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

APPENDIX K

DESCRIPTION OF CONSTRUCTION

State Clearinghouse Number: 2009031043

Regional Connector Transit Corridor
Description of Construction

April 30, 2010

Prepared for

Los Angeles County Metropolitan Transportation Authority

ONE GATEWAY PLAZA

LOS ANGELES, CA 90012

State Clearinghouse Number: 2009031043

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ACRONYMS

EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPB	Earth Pressure Balance
LRT	Light Rail Transit
MSE	Mechanically Stabilized Earth
SEM	Sequential Excavation Method
TBM	Tunnel boring machine
TPSS	Traction power substations
TSM	Transportation Management System
UG	Underground

1.0 INTRODUCTION

This description of construction is based on information known to date about construction of the Regional Connector Transit Corridor project. Construction specifics are rarely known before design. For purposes of the Draft Environmental Impact Statement/Draft Environmental Impact Report DEIS/DEIR, maximum potential impact is analyzed using a reasonable worst case approach to describe the potential impacts. For example, several possible construction staging areas may be analyzed, even though not all of them would be used. This approach means that the environmental analysis can be relied on regardless of which sites are ultimately selected. Analyzing potential "maximum impact," also allows the environmental process to identify potential constraints and mitigation.

Four light rail transit (LRT) construction scenarios are analyzed: the At-Grade Emphasis LRT Alternative, the Underground Emphasis LRT Alternative, and the Fully Underground LRT Alternatives – Variation 1 and Variation 2. A description of the construction activities and locations anticipated for each of these build alternatives is provided in Section 2, Construction Methods Overview.

2.0 CONSTRUCTION METHODS OVERVIEW

The construction of the Regional Connector Transit Corridor project would use conventional construction techniques and equipment currently used in the southern California region and the United States. Depending on the alternative (at-grade emphasis, underground emphasis, or fully underground alternative) more or less at-grade or underground construction would be employed. Major project elements include construction of guideway and trackwork, at-grade station platforms, underground stations, crossovers, tunnels, a grade separation at Alameda Street, pedestrian bridges, installation of specialty system work such as traction power, communications and signaling. These facilities would be constructed in existing geologic conditions ranging from siltstone to alluvium. Some of these facilities would be located in close proximity to existing structures and utilities. The equipment used in construction would include graders, drilling equipment, bulldozers, cranes, concrete trucks, pumping equipment, flat bed trucks, dump trucks to haul dirt, forklift, tunnel boring machines, and other types of excavators such as clamshell, and rail mounted cars to transport spoil material within the tunnels. Spoil materials would be hauled away from the work sites by dump trucks to disposal sites.

Much of the information presented in this section was included in the Conceptual Engineering Design Report prepared for the Regional Connector Alternatives Analysis dated September 2008.

The various work activities would be performed over an estimated four- to five-year construction period. The major elements associated with the build alternatives are anticipated to consist of the following:

At-Grade Emphasis LRT Alternative

- Construction of about 1,600 feet of cut and cover tunnel along Flower Street between the existing 7th Street/Metro Center Station and the open cut portal just south of the proposed station at 2nd and Hope Streets.
- Construction of a cut and cover underground station and crossover along Flower Street between 6th and 5th Streets (Flower/6th/5th Street Station).
- Construction of an open cut underground station at 2nd and Hope Streets.
- Construction of a pedestrian bridge connecting Grand Avenue to the 2nd/Hope Street Station.
- Construction of a connection into the existing 2nd Street tunnel from the 2nd/Hope Street Station area. This would require supporting the existing tunnel, breaking into

the tunnel, and construction of new supports for the openings into the tunnel. Installation of trackwork would be completed inside the existing tunnel to allow one lane of vehicular and two directions of LRT traffic.

- Construction of approximately one mile of at-grade trackwork, demolition of the roadway section being displaced by the LRT trackway, preparation of the track bed, construction of the supporting track slab, and laying of rail, along 2nd, Main, Los Angeles, and Temple Streets to the Little Tokyo/Arts District Station.

- Construction of overhead catenary systems including overhead catenary wire, support brackets, feeder cables, and other electrical components or alternative power distribution systems and street lighting where required.

- Construction of traction power substations (TPSS) adjacent to the right-of-way along at-grade segments, or as part of the station boxes along underground segments. The substations deliver electricity to the overhead catenary systems, and can fit in rooms or standalone buildings of 5,000 square feet or less.

- Construction of two at-grade, high floor station platforms using typical "cast-in-place" or precast concrete construction methods: one on Main Street and one on Los Angeles Street. Both stations would be located just north of 1st Street and would have single direction platforms.

- Construction of an underpass and pedestrian bridge at the intersection of Alameda Street and Temple Streets. The Pedestrian Bridge Type Selection Report will be prepared during the Preliminary Design phase and the type of bridge construction will be identified in that report.

- Modification of the existing Mechanically-Stabilized Earth (MSE) embankment north of the Little Tokyo/Arts District Station, east of Alameda Street.

Underground Emphasis LRT Alternative

- Construction of about 2,200 feet of cut and cover tunnel along Flower Street between the existing 7th Street/Metro Center Station and the proposed 2nd/Hope Street Station.

- Construction of a cut and cover underground station along Flower Street between 4th and 5th Streets (Flower/5th/6th Street Station) and reconstruction of the existing pedestrian bridge.

- Construction of the 2nd/Hope Street Station using either the Sequential Excavation Method (SEM) or the open cut method.

- Construction of a pedestrian bridge connecting Upper Grand Avenue to the 2nd/Hope Street Station.
- Demolition of existing structures at construction staging sites and station entrance areas including the Office Depot at the construction staging/ Tunnel Boring Machine (TBM) launch site north of 2nd Street from Alameda Street to approximately 300 feet west of Central Avenue.
- Construction of temporary retaining walls and portal structures on 2nd Street between Central Avenue and Alameda Street. The portal structure area would also be used for the TBM launch shaft.
- Construction of about 0.65 mile of (twin) tunnel by TBM along 2nd Street from the launch shaft at Central Avenue/2nd Street westward towards 2nd/Hope Street Station.
- Construction of a cut and cover underground station along 2nd Street either between Los Angeles and Main Streets (Los Angeles Street Option) or between Broadway and Spring Streets (Broadway Option).
- Construction of an underpass and pedestrian bridge at the intersection of Alameda and 1st Streets, and construction of a roadway bridge on 1st Street over Alameda Street. The construction would include retaining walls, a pedestrian bridge structure and utility relocations. The Pedestrian and Roadway Bridge Type Selection Report will be prepared during the Preliminary Design phase and the type of bridge construction will be identified in that report.
- Construction of emergency, ventilation, and entrance shafts for 2nd/Hope Street Station.
- Relocation or support-in-place of a major storm drain along 2nd Street.
- Construction of overhead catenary systems, including overhead catenary wire, support brackets, feeder cables, and other components or alternative power distribution systems, and street lighting where required.

Fully Underground LRT Alternative – Variation 1

- The proposed alignment is generally the same as the Underground Emphasis LRT Alternative, except as noted below. Trains would continue to travel underground northeast from under the intersection of 2nd Street and Central Avenue to just east of the intersection of Alameda and 1st Streets, making 1st and Alameda a fully grade separated intersection. Alameda Street would remain at-grade.

- A three-way junction would be constructed underground beneath the 1st and Alameda Streets intersection.
- Construction of two portals. One portal would be constructed along 1st Street east of Alameda (East Portal) to allow a connection to the Metro Gold Line to the east. 1st Street would be widened to the north to accommodate the portal. The widening would initiate at Alameda Street and continue east, tapering down significantly as it crosses Hewitt Street to join the existing 1st Street LRT tracks, just west of the 1st Street Bridge.
- The second portal would allow for a connection to the Metro Gold Line to the north (north portal to Pasadena). It would be constructed northeast of the existing Little Tokyo/Arts District Station. The portal would be connected to the 1st and Alameda junction by a new tunnel crossing beneath Temple Street and the property proposed for the Nikkei Development (the parcel on the northeast corner of 1st and Alameda Streets), running immediately east of the existing Little Tokyo/Arts District station and tracks.
- An additional underground station would be constructed within the block bounded by 1st Street, Alameda Street, 2nd Street, and Central Avenue, (2nd Street/Central Avenue Station).
- The 2nd Street Station/Los Angeles Street Option would not be part of this alternative. The 2nd Street Station/Broadway Option would be constructed.
- Reconstruction of the existing embankment from Little Tokyo/Arts District Station to the south US 101 bridge abutment is required for the earlier transition to all underground alternatives.
- Cut and cover section would begin west of Central Avenue to the Office Depot site (also referred to as “Block 6” by the CRS). A center platform station is constructed at this site, with tracks to the north and east proceeding at the same grade.
- North and East portals are wide enough to accommodate out-bound and in-bound trains in a single structure.

Fully Underground LRT Alternative – Variation 2

- This alternative is similar to Variation 1, except as noted below. The cut and cover section would begin west of Central Avenue to the Office Depot site – similar to Variation 1. However, in Variation 2, the tunnels transition to an “over and under” configuration to eliminate tracks crossing at the same elevation within the wye. The 2nd Street/Central Avenue Station would be a side platform station with the northbound platform above the eastbound. The portal structures along 1st Street would be staggered to allow transition from the upper and lower platform grade to the street.

Elements Common to All Build Alternatives

- Use of building protection measures such as underpinning or ground improvement combined with a geotechnical monitoring program as required to monitor and protect structures identified for such measures.
- Relocation, modification, or protection in place of existing utilities in the path of the planned excavations for street level trackwork, tunnels, portals, and stations. The extent of utility relocation is generally greater for the Underground Emphasis LRT Alternative and Fully Underground LRT Alternative.
- Construction of underground duct banks for electrical power feeds and for signaling/communications systems.
- Removal or relocation of structures at construction staging sites and area around station entrances, where necessary.
- Construction of a connection to the existing 7th Street/Metro Center Station.
- Cut and cover construction on Flower Street between Wilshire Boulevard and 3rd Street.
- Construction of entrances to the underground stations.
- Construction of urban design enhancements within 1,000 feet around stations and portals.
- Construction of surface and subsurface drainage systems.
- Construction of traction power substations with electrical power feeds.
- Installation of traffic signals and train control improvements.
- Construction of trackwork complete with preparation of track bed, track slab, rail, fasteners, and infill concrete in street level areas.
- Installation of the overhead catenary system, which includes wires, poles, support brackets, feeders, and other components. Currently, catenary (two-wire configuration) is being assumed for all of the alternatives, but this may need to be changed during further design phases.

- Construction of station finishes, such as canopies, fare vending equipment, station furniture, ramps, elevators, escalators, landscaping, and all other amenities necessary for a functional station.
- Conducting system integration testing including existing operating lines.
- Conducting simulated revenue operation test runs and final commissioning of the system.

Maps of each build alternative are provided in Figure 3-1 through 3-3.

The tunnel and stations would be constructed with a number of tunneling techniques, depending on the geological and environmental conditions, cost, schedule, alignment, and other factors. The following sections describe the main methods that would be employed in construction of the major elements noted above.

2.1 Cut and Cover Construction and Open-Cut Construction

This is a very common construction method for underground facilities and it entails excavating down from the ground surface. A temporary excavation support is provided to stabilize the ground and excavation is carried out inside the supported area. Temporary concrete decking can be placed over the cut immediately following the first lift of excavation (at about 12 to 15 feet below ground surface) to allow traffic to pass above. Once the deck is in place, excavation and internal bracing would continue to the required depth. Once the desired construction is completed inside the excavated area, the excavation is backfilled and the surface is restored permanently. Temporary excavation support and retaining walls are installed before significant excavation commences. Depending on the depth of excavation and ground conditions, the excavation support could consist of reinforced concrete drilled-in-place piles (tangent pile wall), secant pile wall, sheet pile wall, soldier piles and lagging, or slurry walls. These wall systems are braced with internal struts or supported by tiebacks as the excavation progresses. Tiebacks consist of horizontal or inclined wire strands or steel rods installed in drilled holes in the ground behind the wall. One end of the tieback is secured to the wall and the other end is anchored to stable ground to provide sufficient resistance and to limit ground movement.

Figure 2-1 illustrates a schematic of the sequence associated with a cut and cover construction.

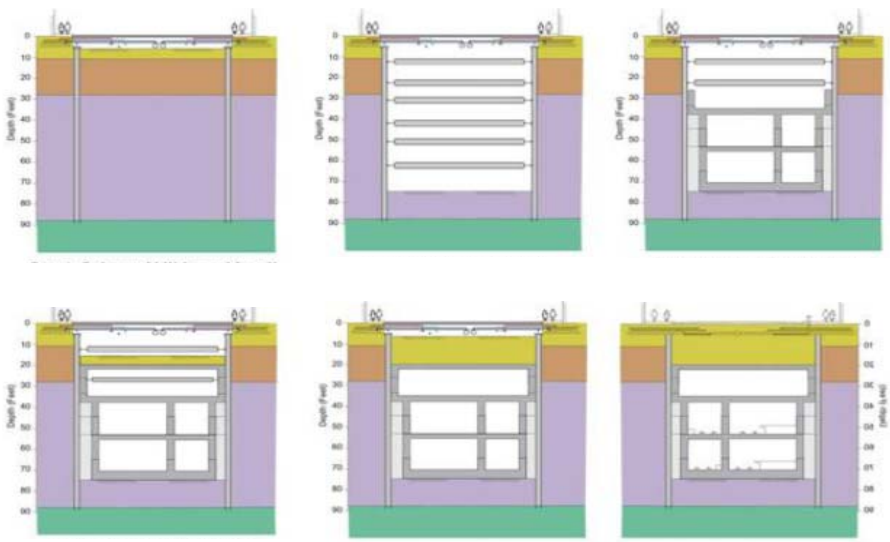

Figure 2-1: Typical Cut and Cover Construction

Open cut construction is similar to cut and cover construction, except temporary decking is not used.

All underground stations and some portions of the tunnel alignment would be constructed using the cut and cover technique, except the 2nd/Hope Street station under the Underground Emphasis LRT Alternative and the Fully Underground LRT Alternative, and the 2nd Street/Central Avenue station under the Fully Underground LRT Alternative. The 2nd/Hope Street Station may be constructed using the Sequential Excavation Method (SEM) as will be described in Section 2.3, or the open cut method. Also, the 2nd Street/Central Avenue Station on the Fully Underground LRT Alternative would be constructed using the open cut method.

Many of the existing structures adjacent to the alignment have underground basements that utilized temporary shoring and tieback systems during their original construction. The tiebacks were typically left in place and decommissioned after basement construction, in general accordance with local practice in the City of Los Angeles and southern California. These abandoned/decommissioned tiebacks could be encountered under many parts of Flower Street since the existing deep basement/parking garage used tiebacks to support the original excavations during construction. Steel tieback cables could pose a problem for tunnel boring machines. The cut and cover method provides greater flexibility and the ability to overcome underground obstructions more easily than the TBM method. These obstructions would potentially be problematic for TBM excavation on Flower Street due to the shallow depths of the tunnels, which is partly why cut and cover construction is planned for this area. On 2nd Street, the TBM tunnel alignment would be deeper, and would pass beneath these underground obstructions. The presence of abandoned tiebacks in conjunction with the shorter length of the alignment between stations favors the cut and cover method along Flower Street for all build alternatives.

Typical cut and cover construction activities used on the Metro Gold Line Eastside Extension project from initial excavation through decking as viewed from the surface are shown on Figure 2-2.

Figure 2-2. Typical Cut and Cover Construction Activities

2.1.1 Construction of Retaining Walls

Cut and cover construction begins with the identification and relocation of utilities in the project area. Once the utilities are relocated, construction of temporary retaining walls would be required to support the soils laterally for excavation of the cut and cover tunnel, the underground stations, and the underpass to the required depths. Depending on the depth of excavation, the ground conditions, the proximity of adjacent structures to the proposed construction, building foundation type, and the potential for construction-induced ground movement, an appropriate temporary support method would be selected. Construction activities related to each potential temporary support method are described below.

2.1.1.1 Soldier Pile and Lagging

Figure 2-3. Typical Soldier Pile Installation

Soldier pile and lagging walls are a type of shoring system typically constructed along the perimeter of excavation areas to hold back the soil around the excavated pit. This support system consists of installing soldier beams (vertical steel beams) at regular intervals and placing precast panels or other lagging materials in between the beams to form the retaining wall. Pre-auguring would likely be necessary for installation of the soldier piles, to eliminate pile driving which would cause vibration and noise. Pre-auguring involves drilling holes for each pile from the street surface.

The construction sequence would start with the contractor occupying one side of the street to install one line of soldier piles while the other side would remain open for traffic. The equipment required for installation of the soldier piles would include drill rigs, concrete trucks, cranes, and dump trucks.

A soldier pile wall is generally used where groundwater is not a hazard or where grouting, or dewatering can be used to mitigate leakage between piles. A typical soldier pile installation and soldier pile and lagging with cross bracing for the Mariachi Station on the Metro Gold Line Eastside Extension project are shown in Figure 2-3.

2.1.1.2 Tangent Pile Walls

Tangent pile walls consist of contiguous drilled piles touching each other. This system can provide a temporary support which can then be converted into a permanent structure. The contiguous wall generally provides a better groundwater seal than the soldier pile and lagging system, but some grouting or dewatering could still be needed to control leakage between piles. Similar to the soldier pile installation described above, the contractor would occupy one side of the street and drill the piles sequentially to form the retaining wall. The equipment required for installation of the tangent pile wall includes drill rigs, concrete trucks, cranes, and dump trucks.

2.1.1.3 Secant Pile Walls

This system is similar to the tangent pile wall but the piles have some overlap, facilitating better water tightness and rigidity. The method consists of boring and concreting the primary piles at centers slightly less than twice the pile diameter. Secondary piles are then bored in between the primary piles, prior to the concrete achieving much of its strength. The completed secant pile wall for the Barnsdall

Figure 2-4. Secant Pile Wall for the Barnsdall Shaft in Hollywood

Shaft in Hollywood for the Red Line project is shown on Figure 2-4.

2.1.1.4 Diaphragm/Slurry Walls

Diaphragm/slurry walls are underground structural elements commonly used for retention systems and permanent foundation walls. Diaphragm walls are constructed inside trenches which are kept open by filling them with bentonite slurry. The structural elements are lowered into the slurry filled trench and concrete is pumped from the bottom of the trench, displacing the slurry. Construction is done in discontinuous sections such that no two adjacent panels are worked on simultaneously. Stop-end pipes are placed vertically at each end of the primary panel to form joints for adjacent secondary panels. Panels are usually 8 to 20 feet long, with widths varying from two to five feet

Slurry wall construction would occur in stages, working on one side of the street at a time. Once the excavation of a section is complete, a steel reinforcement cage is placed in the center of the panel. Concrete is poured in one continuous operation through one or more tremie pipes (pipes that inject concrete below the slurry) that extend to the bottom of the trench. The tremie pipes are extracted as the concrete rises; however, the discharge end of the tremie pipe always remains embedded in the fresh concrete. The slurry that is displaced by the concrete is saved and reused for subsequent panel excavations. As the concrete sets, the end pipes are withdrawn. Similarly, secondary panels are constructed between the primary panels to create a continuous wall.

Diaphragm walls have been constructed in virtually all soil types to provide a watertight support system in addition to greater wall stiffness to control ground movement. Diaphragm walls may in some cases be used as the permanent wall. However, diaphragm walls are generally not adaptable to utility crossings and all utilities crossed by the wall would require relocation. The equipment required for installation of the slurry wall includes clamshell excavator or rotary head, concrete trucks, slurry mixing equipments, cranes, slurry treatment plant, and dump trucks. The bentonite slurry would require disposal after a number of cycles.

2.1.2 Excavation and Decking

After installation of the temporary shoring support system and initial excavation, the contractor would proceed with installation of the deck beams, followed by multiple sequences of excavation and installation of cross bracing or tieback systems. Using pre-cast concrete panels (decking) allows traffic and pedestrian circulation to resume after the initial excavation since they would be installed flush with existing street or sidewalk levels. Deck installation would require lane and night street closures at the cut and cover areas. Concrete decking would be installed in progressive stages. Portal construction would follow similar construction methods as for the station excavations and retaining walls but the portal would remain permanently open and thus no decking would be used during construction.

2.2 Tunnel Boring Machine (TBM)

The portion of the Underground Emphasis LRT Alternative and the Fully Underground LRT Alternative to be bored with TBM along 2nd Street would consist of twin tunnels with outside diameters of up to about 22 feet. TBMs are large-diameter horizontal drills that continuously excavate predominantly circular tunnel sections. Different machine types are designed for different geological conditions. The excavated materials are removed through the tunnel using hopper type rail cars or by a conveyor system. As the machine advances, both the ground in front of the machine and the hole it creates are continually supported by the machine shield and pre-cast concrete tunnel liners. This method creates a tunnel with little or no disruption at the surface, and is especially suitable for creating a circular opening at greater depths that would not be practical for cut and cover construction. When the concrete tunnel liner segments have rubber gaskets between them, water is prevented from entering the tunnel and excavation can proceed below the ground water level.

The TBM requires a launching shaft to start the tunneling operation. The launching shaft for the TBM would be planned near the east end of the project, on 2nd Street between Central Avenue and Alameda Street. From there, the machine would bore westward along 2nd Street towards the 2nd/Hope Street Station site, passing through the proposed 2nd Street Station area at either Broadway or Los Angeles Streets. The TBM would be dismantled and retrieved through a vertical shaft created by cut and cover method adjacent to the 2nd/Hope Street Station. It would then be transported back to the launching shaft, reassembled, and repeat its journey for the second twin tunnel. Alternatively, two TBMs could be launched at the same time.

Tunnel driving operations consist of a series of activities. The TBM is advanced a small distance (typically 4 to 5 feet) by means of hydraulic jacks, which push against the previously installed tunnel lining ring. The jacks are retracted and another tunnel lining ring is erected. The machine is advanced and the process is repeated until the entire length of tunnel has been excavated. The pre-cast concrete liners are fabricated off-site and delivered by truck to the site. Segment loads are estimated to be 6 to 10 truck loads per day for the duration of tunneling based on an average excavation rate of 30 to 50 feet per day. Several days' production of segments is generally stored at the worksite to allow continuous tunneling. Tunneling operation is typically continuous, occurring seven days a week with two 10-hour shifts per day.

Excavated material (spoils) is taken to the rear of the TBM by a screw conveyor and deposited on a conveyor belt. The conveyor belt drops the spoils into mine cars, which are then taken back to the launching shaft by a locomotive operating on temporary rail tracks fastened to the bottom of the tunnel. At the shaft, the mine cars are lifted out by a crane or hoist and the material is loaded into trucks for off-site disposal or temporarily stockpiled at the site for later disposal. Alternatively, belt conveyor systems could be used to transport spoils, through the tunnel and/or from the shaft to the surface.

On the Metro Gold Line Eastside Extension project, Earth Pressure Balance (EPB) TBMs were successfully used to mine about 1.4 miles of tunnel, comparable in length and diameter to the proposed LRT build alternatives. The excavation method for EPB shield TBM is based on the principle that tunnel face support is provided by the excavated spoil itself. Tunneling for the Underground Emphasis LRT Alternative and the Fully Underground LRT Alternatives would encounter both alluvial soils, where the profile is relatively shallow, and weathered siltstone/shale bedrock of the Fernando or Puente Formations. Groundwater may be perched on the Fernando Formation or other clay layers. Gassy tunneling conditions are also anticipated based on previous Metro studies for the Red Line and adjacent building investigations. EPB TBMs are generally well suited for mining in soft ground with these variable soil, groundwater, and methane conditions and may also be adapted for harder materials.

The excavated soil in an EPB TBM is contained in a chamber behind the cutting wheel by a bulkhead as shown in Figure 2-5. The "earth pressure" in this chamber balances the external soil and groundwater load which in turn minimizes movement of the ground in front of the TBM. The screw conveyor restricts the rate of soil removed from the chamber to maintain the earth pressure. Non-toxic, biodegradable conditioners added to the soils in the chamber improve material flow and handling characteristics.

For the Underground Emphasis LRT Alternative and the Fully Underground LRT Alternative, an alternative tunnel boring approach is possible that would use a single, larger diameter tunnel instead of two smaller diameter tunnels. A single large TBM could be used to bore one tunnel big enough to contain both tracks and possibly the station platforms. Further studies will determine if such an approach would be feasible for the Regional Connector.

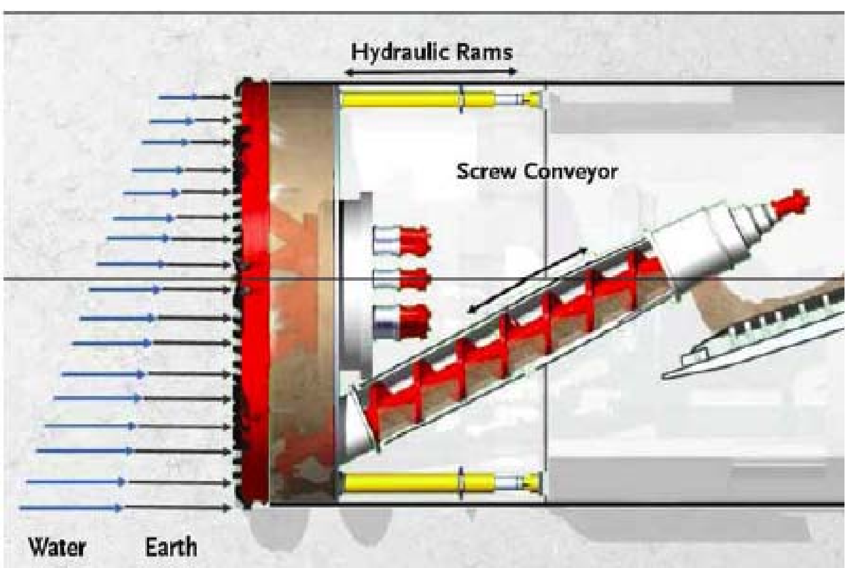

Figure 2-5: Schematic of EPB TBM

2.3 Sequential Excavation Method (SEM)

Because of the depth of the 2nd/Hope Street Station for the Underground Emphasis LRT Alternative and the Fully Underground LRT Alternatives, Sequential Excavation Method (SEM) construction may be considered as an alternative to the open cut method. The open cut technique may be less cost effective than SEM due to the station depth. Application of the SEM would have less surface interruption since the excavation would be performed mostly underground and accessed via a vertical shaft. Sequential excavation and support methods call for the ground to be excavated incrementally in small areas and supported with steel supports advanced beyond the opening and shotcrete (sprayed concrete) as shown on the schematic diagram on Figure 2-6. Analysis of both open cut and SEM will be undertaken for the 2nd/Hope Street Station.

Generally, SEM is applied for large non-circular tunnels or short tunnels where TBMs are not economical or feasible. All operations would be conducted from an access shaft for spoils removal and future entrance(s). The sequence of excavation for the SEM method would be determined during design stage and controlled and modified as needed during construction based on actual conditions encountered. After all the predetermined sequence areas are excavated and supported as shown on Figure 2-6, the larger area of the station or tunnel would be completed. Whereas TBMs can only excavate a fixed (circular) shape, the sequential method permits a tunnel of horseshoe or sub-rounded shape. This construction technique is considered in special instances where the planned depth, shape, or length of the tunnel may not be cost effective using more traditional methods. In addition to the 2nd/Hope Street Station, SEM is also under consideration for approximately 350 feet of the curved portion of the alignment west of the station.

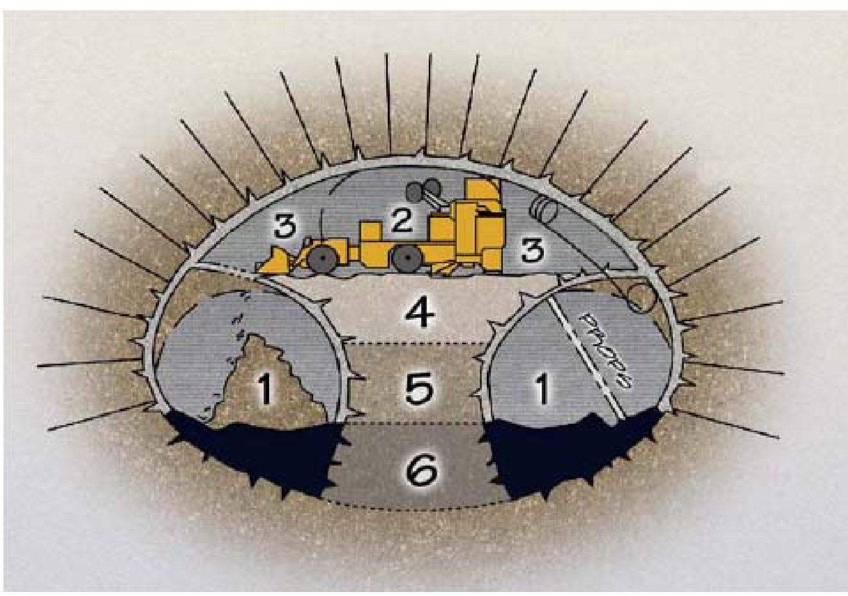

Figure 2-6: Typical SEM Excavation Sequence

3.0 CONSTRUCTION SCENARIOS

This section outlines the details of the preliminary construction scenario for the Build Alternatives. There would be no major construction activities under the No Build and TSM Alternatives, and no major adverse construction effects are anticipated. Accordingly, the focus of the construction impacts analysis is on the At-Grade Emphasis LRT, the Underground Emphasis LRT, and Fully Underground LRT Alternatives – Variations 1 and 2.

All alternatives include the construction of new facilities, operations, and maintenance. Key site conditions that would likely affect construction activities are also discussed. Conditions and elements common to both alternatives are described once in the general scenario below. Other elements unique to each alternative are addressed in the specific scenario description.

3.1 General Construction Scenario

The construction duration for either of the build alternatives would be approximately a four- to five-year period. Surface streets would be impacted for approximately 24 to 48 months.

LRT construction could begin simultaneously at several locations along the selected route to accommodate areas requiring lengthy construction times, such as tunnels, underground stations, and grade separation segments, so that the various segments can be brought to completion at approximately the same time.

Many contractors specializing in various methods of construction would be working on the project for the full duration of construction. Construction would involve the methods most suitable for each segment of the project including cut and cover/open cut excavation for tunnel and stations, potential use of SEM for the 2nd/Hope Street Station (and possibly a portion of the tunnel to the west) on the Underground Alternatives, and TBM tunneling for portions of the Underground Alternatives beneath 2nd Street.

In some areas, it may be necessary to use protective measures to support existing building foundations before tunnel or station excavation, to provide structures with adequate rigidity and support, and to reduce potential for damage caused by construction-induced movement. Protective measures are described in Section 4.3.

To provide an understanding of the likely steps involved, the anticipated construction activities are described below. This potential construction sequence does not imply that the construction activities would be performed in this order or in a linear sequence. Actual construction is a complex process with many simultaneous activities taking place. Some of the construction methods and sequences would be at the discretion of the construction contractor.

3.1.1 Utility Relocation and Street Closures

The first step in cut and cover construction would involve closing off approximately half of the street in the affected area using barriers and sidewalk sheds, or street and sidewalk protection. Approximately two to three blocks would be closed at a time and this would occur in stages, alternating between the opposite sides of the street.

After closure of portions of the streets, the contractor would relocate, modify, or protect in place all existing utilities and underground structures that could conflict with excavations for street level trackwork, tunnels, portals, station structures, and the grade separations. Shallow utilities, such as maintenance holes or pull boxes, which would interfere with guideway excavation work, would require relocation. Utilities would be modified and moved away from the proposed facilities. Temporary interruptions in services (several hours) could be experienced during re-location or re-routing of utilities. Depending on the extent of utility relocation work, the estimated construction durations are two to four months for a two-block segment of construction activities. Some of the major utilities (greater than 18-to 24-inch diameter) such as the storm drain on 2nd street and the 72-inch storm drain on Flower Street may have more complex construction sequences and schedules for relocations and/or utility supports.

The age of the downtown area and the existing narrow streets, in combination with the locations of the proposed stations, station entrances, and other appurtenant structures means that, in many instances, conflicting utilities would need to be relocated. Utilities, such as high pressure water mains and gas lines, which could pose a potential hazard during cut and cover and open cut station construction, and which are not to be permanently relocated away from the work site, would be re-routed temporarily to prevent accidental damage to the utilities, construction personnel, and the adjoining community.

3.1.2 Other Activities Prior to Major Construction

In addition to utilities, other potential obstructions along the proposed alignments have been identified. These include the former Pacific Electric tunnel perpendicular to the Flower Street alignment approximately 150 feet south of the intersection of Flower and 4th Streets, the pier columns for the 4th Street bridge and ramps, and the caisson foundations associated with Grand Avenue bridge. Further research is needed to determine whether these obstructions would need to be relocated, or whether the proposed alignments would need to be adjusted to avoid the obstructions. Any necessary relocations would need to be performed before tunnel construction begins.

Other preconstruction activities would also be carried out at each site prior to major excavation at stations and tunnels. Documentation of existing conditions prior to construction is common practice to establish a reference to measure ground movements. There are a variety of monitoring systems that could be installed. For the most part, these are non-intrusive activities such as surveying and photo and video documentation. However, in some areas, more elaborate measurement systems involving drill rigs may be installed. Some activities like potholing or installation of geotechnical instrumentation may require temporary, partial street closures and the use of drilling equipment and excavators.

Site clearance and demolition of existing structures at the construction staging areas would also be necessary before major construction can begin.

Traffic detours and truck routes would be required during construction. When construction would affect existing streets, traffic control measures would be implemented to help mitigate the effects of construction activities while maintaining reasonable construction progress. This may involve temporary, partial or full street closures, full or partial sidewalk closures, and detour routes. Traffic management plans would be prepared during subsequent design phases in coordination with the agencies involved to minimize disruption to traffic during construction.

3.1.3 Construction Staging Areas

Temporary easements, typically a portion of the sidewalk, traffic lanes, and parking areas would be required at various locations for construction staging. Construction within the streets is also envisioned where no off-street area can be identified for worksites and/or access to underground excavations.

Prior to underground construction, work sites and staging areas may require clearing and building demolition in some areas. Demolition equipment typically includes bulldozers and loaders. The street alongside the stations and track areas, supplemented by adjacent off-street areas, would be used for construction staging and for equipment and material storage.

The following is a list of anticipated staging areas that may be used during At-Grade Emphasis LRT Alternative construction. The anticipated footprints of each area are delineated in the Draft Construction Staging Sites drawings and in
Figure 3-1:

- Flower/6th/5th Street Station
- 2nd/Hope Street Station
- Main/1st Street Station (southbound)
- Main/Los Angeles Street Station (northbound)
- Temple and Alameda Junction

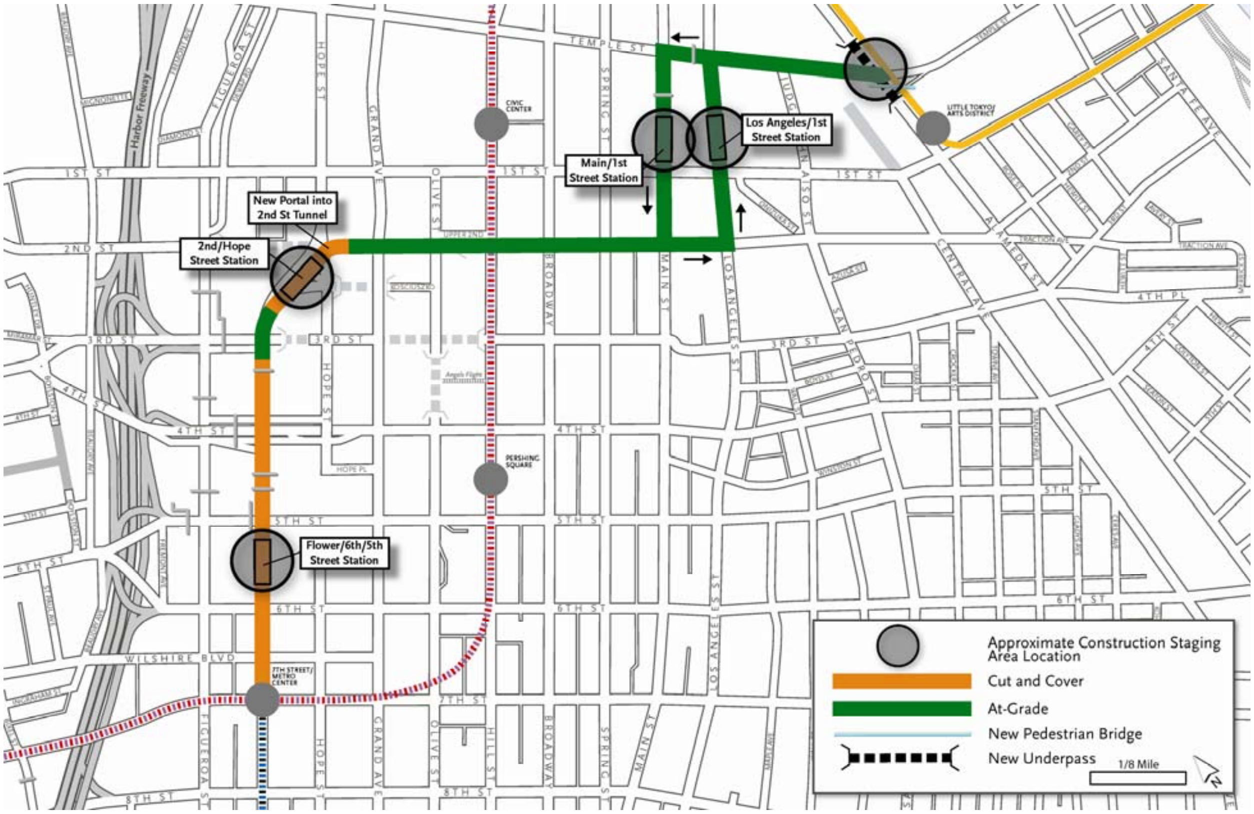

Figure 3-1. At-Grade Emphasis LRT Alternative – Construction Staging Site Locations and Construction Methods

For the Underground Emphasis and Fully Underground LRT Alternatives, the following is a list of possible staging areas. The footprints of the anticipated sites are shown in the Draft Construction Staging Sites drawings and in Figure 3-2 and Figure 3-3:

- Flower/5th/4th Street Station
- 2nd/Hope Street Station
- 2nd Street Station (Los Angeles Street Option, Underground Emphasis Alternative only)
- 2nd Street Station (Broadway Option)
- 1st and Alameda Junction

For excavated materials, haul routes to disposal sites would be predetermined by agreement with local authorities before construction. They would follow streets and highways forming the safest or shortest route with the least adverse effect on traffic, residences, and businesses.

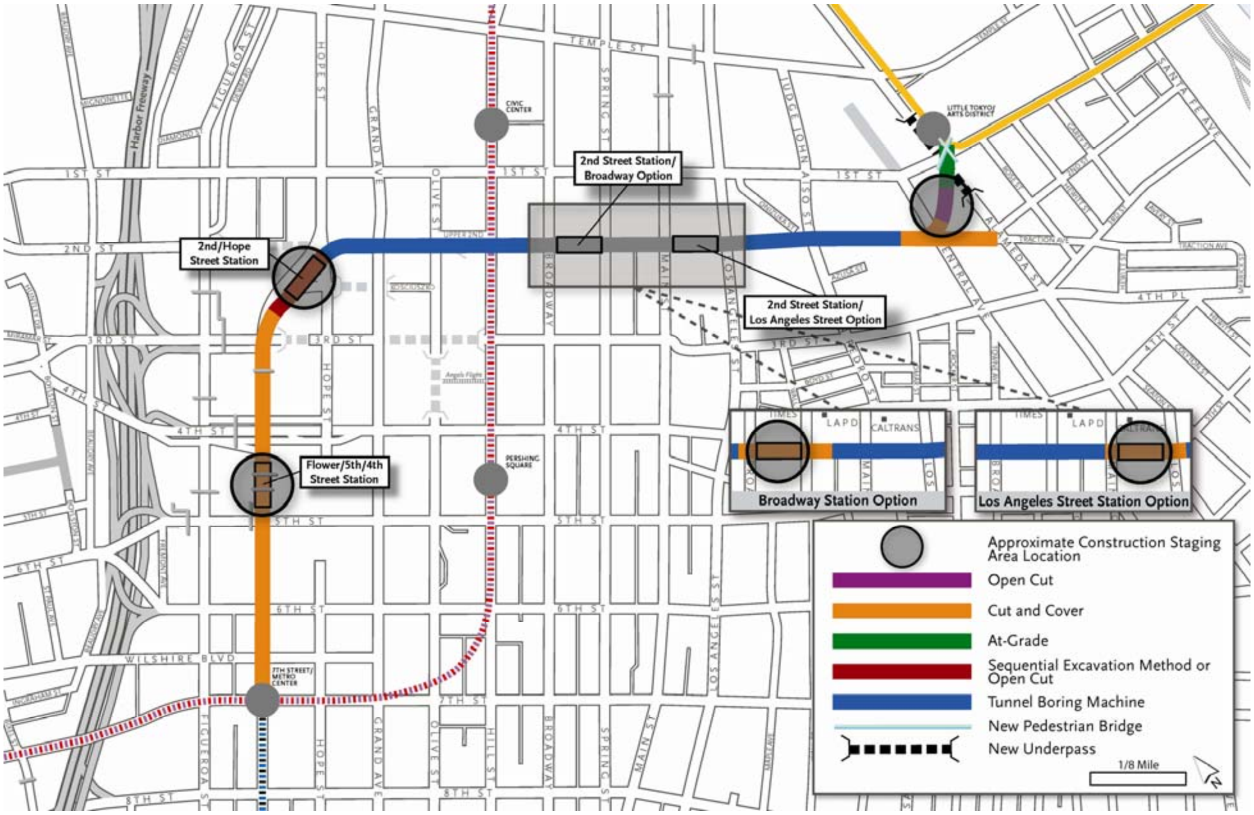

Figure 3-2. Underground Emphasis LRT Alternative –
Construction Staging Site Locations and Construction Methods

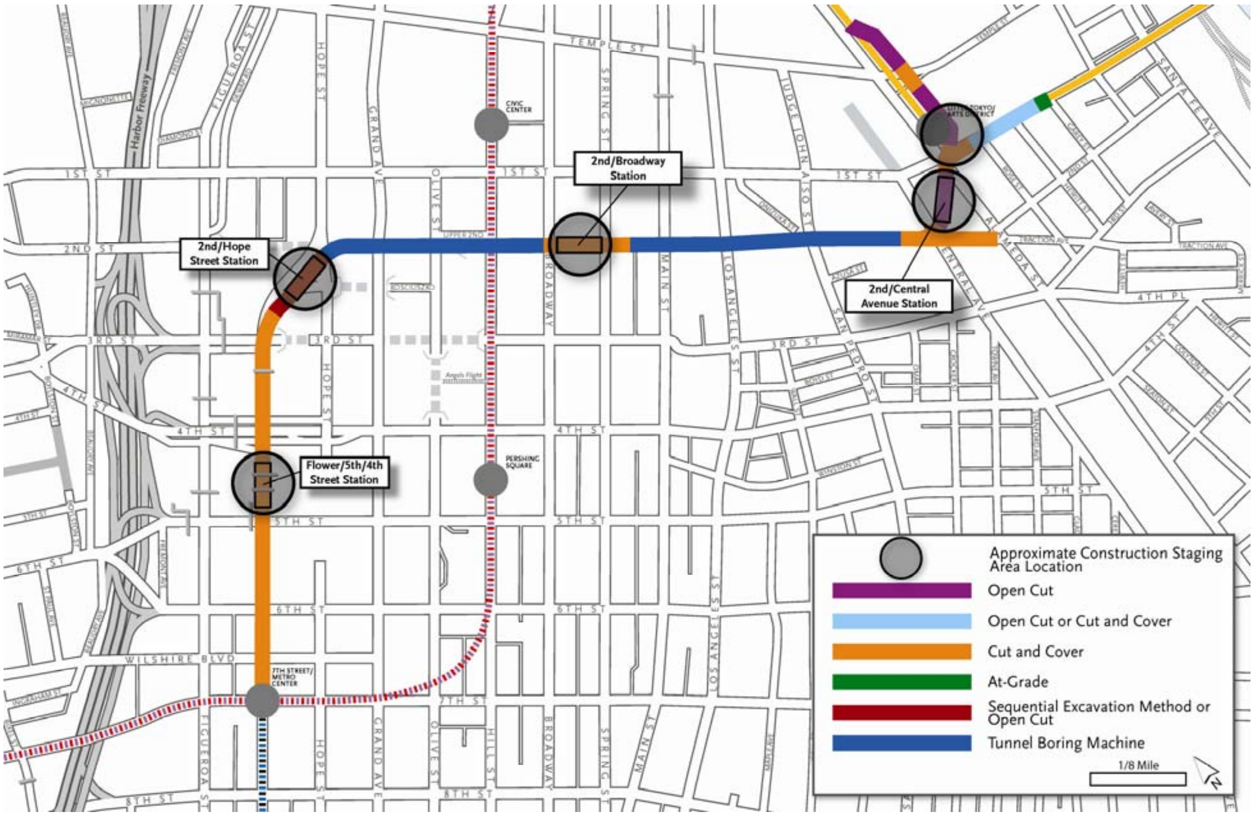

Figure 3-3. Fully Underground LRT Alternatives –
Construction Staging Site Locations and Construction Methods

Table 3-1, Table 3-2 and Table 3-3 provide a summary of the construction activities for the At-Grade Emphasis Underground Emphasis, and Fully Underground LRT Alternatives, respectively. These tables summarize the type of activity, the estimated duration for each activity, the type of equipment anticipated, the quantities of earth removal that may be transported, the estimated truck trips per day, and the estimated number of workers for each activity.

Table 3-1. Construction Activity Summary for the At-Grade Emphasis LRT Alternative

Activity	Duration (months)	Construction Equipment							Soil (CY)	Concrete (CY)	Truck Trips per Day	Workers per Day
		Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed				
Pre-Construction	4-6						X	X	N/A	N/A	5	10-20
Site Preparation	6-12	X	X	X	X				<1,000	<500	10	20-30
Flower Street Cut and Cover Tunnel	24-48	X	X	X	X	X	X	X	70,000	12,000	20-30	20-30
Flower/6th/5th Cut and Cover Station	24-48	X	X	X	X	X	X	X	50,000	9,500	20-30	20-30
Portal on Flower South of 3rd	12-18	X	X	X	X	X	X	X	20,000	3,500	20-30	20-30
Portal northeast of Flower and 3rd	TBD	X	X	X	X	X	X	X	10,600	4,000	20-30	20-30
2nd/Hope Street Open Cut Station	24-28	X	X	X	X	X	X	X	55,000	17,500	20-30	20-30
New Portal into 2nd Street Tunnel	TBD	X	X	X	X	X	X	X	40,000	11,700	TBD	TBD
Surface Trackwork	12-18	X	X	X	X	X		X	10,000	8,000	5-10	5-10

Table 3-1. Construction Activity Summary for the At-Grade Emphasis LRT Alternative												
Activity	Duration (months)	Construction Equipment							Soil (CY)	Concrete (CY)	Truck Trips per Day	Workers per Day
		Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed				
Main and Los Angeles At-Grade Stations	12-18	X	X	X	X	X	X	X	<1,000	1,500	5-10	5-10
Temple and Alameda Junction	24-36	X	X	X	X	X	X	X	65,000	12,000	15-20	20-30
Operating Systems Installation	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

Table 3-2. Construction Activity Summary for the Underground Emphasis LRT Alternative

Activity	Duration (months)	Construction Equipment							Soil (CY)	Concrete (CY)	Truck Trips per Day	Workers per Day
		Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed				
Pre-Construction	4-6						X	X	N/A	N/A	5	10-20
Site Preparation	12-18	X	X	X	X				1,000	1,000	10-20	20-30
Flower Street Cut and Cover Tunnel	24-48	X	X	X	X	X	X	X	280,000	27,750	20-30	20-30
Flower/5th/4th St Cut and Cover Station	24-48	X	X	X	X	X	X	X	105,000	26,000	15-20	20-30
Cut and Cover Approach to 2nd/Hope Street Station	24-48	X	X	X	X	X	X	X	30,000	5,500	15-20	20-30
2nd/Hope Street Station (SEM)	24-48	X	X	X	X	X		X	50,000	8,250	10-15	20-25
2nd/Hope Street Station (Open Cut)	24-48	X	X	X	X	X	X	X	147,500	17,250	20-30	20-30
2nd Street TBM Tunnel	24-48	X	X	X	X	X		X	120,000	Precast Segments	35-70	15-20

Table 3-2. Construction Activity Summary for the Underground Emphasis LRT Alternative												
Activity	Duration (months)	Construction Equipment							Soil (CY)	Concrete (CY)	Truck Trips per Day	Workers per Day
		Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed				
2nd Street Cut and Cover Station (Broadway Option)	24-48	X	X	X	X	X	X	X	200,000	47,250	15-20	15-20
2nd St. Cut and Cover Station (Los Angeles Street Option)	24-48	X	X	X	X	X	X	X	175,000	48,500	15-20	15-20
Portal	12-24	X	X	X	X	X	X	X	20,000	7,500	5-10	15-20
TBM Launch Site	2-4	X	X	X	X	X	X	X	20,000	N/A	5-10	15-20
1st and Alameda Junction	24-36	X	X	X	X	X		X	65,000	12,000	15-20	20-30
Operating Systems Installation	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

Table 3-3. Construction Activity Summary for Fully Underground LRT Alternative – Little Tokyo Variation 1

Activity	Duration (months)	Construction Equipment							Soil (CY)	Concrete (CY)	Truck Trips per Day	Workers per Day
		Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed				
Pre-Construction	4-6						X	X	N/A	N/A	5	10-20
Site Preparation	12-18	X	X	X	X				1,000	1,000	10-20	20-30
Flower Street Cut and Cover Tunnel	24-48	X	X	X	X	X	X	X	280,000	27,750	20-30	20-30
Flower/5th/4th St Cut and Cover Station	24-48	X	X	X	X	X	X	X	105,000	26,000	15-20	20-30
Cut and Cover Approach to 2nd/Hope Street Station	24-48	X	X	X	X	X	X	X	30,000	5,500	15-20	20-30
2nd/Hope Street Station (SEM)	24-48	X	X	X	X	X		X	50,000	8,250	10-15	20-25
2nd/Hope Street Station (Open Cut)	24-48	X	X	X	X	X	X	X	147,500	17,250	20-30	20-30
2nd Street TBM Tunnel	24-48	X	X	X	X	X		X	120,000	Precast Segments	35-70	15-20

Table 3-3. Construction Activity Summary for Fully Underground LRT Alternative – Little Tokyo Variation 1

Activity	Duration (months)	Construction Equipment							Soil (CY)	Concrete (CY)	Truck Trips per Day	Workers per Day
		Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed				
2nd Street Cut and Cover Station (Broadway Option)	24-48	X	X	X	X	X	X	X	200,000	47,250	15-20	15-20
Cut and Cover Tunnel from TBM to 2nd/Central Avenue Station	12-24	X	X	X	X	X	X	X	20,000	TBD	15-20	15-20
2nd /Central Avenue Open Cut Station	18-36	X	X	X	X	X	X	X	55,000	TBD	20-30	15-20
Open Cut/Cut and Cover from 2nd/Central Avenue to East Portal	12-24	X	X	X	X	X	X	X	45,000	TBD	15-20	15-20
Open Cut/Cut and Cover from 2nd/Central Avenue to North Portal	12-24	X	X	X	X	X	X	X	95,000	TBD	15-20	15-20
TBM Launch Site	2-4	X	X	X	X	X	X	X	20,000	TBD	5-10	15-20
Improvements near 1st and Alameda Streets	12-24	X	X	X	X	X		X	N/A	TBD	15-20	15-20
Operating Systems Installation	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

Table 3-4. Construction Activity Summary for Fully Underground LRT Alternative – Little Tokyo Variation 2

Activity	Duration (months)	Construction Equipment							Soil (CY)	Concrete (CY)	Truck Trips per Day	Workers per Day
		Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed				
Pre-Construction	4-6						X	X	N/A	N/A	5	10-20
Site Preparation	12-18	X	X	X	X				1,000	1,000	10-20	20-30
Flower Street Cut and Cover Tunnel	24-48	X	X	X	X	X	X	X	280,000	27,750	20-30	20-30
Flower/5th/4th St Cut and Cover Station	24-48	X	X	X	X	X	X	X	105,000	26,000	15-20	20-30
Cut and Cover Approach to 2nd/Hope Street Station	24-48	X	X	X	X	X	X	X	30,000	5,500	15-20	20-30
2nd/Hope Street Station (SEM)	24-48	X	X	X	X	X		X	50,000	8,250	10-15	20-25
2nd/Hope Street Station (Open Cut)	24-48	X	X	X	X	X	X	X	147,500	17,250	20-30	20-30
2nd Street TBM Tunnel	24-48	X	X	X	X	X		X	120,000	Precast Segments	35-70	15-20

Table 3-4. Construction Activity Summary for Fully Underground LRT Alternative – Little Tokyo Variation 2

Activity	Duration (months)	Construction Equipment							Soil (CY)	Concrete (CY)	Truck Trips per Day	Workers per Day
		Haul Truck	Concrete Truck	Dozer	Excavator	Crane	Drill Rig	Flatbed				
2nd Street Cut and Cover Station (Broadway Option)	24-48	X	X	X	X	X	X	X	200,000	47,250	15-20	15-20
Cut and Cover Tunnel from TBM to 2nd/Central Avenue Station	12-24	X	X	X	X	X	X	X	25,000	TBD	5-10	15-20
2nd/Central Avenue Open Cut Station	18-36	X	X	X	X	X	X	X	80,000	TBD	15-20	15-20
Open Cut/Cut and Cover from 2nd/Central Avenue to East Portal	12-24	X	X	X	X	X	X	X	90,000	TBD	20-30	15-20
Open Cut/Cut and Cover from 2nd/Central Avenue to North Portal	12-24	X	X	X	X	X	X	X	125,000	TBD	15-20	15-20
TBM Launch Site	2-4	X	X	X	X	X	X	X	20,000	TBD	5-10	15-20
Improvements near 1st and Alameda Streets	12-24	X	X	X	X	X		X	N/A	TBD	15-20	15-20
Operating Systems Installation	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

3.2 At-Grade Emphasis LRT Alternative

Construction of the At-Grade Emphasis LRT Alternative is anticipated to consist of the following major activities:

- Relocation and protection of major utilities. The largest utility that would be encountered is the 72-inch storm drain between 4th and 5th Street. A list of the major utilities that could be affected and potential solutions is presented in Table 3-5.

Table 3-5. At-Grade Emphasis LRT Alternative – List of Affected Utilities

Utilities Affected	Feasible Alternatives
72-inch storm drain (SD) beneath Flower Street	Move SD to the west and reconnect with existing pipe
SD lateral that connects to the 72-inch SD across the intersection of 4th Street and Flower Street is assumed to be in conflict at the portal. Diameter of lateral is unknown	Being reviewed
18-inch SD lateral that connects a Catch Basin (CB) to the 72-inch SD is in conflict with the portal.	Reconnect this CB across 4th Street to the proposed 15-inch SD.

- Cut and cover construction of a connection to the existing 7th Street/Metro Center Station Blue Line tail tracks near the intersection of Flower/6th Streets.
- Construction of approximately 200 feet of cut and cover tunnel at 0.3 percent slope near the intersection of Flower and 6th Streets from the connection point to the existing 7th Street/Metro Center Station and the proposed Flower/6th/5th Station.
- Construction of a cut and cover station on Flower Street between 6th and 5th Streets. The station would be constructed in front of the City National Tower complex. Invert elevation at the station varies from 235 to 238 with a 0.95 percent slope.
- Construction of a cut and cover tunnel at 6 percent slope along Flower Street from the Flower/6th/5th Station to the portal just south of 3rd Street.
- At-grade track construction near the intersection of Flower and 3rd Street. Construction of a portal structure at the northeast corner of Flower and 3rd Streets and open cut

tunnel for approximately 200 feet to the 2nd/Hope Street Station. The portal structure would vary in height from approximately 10 feet to about 30 feet.

- Construction of an open cut station at 2nd and Hope Streets with an entrance to serve the Bunker Hill area. The station structure would be approximately 600 feet long and 42 feet high.
- Construction of a pedestrian bridge from Upper Grand Avenue to the 2nd/Hope Street Station.
- Cut and cover construction of a connection into the existing 2nd Street Tunnel. Connection to the existing tunnel would require major construction work, including installation of the shoring system for soil removal, removal of soil load above the 2nd Street tunnel crown (~ 45ft), reinforcement of the tunnel structure and installation of supporting elements at the location of the new openings. This could require full or partial tunnel closures and closures of the street above during the construction period.
- Installation of tracks and overhead catenary systems in the eastern 800 feet of the 2nd Street tunnel and cut and cover tunnel area. The construction of trackwork includes preparation of track bed, track slab, rail installation, fasteners, and infill concrete. The overhead systems include wires, support brackets, feeders, and other components or alternative power distribution systems, and street lighting where required.
- Construction of an at-grade alignment on the south side of 2nd Street between the 2nd Street tunnel and Main Street. At Main Street, northbound track continues on 2nd Street to Los Angeles Street, while the southbound track curves north onto Main Street. This segment would require the same installation of tracks and overhead catenary systems as described for the 2nd Street tunnel.
- Installation of a single track for the southbound traffic on Main Street. The southbound single track alignment would turn from the south side of 2nd Street to the east side of Main Street. It would continue north on Main Street and turn east onto East Temple Street. This segment would require installation of tracks and overhead catenary systems as described previously. In addition, the at-grade overhead system would be supported on poles, which are typically spaced approximately 100 to 200 feet apart. A typical pole installation for the Metro Gold Line Eastside Extension project is shown on Figure 3-4.
- Construction of the Main Street southbound station. A single platform station would be located on the east side of the Main Street north of 1st Street. Construction of high floor station platforms would be completed using typical “cast-in-place” or pre-cast concrete construction methods.

- Installation of a northbound single track on Los Angeles Street from 2nd Street to Temple Street. The northbound single track alignment would continue on south side of 2nd Street between Main Street and Los Angeles Street, before turning north onto the east side of Los Angeles Street. It would then continue on Los Angeles Street and turns east onto Temple Street. This stage would require installation of tracks and overhead catenary systems including poles, overhead catenary wires, support brackets, feeders, and other components as needed.

- Construction of the Los Angeles Street northbound station. A single platform station would be located on the east side of Los Angeles Street just north of 1st Street. Construction of high floor station platforms would be completed using typical "cast-in-place" or pre-cast concrete construction methods.

- Construction of a connection to the existing Metro Gold Line tracks at Temple and Alameda Streets. The southbound and northbound single tracks would meet at the corner of Temple and Los Angeles Streets. The double tracks would continue east on Temple Street to San Pedro Street, after which they continue to the south side of Temple Street for approximately 300 feet before reaching a 3-way (wye) junction just west of Alameda Street. Tracks would branch to the north and south at this point to meet the Metro Gold Line tracks just north of the little Tokyo Station. A portion of the Gold Line is supported on mechanically stabilized earth (MSE) embankment from north of Temple Street to the US 101 bridge. The embankment would require some modification and reconstruction to accommodate the Regional Connector at the junction with Alameda Street.

- Construction of an underpass at the intersection of Temple and Alameda Streets that would carry Alameda Street through traffic beneath Temple Street and the new rail junction.

- Construction of a pedestrian bridge above the Alameda underpass that spans the intersection of Alameda and Temple Streets. Due to its irregular shape, the bridge substructures would likely be constructed at several spots in and around the intersection and be integrated into the Alameda underpass structure. Bridge construction would involve heavy construction equipment including crane(s) for erection of the superstructure.

- Construction of urban design enhancements within 1,000 of the centerlines of the stations and portals.

Figure 3-4. Typical Drilling and Installation of Pole

3.3 Underground Emphasis and Fully Underground LRT Alternatives

Construction of the Underground Emphasis and Fully Underground Alternatives would be similar with the exception of the sections east of Central Avenue. The major similar activities are anticipated to consist of the following:

- Relocation and protection of major utilities including the 72-inch storm drain between 4th and 5th Street and the 11.5 feet by 13 feet rectangular reinforced concrete storm drain along 2nd Street. A list of major utilities that could be affected and potential solutions are presented in Table 3-6 and Table 3-7.
- Construction of the tunnel and portal access to the tunnels would require taking the property bounded by 1st and 2nd Streets between Central Avenue and Alameda Street. The existing Office Depot building would be demolished, cleared, and grubbed. Removal of any asbestos in the demolition debris would be addressed in accordance with local standards. Temporary construction trailers would be brought in for the work site offices. This activity would involve dozers and other equipment needed for demolition and site preparation.
- Site clearance and demolition of existing structures within the construction staging areas.
- Cut and cover construction of a connection to the existing 7th Street/Metro Center Station Blue Line tail tracks.

Table 3-6. Underground Emphasis LRT Alternative– List of Affected Utilities

Utilities Affected	Feasible Alternatives
72" SD beneath Flower Street is potentially in conflict with stair ways/elevators of proposed station.	Relocate to the west of the station and reconnect with existing line.
24" SD in conflict with Emergency Exit Shaft at 2nd/Hope Street Station shown on current proposed drawing	Move location of Emergency Shaft (being evaluated by design team)
Reinforced Concrete Box Culvert along 2nd Street at proposed station limits	The existing box culvert has dimension of 11.5 by 13 feet with an invert within 20 feet of the existing grade. The culvert would be in conflict with the Underground Emphasis LRT

Table 3-6. Underground Emphasis LRT Alternative– List of Affected Utilities	
Utilities Affected	**Feasible Alternatives**
and near the portal	Alternative. Methods consist of maintaining the culvert on 2nd Street and temporarily supporting the affected culvert within the cut and cover construction for the station and near the portal. The temporary support could consist of hanging/suspending the culvert at the top of the temporary decking during station construction. Another alternative would be to replace the concrete box culvert with temporary multiple HDPE pipes with equivalent capacity and suspending them at the temporary decking during station construction. Similarly, the affected portion near the portal could be temporarily suspended near the top of the open cut portal. The temporary measures would be replaced with a permanent box culvert at the end of tunnel construction. If relocation to 3rd Street is preferred, it could take 12 to 18 months. Either partial/full closure of 3rd Street and re-routing of traffic to adjacent streets would be required.
75 inch Storm Drain Alameda Street	TBD

Table 3-7. Fully Underground LRT Alternatives– List of Affected Utilities	
Utilities Affected	**Feasible Alternatives**
72" SD beneath Flower Street is potentially in conflict with stair ways/elevators of proposed station.	Relocate to the west of the station and reconnect with existing line.
24" SD in conflict with Emergency Exit Shaft at 2nd/Hope Street Station shown on current proposed drawing	Move location of Emergency Shaft (being evaluated by design team)
Reinforced Concrete Box Culvert along 2nd Street at proposed station limits and near the portal	The existing box culvert has dimension of 11.5 by 13 feet with an invert within 20 feet of the existing grade. The culvert would be in conflict with the Underground Emphasis LRT Alternative. Methods consist of maintaining the culvert on 2nd Street and temporarily supporting the affected culvert within the cut and cover construction for the station and near the portal. The

Table 3-7. Fully Underground LRT Alternatives– List of Affected Utilities

Utilities Affected	Feasible Alternatives
	temporary support could consist of hanging/suspending the culvert at the top of the temporary decking during station construction. Another alternative would be to replace the concrete box culvert with temporary multiple HDPE pipes with equivalent capacity and suspending them at the temporary decking during station construction. Similarly, the affected portion near the portal could be temporarily suspended near the top of the open cut portal. The temporary measures would be replaced with a permanent box culvert at the end of tunnel construction. If relocation to 3rd Street is preferred, it could take 12 to 18 months. Either partial/full closure of 3rd Street and re-routing of traffic to adjacent streets would be required.

- Construction of approximately 760 feet of cut and cover tunnel along Flower Street between the existing 7th Street/Metro Center Station and the Flower/5th/4th Station. The invert of cut and cover tunnel is at approximately elevation +236 feet.

- Construction of the Flower/5th/4th Station between 5th and 4th Streets. The station would be constructed using the cut and cover method. The station invert is at approximate elevation of +232 feet with existing ground at approximately +292 feet. The station would be located adjacent to the underground parking structure of the Bonaventure Hotel as well as the parking structure to the east (CitiGroup Building). Construction of this station would require relocation of the existing 72-inch reinforced concrete storm drain pipe between 5th and 4th Streets.

- Reconstruction of the existing pedestrian bridge across Flower Street just north of 5th Street.

- Cut and cover construction along Flower Street from the 4th Street to north of 3rd Street to the 2nd/Hope Street Station. This segment of cut and cover would include both straight and curved segments. The construction of straight portion of the cut and cover may impact the 4th Street overpass bridge foundation and mitigation measurements could be required to reinforce this overpass bridge foundation. There is also a possibility that the curved tunnel section could be constructed by SEM. The invert of the cut and cover tunnel is at approximately elevation +236 feet.

- Construction of the 2nd/Hope Street Station with the open cut method. The station is approximately 405 feet long. Based on preliminary design drawings, the station is over 100 feet below grade with station invert elevation at 230 feet and the existing ground surface elevation between 335 and 360 feet. It is anticipated that a portion of the 2nd/Hope Street Station construction would likely be performed under groundwater. The station design would also include at least three shafts for entrance, emergency exit, and ventilation purposes. The station would be constructed in close proximity to a chilled water plant with a deep caisson foundation. Because of the depth of 2nd/Hope Street Station, SEM is being considered in addition to the cut and cover method. Excavation could have an impact on the stability of the caisson foundation and would be evaluated during design. Mitigation measures could require underpinning of the existing foundation.

- Construction of a pedestrian bridge from Upper Grand Avenue to the 2nd/Hope Street Station.

- Relocation of a large 11.5 feet x 13 feet reinforced box culvert storm drain that currently runs underneath 2nd Street. This box culvert would be in conflict with the proposed entry shaft and cut and cover section near Central Avenue. In addition, the culvert would also be in conflict with the proposed station construction on 2nd Street. The affected segment of the storm drain would need to be relocated or temporarily supported. Alternatives are being reviewed and coordinated with the County of Los Angeles Department of Public Works.

- Tunnel construction shaft by the cut and cover method: A tunnel construction shaft is necessary to assemble the TBM and to start construction of both the east and west bound tunnels along 2nd Street. The construction shaft to begin the TBM drive would be excavated on 2nd Street near Central Avenue. TBMs should start in a straight line and at adequate depth, so the proposed staging area to the north of 2nd Street and Central Avenue cannot be used for TBM mining due to the necessary depth and orientation for the TBMs. The construction shaft would extend along 2nd Street and be approximately 650 feet long and 65 feet wide. Once the TBM is advanced, a portion of construction shaft would be covered by a temporary deck to facilitate normal traffic along Central Avenue. The TBM would be lowered into the construction shaft by a crane and would mine from the shaft along 2nd Street westward from Central Avenue to the 2nd/Hope Street Station. The TBM would be retrieved west of Bunker Hill at the cut and cover section near the 2nd/Hope Street Station.

- An alternative to launching the TBMs from the 2nd and Central Streets area would be to launch them from the 2nd/Hope Street Station and mine towards the Central Avenue shaft. In this scenario, the excavated materials from the tunneling would be removed from the 2nd/Hope Street worksite.

- Once the construction shaft is completed, the TBM would be assembled in the shaft to start boring the tunnel. An EPB TBM would likely be used to construct two (twin) bored tunnels between the portal and the 2nd Street Station either near Los Angeles Street or Broadway. The tunnel invert elevations along this segment range between 200 to 220 feet and ground surface elevations range between approximately 268 to 282 feet. The bored tunnel along this segment would pass in close proximity to several buildings on both sides of the alignment. Major structures in this area include the Weller Court shopping mall basement, Union Bank building, and Japanese Village Plaza. If later evaluations determine that these could be impacted by tunnel construction activities, mitigation measures would be developed to reinforce and protect these buildings. Depending on further evaluation, the retail stores or multi-story buildings between San Pedro Street and Central Avenue could also require mitigation since they are supported on shallow foundations. Further evaluations in subsequent phases would help determine the level of protection required. An alternative tunnel boring approach is possible that would use a single, larger diameter tunnel instead of two smaller diameter tunnels. A single large TBM could be used to bore one tunnel big enough to contain both tracks and possible the station platforms. Further studies will determine if such an approach would be feasible for the Regional Connector.

- Cut and cover construction for the proposed station on 2nd Street. The proposed station would be located between Main and Los Angeles Streets (Los Angeles Street Option) with an alternate station between Broadway and Spring Streets (Broadway Option). The existing storm drain within the station excavation area would either be protected in-place or relocated. Construction of the cut and cover station would require installation of temporary shoring and installation of deck beams to allow support concrete deck panels to resume on 2nd Street. Excavation could continue under the cover deck to the required depth. The buildings in close proximity include: Kyoto Grand Hotel and Caltrans underground parking on the north side and the Little Tokyo Library and St. Vibiana Cathedral Annex on the south side. The excavation for the station entrance on the south side would likely require a more rigid shoring system (e.g. Tangent piles) for additional protection of adjacent structures. The TBM could be transported through the station. For the alternate station between Broadway and Spring Street, protection/relocation of the storm drain as well as installation of the temporary shoring system would also be required prior to excavation. The major building in the vicinity of this station is the LA Times basement to the north of 2nd Street.

- After being transported through the station excavation, the TBM would continue to mine the twin bored tunnels west of either Main or Broadway Streets towards the Bunker Hill area. The bored tunnel along this segment would be excavated underneath the existing Red Line Tunnels near the intersection with Hill Street. In addition, a portion of the basement for the historic Thomas Higgins building (located at the southwest corner of Main and 2nd Streets) is anticipated to be above the tunnel alignment. Other major buildings in the vicinity of the alignment including the LA Times and the LA Police Department parking structures could be impacted by tunnel construction activities and may require mitigation measures to reinforce and protect them.

- Construction of urban design enhancements within 1,000 feet of the centerlines of the stations and portals.

3.3.1.1 At-Grade Emphasis only:

- Cut and cover construction of a section of the tunnel beneath 2nd Street west of Central Avenue: This section of portal would be finished after completion of bored tunnels to facilitate the emergence of the tracks to grade level (i.e. The portal).

- Grade separation of Alameda Street at 1st Street would allow uninterrupted vehicular traffic below the new tracks. This construction would consist of lowering of Alameda Street, construction of retaining walls to support above ground facilities and a pump house to pump storm water that could accumulate in the depressed roadway. A permanent bridge would be constructed over Alameda Street to facilitate traffic on 1st Street and to support the new tracks. Utilities to be relocated include a 75-inch storm drain running in Alameda Street.

- Construction of a pedestrian bridge over Alameda underpass. This bridge would span the intersection of Alameda and 1st Street to provide pedestrian access across the intersection and to the existing Little Tokyo/Arts District Station. Due to its irregular shape, the bridge substructures would likely be constructed at several spots in and around the intersection and likely be integrated into the Alameda underpass structure. Bridge construction would involve heavy construction equipment including crane(s) for erection of the superstructure.

- Construction of the curved U-section of the portal between 2nd and 1st Streets. This would be constructed using open cut technique. Since it is traversing the primary construction yard, it would likely be done in the later phases of construction. Work within the yard for this relatively shallower excavation would have limited impact on surrounding areas.

3.3.1.2 Fully Underground LRT Alternative – Variation 1:

- Cut and cover construction of a section of the tunnel beneath 2nd Street west of Central Avenue. This cut and cover section would continue into the Office Depot site where an open cut underground station with a center platform configuration would be built.

This station may be completely underground, or constructed as an open below-grade station with no roof.

- Grade separation of the LRT tracks from Alameda Street using a cut and cover structure for continuing the tracks underground from the station across Alameda Street with a wye or crossing diamond under Alameda Street to allow train movements either eastbound to 1st Street or northbound toward Union Station. Temporary decking (pre-cast concrete panels) would be used to support Alameda Street, 1st Street and the existing Gold Line tracks to the east.

- Construction of the underground sections from Alameda street and portal structures by cut and cover and open cut methods would occur along 1st Street from the east side of Alameda to about Hewitt street and on the Nikkei property along the east side of the Little Tokyo/Arts District Station to just north of Temple Street. U-shaped sections or retaining walls would be used for the transition structure to the surface.

- Prior to construction of the portal and retaining structures along 1st Street, the street would require permanent relocation to the north of its existing location between Alameda Street and about Garey Street.

- Existing Gold Line tracks would be relocated to north and south of the new portals.

- Reconstruction of the existing MSE Wall to slope more steeply to the portal entrance north of Temple Street. If trains between the Gold Line Eastside Extension and Union Station are to remain in service during construction, a temporary track or "shoofly" would be added for single track operations between the Little Tokyo/Arts District Station and the US-101 Bridge. It is estimated that existing traffic lanes along Alameda would have to be reduced to a total of 3-12 ft lanes during construction.

3.3.1.3 Fully Underground LRT Alternative – Variation 2

- As for Variation 1, requires cut and cover construction of a section of the tunnel beneath 2nd Street west of Central Avenue. This cut and cover section would continue into the Office Depot site where an open cut underground station with a split-level side platform configuration would be built. For Variation 2, the station would be deeper and narrower with side platforms on separate levels.

- Grade separation of the tracks from Alameda Street would use a cut and cover structure for continuing the tracks underground – in over and under configuration to avoid tracks crossing at the same elevation. Because the east and west bound tracks are at different elevations at the turnout (switch) location, they transition to the surface in a "staggard" location along 1st Street. The eastbound portal is further to the east – beginning at Hewitt Street with the U section ending east of Garey Street. The westbound portal begins between Alameda and Rose Street and ends just east of Hewett Street.

- Like Variation 1, construction of the portal and retaining structures along 1st Street, would require permanent relocation of 1st Street to the north of its existing location between Alameda Street and about Garey Street.
- Reconstruction of the existing MSE Wall to slope to portal entrance north of Temple Street is also required for Variation 2. If trains between the Gold Line Eastside Extension and Union Station are to remain in service during construction, a temporary track or "shoofly" would be added for single tracking operations between the Little Tokyo/Arts District Station and the US-101 Bridge. It is estimated that existing traffic lanes along Alameda would have to be reduced to a total of 3-12ft lanes during construction.
- Support in place of the existing Gold Line tracks were they cross the proposed underground sections along 1st street and just south of Little Tokyo/Arts District Station

4.0 CONSTRUCTION ACTIVITIES

4.1 Typical Cut and Cover and Open Cut Construction

Cut and cover methods will be common to all LRT alternatives. Once the staging area and the utility relocations have been completed, the contractor(s) can begin the major construction activities including cut and cover construction for the stations and the tunnels. The cut and cover construction described below is applicable to all LRT Alternatives.

All underground stations would be built with the cut and cover technique. A potential exception is the 2nd/Hope Street Station where the SEM method is considered an option for the construction due to its greater depth. A typical cut and cover construction would start with installation of a temporary shoring system with the methods described in Section 2.

Prior to installation of a temporary ground support system, dewatering may be required at underground stations and/or tunnel sites in alluvium to temporarily lower the groundwater level below the excavation depth or to an impermeable layer. This facilitates installation of soldier piles or other type of shoring systems which are not watertight, improves soil stability, and allows excavation in dry conditions. Groundwater would be pumped from wells installed around the perimeter of the excavation. If contaminated water is encountered, it would be treated at the site or hauled to a treatment facility. At the completion construction of the stations, pumping would be discontinued and groundwater levels would return to their natural level. The need for dewatering would be evaluated after geotechnical investigations have been completed. Although anticipated to be minor, the effect of dewatering on adjacent structures would be determined during design.

Once shoring is in place, excavation can begin. Concrete decking would be installed after the initial lift of excavation to restore traffic on the street above. The excavation and internal bracing/tieback installation would be performed within the excavation to the designed depth. Decking would require lane closures at the excavation area and is typically performed at night to minimize traffic impact. Once the deck is in place, the excavation and internal bracing continues below the decking to the required depth.

Open cut construction is similar to cut and cover construction, but does not include temporary decking.

Sequences described for underground station construction could be up to 48 months and is applicable to both alternatives. Based on the anticipated volume of excavation for the cut and cover tunnel and stations, it is estimated that an average of 20 to 30 dump trucks per day would be required to haul and dispose of the excavated soils during excavation cycles.

4.2 Ground Surface Settlement Resulting from Tunneling and Underground Excavation

During TBM tunneling some ground loss would occur in the alluvial soils potentially producing surface settlement. The amount of settlement measured at the surface would be a function of the tunnel depth, size, number of tunnels, distance between adjacent tunnels, TBM design and tunneling techniques, and geology. Ground movements possibly resulting in surface settlement could also occur during SEM for stations or tunnels. The amount of settlement would be a function of the sequence of excavation, amount of ground support, and thickness of shotcrete support, each of which are adjusted during mining to control ground settlement.

Underground excavation for stations and tunnel using the cut and cover technique would result in ground relaxation and deformation of the retained earth. The magnitude of ground movement depends on the strength of the alluvial soils/bedrock and the rigidity of the shoring system.

For TBM tunneling and SEM, the width of the potential settlement zone is approximately two times the depth of the tunnel invert. For cut and cover excavation, the zone potentially susceptible to ground movement generally extends a lateral distance approximately one to one-and-the-half times the depth of the excavation. Accordingly, structures located within these settlement/deformation zones would be further evaluated for potential impact and required mitigation measures.

4.3 Protection of Existing Structures

The alignment of the Regional Connector LRT project and stations have been planned to minimize construction near or beneath the existing structures. However, there are areas where this cannot be avoided such as adjacent to the basement of the Higgins building at the southwest corner with the intersection of 2nd and Main Streets for the Underground Emphasis LRT Alternative. In addition, a majority of the existing structures of either side of the alignment on Flower and 2nd Streets would be close to the excavation sites or the tunnel alignment. Building assessments would be necessary as part of the pre-construction evaluation of existing structures along the alignment. During preliminary and final design of the project, subsurface (geotechnical) investigations would be undertaken to evaluate soil, groundwater, seismic, and environmental conditions along the alignment. The geologic conditions will influence design and construction methods specified for stations and tunnels as well as foundations, and protection of existing facilities.

Before any construction, a survey of structures within the anticipated zone of construction influence would be conducted in order to establish baseline conditions. A monitoring plan would be developed and adhered to during construction to ensure appropriate measures are taken to address any construction-induced movement.

If assessments indicate the necessity to protect nearby structures, additional support for the structures by underpinning or other ground improvement techniques would be required prior to the underground construction. A preliminary list of the buildings along Flower and 2nd Streets potentially located within the influence zone is tabulated in Table 4-1.

Table 4-1. Preliminary List of Structures Potentially Affected by Tunneling, Cut and Cover, and Open Cut Operations

Address	Current Name	Nearby Construction
*550 S. Flower Street, Los Angeles, CA 90017	The Standard Hotel	Cut & Cover
*538 S. Flower Street, Los Angeles, CA 90017	California Club	Cut & Cover
Bridge Pier at 4th and Flower Streets	N/A	Cut & Cover
Hope and 3rd Streets	Bunker Hill Plaza	Cut & Cover or SEM
Hope and 3rd Streets	Chilled Water Distribution	Cut & Cover or SEM
*111 S. Grand Avenue, Los Angeles, CA 90012	Walt Disney Concert Hall	Cut & Cover
*On 2nd Street Between Figueroa and Broadway Streets	2nd Street Tunnel	Cut & Cover
2nd Street between Olive and Hill Streets	Angelus Plaza	TBM
*202 W. 1st Street, Los Angeles, CA 90012	Los Angeles Times Building	Cut & Cover
2nd Street between Spring and Main Streets	Los Angeles Police Department (New)	TBM
*108 W. 2nd Street, Los Angeles, CA 90012	Higgins Building	TBM
*214 S. Main Street, Los Angeles, CA 90012	St Vibiana's Cathedral	TBM or Cut & Cover

Address	Current Name	Nearby Construction
2nd Street between Los Angeles and San Pedro Streets	Weller Court	TBM
2nd Street between San Pedro Street and Central Avenue	Union Bank	TBM
2nd Street between San Pedro Street and Central Avenue	Retail Structures	TBM or Cut & Cover
*355-369 E. 1st Street, Los Angeles, CA	Japanese American National Museum	Cut & Cover
Alameda Street	Existing Little Tokyo/Arts District Station	Cut & Cover

Table 4-1. Preliminary List of Structures Potentially Affected by Tunneling, Cut and Cover, and Open Cut Operations

**Historic*

Some of the buildings along the alignment are considered historic (denoted by *). It should be noted that not all buildings on the list would require mitigation. For buildings adjacent to cut and cover construction, it is anticipated that the shoring system in conjunction with internal bracing could provide a relatively rigid temporary support for the proposed excavation that would result in deformation generally within the tolerable limits of the structures. Evaluations during future phases will help determine the appropriate levels of monitoring, protection, and mitigation measures required during construction.

To reduce surface settlement and the potential for ground loss and soil instability (sloughing, caving) at the tunnel face due to tunneling, pressure-face TBMs and pre-cast, bolted, gasketed lining systems would be employed. In combination with the face pressure, the grout would be placed immediately behind the TBM, in the annular space between the installed precast concrete liners (tunnel rings) and the excavated ground. The pressure-face TBM can tunnel below the groundwater table without requiring dewatering or lowering of the groundwater table.

Where conditions warrant, for example, shallow tunnels directly below sensitive structures or utilities, additional methods to reduce settlement would be specified. Following is brief summary of the various types of protective methods that could be employed along the alignment.

Permeation grouting to improve the ground prior to tunneling

Chemical (sodium silicate) or cement based grouts are injected into the ground to fill voids between soil particles – typically sandy soils - and provide greater strength and stand-up time for the soil. This grout can be placed through pipes from the surface before the tunnel reaches the grouted area, from pits or shafts adjacent to the grouted area, or in some instances from the tunnel face. In this latter case, the tunneling machine must be stopped for a period of time to drill grout placement pipes, pump grout, and allow the grout to set. The permeation grouting method has been used successfully for the Metro Red Line in instances where the tunnel passed under potentially sensitive or important structures such as the US 101 freeway (downtown, Hollywood and at Universal City).

Compaction grouting as the tunnel is excavated

This method involves injection of a stiff "grout," typically sand with small amounts of cement, above the tunnel crown as the tunnel advances. The grout densifies soil above the tunnel crown and replaces some of the lost ground, and thereby preventing settlement from propagating to the surface. This method was used in several instances for the Metro Red Line project in the Downtown Los Angeles area and along portions of Hollywood Boulevard.

Compensation Grouting

Compensation grouting involves carefully controlled injection of grout between underground excavations and structures requiring protection from settlement. For tunnel applications, the pipes for grouting are installed above the intended tunnel position, in advance of tunneling. A key component in controlling compensation grouting is careful monitoring of both structure and ground movements to allow the timing and quantities of grout injected to be optimized. Grout injection can take place before, during, and after tunneling activity by reusing the grout pipes.

For grouting methods, surface preparation would likely be required (removal of landscaping etc.) to allow space for drilling equipment, installation of grout pipes, and injection of grout. In cases where large structures are directly over the tunnel, access into the building or basements, where basements exist, could be required for grouting operations, and use of the building could be limited during the grouting operations. After grouting is completed, the area would be restored to its existing condition.

Underpinning

Underpinning involves supporting the foundations of an existing building by carrying its load bearing element to deeper levels than its previous configuration. This helps protect the building from settlement that may be caused by construction work in the soils near that foundation. It permanently extends the foundations of a structure to an appropriate level beyond the range of influence of the construction activity. This can be accomplished by providing deeper piles adjacent to or directly under the existing foundation and transferring the building foundation loads onto the new system.

4.4 At-Grade Emphasis LRT Alternative Construction Activities

4.4.1 Surface Trackwork

Trackwork construction involves demolition of the roadway section being displaced by the LRT trackway, preparation of the track bed, construction of the supporting track slab, and laying of rail. Foundations for overhead wires poles may be installed with the track installation. At this stage of construction, affected traffic lanes would be closed, which would effectively eliminate all mid block turns and street parking. Typical drilling of the shaft for the catenary pole and track installation are relatively shallow.

Given the urban context, approximately 2-block segments of the roadway are likely to be reserved for construction activities to achieve economies of scale and minimize the schedule. Rails would be brought to the site by trucks, stockpiled at designated storage areas, welded into rail strings and moved into place as work progresses. Construction durations for a 2-block segment are estimated to be two to four months to complete trackwork in each roadway segment. Periodic lane closures, typically on just one side of the work zone, would be required for delivery of materials and other construction activities such as concrete pours. Construction of station platform slabs would likely be included in line segment contracts and would be coordinated with trackwork installation within each segment.

During construction within a segment, cross streets and alleyways may also be temporarily closed. Major cross streets would require partial closure, usually half of the street at a time, while utilities are relocated, if necessary, for surface stations and constructing the light rail trackbed. Depending on allowable working hours, full blocks may require closures during excavation, preparation of subgrade, drilling for soldier pile installation, and track foundation placement. Closures would be staggered to facilitate traffic control. Where streets are not fully closed, two-way traffic would be allowed on half of the street. After the trackbed is constructed across a local street and the roadway is restored to its permanent condition, vehicles can resume planned traffic patterns (e.g. 2nd street would have single direction traffic).

Rails would be brought to the sites by truck, and local rail storage areas would be necessary for short-term storage and to facilitate placement of rails. Equipment used for construction of surface tracks (and surface stations) would be similar to what is required for relocation of utilities with the addition of track-laying equipment, paving machines, concrete mixers, and concrete finishers.

4.4.2 Grade Separation at Alameda and Temple Streets

As previously described in the construction scenarios, an underpass would be constructed near the intersection of Temple and Alameda Streets that would allow through traffic on Alameda Street to continue beneath Temple Street and the new rail junction. In addition, a pedestrian bridge would be constructed above the Alameda underpass that spans the intersection of Alameda and Temple Streets. Bridge construction would involve heavy construction equipment including crane(s) for erection of the superstructure. The work would involve installation of an appropriate shoring system followed by excavation to the required depth of the underpass. Lane closures and traffic rerouting would be required for the duration of the construction.

Currently, an existing modular wall system provides support for the existing rails. Lowering Alameda Street in this area would require either underpinning the existing wall, or constructing a new, higher wall to replace the existing wall.

4.4.3 At-Grade Stations

The at-grade stations on Main and Los Angeles could be constructed simultaneously with other segments of the alternative, although the construction contractor may elect to construct them sequentially. Materials would be delivered to staging areas and station sites for the proposed construction via the shortest and safest route from the freeway. These stations would be constructed from standard building materials such as concrete, steel, aluminum, and heavy plastic, which are durable and resistant to vandalism. The stations would be similar to the existing Blue Line and Gold Line stations.

4.4.4 Underground Station

The underground station section in the At-Grade Emphasis LRT Alternative would be constructed using cut and cover methods as described in Section 4.5.1

4.4.5 Connection to the Existing 2nd Street Tunnel

Connection to the existing 2^{nd} Street tunnel would require major construction work, including installation of a temporary shoring system, construction of retaining walls to support soil removal, reinforcement of the tunnel structure, and installation of supporting elements at the location of the new openings.

4.4.6 Operating Systems Installation

Operating systems for the LRT include traction power, an overhead catenary system, communications, and signal system. Catenary systems consist of poles connected to drilled shaft foundations with overhead wires to supply power to the trains. The power would include substations to provide direct power to the trains. These include ground systems and prefabricated units which are placed on foundation slabs by crane and connected to the system. Construction equipment would include highrail vehicles for installation of the wires from the guideway area. While wires are strung at cross streets, temporary street closures of a few hours during nighttime are anticipated. Traction power substation (TPSS) equipment would also need to be installed adjacent to the alignment along at-grade segments, or within station boxes along underground segments.

4.4.7 Permanent Constructed Features

The permanent constructed features of the At-Grade Emphasis LRT Alternative would include the following:

- Tunnel beneath Flower Street
- Station entrances near 5th Street between 6th and 5th Streets
- Portal on Flower Street south of 3rd Street
- At-grade tracks across the intersection of 3rd and Flower Streets
- Portal at the northeast corner of 3rd and Flower Streets
- Pedestrian bridge from Upper Grand Avenue to the 2nd/Hope Street Station
- New portals into the existing 2nd Street tunnel
- Tracks in 2nd Street tunnel
- At-grade tracks along 2nd Street from Hill to Los Angeles Streets, tracks on Main and Los Angeles Streets between 2nd and Temple Streets, and tracks on Temple between Main and Alameda Streets
- At-grade one-way stations at 1st and Main Streets and 1st and Los Angeles Streets
- Pedestrian Bridge landings near Temple and Alameda Streets.
- Underpass and 3-way (wye) junction at Temple and Alameda Streets
- Urban design enhancements within 1,000 feet of the centerlines of stations and portals

4.5 Underground Emphasis LRT and Fully Underground LRT Alternatives

The following methods apply to all of the underground alternatives. Table

4.5.1 Underground Station Construction

The underground stations as well as the portals would be constructed by cut and cover with decking for streets and open cut methods. A possible exception to the these methods would be the excavation for the 2nd/Hope Street Station and possibly the adjacent curved tunnel section between the station and Flower Street where mining with the SEM method is also under consideration due to its depth. The stations need to be deep to avoid utilities and existing underground structures, including the existing Red Line tunnels, access to station platforms, structure thickness, and for cover over the tunnels extending from the stations. Station widths are about 60 feet to include trackways and center platforms. Portals are designed to accommodate the twin tracks, and traffic flow around the portal.

4.5.2 Construction of Station and Final Portal Structures

The construction sequence for the final station structure would include construction of the foundation base slab, followed by the installation of exterior walls and any interior column elements. Slabs are poured as the columns and intermediate floor and roof wall pours progress. Portal structures would use similar construction methods involving placement of concrete inverts, walls, and walkways. Station entrance locations are generally used as access points to the underground station during the construction process. Exterior entrances would be constructed after the station structure has been completed.

During station construction, approximately 5 to 10 concrete trucks per day should be anticipated for normal operation. Occasional large pours would be needed at the station depending on the construction sequencing and schedule, potentially requiring 30 to 40 trucks per day. The larger pours are expected to be performed at night to ensure supply of concrete and to minimize traffic impacts. Other support and delivery trucks, approximately up to 10 to 20 trucks per day, would also be anticipated during the duration of construction to bring materials such as rails, structural steel, and mechanical and electrical equipment. Approximately 25 to 50 workers are anticipated at each station site during construction. Once station structure work is complete, the station excavation will be backfilled and permanent roadway will be constructed.

Construction of 2nd/Hope Street Station using the SEM method would require construction of an access shaft to commence the excavation, remove the spoils, and to deliver shotcrete and other necessary construction materials. In addition, construction using the SEM method may require a variety of special measures, such as dewatering, forepoling, grouting (regular grouting or horizontal jet grouting), compressed air, and face bolts.

4.5.3 Grade Separation at Alameda and 1st Streets

Similar to the At-Grade Emphasis LRT Alternative, the Underground Emphasis LRT Alternative would require the construction of a grade separation at 1st and Alameda Streets. This construction would include the lowering of Alameda Street and allow uninterrupted traffic flow below 1st Street. The construction would include retaining walls, a pump station, and a 1st Street bridge across Alameda to allow traffic on 1st Street and support LRT trains.

In addition, the work would include the construction of a pedestrian bridge over the Alameda underpass. Related construction activities would be similar to those described in Section 4.4.2.

4.5.4 Operating Systems Installation

Construction equipment would include highrail vehicles for installation of overhead catenary system wires from the guideway area along the at-grade segment of the alignment. The wires would be suspended from poles installed within or adjacent to the right-of-way. While wires are strung at the intersection of 1st and Alameda Street, temporary street closures of a few hours during nighttimes are anticipated. TPSS equipment would also need to be installed within station boxes along the underground segments.

4.5.5 Permanent Constructed Features

The permanent constructed features of the Underground Alternatives are shown in Table 4-2.

Table 4-2. Permanent Features, Underground Alternatives

	Underground Emphasis LRT Alternative	Fully Underground LRT Alternative – Version 1	Fully Underground LRT Alternative – Version 2
Tunnel beneath Flower and 2nd Streets	✓	✓	
Station entrance near 5th Street, south side of Flower Street	✓	✓	
Station entrances, shafts, and pedestrian bridge at 2nd/Hope Street Station	✓	✓	
Station entrances on the south side of 2nd Street either between Main/Los Angeles Streets or Broadway/Spring Street	✓	✓	
Pedestrian Bridge landings near 1st and Alameda Streets	✓	X	X
Underpass and at-grade wye junction at 1st and Alameda Streets	✓	X	X
Underground three-way junction beneath 1st and Alameda Streets	✓	✓	✓

Table 4-2. Permanent Features, Underground Alternatives			
	Underground Emphasis LRT Alternative	Fully Underground LRT Alternative – Version 1	Fully Underground LRT Alternative – Version 2
Underground Station at 2nd Street and Central Avenue	X	✓	✓
Portal between Alameda Street, Central Avenue, 1st, and 2nd Streets	✓	✓	✓
Urban design enhancements within 1,000 of the centerlines of stations and portals	✓	✓	

4.6 Ventilation Shafts and Emergency Exits

The subway segments would include a number of ventilation and emergency exit areas for the below grade segment in the vicinity of the subway stations. The stations would house emergency ventilation fan shafts as well as separate emergency exit shafts at both ends of the stations. Ventilation fans are used for extracting smoke from tunnels and stairs for evacuation in the event of an emergency such as a fire in the underground areas. The exact location of these facilities would be determined during the final design. These shafts are constructed as extensions of the station excavation, using cut-and-cover construction methods.

4.7 Construction Personnel and Parking

The estimated number of construction personnel for different activities are as summarized in Tables 3-1 and 3-2. Arrangement for offsite parking locations would be required for the construction workers and transportation would be provided at the beginning and end of shifts to transport workers to work areas.

4.8 Hauling of Soil

With the decking installed and the utilities supported, the major excavation work for the station box can proceed. The method of removing material from the job site is usually a choice made by the contractor. A typical operation would be for bulldozers and/or overhead loaders to move material to a central pickup point or several such points, where a bucket from a crane or a vertical or diagonal conveyor belt can hoist the material and place it into waiting trucks or a loading hopper. Spoils from station sites would be moved out from under the deck onto an off street work site or closed lane and loaded from there into hauling trucks. Occasionally spoils loading in the street during excavation and the initial drilling of soldier piles and deck installation could be required. Spoils from tunnel construction would be transported through the bored tunnels to the shaft site for loading onto trucks. An example of TBM spoils being removed from a tunnel at a construction staging site is depicted in Figure 4-1.

Excavated soils and excess material would be transported off-site to approved disposal sites along designated routes. Testing of materials would be required prior to transportation. Depending on the test results of the soils, disposal options could include the following sites:

California Hazardous (metals) Class I facilities:

- Waste Management Inc., Kettleman City, CA
- Clean Harbors Environmental Services, Buttonwillow, CA
- Veolia Environmental Services, Azusa, CA
- US Ecology Nevada, Inc., Beatty, NV

Non-hazardous, Total Petroleum hydrocarbon-containing wastes:

- Thermal Processing Systems Treatment, Adelanto, CA

Non-hazardous soil:

- Philadelphia Recycling, Mira Loma, CA
- Municipal landfills
- Other locations identified by the contractor

4.9 Street and Site Restoration

After the cut and cover underground station structures have been completed and the roof slab allowed to cure for a specified period, backfilling can begin. During backfilling operations, utilities would be restored to their permanent locations. Where sidewalks have been demolished due to cut and cover construction, they would be restored. After backfilling, the permanent street would be constructed and the sidewalks and pavement restored to City standards. Contractor work sites would be restored for future use in a similar manner.

It is anticipated that partial street closures would be required during backfilling and site restoration.

Figure 4-1: Wet Soil at Surface EPB TBM