SECTION 7

Site Conditions for Zone 1

7.1 General

Zone 1 is located entirely within the City of Los Angeles. As depicted on Plates 1 and 5, Zone 1 is generally located west to northwest of the northern terminus of I-710, southeast of the SR-2/I-5 intersection, and south of Mount Washington; it includes Elysian Valley and the northern portion of Elysian Park. Zone 1 terminates at SR-2 and measures approximately 5.0 to 5.5 miles long by 1.5 miles wide at its western limit. The delineation of Zone 1 anticipates a connection between the northern terminus of I-710 and SR-2 or I-5 to the northwest. The general location of Zone 1 relative to the other study zones is shown in Figure 7-1.

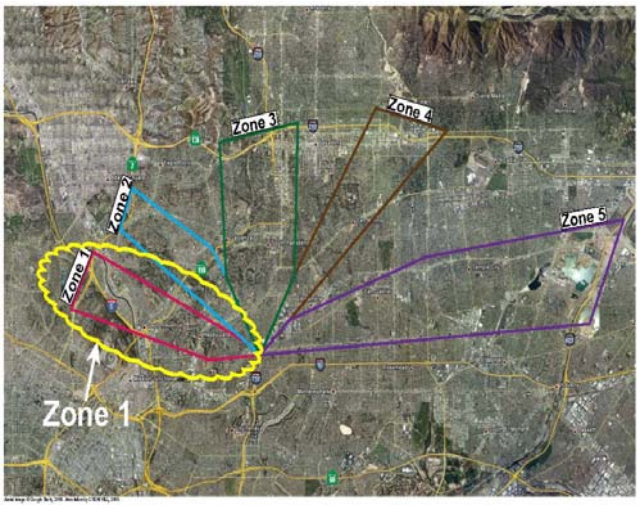

Figure 7-1. Zone 1 Location Map.

7.2 Existing Developments

Most of the Zone 1 area is densely populated and is occupied predominantly by residential and commercial/industrial developments. Two major southern California freeways cross the western half of Zone 1. I-5 runs in a northwest-southeast direction along the northeastern foothills of the Elysian Park Hills, and SR-110 crosses perpendicularly the central portion of the zone. Other important surface roads include, from east to west, Alhambra Avenue, Eastern Avenue, Mission Road, Pasadena Avenue, Figueroa Street, San Fernando Road and Eagle Rock Boulevard. Railroad tracks cross the eastern portion of the zone between Mission Road and Valley Boulevard.

The former Taylor railroad yard, a relatively large rail yard, was located within the western portion of Zone 1, along the northern flood plain of the Los Angeles River and immediately south of San Fernando Road. The majority of the former rail yard has been redeveloped and now consists of open space, an industrial park, and a state park. The remaining part is a switching yard and maintenance facility for the Metro light rail system.

The Upper Reach of the NEIS line tunnel extends northwesterly from just south of the intersection of the Los Angeles River and SR-110 to the intersection of San Fernando Road and Division Street (immediately to the east of the former Taylor rail yard). The Upper Reach of the NEIS sewer line consists of a concrete-lined tunnel that is approximately 12 feet in diameter and 2 miles long and is located along the Los Angeles River floodplain, below the San Fernando Road centerline. At Division Street, the Upper Reach of the NEIS sewer

line is at an approximate elevation of 230 feet above mean sea level (msl), or roughly 150 feet bgs. In the vicinity of the southern limit of Zone 1, the sewer line is located at an approximate elevation of 220 feet msl, or a depth of roughly 125 feet bgs. In the vicinity of SR-110, the invert of the Upper Reach of the NEIS sewer line is located approximately 150 feet bgs.

An abandoned water supply tunnel, known as the "Narrows Gallery," intersected the NEIS sewer tunnel alignment approximately 400 feet north of its Humboldt Shaft. This location is approximately 1,500 feet to the south of the southern limit of Zone 1 near the corner of San Fernando Road and Humboldt Street. This abandoned water supply tunnel was constructed in 1904 and later abandoned in the 1950s due to reported high levels of contamination. The tunnel is reported to be elliptical in shape and is approximately 5.2 feet high by 4.9 feet wide. The orientation length and depth of the tunnel are unknown.

7.3 Zone Geology

7.3.1 Physiography

From west to east, Zone 1 includes the Elysian Hills, Los Angeles River flood plain, Arroyo Seco and several associated local low-lying areas, and the Repetto Hills (Plate 1). Mount Washington, the highest point within the Repetto Hills, with an approximate peak elevation of 850 feet msl, is north of the confluence of the Los Angeles River and Arroyo Seco. The Elysian Hills west of the river rise to a peak elevation of approximately 740 feet msl. The lowest point within Zone 1 is in the vicinity of the confluence of the Los Angeles River and Arroyo Seco, at an approximate elevation of 320 feet msl.

Both the Elysian Hills and the Repetto Hills comprise gently to steeply sloping hills. The southeasterly draining Los Angeles River has eroded a wide floodplain between the Elysian Hills to the west and the Repetto Hills to the east. The southwesterly draining Arroyo Seco has formed a major southwesterly draining valley between the northwestern (Mount Washington area) and southeastern (Montecito Heights) portions of the Repetto Hills. The Arroyo Seco joins the Los Angeles River in the vicinity of the Elysian Hills. Four other smaller intermittent drainages, that flow south to southwesterly with narrow gently sloping floodplains, dissect the Repetto Hills in the eastern half of Zone 1.

7.3.2 Stratigraphy

The geologic formations comprising Zone 1 consist predominantly of Puente Formation and Quaternary Alluvium (Plates 1 and 5). The majority of the tunnel is expected to be within the Puente Formation. Alluvium is expected to be encountered only at the portal area and along the Los Angeles River. The general characteristics of the alluvium and rock units are described in Section 4.1.2. As described in Sections 5 and 6, groundwater within the alluvium at the west portal area is contaminated.

The shear wave velocities obtained as part of the surface wave survey at different points through Zone 1 allowed for the interpretation of the thickness of the alluvial materials and its contact with the underlying bedrock. This information was used to complement our knowledge of the subsurface conditions along the Los Angeles River, Arroyo Seco, and other smaller drainages, at points where no borings were advanced and/or where no such

data existed. In addition, when surface wave survey points were located at the end of the seismic refraction lines, the same parameters were interpreted since the seismic reflection array used could not allow for a good resolution at shallow depths.

Alluvial materials within Zone 1 also occur along the Arroyo Seco and all other secondary drainages that dissect Zone 1. The alluvial materials are approximately 75 feet thick at the confluence of the Los Angeles River and Arroyo Seco, whereas thicknesses in excess of 200 feet are reported near the northwesternmost corner of Zone 1 (Yerkes et al., 1977). The thickness of the alluvial materials along the Arroyo Seco decrease upgradient to approximately 25 feet at the northern limit of Zone 1. The alluvial materials in all other smaller drainages located in the eastern half of Zone 1 range in thickness between 40 to more than 100 feet. The water-bearing young alluvium commonly is considered to be susceptible to liquefaction.

The Puente Formation is expected at the tunnel depth in Zone 1. Except for the easternmost 2,000 linear feet that are anticipated to be excavated into rocks of the siltstone member (Tpsl) of the Puente Formation, a typical tunnel would be constructed in the sandstone member (Tpss). The sandstone member contains approximately 20 to 30 percent fine-grained interbeds (siltstone). In addition to these two units, the shale member (Tpsh) crops out in portions of Zone 1 and could occur mostly at shallow depths above a typical tunnel.

7.3.3 Structural Geology

Zone 1 generally parallels the trend of the major geologic structural features of the Elysian Hills and Repetto Hills. The representative geologic profile for Zone 1 (Plate 5) shows the typical structural conditions anticipated throughout this zone. Faulting along the Elysian Park blind-thrust fault deep below Zone 1 has folded rocks within the northwest-trending and southeast-plunging Elysian Park Anticline (Oskin et al., 2000). Uplift of this anticline has produced the Elysian and Repetto Hills. Topographic relief throughout the region correlates well with the areal extent of the anticline and with the trends of secondary folds (Plate 1 and Plate 5). However, the anticline has been extensively modified by surficial erosion.

The axis of the Elysian Park Anticline trends approximately along the middle of Zone 1. As a result, bedding within the northern portion of Zone 1 generally dips toward the northeast at 40 to 55 degrees, whereas southwest-dipping beds predominate along the southern portion of the zone, dipping at 20 to 30 degrees. Local deviations from these orientations can occur anywhere within the region due to secondary folding and faulting. A review of the ATV logs (see Appendix C.1) for the boreholes excavated north and south of the anticline axis generally confirmed the northeast and south-southwest dipping beds as discussed above and as shown on the geologic base map (Plate 1). The ATV logs and field boring logs also show very slightly to slightly fractured bedrock. Numerous secondary folds and inactive faults associated with the folding of the Elysian Park Anticline have been mapped within Zone 1, particularly in the eastern portion. The majority of these secondary folds and the more continuous faults generally parallel the trend of the Elysian Park Anticline; however, several shorter faults have been mapped trending perpendicular and oblique to the Elysian Park Anticline.

The geologic structure and distribution of the geologic units to be encountered within a typical tunnel depth will be a function of which limb of the Elysian Park Anticline that the selected alignment will cut through.

7.4 Faulting

Zone 1 is not located within an APEFZ, and no active faults are mapped as crossing or projecting toward Zone 1 in available geologic literature. Therefore, the potential for ground-surface fault rupture and fault displacements inside this zone are considered low.

Seven faults were mapped within the limits of Zone 1 by Lamar (1970). All of the mapped faults are considered inactive. The longest of these faults is the southeast-trending Elysian Park fault (not to be confused with the subsurface Elysian Park Fold and Thrust Belt). The steeply northward-dipping and Pliocene-age Elysian Park fault as mapped by Lamar (1970) exhibits approximately 2,100 feet of north-side down-vertical separation. The Elysian Park fault and all other, steeply dipping faults mapped in this area at the currently anticipated tunnel depth could juxtapose various units of the Puente Formation, but generally the rock types on both sides of a fault are expected to have similar geotechnical properties. No new fault displacements are anticipated to occur along these inactive faults.

An inclined continuous-core boring, with a total depth of 291 feet bgs, was drilled to investigate the presence and characteristics of the Elysian Park fault at depth. R-09-Z1B2 was located a couple of hundred feet to the north of the trace of the fault mapped by Lamar (1970) where it crosses Stadium Way in the Elysian Hills. The boring was drilled at an angle of 60 degrees (from horizontal) in an attempt to intersect the fault. No indications of faulting, such as clay gouge or change in rock type, were encountered in R-09-Z1B2. In addition, continuous seismic reflectors dipping to the southwest can be observed in the seismic-reflection profile of Line Z1-G3 located directly across the fault. Furthermore, Dibblee's (1989b) geologic map for the Los Angeles quadrangle does not show the Elysian Park fault. This suggests that the Elysian Park fault might not exist or is a minor feature at the location mapped by Lamar (1970).

7.5 Groundwater and Surface Water Conditions

The depth to groundwater along the portion of the Los Angeles River encompassed by Zone 1 decreases gradually from the southeast to the northwest, opposite to the river flow, and exists under unconfined conditions. In 2006, the shallowest groundwater conditions of 20 feet bgs were observed approximately 4,500 feet north of SR-110, whereas a groundwater depth of approximately 50 feet bgs is reported near the intersection of the Los Angeles River and SR-2. Drilling by others in the bottom of the river reveals water flowing within the sand and gravel below the concrete bottom. The deeper groundwater conditions and inverted groundwater flow are influenced by groundwater extraction at the LADWP Pollock Treatment Plant located northwest of the intersection of the Los Angeles River and SR-2.

These shallow groundwater conditions along the Los Angeles River were confirmed by the estimation of groundwater depths at 16 of the surface wave soundings. Groundwater was modeled in the 10- to 33-foot depth range at these locations. The other four soundings (Z1-S1, Z1-S3, Z1-S5, and Z1-S6) in Zone 1 were located at higher elevations and in bedrock materials and MASW arrays were not long enough to map the approximate groundwater depth at these locations. Seismic reflection shot records along seismic line Z1-G3 indicate that the groundwater level may be shallower along surface wave soundings Z1-S5 and Z1-S6. Groundwater depth varied from 22 to 40 feet bgs in the six piezometers installed as part of the current study in Zone 1.

Based on groundwater information collected for this exploration, the groundwater table within Arroyo Seco was not observed within the upper 35 feet. According to the CDMG (1998d), the historical highest groundwater level at the Los Angeles River is reported to have been approximately 20 feet bgs.

No historical highest groundwater information is provided by CDMG (1998d) for Arroyo Seco or other smaller drainages located in the eastern portion of Zone 1.

The rocks of the Puente Formation are generally considered non-water-bearing. Perched groundwater conditions might be locally present within faulted and/or fractured zones; however, none were observed during our exploration.

The Los Angeles River and Arroyo Seco are surface water bodies located within Zone 1. The Los Angeles River flows through the western portion of Zone 1 and Arroyo Seco flows through the central portion of Zone 1. The Los Angeles River and Arroyo Seco are generally concrete and riprap-lined channels. No major springs are known to occur in the upland bedrock areas. Although there are no large surface water recharge areas within Zone 1, normal inflow of water from the ground surface will occur during periods of rainfall.

7.6 Hazardous Materials

The ISAs and ESA identified 10 open or active sites located within Zone 1. The locations of these sites are shown in Figure 6-1. The southern region of the San Fernando Valley (Area 4) Pollock Wellfield NPL Site is located in the western portion and the west portal zone of Zone 1. A portion of this groundwater basin is currently contaminated with chlorinated VOCs (trichloroethylene [TCE] and tetrachloroethylene [PCE]), methyl tertiary butyl ether (MTBE), perchlorate, nitrate, chromium VI, manganese, and thallium. Concentrations of PCE and TCE within Zone 1 range from greater than detection limit to approximately 100 µg/L (CH2M HILL, 2007). The approximate plume boundaries for the San Fernando Valley (Area 4) Pollock Wellfield NPL Site above MCLs are shown in Figure 6-1.

An Interim Investigation was completed for the San Fernando Valley Pollock Wellfield NPL site in April 1994. In 1998, treatment of groundwater was reactivated by the Los Angeles Department of Water and Power. Investigations for this NPL site are ongoing to determine the full nature and extent of contamination at this area. A Cooperative Agreement between USEPA and the California RWQCB has been initiated to perform an investigation of potential sources of the contamination in the San Fernando Basin (USEPA, 2009).

Ten sites (including the San Fernando Valley [Area 4] Pollock NPL Site) with localized groundwater or soil contamination are located within Zone 1. One of these sites, summarized below, is located in proximity (that is, less than 0.5 mile) to a western portal zone for Zone 1:

- Hurst Chemicals, 2500 San Fernando Road, Los Angeles, California (Map ID 255/12), which is located within 0.5 mile of the western portal for Zone 1. The site has contaminated the groundwater with TCE. Depending on the final tunnel alignment, this site could potentially impact the project because it is located within the western portal zone for Zone 1 and has impacted the groundwater.

The remaining eight sites (not including the NPL site) with localized soil or groundwater contamination were identified as being in the central portion of Zone 1 and are considered to have a low potential to impact the project because they are located within the tunnel zone and are characterized with soil or groundwater contamination at a depth of less than 150 feet bgs. Additional details for each of these sites, including the corresponding soil and/or groundwater contaminants, corresponding concentrations, and depth of maximum concentration, are included in the Environmental Screening Evaluation in Appendix F.

7.7 Potential for Naturally Occurring Gas

The Puente Formation is one of the more prolific petroleum sources in the Los Angeles Basin. Although, no known oil or natural gas fields are located within Zone 1, naturally occurring tar and hydrocarbon odors were encountered within the Puente Formation during drilling at boring R-09-Z1B7 and R-09-Z3B12 locations.

During the field investigation performed for the Upper Reach segment of the NEIS sewer line and during its construction, hydrogen sulfide (H_2S) gas was encountered. After careful examination, it was determined that the hydrogen sulfide gas was released into the atmosphere from groundwater flowing into the cutting chamber of the tunnel boring machine (TBM). In addition, methane gas, in excess of 20 percent of the lower explosive limit (LEL), was encountered during tunnel excavation.

Based on previous observations of naturally occurring gas in other tunneling projects, naturally occurring gas conditions can be expected within Zone 1. The levels of gassy conditions encountered to-date in the zone and elsewhere within the Los Angeles basin should be manageable, as long as appropriate considerations is given to this condition during construction.

7.8 Geotechnical Considerations for Tunnel Design and Construction

7.8.1 Key Ground Characteristics

Based on the results of this evaluation, the key geologic factors for this zone in terms of tunnel design and construction considerations (along the generalized geologic profile shown in Plate 5) are:

- Subsurface conditions are fairly uniform in most of this zone, consisting mainly of weak sedimentary rocks of the Puente Formation. Typically, the formation in this zone consists mostly of sandstone, siltstone, and shale. Locally, there is a potential for encountering alluvium (or soil) near the portals and in shallow cover beneath the Los Angeles River.
- Rock mass is generally only slightly fractured. Although several inactive faults will likely be encountered, no active faults are mapped within this zone.
- Most of the rock is considered weak to moderately weak, although there is a potential for stronger cemented layers and concretions within the Puente Formation.
- The groundwater table within the alluvium is shallow (approximately 20 to 50 feet below grade) in parts of this zone. The rock mass is not expected to transmit large quantities of groundwater into the tunnel, except for possibly beneath the Los Angeles River. In this area recharge from the river could lead to higher sustained groundwater inflows. High groundwater inflows are also expected in the saturated alluvium at the portal areas.
- The water-bearing alluvial materials along the Los Angeles River within the limits of Zone 1 are considered to be susceptible to liquefaction (CDMG, 1999d) in areas where groundwater is near the ground surface and loose cohesionless soils occur.
- One Superfund site is located in the northwest portion of the zone, which could be a source of contaminated soil and groundwater in the tunnel. This concern applies mainly to the portal area and approach excavations for the tunnel.
- There is a relatively high potential of encountering naturally occurring gas (methane and/or hydrogen sulfide) in this zone.

7.8.2 Preliminary Assessment of Tunneling Considerations

Information presented above and in previous sections of this report was used to perform a preliminary assessment of tunnel design and construction requirements, as summarized below.

Tunnel excavation in this zone at the likely tunnel depth would be almost entirely in the Puente Formation sandstone (Tpss)—the exception being at the portals where the tunnel would likely encounter alluvium in the transition from the ground surface to the tunnel. The Puente Formation generally consists of weak sedimentary rocks that can be excavated with modern tunneling equipment such as a TBM. Several tunnels have been successfully constructed through this same formation in the Los Angeles area. Due to the relative uniformity of the geologic conditions in this zone, it is likely that only a single excavation method would be needed. The strength and uniformity of the ground conditions in this zone reduce the demand on the tunneling equipment and construction processes and allow for more efficient construction and higher production rates.

Some inherent variability exists in the Puente Formation, such as occasional strong to very strong cemented layers and concretions within the formation. These layers should be considered in the selection/design of tunnel excavation equipment. Although they would reduce tunnel excavation advance rates somewhat, the layers do not impact the feasibility of constructing a tunnel in this formation.

The tunnel profile will have to be low enough to avoid conflicting with the existing NEIS tunnel (Plate 5). Depending on the rock mass quality at this crossing, a clear distance of about 15 to 25 feet is needed to avoid impacts to the existing tunnel.

Water-saturated alluvium (or soil) would likely be encountered in excavations for the portals and limited portions of shallow tunnels beyond the portal areas. The risks of open excavation and tunneling in saturated alluvium include high groundwater inflows, flowing ground conditions, loss of ground outside the excavation, and settlement of the ground surface. The amount of settlement would depend on a variety of factors including the tunnel excavation and support methods, ground characteristics, diameter of the tunnel, and cover above the tunnel (i.e., distance from the tunnel crown to the ground surface). Typically, a ground cover of at least two tunnel diameters is desirable for minimizing settlement magnitudes. To actively control settlement, ground loss should be controlled at the face of the tunnel so that the effects of that loss of ground do not propagate to the surface.

Tunneling methods are available to handle saturated alluvium conditions. Control of unstable ground conditions and groundwater inflows can be provided by specialized tunneling machines with face control capabilities. These machines generally utilize either earth-pressure balance (EPB) or slurry methods. Such machines have been used successfully on previous tunneling projects in Los Angeles, and this technology could be applied to the SR-710 extension as well. In some cases, it is possible to implement systematic ground improvement measures including a combination of dewatering, permeation grouting, or jet grouting to stabilize the deposits and reduce the loss of ground to tolerable limits.

In the alluvium, it will be necessary to have a watertight lining system to avoid groundwater inflows, which could impact groundwater levels adjacent to the tunnel and result in additional maintenance within the tunnel. This type of lining, while more expensive, has been used for most of the Los Angeles Metro tunnels. Watertight linings typically have rubber gaskets along the circumferential and longitudinal joints to control groundwater inflows and to make the lining essentially watertight.

Below the Los Angeles River, even if the tunnel is located in the Puente Formation, there is a potential for encountering higher groundwater inflows and also unstable ground conditions. Often rock formations below river valleys are more highly fractured and more deeply weathered leading to weaker, more pervious ground conditions. Greater bedrock cover may be required in this area to minimize instability and the potential for high groundwater inflows. The bedrock surface in this area could also be highly variable (or undulating) and additional cover may be desirable to avoid the risk of encountering saturated alluvium in the tunnel unexpectedly.

Although several steeply dipping faults are located in Zone 1, they are all considered inactive. Tunneling through these faults will require the excavation of fractured rock, control of groundwater, and may involve excavation of clay gouge formed by prior fault movements. Specialized TBMs should be able to complete this work without major difficulty, but with slower progress. Furthermore, fault zones have the potential to act as groundwater barriers; therefore, the groundwater conditions should be fully characterized prior to tunnel construction to determine what types, if any, of groundwater control measures are necessary.

The Puente Formation is expected to require immediate support in the large tunnel excavations proposed for this project. If the tunnel is excavated by a full-face TBM, the ground support is expected to be a precast reinforced concrete segmental lining placed as the TBM advances. If the tunnel is excavated by other methods, the ground support may be shotcrete and rock bolts or steel ribs and lagging. Control of the tunnel face and effective installation of ground supports will be required to control loss of ground and ground surface settlement.

The Superfund site in the northwest portion of Zone 1 has a potential to impact the tunnel excavation and muck disposal operations. Depending on the extent of the contaminated soils and groundwater, a tunnel in this zone could encounter hazardous materials. This would affect the tunneling operations if the contaminant concentrations are high enough to significantly affect working conditions in the tunnel; it would also affect tunneling costs if concentrations require special disposal of the tunnel spoils. It would be undesirable if tunneling operations impacted a contaminated groundwater plume or caused it to migrate. However, the potential for migration along the tunnel alignment is very low. Normal grouting operations associated with tunneling will close off any path of water migration.

Another important tunnel construction consideration is the potential for naturally occurring gas in the Puente Formation. Based on the findings reported by Dubnewych et al. (2005) for the Upper Reach of the NEIS tunnel line, the presence of methane and/or hydrogen sulfide gas is expected in this zone and the tunnel will likely be classified as “Potentially Gassy” or “Gassy” by California Occupational Safety and Health Administration (Cal-OSHA). This is not unusual in the Los Angeles area and several tunnels (such as the NEIS and ECIS) have been safely excavated within areas of naturally occurring gas, with proper provisions. The tunnel muck excavated from areas of naturally occurring gas may need to be disposed at hazardous waste landfills if concentrations of the contaminants exceed certain limits.

Based on the information collected and reviewed in Zone 1, tunneling is feasible in this zone from a geotechnical standpoint. Subsurface conditions and other tunneling considerations discussed for this zone should be further evaluated in more detailed tunnel design studies.