensions and not just the extension itself.

[2] Metro C (Green) Line extension to Torrance includes new construction from Redondo Beach to Torrance; however, the line will operate from Torrance to 96th Street.

[3] The currently under construction Metro Crenshaw/LAX Line will operate as the Metro C (Green) Line.

[4] The municipality bus network system is based on service patterns for Bellflower Bus, Cerritos on Wheels, Cudahy Area Rapid Transit, Get Around Town Express, Huntington Park Express, La Campana, Long Beach Transit, Los Angeles Department of Transportation, Norwalk Transit System and the Orange County Transportation Authority.

BRT = bus rapid transit; I- = Interstate; LAUS = Los Angeles Union Station; LAX = Los Angeles International Airport; LRT =light rail transit; SR- = State Route; VA = Veterans Affairs

2.3 Build Alternatives

2.3.1 Proposed Alignment Configuration for the Build Alternatives

This section describes the alignment for each of the Build Alternatives. The general characteristics of the four Build Alternatives are summarized in Table 2.2. Figure 2-5 illustrates the freeway crossings along the alignment. Additionally, the Build Alternatives would require relocation of existing freight rail tracks within the ROW to maintain existing operations where there would be overlap with the proposed light rail tracks. Figure 2-6 depicts the alignment sections that would share operation with freight and the corresponding ownership.

Table 2.2. Summary of Build Alternative Components

Component	Quantity			
Alternatives	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Alignment Length	19.3 miles	19.3 miles	14.8 miles	6.6 miles
Stations Configurations	11 3 aerial; 6 at-grade; 2 underground[3]	12 3 aerial; 6 at-grade; 3 underground	9 3 aerial; 6 at-grade	4 1 aerial; 3 at-grade
Parking Facilities	5 (approximately 2,780 spaces)	5 (approximately 2,780 spaces)	5 (approximately 2,780 spaces)	4 (approximately 2,180 spaces)
Length of underground, at-grade, and aerial	2.3 miles underground; 12.3 miles at-grade; 4.7 miles aerial[1]	2.3 miles underground; 12.3 miles at-grade; 4.7 miles aerial[1]	12.2 miles at-grade; 2.6 miles aerial[1]	5.6 miles at-grade; 1.0 miles aerial[1]
At-grade crossings	31	31	31	11
Freight crossings	10	10	9	2
Freeway Crossings	6 (3 freeway undercrossings[2] at I-710; I-605, SR-91)	6 (3 freeway undercrossings[2] at I-710; I-605, SR-91)	4 (3 freeway undercrossings[2] at I-710; I-605, SR-91)	3 (2 freeway undercrossings [2] at I-605, SR-91)
Elevated Street Crossings	25	25	15	7
River Crossings	3	3	3	1
TPSS Facilities	22[3]	23	17	7
Maintenance and Storage Facility Site Options	2	2	2	2

Source: WSP 2020

Notes: [1] Alignment configuration measurements count retained fill embankments as at-grade.

[2] The light rail tracks crossing beneath freeway structures.

[3] Under Design Option 2 – Add Little Tokyo Station, an additional underground station and TPSS site would be added under Alternative 1.

Figure 2-5. Freeway Crossings

Source: WSP 2020

Figure 2-6. Existing Rail Right-of-Way Ownership and Relocation

Source: WSP 2020

2.3.2 Alternative 1: Los Angeles Union Station to Pioneer Station

The total alignment length of Alternative 1 would be approximately 19.3 miles, consisting of approximately 2.3 miles of underground, 12.3 miles of at-grade, and 4.7 miles of aerial alignment. Alternative 1 would include 11 new LRT stations, 2 of which would be underground, 6 would be at-grade, and 3 would be aerial. Under Design Option 2, Alternative 1 would have 12 new LRT stations, and the Little Tokyo Station would be an additional underground station. Five of the stations would include parking facilities, providing a total of up to 2,780 new parking spaces. The alignment would include 31 at-grade crossings, 3 freeway undercrossings, 2 aerial freeway crossings, 1 underground freeway crossing, 3 river crossings, 25 aerial road crossings, and 10 freight crossings.

In the north, Alternative 1 would begin at a proposed underground station at/near LAUS either beneath the LAUS Forecourt or, under Design Option 1, east of the MWD building beneath the baggage area parking facility (Section 2.3.6). Crossovers would be located on the north and south ends of the station box with tail tracks extending approximately 1,200 feet north of the station box. A tunnel extraction portal would be located within the tail tracks for both Alternative 1 terminus station options.

From LAUS, the alignment would continue underground crossing under the US-101 freeway and the existing Metro L (Gold) Line aerial structure and continue south beneath Alameda Street to the optional Little Tokyo Station between 1st Street and 2nd Street (note: under Design Option 2, Little Tokyo Station would be constructed). From the optional Little Tokyo Station, the alignment would continue underground beneath Alameda Street to the proposed Arts/Industrial District Station under Alameda Street between 6th Street and Industrial Street. (Note, Alternative 2 would have the same alignment as Alternative 1 from this point south. Refer to Section 2.3.3 for additional information on Alternative 2.)

The underground alignment would continue south under Alameda Street to 8th Street, where the alignment would curve to the west and transition to an aerial alignment south of Olympic Boulevard. The alignment would cross over the I-10 freeway in an aerial viaduct structure and continue south, parallel to the existing Metro A (Blue) Line at Washington Boulevard. The alignment would continue in an aerial configuration along the eastern half of Long Beach Avenue within the UPRR-owned Wilmington Branch ROW, east of the existing Metro A (Blue) Line and continue south to the proposed Slauson/A Line Station. The aerial alignment would pass over the existing pedestrian bridge at E. 53rd Street. The Slauson/A Line Station would serve as a transfer point to the Metro A (Blue) Line via a pedestrian bridge. The vertical circulation would be connected at street level on the north side of the station via stairs, escalators, and elevators. (The Slauson/A Line Station would serve as the northern terminus for Alternative 3; refer to Section 2.3.4 for additional information on Alternative 3.)

South of the Slauson/A Line Station, the alignment would turn east along the existing La Habra Branch ROW (also owned by UPRR) in the median of Randolph Street. The alignment would be on the north side of the La Habra Branch ROW and would require the relocation of existing freight tracks to the southern portion of the ROW. The alignment would transition to an at-grade configuration at Alameda Street and would proceed east along the Randolph Street median. Wilmington Avenue, Regent Street, Albany Street, and Rugby Avenue would be closed to traffic crossing the ROW, altering the intersection design to a right-in, right-out configuration. The proposed Pacific/Randolph Station would be located just east of Pacific Boulevard.

From the Pacific/Randolph Station, the alignment would continue east at-grade. Rita Avenue would be closed to traffic crossing the ROW, altering the intersection design to a right-in, right-out configuration. At the San Pedro Subdivision ROW, the alignment would transition to an aerial configuration and turn south to cross over Randolph Street and the freight tracks, returning to an at-grade configuration north of Gage Avenue. The alignment would be located on the east side of the existing San Pedro Subdivision ROW freight tracks, and the existing tracks would be relocated to the west side of the ROW. The alignment would continue at-grade within the San Pedro Subdivision ROW to the proposed at-grade Florence/Salt Lake Station south of the Salt Lake Avenue/Florence Avenue intersection.

South of Florence Avenue, the alignment would extend from the proposed Florence/Salt Lake Station in the City of Huntington Park to the proposed Pioneer Station in the City of Artesia, as shown on Figure 2-4. The alignment would continue southeast from the proposed at-grade Florence/Salt Lake Station within the San Pedro Subdivision ROW, crossing Otis Avenue, Santa Ana Street, and Ardine Street at-grade. The alignment would be located on the east side of the existing San Pedro Subdivision freight tracks and the existing tracks would be relocated to the west side of the ROW. South of Ardine Street, the alignment would transition to an aerial structure to cross over the existing UPRR tracks and Atlantic Avenue. The proposed Firestone Station would be located on an aerial structure between Atlantic Avenue and Firestone Boulevard.

The alignment would then cross over Firestone Boulevard and transition back to an at-grade configuration prior to crossing Rayo Avenue at-grade. The alignment would continue south along the San Pedro Subdivision ROW, crossing Southern Avenue at-grade and continuing at-grade until it transitions to an aerial configuration to cross over the LA River. The proposed LRT bridge would be constructed next to the existing freight bridge. South of the LA River, the alignment would transition to an at-grade configuration crossing Frontage Road at-grade, then passing under the I-710 freeway through the existing box tunnel structure and then crossing Miller Way. The alignment would then return to an aerial structure to cross the Rio Hondo Channel. South of the Rio Hondo Channel, the alignment would briefly transition back to an at-grade configuration and then return to an aerial structure to cross over Imperial Highway and Garfield Avenue. South of Garfield Avenue, the alignment would transition to an at-grade configuration and serve the proposed Gardendale Station north of Gardendale Street.

From the Gardendale Station, the alignment would continue south in an at-grade configuration, crossing Gardendale Street and Main Street to connect to the proposed I-105/C Line Station, which would be located at-grade north of Century Boulevard. This station would be connected to the new infill C (Green) Line Station in the middle of the freeway via a pedestrian walkway on the new LRT bridge. The alignment would continue at-grade, crossing Century Boulevard and then over the I-105 freeway in an aerial configuration within the existing San Pedro Subdivision ROW bridge footprint. A new Metro C (Green) Line Station would be constructed in the median of the I-105 freeway. Vertical pedestrian access would be provided from the LRT bridge to the proposed I-105/C Line Station platform via stairs and elevators. To accommodate the construction of the new station platform, the existing Metro C (Green) Line tracks would be widened and, as part of the I-105 Express Lanes Project, the I-105 lanes would be reconfigured. (The I-105/C Line Station would serve as the northern terminus for Alternative 4; refer to Section 2.3.5 for additional information on this alternative.)

South of the I-105 freeway, the alignment would continue at-grade within the San Pedro Subdivision ROW. In order to maintain freight operations and allow for freight train crossings, the alignment would transition to an aerial configuration as it turns southeast and enter the PEROW. The existing freight track would cross beneath the aerial alignment and align on the north side of the PEROW east of the San Pedro Subdivision ROW. The proposed Paramount/Rosecrans Station would be located in an aerial configuration west of Paramount Boulevard and north of Rosecrans Avenue. The existing freight track would be relocated to the east side of the alignment beneath the station viaduct.

The alignment would continue southeast in an aerial configuration over the Paramount Boulevard/Rosecrans Avenue intersection and descend to an at-grade configuration. The alignment would return to an aerial configuration to cross over Downey Avenue descending back to an at-grade configuration north of Somerset Boulevard. One of the adjacent freight storage tracks at Paramount Refinery Yard would be relocated to accommodate the new LRT tracks and maintain storage capacity. There are no active freight tracks south of the World Energy facility.

The alignment would cross Somerset Boulevard at-grade. South of Somerset Boulevard, the at-grade alignment would parallel the existing Bellflower Bike Trail that is currently aligned on the south side of the PEROW. The alignment would continue at-grade crossing Lakewood Boulevard, Clark Avenue, and Alondra Boulevard. The proposed at-grade Bellflower Station would be located west of Bellflower Boulevard.

East of Bellflower Boulevard, the Bellflower Bike Trail would be realigned to the north side of the PEROW to accommodate an existing historic building located near the southeast corner of Bellflower Boulevard and the PEROW. It would then cross back over the LRT tracks at-grade to the south side of the ROW. The LRT alignment would continue southeast within the PEROW and transition to an aerial configuration at Cornuta Avenue, crossing over Flower Street and Woodruff Avenue. The alignment would return to an at-grade configuration at Walnut Street. South of Woodruff Avenue, the Bellflower Bike Trail would be relocated to the north side of the PEROW. Continuing southeast, the LRT alignment would cross under the SR-91 freeway in an existing underpass. The alignment would cross over the San Gabriel River on a new bridge, replacing the existing abandoned freight bridge. South of the San Gabriel River, the alignment would transition back to an at-grade configuration before crossing Artesia Boulevard at-grade.

East of Artesia Boulevard the alignment would cross beneath the I-605 freeway in an existing underpass. Southeast of the underpass, the alignment would continue at-grade, crossing Studebaker Road. North of Gridley Road, the alignment would transition to an aerial configuration to cross over 183rd Street and Gridley Road. The alignment would return to an at-grade configuration at 185th Street, crossing 186th Street and 187th Street at-grade. The alignment would then pass through the proposed Pioneer Station on the north side of Pioneer Boulevard at-grade. Tail tracks accommodating layover storage for a three-car train would extend approximately 1,000 feet south from the station, crossing Pioneer Boulevard and terminating west of South Street.

2.3.3 Alternative 2: 7th Street/Metro Center to Pioneer Station

The total alignment length of Alternative 2 would be approximately 19.3 miles, consisting of approximately 2.3 miles of underground, 12.3 miles of at-grade, and 4.7 miles of aerial alignment. Alternative 2 would include 12 new LRT stations, 3 of which would be underground, 6 would be at-grade, and 3 would be aerial. Five of the stations would include parking facilities, providing a total of approximately 2,780 new parking spaces. The alignment would include 31 at-grade crossings, 3 freeway undercrossings, 2 aerial freeway crossings, 1 underground freeway crossing, 3 river crossings, 25 aerial road crossings, and 10 freight crossings.

In the north, Alternative 2 would begin at the proposed WSAB 7th Street/Metro Center Station, which would be located underground beneath 8th Street between Figueroa Street and Flower Street. A pedestrian tunnel would provide connection to the existing 7th Street/Metro Center Station. Tail tracks, including a double crossover, would extend approximately 900 feet beyond the station, ending east of the I-110 freeway. From the 7th Street/Metro Center Station, the underground alignment would proceed southeast beneath 8th Street to the South Park/Fashion District Station, which would be located west of Main Street beneath 8th Street.

From the South Park/Fashion District Station, the underground alignment would continue under 8th Street to San Pedro Street, where the alignment would turn east toward 7th Street, crossing under privately owned properties. The tunnel alignment would cross under 7th Street and then turn south at Alameda Street. The alignment would continue south beneath Alameda Street to the Arts/Industrial District Station located under Alameda Street between 7th Street and Center Street. A double crossover would be located south of the station box, south of Center Street. From this point, the alignment of Alternative 2 would follow the same alignment as Alternative 1, which is described further in Section 2.3.2.

2.3.4 Alternative 3: Slauson/A (Blue) Line to Pioneer Station

The total alignment length of Alternative 3 would be approximately 14.8 miles, consisting of approximately 12.2 miles of at-grade, and 2.6 miles of aerial alignment. Alternative 3 would include 9 new LRT stations, 6 would be at-grade and 3 would be aerial. Five of the stations would include parking facilities, providing a total of approximately 2,780 new parking spaces. The alignment would include 31 at-grade crossings, 3 freeway undercrossings, 1 aerial freeway crossing, 3 river crossings, 15 aerial road crossings, and 9 freight crossings. In the north, Alternative 3 would begin at the Slauson/A Line Station and follow the same alignment as Alternatives 1 and 2, described in Section 2.3.2.

2.3.5 Alternative 4: I-105/C (Green) Line to Pioneer Station

The total alignment length of Alternative 4 would be approximately 6.6 miles, consisting of approximately 5.6 miles of at-grade and 1.0 mile of aerial alignment. Alternative 3 would include 4 new LRT stations, 3 would be at-grade, and 1 would be aerial. Four of the stations would include parking facilities, providing a total of approximately 2,180 new parking spaces. The alignment would include 11 at-grade crossings, 2 freeway undercrossings, 1 aerial freeway crossing, 1 river crossing, 7 aerial road crossings, and 2 freight crossings. In the north, Alternative 4 would begin at the I-105/C Line Station and follow the same alignment as Alternatives 1, 2, and 3, described in Section 2.3.2.

2.3.6 Design Options

Alternative 1 includes two design options:

- **Design Option 1:** LAUS at the Metropolitan Water District (MWD) – The LAUS station box would be located east of LAUS and the MWD building, below the baggage area parking facility instead of beneath the LAUS Forecourt. Crossovers would be located on the north and south ends of the station box with tail tracks extending approximately 1,200 feet north of the station box. From LAUS, the underground alignment would cross under the US-101 freeway and the existing Metro L (Gold) Line aerial structure and continue south beneath Alameda Street to the optional Little Tokyo Station between Traction Avenue and 1st Street. The underground alignment between LAUS and the Little Tokyo Station would be located to the east of the base alignment.
- **Design Option 2:** Add the Little Tokyo Station – Under this design option, the Little Tokyo Station would be constructed as an underground station and there would be a direct connection to the Regional Connector Station in the Little Tokyo community. The alignment would proceed underground directly from LAUS to the Arts/Industrial District Station primarily beneath Alameda Street.

2.3.7 Maintenance and Storage Facility

MSFs accommodate daily servicing and cleaning, inspection and repairs, and storage of light rail vehicles (LRV). Activities may take place in the MSF throughout the day and night depending upon train schedules, workload, and the maintenance requirements.

Two MSF options are evaluated; however, only one MSF would be constructed as part of the Project. The MSF would have storage tracks, each with sufficient length to store three-car train sets and a maintenance-of-way vehicle storage. The facility would include a main shop building with administrative offices, a cleaning platform, a TPSS, employee parking, a vehicle wash facility, a paint and body shop, and other facilities as needed. The east and west yard leads (i.e., the tracks leading from the mainline to the facility) would have sufficient length for a three-car train set. In total, the MSF would need to accommodate approximately 80 LRVs to serve the Project's operations plan.

Two potential locations for the MSF have been identified—one in the City of Bellflower and one in the City of Paramount. These options are described further in the following sections.

2.3.8 Bellflower MSF Option

The Bellflower MSF site option is bounded by industrial facilities to the west, Somerset Boulevard and apartment complexes to the north, residential homes to the east, and the PEROW and Bellflower Bike Trail to the south. The site is approximately 21 acres in area and can accommodate up to 80 vehicles (Figure 2-7).

2.3.9 Paramount MSF Option

The Paramount MSF site option is bounded by the San Pedro Subdivision ROW on the west, Somerset Boulevard to the south, industrial and commercial uses on the east, and All American City Way to the north. The site is 22 acres and could accommodate up to 80 vehicles (Figure 2-7).

Figure 2-7. Maintenance and Storage Facility Options

Source: WSP 2020

3 REGULATORY FRAMEWORK

This section provides a summary of the federal, state and local regulatory framework applicable to geologic hazards (including seismicity) in the Affected Area.

3.1 Federal

There are no federal policies or regulations directly applicable to the project geology and soils analysis.

3.2 State

3.2.1 Alquist-Priolo Earthquake Fault Zoning Act

The California legislation protecting the population of California from the effects of fault-line ground-surface rupture is the Alquist-Priolo Earthquake Fault Zoning Act[2] (Public Resources Code 2621 *et seq*.). The Alquist-Priolo Act (CGS 2018) is the state's principal guidance to prevent the construction of habitable structures on the surface trace of active earthquake faults. The Alquist-Priolo Act only addresses the hazard of surface fault rupture and does not consider other earthquake hazards.

3.2.2 Seismic Hazards Mapping Act

The California Seismic Hazards Mapping Act (Public Resources Code 2690-2699.6) became effective in 1991 to identify and map seismic hazard zones for the purpose of assisting cities and counties in preparing the safety elements of their general plans, and to encourage land use management policies and regulations that reduce seismic hazards. The recognized hazards include strong ground shaking, liquefaction, landslides and other ground failure. The Act has resulted in the preparation of maps delineating liquefaction and earthquake-induced landslide Zones of Required Investigation. In addition, the California Geological Survey's (CGS) Special Publication 117A, *Guidelines for Evaluating and Mitigating Seismic Hazards in California* (2008), provides guidance for the evaluation of earthquake-related hazards for projects in designated Zones of Required Investigations, and for recommending mitigation measures as required by Public Resources Code Section 2695(a).

3.2.3 Surface Mining and Reclamation Act

The State Surface Mining and Reclamation Act (Public Resources Code 2710 et seq.) became effective in 1975 to establish policy for the reclamation of mined lands and the conduct of surface mining operations. The Affected Area is not located on an existing or previously mined area and no local ordinances or regulations allow surface mining within the Affected Area; however, the issue of loss of mineral resources due to the Project is evaluated in this study.

3.2.4 California Building Code

In addition to the preceding state acts, California regulations protecting the public from geo-seismic hazards are contained in the 2016 California Code of Regulations (CCR), Title 24,

[2] The Alquist-Priolo Earthquake Fault Zoning Act was enacted in 1972 to mitigate the hazard of surface faulting to structures for human occupancy. In accordance with this act, the State Geologist established regulatory zones, called "earthquake fault zones," around the surface traces of active faults and published maps showing these zones. Buildings for human occupancy are not permitted to be constructed across the surface trace of active faults.

Part 2 California Building Code (CBC). For surface structures other than guideways and bridges, the *Metro Rail Design Criteria* (MRDC) require conformance with the LA County Building Code, which is based on the CBC. The CBC dictates the requirements for design of structures and includes requirements to perform site-specific geotechnical investigations and prepare design reports in accordance with the CBC-specified methodologies. These investigations and reports would be conducted in concert with and during the final design stage of the Project and would address the hazards (for surface structures other than guideways and bridges) discussed in this report.

Chapter 16 of the CBC deals with structural design requirements governing seismically resistant construction (Section 1604), including, but not limited to, factors and coefficients used to establish seismic site class for the soil/rock at the building location and seismic occupancy category for the proposed building design (Sections 1613.3 through 1613.5). Chapter 18 includes, but is not limited to, the requirements for foundation and soil investigations (Section 1803); excavation, grading and fill (Section 18/04); allowable load-bearing values of soils (Section 1806); and the design of footings, foundations and slope clearances (Sections 1808 and 1809), retaining walls (Section 1807) and pier, pile, driven and cast-in-place foundation support systems (Section 1810). Chapter 33 includes, but is not limited to, requirements for safeguards at work sites so that excavations and cut or fill slopes are stable (Section 3304). Appendix J of the CBC includes, but is not limited to, grading requirements for the design of excavations and fills (Sections J106 and J107) and for erosion control (Section J110).

3.2.5 California Division of Occupational Safety and Health (Cal/OSHA)

Construction activities included with the Build Alternatives are subject to occupational safety standards for excavation, shoring and trenching as specified in California Occupational Safety and Health Administration (Cal/OSHA) regulations (CCR, Title 8). This includes the Cal/OSHA normal ventilation requirements for underground work areas (including tunnels), which includes the following:

- Fresh air must be supplied to all underground work areas in sufficient amounts to prevent any dangerous or harmful accumulation of dusts, fumes, mists, vapors, or gases. If natural ventilation does not provide the necessary air quality through sufficient air volume and air flow, the employer must provide mechanical ventilation such that each employee working underground has at least 200 cubic feet of fresh air per minute.
- When performing work that is likely to produce dust, fumes, mists, vapors, or gases, the linear velocity of air flow in the tunnel bore, shafts, and all other underground work areas must be at least 30 feet per minute. When such operations are complete, the ventilation systems must exhaust smoke and fumes to the outside atmosphere before resuming work. When drilling rock or concrete, dust control measures such as wet drilling, vacuum collectors, and water mix spray systems must be used to maintain dust levels within limits set in 29 CFR 1926.55, which includes gases, vapors, fumes, dusts, and mists.

3.3 Local

3.3.1 Los Angeles County Metropolitan Transportation Authority

The MRDC establish the design criteria for all Metro transit projects, including aboveground and belowground features of light rail transit projects. Section 5 of the MRDC, Structural/Geotechnical, indicates the following:

> The criteria and codes specified herein shall govern all matters pertaining to the design of Los Angeles County Metropolitan Transportation Authority (Metro) owned facilities including bridges, aerial guideways, cut-and-cover subway structures, tunnels, passenger stations, earth-retaining structures, surface buildings, miscellaneous structures such as culverts, sound walls, and equipment enclosures, and other non-structural and operationally critical components and facilities supported on or inside Metro structures. These criteria also establish the design parameters for temporary structures… The main reference document controlling the seismic design of Metro facilities under these criteria is the MRDC Section 5 Appendix, Metro Supplemental Seismic Design Criteria.

The MRDC provide guidance on the procedures and methods to be used during design of structures. Section 5 of the MRDC also provides detailed design requirements that address the geologic conditions and hazards discussed in this report. Specifically, MRDC Section 5.6, Geotechnical, requires subsurface investigation and laboratory testing, geotechnical reporting, and temporary excavation and detailed foundation design requirements that would address the hazards discussed in this report.

All new structures must be designed to resist the earthquake forces and ground displacement stipulated in the MRDC. The MRDC Section 5 Appendix, Metro Supplemental Seismic Design Criteria, dictate the required seismic performance criteria for structures. For structures other than above-ground and underground guideways and bridges, such as buildings and some retaining walls, the MRDC require conformance with the LA County Building Code, which is based on the CBC. For bridges and aerial structures, the MRDC require mandatory conformance with the latest version of the California Department of Transportation (Caltrans) *Bridge Design Specifications* (2018), Caltrans *Seismic Design Criteria* (Caltrans 2019a), and American Association of State Highway and Transportation Officials (AASHTO) *Load and Resistance Factor Design (LRFD) Bridge Design Specifications* (AASHTO 2017 and Caltrans 2019b), or American Railway Engineering and Maintenance-of-Way Association (AREMA) 2019 specifications, as applicable, depending on the location of the structure. Retaining walls subject to LRT loading will also be designed in conformance with the AASHTO with Caltrans Amendments, in accordance with MRDC Section 5.1.3.C.5. Underground structures would be designed to conform with Metro design specifications for underground guideways and structures.

The Metro Supplemental Seismic Design Criteria (SDC) (Metro 2017) would be used for the final design stage of the Project to provide seismic design recommendations for the Build Alternatives. In concert with these recommendations, Metro has a two-level design approach for both aerial and underground structures:

1. The Operating Design Earthquake (ODE), defined as an earthquake event likely to occur only once during the design life, where structures are designed to respond without significant structural damage. The ODE has a 150-year average return period (ARP).

2. The Maximum Design Earthquake (MDE), defined as an earthquake event with a low probability of occurring during the design life, where structures are designed to respond with repairable damage and to maintain life safety. The MDE has a 2,500-year ARP.

The Metro SDC also require the following:

- Bridge, aerial, and underground structures would be designed in accordance with the Metro MDE, which has a 2,500-year ARP.
- Surface structures not covered by the Caltrans seismic design criteria would be designed in accordance with the LA County Building Code. The LA County Building Code uses the maximum considered earthquake with a 2,500-year ARP.
- Bridges supporting railroads would be designed in accordance with the requirements of the applicable railroad, or the AREMA standards in lieu of specific railroad requirements. The ARP for AREMA-owned facilities varies, depending on the Structure Importance Classification, and ranges from a 50- to 2,400-year ARP.

If a structure is governed by more than one set of seismic design criteria and conflict exists, the most critical set of requirements would apply to the design.

When tunneling is included in a project, Metro would mandate that the Tunnel Advisory Panel (TAP) review designs with respect to subsurface gas and other tunneling-related hazards. The members of the TAP have extensive experience with tunneling projects in the Los Angeles Basin and seek to verify that the requirements of the MRDC are successfully implemented.

3.3.2 City of Los Angeles

3.3.2.1 Methane Ordinance

In 2004, the City of Los Angeles adopted the City of Los Angeles Methane Ordinance (No. 175790), which requires compliance with the Methane Mitigation Standards outlined in the Methane Seepage Regulations (Division 71, Section 91-7101 to 91-7109), and as directed and approved by the Los Angeles Department of Building and Safety (LADBS) and Los Angeles Fire Department. The ordinance outlines the general methane requirements for mitigation; testing, maintenance and service of gas-detection and mechanical ventilation systems; emergency procedures; application of methane seepage regulations to locations or areas outside the methane zone and methane buffer zone boundaries; and additional remedial measures (General, Abandoned Oil Wells).

Additionally, the City of Los Angeles Department of Public Work's Bureau of Engineering has mapped potential methane zones and methane buffer zones where additional assessment is required. Specifically, the City of Los Angeles Municipal Code requires projects located within a methane zone or methane buffer zone to comply with the City's Methane Mitigation Standards as amended by Ordinance 175790 (LADBS 2004).

3.3.2.2 Department of Building and Safety

The Methane Mitigation Standards require that an initial assessment for methane and hydrogen sulfide be completed in accordance with LADBS guidelines where the Affected Area passes through oil fields, methane zones, and/or methane buffer zones. The initial assessment shall be conducted in accordance with 2014 LADBS *Site Testing Standards for Methane*.

3.3.2.3 Municipal Code

The City of Los Angeles Municipal Code, Chapter IX, Building Regulations, Article 1, Division 71, Methane Seepage Regulations (City of Los Angeles 2004), requires construction projects located within a methane zone or methane buffer zone to comply with the City's methane mitigation standards to control methane intrusion emanating from geologic formations. Mitigation requirements are determined according to the actual methane levels and pressures detected in the subsurface at a site. Mitigation measures can include both active and passive ventilation systems that provide the exchange of air, gas barriers (membranes around basements and foundations), and sensors in interior spaces that monitor the presence of gas and its pressure.

4 AFFECTED ENVIRONMENT/EXISTING CONDITIONS

The existing conditions of the Affected Area as they relate to geology, soils and seismicity have been identified from a review of available published and unpublished geotechnical literature pertinent to the Project. These include, but are not limited to, the following:

- Safety elements of the general plans for the cities in the Affected Area and the County of Los Angeles
- Official Alquist-Priolo Earthquake Fault Zone maps
- Official seismic hazard zone maps and reports
- Geologic and topographic maps
- Other publications by the CGS, United States Geological Survey (USGS) and the California Department of Conservation, Division of Oil, Gas, and Geothermal Resources (DOGGR)
- City of Los Angeles methane and methane buffer zone maps

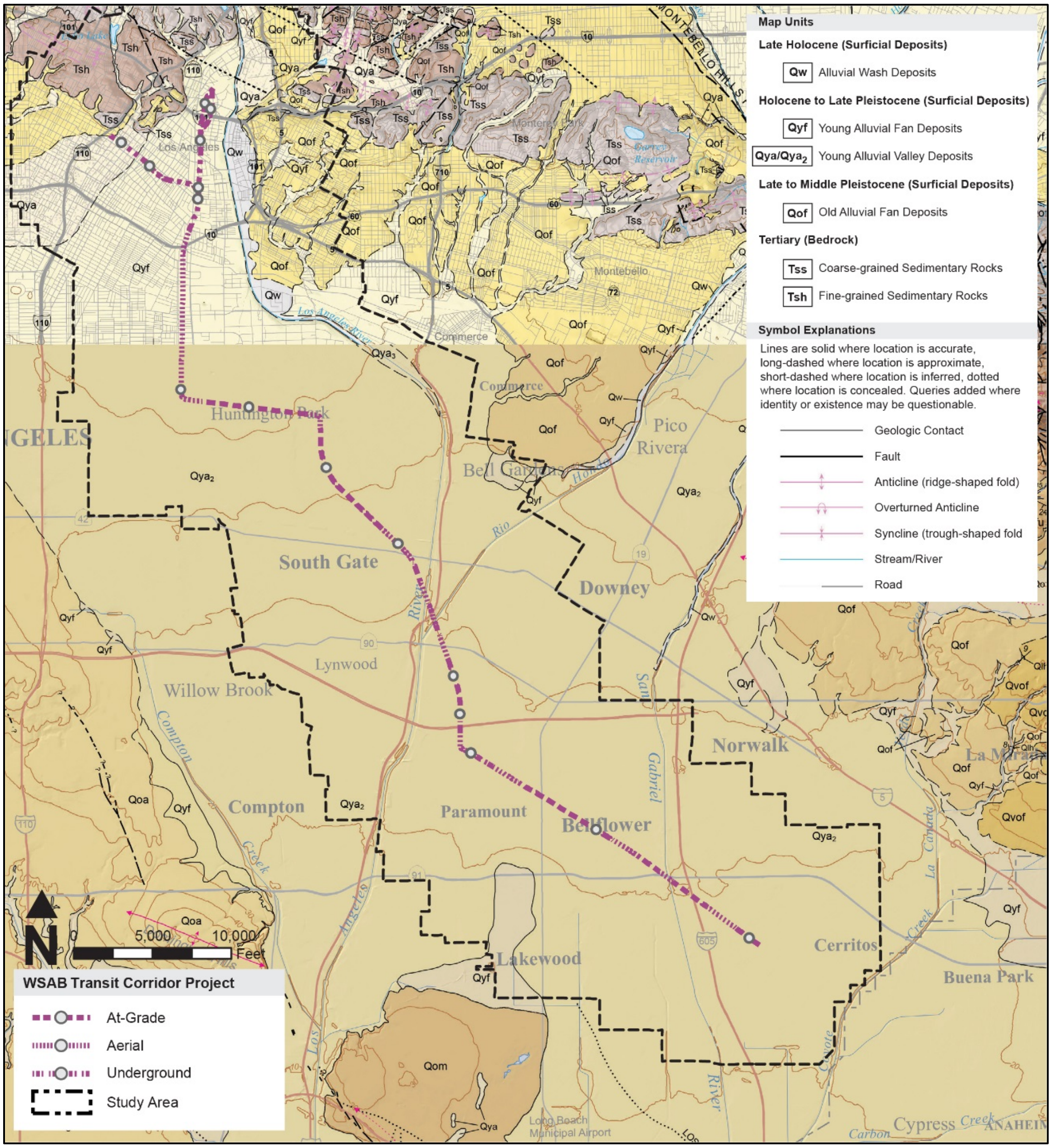
4.1 General Discussion

The existing geologic conditions within the Affected Area include alluvial soils and sedimentary, igneous and metamorphic bedrock; variable groundwater conditions; and the potential for ground shaking and liquefaction. The entire Affected Area is blanketed by alluvial soil, overlain locally by artificial fill soils. The topography is relatively flat, gently sloping to the south-southwest toward the Pacific Ocean. The existing geotechnical, geologic and seismic conditions within the Affected Area are summarized below.

4.2 Regional Geologic Setting

The Affected Area is located within the Los Angeles Basin portion of the Peninsular Ranges geomorphic province of California. The Peninsular Ranges province is characterized by a series of northwest-trending mountains, valleys and faults, all of which generally parallel the San Andreas Fault system. The Elysian Park-Repetto Hills, as well as the Newport-Inglewood Fault Zone, are prime examples of this northwest-trending regional structure. The Los Angeles Basin is a structural trough overlying bedrock formations between the Western Continental Shelf and the San Gabriel Mountains. Near the central part of the basin, this structural trough has been filled with nearly 30,000 feet of marine and alluvial deposits of the Quaternary (up to 2.6 million years old) and Tertiary (2.6 to 65 million years old) ages (Yerkes et al. 1965). These Quaternary and Tertiary units are underlain by Cretaceous-age crystalline bedrock. The geology of the Affected Area is shown on Figure 4-1; given the scale of the figure, the limits of the Affected Area for the conducted geotechnical analysis (250-foot buffer) are not illustrated.

Figure 4-1. Geologic Map



Sources: Prepared by Jacobs in 2020 (based on information from Bedrossian et al. 2012; Saucedo et al. 2016)

4.3 Physiography and Topography

The Affected Area is on a gently sloping (relatively flat) alluvial surface (the inactive Los Angeles and San Gabriel River floodplains) within the Los Angeles Basin. Elevations along the Affected Area vary from approximately 280 feet above mean sea level (msl) on the north end to 40 feet msl on the southeast end (USGS 1964a, 1964b, 1965, 1966a, and 1966b). Overall, the Affected Areas slope towards the south and southwest.

As shown on Figure 4-1, the Affected Area is transected by the concrete-lined Los Angeles River and Rio Hondo channels just west and east, respectively, of Interstate (I)-710, and the concrete-lined San Gabriel River channel just west of I-605.

4.4 Stratigraphy

The following discussion on the Affected Area geologic units is derived from a combination of regional geologic maps and their associated literature (Bedrossian et al. 2012; Campbell et al. 2014; Dibblee 1989; Lamar 1970; Saucedo et al. 2016; Yerkes et al. 1977). The geologic units relevant to the Affected Area include alluvial soils and sedimentary bedrock. Igneous and metamorphic bedrock are also present in the Affected Area at great depths (up to 30,000 feet below ground surface [bgs]). Due to these great depths, the igneous and metamorphic bedrock are not a geological concern for the Project. Figure 4-1 depicts the surficial geology of the Affected Area. In addition to the mapped geologic units shown on Figure 4-1, artificial fill soils overlie the alluvial deposits locally within the Affected Area.

4.4.1 Artificial Fill Soil

Artificial fill soils are present locally within the Affected Area as the area is urban and developed. Historically, artificial fill soils have been placed during the construction of some past projects to generally raise the grade (ground level) at a site, or to replace soils that were considered detrimental to a proposed development. The depth and lateral extent of these fill soils depend on the original topography as well as urban development within the Affected Area. Based on information available from the Regional Connector project, artificial fill soils 5 to 20 feet deep are present along the Regional Connector alignment (Metro 2012). The Regional Connector is a Metro project that has endpoints that overlap with the Affected Area. The Regional Connector extends from a new underground Little Tokyo/Arts District Station to the existing 7th Street/Metro Center Station. Fills of similar thickness may be present throughout the Affected Area, although local areas may be underlain by thicker fills. The composition of the fill soils is variable, depending on the source.

4.4.2 Alluvial Soil

The alluvial soil units (map units Qw, Qyf, Qya/Qya2, and Qof as shown on Figure 4-1) along the Affected Area Section generally consist of interbedded lenses and/or discontinuous layers of fine-grained sediment (silt and clay) and coarse-grained sediment (sand, gravel, cobbles and boulders). From a geologic perspective, the alluvial soils are considered unconsolidated because the soils lack cementation typically associated with rock formations. The contact between the alluvial materials and underlying bedrock is irregular because the alluvium has overlain landscapes developed by erosion into older deposits. The approximate depth to the alluvial soil/bedrock contact varies in the downtown Los Angeles Area, as discussed further in Section 4.4.3. South of Randolph Street, the alluvial sediments are expected to be present to depths greater than 1,000 feet bgs (Yerkes et al. 1965).

Within the downtown Los Angeles area alluvial soils, cobbles, and boulders (3-foot diameter and greater) are widespread, but not uniformly distributed. The cobbles and boulders were reported at depths that vary from 0 feet to over 120 feet bgs (Yerkes et al. 1977).

4.4.3 Sedimentary Bedrock

The Pliocene-age Fernando Formation (represented by Unit “Tsh” on Figure 4-1) is a sedimentary unit generally consisting of soft, gray to black, vaguely bedded, claystone and siltstone. Scattered hard concretions and thin hard layers occur within this unit. The degree of weathering in these rocks decreases with increasing depth from decomposed to fresh. The unit is present in the shallow subsurface in the downtown Los Angeles area. The depth to the Fernando Formation bedrock is variable, ranging from approximately 40 feet bgs near US-101 (Metro 2002) and near the 1st/Central Avenue Station (Metro 2013), to 20 feet bgs at the 7th Street Metro Center Station (Converse 1983 and Metro 2013), to 400 to 500 feet bgs near I-10, and to over 1,000 feet bgs near Randolph Street (Yerkes et al. 1977). According to Lamar (1970), the Fernando Formation claystone/siltstone unit can be over 4,300 feet thick. The Fernando Formation also has a coarse-grained member (represented by Unit “Tss” on Figure 4-1) consisting of sandstone and conglomerate bedrock. Review of existing data (Converse 1983; Metro 2002 and 2013) indicates that the coarse-grained unit would not be encountered during construction of the Build Alternatives. Based on the mapping by Lamar (1970) and Dibblee (1989) in the Elysian Park-Repetto Hills area (immediately northwest and northeast, respectively, of the downtown Los Angeles area), the Fernando formation generally dips 20 to 70 degrees to the south.

4.5 Groundwater and Surface Water

4.5.1 Surface Water

The Project is transected (from west to east) by the concrete-lined Los Angeles River, Rio Hondo, and San Gabriel River. The Affected Area drains by sheet flow to these major drainages or to secondary drainages, which all ultimately drain into the Pacific Ocean.

4.5.2 Groundwater

Historically, the highest groundwater levels within the Affected Area generally range from 20 feet bgs near US-101 to 160 feet bgs near 7th Street (at Alameda Street) to approximately 40 feet bgs near Randolph Street (CGS 1998b and 1998c). The historically highest groundwater level near the 7th Street/Metro Center Station of Alternative 2 is approximately 60 feet bgs (CGS 1998e). From Randolph Street, the historic high groundwater levels increase to approximately 10 feet bgs or less from near Florence Avenue to the southeastern end of the Affected Area (CGS 1998a, 1998c, and 1998d).

Based on relatively recent data, groundwater was reported at approximately: 40 feet bgs near US-101 in 2002 (Metro 2002); 20 feet bgs at Union Station in 1993 (Law/Crandall 1994); 40 feet bgs (in 2013) at the Regional Connector 1st/Central Avenue Station (Metro 2013); and 30 feet bgs (in 1983 and 2013) at the 7th Street/Metro Center Station (Converse 1983 and Metro 2013). Based on the available Caltrans as-built Log of Test Boring sheets, groundwater levels were noted at 5 feet bgs (in the 1950s) at I-710 and the Los Angeles River, 40 feet bgs (in the 1980s) at I-105 and the UPRR crossing, and 20 feet bgs (in the 1960s) at I-605 and Artesia Boulevard.

The bedrock units that could impact the Affected Area generally do not have a fixed groundwater table. However, the bedrock can hold and transport groundwater in the form of seepages present within sandstone beds as well as fault and/or fracture zones. Based on experience with underground excavation projects in the downtown Los Angeles area (such as the Metro Regional Connector, B [Red] Line, and D [Purple] Line), it is known that substantial amounts of groundwater inflows can be expected locally in alluvial deposits below the groundwater table.

4.6 Faulting and Seismicity

4.6.1 General Setting

Faults designated as active faults under the Alquist-Priolo Earthquake Fault Zoning Act have the potential for ground surface rupture during an earthquake event (CGS 2018). This designation indicates the faulting has resulted in surface offsets in Holocene time (~the last 12,000 years) and the fault's location is well defined. Potentially active faults may not be identified as active according to the Alquist-Priolo Act simply because their locations are not well defined and/or they have not been confirmed to have had surface ruptures in Holocene time. A potentially active fault is defined by the Alquist-Priolo Act as a fault that has experienced surface displacement within the Quaternary period (between approximately 12,000 years and 1.6 million years) but has not been confirmed to have younger Holocene displacements (CGS 2018).

No known active faults capable of ground rupture are mapped within the Affected Area, and the Project is not located in an Alquist-Priolo Earthquake Fault Zone (CGS 2016a through 2016e). Two active blind thrust fault systems (Elysian Park and Puente Hills) underlie the Affected Area. These fault systems do not extend to the ground surface and are not considered capable of direct ground rupture during an earthquake. However, movements along these faults do generate earthquakes, and surficial ground deformation has been documented due to activity along some blind thrust faults. Known active and potentially active faults that are mapped within five miles of the Affected Area are summarized in Table 4.1 and are discussed below in Sections 4.6.2 and 4.6.3. Nearby active and potentially active faults are shown on Figure 4-2.

Table 4.1. Summary of Nearby Active and Potentially Active Faults

Fault Name	Fault Type[a]	Slip Rate[a] (millimeters per year)	Maximum Moment Magnitude (M_{max})[a]	Closest Distance to Affected Area (miles)[b]
Lower Elysian Park Fault	Blind Thrust	0.1	6.7	0
Puente Hills Fault – Los Angeles Section	Blind Thrust	0.9	6.9	0
Upper Elysian Park Fault	Blind Thrust	1.9	6.6	0.8
Puente Hills Fault – Santa Fe Springs Section	Blind Thrust	0.9	6.6	0.8
Los Alamitos Fault	Uncertain	Uncertain	Uncertain	2.6
Puente Hills Fault – Coyote Hills Springs Section	Blind Thrust	0.9	6.8	3.1
Raymond Fault	Left-Lateral with Reverse	2	6.7	4.5
Hollywood Fault	Left-Lateral with Reverse	0.9	6.6	4.7

Sources: Caltrans 2017; USGS and CGS 2006
Notes: [a] Caltrans 2017
[b] Blind thrust faults – Caltrans 2017 (distance tabulated is the vertical projection of the blind thrust fault to the surface)
Other faults – USGS and CGS 2006; see Figure 4-2.
M_{max} = maximum moment magnitude

Figure 4-2. Fault Location Map

Sources: Prepared by Jacobs in 2020 (based on information from Caltrans 2017; USGS and CGS 2006)
Notes: Fault locations are approximate.
A Historic fault is a fault that has ruptured in the last 150 years. A Holocene-Latest Pleistocene fault is a fault that has ruptured in the last 15,000 years. A Late Quaternary fault is a fault that has ruptured in the last 130,000 years.

In addition, numerous active faults are present in Southern California that also contribute to the ground shaking hazard for the Project. These faults are considered in the seismic analysis presented in Section 4.6.4.

4.6.2 Nearby Active Faults

4.6.2.1 Surface Faults

The closest active faults capable of ground rupture near the Affected Area are the Raymond Fault, located roughly 4.5 miles north of the Affected Area, and the Hollywood Fault, located roughly 4.7 miles north of the Affected Area. The geographic boundary between these two faults is the Los Angeles River.

The Raymond Fault is a north-dipping, east-west-trending fault that has a dominant left-lateral sense of offset (Jones et al. 1990; Weaver and Dolan 2000), although some north side-up reverse slip also occurs. The geometry of the Hollywood Fault is very similar to that of the Raymond Fault. Caltrans (2017) currently assumes a slip rate of 2.0 millimeters per year (mm/yr) and a maximum moment magnitude (M_{max}, 1,000-year return period) of 6.7 for the Raymond Fault, and a slip rate of 0.9 mm/yr and an M_{max} of 6.6 for the Hollywood Fault.

4.6.2.2 Blind Thrust Faults

The Affected Area is underlain by the active Elysian Park Blind Thrust Fault (EPBT) and Puente Hills Blind Thrust Fault (PHBT) (Shaw and Suppe 1996; Shaw et al. 2002). These blind thrust faults are not considered capable of direct ground rupture. However, there is potential for co-seismic deformation (gentle folding of the ground surface) to occur in the Affected Area -related to the Coyote Pass escarpment of the Upper EPBT (UEPBT) (Oskin et al. 2000). The EPBT and PHBT would be considered in the seismic design for the Build Alternatives.

Puente Hills Blind Thrust Fault

The PHBT system is the name currently given to a series of northerly dipping, blind subsurface thrust faults extending approximately 25 to 28 miles along the eastern margin of the Los Angeles Basin. To interpret three discrete thrust faults underlying the La Brea/Montebello Plain (Los Angeles Segment), Santa Fe Springs Plain (Santa Fe Springs Segment) and Coyote Hills (Coyote Hills Segment), oil company data and seismicity were synthesized (Shaw and Shearer 1999). These faults form an en-echelon (parallel) arrangement from the northern Los Angeles Basin to the southern part of the Puente Hills.

A potential earthquake M_{max} of 6.6 to 6.9 has been estimated for the individual PHBT segments (Caltrans 2017). Caltrans (2017) assumes a slip rate of 0.9 mm/yr for each of the various sections of the Puente Hills Fault. Although the Puente Hills Fault system might generate strong ground motion in the Affected Area, it is not considered capable of generating surface rupture. The projection of the PHBT Los Angeles Section to the ground surface intersects the Affected Area of Alternative 1 and 2 in the general vicinity of Florence Avenue(Bergen et al. 2017 and Rollins et al., 2018). Because the PHBT is a much deeper feature than the EPBT (the EPBT is situated atop the PHBT (Shaw et al., 2002) and may merge with it at depth), direct evidence for surface expression (deformation) (such as the Coyote Pass Escarpment for the EPBT) has not been noted for the PHBT in the Los Angeles Basin. As an example, the 1987 Whittier Narrows Earthquake occurred on the PHBT, and rupture of the PHBT did not break the ground surface (Hauksson et. al. 1988). The PHBT fault does not penetrate Quaternary aged sediments in the LA Basin, the fault tip is buried by the sediment, which are very broadly folded as a result of the fault (Rollins et al. 2018).

Elysian Park Blind Thrust Fault

The EPBT consists of the Upper and Lower Sections, although most seismic analysis recognizes only the UEPBT. The UEPBT is theorized to be bound by the Hollywood Fault to the northwest and the Alhambra Wash Fault (the northerly extension of the Elsinore/Whittier Fault Zone) to the southeast (Oskin et al. 2000 and Shaw et al. 2002). The UEPBT has been modeled dipping to the north at angles ranging from 30 to 60 degrees from horizontal (Oskin et al. 2000); the actual dip of the fault is unknown at this time.

Estimated earthquake magnitudes (M_W) associated with seismic events on the UEPBT could range from 6.6 to 7.3 M_W, with recurrence intervals in the range of 340 to 1,000 years (Shaw and Suppe 1996). The CGS, following the lead of Oskin et al. (2000), models the UEPBT as a feature about 11 miles long and dipping 50 degrees northeasterly with a slip rate estimate of approximately 1.3 ± 0.4 mm/yr. Caltrans (2017) assumes a slip rate of 1.9 mm/yr and an M_{max} of 6.6 for the UEPBT. Movements along the UEPBT have resulted in local co-seismic deformation at the ground surface, as discussed below.

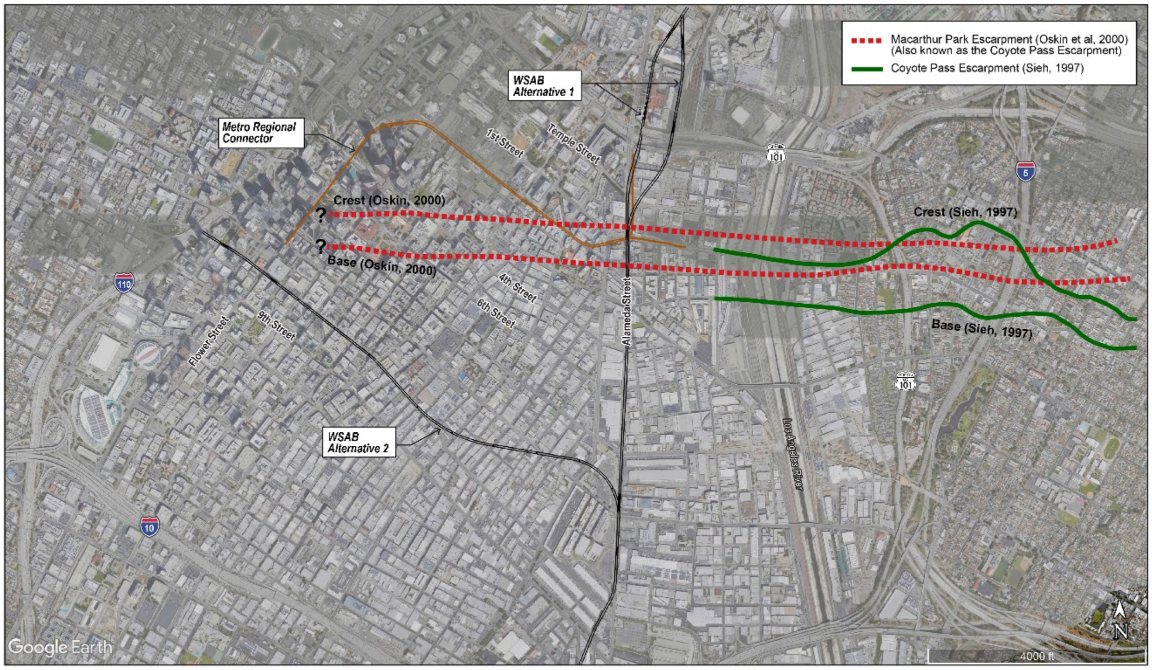
Coyote Pass Escarpment

Movements along the UEPBT have resulted in local co-seismic deformation near the surface. In addition, numerous folds and escarpments (a relatively long and linear steep slope) that have formed as a result of movement along the UEPBT have been identified, some of which are visible at the surface (Oskin et al. 2000). These features have been mapped in the area generally south of York Boulevard in northeast Los Angeles, north of State Route (SR)-60 in East Los Angeles, west of Rosemead Boulevard in the Whittier Narrows area and east of Van Ness Avenue in the Hollywood area. Of these features, the Coyote Pass escarpment is the feature of most concern (Oskin et al. 2000).

The Coyote Pass escarpment transects the Affected Area in the downtown Los Angeles area, although the escarpment is mapped as concealed by the Los Angeles River floodplain (Oskin et al. 2000). A deformation study on the Coyote Pass escarpment was conducted by Earth Consultants International (ECI) near the intersection of Soto Street and 1st Street in Los Angeles for the Metro L (Gold) Line Soto Station, a subterranean LRT station located approximately 1.3 miles east of the Northern Section (ECI 2001). As identified therein, the Soto Station is located near the toe of the Coyote Pass escarpment, and deformation at the Coyote Pass escarpment in this area has a recurrence interval of 2,800 to 3,900 years; however, no data were available to constrain the timing of the most recent event. Each event was estimated to result in uplift of 23 to 34 inches (ECI 2001), yielding compression in the subsurface. The top of the escarpment would also experience deformation during a UEPBT event. Although this deformation was not quantified by ECI (2001), it would presumably be similar in magnitude to subsurface deformation, though extensional and potentially more broadly dispersed.

The location of the Coyote Pass escarpment in the vicinity of the Affected Area is approximate as the escarpment in this area has been eroded away by the Los Angeles River. Based on the Coyote Pass escarpment studies conducted for the Regional Connector project study (AMEC 2013), the Coyote Pass escarpment crosses North Alameda Street between Temple Street on the north and 4th Street on the south. The location of the escarpment in the Affected Area was projected from this area at North Alameda Street to the west, where topographic expression of the feature is evident near SR-110. Based on this projection, the Coyote Pass escarpment continues westerly from North Alameda Street to an approximate location between 4th Street (on the north) and 9th Street (on the south) along Flower Street. The projected location of the escarpment is shown on Figure 4-3.

Figure 4-3. Coyote Pass Escarpment



Sources: Prepared by Jacobs in 2019 (based on information from WSP 2019; Oskin et al. 2000; Sieh 1997; AMEC 2013)
Note: Escarpment locations are not exact, and are a graphic representation of a broad area.

4.6.3 Nearby Potentially Active Faults

One potentially active fault is located within 5 miles of the Affected Area, the Los Alamitos Fault, mapped approximately 2.6 miles southwest of the Affected Area in the vicinity of the San Gabriel River (USGS and CGS 2006). The exact location, slip rate, and potential earthquake magnitude have not been established specifically for the Los Alamitos Fault as it is a relatively newly discovered fault. Yeats and Verdugo (2010) theorize that the Los Alamitos Fault is related to the Los Angeles Segment of the PHBT and the Newport-Inglewood Fault Zone, which is mapped further southwest from the Los Alamitos, as shown on Figure 4-2. The Southern California Earthquake Data Center indicates that the Los Alamitos Fault may be a part of the larger Compton-Los Alamitos Fault, located farther south of the Project.

4.6.4 Seismic Shaking

The Project is located within the seismically active region of Southern California and may be subject to seismic ground shaking over time. Preliminary seismic data research and review were conducted for the Affected Area using the USGS seismic design maps (American Society of Civil Engineers [ASCE] 2019). Considering the conceptual level of the Project, the MDE is used to provide a general frame of reference for the ground accelerations (the severity of ground shaking) that would be utilized in the design of the Project. USGS parameter PGA_M is the peak ground acceleration (PGA) corrected for site effects (i.e., subsurface conditions). The PGA is an estimation of maximum ground shaking a site can experience over a specified period of time. The period of time considered is termed the average return period or ARP. The ARP is dictated by the MRDC as discussed in Section 3.3.1 of this report. Based on available subsurface data from historical borings, soils within the upper 100 feet of the Affected Area can be generally classified as Site Class D for this conceptual level of study. Using the 2017 USGS Seismic Design Maps, PGA_M varies along the Affected Area, ranging from 0.94g (g = acceleration due to gravity) near the northern end (near US-101) to 0.72g near the southern end (near Pioneer Station). The actual PGA that would be used during the final design stage of the project's structures would be developed as the project designs progress, and it would utilize the Site Class developed from the geotechnical field investigation that would be performed for the Project.

4.6.5 Other Seismic Hazards

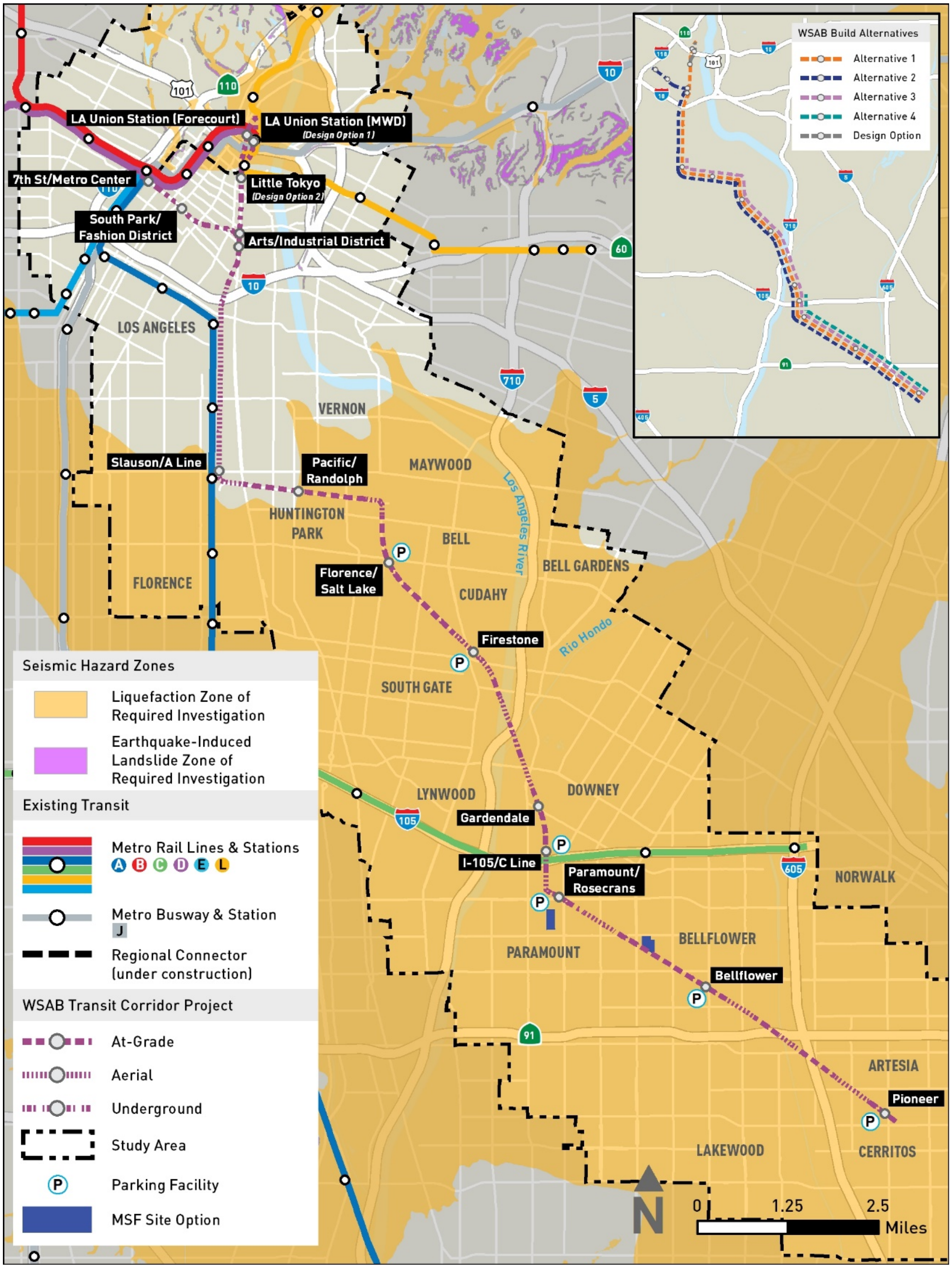
A number of geologic hazards can occur in direct relation to a seismic event. The hazards range from liquefaction to tsunamis and seiches. The potential for these hazards to occur in the Affected Area in correlation with a seismic event is discussed below.

4.6.5.1 Liquefaction

Soil liquefaction occurs in the upper 50 to 75 feet bgs when saturated, loose soils lose their strength because of excess pore water pressure caused by earthquake ground shaking. Pore pressures develops when the space (pores) between the soil particles is completely filled with water, which exerts pressure on the soil particles, thereby influencing how tightly the soil particles are pressed together. Prior to an earthquake, the pore water pressure is static depending on the depth below the groundwater table; however, the shaking caused by an earthquake can increase the pore water pressure to a point where the soil loses strength and ground deformation can occur.

The primary factors affecting the possibility of liquefaction in a soil deposit are the intensity and duration of the earthquake shaking, the soil type, the relative density of the soil, the pressures of material above the soil, and the depth to groundwater. The types of soils most susceptible to liquefaction are clean, loose, uniformly graded, fine-grained sands; non-plastic silts that are saturated; and silty sands. When liquefaction occurs, the strength of the soil decreases, and the ability of the soil to support structures is reduced. The potential impacts of liquefaction may include settlement of the ground surface, additional forces pushing down on foundation piles as a result of soil settlement above the liquefied layers (downdrag), lateral spreading (similar to a landslide), and reduction of the shear strength of the liquefied soil, resulting in reduced load-carrying capacity. Liquefied soils can also exert additional dynamic pressures on retaining walls, which can cause them to tilt or slide. Liquefaction-induced ground failure has historically been a major cause of earthquake damage in Southern California. As shown on Figure 4-4, portions of the Affected Area in the downtown Los Angeles area, and the entire Affected Area, from the Huntington Park area to the Artesia area, are located in a Liquefaction Zone of Required Investigation (CGS 2016a through 2016e). Because of the scale of the figure, the limits of the Affected Area are not illustrated. Liquefaction Zones of Required Investigation are zones delineated by CGS in areas that have historically experienced liquefaction, or in areas where conditions favorable to liquefaction exist, including the presence of a shallow groundwater table and loose soils.

Figure 4-4. Seismic Hazard Zones Map



Sources: Prepared by Jacobs in 2021 (based on information from CGS 2016a through 2016e)

4.6.5.2 Seismically Induced Landslides

The potential for seismically induced landslides to occur depends on the steepness of the slope, strength and structure of the soil/rock, groundwater depth and extent, and level of ground shaking. The Affected Area is relatively flat, and no significant slopes are present. The Affected Area is not located in an Earthquake-induced Landslide Zone of Required Investigation (CGS 2016a through 2016d), as shown on Figure 4-4.

4.6.5.3 Seismically Induced Settlement

Loose, unsaturated granular soils are susceptible to settlement during an earthquake (as the earthquake shaking causes the soil grains to rearrange and densify). This settlement can result in structural distress as the ground settles. Seismically induced settlement occurs primarily within loose to moderately dense sandy soils due to volume reduction during or shortly after an earthquake event. The artificial fill soils present along the alignment are expected to be undocumented and could include these loose soils. In addition, a portion of the alluvial soils along the alignment are anticipated to be loose to medium dense. Within the entire Affected Area, unsaturated (above the groundwater table), undocumented fill soils and granular alluvial soils in the upper 50 to 75 feet bgs are potentially susceptible to seismically induced settlement.

4.6.5.4 Seismically Induced Inundation

Seismically induced inundation can occur when an earthquake causes catastrophic failure of a water-retaining structure such as a reservoir, dam, or levee, and subsequent flooding occurs due to the release of water from the structure. Based on a review of state inundation maps, floodwaters resulting from dam inundation are not expected to affect tunnel portals or underground stations included with Alternatives 1 and 2, including Design Options 1 and 2. The proposed portals and underground station locations are outside of the dam inundation areas identified by the California Dam Breach Inundation Maps produced by the California Department of Water Resources (2019). All of the Build Alternatives' portals and underground stations are within the City of Los Angeles. According to the 2017 *City of Los Angeles Local Hazard Mitigation Plan*, probability of dam failure is low in today's regulatory environment (City of Los Angeles 2017).

4.6.5.5 Tsunamis and Seiches

Tsunamis are waves typically generated offshore or within large, open bodies of water primarily during subaqueous fault rupture or a subaqueous landslide event. Seiches are waves generated within a large closed body of water, also caused either by subaqueous fault rupture or landslide events or by ground oscillations from distant earthquakes. At its closest point to the Project, the Pacific Ocean is located over eight miles to the southwest. There are no closed bodies of water within or adjacent to the Affected Area. Based on the distance between the Affected Area and large bodies of water, the risk for tsunami or seiche in the subject Affected Area is negligible. In addition, the Affected Area is not located within a Tsunami Inundation Area according to LA County (2012).

4.7 Non-seismic Hazards

Potential non-seismic geologic hazards may exist within the Affected Area, as summarized in the following subsections. See the *West Santa Ana Branch Transit Corridor Project Final*

Hazardous Materials Impact Analysis Report (Metro 2021b) for discussion regarding potential hazardous materials.

4.7.1 Slope Stability

The stability of a slope depends on the inclination, geology and geologic structure, soil and rock strength, and ground and surface water conditions within the slope. The Affected Area is relatively flat, and no significant slopes are present.

4.7.2 Expansive Soils

Expansive soils are clay-rich soils that swell and shrink with wetting and drying. The shrink-swell capacity of expansive soils can result in differential movement below or adjacent to a structure. This differential movement can result in significant damage to pavements, as well as foundations and associated structures. Clay-rich soils may exist locally within alluvial soils present in the Affected Area. In addition, bedrock units also can exhibit expansive properties due to the clay content within the bedrock; this includes the Fernando Formation bedrock present within the shallow subsurface in the downtown Los Angeles area.

4.7.3 Ground Settlement and Collapsible Soils

Near the surface, ground settlement can occur when new loads are added to soil, or when a change in water levels results in a decrease in pore water pressures within compressible soils. Collapsible soils consist predominantly of sand- and silt-size particles arranged in a loose “honeycomb” structure. This loose structure is held together by small amounts of water-softening cementing agents, such as clay or calcium carbonate. When the soil becomes wet, these cementing agents soften, the honeycomb structure collapses and generates ground settlement. The alluvial soils within the entire Affected Area may be prone to collapse/settlement, which can result in differential movement beneath foundations, potentially causing structural distress.

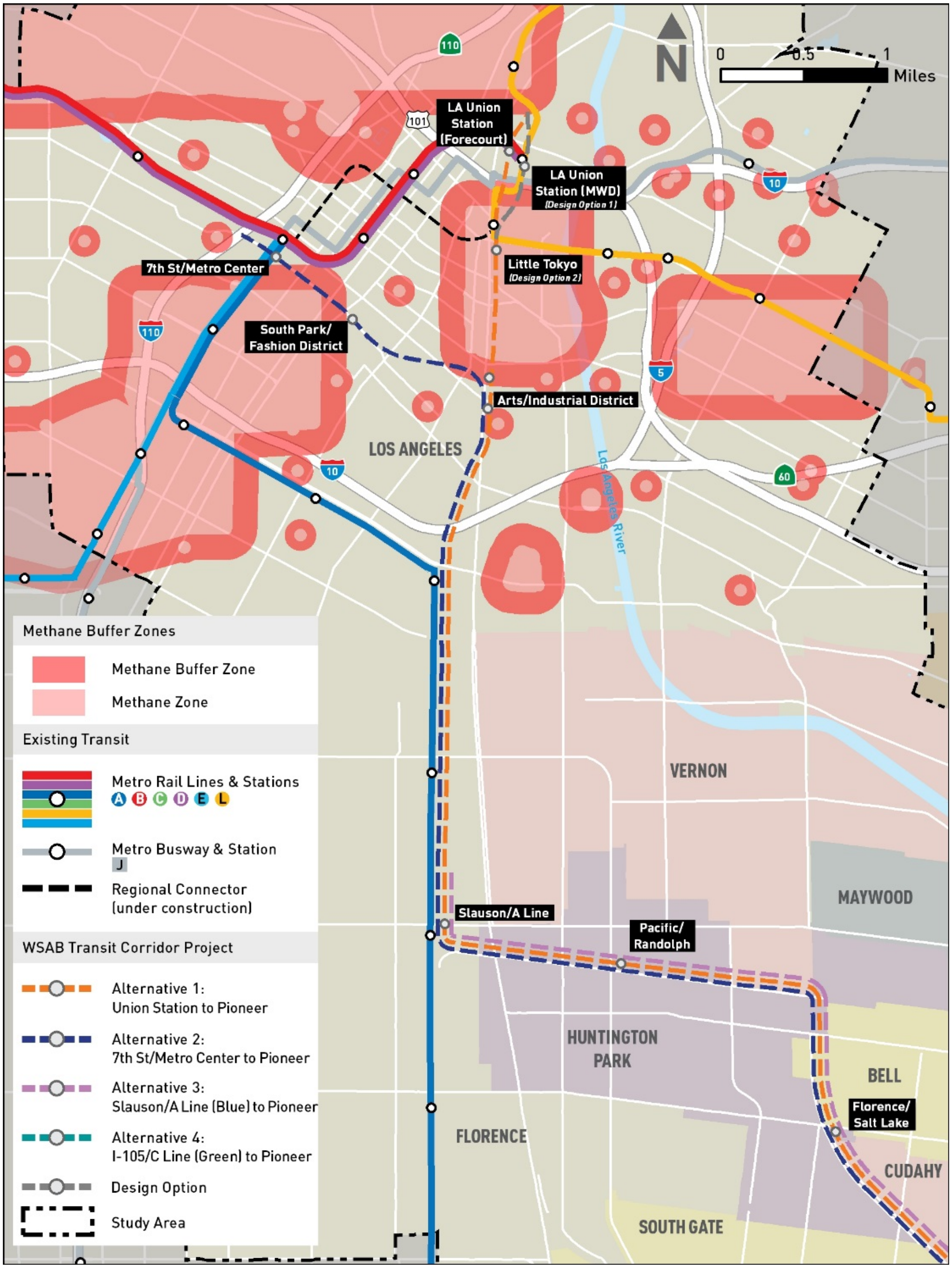
4.7.4 Regional Subsidence

Regional subsidence results from the withdrawal of groundwater and/or hydrocarbons from the subsurface. As the groundwater or hydrocarbons are pumped out of the ground, the resultant voids or pores are compressed under the pressures of the soils above. Accumulation of the compression results in subsidence of the ground surface. The California Department of Water Resources (2014) estimated the potential for future land subsidence within the Affected Area to be low because groundwater withdrawal is restricted and managed, and, where performed, is compensated for by reinjection of water in volumes similar to what is withdrawn. Regional subsidence is not considered to be a significant hazard to the Project.

4.7.5 Naturally Occurring Subsurface Gas

Naturally occurring oil and gas are present in the Affected Area, as shown on Figure 4-5. As detailed in the Final Hazardous Materials Impact Analysis Report (Metro 2021b), portions of the Alternative 1 alignment (including Design Option 1 [MWD], and Design Option 2) and Alternative 2 alignment are located upon the Union Station Oil Field (abandoned) and Los Angeles City Oil Field. In addition, and as detailed in the Final Hazardous Materials Impact Analysis Report, oil and gas wells exist in the Affected Area of Alternatives 1, 2, and 3. Oil and gas wells have not been identified in Alternative 4 or in the Affected Areas of the Paramount and Bellflower MSF site options.

Figure 4-5. Methane and Methane Buffer Zones Map



Source: Prepared by Jacobs in 2020 (based on information from City of Los Angeles 2004)

Methane is a naturally occurring gas associated with the decomposition of organic materials. Methane gas is common in oil and gas fields and often occurs with hydrogen sulfide gas (H_2S). H_2S is produced by anaerobic decomposition of any type of organic or inorganic mater that contains sulfur. Methane and H_2S are considered hazardous gases due to their explosive properties. H_2S is also highly toxic when inhaled and typically has a strong rotten-egg-like odor at lower, non-toxic levels. Methane and H_2S can be present in soil and/or groundwater. These gases can seep into tunnels and other excavations through soil and also through discontinuities (fractures, faults, etc.) in bedrock.

The City of Los Angeles Department of Public Works Bureau of Engineering has mapped potential methane zones and methane buffer zones, and most recently updated its map in 2004. As shown on Figure 4-5, portions of the Alternative 1 and 2 (including Design Options 1 and 2) Affected Areas are located within a methane zone or methane buffer zone designated by the City of Los Angeles (2004). These methane zones and methane buffer zones have been established where there is a potential for naturally occurring methane to create a hazard to life and property.

Methane gas is explosive when its concentration is between 5 and 15 percent at atmospheric oxygen levels, but it is not toxic. Five percent and 15 percent are the lower and upper explosive limits, respectively. At higher percentages in air, it can be an asphyxiant because it displaces oxygen. Under normal atmospheric conditions, the oxygen content in air is approximately 21 percent by volume. If the oxygen content is reduced below 19.5 percent by volume by displacement due to other gases, the air is oxygen-deficient in accordance with federal Occupational Safety and Health Administration guidelines. Methane (density ~0.72 grams per liter at atmospheric pressure) is lighter than air and it tends to rise through the ground and dissipate. Methane is moderately soluble in water. A total weighted average exposure of 1,000 parts per million (ppm) (0.1 percent) is included in the American Conference of Governmental Industrial Hygienists' (ACGIH) (ACGIH 2000b) recommended practices. Peak values are allowed to be higher than 1,000 ppm, but a weighted average exposure of 1,000 ppm is used in order to prevent adverse health hazards for prolonged exposure.

The following paragraph is from the geotechnical baseline report prepared for the Regional Connector (Metro 2013); similar conditions can be expected within the Affected Area of Alternatives 1 and 2, including Design Options 1 and 2:

> Methane and hydrogen sulfide gases are anticipated to be encountered during the tunnel drive and the open cut excavations. These gases are expected to exist and seep through pore spaces and discontinuities, and would be generated from off-gassing of groundwater that flows into the excavation. Also, the excavated material exposed to the underground environment will emit these gases during handling and hauling. The concentration, pressure, and volume of these gases are expected to be sufficiently low that the inflow and off-gassing of these gases can be mitigated within the open cut, crossover cavern, cross-passage, and bored tunnel excavations through adequate ventilation, proper shotcrete application, and pressurized-face TBM [tunnel boring machine] tunneling with a precast concrete segmental tunnel lining as described in the Project Requirements. The underground work has been classified as "potentially gassy" by the State of California, Department of Industrial Relations, Division of Occupational Safety and Health Administration (Cal/OSHA).

H_2S and petroliferous odors were reported during the geotechnical investigation for the Metro L (Gold) Line LRT bridge over US-101 (Metro 2002). Methane concentration levels detected along the Union Station to Civic Center portion of the Metro B (Red) Line alignment were less than 5 percent by volume (Metro 2011). Methane concentration levels detected along the Fifth/Hill to Metro Center portion of the Metro B (Red) Line alignment were over 50 percent by volume (Metro 2011).

H_2S is potentially explosive at concentrations between 4 and 46 percent, and it is highly corrosive. H_2S (density ~1.54 grams per liter at atmospheric pressure) is heavier than air. As such, at very high concentrations H_2S can accumulate within depressions or just above the groundwater table in the subsurface. It is highly soluble in water. According to the ACGIH (2001a), H_2S has an exposure limit or threshold limit value (TLV)/time-weighted average of 10 ppm for continuous exposure and 15 ppm for TLV/short-term exposure limit. This TLV is the concentration to which it is believed that workers can be exposed continuously for a short period of time without suffering from irritation, chronic or irreversible tissue damage, or narcosis of sufficient degree to increase the likelihood of accidental injury, impaired self-rescue ability, or materially reduced work efficiency, provided that the daily exposure limit is not exceeded. A short-term exposure limit is defined as a 15-minute total weighted average exposure that should not be exceeded at any time during a workday. Cal/OSHA also sets these as the exposure limits. H_2S is perceptible to most people at concentrations at or below approximately 1 ppm.

Radon gas is produced by the decay of uranium, which may be naturally present at varying levels in soil and rock. Once present, the gas moves through the ground and may enter structures through utility corridors, openings or cracks in foundations, and construction joints. Because radon gas is very dense, it may accumulate in basements or crawl spaces. Radon exposure has been linked to lung cancer. The U.S. Environmental Protection Agency (EPA) action level for radon is above 4.0 picocuries per liter of air (pCi/l). EPA has mapped Los Angeles County as a Zone 2 radon area, which is defined as an area with a general indoor radon potential of between 2.0 and 4.0 pCi/l (EPA 2019), thus, radon is not anticipated to be present at harmful concentrations in the Affected Area.

4.8 Mineral Resources

The Affected Area is situated atop alluvial soils, some of which could likely be used as construction aggregate. However, considering the highly urbanized nature of the Affected Area, mining of these materials is not economically viable, and therefore there would be no loss of viable mineral resources.

5 ENVIRONMENTAL IMPACTS/ENVIRONMENTAL CONSEQUENCES

This section presents the environmental impacts and consequences of the Project as they relate to geology, soils, and seismicity. The following comparative discussion is based on the existing conditions described in Section 4.

5.1 No Build Alternative Impacts

Under the No Build Alternative, no new transportation-related infrastructure would be constructed in the Affected Area except those projects identified in Metro's 2009 LRTP and SCAG's 2016 RTP/SCS, as well as additional projects funded by Measure M. These projects would be designed and operated to established standards, and adherence to those criteria and standards would minimize geologic and geotechnical related impacts and avoid adverse effects.

5.2 Build Alternatives Common Impacts

The following subsection presents the environmental impacts and consequences that are common amongst Alternatives 1, 2, 3 and 4. Section 5.3 presents the environmental impacts and consequences that are alternative-specific. Development of Alternative 1, 2, 3, or 4 could expose people and structures to the geologic hazards discussed below.

5.2.1 Seismic Shaking and Fault-Induced Ground Rupture

As discussed in Section 4.6, no known active faults capable of ground rupture are mapped within the Affected Area, and the Build Alternative alignments are not located in an Alquist-Priolo Earthquake Fault Zone, in accordance with Division of Mines and Geology Special Publication 42 (CGS 2016a through 2016e). The closest active faults capable of ground rupture near the Affected Area are the Raymond Fault, approximately 4.5 miles north of the Affected Area, and the Hollywood Fault, approximately 4.7 miles north of the Affected Area. Considering that no known active faults capable of ground rupture are mapped in the Affected Area, there is no potential for ground rupture due to known active faulting for the Build Alternatives. However, there is potential for co-seismic deformation (gentle folding of the ground surface) to occur in the Affected Area of Alternatives 1 and 2, related to the Coyote Pass escarpment of the UEPBT. The impacts of co-seismic deformation are discussed in Section 5.3.1.

Because the Affected Area is within the seismically active region of Southern California, operations of the Build Alternatives would potentially subject people and structures to moderate to strong seismic ground shaking, which could result in human injury or death, or damage to structures.

Project Measure GEO PM-1 (Geotechnical Design [Operation]) (see Section 8.1.1) would include development of site-specific design parameters to account for the anticipated level of seismic ground shaking. The intensity of ground shaking at a given location depends primarily upon the earthquake magnitude, the distance from the source, and the site response characteristics. As indicated in Section 4.6.4, the conceptual PGA varies along the Affected Area, ranging from 0.94g near the northern end (near US 101) to 0.72g near the southern end (near Pioneer Station) for the MDE. As discussed below, the estimated levels of ground shaking are integral parameters considered during the geotechnical and structural designs of the Project.

The Build Alternatives would be designed in accordance with the MRDC (or equivalent) design standards discussed in Section 3.3.1 of this report. Structures included in the Project would be designed to perform in accordance with the MDE and ODE thresholds indicated in Section 3.3.1. As also described in Section 3.3.1, the design criteria (MRDC, Caltrans *Seismic Design Criteria*, LA County Building Code/CBC, or equivalents) dictate the ARP that would be used in the design. Above-grade, at-grade, and below-grade structures would be designed and would perform in accordance with the thresholds indicated in Section 3.3.1 for seismicity. Under NEPA, impacts to all the Build Alternatives would be minimized, adverse effects would be avoided, and no mitigation measures would be required.

5.2.2 Liquefaction/Seismically Induced Settlement

As discussed in Section 4.6.5.1 and shown on Figure 4-4, the Alternative 1, 2, and 3 alignments from the Huntington Park area south and all of the Alternative 4 alignment are located in a Liquefaction Zone of Required Investigation (CGS 2016a through 2016e). In addition, the Alternative 1 alignment, generally north of the Little Tokyo area, is also located within a Zone of Required Investigation for liquefaction hazards. This means that the areas have historically experienced liquefaction, and/or conditions are favorable to liquefaction. In addition, the alluvial soils located above the groundwater table within the Affected Area of Alternatives 1, 2, 3, and 4 are susceptible to seismically-induced settlement. As such, operation of the Build Alternatives would potentially subject people and structures to the effects of liquefaction or seismically induced settlement, which could result in human injury or death, or damage to structures.

Project Measure GEO PM-1 (Geotechnical Design [Operation]) requires that the Build Alternatives would be designed in accordance with design standards, including standards specific to liquefaction and seismic settlement, such as the MRDC Section 5, Structural; Metro's Supplemental Seismic Design Criteria (2017); and the California Seismic Hazards Mapping Act. These design standards (included in Project Measure GEO PM-1) dictate that during final design, a geotechnical investigation be conducted for the selected Build Alternative, including detailed evaluation of these hazards. The investigation would be part of Metro's comprehensive geologic/geotechnical field investigation program that is being currently developed (Metro 2020a) and would include a detailed evaluation of these hazards. The design-level geotechnical investigations would provide information pertaining to the depths and areal extents of liquefaction and an estimate of the anticipated ground deformation associated with liquefaction, lateral spread, and seismically induced settlement.

Structures included with the Project would be designed to perform in accordance with the MDE and ODE thresholds indicated in Section 3.3.1. During the design process, if it is determined that these hazards could result in an unacceptable soil or structural response (to be defined during final design and dependent on the type of structure), ground improvements such as dynamic compaction, stone columns, jet grouting, and cement deep soil mixing and compaction grouting would be implemented consistent with the design standards provided in Section 3.3.1. The required consistency with these design standards would reduce the potential deformation to acceptable levels. In lieu of ground improvements, structures and foundations would be designed to tolerate the estimated amount of displacements.

Project design plans would incorporate the design requirements mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]) and described in Section 3.3.1. Under NEPA, by implementing these mandatory design requirements, impacts to all the Build Alternatives would be minimized, adverse effects would be avoided, and no mitigation measures would be required.

5.2.3 Seismically Induced Inundation

Seismically induced inundation can occur when an earthquake causes catastrophic failure of a water-retaining structure such as a reservoir, dam, or levee, and subsequent flooding occurs due to the release of water from the structure. Based on review of State inundation maps, floodwaters resulting from dam inundation are not expected to impact tunnel portals or underground stations included with Build Alternatives 1 and 2. The proposed portals and underground stations are outside of the dam inundation areas identified by the California Dam Breach Inundation Maps produced by the California Department of Water Resources (2019). All of the Build Alternatives' portals and underground stations are within the City of Los Angeles. According to the 2017 *City of Los Angeles Local Hazard Mitigation Plan*, probability of dam failure is low in today's regulatory environment (City of Los Angeles 2017). For the at-grade elements included in Alternatives 1, 2, 3, and 4, if seismically induced inundation occurred, the inundation would be short-lived and the water drained by the current and future WSAB drainage improvements. For any of the Build Alternatives, modifications to local storm drain systems would be required to discharge runoff from the project alignment. New drainage pipes under at-grade track would collect stormwater to earthen or concrete drainage swales running parallel to the track, which would discharge to the existing local stormwater infrastructure. Drainage systems within the portions of elevated track and near tunnel portals would similarly collect and discharge stormwater. Therefore, under NEPA, impacts to all the Build Alternatives would be minimized, adverse effects would be avoided, and mitigation would not be required.

5.2.4 Expansive Soils

As discussed in Section 4.7.2, clay-rich soils may exist locally within alluvial soils present in the Affected Area that could swell and shrink with wetting and drying. In addition, bedrock units also can exhibit expansive properties because of the clay content within the bedrock; this includes the Fernando Formation bedrock present within the shallow subsurface in the downtown Los Angeles area. The placement of structures on expansive soil could result in structural distress.

As such, operation of the above-grade and at-grade structures associated with the Build Alternatives would potentially subject people and structures to the effects of expansive soils, which could result in damage to structures.

As part of Project Measure GEO PM-1 (Geotechnical Design [Operation}), the Build Alternatives would be designed and constructed in accordance with the recommendations to be included in the detailed geotechnical final design reports. Expansive soil remediation could include soil removal and replacement, chemical treatment, or structural enhancements. Therefore, under NEPA, impacts to all the Build Alternatives related to expansive soils would be minimized, adverse effects would be avoided, and no mitigation measures would be required.

5.2.5 Ground Settlement and Collapsible soils

As discussed in Section 4.7.3, the alluvial soils along the Build Alternatives Corridor may be prone to collapse/settlement, which can result in differential movement beneath foundations, potentially causing distress to above- and at-grade structures. As such, operation of the above- and at-grade structures associated with the Build Alternatives would potentially subject people and structures to the effects of ground settlement, which could result in damage to structures.

Detrimental ground settlement from new structures or earth loads is typically alleviated by removal and replacement of the settlement-prone or collapse-prone soils. Also, implementation of ground improvement methods (similar to those indicated for liquefaction) and structural support systems would minimize the potential for impacts related to collapse or settlement.

Additionally, and as part of Project Measure GEO PM-1 (Geotechnical Design [Operation]), the Build Alternatives would be designed in accordance with the recommendations to be included in the detailed geotechnical advance design reports. Recommendations specific to detrimental ground settlement from new structures or earth loads would be provided, based on site-specific geotechnical investigations. Therefore, under NEPA, potential impacts to all the Build Alternatives related to settlement-prone/collapse-prone soils would be minimized, adverse effects would be avoided, and no mitigation measures would be required.

5.2.6 Naturally Occurring Oil and Gas

Foundation excavations for viaducts or other support structures may encounter hazardous gases resulting in a construction hazard. Viaducts and other support structures would be included as part of Alternatives 1, 2, 3, or 4. Subterranean structures are not included as part of Alternatives 3 and 4, and there are no oil or gas fields in their respective Affected Areas for geotechnical, subsurface, and seismic resources. Therefore, under NEPA, naturally occurring oil and gas hazards are not anticipated to be a concern during operation of Alternatives 3 and 4 or the at- or above-grade portions of Alternatives 1 and 2; therefore, there would be no adverse effects, and mitigation would not be required.

See Section 5.3.2 regarding the naturally occurring oil and gas hazard as applicable to the operation of underground portions of Alternatives 1 and 2.

5.3 Build Alternative Specific Impacts

The following subsections present the environmental impacts and consequences that are not common to all of the Build Alternatives. Section 5.2 presents the environmental impacts and consequences that are common to all Build Alternatives.

5.3.1 Co-Seismic Deformation

As discussed in Section 4.6.3, the Coyote Pass escarpment transects the downtown Los Angeles area (including the Alternative 1 and 2 alignments) in the subsurface. The Coyote Pass escarpment is a feature created by co-seismic deformation related to movement of the UEPBT. This deformation (gentle folding) could result in damage to aerial structures, tunnels, subterranean stations, and/or the at-grade stations included as part of Alternatives 1 and 2. The Coyote Pass escarpment trends roughly east-west and transects the alignments of Design Options 1 and 2 of Alternative 1, and the northwestern portion of Alternative 2. The Coyote Pass escarpment does not cross the Alternatives 3 or 4 alignments.

The generalized location of the Coyote Pass escarpment is shown on Figure 4-3. Based on the available data, the Coyote Pass escarpment (see Section 4.6.3) likely crosses North Alameda Street between Temple Street on the north and 4th Street on the south. The location of the escarpment in the Affected Area was projected from this area at North Alameda Street to the west, where topographic expression of the feature is evident near SR-110. Based on this projection, the Coyote Pass escarpment continues westerly from North Alameda Street to an approximate location between 4th Street (on the north) and 9th Street (on the south) along Flower Street.

Operation of the stations, tunnels, and other design features associated with Alternatives 1 and 2 would potentially subject people and structures to the effects of co-seismic deformation, which could result in human injury or death, or damage to structures.

As part of Project Measure GEO PM-1 (Geotechnical Design [Operation]), the design of either Alternative 1 or 2 would consider the effects of the EPBT and associated uplift of the Coyote Pass escarpment, in general accordance with MRDC Section 5 Rev 12 (dated November 20, 2017), page 5A-35. The MRDC states that "for blind thrust faults in the vicinity of underground structures, it may be necessary to estimate surface uplift, as in the case of the Eastside Coyote Escarpment..." There is a potential for ground deformation due to folding of the Coyote Hills escarpment, which, if it extended beneath an underground station or tunnel, could have an impact on the stations structure or tunnel lining. Ground conditions would be verified during the final design phase, and the stations' structures and tunnel linings would be designed to accommodate the estimated deformation along the escarpment, where needed. The two-level seismic design approach, based on the MDE and ODE requirements of MRDC, would be used to estimate the amount of deformation to be assumed during final design. As described in Section 3.3.1, the design approach (MRDC, Caltrans *Seismic Design Criteria*, LA County Building Code/CBC, or equivalents) dictates the ARP that would be used in the design. The ARP is directly correlated to the amount of deformation to be assumed in the design of structures that cross the escarpment (the longer the return period, the greater the amount of deformation). Above-grade, at-grade, and below-grade structures would perform in accordance with the MDE and ODE thresholds indicated in Section 3.3.1.

As mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), Alternatives 1 and 2 would be designed, constructed, and operated according to the analysis described above and the design standards provided in Section 3.3.1. Therefore, under NEPA, the potential for co-seismic deformation impacts on Alternatives 1 and 2 would be minimized, consistent with established standards; therefore, no adverse effects would occur, and mitigation would not be required.

5.3.2 Naturally Occurring Oil and Gas

Naturally occurring oil and gas are present in the Affected Area of Alternatives 1 and 2 (including Design Options 1 and 2). As shown on Figure 4-5, portions of Alternatives 1 and 2 (including Design Options 1 and 2) are located within a methane zone or methane buffer zone. Alternatives 3 and 4 do not include tunnels or underground stations, and there are no oil or gas fields in their respective Affected Area. Therefore, naturally occurring oil and gas hazards are not anticipated to be a concern during operation of Alternatives 3 and 4.

Design and operation of the Build Alternatives would be in accordance with the design standards and recommendations, including MRDC - Section 2, *Environmental Considerations*, the City of Los Angeles Methane Seepage Regulations (City of Los Angeles Ordinance 175790) and the LA County Code. These regulations require ventilation and/or protection from oil and gas intrusion into a structure such as a tunnel or station (either above or below grade), during operation. Underground structures part of Alternatives 1 and 2 (including Design Options 1 and 2) may include sealing from gas intrusion, such as with special gas-resistant membranes and/or joint sealants, which would reduce potential leakages and be "self-healing" against small movements. Stations would also include gas monitoring and detection systems with alarms, as well as special ventilation equipment to dissipate gas.

Because the planned tunnels in Alternatives 1 and 2 would be ventilated spaces with vapor barriers preventing communication of gases between the interior and exterior of the tunnel, the presence of the tunnel would not influence the gases already present within the ground. Considering the above-described design enhancements, and given that the tunnel would be relatively small when compared with the underground gassy area, the tunnel's presence would not change long-term flow patterns of water and gas in the subsurface. The tunnels also would not provide new pathways for gas transmission because it would be constructed with grout along its length such that the space around the tunnel would be sealed by the grout. The final presence of the constructed tunnel would then have no impact on the long-term migration of gases to the ground surface during operation.

Accumulation of hazardous surface gases within tunnels or stations during operation would pose a risk of fire/explosion and a health risk from toxic gas exposure. Project Measure GEO PM-2 (Oil and Gas Zones [Operation]) would be implemented to identify, reduce, and minimize potential impacts to operators and the public during operation. However, given the broad spectrum of project design features included as part of Alternatives 1 and 2, under NEPA, the adverse effects would be minimized but would not be completely eliminated. Therefore, Mitigation Measures GEO-1 (Hazardous Gas [Operation]), GEO-2 (Structural Design), GEO-3 (Gas Monitoring [Operation]), and GEO-4 (Tunnel Advisory Panel) would be implemented to further reduce adverse effects during operation. With implementation of these measures for Alternatives 1 and 2, no adverse effects related to potential hazardous subsurface gases would occur during operation.

5.4 Design Options

Design Option 1 (MWD) would move the Alternative 1 terminus point behind the MWD building. Design Option 2 would add the Alternative 1 little Tokyo Station. The evaluation for the Alternative 1 design options considered seismic shaking and ground rupture, liquefaction/seismically induced settlement, seismically induced inundation, co-seismic deformation, expansive soils, ground settlement and collapsible soils, and naturally occurring oil and gas. The design options are substantially similar to Alternative 1 in regard to potential geotechnically related operational impacts and effect determinations. Therefore, the conclusions provided for Alternative 1 in Sections 5.2 and 5.3 are also applicable to the design options. Under NEPA, with implementation of the measures indicated in Sections 5.2 and 5.3, no adverse effects would occur during operation of either Design Option 1 or 2.

5.5 Maintenance and Storage Facilities

Two potential locations for an MSF have been identified: one in the City of Bellflower and one in the City of Paramount. Only one MSF would be constructed as part of the Project.

The evaluation for the two MSF sites considered seismic shaking and ground rupture, liquefaction/seismically induced settlement, seismically induced inundation, co-seismic deformation, expansive soils, ground settlement and collapsible soils, and naturally occurring oil and gas.

In addition to train storage tracks, the selected MSF would include a number of building structures. These design enhancements are similar to those discussed for the build alternatives. Like the Build Alternatives, the Paramount and Bellflower MSF site options would be subject to the prescribed standards, requirements, and guidance related to the design and construction of the proposed building structures, including the requirements of the CBC. The Paramount and Bellflower MSF site options and Alternative 4 have substantially similar geologic settings, potential geotechnical operational impacts, and effect determinations. The risks and effects related to seismic shaking and ground rupture, liquefaction/seismically induced settlement and inundation, expansive soils, ground settlement, and collapsible soils at the MSF sites would be substantially similar to those effects identified for Alternative 4 and discussed in Section 5.2.

As part of Project Measure GEO PM-1 (Geotechnical Design [Operation]), the Build Alternatives, including the Paramount and Bellflower MSF site options, would be designed in accordance with the recommendations to be included in the detailed geotechnical design report. Recommendations addressing seismic shaking and ground rupture, liquefaction/seismically induced settlement and inundation, expansive soils, ground settlement, and collapsible soils would be provided, based on site-specific geotechnical investigation. Therefore, under NEPA, the Paramount or Bellflower MSF site option impacts related to these hazards would be minimized, adverse effects would be avoided, and mitigation would not be required.

6 CEQA DETERMINATION

To satisfy CEQA requirements, geology and soils operational impacts have been analyzed in accordance with Appendix G of the CEQA Guidelines. The CEQA determination presented below are based on the existing conditions described in Section 4 of this report and the environmental impacts analysis presented in Section 5.

CEQA is only concerned with the effects of a project on the environment, not the effects of the environment on the project (California Building Industry Association v. Bay Area Air Quality Management District [2015] 62 Cal. 4th 369.) For informational purposes, however, the following analyzes the potential impacts of developing the Project within the seismically active region of Southern California. The following analysis also considers whether the Project might exacerbate geological, seismic, and related hazards (see State CEQA Guidelines, 14 CCR §15126.2(a)). The analysis is based on the questions presented in Appendix G of the State CEQA Guidelines.

The CEQA determinations for naturally occurring gases as they relate to the project Alternatives, including environmental and health impacts, are discussed in the Final Hazardous Materials Impact Analysis Report (Metro 20221b).

6.1 Would the project directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault?

6.1.1 No Project Alternative

Under the No Project Alternative, the Build Alternatives would not be constructed, and the Affected Area would remain unchanged. There would be no impact to the geology (including faulting) and soils in the Affected Area. Therefore, the operational-related impacts for the No Project Alternative would be less than significant, and no mitigation measures would be required.

6.1.1.1 Mitigation Measures

No mitigation measures required.

6.1.1.2 Impacts Remaining after Mitigation

No impact.

6.1.2 Alternative 1: Los Angeles Union Station to Pioneer Station and Alternative 2: 7th Street/Metro Center to Pioneer Station

Alternatives 1 and 2 could potentially experience impacts associated with a known earthquake fault. The Affected Area is not located within an Earthquake Fault Zone established by the State of California Alquist-Priolo Earthquake Fault Zoning Act (CGS Special Publication 42). However, Alternatives 1 and 2 could experience significant impacts associated with co-seismic deformation along the Coyote Pass escarpment.

As indicated in Section 5.3.1, and as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), the Project would be designed to accommodate the anticipated levels of ground deformation associated with a design seismic event, and structures would perform in accordance with the MRDC MDE and ODE thresholds discussed in Section 3.3.1. As such, operation of the Alternatives 1 and 2, would not result in potentially significant impacts, including the risk of loss, injury, or death, from rupture of a known earthquake fault. Therefore, impacts related to rupture along a known earthquake fault and co-seismic deformation would be less than significant with design and construction performed per applicable design criteria. No mitigation measures would be required.

6.1.2.1 Mitigation Measures

No mitigation measures required.

6.1.2.2 Impacts Remaining after Mitigation

No impact.

6.1.3 Alternative 3: Slauson/A (Blue) Line to Pioneer Station

Alternative 3 is not underlain by a known active fault capable of ground rupture and is not located within an Earthquake Fault Zone established by the State of California Alquist-Priolo Earthquake Fault Zoning Act (Division of Mines and Geology Special Publication 42). As such, operation of Alternative 3 would not result in potentially significant impacts, including the risk of loss, injury, or death, from ground rupture of a known earthquake fault. There would be no impacts related to ground rupture along a known active earthquake fault, and no mitigation measures would be required.

6.1.3.1 Mitigation Measures

No mitigation measures required.

6.1.3.2 Impacts Remaining after Mitigation

No impact.

6.1.4 Alternative 4: I-105/C (Green) Line to Pioneer Station

Alternative 4 is not underlain by a known active fault capable of ground rupture and is not located within an Earthquake Fault Zone established by the State of California Alquist-Priolo Earthquake Fault Zoning Act (Division of Mines and Geology Special Publication 42). As such, operation of Alternative 4 would not result in potentially significant impacts, including the risk of loss, injury, or death, from ground rupture of a known earthquake fault. There would be no impacts related to ground rupture along a known active earthquake fault, and no mitigation measures would be required.

6.1.4.1 Mitigation Measures

No mitigation measures required.

6.1.4.2 Impacts Remaining after Mitigation

No impact.

6.1.5 Design Option 1: Los Angeles Union Station at the Metropolitan Water District and Design Option 2: Add Little Tokyo Station

The Design Option 1 and 2 locations and proposed improvements are substantially similar, and the determination provided in Section 6.1.2 for Alternative 1 is applicable to either Design Option 1 or 2. Impacts related to rupture along a known earthquake fault and co-seismic deformation would be less than significant with design and construction performed per applicable design criteria. No mitigation measures would be required.

6.1.5.1 Mitigation Measures

No mitigation measures required.

6.1.5.2 Impacts Remaining after Mitigation

No impact.

6.1.6 Maintenance and Storage Facility

The Bellflower and Paramount MSF site option locations and proposed improvements are substantially similar, and the determination provided in Section 6.1.4 for Alternative 4 is applicable to either MSF site. There would be no impacts, and no mitigation measures would be required.

6.1.6.1 Mitigation Measures

No mitigation measures required.

6.1.6.2 Impacts Remaining after Mitigation

No impact.

6.2 Would the project directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving strong seismic ground shaking?

6.2.1 No Project Alternative

Under the No Project Alternative, the Build Alternatives would not be constructed, and the Affected Area would remain unchanged. There would be no impact related to strong seismic ground shaking in the Affected Area. Therefore, the operational-related impacts for the No Project Alternative would be less than significant, and no mitigation measures would be required.

6.2.1.1 Mitigation Measures

No mitigation measures required.

6.2.1.2 Impacts Remaining after Mitigation

No impact.

6.2.2 Alternative 1: Los Angeles Union Station to Pioneer Station and Alternative 2: 7th Street/Metro Center to Pioneer Station

As discussed in Section 5.2.1, Alternatives 1 and 2 could be exposed to strong seismic ground shaking. However, as discussed in Section 3.3.1, and as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), the Build Alternatives would be designed to accommodate the anticipated levels of ground shaking associated with a design seismic event, and structures would perform in accordance with the MRDC MDE and ODE thresholds discussed in Section 3.3.1.

The potential to experience substantial seismic ground shaking is a common hazard for every project in Southern California, and the hazard cannot be avoided. Structures (aerial, at-grade, and underground) have been and continue to be successfully designed and constructed based on mandatory design criteria. Experience in California and worldwide shows that bored tunnels generally perform well during earthquake ground shaking, typically suffering less damage than surface structures. Because 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 (Hashash et al. 2001). Considering the seismic design requirements mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), operation of Alternatives 1 and 2 would not result in substantial adverse effects, including the risk of loss, injury, or death, related to seismic shaking.

Operation of Alternatives 1 and 2 would not have an adverse effect on the geologic environment. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions related to seismic shaking. Therefore, impacts related to seismic shaking would be less than significant with design and construction performed in accordance with applicable design criteria.

6.2.2.1 Mitigation Measures

No mitigation measures required.

6.2.2.2 Impacts Remaining after Mitigation

No impact.

6.2.3 Alternative 3: Slauson/A (Blue) Line to Pioneer Station

As discussed in Section 5.2.1, Alternative 3 could be exposed to strong seismic ground shaking. However, as discussed in Section 3.3.1, and as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), the Build Alternatives would be designed to accommodate the anticipated levels of ground shaking associated with a design seismic event, and structures would perform in accordance with the MRDC MDE and ODE thresholds discussed in Section 3.3.1.

The potential to experience substantial seismic ground shaking is a common hazard for every project in Southern California, and the hazard cannot be avoided. Structures (aerial and at-grade) have been and continue to be successfully designed and constructed based on mandatory design criteria. Considering the mandatory design requirements associated with seismic shaking, operation of Alternative 3 would not result in substantial adverse effects, including the risk of loss, injury, or death, related to seismic shaking.

Operation of Alternative 3 would not have an adverse effect on the geologic environment. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions related to seismic shaking. Therefore, impacts related to seismic shaking would be less than significant with design and construction performed in accordance with applicable design criteria.

6.2.3.1 Mitigation Measures

No mitigation measures required.

6.2.3.2 Impacts Remaining after Mitigation

No impact.

6.2.4 Alternative 4: I-105/C (Green) Line to Pioneer Station

As discussed in Section 5.2.1, Alternative 4 could be exposed to strong seismic ground shaking. However, as discussed in Section 3.3.1, and as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), the Build Alternatives would be designed to accommodate the anticipated levels of ground shaking associated with a design seismic event, and structures would perform in accordance with the MRDC MDE and ODE thresholds discussed in Section 3.3.1.

The potential to experience substantial seismic ground shaking is a common hazard for every project in Southern California, and the hazard cannot be avoided. Structures (aerial and at-grade) have been and continue to be successfully designed and constructed based on mandatory design criteria. Considering the mandatory design requirements associated with seismic shaking, operation of Alternative 4 would not result in substantial adverse effects, including the risk of loss, injury, or death, related to seismic shaking. Operation of Alternative 4 would not have an adverse effect on the geologic environment. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions related to seismic shaking. Therefore, impacts related to seismic shaking would be less than significant with design and construction performed in accordance with applicable design criteria.

6.2.4.1 Mitigation Measures

No mitigation measures required.

6.2.4.2 Impacts Remaining after Mitigation

No impact.

6.2.5 Design Option 1: Los Angeles Union Station at the Metropolitan Water District and Design Option 2: Add Little Tokyo Station

The Design Option 1 and 2 locations and proposed improvements are substantially similar, and the determination provided in Section 6.2.2 for Alternative 1 is applicable to either Design Option 1 or 2. Impacts related to seismic shaking would be less than significant with design and construction performed per applicable design criteria as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), and no mitigation measures would be required.

6.2.5.1 Mitigation Measures

No mitigation measures required.

6.2.5.2 Impacts Remaining after Mitigation

No impact.

6.2.6 Maintenance and Storage Facility

The Bellflower and Paramount MSF site option locations and proposed improvements are substantially similar, and the determination provided in Section 6.2.4 for Alternative 4 is applicable to either MSF site. Impacts related to seismic shaking would be less than significant with design and construction performed per applicable design criteria as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), and no mitigation measures would be required.

6.2.6.1 Mitigation Measures

No mitigation measures required.

6.2.6.2 Impacts Remaining after Mitigation

No impact.

6.3 Would the project directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving Seismic-related ground failure, including liquefaction?

6.3.1 No Project Alternative

Under the No Project Alternative, the Build Alternatives would not be constructed, and the Affected Area would remain unchanged. There would be no impact to the geology and soils (including seismic-related ground failure and liquefaction potential) in the Affected Area. Therefore, the operational-related impacts for the No Project Alternative would be less than significant, and no mitigation measures would be required.

6.3.1.1 Mitigation Measures

No mitigation measures required.

6.3.1.2 Impacts Remaining after Mitigation

No impact.

6.3.2 Alternative 1: Los Angeles Union Station to Pioneer Station and Alternative 2: 7th Street/Metro Center to Pioneer Station

As discussed in Section 5.2.2, Alternatives 1 and 2 could be exposed to seismic-related ground failure, including liquefaction, lateral spreading, and seismically induced settlement. However, as discussed in Sections 3.3.1 and 5.2.2, and as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), the Build Alternatives would be designed to accommodate the anticipated levels of deformation associated with a design seismic event, and structures would perform in accordance with the MRDC MDE and ODE thresholds discussed in Section 3.3.1.

The seismic-related ground failure hazard is a well-known hazard in Southern California and structures (aerial, at-grade, and underground) have been and continue to be successfully designed and constructed based on the referenced mandatory design criteria. Where warranted by site-specific subsurface conditions identified during the final design stage, design enhancements (e.g., ground improvements or structural enhancements) can reduce potentially significant impacts to levels within the acceptable limits for the structure (to be determined during final design). Considering the seismic design requirements mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), operation of Alternatives 1 and 2 would not result in substantial adverse effects, including the risk of loss, injury, or death related to seismic-related ground failure, including liquefaction. Operation of Alternatives 1 and 2 would not have an adverse effect on the geologic environment. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions related to seismic-related ground failure. Therefore, impacts would be less than significant with design and construction performed in accordance with applicable design criteria.

6.3.2.1 Mitigation Measures

No mitigation measures required.

6.3.2.2 Impacts Remaining after Mitigation

No impact.

6.3.3 Alternative 3: Slauson/A (Blue) Line to Pioneer Station

As discussed in Section 5.2.2, Alternative 3 could be exposed to seismic-related ground failure, including liquefaction, lateral spreading, and seismically induced settlement. However, as discussed in Sections 3.3.1 and 5.2.2, and as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), the Build Alternatives would be designed to accommodate the anticipated levels of deformation associated with a design seismic event, and structures would perform in accordance with the MRDC MDE and ODE thresholds discussed in Section 3.3.1.

The seismic-related ground failure hazard is a well-known hazard in Southern California and structures (aerial and at-grade) have been and continue to be successfully designed and constructed based on the referenced mandatory design criteria. Where warranted by site-specific subsurface conditions identified during the final design stage, design enhancements (e.g., ground improvements or structural enhancements) can reduce potentially significant impacts to levels within the acceptable limits for the structure (to be determined during final design). Considering the mandatory design requirements associated with seismic-related ground failure, operation of Alternative 3 would not result in significant impacts, including the risk of loss, injury, or death, involving seismic-related ground failure, including liquefaction. Therefore, impacts related to seismic-related ground failure would be less than significant with design and future operation performed per applicable design criteria, and no mitigation measures would be required.

6.3.3.1 Mitigation Measures

No mitigation measures required.

6.3.3.2 Impacts Remaining after Mitigation

No impact.

6.3.4 Alternative 4: I-105/C (Green) Line to Pioneer Station

As discussed in Section 5.2.2, Alternative 4 could be exposed to seismic-related ground failure, including liquefaction, lateral spreading, and seismically induced settlement. However, as discussed in Sections 3.3.1 and 5.2.2, and as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), the Build Alternatives would be designed to accommodate the anticipated levels of deformation associated with a design seismic event, and structures would perform in accordance with the MRDC MDE and ODE thresholds discussed in Section 3.3.1.

The seismic-related ground failure hazard is a well-known hazard in Southern California and structures (aerial and at-grade) have been and continue to be successfully designed and constructed based on the referenced mandatory design criteria. Where warranted by site-specific subsurface conditions identified during the final design stage, design enhancements (e.g., ground improvements or structural enhancements) can reduce potentially significant impacts to levels within the acceptable limits for the structure (to be determined during final design). Considering the mandatory design requirements associated with seismic-related ground failure, operation of Alternative 4 would not result in significant impacts, including the risk of loss, injury, or death, involving seismic-related ground failure, including liquefaction. Therefore, impacts related to seismic-related ground failure would be less than significant with design and future operation performed per applicable design criteria, and no mitigation measures would be required.

6.3.4.1 Mitigation Measures

No mitigation measures required.

6.3.4.2 Impacts Remaining after Mitigation

No impact.

6.3.5 Design Option 1: Los Angeles Union Station at the Metropolitan Water District and Design Option 2: Add Little Tokyo Station

The Design Option 1 and 2 locations and proposed improvements are substantially similar and the determination provided in Section 6.3.2 for Alternative 1 is applicable to either Design Option 1 or 2. Impacts related to seismic-related ground failure would be less than significant with design and operation performed per applicable design criteria as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), and no mitigation measures would be required.

6.3.5.1 Mitigation Measures

No mitigation measures required.

6.3.5.2 Impacts Remaining after Mitigation

No impact.

6.3.6 Maintenance and Storage Facility

The Bellflower and Paramount MSF site option locations and proposed improvements are substantially similar, and the determination provided in Section 6.3.4 for Alternative 4 is applicable to either MSF site. Impacts related to seismic-related ground failure would be less than significant with design and operation performed per applicable design criteria as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), and no mitigation measures would be required.

6.3.6.1 Mitigation Measures

No mitigation measures required.

6.3.6.2 Impacts Remaining after Mitigation

No impact.

6.4 Would the project directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving landslides?

6.4.1 No Project Alternative

Under the No Project Alternative, the Build Alternatives would not be constructed, and the Affected Area would remain unchanged. There would be no impact to the geology (including landslides) and soils in the Affected Area. Therefore, the operational-related impacts for the No Project Alternative would be less than significant, and no mitigation measures would be required.

6.4.1.1 Mitigation Measures

No mitigation measures required.

6.4.1.2 Impacts Remaining after Mitigation

No impact.

6.4.2 Alternative 1: Los Angeles Union Station to Pioneer Station and Alternative 2: 7th Street/Metro Center to Pioneer Station

The landscape within the Affected Area of Alternatives 1 and 2 is relatively flat, and no landslides have been mapped in the vicinity of the Affected Area. Natural landslides are not considered a hazard to the Project; therefore, impacts would be less than significant, and no mitigation measures would be required. Temporary excavations, which could introduce the potential for construction-related landslides, are discussed in Section 7.

Operation of Alternatives 1 and 2 would not have a potentially significant impact on the geologic environment. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions. Therefore, impacts would be less than significant, and no mitigation measures are required.

6.4.2.1 Mitigation Measures

No mitigation measures required.

6.4.2.2 Impacts Remaining after Mitigation

No impact.

6.4.3 Alternative 3: Slauson/A (Blue) Line to Pioneer Station

The landscape within the Affected Area of Alternative 3 is relatively flat is relatively flat, and no landslides have been mapped in the vicinity of the Affected Area. Natural landslides are not considered a hazard to the Project; therefore, impacts would be less than significant, and no mitigation measures would be required. Temporary excavations, which could introduce the potential for construction-related landslides, are discussed in Section 7.

Operation of Alternative 3 would not have a potentially significant impact on the geologic environment. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions. Therefore, impacts would be less than significant, and no mitigation measures are required.

6.4.3.1 Mitigation Measures

No mitigation measures required.

6.4.3.2 Impacts Remaining after Mitigation

No impact.

6.4.4 Alternative 4: I-105/C (Green) Line to Pioneer Station

The landscape within the Affected Area of Alternative 4 is relatively flat is relatively flat, and no landslides have been mapped in the vicinity of the Affected Area. Natural landslides are not considered a hazard to the Project; therefore, impacts would be less than significant, and no mitigation measures would be required. Temporary excavations, which could introduce the potential for construction-related landslides, are discussed in Section 7.

Operation of Alternative 4 would not have a potentially significant impact on the geologic environment. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions. Therefore, impacts would be less than significant, and no mitigation measures are required.

6.4.4.1 Mitigation Measures

No mitigation measures required.

6.4.4.2 Impacts Remaining after Mitigation

No impact.

6.4.5 Design Option 1: Los Angeles Union Station at the Metropolitan Water District and Design Option 2: Add Little Tokyo Station

The Design Options 1 and 2 locations and proposed improvements are substantially similar, and the determination provided in Section 6.4.2 for Alternative 1 is applicable to either Design Option 1 or 2. Impacts related to landslides would be less than significant with design and operation performed per applicable design criteria as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), and no mitigation measures would be required.

6.4.5.1 Mitigation Measures

No mitigation measures required.

6.4.5.2 Impacts Remaining after Mitigation

No impact.

6.4.6 Maintenance and Storage Facility

The Bellflower and Paramount MSF site option locations and proposed improvements are substantially similar, and the determination provided in Section 6.4.4 for Alternative 4 is applicable to either MSF site. Impacts related to landslides would be less than significant with design and operation performed per applicable design criteria as mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), and no mitigation measures would be required.

6.4.6.1 Mitigation Measures

No mitigation measures required.

6.4.6.2 Impacts Remaining after Mitigation

No impact.

6.5 Would the project result in substantial soil erosion or the loss of topsoil?

6.5.1 No Project Alternative

Under the No Project Alternative, the Build Alternatives would not be constructed, and the Affected Area would remain unchanged. There would be no impact to the geology and soils (including loss and erosion) in the Affected Area. Therefore, the operational-related impacts for the No Project Alternative would be less than significant, and no mitigation measures would be required.

6.5.1.1 Mitigation Measures

No mitigation measures required.

6.5.1.2 Impacts Remaining after Mitigation

No impact.

6.5.2 Alternative 1: Los Angeles Union Station to Pioneer Station and Alternative 2: 7th Street/Metro Center to Pioneer Station

Alternatives 1 and 2 are located in an urban setting and the topsoil layer in most of the Affected Area has been disturbed or concealed by previous human activities. The potential impacts would involve the loss of topsoil as an agricultural resource and loss of an erosional barrier. Post-construction operation of the Project would not result in ground surface disturbance, site clearance, excavation, or grading that would otherwise create the potential for soil erosion to occur. Alternatives 1 and 2 would operate on designed and constructed facilities implemented in accordance with state and local guidelines regarding erosion. Additionally, a required Stormwater Pollution Prevention Plan and Water Quality Control Plan would be in place as part of operation, among other regulatory requirements, as detailed in the *West Santa Ana Branch Transit Corridor Project Final Water Resources Impact Analysis Report* (Metro 2021c).

The Affected Area is not used for agricultural purposes and the topsoil layer has already been disturbed or concealed by previous human activities. Considering the design requirements associated with erosion and mandatory best management practices detailed in the Final Water Resources Impact Analysis Report, operation of Alternatives 1 and 2 would not result in substantial soil erosion or loss of topsoil. Therefore, impacts would be less than significant with design and construction performed per applicable design criteria, and no mitigation measures would be required.

6.5.2.1 Mitigation Measures

No mitigation measures required.

6.5.2.2 Impacts Remaining after Mitigation

No impact.

6.5.3 Alternative 3: Slauson/A (Blue) Line to Pioneer Station

Alternative 3 is located in an urban setting and the topsoil layer in most of the Affected Area has been disturbed or concealed by previous human activities. The potential impacts would involve the loss of topsoil as an agricultural resource and loss of an erosional barrier. Post-construction operation of the Project would not result in ground surface disturbance, site clearance, excavation, or grading that would otherwise create the potential for soil erosion to occur. Alternative 3 would operate on designed and constructed facilities implemented in accordance with state and local guidelines regarding erosion. Additionally, a required Stormwater Pollution Prevention Plan and Water Quality Control Plan would be in place as part of operation, among other regulatory requirements, as detailed in the Final Water Resources Impact Analysis Report (Metro 2021c).

The Affected Area is not used for agricultural purposes and the topsoil layer has already been disturbed or concealed by previous human activities. Considering the design requirements associated with erosion and mandatory best management practices detailed in the Final Water Resources Impact Analysis Report, operation of Alternative 3 would not result in substantial soil erosion or loss of topsoil. Therefore, impacts would be less than significant with design and construction performed per applicable design criteria, and no mitigation measures would be required.

6.5.3.1 Mitigation Measures

No mitigation measures required.

6.5.3.2 Impacts Remaining after Mitigation

No impact.

6.5.4 Alternative 4: I-105/C (Green) Line to Pioneer Station

Alternative 4 is located in an urban setting, and the topsoil layer in most of the Affected Area has been disturbed or concealed by previous human activities. The potential impacts would involve the loss of topsoil as an agricultural resource and loss of an erosional barrier. Post-construction operation of the Project would not result in ground surface disturbance, site clearance, excavation, or grading that would otherwise create the potential for soil erosion to occur. Alternative 4 would operate on designed and constructed facilities implemented in accordance with state and local guidelines regarding erosion. Additionally, a required

Stormwater Pollution Prevention Plan and Water Quality Control Plan would be in place as part of operation, among other regulatory requirements, as detailed in the Final Water Resources Impact Analysis Report (Metro 2021c).

The Affected Area is not used for agricultural purposes and the topsoil layer has already been disturbed or concealed by previous human activities. Considering the design requirements associated with erosion and mandatory best management practices detailed in the Final Water Resources Impact Analysis Report, operation of Alternative 4 would not result in substantial soil erosion or loss of topsoil. Therefore, impacts would be less than significant with design and construction performed per applicable design criteria, and no mitigation measures would be required.

6.5.4.1 Mitigation Measures

No mitigation measures required.

6.5.4.2 Impacts Remaining after Mitigation

No impact.

6.5.5 Design Option 1: Los Angeles Union Station at the Metropolitan Water District and Design Option 2: Add Little Tokyo Station

The Design Option 1 and 2 locations and proposed improvements are substantially similar and the determination provided in Section 6.5.2 for Alternative 1 is applicable to Design Options 1 and 2. Design Options 1 and 2 would not result in substantial soil erosion or loss of topsoil and impacts would be less than significant with design and operation performed per applicable design criteria, no mitigation measures would be required.

6.5.5.1 Mitigation Measures

No mitigation measures required.

6.5.5.2 Impacts Remaining after Mitigation

No impact.

6.5.6 Maintenance and Storage Facility

The Bellflower and Paramount MSF site option locations and proposed improvements are substantially similar, and the determination provided in Section 6.5.4 for Alternative 4 is applicable to either MSF site. Impacts related to substantial soil erosion or loss of topsoil would be less than significant with design and operation performed per applicable design criteria, and no mitigation measures would be required.

6.5.6.1 Mitigation Measures

No mitigation measures required.

6.5.6.2 Impacts Remaining after Mitigation

No impact.

6.6 Would the project 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?

6.6.1 No Project Alternative

Under the No Project Alternative, the Build Alternatives would not be constructed, and the Affected Area would remain unchanged. There would be no impact to the geology and soils that would affect the potential for these hazards in the Affected Area. Therefore, the operational-related impacts for the No Project Alternative would be less than significant, and no mitigation measures would be required.

6.6.1.1 Mitigation Measures

No mitigation measures required.

6.6.1.2 Impacts Remaining after Mitigation

No impact.

6.6.2 Alternative 1: Los Angeles Union Station to Pioneer Station and Alternative 2: 7th Street/Metro Center to Pioneer Station

Operational analysis and impact determinations for Alternatives 1 and 2 related to liquefaction, lateral spreading, and landslides are provided above. See Section 6.3 regarding the CEQA determination for ground failure (including liquefaction and lateral spreading), and Section 6.4 for the landslide hazard determination.

The Affected Area of Alternatives 1 and 2 may be prone to collapse or settlement, which can result in differential movement beneath foundations potentially causing distress to above-grade and at-grade structures. As such, operation of the above- and at-grade structures associated with Alternatives 1 and 2 would potentially subject people and structures to the effects of ground settlement, which could result in damage to structures.

Detrimental ground settlement from new structures or earth loads is typically alleviated by removal and replacement of the settlement/collapse-prone soils. Also, implementation of ground improvement methods (similar to those indicated for liquefaction) and structural support systems would minimize the potential for impacts related to collapse or settlement. As part of Project Measure GEO PM-1 (Geotechnical Design [Operation]), Alternatives 1 and 2 would be designed in accordance with the mandatory design requirements of the MRDC or equivalent, including design criteria identified in the design reports from site-specific geotechnical investigations. The recommendations that would be provided with those requirements and considered in the final design stage of the Project would specifically address detrimental ground settlement from new structures or earth loads. Based on the analysis presented above, operation of Alternatives 1 and 2 would not result in potentially significant impacts related to the risk of settlement or collapsible soil. Therefore, impacts related to settlement or collapsible soil would be less than significant with design and construction performed per applicable design criteria, and no mitigation measures would be required.

Regional subsidence results from the withdrawal of groundwater and/or hydrocarbons from the subsurface. The California Department of Water Resources (2014) estimated the potential for future land subsidence within the Affected Area to be low because groundwater withdrawal is restricted and managed, and, where performed, it is compensated for by reinjection of water in volumes similar to what is withdrawn. Potential impacts related to regional subsidence would be a less-than-significant hazard to the Project, and no mitigation measures would be required.

Considering the design requirements in place for the subject hazards, operation of Alternatives 1 and 2 would not have an adverse effect on the geologic environment. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions.

6.6.2.1 Mitigation Measures

No mitigation measures required.

6.6.2.2 Impacts Remaining after Mitigation

No impact.

6.6.3 Alternative 2: 7th Street/Metro Center to Pioneer Station

Operational analysis and impact determinations for Alternative 2 related to liquefaction, lateral spreading, and landslides are provided above. See Section 6.3 regarding the CEQA determination for ground failure (including liquefaction and lateral spreading), and Section 6.4 for the landslide hazard determination.

The Affected Area of Alternative 2 may be prone to collapse or settlement, which can result in differential movement beneath foundations potentially causing distress to above-grade and at-grade structures. As such, operation of the above- and at-grade structures associated with Alternative 2 would potentially subject people and structures to the effects of ground settlement, which could result in damage to structures.

Detrimental ground settlement from new structures or earth loads is typically alleviated by removal and replacement of the settlement/collapse-prone soils. Also, implementation of ground improvement methods (similar to those indicated for liquefaction) and structural support systems would minimize the potential for impacts related to collapse or settlement. As part of Project Measure GEO PM-1 (Geotechnical Design [Operation]), Alternative 2 would be designed in accordance with the mandatory design requirements of the MRDC or equivalent, including design criteria identified in the design reports from site-specific geotechnical investigations. The recommendations that would be provided with those requirements and considered in the final design stage of the Project would specifically address detrimental ground settlement from new structures or earth loads. Based on the analysis presented above, operation of Alternative 2 would not result in potentially significant impacts related to the risk of settlement or collapsible soil. Therefore, impacts related to settlement or collapsible soil would be less than significant with design and construction performed per applicable design criteria, and no mitigation measures would be required.

Regional subsidence results from the withdrawal of groundwater and/or hydrocarbons from the subsurface. The California Department of Water Resources (2014) estimated the potential for future land subsidence within the Affected Area to be low because groundwater withdrawal is restricted and managed, and, where performed, it is compensated for by reinjection of water in volumes similar to what is withdrawn. Potential impacts related to regional subsidence would be a less-than-significant hazard to the Project, and no mitigation measures would be required.

Considering the mandatory design requirements in place for the subject hazards, operation of Alternative 2 would not have an adverse effect on the geologic environment. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions.

6.6.3.1 Mitigation Measures

No mitigation measures required.

6.6.3.2 Impacts Remaining after Mitigation

No impact.

6.6.4 Alternative 3: Slauson/A (Blue) Line to Pioneer Station

Operational analysis and impact determinations for Alternative 3 related to liquefaction, lateral spreading, and landslides are provided above. See Section 6.3 regarding the CEQA determination for ground failure (including liquefaction and lateral spreading), and Section 6.4 for the landslide hazard determination.

The Affected Area of Alternative 3 may be prone to collapse or settlement, which can result in differential movement beneath foundations potentially causing distress to above-grade and at-grade structures. As such, operation of the above- and at-grade structures associated with Alternative 3 would potentially subject people and structures to the effects of ground settlement, which could result in damage to structures.

Detrimental ground settlement from new structures or earth loads is typically alleviated by removal and replacement of the settlement/collapse-prone soils. Also, implementation of ground improvement methods (similar to those indicated for liquefaction) and structural support systems would minimize the potential for impacts related to collapse or settlement. As part of Project Measure GEO PM-1 (Geotechnical Design [Operation]), Alternative 3 would be designed in accordance with the mandatory design requirements of the MRDC or equivalent, including design criteria identified in the design reports from site-specific geotechnical investigations. The recommendations that would be provided with those requirements and considered in the final design stage of the Project would specifically address detrimental ground settlement from new structures or earth loads. Based on the analysis presented above, operation of Alternative 3 would not result in potentially significant impacts related to the risk of settlement or collapsible soil. Therefore, impacts related to settlement or collapsible soil would be less than significant with design and construction performed per applicable design criteria, and no mitigation measures would be required.

Regional subsidence results from the withdrawal of groundwater and/or hydrocarbons from the subsurface. The California Department of Water Resources (2014) estimated the potential for future land subsidence within the Affected Area to be low because groundwater withdrawal is restricted and managed, and, where performed, it is compensated for by reinjection of water in volumes similar to what is withdrawn. Potential impacts related to regional subsidence would be a less-than-significant hazard to the Project, and no mitigation measures would be required.

Considering the mandatory design requirements in place for the subject hazards, operation of Alternative 3 would not have an adverse effect on the geologic environment. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions.

6.6.4.1 Mitigation Measures

No mitigation measures required.

6.6.4.2 Impacts Remaining after Mitigation

No impact.

6.6.5 Alternative 4: I-105/C (Green) Line to Pioneer Station

Operational analysis and impact determinations for Alternative 4 related to liquefaction, lateral spreading, and landslides are provided above. See Section 6.3 regarding the CEQA determination for ground failure (including liquefaction and lateral spreading), and Section 6.4 for the landslide hazard determination.

The Affected Area of Alternative 4 may be prone to collapse or settlement, which can result in differential movement beneath foundations potentially causing distress to above-grade and at-grade structures. As such, operation of the above- and at-grade structures associated with Alternative 4 would potentially subject people and structures to the effects of ground settlement, which could result in damage to structures.

Detrimental ground settlement from new structures or earth loads is typically alleviated by removal and replacement of the settlement/collapse-prone soils. Also, implementation of ground improvement methods (similar to those indicated for liquefaction) and structural support systems would minimize the potential for impacts related to collapse or settlement. As part of Project Measure GEO PM-1 (Geotechnical Design [Operation]), Alternative 4 would be designed in accordance with the mandatory design requirements of the MRDC or equivalent, including design criteria identified in the design reports from site-specific geotechnical investigations. The recommendations that would be provided with those requirements and considered in the final design stage of the Project would specifically address detrimental ground settlement from new structures or earth loads. Based on the analysis presented above, operation of Alternative 4 would not result in potentially significant impacts related to the risk of settlement or collapsible soil. Therefore, impacts related to settlement or collapsible soil would be less than significant with design and construction performed per applicable design criteria, and no mitigation measures would be required.

Regional subsidence results from the withdrawal of groundwater and/or hydrocarbons from the subsurface. The California Department of Water Resources (2014) estimated the potential for future land subsidence within the Affected Area to be low because groundwater withdrawal is restricted and managed, and, where performed, it is compensated for by reinjection of water in volumes similar to what is withdrawn. Potential impacts related to regional subsidence would be a less-than-significant-hazard to the Project, and no mitigation measures would be required.

Considering the mandatory design requirements in place for the subject hazards, operation of Alternative 4 would not have an adverse effect on the geologic environment. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions.

6.6.5.1 Mitigation Measures

No mitigation measures required.

6.6.5.2 Impacts Remaining after Mitigation

No impact.

6.6.6 Design Option 1: Los Angeles Union Station at the Metropolitan Water District and Design Option 2: Add Little Tokyo Station

The Design Option 1 and 2 locations and proposed improvements are substantially similar, and the determination provided in Section 6.6.2 for Alternative 1 is applicable to either Design Option 1 or 2. Impacts related to collapse, settlement and subsidence would be less than significant with design and operation performed per applicable design criteria mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), and no mitigation measures would be required.

6.6.6.1 Mitigation Measures

No mitigation measures required.

6.6.6.2 Impacts Remaining after Mitigation

No impact.

6.6.7 Maintenance and Storage Facility

The Bellflower and Paramount MSF site option locations and proposed improvements are substantially similar, and the determination provided in Section 6.6.5 for Alternative 4 is applicable to either MSF site. Impacts related to collapse, settlement, and subsidence would be less than significant with design and operation performed per applicable design criteria mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), and no mitigation measures would be required.

6.6.7.1 Mitigation Measures

No mitigation measures required.

6.6.7.2 Impacts Remaining after Mitigation

No impact.

6.7 Would the project be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property?

6.7.1 No Project Alternative

Under the No Project Alternative, the Build Alternatives would not be constructed, and the Affected Area would remain unchanged. There would be no impact to the geology and soils (including expansive soil potential) in the Affected Area. Therefore, the operational-related impacts for the No Project Alternative would be less than significant, and no mitigation measures would be required.

6.7.1.1 Mitigation Measures

No mitigation measures required.

6.7.1.2 Impacts Remaining after Mitigation

No impact.

6.7.2 Alternative 1: Los Angeles Union Station to Pioneer Station and Alternative 2: 7th Street/Metro Center to Pioneer Station

As discussed in Section 4.7.2, clay-rich soils may exist locally within alluvial soils present in the Affected Area. In addition, bedrock units also can exhibit expansive properties due to the clay content within the bedrock; this includes the Fernando Formation bedrock present within the shallow subsurface of the northern portion of Alternative 1, and the northwestern portion of Alternative 2. The placement of structures on expansive soil could result in structural distress. Therefore, operation of the at-grade, above-grade, and below-grade structures associated with Alternatives 1 and 2 would potentially subject people and structures to the effects of expansive soils, which could result in damage to structures.

As mandated by GEO PM-1 (Geotechnical Design [Operation]), structures to be constructed as part of Alternatives 1 and 2 would be designed and constructed in accordance with MRDC and CBC standards (the Uniform Building Code [UBC] is no longer applicable) or equivalent (see Section 3.3) specific to expansive soils. These required design standards would yield structures that would tolerate the effects of expansive soil, or the expansive soils would be remediated. Expansive soil remediation could include soil removal and replacement, chemical treatment, or structural enhancements.

As part of Project Measure GEO PM-1 (Geotechnical Design [Operation]), Alternatives 1 and 2 would be designed in accordance with the recommendations to be included in the future detailed geotechnical design reports. Considering the mandatory design requirements associated with expansive soils, operation of Alternatives 1 and 2 would not result in significant impacts, including the risk of loss, injury, or death related to expansive soils. Therefore, impacts related to expansive soils would be less than significant with design and construction performed per applicable design criteria, and no mitigation measures would be required.

6.7.2.1 Mitigation Measures

No mitigation measures required.

6.7.2.2 Impacts Remaining after Mitigation

No impact.

6.7.3 Alternative 3: Slauson/A (Blue) Line to Pioneer Station

As discussed in Section 4.7.2, clay-rich soils may exist locally within alluvial soils present in the Affected Area. The placement of structures on expansive soil could result in structural distress. Therefore, operation of the at-grade and above-grade structures associated with Alternative 3 would potentially subject people and structures to the effects of expansive soils, which could result in damage to structures.

As mandated by GEO PM-1 (Geotechnical Design [Operation]), structures to be constructed as part of Alternative 3 would be designed and constructed in accordance with MRDC and CBC standards (the UBC is no longer applicable) or equivalent (see Section 3.3) specific to expansive soils. These required design standards would yield structures that would tolerate the effects of expansive soil, or the expansive soils would be remediated. Expansive soil remediation could include soil removal and replacement, chemical treatment, or structural enhancements.

As part of Project Measure GEO PM-1 (Geotechnical Design [Operation]), Alternative 3 would be designed in accordance with the recommendations to be included in the future detailed geotechnical design reports. Considering the mandatory design requirements associated with expansive soils, operation of Alternative 3 would not result in significant impacts, including the risk of loss, injury, or death related to expansive soils. Therefore, impacts related to expansive soils would be less than significant with design and construction performed per applicable design criteria, and no mitigation measures would be required.

6.7.3.1 Mitigation Measures

No mitigation measures required.

6.7.3.2 Impacts Remaining after Mitigation

No impact.

6.7.4 Alternative 4: I-105/C (Green) Line to Pioneer Station

As discussed in Section 4.7.2, clay-rich soils may exist locally within alluvial soils present in the Affected Area. The placement of structures on expansive soil could result in structural distress. Therefore, operation of the at-grade and above-grade structures associated with Alternative 4 would potentially subject people and structures to the effects of expansive soils, which could result in damage to structures.

As mandated by GEO PM-1 (Geotechnical Design [Operation]), structures to be constructed as part of Alternative 4 would be designed and constructed in accordance with MRDC and CBC standards (the UBC is no longer applicable) or equivalent (see Section 3.3) specific to expansive soils. These required design standards would yield structures that would tolerate the effects of expansive soil, or the expansive soils would be remediated. Expansive soil remediation could include soil removal and replacement, chemical treatment, or structural enhancements.

As part of Project Measure GEO PM-1 (Geotechnical Design [Operation]), Alternative 4 would be designed in accordance with the recommendations to be included in the future detailed geotechnical design reports. Considering the mandatory design requirements associated with expansive soils, operation of Alternative 4 would not result in significant impacts, including the risk of loss, injury, or death related to expansive soils. Therefore, impacts related to expansive soils would be less than significant with design and construction performed per applicable design criteria, and no mitigation measures would be required.

6.7.4.1 Mitigation Measures

No mitigation measures required.

6.7.4.2 Impacts Remaining after Mitigation

No impact.

6.7.5 Design Option 1: Los Angeles Union Station at the Metropolitan Water District and Design Option 2: Add Little Tokyo Station

The Design Option 1 and 2 locations and proposed improvements are substantially similar, and the determination provided in Section 6.7.2 for Alternative 1 is applicable to either Design Option 1 or 2. Impacts related to expansive soils would be less than significant with design and operation performed per applicable design criteria mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), and no mitigation measures would be required.

6.7.5.1 Mitigation Measures

No mitigation measures required.

6.7.5.2 Impacts Remaining after Mitigation

No impact.

6.7.6 Maintenance and Storage Facility

The Bellflower and Paramount MSF site option locations and proposed improvements are substantially similar, and the determination provided in Section 6.7.4 for Alternative 4 is applicable to either MSF site. Impacts related to expansive soils would be less than significant with design and operation performed per applicable design criteria mandated by Project Measure GEO PM-1 (Geotechnical Design [Operation]), and no mitigation measures would be required.

6.7.6.1 Mitigation Measures

No mitigation measures required.

6.7.6.2 Impacts Remaining after Mitigation

No impact.

6.8 Would the project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

6.8.1 No Project Alternative

Under the No Project Alternative, the Build Alternatives would not be constructed, and the Affected Area would remain unchanged. The Affected Area is in a highly urbanized area served by existing municipal sewage systems. Therefore, the operational-related impacts for the No Project Alternative would be less than significant, and no mitigation measures would be required.

6.8.1.1 Mitigation Measures

No mitigation measures required.

6.8.1.2 Impacts Remaining after Mitigation

No impact.

6.8.2 Alternative 1: Los Angeles Union Station to Pioneer Station and Alternative 2: 7th Street/Metro Center to Pioneer Station

Alternatives 1 and 2 are located in a highly urbanized area served by existing municipal sewage systems. The use of septic tanks or alternative wastewater systems is not anticipated under Alternatives 1 and 2. Therefore, Alternatives 1 and 2 would not expose people or structures to significant impacts involving the adequacy of soils to support septic tanks or alternative waste disposal systems. No impacts would occur, and no mitigation measures would be required.

6.8.2.1 Mitigation Measures

No mitigation measures required.

6.8.2.2 Impacts Remaining after Mitigation

No impact.

6.8.3 Alternative 3: Slauson/A (Blue) Line to Pioneer Station

Alternative 3 is located in a highly urbanized area served by existing municipal sewage systems. The use of septic tanks or alternative wastewater systems is not anticipated under Alternative 3. Therefore, Alternative 3 would not expose people or structures to significant impacts involving the adequacy of soils to support septic tanks or alternative waste disposal systems. No impacts would occur, and no mitigation measures would be required.

6.8.3.1 Mitigation Measures

No mitigation measures required.

6.8.3.2 Impacts Remaining after Mitigation

No impact.

6.8.4 Alternative 4: I-105/C (Green) Line to Pioneer Station

Alternative 4 is located in a highly urbanized area served by existing municipal sewage systems. The use of septic tanks or alternative wastewater systems is not anticipated under

Alternative 4. Therefore, Alternative 4 would not expose people or structures to significant impacts involving the adequacy of soils to support septic tanks or alternative waste disposal systems. No impacts would occur, and no mitigation measures would be required.

6.8.4.1 Mitigation Measures

No mitigation measures required.

6.8.4.2 Impacts Remaining after Mitigation

No impact.

6.8.5 Design Option 1: Los Angeles Union Station at the Metropolitan Water District and Design Option 2: Add Little Tokyo Station

The Design Option 1 and 2 locations and proposed improvements are substantially similar to Alternative 1 and are located in a highly urbanized area served by existing municipal sewage systems. The use of septic tanks or alternative wastewater systems is not anticipated for either Design Option. Therefore, Design Option 1 or 2 would not expose people or structures to significant impacts involving the adequacy of soils to support septic tanks or alternative waste disposal systems. No impacts would occur, and no mitigation measures would be required.

6.8.5.1 Mitigation Measures

No mitigation measures required.

6.8.5.2 Impacts Remaining after Mitigation

No impact.

6.8.6 Maintenance and Storage Facility

The Bellflower and Paramount MSF site option locations and proposed improvements are substantially similar and are located in a highly urbanized area served by existing municipal sewage systems. The use of septic tanks or alternative wastewater systems is not anticipated for either MSF. Therefore, the Paramount and Bellflower MSF site options would not expose people or structures to significant impacts involving the adequacy of soils to support septic tanks or alternative waste disposal systems. No impacts would occur, and no mitigation measures would be required.

6.8.6.1 Mitigation Measures

No mitigation measures required.

6.8.6.2 Impacts Remaining after Mitigation

No impact.

6.9 Would the project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

See the Paleontological Resource Impacts Analysis Report (Metro 2021a) for determination.

7 CONSTRUCTION IMPACTS

7.1 Construction Activities

Construction Activities associated with the WSAB Project are detailed in the *West Santa Ana Branch Transit Corridor Project Construction Methods Report* (Metro 2021c).

7.2 Construction Methodology

The construction determinations presented below are based on the existing conditions described in Section 4 of this report and the environmental impacts analysis presented in Section 5.

CEQA is only concerned with the effects of a project on the environment, not the effects of the environment on the project (California Building Industry Association v. Bay Area Air Quality Management District [2015] 62 Cal. 4th 369.) For informational purposes, however, the following analyzes the potential impacts of constructing the Project within the seismically active region of Southern California. The following analysis also considers whether the Project might exacerbate geological, seismic, and related hazards (see State CEQA Guidelines, 14 CCR § 15126.2(a)).

7.3 Construction Impacts

This section describes the temporary construction impacts of the Build Alternatives, including the Design Options 1 and 2 and MSF site options on geotechnical, subsurface, and seismic resources. Information on the various construction techniques that may be used are included in the Construction Methods Report (Metro 2021c). As summarized in this report, the Affected Area is underlain by alluvial soils with a locally shallow groundwater table. It is situated near active faults and traverses oil fields and methane hazard and buffer zones. Potential impacts associated with the construction of the Build Alternatives, Design Options 1 and 2, and MSF sites would be minimized through compliance with the methodology and established design standards discussed in Section 3 and implemented through Project Measures GEO PM-3 (Geotechnical Design [Construction]) and GEO PM-4 (Oil and Gas Zones [Construction]), and through Mitigation Measure GEO-5 (Gas Monitoring [Construction]). Project Measure GEO PM-3 is applicable to all of the Build Alternatives, Design Options 1 and 2, and MSF sites. Project Measure GEO PM-4 and Mitigation Measure GEO-5 are specific to Build Alternatives 1 and 2. As a result, adverse impacts to geotechnical, subsurface, and seismic resources would be minimized. Note that construction impacts associated with oil and gas fields, including environmental and health impacts, are discussed in the Hazardous Materials Impact Report.

7.3.1 Build Alternatives

During project construction, temporary conditions might arise that could result in potential impacts related to human injury and loss or damage to structures. Worker health and safety plans specific to each of the major tasks involved in development of the Build Alternatives (including Design Options 1 and 2, and the MSF) would be prepared in accordance with Metro and Cal/OSHA requirements. Strict compliance with these worker health and safety plans would reduce the risks to workers, and no adverse effects would result. Additional information on the various construction techniques that may be utilized are included in the Construction Methods Report (Metro 2021c).

Project and Mitigation Measures are defined in Section 8. As part of Project Measure GEO PM-3 (Geotechnical Design [Construction]), during final design of the Build Alternatives, including Design Options 1 and 2, and the MSF, a comprehensive geologic and geotechnical investigation would be conducted and a design-level geotechnical report would be prepared. The design-level geotechnical report would also provide detailed geotechnical construction recommendations, which would address the temporary conditions discussed below that may arise during construction. These recommendations would also comply with the standards discussed in Section 3.3.1.

7.3.1.1 Build Alternative 1

Naturally Occurring Oil and Gas

At- and Above-grade Design Features

If any oil wells are encountered during construction, the wells would be abandoned in accordance with state guidelines. See the Final Hazardous Materials Impact Analysis Report (Metro 2021b) for additional discussion on oil wells in the Affected Area.

As discussed below, hazardous subsurface gases are present in the Affected Area of Build Alternative 1. If subsurface gases were to be encountered during excavation for foundation excavations for viaducts or other support structures, this could pose to be a fire/explosion hazard during construction. Additionally, accumulation of methane gas in an excavation could replace oxygen in the breathing zone, and accumulation of hydrogen sulfide would be highly toxic when inhaled at high concentrations, thus creating a health hazard during construction. Methane and H_2S are considered hazardous gases because of their explosive properties. H_2S is also highly toxic when inhaled and typically has a strong rotten-egg-like odor at lower, non-toxic levels. Foundation excavations for viaducts or other support structures in hazardous areas may need to be considered “potentially gassy,” and precautions such as forced-air circulation and air monitoring may need to be implemented during construction.

In accordance with Project Measure GEO PM-3 (Geotechnical Design [Construction]), this potential hazard to Alternatives 1 (including Design Options 1 and 2) would be further studied, and the geotechnical report's recommendations would be incorporated into the project plans and specifications. Comprehensive geologic, geotechnical, and environmental investigations would be conducted, and design-level documents would be prepared for the selected alternative. These design-level reports would verify and document the hazardous subsurface conditions in the project area and support the design recommendations in compliance with the applicable regulations and standards for hazardous gases. By implementing these mandatory design requirements, under NEPA, impacts related to naturally occurring oil and gas would be minimized, adverse effects would be avoided, and no mitigation would be required for the at- and above-grade design features.

Subterranean Design Features

As discussed in Sections 4.7.5 and 5.3.2, there is moderate to high potential to encounter naturally occurring oil and/or gas during tunneling (bored or cut-and-cover such as the tunnel portals) or during excavation for the Alternative 1 underground stations

(Arts/Industrial District, Little Tokyo [added with Design Option 2], LAUS [Forecourt/MWD as Design Option 1]), or other deep excavations (such as tunnel shafts). If subsurface gases were to be encountered during excavation for tunnels or stations, this could pose to be a fire/explosion hazard during construction. Additionally, accumulation of methane gas in an excavation could replace oxygen in the breathing zone, and accumulation of hydrogen sulfide would be highly toxic when inhaled at high concentrations, thus creating a health hazard during construction. Methane and H2S are considered hazardous gases because of their explosive properties. H2S is also highly toxic when inhaled and typically has a strong rotten-egg-like odor at lower, non-toxic levels. In accordance with Project Measure GEO PM-3 (Geotechnical Design [Construction]) and Mitigation Measure GEO-4 (Tunnel Advisory Panel), investigations would be conducted on the selected alternative that would verify and quantify the gas hazard. Various construction techniques are available that can satisfy the requirements of Project Measure GEO PM-3 and Mitigation Measure GEO-4. The following discussion provides potential options that may be implemented, dependent on the anticipated and actual conditions encountered during construction.

The use of a slurry-face TBM or an earth-pressure-balance TBM (both pressurized-face TBMs) would minimize the exposure of workers to elevated gas concentrations underground because the excavated soil is removed in a fully enclosed slurry pipeline to an aboveground, enclosed treatment plant. See the Construction Methods Report (Metro 2021c) for additional information on TBMs.

In areas of potential H2S exposure, there are several techniques that could be used to lower the risk of exposure. Areas determined to be at risk of elevated H2S levels could be pretreated by displacing and oxidating the H2S by injecting large quantities of H2S-free water containing dilute hydrogen peroxide into the ground and groundwater in advance of the tunnel excavation (Jacobs et al. 1999). This "in situ oxidation" method reduces H2S levels even before the ground is excavated. This pretreatment method is unlikely to be necessary where a slurry face TBM is used but may be implemented in areas with tunnel-to-station connections or at cross-passage excavation areas and where open excavation and limited dewatering may be conducted, such as emergency exit shafts and low-point sump shafts.

In addition to pretreatment of the ground and groundwater mentioned above, and prior to tunneling, additives such as sodium hydroxide can be injected into the bentonite slurry during the tunneling and/or prior to discharge into the slurry separation plant. The use of sodium hydroxide as an additive to maintain the pH of the slurry at 10 or 11 has been found to be effective in suppressing H2S "off-gassing" from the slurry (Jacobs et al. 1999). However, because of health and safety issues associated with use of sodium hydroxide, Cal/OSHA has previously indicated that it would not support such an application in a tunnel environment. If the slurry treatment plant were located above ground, the suppression of off-gassing could be tightly controlled and monitored, and sodium hydroxide dosing may be possible.

A more promising technique is the addition of zinc oxide to the slurry, a method commonly used in oil-field operations. The zinc oxide precipitates out dissolved sulfides to similarly reduce the potential for H2S release or exposure. The slurry pipelines can be equipped with H2S sensors that can automatically start zinc oxide dosing when certain levels are reached. However, if zinc dosages are significant enough, the post-treatment solids could be considered contaminated, which could require disposal at special facilities.

All of these treatments can neutralize the presence of H2S, improving the safety of workers involved in the slurry and separation plant systems. Such treatments have the additional benefit of reducing the corrosive effects of H2S when it is dissolved in the slurry or groundwater.

Where a TBM cannot be used, such as in areas with tunnel-to-station connections or at cross-passage excavation areas and open excavations (for example, emergency exit shafts and low-point sump shafts), the soil/groundwater may be pretreated (mixed or injected) with special additives (prior to construction) to lower gas levels to below threshold levels. The use of relatively impermeable diaphragm or slurry walls may be required to reduce gas inflow in other excavations in gassy areas, such as for stations.

In accordance with CCR Title 8, Division 1, Tunnel Safety Orders would be prepared for Alternative 1 (including Design Options 1 and 2), and if oil and/or gas are anticipated (based on the detailed studies and field investigations that would be conducted prior to construction, as mandated by Project Measure GEO PM-3 (Geotechnical Design [Construction]), the excavation would be classified by Cal/OSHA as a "Gassy or Potentially Gassy Operation." This designation requires that special precautions be taken, and safety measures implemented to protect workers who could be exposed to this hazard. Additional ventilation, monitoring, and worker training for exposure to hazardous gases would also be required during construction. Some work may require additional worker training and use of personal protective equipment such as a fitted breathing apparatus, which may include supplied air.

Based on the above discussions and application of the prescribed standards, requirements, and guidance mandated by Project Measures GEO PM-3 (Geotechnical Design [Construction]) and GEO PM-4 (Oil and Gas Zones [Construction]), and Mitigation Measure GEO-5 (Gas Monitoring [Construction]), under NEPA, impacts to Alternative 1, including Design Options 1 and 2, would be minimized, and adverse effects would be avoided.

Unconsolidated/Saturated Alluvial Soils

At- and Above-grade Design Features

Construction of Build Alternative 1 could result in an adverse effect related to unconsolidated/saturated alluvial soils, if construction (deep excavations) would directly or indirectly cause settlement resulting in distress to existing adjacent improvements. Unconsolidated or water-saturated alluvial soil deposits can be encountered during deep excavations, such as for viaduct foundation elements included in Build Alternative 1 (including Design Options 1 and 2). Shoring, casing, or other ground-stabilization methods would be used to minimize impacts during excavations.

Temporary excavations would be required during construction of the Project. Unsafe excavations could result in risk to life and property as a result of a temporary excavation failure. All temporary excavations would be performed in accordance with the safety requirements of Cal/OSHA. Shoring would be designed in accordance with the MRDC as discussed in Section 3.3.1.

Soil types may mandate various types/styles of bracing or excavation support. However, regardless of soil type, excavation depth and configuration drive the requirement of whether a temporary excavation requires support. Temporary excavation needs would be developed as the designs progress for the selected Build Alternative.

Temporary excavation bracing would be designed to protect adjacent structures, traffic, utilities, and construction personnel. Suitable factors of safety would be used in the design of the temporary supports. Performance of the temporary construction must conform to the requirements stated in the MRDC.

Based on the above discussions and application of the prescribed standards, requirements, and guidance as mandated by Project Measure GEO PM-3 (Geotechnical Design [Construction]), under NEPA, impacts to Alternative 1, including Design Options 1 and 2, would be minimized. Adverse effects would be avoided, and no construction-related mitigation measures would be required for unconsolidated/saturated alluvial soils.

Subterranean Design Features

Construction of Alternative 1 (including Design Options 1 and 2) could result in an adverse impact related to ground loss, subsidence, and settlement if construction (tunnel boring) would directly or indirectly cause settlement resulting in distress to existing adjacent improvements. Construction of Alternative 1 (including Design Options 1 and 2) would include tunnel boring in alluvial soils, which may result in running or flowing ground conditions (depending on groundwater conditions), resulting in ground loss. Ground loss occurs when the soils adjacent to the tunnel excavation enter the excavation, which can result in settlement at the ground surface.

In accordance with Project Measure GEO PM-3 (Geotechnical Design [Construction]), investigations would be conducted which would verify and quantify the ground loss potential. Various construction techniques are available that can adequately control ground loss. The following discussion provides potential options that may be implemented, dependent on the anticipated and actual conditions encountered during construction.

To optimize control of the ground overlying and surrounding the tunnels and limit ground subsidence to acceptable levels, pressurized-face TBMs would be recommended for tunnel construction. These TBMs also allow the tunnel lining to be installed and grout to be injected into the annulus between the lining and the tunnel excavation immediately behind the TBM concurrently and without having to lower potential groundwater levels by dewatering.

As added protection against potential subsidence induced by tunneling and related excavation activities, preconstruction surveys would be required and performed to document the existing conditions of buildings along the alignment before the tunneling begins. During construction, instrumentation (such as ground surface and building monitoring devices) would be in place to measure movements and provide information to the contractor on tunneling performance as well as to document that the settlement specifications are met. If measurements indicate settlement limits would be exceeded, the contractor would be required to change or add methods and/or procedures to comply with those limits. In addition, construction work would be reassessed when settlements exceed action (warning) levels. Contractors would be required to modify construction methods if settlements exceed specified maximum levels.

Where conditions warrant, such as in shallow tunnels directly below sensitive structures or utilities, additional methods to reduce settlement would be evaluated and specified. Such methods could include permeation grouting to improve the ground prior to tunneling, compaction grouting as the tunnel is excavated, and compensation grouting involving the carefully controlled injection of grout between underground excavations and structures requiring protection from settlement or underpinning the structure's foundation. Dewatering is usually not necessary when tunneling with pressurized-face TBMs. However, station construction would require excavations that would likely encounter the groundwater table and/or perched groundwater. Therefore, dewatering may be required to complete the construction in some areas. Dewatering of the excavation during construction could result in potentially damaging subsidence adjacent to the construction area. However, dewatering in sensitive areas would be avoided by utilizing slurry walls or secant pile walls (among other methods) during construction.

Based on the above discussions and application of the prescribed standards, requirements, and guidance as mandated by Project Measure GEO PM-3 (Geotechnical Design [Construction]), under NEPA, impacts to Alternative 1, including Design Options 1 and 2, would be minimized. Adverse effects would be avoided, and no construction-related mitigation measures would be required for unconsolidated/saturated alluvial soils.

7.3.1.2 Build Alternative 2

Naturally Occurring Oil and Gas

At- and Above-grade Design Features

If any oil wells are encountered during construction, the wells would be abandoned in accordance with state guidelines. See the Final Hazardous Materials Impact Analysis Report (Metro 2021b) for additional discussion on oil wells in the Affected Area.

As discussed below, hazardous subsurface gases are present in the Affected Area of Build Alternative 2. If subsurface gases were to be encountered during excavation for foundation excavations for viaducts or other support structures, this could pose to be a fire/explosion hazard during construction. Additionally, accumulation of methane gas in an excavation could replace oxygen in the breathing zone, and accumulation of hydrogen sulfide would be highly toxic when inhaled at high concentrations, thus creating a health hazard during construction. Methane and H_2S are considered hazardous gases because of their explosive properties. H_2S is also highly toxic when inhaled and typically has a strong rotten-egg-like odor at lower, non-toxic levels. Foundation excavations for viaducts or other support structures in hazardous areas may need to be considered "potentially gassy," and precautions such as forced-air circulation and air monitoring may need to be implemented during construction.

In accordance with Project Measure GEO PM-3 (Geotechnical Design [Construction]), this potential hazard to Alternative 2 would be further studied, and the geotechnical report's recommendations would be incorporated into the project plans and specifications. Comprehensive geologic, geotechnical, and environmental investigations would be conducted, and design-level documents would be prepared for the selected alternative. These design-level reports would verify and document the hazardous subsurface conditions in the project area and support the design recommendations in compliance with the applicable regulations and standards for hazardous gases. By implementing these mandatory design requirements, under NEPA, impacts related to naturally occurring oil and gas would be minimized, adverse effects would be avoided, and no mitigation would be required for the at-and above-grade design features.

Subterranean Design Features

As discussed in Sections 4.7.5 and 5.3.2, there is moderate to high potential to encounter naturally occurring oil and/or gas during tunneling (bored or cut-and-cover, such as the tunnel portals) or during excavation for the Alternative 2 underground stations (Arts/Industrial District, South Park/Fashion District, and 7th Street/Metro Center), or other deep excavations (such as tunnel shafts). If subsurface gases were to be encountered during excavation for tunnels or stations, this could pose to be a fire/explosion hazard during construction. Additionally, accumulation of methane gas in an excavation could replace oxygen in the breathing zone, and accumulation of hydrogen sulfide would be highly toxic when inhaled at high concentrations, thus creating a health hazard during construction. Methane and H_2S are considered hazardous gases because of their explosive properties. H_2S is also highly toxic when inhaled and typically has a strong rotten-egg-like odor at lower, non-toxic levels. In accordance with Project Measure GEO PM-3 (Geotechnical Design [Construction]) and Mitigation Measure GEO-4 (Tunnel Advisory Panel), investigations would be conducted that would quantify the gas hazard.

Various construction techniques are available that can satisfy the requirements of Project Measure GEO PM-3 and Mitigation Measure GEO-4. Because of the similar geologic environment and design features, the discussion presented above for the Alternative 1 naturally occurring oil and gas hazard and subterranean structures is also applicable to Alternative 2. Based on the above discussions and application of the prescribed standards, requirements, and guidance mandated by Project Measures GEO PM-3 (Geotechnical Design [Construction]) and GEO PM-4 (Oil and Gas Zones [Construction]), and Mitigation Measure GEO-5 (Gas Monitoring [Construction]), under NEPA, impacts to Alternative 2 would be minimized, and adverse effects would be avoided.

Unconsolidated/Saturated Alluvial Soils

At- and Above-grade Design Features

Construction of Build Alternative 2 could result in an adverse effect related to unconsolidated/saturated alluvial soils, if construction (deep excavations) would directly or indirectly cause settlement resulting in distress to existing adjacent improvements. Unconsolidated or water-saturated alluvial soil deposits can be encountered during deep excavations, such as for viaduct foundation elements included in Build Alternative 2. Shoring, casing, or other ground-stabilization methods would be used to minimize impacts during excavations.

Temporary excavations would be required during construction of the Project. Unsafe excavations could result in risk to life and property as a result of a temporary excavation failure. All temporary excavations would be performed in accordance with the safety requirements of Cal/OSHA. Shoring would be designed in accordance with the MRDC as discussed in Section 3.3.1.

Soil types may mandate various types/styles of bracing or excavation support. However, regardless of soil type, excavation depth and configuration drive the requirement of whether a temporary excavation requires support. Temporary excavation needs would be developed as the designs progress for the selected Build Alternative.

Temporary excavation bracing would be designed to protect adjacent structures, traffic, utilities, and construction personnel. Suitable factors of safety would be used in the design of the temporary supports. Performance of the temporary construction must conform to the requirements stated in the MRDC.

Based on the above discussions and application of the prescribed standards, requirements, and guidance as mandated by Project Measure GEO PM-3 (Geotechnical Design [Construction]), under NEPA, impacts to Alternative 2 would be minimized. Adverse effects would be avoided, and no construction-related mitigation measures would be required for unconsolidated/saturated alluvial soils.

Subterranean Design Features

Construction of Alternative 2 could result in an adverse impact related to ground loss, subsidence, and settlement if construction (tunnel boring) would directly or indirectly cause settlement resulting in distress to existing adjacent improvements. Construction of Alternative 2 would include tunnel boring in alluvial soils, which may result in running or flowing ground conditions (depending on groundwater conditions), resulting in ground loss. Ground loss occurs when the soils adjacent to the tunnel excavation enter the excavation, which can result in settlement at the ground surface.

In accordance with Project Measure GEO PM-3 (Geotechnical Design [Construction]), investigations would be conducted that would verify and quantify the ground loss potential. Various construction techniques are available that can adequately control ground loss. Because of the similar geologic environment and design features, the discussion presented above for the Alternative 1 naturally occurring oil and gas hazard and subterranean structures is also applicable to Alternative 2. Based on the above discussions and application of the prescribed standards, requirements, and guidance as mandated by Project Measure GEO PM-3 (Geotechnical Design [Construction]), under NEPA, impacts to Alternative 2 would be minimized. Adverse effects would be avoided, and no construction-related mitigation measures would be required for unconsolidated/saturated alluvial soils.

7.3.1.3 Build Alternative 3

Naturally Occurring Oil and Gas

At- and Above-grade Design Features

If any oil wells are encountered during construction, the wells would be abandoned in accordance with state guidelines. See the Final Hazardous Materials Impact Analysis Report (Metro 2021b) for additional discussion on oil wells in the Affected Area.

If subsurface gases were to be encountered during excavation for foundation excavations for viaducts or other support structures, this could pose to be a fire/explosion hazard during construction. Additionally, accumulation of methane gas in an excavation could replace oxygen in the breathing zone, and accumulation of hydrogen sulfide would be highly toxic when inhaled at high concentrations, thus creating a health hazard during construction. Methane and H_2S are considered hazardous gases because of their explosive properties. H_2S is also highly toxic when inhaled and typically has a strong rotten-egg-like odor at lower, non-toxic levels. Although not likely in the Affected Area of Build Alternative 3, foundation excavations for viaducts or other support structures in hazardous areas may need to be considered “potentially gassy,” and precautions such as forced-air circulation and air monitoring may need to be implemented during construction. In accordance with Project Measure GEO PM-3 (Geotechnical Design [Construction]), this potential hazard to

Alternative 3 would be further studied, and the geotechnical report's recommendations would be incorporated into the project plans and specifications. Comprehensive geologic, geotechnical, and environmental investigations would be conducted, and design-level documents would be prepared for the selected alternative. These design-level reports would verify and document the hazardous subsurface conditions in the project area and support the design recommendations in compliance with the applicable regulations and standards for hazardous gases. By implementing these mandatory design requirements, under NEPA, impacts related to naturally occurring oil and gas would be minimized, adverse effects would be avoided, and no mitigation would be required for the at- and above-grade design features.

Subterranean Design Features

Subterranean design features are not included as part of Build Alternative 3.

Unconsolidated/Saturated Alluvial Soils

At- and Above-grade Design Features

Construction of Build Alternative 3 could result in an adverse effect related to unconsolidated/saturated alluvial soils, if construction (deep excavations) would directly or indirectly cause settlement resulting in distress to existing adjacent improvements. Unconsolidated or water-saturated alluvial soil deposits can be encountered during deep excavations, such as for viaduct foundation elements included in Build Alternative 3. Shoring, casing, or other ground-stabilization methods would be used to minimize impacts during excavations.

Temporary excavations would be required during construction of the Project. Unsafe excavations could result in risk to life and property as a result of a temporary excavation failure. All temporary excavations would be performed in accordance with the safety requirements of Cal/OSHA. Shoring would be designed in accordance with the MRDC as discussed in Section 3.3.1.

Soil types may mandate various types/styles of bracing or excavation support. However, regardless of soil type, excavation depth and configuration drive the requirement of whether a temporary excavation requires support. Temporary excavation needs would be developed as the designs progress for the selected Build Alternative.

Temporary excavation bracing would be designed to protect adjacent structures, traffic, utilities, and construction personnel. Suitable factors of safety would be used in the design of the temporary supports. Performance of the temporary construction must conform to the requirements stated in the MRDC.

Based on the above discussions and application of the prescribed standards, requirements, and guidance as mandated by Project Measure GEO PM-3 (Geotechnical Design [Construction]), under NEPA, impacts to Alternative 3 would be minimized. Adverse effects would be avoided, and no construction-related mitigation measures would be required for unconsolidated/saturated alluvial soils.

Subterranean Design Features

Subterranean design features are not included as part of Build Alternative 3.

7.3.1.4 Build Alternative 4

Naturally Occurring Oil and Gas

At- and Above-grade Design Features

If any oil wells are encountered during construction, the wells would be abandoned in accordance with state guidelines. See the Final Hazardous Materials Impact Analysis Report (Metro 2021b) for additional discussion on oil wells in the Affected Area.

If subsurface gases were to be encountered during excavation for foundation excavations for viaducts or other support structures, this could pose to be a fire/explosion hazard during construction. Additionally, accumulation of methane gas in an excavation could replace oxygen in the breathing zone, and accumulation of hydrogen sulfide would be highly toxic when inhaled at high concentrations, thus creating a health hazard during construction. Methane and H_2S are considered hazardous gases because of their explosive properties. H_2S is also highly toxic when inhaled and typically has a strong rotten-egg-like odor at lower, non-toxic levels. Although not likely in the Affected Area of Build Alternative 4, including the MSF sites, foundation excavations for viaducts or other support structures in hazardous areas may need to be considered "potentially gassy," and precautions such as forced-air circulation and air monitoring may need to be implemented during construction. In accordance with Project Measure GEO PM-3 (Geotechnical Design [Construction]), this potential hazard to Alternative 4 would be further studied, and the geotechnical report's recommendations would be incorporated into the project plans and specifications. Comprehensive geologic, geotechnical, and environmental investigations would be conducted, and design-level documents would be prepared for the selected alternative. These design-level reports would verify and document the hazardous subsurface conditions in the project area and support the design recommendations in compliance with the applicable regulations and standards for hazardous gases. By implementing these mandatory design requirements, under NEPA, impacts related to naturally occurring oil and gas would be minimized, adverse effects would be avoided, and no mitigation would be required for the at- and above-grade design features.

Subterranean Design Features

Subterranean design features are not included as part of Build Alternative 4, including the MSF sites.

Unconsolidated/Saturated Alluvial Soils

At- and Above-grade Design Features

Construction of Build Alternative 4, including the MSF sites, could result in an adverse effect related to unconsolidated/saturated alluvial soils, if construction (deep excavations) would directly or indirectly cause settlement resulting in distress to existing adjacent improvements. Unconsolidated or water-saturated alluvial soil deposits can be encountered during deep excavations, such as for viaduct foundation elements included in Build Alternative 4, including the MSF sites. Shoring, casing, or other ground-stabilization methods would be used to minimize impacts during excavations.

Temporary excavations would be required during construction of the Project. Unsafe excavations could result in risk to life and property as a result of a temporary excavation failure. All temporary excavations would be performed in accordance with the safety requirements of Cal/OSHA. Shoring would be designed in accordance with the MRDC as discussed in Section 3.3.1.

Soil types may mandate various types/styles of bracing or excavation support. However, regardless of soil type, excavation depth and configuration drive the requirement of whether a temporary excavation requires support. Temporary excavation needs would be developed as the designs progress for the selected Build Alternative.

Temporary excavation bracing would be designed to protect adjacent structures, traffic, utilities, and construction personnel. Suitable factors of safety would be used in the design of the temporary supports. Performance of the temporary construction must conform to the requirements stated in the MRDC.

Based on the above discussions and application of the prescribed standards, requirements, and guidance as mandated by Project Measure GEO PM-3 (Geotechnical Design [Construction]), under NEPA, impacts to Alternative 4 would be minimized. Adverse effects would be avoided, and no construction-related mitigation measures would be required for unconsolidated/saturated alluvial soils.

Subterranean Design Features

Subterranean design features are not included as part of Build Alternative 4, including the Paramount and Bellflower MSF site options.

7.3.1.5 Design Options

Design Option 1 (MWD) would move the terminus point behind the MWD building. Design Option 2 would add the Little Tokyo Station. Design Options 1 and 2 have substantially similar geologic settings, potential geotechnical construction impacts, and effect determinations as Alternative 1. The conclusions provided for Alternative 1 are also applicable to Design Options 1 and 2. With the implementation of Project Measures GEO PM-3 (Geotechnical Design [Construction]) and GEO PM-4 (Oil and Gas Zones [Construction]), and Mitigation Measure GEO-5 (Gas Monitoring [Construction]), under NEPA, impacts to Design Options 1 and 2 would be minimized, and no adverse effects would occur.

7.3.1.6 Maintenance and Storage Facilities

Two potential locations for an MSF have been identified: one in the City of Bellflower and one in the City of Paramount. Only one facility would be constructed as part of the Project. In addition to train storage tracks, the selected MSF would include a number of building structures. The Paramount and Bellflower MSF site options have substantially similar geologic settings, potential geotechnical construction impacts, and effect determinations as Alternative 4. Similar to Build Alternative 4, structures associated with the Paramount and Bellflower MSF site options would be subject to associated prescribed standards, requirements, and guidance related to temporary excavations, including Cal/OSHA requirements for temporary shoring and worker safety. As such, the discussion, analysis, and impact determinations presented for construction of Alternative 4 are applicable to both MSF sites. Impacts to the Paramount and Bellflower MSF site options would be minimized, no adverse effects would occur, and no mitigation would be required.

7.4 California Environmental Quality Act Determination

To satisfy CEQA requirements, the following subsections present Geology and Soils construction impacts analyzed in accordance with Appendix G of the CEQA Guidelines. CEQA is only concerned with the effects of a project on the environment, not the effects of the environment on the project (California Building Industry Association v. Bay Area Air Quality Management District [2015] 62 Cal. 4th 369.) As such, the following analysis considers whether construction of the Project might exacerbate geological, seismic, and related hazards (see State CEQA Guidelines, 14 CCR §15126.2(a)).

The determinations for each of the CEQA Appendix G checklist thresholds are applicable to all of the Build Alternatives (including Design Options 1 and 2, and the MSF sites), unless the determination is subdivided.

The CEQA determinations for naturally occurring gases as they relate to construction of the project Alternatives, including environmental and health impacts, are discussed in the Final Hazardous Materials Impact Analysis Report (Metro 2021b).

7.4.1 No Build Alternative

Under the No Project Alternative, project-related construction activities would not occur, no construction-related impacts would occur, and no mitigation measures would be required. As such, the No Project Alternative is not specifically addressed in the following subsections.

7.4.2 Would the project directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault?

7.4.2.1 Build Alternatives, Design Options and MSF Site Options

Construction of the Build Alternatives, including Design Options 1 and 2, and the MSF sites, would not have a significant impact on the faults in the Affected Area. The design features being considered are not uncommon for the Los Angeles region. The improvements included in the Build Alternatives are shallow from a geologic perspective and would not exacerbate existing geologic conditions related to active faulting during construction. Therefore, impacts would be less than significant, and no mitigation measures would be required.

Mitigation Measures

No mitigation measures required.

Impacts Remaining after Mitigation

No impact.

7.4.3 Would the project directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving Strong seismic ground shaking?

7.4.3.1 Build Alternatives, Design Options and MSF Site Options

Construction of the Build Alternatives, including Design Options 1 and 2, and the MSF sites, would not have significant impacts on the seismic potential of the Affected Area. The design features being considered are not uncommon for the Los Angeles region. The improvements included in the Build Alternatives are shallow from a geologic perspective and would not exacerbate existing geologic conditions related to seismic shaking. Therefore, impacts would be less than significant, and no mitigation measures would be required.

Mitigation Measures

No mitigation measures required.

Impacts Remaining after Mitigation

No impact.

7.4.4 Would the project directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving Seismic-related ground failure, including liquefaction?

7.4.4.1 Build Alternatives, Design Options and MSF Site Options

Construction of the Build Alternatives, including Design Options 1 and 2, and the MSF sites, would not result in significant impacts on the geologic environment of the Affected Area. The design features being considered are not uncommon for the Los Angeles region and would not result in new liquefiable areas or exacerbate existing geologic conditions related to seismic-related ground failure, including liquefaction. Therefore, impacts would be less than significant, and no mitigation measures would be required.

Mitigation Measures

No mitigation measures required.

Impacts Remaining after Mitigation

No impact.

7.4.5 Would the project directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving landslides?

7.4.5.1 Build Alternatives, Design Options and MSF Site Options

The landscape within the Affected Area of Build Alternatives, including Design Options 1 and 2, and the MSF site options, is relatively flat, and no landslides have been mapped in the vicinity of the Affected Area.

Construction of Build Alternatives, including Design Options 1 and 2, and the MSF sites, could result in adverse effects related to unconsolidated/saturated alluvial soils, if construction (deep excavations) would directly or indirectly cause settlement resulting in distress to existing adjacent improvements. Unconsolidated or water-saturated alluvial soil deposits can be encountered during deep excavations. Shoring, casing, or other ground-stabilization methods would be used to minimize impacts during excavations.

Temporary excavations would be required during construction of the Project. Unsafe excavations could result in risk to life and property as a result of a temporary excavation failure. All temporary excavations would be performed in accordance with the safety requirements of Cal/OSHA. Shoring would be designed in accordance with the MRDC or equivalent as discussed in Section 3.3.1.

Soil types may mandate various types/styles of bracing or excavation support. However, regardless of soil type, excavation depth and configuration drive the requirement of whether a temporary excavation requires support. Temporary excavation needs would be developed as the designs progress for the selected Build Alternative.

Temporary excavation bracing would be designed to protect adjacent structures, traffic, utilities, and construction personnel. Suitable factors of safety would be used in the design of the temporary supports. Performance of the temporary construction must conform to the requirements stated in the MRDC or equivalent.

Based on the above discussions and application of the prescribed standards, requirements, and guidance as mandated by Project Measure GEO PM-3 (Geotechnical Design [Construction]), impacts would be minimized, and adverse effects associated with unconsolidated/saturated alluvial soils would be avoided. Therefore, impacts would be less than significant, and no mitigation measures would be required. Additional information on the various construction techniques that may be utilized are included in the Construction Methods Report (Metro 2020b).

Mitigation Measures

No mitigation measures required.

Impacts Remaining after Mitigation

No impact.

7.4.6 Would the project result in substantial soil erosion or the loss of topsoil?

7.4.6.1 Build Alternatives, Design Options, and MSF Site Options

The Build Alternatives, including Design Options 1 and 2, and the MSF sites, are located in an urban setting and the topsoil layer in most of the Affected Area has been disturbed or concealed by previous human activities. Construction of the Build Alternatives would result in ground surface disturbance during site clearance, excavation, and grading that could create the potential for soil erosion and loss of topsoil. The Build Alternatives would be designed and constructed in accordance with state and local guidelines regarding erosion control and management (see the Final Water Resources Impact Analysis Report, Metro 2021c). Also, as detailed in the Final Water Resources Impact Analysis Report, a Stormwater Pollution Prevention Plan and Water Quality Control Plan would be required as implementation elements of the Project. These plans would limit potential impacts related to erosion. As such, the Build Alternatives would minimize significant impacts involving soil erosion or loss of topsoil. Therefore, impacts associated with soil erosion or loss of topsoil would be reduced to less-than-significant levels, and no mitigation measures would be required.

Mitigation Measures

No mitigation measures required.

Impacts Remaining after Mitigation

No impact.

7.4.7 Would the project 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?

7.4.7.1 Build Alternative 1, Including Design Options 1 and 2

Construction of the Build Alternative 1, including Design Options 1 and 2, would not result in significant impacts on the geologic environment of the Affected Area. The design features being considered are not uncommon for the Los Angeles region and would not generate new natural geologic hazard areas (landslide, lateral spreading, subsidence, liquefaction, or collapse), or exacerbate existing geologic conditions related to potential on- or off-site lateral spreading, subsidence, liquefaction, or collapse or seismic-related ground failure, including liquefaction. Therefore, impacts would be less than significant, and no mitigation measures would be required. See Section 7.4.5 for discussion on temporary excavations for the Build Alternatives.

Construction of Build Alternative 1 (including Design Options 1 and 2) would use a variety of construction methods, such as tunnel boring, cut and-cover techniques, and deep excavations such as tunnel shafts, particularly during construction of the following project features, which could potentially result in off-site unstable ground (soil settlement):

- Tunnels, including tunnel portals
- LAUS – Forecourt or MWD (Design Option 1 [MWD])
- Little Tokyo Station (Design Option 2)
- Arts/Industrial District Station
- Other deep excavations (such as tunnel shafts)

More specifically, tunnel boring in alluvial soils is planned as part of Alternative 1, including Design Options 1 and 2, and may result in unstable ground, such as running or flowing ground conditions (depending on groundwater conditions), resulting in ground loss. Ground loss occurs when the soils adjacent to the tunnel excavation enter the excavation, which can result in settlement at the ground surface. To optimize control of the ground overlying and surrounding the tunnels and to limit ground subsidence to acceptable levels, and in accordance with Metro standard design procedures for tunneling in the downtown Los Angeles area, pressurized-face TBMs would be required for tunnel construction. TBMs allow the tunnel lining to be installed and grout to be injected into the annulus between the lining and the tunnel excavation immediately behind the TBM, without requiring dewatering to lower groundwater levels around the tunnel.

In accordance with Project Measure GEO PM-3 (Geotechnical Design [Construction]), for protection against potential ground settlement induced by tunneling and other excavation activities, preconstruction surveys would be performed to document the existing conditions of buildings along the alignment before tunneling begins. During construction, instrumentation (ground surface and building monitoring devices) would be put in place to measure movements and provide information to the contractor on tunneling performance and to document that the settlement specifications are met. If measurements indicate that settlement limits would be exceeded, the contractor would be required to change or add methods and procedures to comply with those limits. In addition, construction work would be reassessed when settlements exceed action (warning) levels. Contractors would be required to modify construction methods if settlements exceed specified maximum levels.

Based on the above discussions and application of the prescribed standards, requirements, and guidance, impacts would be reduced to less-than-significant levels, and no construction-related mitigation measures would be required. Additional information on the various techniques that may be used during construction are included in the Construction Methods Report (Metro 2020b).

Mitigation Measures

No mitigation measures required.

Impacts Remaining after Mitigation

No impact.

7.4.7.2 Build Alternative 2

Construction of the Build Alternative 2 would not generate new natural geologic hazard areas (landslide, lateral spreading, subsidence, liquefaction, or collapse), or result in significant impacts on the geologic environment of the Affected Area. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions related to potential on- or off-site lateral spreading, subsidence, liquefaction, or collapse or seismic-related ground failure, including liquefaction. Therefore, impacts would be less than significant, and no mitigation measures would be required. See Section 7.4.5 for discussion on temporary excavations for the Build Alternatives.

Construction of Build Alternative 2 would use a variety of construction methods, such as tunnel boring, cut and-cover techniques, and deep excavations such as tunnel shafts, particularly during construction of the following project features, which could potentially result in off-site soil settlement:

- Tunnels, including tunnel portals
- Arts/Industrial District Station
- South Park/Fashion District Station
- 7th Street/Metro Center Station
- Other deep excavations (such as tunnel shafts)

More specifically, tunnel boring in alluvial soils is planned as part of Alternative 2 and may result in unstable ground, such as running or flowing ground conditions (depending on groundwater conditions), resulting in ground loss. Ground loss occurs when the soils adjacent to the tunnel excavation enter the excavation, which can result in settlement at the ground surface. To optimize control of the ground overlying and surrounding the tunnels and to limit ground subsidence to acceptable levels, and in accordance with Metro standard design procedures for tunneling in the downtown Los Angeles area, pressurized-face TBMs would be required for tunnel construction. TBMs allow the tunnel lining to be installed and grout to be injected into the annulus between the lining and the tunnel excavation immediately behind the TBM, without requiring dewatering to lower groundwater levels around the tunnel.

In accordance with Project Measure GEO PM-3 (Geotechnical Design [Construction]), for protection against potential ground settlement induced by tunneling and other excavation activities, preconstruction surveys would be performed to document the existing conditions of buildings along the alignment before tunneling begins. During construction, instrumentation (ground surface and building monitoring devices) would be put in place to measure movements and provide information to the contractor on tunneling performance and to document that the settlement specifications are met. If measurements indicate that settlement limits would be exceeded, the contractor would be required to change or add methods and procedures to comply with those limits. In addition, construction work would be reassessed when settlements exceed action (warning) levels. Contractors would be required to modify construction methods if settlements exceed specified maximum levels.

Based on the above discussions and application of the prescribed standards, requirements, and guidance, impacts would be reduced to less-than-significant levels, and no construction-related mitigation measures would be required. Additional information on the various techniques that may be used during construction are included in the Construction Methods Report (Metro 2020b).

Mitigation Measures

No mitigation measures required.

Impacts Remaining after Mitigation

No impact.

7.4.7.3 Build Alternative 3

Construction of the Build Alternative 3 would not generate new natural geologic hazard areas (landslide, lateral spreading, subsidence, liquefaction, or collapse), or result in significant impacts on the geologic environment of the Affected Area. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions related to potential on- or off-site lateral spreading, subsidence, liquefaction or collapse or seismic-related ground failure, including liquefaction. Therefore, impacts would be less than significant, and no mitigation measures would be required. See Section 7.4.5 for discussion on temporary excavations for the Build Alternatives. Additional information on the various construction techniques that may be utilized are included in the Construction Methods Report (Metro 2020b).

Mitigation Measures

No mitigation measures required.

Impacts Remaining after Mitigation

No impact.

7.4.7.4 Build Alternative 4, Including the MSF Site Options

Construction of the Build Alternative 4, including the MSF site options, would not generate new natural geologic hazard areas (landslide, lateral spreading, subsidence, liquefaction, or collapse), or result in significant impacts on the geologic environment of the Affected Area. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions related to potential on- or off-site lateral spreading, subsidence, liquefaction or collapse or seismic-related ground failure, including liquefaction. Therefore, impacts would be less than significant, and no mitigation measures would be required. See Section 7.4.5 for discussion on temporary excavations for the Build

Alternatives. Additional information on the various construction techniques that may be utilized are included in the Construction Methods Report (Metro 2020b).

Mitigation Measures

No mitigation measures required.

Impacts Remaining after Mitigation

No impact.

7.4.8 Would the project be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property?

7.4.8.1 Build Alternatives, Design Options and MSF Site Options

Construction of the Build Alternatives, including Design Options 1 and 2, and the MSF sites, would not have a significant impact on the expansive potential of the soils in the Affected Area. The design features being considered are not uncommon for the Los Angeles region and would not exacerbate existing geologic conditions related to expansive soils during construction. Therefore, impacts would be less than significant, and no mitigation measures would be required.

Mitigation Measures

No mitigation measures required.

Impacts Remaining after Mitigation

No impact.

7.4.9 Would the project have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?

7.4.9.1 Build Alternatives, Design Options and MSF Site Options

Construction activities associated with the Build Alternatives, including Design Options 1 and 2, and the MSF sites, would all take place within highly urbanized areas served by existing municipal sewage systems. The use of septic tanks or alternative wastewater systems during construction is not anticipated under the Build Alternatives. No impacts would occur, and no mitigation measures would be required.

Mitigation Measures

No mitigation measures required.

Impacts Remaining after Mitigation

No impact.

7.4.10 Would the project directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?

See the Paleontological Resource Impacts Analysis Report (Metro 2021a) for determination.

8 PROJECT MEASURES AND MITIGATION MEASURES

As discussed in Section 5.2 and 5.3, potential impacts associated with the design and operation of the Build Alternatives, Design Options 1 and 2, and MSF sites, would be minimized through compliance with established design standards discussed in Section 3.3.1 and implemented through Project Measures GEO PM-1 (Geotechnical Design [Operation]) and GEO PM-2 (Oil and Gas Zones [Operation]), and Mitigation Measures GEO-1 (Hazardous Gas [Operation]), GEO-2 (Structural Design), GEO-3 (Gas Monitoring [Operation]), and GEO-4 (Tunnel Advisory Panel). Project Measure GEO PM-1 is applicable to all of the Build Alternatives, design options, and MSF sites. Project Measure GEO PM-2 and Mitigation Measures GEO-1 through GEO-4 are specific to Build Alternatives 1 and 2.

8.1 Project Measures

Metro would verify that the following Project Measures (which were developed in accordance with the design requirements summarized in Section 3) are implemented to reduce geologic-, soils-, and seismicity-related impacts. These Project Measures are required and are part of the Project.

8.1.1 GEO PM-1: Geotechnical Design (Operation)

A number of geotechnical design reports are required for the Project, as detailed in the MRDC, Section 5.6, Geotechnical Investigations, Analysis and Design. Section 5.6 of the MRDC provides detailed requirements for the planning and conducting a geotechnical investigation, geotechnical design methodologies, and reporting. In addition, and as referenced in the MRDC, Caltrans and the County of Los Angeles Building Code have their own design requirements for bridges and aerial structures (Caltrans) and building structures (County of Los Angeles) that are also required.

In accordance with the MRDC, geotechnical report recommendations would be incorporated into the project plans and specifications. These recommendations would be a product of final design and would address the subsurface hazards identified in this report. Without these report recommendations, the project plans and specifications would not be approved, and the Project would not be allowed to advance into the final design stage nor ultimately into construction. As a part of the WSAB conceptual engineering phase, Metro has developed a comprehensive geotechnical field investigation and laboratory testing program (Metro 2020d) and is in the process of implementing the program. Findings from that program would be used to verify the information presented in the final EIS/EIR.

8.1.2 GEO PM-2: Oil and Gas Zones (Operation)

The primary protection for hazardous gases during system operations would be provided by physical barriers, which may include gasketed tunnel liner systems and gas-proofing membranes. Tunnels, stations, and appurtenant facilities would be designed in accordance with the City of Los Angeles Municipal Code, Chapter IX, Building Regulations, Article 1, Division 71, Methane Seepage Regulations, as amended by the City of Los Angeles Methane Ordinance (No. 175790). Design requirements would be specific to verified methane levels and pressures measured along the Affected Area, and would be incorporated into the design and construction. The requirements would include constructing subterranean walls with waterproof and vapor-proof membranes and designing the tunnels and stations to provide a redundant protection system against gas intrusion hazards.

Gases would be purged from the tunnels simply by the air movement caused by the action of trains running through the tunnels. During non-revenue operations, air velocity would be maintained mechanically at a minimum of 100 feet per minute, per Metro's Design Criteria. This air velocity is the minimum that the ventilation system must achieve to direct gases toward the nearest point of extraction and prevent hazardous gases from accumulating during the hours when trains are not operating. Additional mechanical ventilation would also be employed during revenue operations.

Metro has extensively studied methane and hydrogen sulfide impacts on tunnel projects throughout Los Angeles and has developed methods for reducing or eliminating hazardous conditions in its facilities while in operation (Metro 2017). Prior to construction, Metro would require contractors to complete an assessment for methane and hydrogen sulfide in accordance with LADBS Site Testing Standards for Methane (LADBS 2014) guidelines where the Affected Area passes through oil fields, methane zones, and/or methane buffer zones. The assessment would determine where hazardous gases are present and at what quantities. In areas where elevated gases are detected, soil gas probes would be installed to monitor for methane, hydrogen sulfide, oxygen, and carbon dioxide before, during, and after tunneling. In accordance with the MRDC Structural/Geotechnical section, the gas proofing leakage criteria mandates to: Design all underground structures to prevent the ingress from the ground of soil, water, hydrocarbons and gas with no dripping water or visible signs of hydrocarbons. MRDC indicates that during operation of underground structures, no detectable methane or hydrogen sulfide gas above 2.5 percent of the lower explosive limit (LEL) for methane or 1.5 ppm for hydrogen sulfide shall be detectable at an air velocity of 60 feet per minute.

8.1.3 GEO PM-3: Geotechnical Design (Construction)

A number of geotechnical design reports are required for the Project, as detailed in the MRDC, Section 5.6, Geotechnical Investigations, Analysis and Design. Section 5.6 of the MRDC provides detailed requirements for the planning and conducting a geotechnical investigation, geotechnical design methodologies, and reporting. In addition, and as referenced in the MRDC, Caltrans and the County of Los Angeles Building Code have their own design requirements for bridges and aerial structures (Caltrans) and building structures (County of Los Angeles) that are also required.

In accordance with the MRDC, geotechnical report recommendations would be incorporated into the project plans and specifications. These recommendations would be a product of final design and would address the subsurface hazards identified in this report. The design reports would also provide recommendations to be implemented during construction. The construction recommendations would address temporary excavations, ground settlement and ground loss, and would include construction monitoring plans. As part of the construction monitoring plans, and for protection against potential ground settlement induced by tunneling and other excavation activities, preconstruction surveys would be performed to document the existing conditions of buildings along the alignment before tunneling begins. During construction, instrumentation (e.g., ground surface and building monitoring devices) would be put in place to measure movements and provide information to the contractor on tunneling performance and to document that the settlement specifications are met. If measurements indicate settlement limits would be exceeded, the contractor would be required to change or add methods and procedures to comply with those limits. In addition, construction work would be reassessed when settlements exceed action (warning) levels. Contractors would be required to modify construction methods if settlements exceed specified maximum levels. Implementation of these recommendations and monitoring plans would be required, as applicable, for both on-site and off-site properties and existing improvements.

Without these construction recommendations, the project plans and specifications would not be approved, and the Project would not be allowed to advance into the final design stage or ultimately into construction. As a part of the WSAB conceptual engineering phase, Metro has developed a comprehensive geotechnical field investigation and laboratory testing program and is in the process of implementing the program. Findings from that program would be used to verify the information presented in the final EIS/EIR.

8.1.4 GEO PM-4: Oil and Gas Zones (Construction)

Construction of the tunnels, stations, and appurtenant facilities would be designed in accordance with the City of Los Angeles Municipal Code, Chapter IX, Building Regulations, Article 1, Division 71, Methane Seepage Regulations, as amended by the City of Los Angeles Methane Ordinance (No. 175790). Design requirements would be specific to verified methane levels and pressures measured along the Affected Area, and would be incorporated into the design and construction.

Metro would continuously monitor for gaseous environments in its tunnels during construction and would have emergency ventilation in all of its tunnel facilities, in addition to standard ventilation. Tunnels would have adequate ventilation to dilute gases to safe levels. The main ventilation systems would exhaust flammable gas or vapors from the tunnel, be provided with explosion-relief mechanisms, and be constructed of fire-resistant materials (Metro 2012a).

Metro has extensively studied methane and hydrogen sulfide impacts on tunnel projects throughout Los Angeles and has developed methods for reducing or eliminating hazardous conditions in its facilities while under construction (Metro 2017). Prior to construction, Metro would require contractors to complete an assessment for methane and hydrogen sulfide in accordance with Site Testing Standards for Methane (LADBS 2014) guidelines where the Affected Area passes through oil fields, methane zones, and/or methane buffer zones. The assessment would determine where hazardous gases are present and at what quantities. In areas where elevated gases are detected, soil gas probes would be installed to monitor for methane, hydrogen sulfide, oxygen, and carbon dioxide before, during, and after tunneling.

During construction, Metro may use pressurized-face tunnel boring machines that could help control intrusion of hazardous gases into the tunnel. The tunnel boring machines may use an enclosed mucking system to prevent spoil and groundwater from releasing gas into the tunnel. An adequate ventilation system that would dilute and transport gases out of the tunnel would be mandated.

At stations located within methane zones, construction can be accomplished by installing a relatively impervious cut-off wall (such as a slurry wall) that reduces gas migration into the work area during construction or tunnel/station area after construction. The acceptable levels of gas migration during construction and operation are based on OSHA and MRDC requirements.

To protect workers during construction, the California Occupational Safety and Health Act requires monitoring devices to detect gas and trigger automatic shutdown of the tunnel boring machines. Equipment used in the tunnel would be sealed and would be of explosion-proof design. Refuge chambers or alternate escape routes may be required, depending on site-specific conditions.

8.2 Mitigation Measures

8.2.1 GEO-1 Hazardous Gas (Operation)

Metro would 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 for operation, included as part of Mitigation Measure GEO-2 (Structural Design). Measures to monitor and control hazardous subsurface gas would 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 set to send alarms to activate ventilation systems and evacuate structures as follows: methane gas—minor alarm at 10 percent of the LEL (activate ventilation) and major alarm at 20 percent of the LEL (evacuation of area)
- Hydrogen sulfide—Minor alarm at 8 parts per million (ppm) and major alarm at 10 ppm

8.2.2 GEO-2 Structural Design

Protection from hazardous gases during project operation is provided by physical barriers, including tunnel liner membranes and station liner membranes that reduce gas from migrating into an occupied space. The acceptable levels of gas migration during operation are based on OSHA and MRDC requirements, or equivalents.

Designs to reduce gas and groundwater intrusion in tunnels would also be used where appropriate, including the following:

- Additional barriers
- Compartmentalized barriers to facilitate leak sealing
- Flexible sealants, such as poly-rubber gels, along with high-density polyethylene-type materials
- Secondary station walls to provide additional barriers
- Active ventilation systems

The evaluations for station and tunnel construction materials would include laboratory testing during development of the system and material selection. The testing programs would review the following:

- Segment leakage: Pressurized gasket seal testing before, during, and after seismic movements, including various gasket materials and varying gasket profiles
- Gasket material properties: Effective product-life testing and resistance testing to deterioration when subjected to manmade and natural contaminants, including methane/hydrogen sulfide gases, asphaltic materials, and other typical and potentially damaging construction materials
- Various high-density polyethylene products (including poly-rubber gels currently used in ground containing methane in other cities): to be tested/utilized as appropriate/needed

Alternative methods for field testing of high-density polyethylene joints would be examined to provide additional quality control during installation.

Metro's gas proofing leakage criteria mandates to: Design all underground structures to prevent the ingress from the ground of soil, water, hydrocarbons and gas with no dripping water or visible signs of hydrocarbons. During operation of underground structures, no detectable methane or hydrogen sulfide gas above 2.5 percent of the LEL for methane or 1.5 ppm for hydrogen sulfide shall be detectable at an air velocity of 60 feet per minute.

8.2.3 GEO-3 Gas Monitoring (Operation)

In accordance with MRDC requirements or equivalent, during operation of the Project, monitoring and recording of hazardous gas levels would be required to protect the public in areas of known or suspected gassy soil conditions. The hazardous gas levels in the operating environment would be continuously monitored and recorded. During operation, if gas levels increase (trigger levels are included as part of Mitigation Measure GEO-1 [Hazardous Gas [Operation] and GEO-2 [Structural Design]) and pose risk to life, alarms would be triggered, and the area would be evacuated immediately. After evacuation, procedures would be in place instructing personnel on how to safely proceed if elevated levels are detected.

8.2.4 GEO-4 Tunnel Advisory Panel

As was done for other recent Metro projects, Metro TAP would review designs with respect to subsurface gas hazards in the areas of identified higher risk: (i.e., the Alternative 1 and Alternative 2 tunnel and station areas within mapped methane zones and methane buffer zones). The advisory panel consists of highly qualified tunnel design experts who would provide guidance on hazardous gases, gas intrusion, and ground contaminant effects on underground structures.

8.2.5 GEO-5 Gas Monitoring (Construction)

In accordance with the MRDC or equivalent, during construction of underground portions of the Project, monitoring and recording of hazardous gas levels would be required to protect the public and workers in areas of known or suspected gassy soil conditions. The hazardous gas levels in the construction environment would be continuously monitored and recorded. If monitoring gas levels exceed the most recent thresholds established by Cal/OSHA, construction schedules and processes would be altered to maintain a safe worksite atmosphere (such as by increasing mechanical ventilation, or by installing a relatively impervious cut-off wall that reduces gas migration into the work area during construction). The working environment would comply with federal, state, and local regulations, including the South Coast Air Quality Management District and Cal/OSHA standards.

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