Regional Connector Transit Corridor
Draft Environmental Impact Statement/
Draft Environmental Impact Report

APPENDIX U

GEOTECHNICAL/SUBSURFACE/ SEISMIC/HAZARDOUS MATERIALS

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Regional Connector Transit Corridor Geotechnical/Subsurface/Seismic/ Hazardous Materials Technical Memorandum

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TABLE OF CONTENTS

1.0 Summary 1
2.0 Introduction 3
3.0 Methodology for Impact Evaluation 5
3.1 Regulatory Framework 5
3.1.1 Federal 5
3.1.1.1 Geology, Soils, and Seismicity 5
3.1.1.2 Hazardous Materials Resources 5
3.1.1.2.1 RCRA 5
3.1.1.2.2 CERCLA 5
3.1.1.2.3 SARA 5
3.1.1.2.4 Toxic Substances Control Act (TSCA) 6
3.1.1.2.5 Federal Occupational Safety and Health Act 6
3.1.2 State 6
3.1.2.1 Geology, Soils, and Seismicity 6
3.1.2.2 Hazardous Materials Resources 7
3.1.2.3 California Hazardous Waste Control Law, California Health and Safety Code, Division 20, Chapter 6.5 7
3.1.2.4 Carpenter-Presley-Tanner Hazardous Substances Account Act, California Health and Safety Code, Division 20, Chapter 6.8 7
3.1.2.5 State California Occupational Safety and Health Act 7
3.1.2.6 Unified Hazardous Waste and Hazardous Materials Management Regulatory Program 7
3.1.2.7 Waters Bill of 1985 (Business Emergency Plan/Hazardous Materials Business Plan) 8
3.1.2.8 La Follette Bill of 1986 (Risk Management Plan) 8
3.1.2.9 South Coast Air Quality Management District (SCAQMD) Rule 1403 8
3.1.3 Local 9
3.2 Standards of Significance 9
3.2.1 National Environmental Policy Act (NEPA) 9
3.2.2 California Environmental Quality Act (CEQA) 10
3.3 Evaluation Methodology 11
4.0 Affected Environment 13
4. 1 Regional Setting 13
4.2 Regional Geology 13
4.3 Faulting and Seismicity 14
4.3.1 General Setting 14
4.3.2 Active Faults 14

4.3.2.1 Potentially Active Faults ... 15
4.3.2.2 Blind Thrust Fault Zones ... 15
4.3.2.3 Coyote Pass Escarpment ... 18
4.3.2.4 Ground Shaking ... 26
4.3.2.5 Liquefaction ... 28
4.3.2.6 Settlement ... 29
4.3.2.7 Landslides ... 29
4.3.2.8 Flooding ... 30
4.3.2.9 Seiches and Tsunamis ... 32
4.4 Mineral Resources ... 32
4.5 Hazardous Materials ... 32

5.0 Impacts ... 39

5.1 No Build Alternative ... 39
5.1.1 Geotechnical, Subsurface, and Seismic Hazards ... 39
5.1.2 Hazardous Materials ... 39
5.1.2.1 Direct Impacts ... 39
5.1.2.2 Indirect Impacts ... 39
5.1.2.3 Cumulative Impacts ... 39
5.2 Transportation System Management (TSM) Alternative ... 39
5.2.1 Geotechnical, Subsurface, and Seismic Hazards ... 39
5.2.2 Hazardous Materials ... 40
5.2.2.1 Direct Impacts ... 40
5.2.2.2 Indirect Impacts ... 40
5.2.2.3 Cumulative Impacts ... 40
5.3 At-Grade Emphasis Light Rail Transit (LRT) Alternative ... 40
5.3.1 Geotechnical, Subsurface, and Seismic Hazards ... 40
5.3.2 Hazardous Materials ... 41
5.3.2.1 Direct Impacts ... 41
5.3.2.1.1 Hazardous Materials Encountered in Soil and/or Groundwater During Construction ... 41
5.3.2.1.2 Accidental Release of Construction-Related Hazardous Materials ... 42
5.3.2.1.3 Accidental Release of Hazardous Materials During Operation ... 43
5.3.2.1.4 Hazards Associated with Subsurface Oilfield Gases ... 43
5.3.2.1.5 Release of Asbestos Fibers and/or Lead-Based Paint Particles ... 44
5.3.2.1.6 Hazards Associated with Electromagnetic Fields (EMFs) ... 44
5.3.2.2 Indirect Impacts ... 44
5.3.2.3 Cumulative Impacts ... 44
5.4 Underground Emphasis LRT Alternative ... 45
5.4.1 Geotechnical, Subsurface, and Seismic Hazards ... 45
5.4.2 Hazardous Materials ... 46
5.4.2.1 Direct Impacts ... 46

5.4.2.1.1 Hazardous Materials Encountered in Soil and/or Groundwater During Construction ... 46
5.4.2.1.2 Accidental Release of Construction-Related Hazardous Materials ... 47
5.4.2.1.3 Accidental Release of Hazardous Materials During Operation ... 47
5.4.2.1.4 Hazards Associated with Subsurface Oilfield Gases ... 48
5.4.2.1.5 Release of Asbestos Fibers and/or Lead-Based Paint Particles ... 48
5.4.2.1.6 Hazards Associated with Electromagnetic Fields (EMF) ... 48
5.4.2.2 Indirect Impacts ... 48
5.4.2.3 Cumulative Impacts ... 49
5.5 Fully Underground LRT Alternative – Little Tokyo Variation 1 ... 49
5.5.1 Geotechnical, Subsurface, and Seismic Hazards ... 49
5.5.2 Hazardous Materials ... 50
5.5.2.1 Direct Impacts ... 50
5.5.2.1.1 Hazardous Materials Encountered in Soil and/or Groundwater During Construction ... 50
5.5.2.1.2 Accidental Release of Construction-Related Hazardous Materials ... 51
5.5.2.1.3 Accidental Release of Hazardous Materials During Operation ... 51
5.5.2.1.4 Hazards Associated with Subsurface Oilfield Gases ... 51
5.5.2.1.5 Release of Asbestos Fibers and/or Lead-Based Paint Particles ... 51
5.5.2.1.6 Hazards Associated with Electromagnetic Fields (EMF) ... 51
5.5.2.2 Indirect Impacts ... 51
5.5.2.3 Cumulative Impacts ... 52
5.6 Fully Underground LRT Alternative – Little Tokyo Variation 2 ... 52
6.0 Potential Mitigation Measures ... 53
6.1 Potential Construction Mitigation Measures ... 53
6.2 Potential Operational Mitigation Measures ... 55
7.0 Conclusions ... 57
7.1 No Build Alternative ... 57
7.1.1 NEPA Finding ... 57
7.1.2 CEQA Determination ... 57
7.2 TSM Alternative ... 57
7.2.1 NEPA Finding ... 57
7.2.2 CEQA Determination ... 57
7.3 At-Grade Emphasis LRT Alternative ... 57
7.3.1 NEPA Finding ... 57
7.3.2 CEQA Determination ... 57
7.4 Underground Emphasis LRT Alternative ... 58
7.4.1 NEPA Finding ... 58
7.4.2 CEQA Determination ... 58
7.5 Fully Underground LRT Alternative – Little Tokyo Variation 1 ... 58

7.5.1 NEPA Finding 58
7.5.2 CEQA Determination 58
7.6 Fully Underground LRT Alternative – Little Tokyo Variation 2 58
7.6.1 NEPA Finding 58
7.6.2 CEQA Determination 59
8.0 References Cited 61
Appendix A Description of Construction Activities for Build Alternatives 63

Tables

4-1. Active Faults Near Flower and 5th Streets 19
4-2. Active Faults Near Bunker Hill 21
4-3. Active Faults Near 2nd Street and Central Avenue 23
4-4. Potential Ground Motion Along Project Alignment 27
4-5. Properties of High/Moderate Concern 34

Figures

4-1. Regional Geology 16
4-2. Regional Faults and Alquist-Priolo Earthquake Fault Zones 17
4-3. Liquefaction and Landslide Hazards 31
4-4. Known or Suspected Hazardous Materials in Soil and/or Groundwater within 0.25 Miles of Proposed Alignments 37

ACRONYMS

BEP	Business Emergency Plan
BMPs	Best Management Practices
Cal OSHA	California Occupational Safety and Health Administration
CBC	California Building Code
CDMG	California Division of Mines and Geology
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CGS	California Geological Survey
CUPA	Certified Unified Program Agencies
DEIR	Draft Environmental Impact Report
DEIS	Draft Environmental Impact Statement
DTSC	California Department of Toxic Substances Control
EDR	Environmental Data Resources
EMF	Electromagnetic Field
EPCRA	Emergency Planning and Community Right-to-Know Act
HMBP	Hazardous Materials Business Plan
LPA	Locally Preferred Alternative
LRT	Light Rail Transit
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NGA	Next Generation Attenuation

OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated biphenyls
PCE	Tetrachloroethene
RCRA	Resource Conservation and Recovery Act
RMP	Risk Management Plan
RWQCB	Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act
SCAQMD	South Coast Air Quality Management District
TBM	Tunnel boring machine
TPH-g	Total petroleum hydrocarbons - gasoline
TSCA	Toxic Substances Control Act
TSM	Transportation Management System
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tank
VOC	Volatile Organic Compound

1.0 SUMMARY

This technical memorandum presents an evaluation of the potential impacts related to the geologic conditions of the Regional Connector project area, including the general topography, geologic materials, faults, seismicity, and potential hazardous materials. The regulatory framework and a discussion of potential impacts related to these conditions are presented.

The project alignment is not located within the Alquist-Priolo Earthquake Fault zone. No adverse effects are anticipated related to geotechnical, subsurface, or seismic hazards from the No Build Alternative or the TSM Alternative. However, ground shaking would be expected during a seismic event on one of the nearby faults. There is some potential for adverse impacts related to liquefaction or seismically-induced settlement along portions of all of the build alternatives (the At-Grade Emphasis LRT Alternative, the Underground Emphasis LRT Alternative, the Fully Underground LRT Alternative – Little Tokyo Variation 1, and the Fully Underground LRT Alternative – Little Tokyo Variation 2), but there would be no potential for adverse impacts related to fault rupture, landslides, flooding, seiches, or tsunamis for any of these alternatives. In addition to the seismic hazards, there would be a potential for ground loss due to tunneling for the Underground Emphasis LRT Alternative, and the Fully Underground LRT Alternative – Little Tokyo Variation 1 and Little Tokyo Variation 2.

A geotechnical investigation would be performed during preliminary design along the preferred alignment to supplement and provide site specific data to facilitate design for maintaining the integrity of existing structures under static and seismic loading and operational demands. Although portions of the alignment would be constructed in potential liquefaction zones, none are expected to result in or exacerbate geologic hazards. The subway tunnels and the stations would be located at depths generally below soils prone to liquefaction, and would be subject to standard design specifications to keep potential risks of damage from liquefaction to an acceptable level.

Potential ground loss due to tunneling and settlement of adjacent structures (including historical buildings)would be mitigated with a number of measures including: a preconstruction survey to establish baseline conditions; ground improvement such as grouting along the alignment and adjacent structures potentially affected by the tunneling work; instrumentation and monitoring during tunneling; requirements on the contractor to use earth pressure balance or slurry shield tunnel boring machine and method of operation based on the anticipated ground conditions; and limiting potential settlement to below an acceptable threshold value established during final design.

While there would be no impacts related to hazardous materials from the No Build Alternative or the TSM Alternative, there is potential for direct, indirect, and cumulative impacts from the build alternatives. These impacts relate primarily to the potential for release of hazardous materials encountered in soil and/or groundwater during construction at properties of

concern along the proposed alignments. These hazardous materials include petroleum gases in the subsurface associated with oil deposits in the project area. Impacts may also occur from release of fibers from asbestos-containing materials or lead-based paint during building demolition, or the accidental release of construction-related hazardous materials such as fuels.

Compliance with applicable laws and regulations as well as implementation of best management practices (BMPs) regarding the use, storage, and transport of hazardous materials and wastes would ensure these potential impacts would be less than significant.

In addition, mitigation would be required to address the potential presence of hazardous subsurface gases along the proposed alignment during both construction and operation. Testing and abatement of asbestos containing materials and lead-based paint would also be implemented. With mitigation, impacts related to hazards and hazardous materials would be less than significant.

2.0 INTRODUCTION

Geology, soils, seismicity, and hazardous materials are factors that determine design criteria for the development of transit improvements, particularly when subsurface or aerial stations or structures are involved. In addition, downtown Los Angeles has a long history of residential, commercial, and industrial land uses which entailed the use, handling, storage, and disposal of hazardous materials. If releases of hazardous materials have occurred at properties located along or near the proposed Regional Connector alignments, there is a potential to encounter contaminated soil and/or groundwater during construction. Naturally-occurring hazardous materials may also be present within the project area from the oil- and/or gas-bearing geologic formations that underlie Los Angeles. These natural hazards include methane and hydrogen sulfide gas. Other hazards include the potential for release of construction-related hazardous materials and the introduction of electromagnetic fields (EMF). This technical memorandum presents an evaluation of potential impacts geology, soils, seismicity, and hazardous materials would have on the project and proposed mitigation measures to address these impacts.

3.0 METHODOLOGY FOR IMPACT EVALUATION

3.1 Regulatory Framework

The following sections present brief discussions of the regulatory framework applicable to the jurisdictions located within the project area.

3.1.1 Federal

3.1.1.1 Geology, Soils, and Seismicity

There are no specific federal regulations related to the geologic hazards of soils and seismicity.

3.1.1.2 Hazardous Materials Resources

The United States Environmental Protection Agency (USEPA) is the lead federal agency responsible for enforcing federal regulations regarding hazardous materials. The primary legislation governing hazardous materials includes the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the Superfund Amendments and Reauthorization Act (SARA).

3.1.1.2.1 RCRA

RCRA regulates the generation, transportation, treatment, storage and disposal of hazardous waste through comprehensive life cycle or "cradle to grave" tracking requirements. These include maintaining inspection logs of hazardous waste storage locations, records of quantities being generated and stored, and manifests of pick-ups and deliveries to licensed treatment/storage/ disposal facilities. RCRA also identifies standards for treatment, storage, and disposal.

3.1.1.2.2 CERCLA

CERCLA, also known as Superfund, created a tax on the chemical and petroleum industries to provide for response and cleanup of hazardous substances that may endanger public health or the environment. CERCLA established requirements for abandoned hazardous waste sites and provided for liability of persons responsible for releases of hazardous waste at these sites.

3.1.1.2.3 SARA

SARA amended CERCLA to increase state involvement and required Superfund actions to consider state environmental laws and regulations. SARA also established a regulatory program for underground storage tanks (USTs) and the Emergency Planning and Community Right-to-Know Act (EPCRA).

3.1.1.2.4 Toxic Substances Control Act (TSCA)

TSCA established the mechanisms by which USEPA tracks, screens, and tests industrial chemicals currently produced or imported into the United States that may pose an environmental or human-health hazard. TSCA addresses the production, importation, use, and disposal of specific chemicals including polychlorinated biphenyls (PCBs), asbestos, radon and lead-based paint.

3.1.1.2.5 Federal Occupational Safety and Health Act

The Occupational Safety and Health Administration (OSHA) administers this legislation which requires special training of handlers of hazardous materials, notification to employees who work in the vicinity of hazardous materials, acquisition from the manufacturer of material safety data sheets which describe the proper use of hazardous materials, and training of employees to remediate any hazardous material accidental releases.

This legislation regulates lead and asbestos as it relates to employee safety through a set of notification and corrective action requirements, warning signs and labels, controlled access, use of protective equipment, demolition/renovation procedures, housekeeping controls, training, and in certain cases, air monitoring and medical surveillance to reduce potential exposure. This legislation also requires contractors conducting lead-based paint and asbestos surveys and removal to be certified by the California Occupational Safety and Health Administration (Cal OSHA).

3.1.2 State

3.1.2.1 Geology, Soils, and Seismicity

The principal state guidance relating to geologic hazards is contained in the Alquist-Priolo Act (P.R.C. 2621 et seq.) and the Seismic Hazards Mapping Act of 1990 (P.R.C. 2690-2699.6). The Alquist-Priolo Act prohibits the location of most types of structures for human occupancy across active traces of faults in earthquake fault zones, shown on maps prepared by the state geologist, and regulates construction in the corridors along active faults (earthquake fault zones). Earthquake Fault Zones are regulatory zones around active faults designated by the State. The zones vary in width, but average about one-quarter mile wide.

The Seismic Hazards Mapping Act of 1990 focuses on hazards related to strong ground shaking, liquefaction, and seismically-induced landslides. Under its provisions, the state is charged with identifying and mapping areas at risk of strong ground shaking, liquefaction, landslides, and other corollary hazards. The maps are to be used by cities and counties in preparing their general plans and adopting land use policies to reduce and mitigate potential hazards to public health and safety.

Pursuant to the Surface Mining and Reclamation Act (P.R.C. 2710 et seq.), the State Mining and Geology Board identifies, in adopted regulations, areas of regional significance that are known to contain mineral deposits judged to be important in meeting the future needs of the area (P.R.C. 2426 and 2790; Title 14 P.C.R. 3350, et seq.). The State Mining and Geology Board also adopts state policy for the reclamation of mined lands and certifies local ordinances for the approval of reclamation plans as being consistent with state policies (P.R.C. 2755-2764, 2774 et seq.).

3.1.2.2 Hazardous Materials Resources

The California Department of Toxic Substances Control (DTSC) and the Regional Water Quality Control Board (RWQCB) are the state agencies primarily responsible for the regulation of hazardous materials in California. DTSC is responsible for the management of hazardous substances and oversees the investigation and remediation of contaminated sites. The Los Angeles RWQCB is primarily responsible for the protection of groundwater and surface water resources from hazardous materials in the project area.

3.1.2.3 California Hazardous Waste Control Law, California Health and Safety Code, Division 20, Chapter 6.5

This state legislation is the basic hazardous waste statute in California and is administered by DTSC. Similar to but more stringent than RCRA, this law applies to a broader range of hazardous wastes and requires recycling and waste reduction programs.

3.1.2.4 Carpenter-Presley-Tanner Hazardous Substances Account Act, California Health and Safety Code, Division 20, Chapter 6.8

This legislation authorizes DTSC and RWQCB to require, oversee, and recover costs for the remediation of sites where contamination of soil and water present a hazard to human health or the environment.

3.1.2.5 State California Occupational Safety and Health Act

Cal OSHA regulates worker safety similar to federal OSHA but also requires preparation of an Injury and Illness Prevention Program, an employee safety program of inspections, procedures to correct unsafe conditions, employee training, and occupational safety communication. In addition, Cal OSHA regulations indirectly protect the general public by requiring construction managers to post warnings signs, limit public access to construction areas, and obtain permits for work considered to present a significant risk of injury, such as excavations greater than five feet.

3.1.2.6 Unified Hazardous Waste and Hazardous Materials Management Regulatory Program

The California Environmental Protection Agency (Cal EPA) adopted regulations in 1996 to establish a Unified Hazardous Waste and Hazardous Materials Management Regulatory Program and designated local agencies called Certified Unified Program Agencies (CUPAs).

These local agencies have jurisdiction to manage hazardous substances with respect to the following:

- Hazardous waste generators and hazardous waste onsite treatment;
- Underground Storage Tanks ;
- Aboveground storage tanks;
- Hazardous materials release response plans and inventories (business emergency plans), including Unified Fire Code hazardous materials management plans and inventories; and
- Risk management and accidental release prevention programs.

The CUPA with local jurisdiction over the proposed project area is the Los Angeles County Fire Department, Health Hazardous Materials Division.

3.1.2.7 Waters Bill of 1985 (Business Emergency Plan/Hazardous Materials Business Plan)

Administered by the CUPA, this State legislation requires facilities which meet minimum hazardous materials use/storage thresholds to file a Business Emergency Plan (BEP), or a Hazardous Materials Business Plan (HMBP), which includes a complete inventory of the hazardous materials being used and stored on a site. Employee training and emergency response plans and procedures for the accidental release of hazardous materials are also included in a BEP.

3.1.2.8 La Follette Bill of 1986 (Risk Management Plan)

Administered by the CUPA, this State legislation requires preparation of a Risk Management Plan (RMP) for commercial operations which use hazardous materials at defined thresholds. The RMP includes management, engineering and safety studies, and plans for physical improvements to minimize accidental hazardous materials releases. It is implemented via fire inspections, plan checking, BEP/HMBP disclosure requirements, and filing of the RMP (updated every three years).

3.1.2.9 South Coast Air Quality Management District (SCAQMD) Rule 1403

This State legislation regulates asbestos as a toxic material and controls the emission of asbestos from demolition and renovation. Rule 1403 establishes requirements for surveying structures and procedures for the removal, handling, storage, and disposal of asbestos-containing materials.

3.1.3 Local

Local jurisdictions, departments, and documents that regulate and oversee issues related to geology, soils, seismicity, and hazardous materials within the study area are listed below.

Geology, Soils, and Seismicity:

- The 1996 City of Los Angeles General Plan, Safety Element
- The City of Los Angeles Department of Building and Safety
- The 1990 Los Angeles County General Plan, Seismic Safety Element
- The County of Los Angeles Department of Public Works

Hazardous Materials:

- The City of Los Angeles Department of Building and Safety
- The City of Los Angeles Bureau of Sanitation, Industrial Waste Management Division
- The City of Los Angeles Fire Department, Hazardous Materials Divisions
- The City of Los Angeles Fire Department, Underground Storage Tank Division
- Uniform Fire Code
- Los Angeles Municipal Code- Methane and Methane Buffer Zones

3.2 Standards of Significance

Standards of significance provide thresholds for determining whether potential impacts are more than insignificant.

3.2.1 National Environmental Policy Act (NEPA)

NEPA does not have specific requirements related to geologic hazards or soils. NEPA requires an evaluation of potential impacts related to hazardous materials, which may be categorized in two different ways. First, there is potential for hazardous materials associated with previous land use to pose an impact for the proposed project. Second, there is potential for the proposed project to generate hazardous material impacts to the surrounding human and natural environments. Impacts associated with hazardous materials may occur during construction or operation of the project.

3.2.2 California Environmental Quality Act (CEQA)

Potential impacts related to geology, soils, and seismicity are addressed in the *Los Angeles CEQA Threshold Guide* under Section E, Geology. There are four areas of study relative to geology: E.1 geologic hazards, E.2 sedimentation and erosion, E.3 landform alteration, and E.4 mineral resources. The first three areas of study are addressed in this section. Mineral resources are not expected to be considered in the Draft Environmental Impact Statement (DEIS)/Draft Environmental Impact Report (DEIR) as they are not known to be present in the downtown Los Angeles project area. The *Los Angeles CEQA Threshold Guide* (2006, page E.1-4) states that a project would normally have a significant geologic hazard impact if it would:

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

The *Los Angeles CEQA Thresholds Guide* (page E.2-3) states that a project would normally have a significant sedimentation and erosion impact if it would:

- Constitute a geologic hazard to other properties by causing or accelerating instability from erosion; or

- Accelerate natural processes of wind and water erosion and sedimentation, resulting in sediment runoff or deposition which would not be contained or controlled on-site.

Additionally, the *Los Angeles CEQA Thresholds Guide* (page E.3-2) states that a project would normally have a significant landform alteration impact if:

- One or more distinct and prominent geologic or topographic features would be destroyed, permanently covered or materially and adversely modified. Such features may include, but are not limited to, hilltops, ridges, hill slopes, canyons, ravines, rock outcrops, water bodies, streambeds, and wetlands.

The *Los Angeles CEQA Thresholds Guide* addresses impacts with respect to hazards under Section F, including F.1 Risk of Upset/Emergency Preparedness and F.2 Human Health Hazards. The *Los Angeles CEQA Thresholds Guide* (page F.1-2) states that a project would normally have a significant impact with respect to hazards if it would:

- Create a significant hazard to the public or environment through the routine transport, storage, use, or disposal of hazardous materials;

- Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment;

- Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school;
- Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5, and, as a result, create a significant hazard to the public or the environment; or
- Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan.

3.3 Evaluation Methodology

The method for assessing impacts involved reviewing and examining the project corridor for known geologic hazards and hazardous materials. Documents reviewed included, but were not limited to: the safety elements of the general plans for the City and County of Los Angeles; official Alquist-Priolo Earthquake Fault Zone Maps; official Seismic Hazard Zone Maps, geologic and topographic maps, and other publications by the California Geological Survey (CGS, previously California Division of Mines and Geology (CDMG)), United States Geological Survey, and California Division of Oil and Gas). If proposed stations or structures are located within or adjacent to geologic hazard areas or areas that are impacted by hazardous materials, there would be a potential for impact that would require additional geotechnical studies and may require enhanced design to eliminate or mitigate the potential hazards.

In general, impacts related to hazardous materials associated with current or previous land use are most relevant to the project alternatives that entail property acquisition and/or construction and thus have the potential to encounter hazardous materials, including contaminated soil and/or groundwater that may exist in the area of potential impact. The appropriate significance criteria as listed below were considered to determine the potential for each alternative to generate hazardous materials impacts.

The project build alternatives that entail property acquisition and/or construction (the At-Grade Emphasis LRT Alternative, the Underground Emphasis LRT Alternative, the Fully Underground LRT Alternative – Little Tokyo Variation 1, and the Fully Underground LRT Alternative – Little Tokyo Variation 2), have the potential to encounter hazardous materials that may exist in soil and/or groundwater. The methodology used to evaluate potential hazardous materials impacts associated with these alternatives entailed gathering information from a variety of sources to identify potential or existing conditions that would present environmental health and safety concerns within 0.25 mile of each side of the proposed alignments. These information sources included:

- Regulatory databases - The regulatory database search included local, state, and federal environmental databases for hazardous waste facilities, underground storage tank leak sites, former dry cleaners, chemical spill sites, county, state or federally directed waste cleanup sites, and other relevant environmental data.

- Regulatory agency files - For sites where hazardous materials may be a potential concern, supplemental information, such as investigation data, was gathered from regulatory agency files.
- Historical environmental information - This information was obtained from Sanborn fire insurance maps, historical aerial photographs, and historical topographic maps of the area of potential impact.
- Methane zones - Information on known methane zones was based on the City of Los Angeles Methane and Methane Buffer Zones map. This information will be supplemented as needed with field assessments of methane concentrations and pressure from geotechnical borings in the area of potential impact.
- Oil and natural gas - An analysis of potential hazards from known oil fields and oil or gas wells (active or abandoned) was based on California Department of Oil, Gas and Geothermal Resources maps and records reviews.
- Other hazardous materials - Potential impacts due to the presence of lead-based paint, asbestos containing materials, electromagnetic fields, and other hazards were evaluated.

In addition, a site reconnaissance was performed to observe surface conditions along the proposed alignments associated with the build alternatives.

A detailed evaluation of the results of the site reconnaissance and information gathered from the sources listed above is presented in the Hazardous Materials Investigation and Analysis report (CDM 2009). The Hazardous Materials Investigation and Analysis report identifies the sites located along the proposed alignments or on surrounding properties and provides a determination regarding the level of concern associated with environmental contaminants and/or naturally occurring hazardous substances that are known or suspected to exist at each site. Potential impacts from these sites were then evaluated for this section using the significance criteria described in Section 3.2.

4.0 AFFECTED ENVIRONMENT

4.1 Regional Setting

The proposed Regional Connector Transit Corridor project alignment is located in the northern portion of the Los Angeles Basin. This basin is a major elongated northwest-trending structural depression that has been filled with sediments up to 13,000 feet thick since middle Miocene time. On a regional scale, the project area lies within the northernmost portion of the Peninsular Ranges geomorphic provinces near its boundary with the Transverse Ranges geomorphic provinces. The Peninsular Ranges province is characterized by elongated northwest-trending mountain ridges separated by sub-parallel, sediment-filled valleys. This province is bounded by the San Jacinto fault zone to the east, the Pacific Ocean Coastline to the west, and the Transverse Ranges geomorphic province to the north. In contrast, the Transverse Ranges are characterized by east-west trending geologic structures and mountain ranges that include the Santa Ynez, San Gabriel, San Bernardino, and Santa Monica Mountains, and associated valleys. The Transverse Ranges province is a composite structural block bounded by the Big Pine fault on the north, the San Andreas fault zone to the east, the Pacific Ocean to the west, and the Malibu Coast, Santa Monica, Hollywood, Raymond, Sierra Madre, and Cucamonga faults to the south.

4.2 Regional Geology

The proposed project alignments will traverse the southeastern end of the Elysian Park Hills and the ancient floodplain of the Los Angeles River. The Elysian Hills comprise the low-lying hills west of the Los Angeles River and southeast of the eastern end of the Santa Monica Mountains. The Hollywood fault separates the northern end of the Elysian Hills from the Santa Monica Mountains. The Elysian Hills are comprised largely of Miocene age sedimentary rocks with Pliocene-age rocks flanking the southeastern edges of the hills. Previous geologic mapping identified several major geologic structures within the Elysian Hills, including the Elysian Park anticline and northwest trending faults. The southern limb of the anticlinorium contains apparent secondary folds of relatively shorter wavelength and lesser continuity of fold axes. In the vicinity of the proposed project alignments, bedding within the Fernando and Puente formations strike approximately east-west to slightly north of east and dips moderately to steeply to the south. The regional geology in the project vicinity is shown on Figure 4-1.

The geomorphology along the proposed alignments ranges from gently sloping alluvial floodplain surfaces to hillside slopes of moderate relief and grade. The steepest slopes along the alignment surface are between 3rd Street at Flower Street and Olive Street at 2nd Street. A review of the historical United States Geological Survey (USGS) topographic map of the Hollywood and Los Angeles Quadrangles shows a relatively narrow alluvial valley following Flower Street from 6th Street up-gradient to 3rd Street, then diverging to the northwest towards Glendale Boulevard (west of the SR 110 Harbor Freeway). This alluvial valley appears to be a tributary drainage course to an ancestral course of the Los Angeles River (i.e., prior to channelization of the modern Los Angeles River). The Los Angeles River floodplain covers the broad, gently sloping, alluvial terrain east of the Bunker Hill area. Artificial fill of variable thickness underlies the proposed alignment near the surface. Fill materials consist of mixtures of sand, silt, clay, with variable amounts of construction debris. Deep areas of fill to depths of approximately 25 feet below ground surface are present at abandoned tunnels and storm drain excavations that have been backfilled.

The historical high groundwater in the vicinity of the alignment ranged between 30 to 70 feet below the existing grade based on available historic borehole data presented in the Seismic Hazard Evaluation reports of the Los Angeles and Hollywood 7.5-Minute Quadrangles (CDMG 1998a and b). Additional groundwater information has been presented in the Water Resources Technical Memorandum.

4.3 Faulting and Seismicity

4.3.1 General Setting

The primary seismic considerations are surface rupture of the earth materials along fault traces and damage to structures due to seismically-induced ground shaking. There are numerous faults in Southern California including active, potentially active, and inactive faults. The fault classification system is based on criteria adopted by the CGS for the Alquist-Priolo Earthquake Zoning Program. An active fault is one that has had surface displacement within Holocene time (about the last 11,000 years). A potentially active fault is a fault that has demonstrated surface displacement of Quaternary age deposits (last 1.6 million years). Inactive faults have not moved in the last 1.6 million years. Active and potentially active faults that are located within ten miles of the alignment are discussed below with respect to their known activity status and location relative to the proposed alignments along Flower Street to 2nd Street.

Based on review of the available data, no known Holocene Active or Latest Pleistocene Active faults trend through the project area. The project area is not located within a currently established Alquist-Priolo earthquake fault zone for surface fault rupture and the proposed alignment does not traverse any known active fault. The location of the project area in relation to known faults is shown in Figure 4-2.

4.3.2 Active Faults

The Holocene active fault with surface expression closest to the project area is the Hollywood fault, located approximately 4.3 miles to the northwest of the proposed alignment. Active blind thrust faults in vicinity of the site are discussed separately below. Holocene Active faults within ten miles of the planned alignment include the Raymond fault (4.9 miles northeast of proposed alignment), the Newport-Inglewood fault zone (7.0 miles west-northwest of proposed alignment), Verdugo fault (7.1 miles north-northeast of the proposed alignment) and the Santa Monica fault (9.2 miles west of the proposed alignment).

The active Hollywood fault trends east-west along the base of the Santa Monica Mountains from the West Beverly Hills Lineament in the West Hollywood-Beverly Hills area to the Los Feliz area of Los Angeles. The fault is a groundwater barrier within Holocene sediments. Studies by several investigators have indicated that the fault is active based on geomorphic evidence, stratigraphic correlation between exploratory borings, and fault trenching studies. Although the Hollywood fault is considered active by the State Geologist, an Alquist-Priolo Earthquake Fault Zone has not yet been established for the Hollywood fault due to its poorly defined location along its length. For planning purposes, the City of Los Angeles considers the Hollywood fault active, and the CGS includes the fault in its database of seismic sources.

4.3.2.1 Potentially Active Faults

The inferred trace of the MacArthur Park fault is located approximately 0.5 mile southeast of the proposed alignment. The fault has not been definitively proven to exist. It is inferred west of downtown Los Angeles and has been located based on south-facing scarps, truncated drainages, and other geomorphic features. The Eagle Rock fault, a late Pleistocene active fault is located approximately eight miles to the northeast.

4.3.2.2 Blind Thrust Fault Zones

Several buried thrust faults, commonly referred to as blind thrusts, underlie the Los Angeles Basin at depth. These faults are not exposed at the ground surface and are typically identified at depths greater than three kilometers. These faults do not present a potential surface fault rupture hazard; however, they are considered active and potential sources for future earthquakes. The nearest thrust is the Elysian Park Thrust. Previously defined as the Elysian Park Fold and Thrust Belt, the Elysian Park Thrust was thought to extend northwesterly from the Santa Ana Mountains to the Santa Monica Mountains, extending westerly to parallel the Santa Monica-Hollywood and Malibu Coast faults. The Elysian Park Thrust is now believed to be smaller, only underlying the central Los Angeles Basin.

The Elysian Park Thrust underlies the project area approximately six to nine miles below ground surface. Like other blind thrust faults in the Los Angeles area, the Elysian Park Thrust is not exposed at the surface and does not present a potential surface rupture hazard. However, the Elysian Park Thrust should be considered an active feature capable of generating future earthquakes with associated significant ground shaking and possible deformation of the near surface materials.

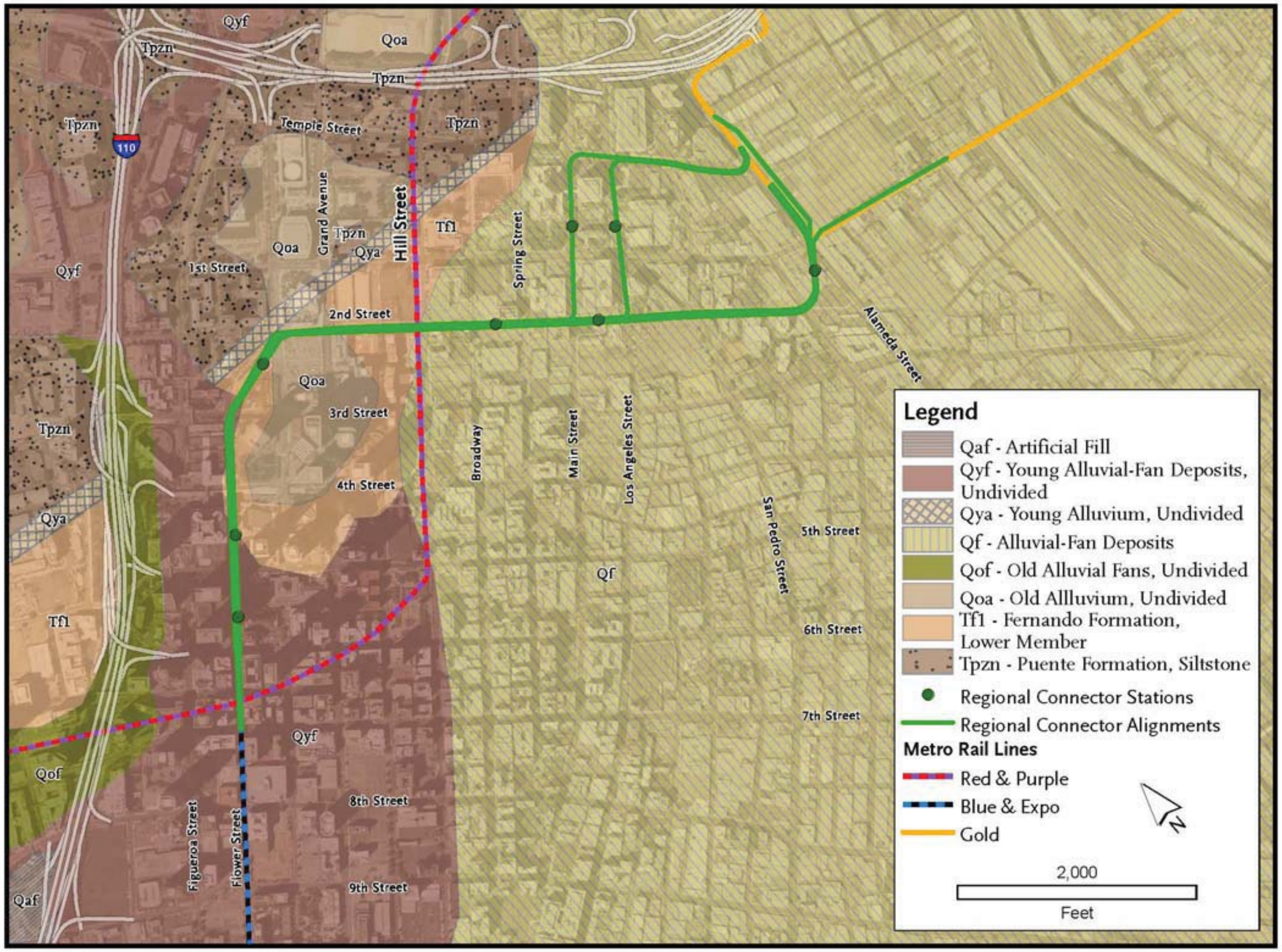

Figure 4-1. Regional Geology

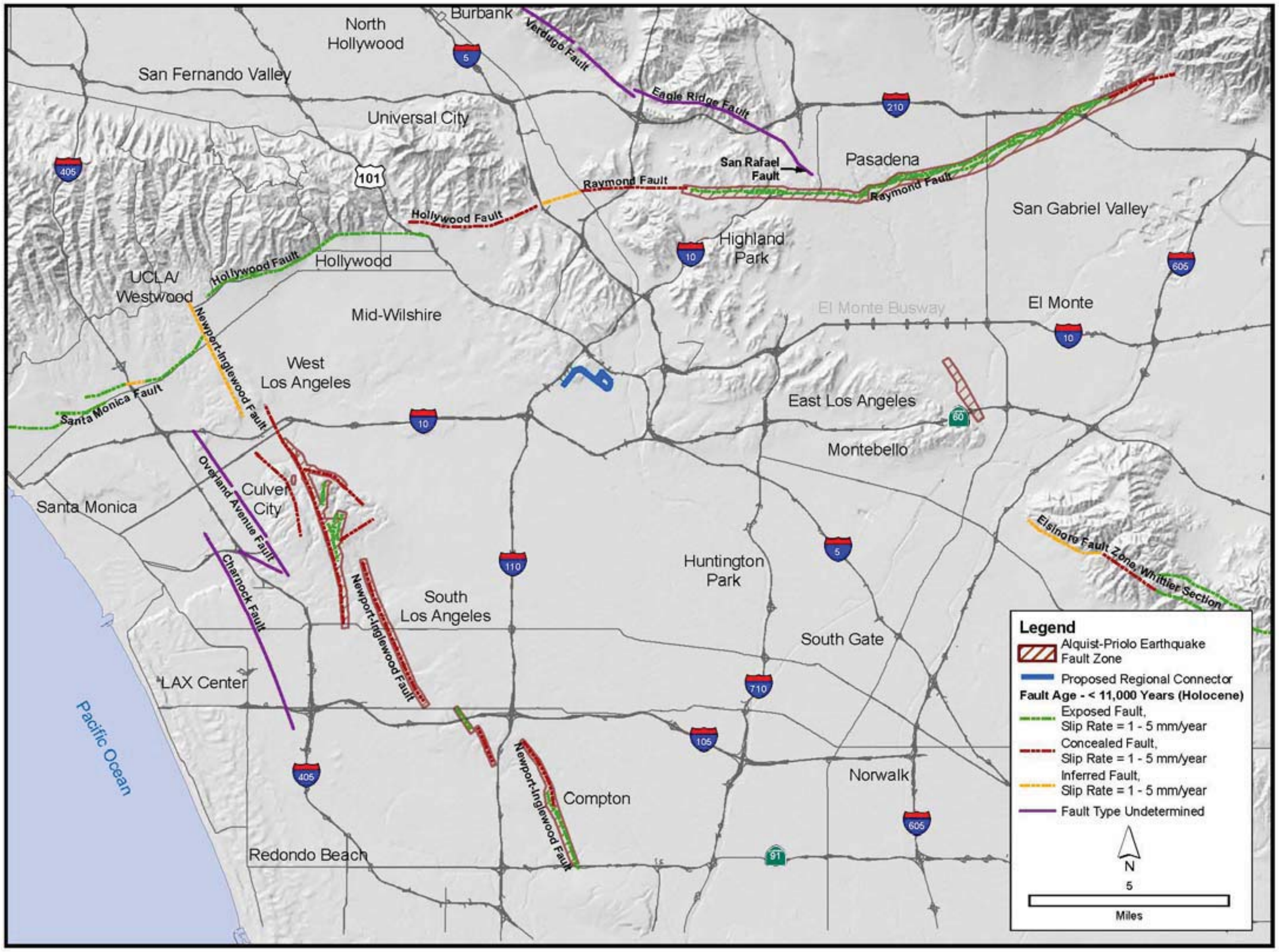

Figure 4-2. Regional Faults and Alquist-Priolo Earthquake Fault Zones

In addition, the Elysian Park fault, a blind thrust fault, is located northeast of and at a shallower depth than the Elysian Park Thrust. The up-dip edge of the blind thrust fault tip is located about 0.6 miles north of downtown Los Angeles. The estimated, average recurrence-interval for events of the Elysian Park fault ranges from 500 to 1,300 years, with an estimated moment magnitude of up to 6.7. Evidence to define the activity of the Elysian Park fault is lacking; however, given the history of seismic events on blind thrust faults in the greater Los Angeles area (i.e. Whittier Narrows and Northridge earthquakes) and proximity to the project area of this newly defined fault, the Elysian Park fault is considered active for planning and design of the project.

4.3.2.3 Coyote Pass Escarpment

The Coyote Pass Escarpment is a gentle south-facing, east-west trending topographic lineament that forms the southern flank of the Repetto Hills, from the Los Angeles River channel eastward to the Monterey Park area. The escarpment is an area of young, near-surface, monoclinal folding believed to be a result of fault rupture on the Elysian Park Thrust and/or the shallower Elysian Park fault. Although the trend of the escarpment beneath the floodplain, west of the Los Angeles River has not been well defined, it has been inferred that the escarpment may align in the subsurface with the MacArthur Park escarpment, located west of SR 110. Recent investigations of the Coyote Pass Escarpment indicate that the Elysian Park fault is active. Future fault rupture at depth along the Elysian Park fault and/or the Elysian Park Thrust could result in near-surface folding of the alluvial sediments and underlying bedrock in the area of the escarpment. Thus, no ground rupture is anticipated along the Coyote Pass Escarpment, but there is a potential for ground deformation (active folding) of the bedrock and the overlying alluvial sediments along the mapped location of the escarpment.

The deterministic ground motions were estimated using the Next Generation Attenuation (NGA) relationships of Abrahamson and Silva (2008), Boore and Atkinson (2008), Campbell and Bozorgnia (2008), and Chiou and Youngs (2008) with the program EZ-Frisk by Risk Engineering (2009). EZ-FRISK uses the relationships developed by Wells and Coppersmith (1994) and others to obtain estimates of earthquake magnitude from rupture size. The fault data used in the analyses were obtained from the United States Geological Survey (USGS, 2002) fault model included with the EZ-Frisk program. The Modified Mercalli Intensities were determined in accordance with Wald, et al. (1999).

Table 4-1 is a summary of the active faults, the approximate distance to the proposed project alignment, the maximum earthquake magnitude, peak ground acceleration (PGA), and the estimated site intensity near the intersection of Flower and 5th Streets. All sources were reviewed for the seismic hazards study and were incorporated for the ground motion study.

Table 4-2 is a summary of the active faults, the approximate distance to the proposed project alignment, the maximum earthquake magnitude, PGA, and the estimated site intensity near the proposed 2nd/Hope Street station under Bunker Hill.

Table 4-3 is a summary of the active faults, the approximate distance to the proposed project alignment, the maximum earthquake magnitude, PGA, and the estimated site intensity near the intersection of 2nd Street and Central Avenue.

Table 4-1. Active Faults Near Flower and 5th Streets

Abbreviated Fault Name	Approximate Distance from Alignment		Maximum Earthquake Magnitude	Peak Site Ground Acceleration	Estimated Site Intensity
	(mi)	(km)	(Mw)	(g)	MMI
Upper Elysian Park	2.5	4.0	6.4	0.559	VIII
Puente Hills Blind Thrust	3.3	5.3	7.1	0.722	IX
Hollywood	4.5	7.2	6.4	0.342	VIII
Raymond	5.2	8.4	6.5	0.325	VIII
Newport - Inglewood	7.0	11.2	7.1	0.324	VII
Verdugo	7.3	11.8	6.9	0.307	VII
Santa Monica	9.2	14.9	6.6	0.229	VII
Sierra Madre	11.7	18.8	7.2	0.249	VII
Whittier	14.4	23.1	6.8	0.178	VII
Sierra Madre - San Fernando	15.8	25.5	6.7	0.161	VI
Malibu Coast	15.9	25.6	6.7	0.160	VI
Palos Verdes	16.9	27.2	7.3	0.193	VII
Clamshell - Sawpit	17.1	27.5	6.5	0.136	VI
Northridge	17.4	28.0	7.0	0.233	VII
San Gabriel	18.5	29.7	7.2	0.173	VI

Table 4-1. Active Faults Near Flower and 5th Streets					
Abbreviated Fault Name	Approximate Distance from Alignment		Maximum Earthquake Magnitude	Peak Site Ground Acceleration	Estimated Site Intensity
	(mi)	(km)	(Mw)	(g)	MMI
San Jose	21.4	34.4	6.4	0.103	VI
Santa Susana	23.2	37.4	6.7	0.115	VI
Anacapa - Dume	25.6	41.1	7.5	0.159	VI
Chino - Central Ave	27.6	44.5	6.7	0.099	VI
Holser	29.4	47.3	6.5	0.083	V
Cucamonga	30.2	48.6	6.9	0.102	VI
Simi-Santa Rosa	30.2	48.6	7.0	0.107	VI
San Joaquin Hills Thrust	30.9	49.7	6.6	0.094	VI
San Andreas - 1857 [model 1]	34.6	55.7	7.4	0.115	VI
San Andreas - 1857 [model 2]	34.6	55.7	7.4	0.115	VI
San Andreas - Mojave [model 1]	34.6	55.7	7.4	0.115	VI
San Andreas – Mojave [model 2]	34.6	55.7	7.4	0.115	VI
San Andreas-All southern segments [model 1]	34.6	55.7	7.5	0.122	VI
Oak Ridge - Onshore	34.8	56.0	7.1	0.111	VI
Newport - Inglewood Offshore	37.4	60.1	7.1	0.091	V
Elsinore - Glen-Ivy	38.0	61.2	6.8	0.075	V
San Cayetano	39.3	63.2	7.0	0.083	V

Table 4-1. Active Faults Near Flower and 5th Streets					
Abbreviated Fault Name	Approximate Distance from Alignment		Maximum Earthquake Magnitude	Peak Site Ground Acceleration	Estimated Site Intensity
	(mi)	(km)	(Mw)	(g)	MMI
San Jacinto - San Bernardino	44.8	72.1	6.7	0.059	V
San Andreas - San Bernardino [model 1]	46.3	74.6	7.5	0.095	VI
San Andreas - Southern 2 Segments [model 1]	46.3	74.6	7.5	0.095	VI
San Andreas - Southern 2 Segments [model 2]	46.3	74.6	7.5	0.095	VI
San Andreas - Carrizo [model 1]	47.0	75.6	7.4	0.088	V
Cleghorn	48.7	78.4	6.5	0.046	IV
Santa Ynez - East Segment	51.8	83.3	7.1	0.066	V
Ventura - Pitas Point	54.5	87.7	6.9	0.061	V

Source: EZ-Frisk by Risk Engineering (2009)

Table 4-2. Active Faults Near Bunker Hill					
Abbreviated Fault Name	Approximate Distance from Alignment		Maximum Earthquake Magnitude	Peak Site Ground Acceleration	Estimated Site Intensity
	(mi)	(km)	(Mw)	(g)	MMI
Upper Elysian Park	2.3	3.7	6.4	0.587	VIII
Puente Hills Blind Thrust	3.4	5.5	7.1	0.749	IX
Hollywood	4.3	6.9	6.4	0.340	VIII

Table 4-2. Active Faults Near Bunker Hill					
Abbreviated Fault Name	Approximate Distance from Alignment		Maximum Earthquake Magnitude	Peak Site Ground Acceleration	Estimated Site Intensity
	(mi)	(km)	(Mw)	(g)	MMI
Raymond	4.9	8.0	6.5	0.324	VII
Verdugo	7.1	11.4	6.9	0.302	VII
Newport - Inglewood	7.2	11.6	7.1	0.306	VII
Santa Monica	9.4	15.1	6.6	0.214	VII
Sierra Madre	11.4	18.3	7.2	0.240	VII
Whittier	14.3	23.0	6.8	0.167	VI
Sierra Madre - San Fernando	15.6	25.1	6.7	0.151	VI
Malibu Coast	16.1	25.9	6.7	0.147	VI
Clamshell - Sawpit	16.8	27.1	6.5	0.127	VI
Palos Verdes	17.2	27.6	7.3	0.178	VII
Northridge	17.4	27.9	7.0	0.220	VII
San Gabriel	18.2	29.4	7.2	0.162	VI
San Jose	21.2	34.1	6.4	0.094	VI
Santa Susana	23.2	37.3	6.7	0.106	VI
Anacapa - Dume	25.8	41.5	7.5	0.147	VI
Chino - Central Ave	27.5	44.2	6.7	0.091	V
Holser	29.3	47.2	6.5	0.075	V
Cucamonga	29.9	48.2	6.9	0.094	VI
Simi - Santa Rosa	30.2	48.6	7.0	0.098	VI

Table 4-2. Active Faults Near Bunker Hill					
Abbreviated Fault Name	Approximate Distance from Alignment		Maximum Earthquake Magnitude	Peak Site Ground Acceleration	Estimated Site Intensity
	(mi)	(km)	(Mw)	(g)	MMI
San Joaquin Hills Thrust	30.9	49.8	6.6	0.085	V
San Andreas - 1857 [model 1]	34.3	55.3	7.4	0.106	VI
San Andreas - 1857 [model 2]	34.3	55.3	7.4	0.106	VI
San Andreas - Mojave [model 1]	34.3	55.3	7.4	0.106	VI
San Andreas - Mojave [model 2]	34.3	55.3	7.4	0.106	VI
San Andreas - All Southern Segments [model 1]	34.3	55.3	7.5	0.113	VI
Oak Ridge - Onshore	34.8	56.0	7.1	0.101	VI
Newport - Inglewood Offshore	37.5	60.3	7.1	0.082	V
Elsinore - Glen-Ivy	37.9	61.0	6.8	0.068	V
San Cayetano	39.2	63.2	7.0	0.076	V
San Jacinto - San Bernardino	44.6	71.8	6.7	0.054	V
San Andreas - San Bernardino [model 1]	46.1	74.2	7.5	0.087	V
San Andreas - Southern 2 Segments [model 1]	46.1	74.2	7.5	0.087	V
San Andreas - Southern 2 Segments [model 2]	46.1	74.2	7.5	0.087	V
San Andreas - Carrizo [model 1]	46.8	75.3	7.4	0.080	V
Cleghorn	48.5	78.0	6.5	0.042	IV

Table 4-2. Active Faults Near Bunker Hill

Abbreviated Fault Name	Approximate Distance from Alignment		Maximum Earthquake Magnitude	Peak Site Ground Acceleration	Estimated Site Intensity
	(mi)	(km)	(Mw)	(g)	MMI
Santa Ynez - East Segment	51.7	83.3	7.1	0.060	V
Ventura - Pitas Point	54.6	87.8	6.9	0.056	V

Source: EZ-Frisk by Risk Engineering (2009)

Table 4-3: Active Faults Near 2nd Street and Central Avenue

Abbreviated Fault Name	Approximate Distance from Alignment		Maximum Earthquake Magnitude	Peak Site Ground Acceleration	Estimated Site Intensity
	(mi)	(km)	(Mw)	(g)	MMI
Upper Elysian Park	2.3	3.7	6.4	0.565	VIII
Puente Hills Blind Thrust	3.5	5.6	7.1	0.711	IX
Hollywood	4.8	7.8	6.4	0.328	VIII
Raymond	5.2	8.4	6.5	0.327	VIII
Verdugo	7.4	11.9	6.9	0.308	VII
Newport - Inglewood	7.7	12.4	7.1	0.309	VII
Santa Monica	10.2	16.5	6.6	0.217	VII
Sierra Madre	11.6	18.7	7.2	0.254	VII
Whittier	13.4	21.5	6.8	0.194	VII
Sierra Madre - San Fernando	16.2	26.1	6.7	0.163	VI
Clamshell - Sawpit	16.4	26.4	6.5	0.146	VI

Table 4-3: Active Faults Near 2nd Street and Central Avenue					
Abbreviated Fault Name	Approximate Distance from Alignment		Maximum Earthquake Magnitude	Peak Site Ground Acceleration	Estimated Site Intensity
	(mi)	(km)	(Mw)	(g)	MMI
Malibu Coast	16.9	27.1	6.7	0.157	VI
Palos Verdes	17.3	27.8	7.3	0.195	VII
Northridge	18.2	29.3	7.0	0.226	VII
San Gabriel	18.8	30.3	7.2	0.176	VII
San Jose	20.4	32.9	6.4	0.112	VI
Santa Susana	24.1	38.7	6.7	0.116	VI
Anacapa - Dume	26.5	42.6	7.5	0.160	VI
Chino - Central Ave	26.7	42.9	6.7	0.107	VI
Cucamonga	29.3	47.2	6.9	0.109	VI
San Joaquin Hills Thrust	30.1	48.4	6.6	0.100	VI
Holser	30.2	48.6	6.5	0.084	V
Simi - Santa Rosa	31.1	50.1	7.0	0.109	VI
San Andreas - 1857 [model 1]	34.4	55.4	7.4	0.121	VI
San Andreas - 1857 [model 2]	34.4	55.4	7.4	0.121	VI
San Andreas - Mojave [model 1]	34.4	55.4	7.4	0.121	VI
San Andreas - Mojave [model 2]	34.4	55.4	7.4	0.121	VI
San Andreas - All Southern Segments [model 1]	34.4	55.4	7.5	0.127	VI

Table 4-3: Active Faults Near 2nd Street and Central Avenue					
Abbreviated Fault Name	Approximate Distance from Alignment		Maximum Earthquake Magnitude	Peak Site Ground Acceleration	Estimated Site Intensity
	(mi)	(km)	(Mw)	(g)	MMI
Oak Ridge - Onshore	35.7	57.5	7.1	0.112	VI
Newport - Inglewood Offshore	36.6	59.0	7.1	0.097	VI
Elsinore - Glen-Ivy	37.0	59.6	6.8	0.081	V
San Cayetano	40.2	64.6	7.0	0.086	V
San Jacinto - San Bernardino	44.0	70.8	6.7	0.063	V
San Andreas - San Bernardino [model 1]	45.5	73.3	7.5	0.101	VI
San Andreas - Southern 2 Segments [model 1]	45.5	73.3	7.5	0.101	VI
San Andreas - Southern 2 Segments [model 2]	45.5	73.3	7.5	0.101	VI
San Andreas - Carrizo [model 1]	47.5	76.5	7.4	0.091	V
Cleghorn	47.9	77.1	6.5	0.050	V
Santa Ynez - East Segment	52.6	84.7	7.1	0.068	V
Ventura - Pitas Point	55.5	89.3	6.9	0.063	V
Coronado Bank	56.7	91.3	7.6	0.087	V

Source: EZ-Frisk by Risk Engineering (2009)

4.3.2.4 Ground Shaking

Seismic hazards that could affect the project alignment include ground shaking from an earthquake along one of the several major active faults in the region. The magnitude of ground shaking is generally characterized by using the peak ground acceleration (PGA).

The PGA for several return periods commonly used for subway projects were developed using the average of the ground motions obtained from the Next Generation Attenuation relationships of Abrahamson and Silva (2008), Boore and Atkinson (2008), Campbell and Bozorgnia (2008), and Chiou and Youngs (2008) with the program EZ-Frisk. The average shear wave velocities over the upper 30 meters were determined from previous reviews of the local geology and previous shear wave velocity measurements taken at the site. For the depth to rock with a shear wave velocity of 1,000 meters per second 1 kilometer was used and 3 kilometers was used for the depth to bedrock with a shear wave velocity of 2,500 meters per second. Each ground motion attenuation relationship was integrated to three standard deviations beyond the median. EZ-FRISK uses the relationships developed by Wells and Coppersmith (1994) and others to obtain estimates of earthquake magnitude from rupture size. The average results are presented in Table 4-4.

Table 4-4. Potential Ground Motion Along Project Alignment

Event	Ground Acceleration (g)		
	Flower/5th	Bunker Hill	2nd/Central
Most Probable Event	0.181	0.168	0.187
Operable Design Earthquake	0.308	0.296	0.311
Design Basis Earthquake	0.452	0.446	0.452
Upper Bound Earthquake	0.582	0.586	0.578
Maximum Design Earthquake	0.737	0.755	0.730
Maximum Considered Earthquake	0.789	0.813	0.780

Source: EZ-Frisk by Risk Engineering (2009).

The results of the analysis indicate the PGA with a 10 percent probability of exceedance in 50 years (recurrence interval of 475 years) is approximately 0.45g. This level of ground motion is considered the Design Basis Earthquake. The PGA with a 10 percent probability of exceedance in 100 years (recurrence interval of 949 years) is approximately 0.58g, which is considered the Upper Bound Earthquake. The design criteria used by the Los Angeles County Metropolitan Transportation Authority (Rail and Transit Design Criteria and Standards, 1996) requires that for important structures such as those comprising this project, special earthquake protection criteria be followed: "The guiding philosophy of earthquake design for the Metro Rail projects is to provide a high level of assurance that the overall system will continue to operate during and after an Operating Design Earthquake." Operating procedures assume safe shut down and inspection before returning to operation. "Further, the system design will provide a high level of assurance that public safety will be maintained during and after a Maximum Design Earthquake." The Operating Design Earthquake is defined as the earthquake event with a 40 percent probability of exceedance in 100 years (recurrence interval of 200 years). Such event can reasonably be expected to occur during the 100-years design life of the project. The Maximum Design Earthquake is defined as the earthquake event with a 5 percent probability of exceedance in 100 years, which corresponds to an average recurrence interval of 2,000 years.

Other criteria for the seismic design of the project are the Most Probable Event and the Maximum Considered Earthquake. The Most Probable Event is defined as the earthquake event with a 50 percent probability of exceedance in 50 years (recurrence interval of 75 years). The Maximum Considered Earthquake is defined as the earthquake event with a 2 percent probability of exceedance in 50 years which corresponds to an average recurrence interval of 2,500 years. The 2007 California Building Code (CBC) uses the Maximum Considered Earthquake as the basis for seismic design requirements. In general, the PGA is lower for an event with a higher probability of occurrence under the same return period.

4.3.2.5 Liquefaction

Liquefaction-induced ground failure has historically been a major cause of earthquake damage in Southern California. Significant damage to roads, utilities, pipelines, and buildings during the 1971 San Fernando and 1994 Northridge earthquakes was caused by liquefaction-induced ground displacement. Localities most susceptible to liquefaction-induced ground displacement are underlain by loose, water-saturated, granular sediment within 50 feet of the ground surface. Liquefaction susceptibility generally decreases as the percentage of clay size particles in the soil increases and/or the coarse sand and gravel content increases. In portions of the project area, sediments susceptible to liquefaction comprise the young (Holocene to late Holocene age) alluvial fan deposits and young (Holocene) alluvial floodplain sediments. The older alluvial deposits are generally medium dense to dense and are considered by the CGS (California Geological Survey, previously California Division of Mines and Geology 1998a, 1998b) to have a low liquefaction susceptibility. The CGS has prepared seismic hazard maps for the Los Angeles Basin. The maps delineate liquefaction zones which have been defined by the CGS as areas where historic occurrence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacement such that mitigation would be required.

The CGS uses criteria developed by the Seismic Hazard Mapping Act Advisory Committee in delineating liquefaction zones on the seismic hazard maps. In areas of limited or no geotechnical data, susceptibility zones are evaluated using a combination of geologic considerations. The CGS has rated the liquefaction susceptibility for the Holocene age sediments in the project area as high, if saturated within 40 feet of the ground surface and, if not saturated, the susceptibility is rated as low. In contrast, the liquefaction susceptibility of older alluvial sediments (terrace deposits) is rated as low or not likely irrespective of groundwater levels.

In this framework, the CGS has identified a portion of the proposed alignment with Holocene sediments along Flower St. between Wilshire Boulevard and 2nd Street to be within a potential liquefaction zone. Likewise, the CGS has identified Holocene sediments along 2nd Street between Hill and San Pedro Streets to be within a potential liquefaction zone, as depicted in Figure 4-3. Young (Holocene age) deposits along the alignment, where present, are on the order of five to 35 feet thick. Preliminary proposed alignment profiles indicate that tunnel crown elevations would be below the young alluvial deposits that are rated as highly susceptible to liquefaction. For proposed station locations with shallow groundwater and younger alluvial deposits, station walls may have to be designed for greater than usual lateral earth pressures to account for liquefaction potential. The risk of settlement beneath the planned stations due to liquefaction is considered remote due to the depth of the Fernando formation beneath the Holocene alluvium at proposed station depths.

4.3.2.6 Settlement

Seismically-induced settlement consists of compression of the dry soils above groundwater and liquefaction-induced settlement of the liquefiable soils below groundwater. These settlements occur primarily within the loose to moderately dense sandy soils due to volume reduction during or shortly after an earthquake event.

Most of the artificial fill along the proposed project alignment is expected to be undocumented. In addition, a portion of the alluvial soils along the alignment are anticipated to be loose to medium dense. Accordingly, the portions of the proposed alignment mapped within the liquefiable zone and underlain by undocumented fill have the potential to experience seismically-induced settlement.

In addition to seismically-induced settlement, the upper soils along the proposed project alignment consist of predominately alluvial soils with some undocumented fill and have the potential to settle due to ground loss during tunnel construction. The majority of the tunnel would be constructed within the bedrock of the Fernando/Puente Formation and below groundwater with an Earth Pressure Balance (EPB) or a slurry Tunnel Boring Machine (TBM). The potential to cause ground loss and associated ground settlement with such machines are less likely. If such settlement occurred, it could adversely affect the overlying roadway and structures located over the distressed areas.

4.3.2.7 Landslides

Landslides and slope failures were significant contributing factors that lead to Los Angeles becoming one of the first municipalities in the nation to adopt hillside-grading ordinances. Rapid uplift of the mountainous areas of Los Angeles from past and ongoing tectonic movements gives rise to a geologic setting conducive to mass wasting. The variable nature of sediments and rocks exposed throughout Los Angeles and the slope conditions created by uncontrolled grading have led to frequent landslides of a variety of types. The hillside areas of Los Angeles, especially the central and eastern Santa Monica Mountains, have geologic and topographic conditions that are conducive to the development of surficial and gross landslides. The City of Los Angeles Department of Building and Safety regulates construction and development in hillside areas of Los Angeles. As part of the City of Los Angeles Building Code and review process, the City has established a Hillside Ordinance, which specifies that a geologic report is required for proposed construction within hillside areas.

The proposed project alignment is not located within the earthquake-induced landslide zone according to the State of California Seismic Hazard Zones for the Hollywood and Los Angeles Quadrangles. However, the northwest portion of the project area in the vicinity of the proposed 2nd/Hope Street station (the area east of the US 101/SR 110 interchange) is within the Hillside Ordinance area according to the City of Los Angeles Seismic Safety Element (1996). The construction of the proposed station should address temporary slope stability as appropriate and the shoring system should be designed to address such sloping condition and any potential for instability. Given that the proposed station would be below grade and located predominately in bedrock, the risk for such a hazard to affect the site is considered low.

4.3.2.8 Flooding

According to the City of Los Angeles Seismic Safety Element (1996), a limited portion of the eastern edge of the proposed alignment near the intersection of Alameda and 1st Streets is within the mapped Inundation Hazard Area. However, the majority of the build alternatives' alignments (At Grade Emphasis LRT Alternative, Underground Emphasis LRT Alternative, Fully Underground LRT Alternative – Little Tokyo Variation 1, and Fully Underground LRT Alternative – Little Tokyo Variation 2) are not located in areas mapped with the potential to be susceptible to flooding. The proposed alignment is located in an urbanized area composed mainly of impervious surfaces that include well-developed drainage infrastructure. The proposed project would neither significantly increase impervious surfaces nor increase the risk of flooding.

Earthquake-induced flooding can be caused by failure of dams or other water retaining structures due to an earthquake. Due to the absence of such structures in the vicinity of the alignment, the potential for such hazards to affect the project is considered low.

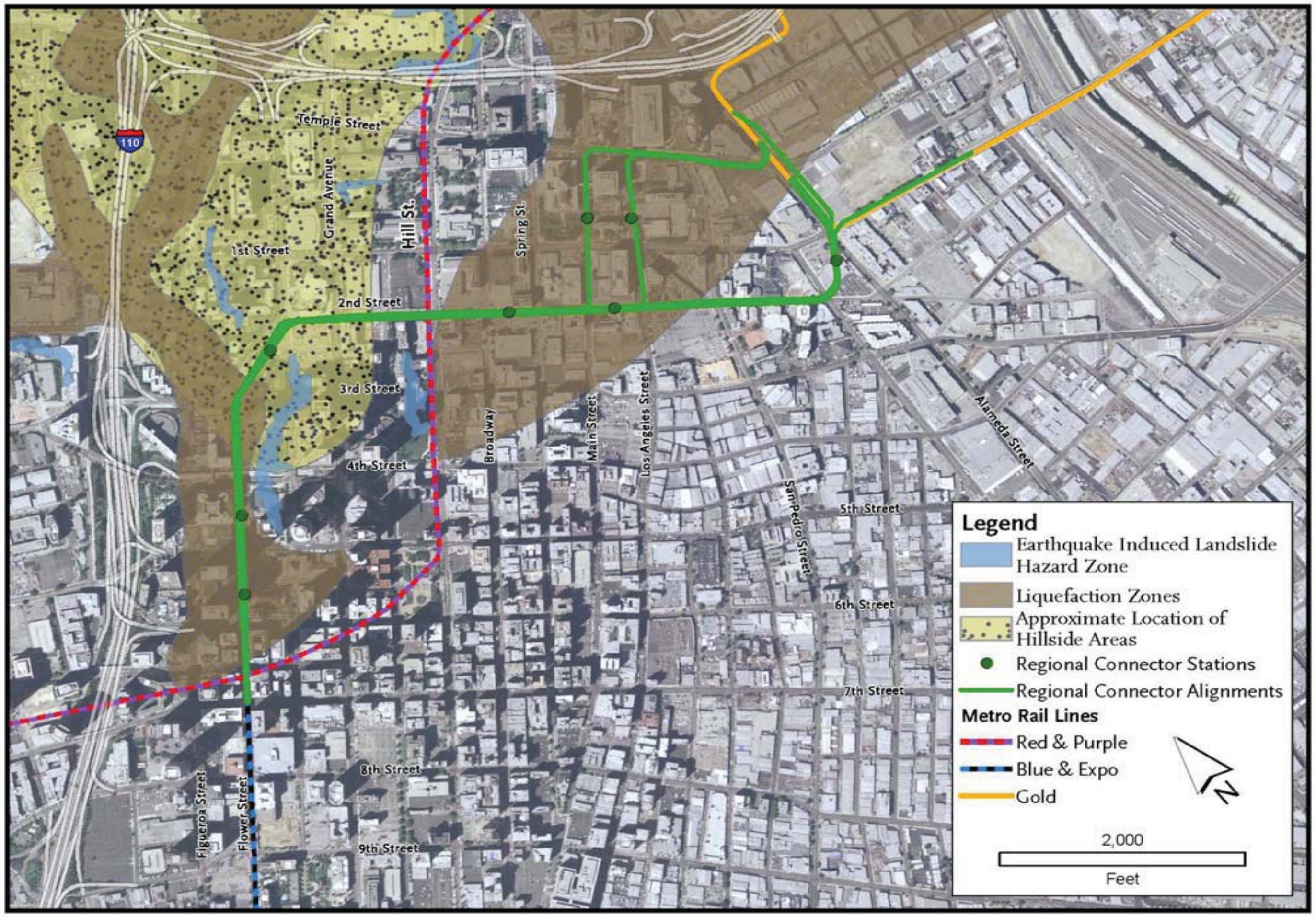

Figure 4-3. Liquefaction and Landslide Hazards

4.3.2.9 Seiches and Tsunamis

Seiches are large waves generated in enclosed bodies of water in response to ground shaking. Tsunamis are tidal waves generated in large bodies of water by fault displacement or major ground movement such as submarine landslides.

According to the City of Los Angeles Seismic Safety Element (1996) and the County of Los Angeles Seismic Safety Element (1990), the project area is more than 10 miles from the ocean and is not located within areas potentially impacted by either tsunamis or seiches.

4.4 Mineral Resources

Regarding the loss of mineral resources, the project area traverses areas underlain by geologic materials such as sand and gravel that may be considered mineral resources and could be used as construction aggregates. However, these materials have not been previously mined along the project alignment. Furthermore, mining of these materials in an urbanized environment is not considered economical. However, there is a potential for re-use of excavated material as fill.

4.5 Hazardous Materials

Environmental Data Resources (EDR) conducted a search of regulatory databases, including federal, state, and local environmental records as well as historical mapping. Thirty federal, 11 state and local, and several proprietary and tribal environmental databases were accessed by EDR for the project (EDR 2009). A total of 178 listed sites were identified within the federal records databases, 732 listed sites were present within the state and local databases, and six potential coal gas plant sites were listed in the EDR proprietary Manufactured Gas Plants database for the search area (CDM 2009). Of those, a total of 69 listed sites are located along the proposed alignments for any of the build alternatives, while a total of 136 sites are located within 0.25 mile of the proposed alignments.

The database search results include facilities that handle hazardous materials but have not necessarily had a release to the environment. Additionally, many sites are documented as closed cases where past satisfactory remediation has occurred. These listings do not represent a potential concern for the proposed project and were eliminated from further evaluation.

In some instances, more information was requested from regulatory agencies to determine the current status of a site. In addition, Sanborn fire insurance maps, maps of the Union Station Methane Buffer Zone and Methane Zone and the Los Angeles City Methane Buffer Zone, and oil well construction and abandonment records provided additional information used to determine which sites pose a potential concern with respect to hazardous materials.

The Hazardous Materials Investigation and Analysis (CDM 2009) classifies properties of concern as High, Moderate, or Low based on the following criteria:

- High - sites with known/probable soil, groundwater, or soil gas contamination that have not been remediated, or where remediation is incomplete or undocumented. Other considerations include the type and mobility of any contamination, distance to a project, groundwater impacts, and the location with respect to the inferred or known direction of groundwater flow.

- Moderate – sites with known/potential soil, groundwater, or soil gas contamination and where remediation is in progress, contaminants do not appear to pose a concern for a project, or where construction would occur within mapped Methane Buffer Zones. Sites may also be considered a Moderate level of concern based on the type and intensity of former land use (e.g., chemical manufacturers, machine shops, gas stations, etc.), even though they did not otherwise have an environmental database listing.

- Low – sites that are not likely or are less likely to impact soil and/or groundwater that would be encountered during construction of a project. These may include sites having permitted air toxic emissions or some sites with spills or leaks to the environment that were subsequently remediated and have received case closure.

Table 4-5 lists the properties of high or moderate concern as identified by CDM (2009). Properties are listed in order of their location, beginning at the 7th Street/Metro Center Station and ending at the project terminus near the Metro Gold Line Little Tokyo/Arts District Station. These properties of concern are presented graphically in Figure 4-4.

In addition to hazardous materials that are known or suspected to exist at the properties listed in Table 4-5, other hazardous materials may be present (CDM 2009). Transformers located above and below grade along the alignments may contain PCBs. Lead may also be present in surface soil from historic emissions of leaded fuel from vehicles on adjacent roadways. Since most soil along the proposed alignment is covered by asphalt or concrete, exposure to these hazardous materials is unlikely. However, buildings along the proposed alignments that were constructed prior to 1979 may contain asbestos and buildings constructed prior to 1978 may contain lead-based paint that could be released during demolition. These hazardous materials would present a concern for the proposed project, as exposure to these materials at certain levels may cause adverse health effects to workers and the general public.

Standards have been established to address the presence of asbestos-containing materials and lead-based paint in buildings to protect public health from exposure during building demolition or renovation. The National Emission Standards for Hazardous Air Pollutants

(NESHAP) for Asbestos, under Section 112 of the Clean Air Act, establishes work practices to minimize the release of asbestos fibers in compliance with federal regulations in 40 CFR Part 61, Subpart M. Likewise, federal regulations under section 403 of the TSCA, as amended by the Residential Lead-Based Paint Hazard Reduction Act of 1992, established standards for lead-based paint in pre-1978 housing in 40 CFR Part 745. Properties constructed before 1978 would be of particular concern for the possible presence of lead based paints and those constructed before 1979 for asbestos containing materials. In compliance with these regulations, lead and asbestos surveys would be conducted prior to demolition and construction, when the locally preferred alternative (LPA) is known.

Table 4-5. Properties of High/Moderate Concern

Address	Name	Description/Level of Concern
404 S. Figueroa Street	Westin Bonaventure Hotel	Tetrachloroethene (PCE) leaked into soil and shallow groundwater. Investigation and monitoring is ongoing. Groundwater plume may be controlled by building acting as a barrier. HIGH
715 W. 3rd Street	Central Plants, Inc.	No identified leaks or spills; however, the facility is actively conducting water treatment for commercial heating and cooling water, has four fuel USTs, and stressed vegetation was observed near Flower Street. MODERATE
1031 W. 2nd Street	76 Service Station No. 250122	Former service station located about 1,350 feet west and up-gradient of the project with total petroleum hydrocarbons-gasoline (TPH-g), benzene, and other contaminants in groundwater. A remediation program for soil and groundwater has been completed; however, work is still being conducted to delineate the south-southwestern extent of the plume. MODERATE
108 N. Fremont Street	Fire Station No. 3	TPH-g and other contaminants in soil and groundwater generally up-gradient of the project. Although the site is 1,450 feet from the project, the case is currently listed as open and in the process of referral for further remediation. MODERATE

Table 4-5. Properties of High/Moderate Concern

Address	Name	Description/Level of Concern
111 N. Hope Street	Los Angeles Department of Water and Power (LADWP)	The site is located approximately 650 feet up-gradient of the project, and volatile organic compounds (VOCs) were previously detected in a groundwater monitoring well installed near the down-gradient edge of the plume beneath the proposed project alignment. Subsequent monitoring did not detect contaminants; however, the project will pass through a portion of the plume that may not have been fully characterized. More information is needed to determine concentration and extent of VOCs. MODERATE
Methane Buffer Zone between the World Trade Center and Disney Hall	Los Angeles City Oil Field	Project crosses through the Methane Buffer Zone where toxic or potentially explosive gasses may be encountered. MODERATE
111 E. 1st Street	Los Angeles City Hall South	Records revealed three historical UST leaks, however, their status is undocumented. Site currently has six USTs. MODERATE
151 Judge John Aiso Street	Parker Center Los Angeles Police Department (LAPD)	Records report the discovery of a diesel leak into soil in 1990, followed by a site assessment. A citation was issued in 2008 for non-submittal of data regarding the leak to the State in electronic format. Although it may have been mitigated, the status of the remediation is unknown. MODERATE
120 S. San Pedro Street	Union Bank of California	Open site assessment for a diesel leak into soil reported in 2005. HIGH
300 block of E. 2nd Street	Various	Historical (1950s and 1960s) activities included two chemical manufacturers, a gas station, gas and oil tanks, an autobody shop, sheet metal shops and a machine shop. MODERATE

Table 4-5. Properties of High/Moderate Concern		
Address	**Name**	**Description/Level of Concern**
401 E. 2nd Street	Unknown	Disposed of 30 tons of contaminated soil. Regulatory status unknown. MODERATE
Methane Zone, Oil Field near eastern terminus of project	Union Station Oil Field and Methane Zone	Project enters the oil field and associated Methane Zone. Hydrogen sulfide gas was reported in groundwater and as gas north of 1st Street and west of the Los Angeles River. MODERATE

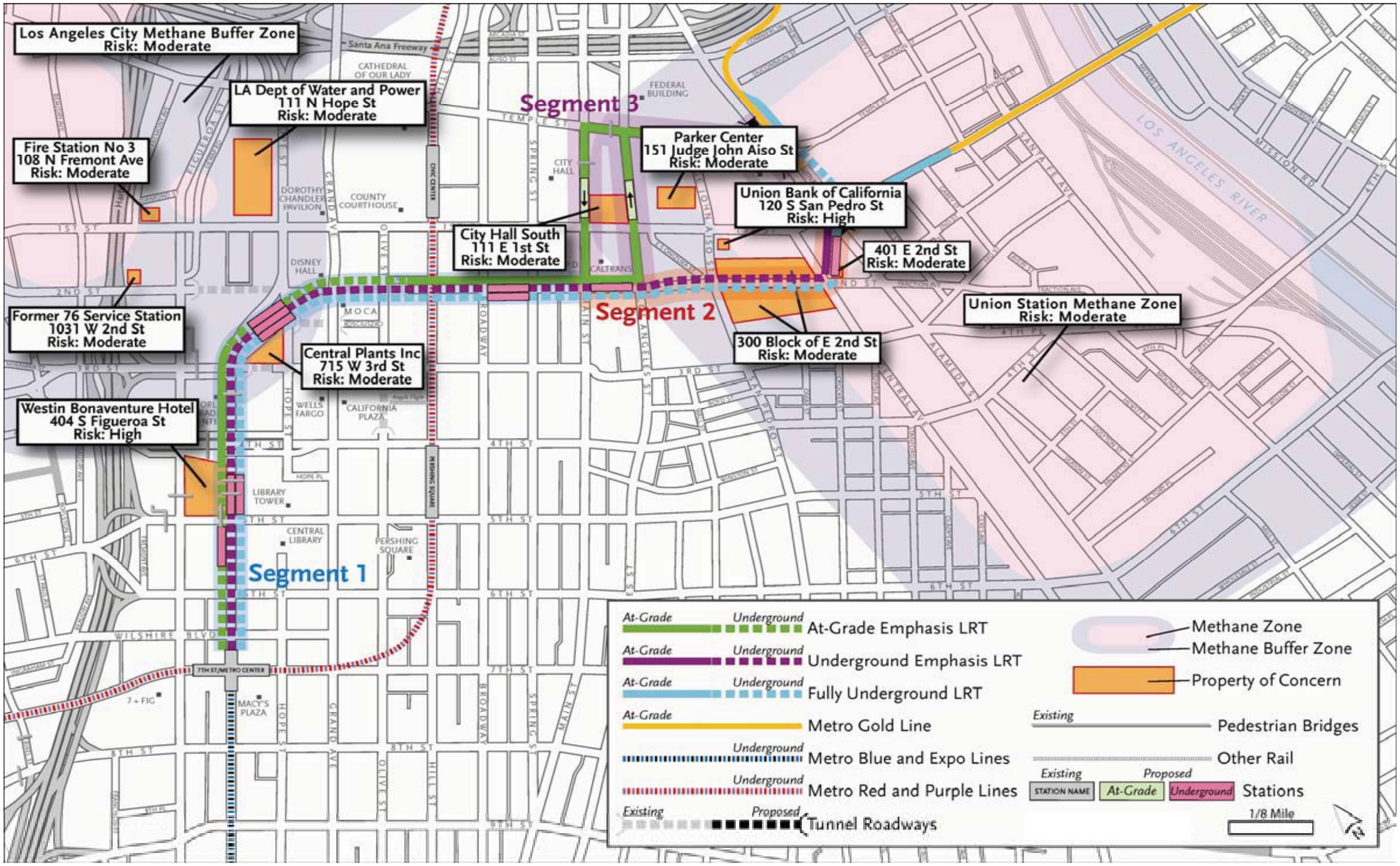

Figure 4-4. Known or Suspected Hazardous Materials in Soil and/or Groundwater within 0.25 Miles of Proposed Alignments

5.0 IMPACTS

5.1 No Build Alternative

5.1.1 Geotechnical, Subsurface, and Seismic Hazards

The No Build Alternative would not include any activities that would result in the potential for risk of fault rupture, liquefaction, seismically-induced settlement, landslides, flooding, seiches or tsunamis. Therefore, the No Build Alternative would not result in adverse effects related to geotechnical, subsurface, or seismic hazards.

5.1.2 Hazardous Materials

5.1.2.1 Direct Impacts

Under the No Build Alternative, there would be no construction and therefore no potential to encounter hazardous materials in soil and/or groundwater in the project area. There would be no construction-related hazardous materials usage, storage, or transport, and no potential for impacts to human health or the environment from the accidental release of hazardous materials. In addition, current operations with respect to hazardous materials would not change, and there would be no impairment of adopted emergency response plans or emergency evacuation plans. Therefore, there would be no direct impacts associated with hazardous materials from the No Build Alternative.

5.1.2.2 Indirect Impacts

The No Build Alternative would not result in indirect impacts with respect to hazardous materials, as there would be no construction or change in existing operations.

5.1.2.3 Cumulative Impacts

Since there would be no direct or indirect impacts from the No Build Alternative, there would also be no cumulative impacts.

5.2 Transportation System Management (TSM) Alternative

5.2.1 Geotechnical, Subsurface, and Seismic Hazards

The TSM Alternative would not include any activities that would result in the potential for risk of fault rupture, liquefaction, seismically-induced settlement, landslides, flooding, seiches or tsunamis. Therefore, no adverse effects related to geotechnical, subsurface or seismic hazards would occur.

5.2.2 Hazardous Materials

5.2.2.1 Direct Impacts

The TSM Alternative would not require construction that could encounter hazardous materials in soil and/or groundwater or release hazardous materials to the environment. Changes in operation under the TSM Alternative would not change the existing types of hazardous materials used, stored, or transported. Operation of the TSM Alternative would not emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within 0.25 mile of an existing or proposed school, and would not impair adopted emergency response plans and emergency evacuation plans. Therefore, there would be no direct impacts associated with hazardous materials from the TSM Alternative.

5.2.2.2 Indirect Impacts

Under the TSM Alternative, there would be no indirect impacts with respect to hazardous materials, as there would be no potential to encounter hazardous materials in soil and/or groundwater, and no change in the types, usage, storage, or transport of hazardous materials during operation.

5.2.2.3 Cumulative Impacts

Since there would be no direct or indirect impacts from the TSM Alternative, there would also be no cumulative impacts.

5.3 At-Grade Emphasis Light Rail Transit (LRT) Alternative

Due to the nature of earth impacts, all impacts in this report pertain primarily to construction activities. Only earthquakes (seismic hazards) concern operations. It should be noted that approximately 45 percent of the At-Grade Emphasis LRT Alternative would be underground primarily along Flower Street.

5.3.1 Geotechnical, Subsurface, and Seismic Hazards

The At-Grade Emphasis LRT Alternative does not cross any known fault. However, the At-Grade Emphasis LRT Alternative is potentially susceptible to liquefaction in portions of the proposed alignment along Flower Street between Wilshire Boulevard and 2nd Street, and along 2nd Street between Hill and San Pedro Streets. The portions of the alignment within the mapped liquefiable zone and underlain by undocumented fill may be susceptible to seismically-induced settlement. In addition, the northwest portion of the project area at the proposed 2nd/Hope Street station (in the area east of the US 101/SR 110 interchange) is within the Hillside Ordinance area. The proposed station would be below grade and located predominately in bedrock, therefore, the potential for a landslide hazard to affect the site is low. However, temporary slope stability during station construction would be evaluated and shoring would be designed to incorporate such slope conditions as appropriate.

The majority of the At-Grade Emphasis LRT Alternative is not located in an area mapped with the potential to be susceptible to flooding. The alignment is located in an urbanized area covered with impervious surfaces and includes a well-developed drainage infrastructure. The proposed project would not increase the risk of flooding. There is also no potential for seiches and tsunamis, as the alignment is more than 10 miles from the Pacific Ocean and there are no reservoirs nearby.

Therefore, there is limited potential for adverse effects related to liquefaction and seismically-induced settlement for portions of the At-Grade Emphasis LRT Alternative, but no potential for adverse impacts related to active or potentially active faults, landslides, flooding, seiches, or tsunamis.

The proposed construction would have the potential for adverse impacts related to ground settlement and differential settlement on adjacent structures including historical buildings. Further evaluation and survey would be performed during design to establish building types, existing conditions, and to develop criteria to limit potential movement to acceptable threshold values. Protection of buildings could involve design of adequately rigid excavation support systems, underpinnings, and/or ground improvements to minimize settlement to tolerable limits. In addition, a preconstruction survey of the adjacent structures and all historical buildings in the vicinity would be conducted to establish a baseline to measure potential construction-induced damage against. Construction monitoring would be required during construction to ascertain that movement does not exceed the threshold values.

With mitigation, potential effects related to geologic, subsurface, or seismic hazards would be reduced to a less than significant level.

5.3.2 Hazardous Materials

5.3.2.1 Direct Impacts

5.3.2.1.1 Hazardous Materials Encountered in Soil and/or Groundwater During Construction

During construction of the At-Grade Emphasis LRT Alternative, there is the potential to encounter hazardous materials along the proposed alignment (Figure 4-4). For both the at-grade and underground sections of this alternative, construction would entail the disturbance of soil and/or shallow groundwater. Construction of the at-grade portions of the alignment would entail clearing and grading of shallow soil, during which shallow groundwater could also be encountered. The underground portions of the At-Grade Emphasis LRT Alternative along Flower Street (approximately 45 percent) would require trenching or tunneling, and as a result would encounter deeper soils and groundwater. See Appendix A for a description of proposed construction activities.

Known and/or suspected soil and/or groundwater contamination exists at properties directly within and near to the proposed alignment, as listed in Table 4-5 above. As recommended by CDM (2009), additional data gathering and/or site specific soil, groundwater, and/or soil gas investigation activities (e.g., Phase II ESA testing), may be necessary at these properties to further delineate potential areas of contamination and guide construction activities.

Along with the concerns presented in Table 4-5, lead may be present in surface soils along the proposed alignment from historical vehicle emissions, and PCBs may exist in surface or subsurface soils from leaking transformers located above or below grade. During construction, release of these hazardous materials in contaminated soil and/or groundwater could result in exposure to workers, the public, and sensitive receptors, such as schools within 0.25 mile. This could occur through the release of dust or vapors from exposed soil and/or groundwater. Until further study is conducted, the actual levels of hazardous materials that could be encountered in soil and/or groundwater during construction are unknown.

Compliance with the federal, state, and local laws and regulations regarding hazardous materials described in Section 3.1 would be required during construction of the At-Grade Emphasis LRT Alternative. Since 45 percent of the alternative would be located underground, dewatering may be necessary during the construction process. Groundwater encountered during construction dewatering would require testing and either on-site treatment and discharge in accordance with applicable standards or transport to a treatment and/or disposal facility. Additional details about dewatering are provided in the Water Resources Technical Memorandum. A Contaminated Soil/Groundwater Management Plan would be implemented during construction to establish procedures for sampling, analysis, and proper handling, storage, transport, and disposal of contaminated materials in coordination with the appropriate regulatory agency. This mitigation measure is described further in Section 6.0.

In addition, mitigation would be required to reduce potential impacts to construction workers from encountering contamination during construction. As described in Section 6.0, a Worker Health and Safety Plan would be implemented prior to the start of construction to establish procedures to be followed if contamination is encountered. This would include required training prior to start of work, personal protective equipment, and emergency procedures.

5.3.2.1.2 Accidental Release of Construction-Related Hazardous Materials

There is the potential for hazardous materials, such as fuels and hydraulic oil used for construction equipment, to be accidentally released during construction. Further, construction of the At-Grade Emphasis LRT Alternative would involve the use, storage, and transport of hazardous materials, such as fuels, paints, lubricating fluids, and solvents for maintenance. As such, there is the potential for direct impacts from an accidental release.

To reduce potential impacts from accidental release of construction-related hazardous materials, the construction contractor would be required to implement best management practices (BMPs) for handling hazardous materials in compliance with existing regulations. These BMPs would include the following:

- Requirements for proper use, storage, and disposal of chemical products and hazardous materials used in construction;
- Spill control and countermeasures, including employee spill prevention/response training;
- Vehicle fueling procedures to avoid overtopping construction equipment fuel tanks;
- Procedures for routine maintenance of construction equipment, including the proper containment and removal of grease and oils; and
- Procedures for the proper disposal of discarded containers of fuels and other chemicals.

The implementation of these BMPs would ensure that potential direct impacts from the accidental release of hazardous materials and/or wastes used or generated during construction are less than significant.

5.3.2.1.3 Accidental Release of Hazardous Materials During Operation

Compliance with hazardous materials laws and regulations would be required during operation as well, including hazardous materials inventory and emergency response planning, risk planning and accident prevention, employee hazard communication, public notification of potential exposure to specific chemicals, and storage of hazardous materials. Adherence to existing laws and regulations would reduce the potential for these direct impacts to a less than significant level. Further, if long-term operation of the underground portions of the alignment requires groundwater to be collected and discharged, compliance with discharge permit standards would be required.

5.3.2.1.4 Hazards Associated with Subsurface Oilfield Gases

The proposed alignment would traverse methane zones and methane buffer zones associated with oil deposits in the vicinity, as shown in Figure 4-4. Excavation within these zones may encounter naturally occurring hydrocarbon gases, including hydrogen sulfide and methane. Hydrogen sulfide is highly toxic and could result in human health effects to individuals who are exposed, particularly construction workers. Methane is explosive if allowed to accumulate and could cause harm to workers and the public if an explosion occurred during construction or operation. Mitigation, as described in Section 6.0, would be required to reduce these impacts to a less than significant level.

5.3.2.1.5 Release of Asbestos Fibers and/or Lead-Based Paint Particles

If construction of the At-Grade Emphasis LRT Alternative requires building demolition, release of hazardous materials including asbestos fibers and lead-based paint particles could occur. Mitigation, as described in Section 6.0, would be required to reduce this potential direct impact.

5.3.2.1.6 Hazards Associated with Electromagnetic Fields (EMFs)

Operation of the At-Grade Emphasis LRT Alternative would introduce new sources of low level EMFs associated with the overhead catenary lines and traction power substations. Compared to overhead power lines which use 400 kV, the LRT would use 0.6 kV and produce very weak EMFs. Therefore, potential impacts from exposure to EMFs would not be anticipated. However, mitigation, as described in Section 6.0, would ensure that impacts would be less than significant.

5.3.2.2 Indirect Impacts

During long-term operation of the At-Grade Emphasis LRT Alternative, there is the potential for the below-grade portions of the alignment to act as a preferential pathway for existing groundwater contamination to move to areas distant from the project. Mitigation measures incorporated into the engineering design would include the use of impermeable grout where necessary to fill the gap between the tunnel and the surrounding earth and ensure the tunnel does not contribute to the spread of contaminated groundwater.

In addition, construction could involve the transport of soil or other media contaminated with hazardous materials to a disposal facility located away from the project area. As such, there is potential for indirect impacts from the accidental release of these hazardous materials. Compliance with existing laws and regulations regarding transport and disposal of hazardous materials would reduce this impact to a less than significant level.

5.3.2.3 Cumulative Impacts

There is the potential for cumulative impacts associated with hazards and hazardous materials from the At-Grade Emphasis LRT Alternative. A number of related construction projects have been identified and some of those projects could involve ground-disturbing construction where there is potential to encounter hazardous materials in soil and/or groundwater. In addition, other construction activities in the project area may entail building demolition, with the potential for release of asbestos fibers from asbestos containing materials and lead particles from lead-based paint. The additive effect of on-going and future activities could result in cumulative impacts to human health or the environment through release of hazardous materials. While these construction activities would require compliance with applicable hazardous waste laws and regulations, mitigation would also be required to ensure cumulative impacts would be less than significant.

5.4 Underground Emphasis LRT Alternative

Due to the nature of earth impacts, all impacts in this report pertain primarily to construction activities. Only earthquakes (seismic hazards) concern operations.

5.4.1 Geotechnical, Subsurface, and Seismic Hazards

The Underground Emphasis LRT Alternative does not cross any known fault; however, there is the potential for liquefaction in portions of the proposed alignment along Flower Street between Wilshire Boulevard and 2nd Street, and along 2nd Street between Hill and San Pedro Streets. In the portions of the proposed alignment within a mapped liquefiable zone and underlain by undocumented fill, there would be limited potential for adverse effects from liquefaction and seismically-induced settlement. In addition, the northwest portion of the project area (east of the US 101/SR 110 interchange) is within the Hillside Ordinance area, where there is a potential for landslides. As discussed in Section 5.3.1, the potential for landslide hazards to affect the site is considered low because the proposed 2nd/Hope Street station would be embedded below grade and located predominately in bedrock. However, temporary slope stability during station construction would be evaluated and the shoring would be designed to incorporate slope conditions as appropriate.

A limited portion at the eastern edge of the alignment near the intersection of 1st and Alameda Streets is within the mapped Inundation Hazard Area. However, the majority of the Underground Emphasis LRT Alternative is not located in an area mapped with the potential to be susceptible to flooding. The alignment is located in an urbanized area covered with impervious surfaces and includes a well-developed drainage infrastructure. The proposed project would not increase the risk of flooding. There is also no potential for seiches and tsunamis, as the alignment is more than 10 miles from the Pacific Ocean and there are no reservoirs nearby.

The Underground Emphasis LRT Alternative alignment is overlain by alluvial soils and undocumented fill that are potentially susceptible to ground loss associated with tunnel construction (see discussion in Section 4.3.2.5). Therefore, there is the potential for adverse effects related to liquefaction, seismically-induced settlement, ground loss due to tunnel construction, and landslides for portions of the Underground Emphasis LRT Alternative, but no potential for adverse impacts related to active or potentially active faults, flooding, seiches, or tsunamis.

The proposed tunneling would have the potential for adverse impacts related to ground settlement and differential settlement immediately above the alignment as well as adjacent structures including the historical buildings. In general, settlement is greatest at the ground surface directly above the alignment and decreases away from the centerline. Further evaluation and site-specific survey would be performed on the affected adjacent buildings located within the influence zone during design to establish criteria to limit potential movement to acceptable threshold values. Potential mitigation methods are discussed in Section 6 of this document. Ground improvement would be required in advance of tunneling to provide adequate support and to minimize settlement. In addition, a preconstruction survey of adjacent structures and all historical buildings in the vicinity would be conducted to establish a baseline against which to measure potential construction-induced damage. Construction monitoring would be required during construction to ascertain the criteria are met.

With mitigation, potential effects related to geologic, subsurface, or seismic hazards would be reduced to a less than significant level.

5.4.2 Hazardous Materials

5.4.2.1 Direct Impacts

5.4.2.1.1 Hazardous Materials Encountered in Soil and/or Groundwater During Construction

As with the At-Grade Emphasis LRT Alternative, there is the potential to encounter hazardous materials along the proposed alignment for the Underground Emphasis LRT Alternative (Figure 4-4). Construction of the Underground Emphasis LRT Alternative would entail trenching or tunneling along most of the proposed alignment, during which contaminated soil and/or groundwater could be encountered. See Appendix A for a description of proposed construction activities. As listed in Table 4-5, known and/or suspected soil and/or groundwater contamination exists at properties directly within and near to the proposed alignment for the Underground Emphasis LRT Alternative. In addition, lead may be present in surface soils from historical vehicle emissions, and PCBs may exist in surface or subsurface soils from leaking transformers located above or below grade. If released, there is potential for impacts to human health and the environment from these hazardous materials. Until further study is conducted, the actual levels of hazardous materials that could be encountered in soil and/or groundwater during construction are unknown.

Compliance with the federal, state, and local laws and regulations regarding hazardous materials described in Section 4.1 would be required during construction of the Underground Emphasis LRT Alternative. Groundwater encountered during construction dewatering would require testing and either on-site treatment and discharge in accordance with applicable standards or transport to a treatment and/or disposal facility. Additional details about dewatering are provided in the Water Resources Technical Memorandum. A Contaminated Soil/Groundwater Management Plan would be implemented during construction to establish procedures for sampling, analysis, and proper handling, storage, transport, and disposal of contaminated materials in coordination with the appropriate regulatory agency. This mitigation measure is described further in Section 6.0.

In addition, mitigation would be required to reduce the potential impacts to construction workers from encountering contamination during construction. As described in Section 6.0, a Worker Health and Safety Plan would be implemented prior to the start of construction activities to establish procedures to follow if contamination is encountered. This would include required training prior to start of work, personal protective equipment, and emergency procedures.

5.4.2.1.2 Accidental Release of Construction-Related Hazardous Materials

There is also the potential for hazardous materials, such as fuels and hydraulic fluids used for construction equipment, to be accidentally released during construction. Since construction of the Underground Emphasis LRT Alternative would involve the use, storage, and transport of hazardous materials, such as fuels, paints, lubricating fluids, and solvents for maintenance, there is the potential for direct impacts from an accidental release.

To reduce potential impacts from the accidental release of construction-related hazardous materials, the construction contractor would be required to implement BMPs for handling hazardous materials in compliance with existing regulations. These BMPs would include the following:

- Requirements for proper use, storage, and disposal of chemical products and hazardous materials used in construction;
- Spill control and countermeasures, including employee spill prevention/response training;
- Vehicle fueling procedures to avoid overtopping construction equipment fuel tanks;
- Procedures for routine maintenance of construction equipment, including the proper containment and removal of grease and oils; and
- Procedures for the proper disposal of discarded containers of fuels and other chemicals.

The implementation of these BMPs would ensure that potential direct impacts from the accidental release of hazardous materials and/or wastes used or generated during construction and are less than significant.

5.4.2.1.3 Accidental Release of Hazardous Materials During Operation

During operation, adherence to hazardous materials laws and regulations would require proper inventory and storage of hazardous materials, accident prevention and emergency response planning, employee training and public health hazard notification. If long-term operation of the underground portions of the alignment requires groundwater to be collected and discharged, compliance with discharge permit standards would be required. Compliance with existing laws and regulations would reduce the potential for these direct impacts to a less than significant level.

5.4.2.1.4 Hazards Associated with Subsurface Oilfield Gases

The Underground Emphasis LRT Alternative would be located within methane zones and methane buffer zones associated with oil deposits, as shown in Figure 4-4. Excavation within these zones may encounter naturally occurring hydrogen sulfide and/or methane, which could result in the potential for harm to workers and the public. Mitigation measures, as described in Section 6.0, would be required to reduce these potential impacts to a less than significant level.

5.4.2.1.5 Release of Asbestos Fibers and/or Lead-Based Paint Particles

Since construction of the Underground Emphasis LRT Alternative would require building demolition, release of hazardous materials including asbestos fibers and lead-based paint particles could occur. Mitigation, as described in Section 6.0, would be required to reduce this potential direct impact to a less than significant level.

5.4.2.1.6 Hazards Associated with Electromagnetic Fields (EMF)

Operation of the Underground Emphasis LRT Alternative would introduce new sources of low level EMFs associated with the overhead catenary lines and traction power substations. The LRT would use only 0.6 kV compared to overhead power lines which use 400 kV. As a result, EMFs produced by the LRT would be very weak, and potential impacts from exposure to EMFs are not anticipated. In addition, most of the alignment would be underground further limiting potential exposure to adjacent land uses. Mitigation, as described in Section 6.0, would ensure impacts would be less than significant.

5.4.2.2 Indirect Impacts

During operation of the Underground Emphasis LRT Alternative, gaps between the tunnel and the surrounding earth could serve as preferential pathways for the migration of groundwater contamination. This would be mitigated to a less than significant level during the engineering process. For example, specifications for impermeable grouting materials to fill the gap between the tunnel and the surrounding earth could be designed to reduce this potential impact.

If, during construction, soil or other media contaminated with hazardous materials is transported to a disposal facility located away from the project area, there would be the potential for indirect impacts from the accidental release of these hazardous materials. Compliance with existing laws and regulations regarding transport and disposal of hazardous materials would reduce this impact to a less than significant level.

5.4.2.3 Cumulative Impacts

There is the potential for cumulative impacts associated with hazards and hazardous materials from the Underground Emphasis LRT Alternative. Construction associated with on-going and future projects in the project area could result in cumulative impacts to human health or the environment through release of hazardous materials encountered in soil and/or groundwater, or released during building demolition. Compliance with applicable hazardous waste laws and regulations, along with the mitigation measures described in Section 6.0, would ensure these potential cumulative impacts would be less than significant.

5.5 Fully Underground LRT Alternative – Little Tokyo Variation 1

Due to the nature of earth impacts, all impacts in this report pertain primarily to construction activities. Only earthquakes (seismic hazards) concern operations.

5.5.1 Geotechnical, Subsurface, and Seismic Hazards

Similar to the Underground Emphasis LRT Alternative, the Fully Underground LRT Alternative – Little Tokyo Variation 1 does not cross any known fault; however, there is the potential for liquefaction in portions of the proposed alignment along Flower Street between Wilshire Boulevard and 2nd Street, and along 2nd Street between Hill and San Pedro Streets. In the portions of the proposed alignment within a mapped liquefiable zone and underlain by undocumented fill, there would be limited potential for adverse effects from liquefaction and seismically-induced settlement (See discussion in Section 4.3.2.5). In addition, the northwest portion of the project area (east of the US 101/SR 110 interchange) is within the Hillside Ordinance area, where there is a potential for landslides. As discussed in Section 5.3.1, the potential for landslide hazards to affect the site is considered low because the proposed 2nd/Hope Street station would be embedded below grade and located predominately in bedrock. However, temporary slope stability during station construction would be evaluated and shoring would be designed to incorporate slope conditions as appropriate.

A limited portion at the eastern edge of the alignment near the intersection of 1st and Alameda Streets is within the mapped Inundation Hazard Area. However, the majority of the Fully Underground LRT Alternative – Little Tokyo Variation 1 is not located in an area mapped with the potential to be susceptible to flooding. The alignment is located in an urbanized area covered with impervious surfaces and includes a well-developed drainage infrastructure. The proposed project would not increase the risk of flooding. There is also no potential for seiches and tsunamis, as the alignment is more than 10 miles from the Pacific Ocean and there are no reservoirs nearby.

The Fully Underground LRT Alternative – Little Tokyo Variation 1 alignment is overlain by alluvial soils and undocumented fill that are potentially susceptible to ground loss associated with tunnel construction.

Therefore, there is the potential for adverse effects related to liquefaction, seismically-induced settlement, ground loss due to tunnel construction, and landslides for portions of the alignment, but no potential for adverse impacts related to active or potentially active faults, flooding, seiches, or tsunamis.

The proposed tunneling would have the potential for adverse impacts related to ground settlement and differential settlement immediately above the alignment as well as adjacent structures including the historical buildings. In general, settlement is greatest at the ground surface directly above the alignment and decreases away from the centerline. Further evaluation and site-specific survey would be performed on the affected adjacent buildings located within the influence zone during design to establish criteria to limit potential movement to acceptable threshold values. Potential mitigation methods are discussed in Section 6 of this document. Ground improvement would be required in advance of tunneling to provide adequate support and to minimize settlement. In addition, a preconstruction survey of adjacent structures and all historical buildings in the vicinity would be conducted to establish baseline against construction-induced damage. Construction monitoring would be required during construction to ascertain the criteria are met.

With mitigation, potential effects related to geologic, subsurface, or seismic hazards would be reduced to a less than significant level.

5.5.2 Hazardous Materials

5.5.2.1 Direct Impacts

5.5.2.1.1 Hazardous Materials Encountered in Soil and/or Groundwater During Construction

During construction of the Fully Underground LRT Alternative – Little Tokyo Variation 1, there is potential to encounter hazardous materials along the proposed alignment. This potential would be similar to that discussed above for the Underground Emphasis LRT Alternative, except that the Fully Underground LRT Alternatives would extend north and east of 1st and Alameda Streets (Figure 4-4), and thus would entail a slightly longer alignment along which trenching or tunneling would occur.

Since the same properties where there is known and/or suspected soil and/or groundwater contamination would be affected by the Fully Underground LRT Alternative – Little Tokyo Variation 1 as by the Underground Emphasis LRT Alternative, impacts associated with encountering this contamination during construction would be the same. Further, there would be the same potential for lead and PCBs to be present in soils along the proposed alignment. Additional investigation would be needed to determine the actual levels of hazardous materials that could be encountered in soil and/or groundwater during construction.

Compliance with the federal, state, and local laws and regulations regarding hazardous materials described in Section 3.1 would be required during construction of the Fully Underground LRT Alternative – Little Tokyo Variation 1. A Contaminated Soil/Groundwater Management Plan and a Worker Health and Safety Plan would be put in place prior to the start of construction activities to establish procedures to follow if contamination is encountered. These mitigation measures are described further in Section 6.0.

5.5.2.1.2 Accidental Release of Construction-Related Hazardous Materials

As with the other alternatives, there is the potential for construction-related hazardous materials, such as fuels and hydraulic fluids, to be accidentally released during construction. The construction contractor would be required to implement BMPs to reduce these potential impacts by handling hazardous materials in compliance with existing regulations.

5.5.2.1.3 Accidental Release of Hazardous Materials During Operation

During operation, there could be direct impacts from the accidental release of hazardous materials. To reduce the potential for these impacts, compliance with hazardous materials laws and regulations would be required. If groundwater would be collected and discharged under this alternative, compliance with discharge permit standards would be required.

5.5.2.1.4 Hazards Associated with Subsurface Oilfield Gases

As shown on Figure 4-4, the Fully Underground LRT Alternative – Little Tokyo Variation 1 would be partially located within methane zones and methane buffer zones, which could result in the potential for harm to workers and the public. Mitigation measures, as described in Section 6.0, would be required to reduce these potential impacts to a less than significant level.

5.5.2.1.5 Release of Asbestos Fibers and/or Lead-Based Paint Particles

During construction, there would be potential for release of hazardous materials including asbestos fibers and lead based paint particles. Mitigation, as described in Section 6.0, would be required to reduce this potential direct impact to a less than significant level.

5.5.2.1.6 Hazards Associated with Electromagnetic Fields (EMF)

As with the other alternatives, operation of the Fully Underground LRT Alternative – Little Tokyo Variation 1 would introduce new low level sources of EMFs. As the alternative would be located entirely underground and the new EMFs would be very weak, potential impacts from exposure to EMFs are not anticipated. Mitigation, as described in Section 6.0, would ensure potential impacts would be less than significant.

5.5.2.2 Indirect Impacts

Indirect impacts from the Fully Underground LRT Alternative – Little Tokyo Variation 1 could occur if preferential pathways for the migration of contaminated groundwater were created during construction. As with the other alternatives, this potential impact would be mitigated through proper engineering practices. Compliance with existing laws and regulations regarding transport and disposal of hazardous materials would reduce potential impacts from the accidental release of hazardous materials during transport to a less than significant level.

5.5.2.3 Cumulative Impacts

Cumulative impacts from the Fully Underground LRT Alternative – Little Tokyo Variation 1 could occur if there were a release of hazardous materials during on-going and future projects in the project area that result in cumulative impacts to human health or the environment. Compliance with applicable hazardous waste laws and regulations, along with the mitigation measures described in Section 6.0, would ensure these potential cumulative impacts would be less than significant.

5.6 Fully Underground LRT Alternative – Little Tokyo Variation 2

The alignment for the Fully Underground LRT Alternative – Little Tokyo Variation 2 is essentially the same as that for the Fully Underground LRT Alternative – Little Tokyo Variation 1. The alignment for this alternative is about a block longer along 1st Street. The design differences between the two alternatives in the vicinity of Alameda and First Streets would not result in different potential impacts with respect to geotechnical, subsurface, and seismic hazards or hazardous materials.

As described in Section 5.5.1, with mitigation, potential effects related to geotechnical, subsurface, or seismic hazards would be less than significant.

As described in Section 5.5.2, there would be some potential for direct, indirect, and cumulative effects related to hazardous materials. The potential impacts would be the same as described in Section 5.5.2 and with mitigation these potential impacts would be less than significant.

6.0 POTENTIAL MITIGATION MEASURES

6.1 Potential Construction Mitigation Measures

A geotechnical investigation would be performed during design for the proposed at-grade and below-grade structures and improvements. The investigation would supplement and provide site specific data to facilitate final design for maintaining the integrity of existing structures under static and seismic loading and operational demands. Although portions of the alignment would be constructed in potential liquefaction zones, none are expected to result in or exacerbate geologic hazards. The proposed subway tunnels and stations would be located at depths below soils prone to liquefaction, and be subject to standard design specifications. Higher design earth pressures would be applied to below grade structures within liquefaction zones during the construction process to keep potential risks of damage from liquefaction and seismically-induced settlement to an acceptable level.

For the any of the build alternatives, the potential for ground movement associated with cut and cover construction and potential ground loss due to tunneling could be mitigated by the following mitigation measures:

- Design criteria would be established during project design that requires the construction contractor to limit movement to less than an acceptable threshold value as a performance standard. This acceptable threshold standard would be a function of several factors including but not limited to the type of structure and its existing condition. Additional data and survey information would be gathered during preliminary engineering for each building to enable assessment of the tolerance of the subject structures. In addition, standard threshold criteria and guidelines published by agencies and for similar type of structures would be reviewed. Additional geotechnical studies would be performed to define the nature of the soils and to refine the means of achieving the performance specification.

- Require ground improvement such as grouting or other methods to fill voids where appropriate and offset potential settlement when excess material has been removed during excavation. The criteria for requiring grouting or ground improvement would be based on the additional data collection and reviews as noted above and the acceptable threshold value.

- Grout tunnel alignment in advance to provide adequate soil support and minimize settlement as geotechnical conditions require.

- Monitor settlement along project alignment using a series of measuring devices above the route of the alignment. Leveling surveys would be conducted prior to tunneling, to monitor for possible ground movements.

- Conduct a preconstruction survey of buildings to establish a baseline to measure potential construction-induced damage against.
- Describe and define tunnel construction monitoring requirements. In addition, provisions could be included to use the Earth Pressure Balance or Slurry TBM for tunnel construction to minimize ground loss. During tunnel construction, the soils encountered will be monitored relative to anticipated soil conditions as described in a Geotechnical Baseline Report.

For the At-Grade Emphasis LRT Alternative, the Underground Emphasis LRT Alternative, the Fully Underground LRT Alternative – Little Tokyo Variation 1, and the Fully Underground LRT Alternative – Little Tokyo Variation 2, a Contaminated Soil/Groundwater Management Plan would be implemented during construction to establish procedures to follow if contamination is encountered. The Plan would be prepared during the Final Design phase of the project, and the construction contractor would be held to the level of performance specified in the Plan. The Plan would include the following:

- Notification procedures and contact information for appropriate regulatory agencies;
- Procedures for sampling and analysis of soil and/or groundwater known or suspected to be impacted by hazardous materials;
- Procedures for the proper handling, storage, transport, and disposal of contaminated soil and/or groundwater, in consultation with regulatory agencies;
- Dust control measures (e.g., soil wetting, wind screens, etc.) for contaminated soil;
- Groundwater collection, treatment and discharge procedures and applicable standards.

In addition, a Worker Health and Safety Plan would be implemented prior to the start of construction activities. All workers would be required to review, receive training if necessary, and sign the plan prior to starting work. The Plan would, at a minimum, identify the following:

- Properties of concern and the nature and extent of contaminants that could be encountered during excavation activities;
- All appropriate worker, public health, and environmental protection equipment and procedures;
- Emergency response procedures, including most direct route to a hospital; and

- Site Safety Officer.

During construction of the underground portions of the build alternatives, mitigation would be required to address the potential for the creation of a preferential pathway and resulting spread of existing groundwater contamination. This could entail the use of impermeable grout where necessary to fill the gap between the tunnel and the surrounding earth along underground portions of the alignment where groundwater contamination exists.

To reduce potential impacts from subsurface gases associated with oilfields in the vicinity of the project area, mitigation measures would be implemented during construction of the underground portions of the build alternatives to address both exposure to toxic gases and the risk of explosion. This would be particularly important in methane zones and methane buffer zones, but testing would be required in all underground segments, as oilfield gases could occur outside of mapped zones. Specific precautions to protect workers and the public from exposure to toxic gases would be required, and specialized excavation methods would be needed to prevent explosion. Prior to building demolition, surveys of asbestos containing materials and lead-based paint would be conducted. If necessary, destructive sampling would be used. All asbestos containing materials and lead-based paint would be removed or otherwise abated prior to demolition. Removal and abatement activities would comply with all applicable laws, regulations, and rules.

6.2 Potential Operational Mitigation Measures

Mitigation would be required to address the potential for intrusion of subsurface gases in the underground portions of any of the build alternatives. Compliance with the Los Angeles City Municipal Code would be necessary for all structures within Methane and/or Buffer zones. The code requires gas concentration/pressure testing on a specified frequency and, based on the results, appropriate mitigation measures or controls to be included in the design. These mitigation measures may include the use of gas-impermeable liners and venting to reduce or eliminate gas intrusion into stations and along the length of the underground segments. The design, construction, and use of this technology have been successfully employed by Metro for various Red Line segments.

Although potential impacts related to the very weak EMFs that would be created by the build alternatives would not be anticipated, additional evaluation of sensitive receptors, including residences, schools, hospitals, day care facilities, and convalescent homes, within 100 feet of the proposed alignments would be warranted. Projected EMF levels produced by the LRT would be compared with International Radiation Protection Association guidelines. If these guidelines are exceeded, mitigation would be implemented to ground or block EMFs or modify the LRT power requirements.

7.0 CONCLUSIONS

7.1 No Build Alternative

7.1.1 NEPA Finding

There would be no adverse impacts from the No Build Alternative with respect to geotechnical, subsurface, seismic hazards or hazardous materials.

7.1.2 CEQA Determination

The No Build Alternative would have no impacts related to geotechnical subsurface, seismic hazards, or hazardous materials.

7.2 TSM Alternative

7.2.1 NEPA Finding

There would be no adverse impacts from the TSM Alternative with respect to geotechnical, subsurface, seismic hazards, or hazardous materials.

7.2.2 CEQA Determination

There would be no impacts related to geotechnical, subsurface, seismic hazards, or hazardous materials from the TSM Alternative.

7.3 At-Grade Emphasis LRT Alternative

7.3.1 NEPA Finding

There is the potential for adverse impacts with respect to liquefaction, seismically-induced settlement, and hazardous materials for portions of the At-Grade Emphasis LRT Alternative. Mitigation would be required to reduce these impacts to a less than significant level.

7.3.2 CEQA Determination

Potential impacts associated with liquefaction, seismically-induced settlement, landslides, flooding, and hazardous materials could occur during construction and operation of the At-Grade Emphasis LRT Alternative. Compliance with federal, state, and local laws and regulations regarding hazardous materials would reduce many of these impacts to a less than significant level. In addition, implementation of mitigation measures would be required to address specific issues (e.g., liquefaction, settlement, potential presence of subsurface gases, asbestos containing materials and lead based paint) to a less than significant level.

7.4 Underground Emphasis LRT Alternative

7.4.1 NEPA Finding

The Underground Emphasis LRT Alternative would have the potential for adverse impacts with respect to liquefaction, seismically-induced settlement, ground loss due to tunneling, and hazardous materials. Mitigation would be required to reduce these impacts to a less than significant level.

7.4.2 CEQA Determination

Potential impacts associated with liquefaction, seismically-induced settlement, ground loss due to tunneling, and hazardous materials could occur during construction and operation of the Underground Emphasis LRT Alternative. Many of these impacts would be addressed with adherence to federal, state, and local laws and regulations regarding hazardous materials. However, mitigation would be required to address specific issues, including potential ground loss due to tunnel construction, liquefaction hazard, presence of subsurface gases, asbestos containing materials, and lead based paint. With mitigation, potential impacts would be less than significant.

7.5 Fully Underground LRT Alternative – Little Tokyo Variation 1

7.5.1 NEPA Finding

The Fully Underground LRT Alternative – Little Tokyo Variation 1 would have the potential for adverse impacts with respect to liquefaction, seismically-induced settlement, ground loss due to tunneling, and hazardous materials. Mitigation would be required to reduce these impacts to a less than significant level.

7.5.2 CEQA Determination

The Fully Underground LRT Alternative – Little Tokyo Variation 1 would have potential impacts associated with liquefaction, seismically-induced settlement, ground loss due to tunneling, and hazardous materials during construction and operation. With mitigation, potential impacts would be less than significant.

7.6 Fully Underground LRT Alternative – Little Tokyo Variation 2

7.6.1 NEPA Finding

The Fully Underground LRT Alternative – Little Tokyo Variation 2 would have the potential for adverse impacts with respect to liquefaction, seismically-induced settlement, ground loss due to tunneling, and hazardous materials. Mitigation would be required to reduce these impacts to a less than significant level.

7.6.2 CEQA Determination

The Fully Underground LRT Alternative – Little Tokyo Variation 2 would have potential impacts associated with liquefaction, seismically-induced settlement, ground loss due to tunneling, and hazardous materials during construction and operation. With mitigation, potential impacts would be less than significant.

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APPENDIX A

DESCRIPTION OF CONSTRUCTION ACTIVITIES FOR BUILD ALTERNATIVES

Table A-1. At-Grade Emphasis LRT Alternative: Construction Activity Summary

Activity	Description	Estimated Duration (Months)	Equipment							Estim. Quantities		Est. Truck Trips/ Day	Est. No. Of Workers/ Day	Remarks (Notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional											
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	Earthwork (Cy)	Concrete (Cy)			
Pre-construction Activities	Survey, install geotechnical instrumentation, pothole, photo/ video documentation	4 to 6						x	x	n/a	n/a	5	10 to 20	
Site Preparation	Mobilize equipment, relocate utilities, secure staging areas along Flower Street, Hope Street, Gen. Thaddeus Kosciuszko Way, Main Street, Los Angeles Street, Temple Street, and Alameda Street	6 to 12	x	x	x	x				<1,000	<500	10	20 to 30	Utility relocation requires pavement breaker, jackhammers
Cut and Cover Tunnel Along Flower Street	Install soldier beam or other suitable wall systems, excavate to place top deck, excavate, dewater, remove obstructions such as tiebacks, construct tunnel structure, break into existing 7th Street/Metro Center Station, backfill	24 to 48	x	x	x	x	x	x	x	70,000	12,000	20 to 30	20 to 30	Flower Street closure until top deck is in place ~ 2 to 4 month closure at 2-block segments
Cut and Cover Station at Flower/ 6th/5th Street	Install soldier beam or other suitable wall systems, excavate to place top deck, excavate, dewater, remove obstructions such as tiebacks, construct station structure, backfill	24 to 48	x	x	x	x	x	x	x	50,000	9,500	20 to 30	20 to 30	5 - 10 concrete trucks per day during concrete pour, 5 - 10 trucks for material delivery during station construction
U-Portal at Flower between 4th and 3rd Streets	Shore and construct U-section portal at Flower Street	12 to 18	x	x	x	x	x	x	x	20,000	3,500	20 to 30	20 to 30	

Table A-1. At-Grade Emphasis LRT Alternative: Construction Activity Summary

Activity	Description	Estimated Duration (Months)	Equipment							Estim. Quantities		Est. Truck Trips/ Day	Est. No. Of Workers/ Day	Remarks (Notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional											
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	Earthwork (Cy)	Concrete (Cy)			
Portal northeast of Flower and 3rd		TBD								10,600	4,000	20 to 30	20 to 30	
Cut and Cover Station at 2nd/Hope Streets	Construct station at Bunker Hill using cut and cover, construct portal and surface tracks west of the station, shore and break into existing 2nd Street tunnel, construct tunnel entry structure	24 to 48	x	x	x	x	x	x	x	55,000	17,500	20 to 30	20 to 30	
Portal into 2nd Street Tunnel		TBD								40,000	11,700	TBD	TBD	
Surface Trackwork	Install tracks and catenary poles in 2nd Street tunnel and at grade along 2nd, Main. Los Angeles, Temple, and Alameda Streets	12 to 18	x	x	x	x	x		x	10,000	8,000	5 to 10	5 to 10	
Improvements at Alameda / Temple Streets	Shore and excavate Alameda Street to create depressed roadway, construct pedestrian bridge, complete surface tracks and tie-in	24 to 36	x	x	x	x	x	x	x	65,000	12,000	15 to 20	20 to 30	
At-Grade Stations	Construct at-grade stations at Main/1st Street and at Los Angeles/1st Street	12 to 18	x	x	x	x	x	x	x	< 1000	1,500	5 to 10	5 to 10	

Table A-1. At-Grade Emphasis LRT Alternative: Construction Activity Summary

Activity	Description	Estimated Duration (Months)	Equipment							Estim. Quantities		Est. Truck Trips/ Day	Est. No. Of Workers/ Day	Remarks (Notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional											
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	Earthwork (Cy)	Concrete (Cy)			
Operating Systems Installation	Install power poles and overhead wires along alignment and power substations at the station locations.		x	x	x	x	x	x	x	TBD	TBD	TBD	TBD	

Note: For all concreting operations, there will be occasional large pours of several hundred yards that could require more than 10 trucks. These are typically scheduled at night to ensure adequate concrete supply and to avoid traffic.

Table A-2. Underground Emphasis LRT Alternative: Construction Activities Summary

Activity	Description	Estimated Duration	Equipment										Estim. Quantities				REMARKS (Notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional							Tunneling							
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	TBM	Roadheader	Conveyor	Earthwork (Cy)	Concrete (Cy)	Est. Truck Trips/ Day	Est. No. Of Workers/ Day	
Pre-construction Activities	Survey, install geotechnical instrumentation, pothole, photo/ video documentation	4 to 6 months						x	x				n/a	n/a	5	10 to 20	
Site Preparation	Mobilize equipment, demolish existing buildings at portal site, clear and grub construction yard, relocate storm drain and other utilities, prepare TBM entry pit, secure staging areas along Flower and 2nd Streets, stabilize critical building foundations if needed	12 to 18 months	x	x	x	x							1,000	1,000	10 to 20	20 to 30	2nd Street closure for entry pit, 2 months
Cut and Cover Tunnel Along Flower Street	Install soldier beam or other suitable wall systems, excavate to place top deck, excavate, dewater, remove obstructions such as tiebacks, construct tunnel structure, break into existing 7th Street/Metro Center Station, backfill	24 to 48 months	x	x	x	x	x	x	x				280,000	27,750	20 to 30	20 to 30	Flower Street closure until top deck is in place 2 to 3 months per 2 block segment
Cut and Cover Station at Flower/ 5th/4th Street	Install soldier beam or other suitable wall systems, excavate to place top deck, excavate, dewater, remove obstructions such as tiebacks, construct station structure, backfill	24 to 48 months	x	x	x	x	x	x	x				105,000	26,000	15 to 20	20 to 30	Flower Street closure until top deck is in place ~2 to 3 months 5 to 10 concrete trucks/day during pour

Table A-2. Underground Emphasis LRT Alternative: Construction Activities Summary

Activity	Description	Estimated Duration	Equipment										Estim. Quantities				REMARKS (Notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional							Tunneling							
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	TBM	Roadheader	Conveyor	Earthwork (Cy)	Concrete (Cy)	Est. Truck Trips/ Day	Est. No. Of Workers/ Day	
Cut and Cover Appurtenances at 2nd/Hope Street Station SEM Option	Construct shafts for mining equipment, complete cut and cover station entrances, construct emergency and ventilation shafts, construct pedestrian bridge	24 to 48 months	x	x	x	x	x	x	x				30,000	5,500	15 to 20	20 to 30	Chiller building underpinning may be needed
SEM Station at 2nd/Hope Streets	Mine and stabilize station excavation, construct station, stabilize adjacent building foundations if needed	24 to 48 months	x	x	x	x	x		x				50,000	8,250	10 to 15	20 to 25	
Cut-and-Cover Station at 2nd/Hope Streets	Mine and stabilize station excavation, construct station, stabilize adjacent building foundations if needed	24 to 48 months	x	x	x	x	x		x		x	x	147,500	17,250	20 to 30	20 to 30	
TBM Tunnel between Central Ave. and Bunker Hill	Bore tunnels with TBM recovering machine at Bunker Hill or Central Avenue, haul away cuttings, provide grouting if needed, remove TBM machine and backfill entry pit	24 to 48 months	x	x	x	x	x		x	x		x	120,000	Precast Segments	35 to 70	15 to 20	Tunnel boring production estimated 12 to 18 months Grouting may be needed at Higgins Building
Cut and Cover Station at 2nd/ Broadway option	Install soldier beam or other suitable wall systems, excavate to place top deck, excavate, dewater, construct station structure, backfill	24 to 48 months	x	x	x	x	x	x	x				200,000	47,250	15 to 20	15 to 20	2nd Street closed until top deck in ~ 2 to 3 mo 5 to 10 concrete trucks/day during pour
Cut and Cover Station at 2nd/ Los Angeles Street option	Install soldier beam or other suitable wall systems, excavate to place top deck, excavate, dewater, construct station structure, backfill	24 to 48 months	x	x	x	x	x	x	x				175,000	48,500	15 to 20	15 to 20	2nd Street closed until top deck in ~ 2 to 3 mo 5 to 10 concrete trucks/day during pour

Table A-2. Underground Emphasis LRT Alternative: Construction Activities Summary																	
Activity	Description	Estimated Duration	Equipment										Estim. Quantities		Est. Truck Trips/ Day	Est. No. Of Workers/ Day	REMARKS (Notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional							Tunneling							
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	TBM	Roadheader	Conveyor	Earthwork (Cy)	Concrete (Cy)			
Cut and Cover Tunnel and U-Portal at 2nd and Central	Complete cut and cover section at end of TBM, construct U-section portal	12 to 24 months	x	x	x	x	x	x	x				20,000	7,500	5 to 10	15 to 20	2nd Street/ Central Avenue temporarily closed ~ 2mo, then East half of Central Avenue permanently closed
TBM Launch Site		2 to 4 months	x	x	x	x	x	x	x				20,000	n/a	5 to 10	15 to 20	
Improvements at Alameda / 1st Street	Shore and excavate Alameda Street to create depressed roadway, construct pedestrian bridge, complete surface tracks and tie-in	24 to 36 months	x	x	x	x	x		x				65,000	12,000	15 to 20	20 to 30	Alameda and 1st Streets closed until deck is in place and while bridge is erected ~ 12 to 18 mo.
Operating Systems Installation	Install power poles and overhead wires along alignment and power substations at the station locations.		x	x	x	x	x	x	x	TBD	TBD	TBD	TBD				

Notes: Earthwork quantities include bulking factor of 1.3
For underground station construction, Concrete volume and truck trips are tbd; 5 to 10 trucks per day can be assumed during concrete pour periods. 5 to 10 trucks per day during material delivery
For all concreting operations during station construction, there will be occasional large pours of several hundred yards that could require more than 10 trucks. These are typically scheduled at night to ensure adequate concrete supply and to avoid traffic.
Truck trip estimates assume full production; full production would not occur through the entire estimated duration

Table A-3. Fully Underground LRT Alternative – Little Tokyo Variation 1: Construction Activities Summary

Activity	Description	Estimated Duration	Equipment										Estim. Quantities		Est. Truck Trips/ Day	Est. No. Of Workers/ Day	REMARKS (notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional							Tunneling							
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	TBM	Roadheader	Conveyor	Earthwork (Cy)	Concrete (Cy)			
Pre-construction Activities	Survey, install geotechnical instrumentation, pothole, photo/ video documentation	4 to 6 months						x	x				n/a	n/a	5	10 to 20	
Site Preparation	Mobilize equipment, demolish existing buildings at portal site, clear and grub construction yard, relocate storm drain and other utilities, prepare TBM entry pit, secure staging areas along Flower and 2nd Streets, stabilize critical building foundations if needed	12 to 18 months	x	x	x	x							1,000	1,000	10 to 20	20 to 30	2nd Street closure for entry pit, 2 months
Cut and Cover Tunnel Along Flower Street	Install soldier beam or other suitable wall systems, excavate to place top deck, excavate, dewater, remove obstructions such as tiebacks, construct tunnel structure, break into existing 7th Street/Metro Center Station, backfill	24 to 48 months	x	x	x	x	x	x	x				280,000	27,750	20 to 30	20 to 30	Flower Street closure until top deck is in place 2 to 3 months per 2 block segment
Cut and Cover Station at Flower/ 5th/4th Street	Install soldier beam or other suitable wall systems, excavate to place top deck, excavate, dewater, remove obstructions such as tiebacks, construct station structure, backfill	24 to 48 months	x	x	x	x	x	x	x				105,000	26,000	15 to 20	20 to 30	Flower Street closure until top deck is in place ~2 to 3 months 5 to 10 concrete trucks/day during pour

Table A-3. Fully Underground LRT Alternative – Little Tokyo Variation 1: Construction Activities Summary

Activity	Description	Estimated Duration	Equipment										Estim. Quantities		Est. Truck Trips/ Day	Est. No. Of Workers/ Day	REMARKS (notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional							Tunneling							
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	TBM	Roadheader	Conveyor	Earthwork (Cy)	Concrete (Cy)			
Cut and Cover Appurtenances at 2nd/Hope Street Station SEM Option	Construct shafts for mining equipment, complete cut and cover station entrances, construct emergency and ventilation shafts, construct pedestrian bridge	24 to 48 months	x	x	x	x	x	x	x				30,000	5,500	15 to 20	20 to 30	Chiller building underpinning may be needed
SEM Station at 2nd/Hope Streets	Mine and stabilize station excavation, construct station, stabilize adjacent building foundations if needed	24 to 48 months	x	x	x	x	x		x				50,000	8,250	10 to 15	20 to 25	
Cut-and-Cover Station at 2nd/Hope Streets	Mine and stabilize station excavation, construct station, stabilize adjacent building foundations if needed	24 to 48 months	x	x	x	x	x		x		x	x	147,500	17,250	20 to 30	20 to 30	
TBM Tunnel between Central Ave. and Bunker Hill	Bore tunnels with TBM recovering machine at Bunker Hill or Central Ave., haul away cuttings, provide grouting if needed, remove TBM machine and backfill entry pit	24 to 48 months	x	x	x	x	x		x	x		x	120,000	Precast Segments	35 to 70	15 to 20	Tunnel boring production estimated 12 to 18 months Grouting may be needed at Higgins Building

Table A-3. Fully Underground LRT Alternative – Little Tokyo Variation 1: Construction Activities Summary

Activity	Description	Estimated Duration	Equipment										Estim. Quantities		Est. Truck Trips/ Day	Est. No. Of Workers/ Day	REMARKS (notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional							Tunneling							
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	TBM	Roadheader	Conveyor	Earthwork (Cy)	Concrete (Cy)			
Cut and Cover Station at 2nd Street/ Broadway	Install soldier beam or other suitable wall systems, excavate to place top deck, excavate, dewater, construct station structure, backfill	24 to 48 months	x	x	x	x	x	x	x				200,000	47,250	15 to 20	15 to 20	2nd Street closed until top deck in ~ 2 to 3 mo 5 to 10 concrete trucks/day during pour
TBM Launch Site		2 to 4 months	x	x	x	x	x	x	x				20,000	n/a	5 to 10	15 to 20	
Cut and Cover Tunnel from TBM to 2nd Street/ Central Avenue Station	Install soldier beam or other suitable wall systems, excavate possibly without top deck, dewater, construct the station structure, backfill. As conditions permit within the vacant lot, construct in open sloped excavation with dewatering and backfill	12 to 24 months	x	x	x	x	x	x	x				20,000	N/A	15 to 20	15 to 20	

Table A-3. Fully Underground LRT Alternative – Little Tokyo Variation 1: Construction Activities Summary

Activity	Description	Estimated Duration	Equipment										Estim. Quantities		Est. Truck Trips/ Day	Est. No. Of Workers/ Day	REMARKS (notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional							Tunneling							
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	TBM	Roadheader	Conveyor	Earthwork (Cy)	Concrete (Cy)			
Open Cut Station at 2nd Street/ Central Avenue	Install soldier beam or other suitable wall systems, excavate possibly without top deck, dewater, construct the station structure, backfill. As conditions permit within the vacant lot, construct in open sloped excavation with dewatering and backfill	18 to 36 months	x	x	x	x	x	x	x				55,000	N/A	20 to 30	15 to 20	
Cut and Cover from 2nd Street/ Central Avenue to East Portal	Install soldier beam or other suitable wall systems, excavate to place top deck (or without deck at the portal), excavate, dewater, construct structure, backfill	12 to 24 months	x	x	x	x	x	x	x				45,000	N/A	15 to 20	15 to 20	
Cut and Cover from 2nd Street/ Central Avenue to North Portal	Install soldier beam or other suitable wall systems, excavate to place top deck or without deck at portal, excavate, dewater, construct structure, backfill	12 to 24 months	x	x	x	x	x	x	x				95,000	N/A	15 to 20	15 to 20	
Improvements at Alameda / 1st /Temple Streets	Roadway re-alignment, MSE Wall reconstruction, utility relocation, other associated works	12 to 24 months	x	x	x	x	x		x				TBD	TBD	15 to 20	20 to 30	

Table A-3. Fully Underground LRT Alternative – Little Tokyo Variation 1: Construction Activities Summary

Activity	Description	Estimated Duration	Equipment										Estim. Quantities		Est. Truck Trips/ Day	Est. No. Of Workers/ Day	REMARKS (notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional							Tunneling							
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	TBM	Roadheader	Conveyor	Earthwork (Cy)	Concrete (Cy)			
Operating Systems Installation	Install power poles and overhead wires along alignment and power substations at the station locations.		x	x	x	x	x	x	x	TBD	TBD	TBD	TBD				

Notes: Earthwork quantities include bulking factor of 1.3
For underground station construction, Concrete volume and truck trips are tbd; 5 to 10 trucks per day can be assumed during concrete pour periods. 5 to 10 trucks per day during material delivery
For all concreting operations during station construction, there will be occasional large pours of several hundred yards that could require more than 10 trucks. These are typically scheduled at night to ensure adequate concrete supply and to avoid traffic.
Truck trip estimates assume full production; full production would not occur through the entire estimated duration

Table A-4. Fully Underground LRT Alternative – Little Tokyo Variation 2: Construction Activities Summary

ACTIVITY	DESCRIPTION	ESTIMATED DURATION	EQUIPMENT										ESTIM. QUANTITIES		Est. Truck Trips/ Day	Est. No. of Workers/ Day	REMARKS (Notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional							Tunneling							
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	TBM	Roadheader	Conveyor	Earthwork (CY)	Concrete (CY)			
Pre-construction Activities	Survey, install geotechnical instrumentation, pothole, photo/ video documentation	4 to 6 months						x	x				n/a	n/a	5	10 to 20	
Site Preparation	Mobilize equipment, demolish existing buildings at portal site, clear and grub construction yard, relocate storm drain and other utilities, prepare TBM entry pit, secure staging areas along Flower and 2nd Streets, stabilize critical building foundations if needed	12 to 18 months	x	x	x	x							1,000	1,000	10 to 20	20 to 30	2nd Street closure for entry pit, 2 months
Cut and Cover Tunnel Along Flower Street	Install soldier beam or other suitable wall systems, excavate to place top deck, excavate, dewater, remove obstructions such as tiebacks, construct tunnel structure, break into existing 7th Street/Metro Center Station, backfill	24 to 48 months	x	x	x	x	x	x	x				280,000	27,750	20 to 30	20 to 30	Flower Street closure until top deck is in place 2 to 3 months per 2 block segment
Cut and Cover Station at Flower/ 5th/4th Streets	Install soldier beam or other suitable wall systems, excavate to place top deck, excavate, dewater, remove obstructions such as tiebacks, construct station structure, backfill	24 to 48 months	x	x	x	x	x	x	x				105,000	26,000	15 to 20	20 to 30	Flower Street closure until top deck is in place ~2 to 3 months 5 to 10 concrete trucks/day during pour

Table A-4. Fully Underground LRT Alternative – Little Tokyo Variation 2: Construction Activities Summary

ACTIVITY	DESCRIPTION	ESTIMATED DURATION	EQUIPMENT – Conventional							EQUIPMENT – Tunneling			ESTIM. QUANTITIES				REMARKS (Notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	TBM	Roadheader	Conveyor	Earthwork (CY)	Concrete (CY)	Est. Truck Trips/ Day	Est. No. of Workers/ Day	
Cut and Cover Appurtenances at 2nd/Hope Street Station SEM Option	Construct shafts for mining equipment, complete cut and cover station entrances, construct emergency and ventilation shafts, construct pedestrian bridge	24 to 48 months	x	x	x	x	x	x	x				30,000	5,500	15 to 20	20 to 30	Chiller building underpinning may be needed
SEM Station at 2nd/Hope Streets	Mine and stabilize station excavation, construct station, stabilize adjacent building foundations if needed	24 to 48 months	x	x	x	x	x		x				50,000	8,250	10 to 15	20 to 25	
Cut-and-Cover Station at 2nd/Hope Streets	Mine and stabilize station excavation, construct station, stabilize adjacent building foundations if needed	24 to 48 months	x	x	x	x	x		x		x	x	147,500	17,250	20 to 30	20 to 30	
TBM Tunnel between Central Ave. and Bunker Hill	Bore tunnels with TBM recovering machine at Bunker Hill or Central Ave., haul away cuttings, provide grouting if needed, remove TBM machine and backfill entry pit	24 to 48 months	x	x	x	x	x		x	x		x	120,000	Precast Segments	35 to 70	15 to 20	Tunnel boring production estimated 12 to 18 months Grouting may be needed at Higgins Building
Cut and Cover Station at 2nd Street/ Broadway	Install soldier beam or other suitable wall systems, excavate to place top deck, excavate, dewater, construct station structure, backfill	24 to 48 months	x	x	x	x	x	x	x				200,000	47,250	15 to 20	15 to 20	2nd St. closed until top deck in ~ 2 to 3 mo 5 to 10 concrete trucks/day during pour
TBM Launch Site		2 to 4 months	x	x	x	x	x	x	x				20,000	n/a	5 to 10	15 to 20	

Table A-4. Fully Underground LRT Alternative – Little Tokyo Variation 2: Construction Activities Summary

ACTIVITY	DESCRIPTION	ESTIMATED DURATION	EQUIPMENT										ESTIM. QUANTITIES		Est. Truck Trips/ Day	Est. No. of Workers/ Day	REMARKS (Notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional							Tunneling							
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	TBM	Roadheader	Conveyor	Earthwork (CY)	Concrete (CY)			
Cut and Cover Tunnel from TBM to 2nd Street/ Central Avenue Station	Install soldier beam or other suitable wall systems, excavate possibly without top deck, dewater, construct the station structure, backfill. As conditions permit within the vacant lot, construct in open sloped excavation with dewatering and backfill	12 to 24 months	x	x	x	x	x	x	x				25,000	N/A	15 to 20	15 to 20	
Open Cut Station at 2nd Street/ Central Avenue	Install soldier beam or other suitable wall systems, excavate possibly without top deck, dewater, construct the station structure, backfill. As conditions permit within the vacant lot, construct in open sloped excavation with dewatering and backfill	18 to 36 months	x	x	x	x	x	x	x				80,000	N/A	20 to 30	15 to 20	
Cut and Cover from 2nd/ Central Avenue to East Portals	Install soldier beam or other suitable wall systems, excavate to place top deck (or without deck at the portals), excavate, dewater, construct structure, backfill	12 to 24 months	x	x	x	x	x	x	x				90,000	N/A	15 to 20	15 to 20	
Cut and Cover from 2nd/ Central Avenue to North Portal	Install soldier beam or other suitable wall systems, excavate to place top deck or without deck at portal, excavate, dewater, construct structure, backfill	12 to 24 months	x	x	x	x	x	x	x				125,000	N/A	15 to 20	15 to 20	

Table A-4. Fully Underground LRT Alternative – Little Tokyo Variation 2: Construction Activities Summary

ACTIVITY	DESCRIPTION	ESTIMATED DURATION	EQUIPMENT										ESTIM. QUANTITIES		Est. Truck Trips/ Day	Est. No. of Workers/ Day	REMARKS (Notes on type and duration of potential higher impact conditions such as street closures, building operation interruption, etc.)
			Conventional							Tunneling							
			Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed	TBM	Roadheader	Conveyor	Earthwork (CY)	Concrete (CY)			
Improvements at Alameda / 1st Street/Temple Street	Roadway re-alignment, MSE Wall reconstruction, utility relocation, other associated works	12 to 24 months	x	x	x	x	x		x				TBD	TBD	15 to 20	20 to 30	
Operating Systems Installation	Install power poles and overhead wires along alignment and power substations at the station locations.		x	x	x	x	x	x	x	TBD	TBD	TBD	TBD				

Notes: Earthwork quantities include bulking factor of 1.3
For underground station construction, Concrete volume and truck trips are tbd; 5 to 10 trucks per day can be assumed during concrete pour periods. 5 to 10 trucks per day during material delivery
For all concreting operations during station construction, there will be occasional large pours of several hundred yards that could require more than 10 trucks. These are typically scheduled at night to ensure adequate concrete supply and to avoid traffic.
Truck trip estimates assume full production; full production would not occur through the entire estimated duration