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Los Angeles River Ecosystem Restoration Feasibility Study

DRAFT – APPENDIX D
GEOTECHNICAL, INCLUDING HTRW

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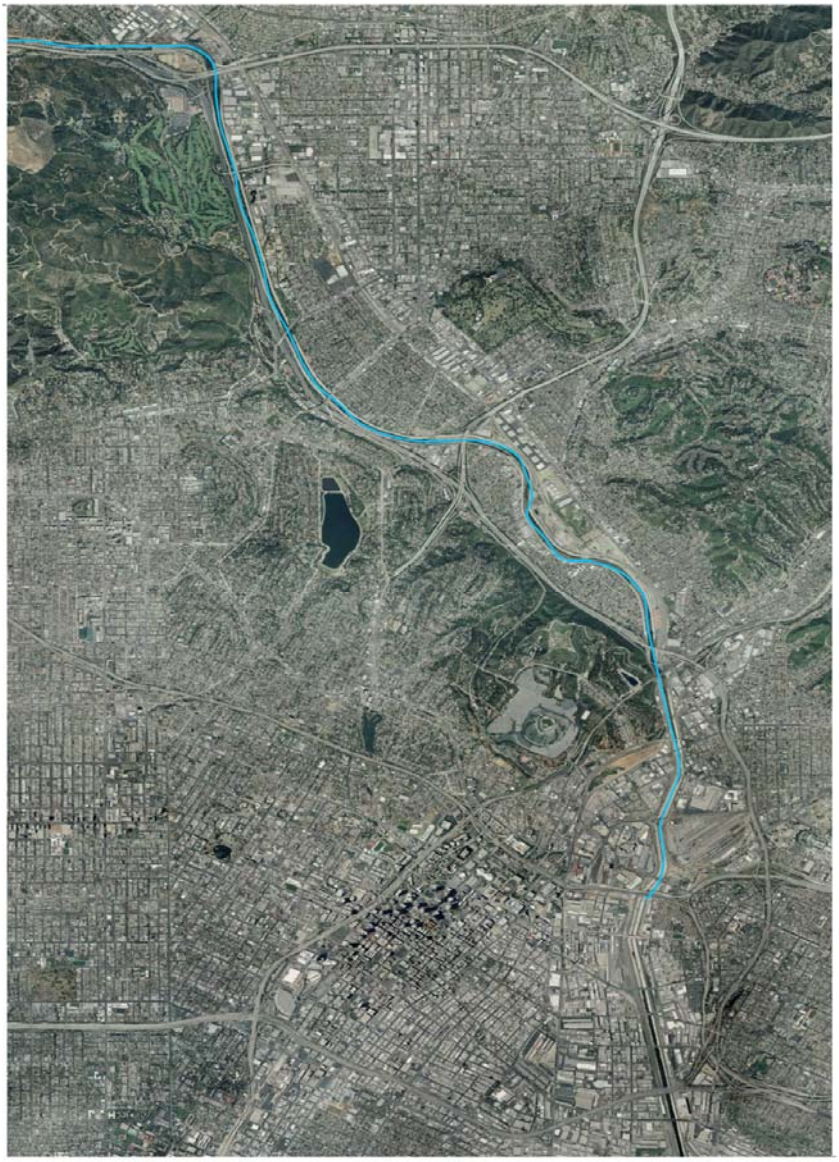
Geotechnical Branch

DRAFT Geotechnical Feasibility Report

Los Angeles River Ecosystem Restoration Study Project Area, Los Angeles County, CA



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1.0 INTRODUCTION

1.1 Context

This Geotechnical Feasibility Report has been prepared in support of the Los Angeles River Ecosystem Restoration Study (referred hereafter as the Study) and provides conditions and considerations from a geologic, geotechnical and environmental engineering perspective to aid in decision-making and alternative selection processes for the Ecosystem Restoration. The Geotechnical Feasibility Report is designed to address geologic, geotechnical and environmental conditions and constraints that are associated with the LA River Ecosystem Restoration Study (the Study) and should not be utilized for other purposes. Some sections and content within this report may also be repeated in other sections or appendices of the Study report.

1.2 Los Angeles River Description and General History

A brief description of the Los Angeles River (LA River), as it pertains to the Study, is presented in this section as background for the geologic, geotechnical and environmental concepts as presented in the report. A more detailed depiction of the LA River as a whole is presented in the Study report and associated appendices.

The LA River begins at the confluence of the Arroyo Calabasas and Bell Creek, flows through the San Fernando Valley, passes through the Glendale Narrows, onto the coastal plain, and eventually drains into the Pacific Ocean. From the confluence of Arroyo Calabasas and Bell Creek, the LA River flows through the western San Fernando Valley and through Sepulveda Reservoir where the flow is joined from the north by the Tujunga Wash. Tujunga Wash includes flow from both Hansen Dam and Pacoima Wash. Downstream of the Sepulveda Reservoir, the Burbank-Western channel, and smaller tributary drainages that emanate from the western San Gabriel Mountains join the River as it flows easterly through the San Fernando Valley. As the river approaches the Study area, it bends around the Hollywood Hills and is joined from the east by the Verdugo Wash, and then flows south through the Glendale Narrows and onto the broad coastal plain. The LA River is joined within the coastal plain by a number of tributaries including the Arroyo Seco and the Rio Hondo Diversion Channel from the Rio Hondo Diversion Channel confluence. The LA River then continues south for 12 miles and finally discharges into the Pacific Ocean at the San Pedro/Long Beach Harbor. Figure 1 presents a graphical depiction of the LA River and the Study area.

The LA River is an ephemeral stream that naturally meanders and periodically floods during the rainy winter season. Development in the LA River's natural floodplain has occurred and continues into the present. As such, the seasonal flows that would have been dispersed over the floodplain have been directed into the main channel. As the population has increased and

development has expanded within the LA River's natural floodplain, flood threats from the storm season flows have also increased. In the late 19th and early 20th centuries, massive storm flows in the LA River caused flooding that resulted in the loss of lives and significant property damage. As a result of these storm events, City of Los Angeles (City) and County of Los Angeles (County) leaders decided to have the LA River channelized. The U.S. Army Corps of Engineers (USACE) completed the task by channelizing the river with concrete bottoms, concrete side slopes, grouted stone slopes, stabilized soft bottoms, channel walls, floodwalls, and levees. Further discussion on the historical impact of the LA River and the construction of the LA River channel can be found in the additional appendices which accompany the main Integrated Feasibility Report (IFR).

1.3 Scope of Work

The geotechnical support for the feasibility study included review and reference of existing geotechnical information, identification of project constraints, preliminary and ongoing evaluation of project alternatives, and preparation of this report. The scope of work included the following:

a. Review of published and unpublished data pertaining to the geotechnical conditions in the general vicinity of the project study;

b. Attendance of project meetings and review sessions;

c. Evaluation of geotechnical, geologic, and groundwater data collected during the review process;

d. Evaluation of the potential impact and the anticipated geologic conditions on proposed alternatives and measures;

e. Development of a list of constraints and considerations potentially impacting the proposed alternatives and measures for ecosystem restoration;

f. Preparation of comments and recommendations for geotechnical considerations on other documents for the study; and

g. Preparation of this report documenting the work performed, information gathered during the review of available data, and geotechnical considerations and constraints.

2.0 STUDY AREA

The Study area is known as the "ARBOR" Reach (Area with Restoration Benefits and Opportunities for Revitalization), an eleven mile portion of the LA River, which extends from the Headworks site downstream to First Street. The ARBOR Reach was chosen for study partly because of the soft-bottom within the "Glendale Narrows". The Study area also contains numerous restoration opportunity locations where restoration may be achieved as the locations are local Sponsor property or property that may be acquired by the local Sponsor. These areas include the following: Headworks, Pollywog Park, Bette Davis Park, Griffith Park, Ferraro Fields, the Burbank Western Channel and Glendale River Walk, Verdugo Wash, the Bowtie and Taylor Yard, Cornfields (LA State Historic Park), Arroyo Seco, Elysian Park, Atwater Park, Piggyback Yard (also known as Mission Yard), and Downtown Los Angeles. Please refer to the main IFR for detailed descriptions and locations of these areas and the importance of these locations to the Study.

The ARBOR Reach has been subdivided into eight sub-reaches (Sub-Reach 1 through Sub-Reach 8). These sub-reaches are defined based on physical characteristics that define channel functions, existing habitat, and surrounding land uses. The selected criteria include: (1) channel bed type (e.g., soft-bottom with groundwater-surface water exchange or concrete); (2) side slope condition (e.g., vertical or trapezoidal); and (3) adjacent land uses (e.g. development or open space). The general extent of these sub-reaches are presented in Figure 1. A summary of the current conditions is presented in the attached Table 1 and a further detailed description of these sub-reaches is provided in the main IFR.

2.1 Proposed Improvements and Alternatives

Extensive plan formulation and community involvement was undertaken to develop the goals, objectives, and alternatives for this Study. Details are presented in the main report and other appendices. Due to the dynamic conditions of the planning processes and study timeframes, a detailed and complete description of plans, alternatives, measures and sub-measures, are not included in this portion of the Study. However, a summary of potential sub-measures and the sub-reaches where those sub-measures may be applied as well as the associated plan are included in the attached Table 2. The four plans considered in this portion of the Study are plan numbers 10, 13, 16, and 20. This numbering is discussed in the main IFR.

2.2 Considered Improvements

A comprehensive list of considered improvements can be found in the main IFR. The considered improvements included tunnels, underground basins, underground channels, ponds and pump stations, and other options. Many of the improvements were not carried forward due to

exorbitant cost or hydraulic infeasibility. Details regarding these improvements can be found in other appendices and in the main IFR.

2.3 Tentatively Selected Plan

The tentatively selected plan (TSP) is currently Alternative 13. For consistency, the potential constraints and options associated with the other alternatives are included in this report.

3.0 SITE CONDITIONS

3.1 General Overview and Topography

The Los Angeles River Ecosystem Restoration Study area is located in Los Angeles County within portions of both the Los Angeles and the San Fernando topographic basins of southern California. These basins are connected by the LA River through a narrow gap between the Santa Monica Mountains and the Elysian Hills, to the west, and the Repetto Hills and the Verdugo Mountains, to the east, which is locally known as the Glendale Narrows. The LA River captures all of the drainage area of the San Fernando topographic basin and flows out onto the upper portion of the Los Angeles topographic basin. These basins and the Study portion of the LA River are depicted on Figure 2. Upstream of the Glendale Narrows, the LA River drains a watershed that is greater than 800 square miles.

Elevations in the Los Angeles River Watershed range from approximately 10,000 feet in the San Gabriel Mountains to sea level at the mouth of the Los Angeles River. Elevations of the river within the Study area itself range from approximately 490 feet at the upstream end of the Study area to approximately 240 feet at the downstream end. The average slope of the LA River is approximately 4 to 14 feet per mile.

The project area includes adjacent neighborhoods in the Cities of Glendale and Burbank in addition to those in the City of Los Angeles. Property uses include private residential, industrial and commercial properties as well as parks, public service yards, utilities, and other community service facilities. Transportation and infrastructure crossing the river includes local streets, an adjacent interstate highway, several state highways, rail yards, and two rail lines. Over 1,000,000 people live within a short distance of this reach.

3.2 Geology

3.2.1 Regional Geology

The Study area is located within a geologically complex region of southern California near the intersection of the Peninsular Ranges Geomorphic Province and the Transverse Ranges

Geomorphic province. The roughly east-west trending Santa Monica-Raymond Hill Fault marks the boundary between the Transverse Ranges and the Peninsular Ranges geomorphic provinces.

The Transverse Ranges are characterized by east-west trending folds and faults (Davis et al., 1989; Wright, 1991). Regional geologic structure in the Transverse Ranges is characterized by right-lateral high angle to vertical strike-slip faults, folds and associated thrust or reverse faults. The Santa Monica Mountains, along with the offshore Channel Islands to the west and the San Bernardino Mountains to the east, are situated within the Transverse Ranges Geomorphic Province. The east-west structure of the Transverse Ranges is oblique to the normal northwest structural trend of the Coast Ranges to the north and the Peninsular Ranges to the south.

The Peninsular Ranges province is characterized by a series of northwest to southeast-oriented valleys, hills and mountains separated by faults associated with, and sub-parallel to, the San Andreas Fault system. The Peninsular Ranges Geomorphic Province extends southward to the tip of Baja California and is for the most part underlain by older metamorphic rocks that have been intruded by granitic rock. Along the coast, the granitic and metamorphic basement rocks are covered by a wedge of marine and non-marine sediments that thicken seaward.

3.2.2 Local Geology

The Study area lies between the eastern end of the Santa Monica Mountains and the Verdugo Mountains with the San Gabriel Mountains further to the east. The valley or gap between the Santa Monica Mountains and the Verdugo Mountains is also locally known as the Glendale Narrows. Within the Glendale Narrows, bedrock is relatively shallow and is covered with relatively thin deposits of alluvium, which increase in thickness to the north and south into the San Fernando and Los Angeles basins, respectively. As a corollary, groundwater is relatively shallow through the Glendale Narrows as well. This condition can be visualized as a small sediment filled bowl (i.e. the San Fernando Basin) with a spout (i.e. the Glendale Narrows) pouring water into a larger sediment filled bowl (i.e. the Los Angeles Basin). This interface between the bedrock, soils and groundwater define the surficial expression and subsurface conditions of the LA River in the Study area. Details of the bedrock, soils, and groundwater are presented in this section.

The local subsurface geology of the project Study area is shown in the LA River Geologic Profile Map, Figure 36. This profile runs approximately southwest to northeast across the project site and is projected in a northwest direction. It averages approximately 6,000 to 7,000 feet thick and expresses the general structure and character of the bedrock and alluvium sediment. The structure of the geology is a series of thick folded sediments (formations of soft and hard bedrock) overlain by very thin (approximately 50 to 300 feet) layers of alluvium (unconsolidated sediment). The LA River and the approximate project Study area are marked on

the profile in red lettering. The Study area is dominated by the Elysian Park Anticline structure and a thin layer of Recent and Older alluvium. The alluvium makes up the LA River floodplain and edges of the surrounding San Fernando basin. The local geology is depicted on Figures 28 through 35.

3.2.2.1 Bedrock

There are very few if any exposures of bedrock within the immediate vicinity of the LA River Study area, except for the eastern foothill section of the Santa Monica Mountains. The foothills are composed of Tertiary age sedimentary rocks. These rocks are located on the west side of the river between sub-reaches 1 and 6 (see Figure 1 for sub-reach locations), and are typically less than 1/2 mile from the LA River.

Exposures of shallow bedrock were uncovered in the 1930s and 1940s during original construction of the USACE built channel-levee, along southern portions of Sub-Reaches 7 to 8. This exposure is shown on the Top of Bedrock Contour Maps Figures 3 through 5. The bedrock here has been mapped and described as soft, sedimentary rock related to the Puente Formation. There is sparse evidence of additional exposures of bedrock within the immediate vicinity of the LA River. This is based on the general local geology as mapped by the California Department of Mines and Geology (CDMG), United States Geologic Survey (USGS), and as indicated on USACE as built records/drawings of the LA River channel-levee system. Additional shallow bedrock has not been described or encountered during subsurface samples taken amongst previous investigations; however, more recent geotechnical related soil-alluvium investigations have been done by others such as: the USACE, City, and various HTRW Potential Responsible Parties (PRPs).

Existing bedrock is buried beneath the LA River floodplain and is well below (potentially greater than 50 feet) the channel bottom in all sub-reaches, except at Sub-Reaches 7 to 8. Within these sub-reaches it is shallow and was encountered above the channel bottom and along the banks of the LA River. It is highly probable that bedrock will not be encountered in most of the excavations required for the structures (i.e. removal and redesign of existing Corps LA River channel, construction of bridges, stairways, trails, bathrooms, buildings, etc.) needed in support of the project. It is also not expected to be encountered in soils removed to support the general planting-cultivation requirements for the habitat plans. The exception will be areas alongside Sub-Reaches 7 to 8 and the Piggy Back property. Bedrock is anticipated to be encountered in the near surface in these areas sporadically. If encountered, the bedrock will likely be composed of soft sedimentary bedrock, which can be excavated with moderate to easy difficulty by using conventional heavy construction equipment, such as backhoes, excavators, etc. There are specialized attachments to this equipment such as rock saws and hoe rams, which can penetrate

harder sedimentary rock, if encountered. These attachments can slice or break up the rock to where it can be removed easily.

3.3 Alluvium and Soils

In general, deposits of sediment along the LA River and on the alluvial fans and floodplains in the watershed drainages are among the youngest surface soils in the Study area. Deposits of soil within the Study area are generally considered alluvium. Alluvium is defined as soils that have been deposited and transported in their current position as a result of moving water by streams, rivers, sheet wash, etc. Recent alluvial deposits are those stream and river derived deposits that are less than 10,000 years old (Holocene age). The San Fernando Valley and Los Angeles basin alluvium can be generally characterized as recent alluvium and is comprised of moderately dense combinations of silt, sand, and gravel, with lesser amounts of clay.

3.3.1 Historical Soil Uses and Fill

The natural surface soils of the Study area have been highly modified as a result of farming, construction grading, and cut and fill practices during the past century. Artificial fill was generally imported and deposited along the major streams and river channels to fill in low lying areas and to channelize the LA River. Fill was also used in both private and public property in the Study area to raise the grade for the construction of roads, bridges, and railroads. In general, fill soils are brownish and consist of silty sands with gravel. However, fill material in the area ranges from clayey silt and silty clay, to angular gravel with sand (City of Los Angeles 2005).

Fill has also been known to contain a mixture of fill soil with solid waste. The solid waste portion of this mixture is known to commonly contain a combination of household trash, vegetation and construction debris. Fill of this character was commonly added to various properties within the Study area and property abutting the banks of the Los Angeles River during the mid 20th century (1920's to 1950's). In some cases the solid waste portion was burned to reduce its density before being mixed in with soil and buried as fill. This practice has been described as "landfilling", which is inappropriate terminology for use in today's solid waste environmental compliance regulatory arena. This is because legal disposal of solid waste and soil fill mixtures on both private and public property currently requires a solid waste permit. Using the loose terminology of "landfilling" assumes a specific set of rules, practices and procedures that must be followed, which are closely regulated according to Federal and California solid waste environmental regulations. There were no landfill permits in effect during the time that this type of fill was used. The more appropriate and general description for this practice is "buried fill containing solid waste and soil". This terminology will be used throughout this report from herein in order to avoid the current regulatory complications inherently related to solid waste environmental regulations in use and enforced.

Buried fill containing solid waste and soil placed in the historical past has been found contaminated with various man made pollutants of metals, petroleum hydrocarbons, etc. The result is that there are various known properties within the Study area and along the upper banks of the LA River that contain this type of contaminated fill. There are also potential unknown amounts of this fill that may still exist in the Study area and particularly along the banks of the LA River because of the past practice of buried fill containing solid waste and soil. Any known contaminated buried solid waste and fill is currently being addressed and regulated by either the California Department of Toxic Substance and Control (DTSC) or the Los Angeles Regional Water Quality Control Board (LARWQCB). This type of fill is regulated not as a landfilled solid waste or landfill derived waste but as a hazardous substance per both the Federal laws of the Comprehensive Environmental Recovery Compensation Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). Further details regarding disposition and use of such fill are described in the Hazardous Toxic and/or Radioactive Waste, HTRW Survey Report appendix.

The banks of many river courses that extended through communities developed during the early part of the last century were used as disposal sites for common trash. Residential and **commercial trash was dumped on stream banks and sometimes burned. The resulting debris was typically carried away by intermittent high stream flow conditions and the dumping process was repeated. Because of the localized nature of this debris, typical geotechnical investigation methods are not always successful in identifying and characterizing these conditions. As a result, construction excavations that encounter this type of debris will need to be evaluated during grading.**

3.3.2 Engineering Description of Soils (USCS)

The engineering classification (Unified Soil Classification System, USCS) for the surface and deeper soils (a.ka. alluvium) for the project Study area ranges from poorly graded sand (SP) to silty sand (SM) to well graded gravel (GW), with some minor amounts of clay. Samples of the soils were collected in the past by both the City of Los Angeles and the Los Angeles District, USACE. The samples were collected using typical geotechnical trenching and borehole methods. The sampling depths ranged from ground surface to approximately 100 feet below ground surface. The locations of the samples are shown on the Borehole Sample Locations Maps, Figures 21 through 27. The locations shown are approximately within 500 feet of the LA River. Additional samples were collected outside those shown and are not depicted on the Maps. The actual sample descriptions and/or logs of the soils are not provided within this appendix, but are available in the Geotechnical Branch archive working files. To access the files, a Freedom of Information Act request must be generated; the phone number is provided on the inside cover of this report.

3.3.3 Anticipated Soil Usage and Disposal

The project will disturb the existing soils within the project area. Disturbance will involve excavation/removal and replacement of soils during the construction of the project habitat. The existing soils will be recycled/re-used as much as possible during construction. Reused soils will be needed for both engineering and landscaping applications. Uses for such soil will likely consist of engineered fill, filter and backfill and plant bedding/amendment mixtures and plant drainage materials.

Some amounts of soil will not have a use and may have to be hauled away from the project for re-use or disposal. Non-useable soils may consist of soils not meeting requirements for engineering or landscaping applications and HTRW contaminated soils. HTRW contaminated soils may be encountered at unknown locations within the project Study area. These soils may be encountered at or near the 23 known HTRW contaminated properties as described in the HTRW Survey Report. These soils are highly likely to be encountered at the Taylor Yard property, since it still contains known amounts of HTRW contaminated soil that have not yet been removed or remediated. According to the USACE Regulation ER 1165-2-132, HTRW Guidance for Civil Works Projects, known amounts of HTRW contaminated soils must be remediated by the project Sponsor in accordance with Federal CERCLA and/or California State or local HTRW environmental laws and should ideally commence before construction. This means that all known HTRW contaminated soils at Taylor Yard will have to be remediated to meet both the human and ecological health risk standards specific to its land use for the study project. For this project, Taylor Yard's intended land use is for habitat restoration and recreation. Further details regarding disposition of HTRW contaminated soil are discussed within the separate HTRW Survey Report and the HTRW Section (6.0) within this report.

4.0 GEOTECHNICAL HAZARDS

Numerous geotechnical hazards exist within the Study area and will impact or could impact the Study area and the project. These hazards include faulting, seismicity and ground shaking, liquefaction and lateral spreading, and landslides.

4.1 Faulting

The intersection of the northwest trending San Andreas Fault System and east-west trending Transverse Ranges Fault system dominates the seismicity of southern California. The project Study area has the potential to experience strong ground shaking from local and regional faults. Three active faults near the Study area include the Verdugo Fault, the San Andreas Fault, and Nothridge Blind Thrust Fault. These three faults and several other faults can be the cause of future seismic induced damage to the Study area. Such damages are impossible to predict, but the impacts would be wide reaching and variable depending on the distance and size of the fault

that would cause the seismic disturbance of an earthquake. Such damages could effect not only the Study area, but also adjacent property, city wide damage, regional damage, and the loss of human life.

The Alquist-Priolo Earthquake Fault Zoning Act was passed in 1972 to mitigate the hazard of surface faulting to structures with human occupancy (California Geologic Survey 2006). The Act prohibits the siting or zoning for most types of structures built post-1972 across the traces of active faults that may pose a potential hazard to occupants and structures (California Department of Conservation 2012). The California Alquist-Priolo Earthquake Fault Zoning Act defines an active fault as one that has ruptured in the last 11,000 years.

The State of California Building Standards Commission provides a minimum standard for building design through the Building Standards Code. The Building Standards Code is used by the Cities of Los Angeles (LADBS 2012), Glendale (2012), and Burbank (2012) as minimum design criteria for construction of buildings and structures to protect against anticipated seismic events.

4.1.1 San Andreas Fault

The San Andreas Fault, located 30 miles to the northwest of the Study area, forms the boundary between the North America and Pacific Tectonic Plates, and is the most significant fault in the area. The fault extends for about 800 miles from the northern tip of the Gulf of California to the Mendocino triple junction west of San Francisco (Harden 1998). The fault runs along the base of the San Bernardino and San Gabriel Mountains.

In addition to the San Andreas Fault, the Study area lies near numerous other active faults. The Elysian Park Fault in Study Sub-Reaches 4-6 is a blind reverse fault that extends approximately 12 miles through the Elysian Park-Repetto Hills from Silverlake on the west to the Whittier Narrows on the east. Blind reverse faults are those that do not and never have extended upward to the surface of the earth. The Elysian Park anticline forms a segment of the southern boundary of the Transverse Ranges and has an estimated time-average rate of slip of 0.8 to 2.2 millimeters per year (mm/year) (Oskin et al. 2000). The Elysian park anticline is formed by the Elysian Park blind reverse fault.

4.1.2 Verdugo Fault

The Verdugo Fault is located less than 2 miles to the northwest from the Study area Sub-Reach 3, and runs 14 miles from the San Fernando Valley in the northwest to the Los Angeles Basin in the southeast, from the City of Pacoima to the City of Glendale. The Verdugo Fault is an active north-dipping reverse fault, with a minimum uplift rate of 1.1 mm/yr, starting 2.3 million years ago (Arkle and Armstrong 2009).

4.1.3 Raymond Fault

The Raymond Fault is about 16 miles long, with a slip rate of between 0.10 and 0.22 mm/yr. Nearby communities include San Marino, Arcadia, and South Pasadena (Southern California Earthquake Data Center 2006). The Raymond Fault forms the eastern portion of the Santa Monica Mountains Frontal Fault System and extends from western Hollywood east to Pasadena. The fault runs east-west through the Study area in Sub-Reaches 4-6 upstream of Glendale Blvd, across the Los Angeles Narrows (City of Los Angeles 2005).

4.1.4 Hollywood Fault

The Hollywood Fault is about 9.3 miles long and has a slip rate of between 0.33 mm/yr and 0.75 mm/yr. Nearby communities include Hollywood, Beverly Hills, and Glendale. The eastern part of the Hollywood Fault zone extends along the base of the Santa Monica Mountains, near Los Feliz Blvd. From there, the fault trends eastward across the alluvial deposits of the Los Angeles River in the Atwater area. It can be considered a westward extension of the Raymond Fault and runs through the Sub-Reaches 4-6, parallel to the Santa Monica Fault (Southern California Earthquake Data Center 2006).

4.1.5 San Fernando Fault

The San Fernando Fault is about 10.5 miles long and runs from the area of Big Tujunga Canyon north to the San Fernando Valley. The slip rate is not well known, but is believed to be about 5 mm/yr. The last major rupture was February 9, 1971, and is known as the Sylmar or San Fernando Earthquake, which had a magnitude of 6.6. The rupture was roughly 12 miles long, with a maximum slip of six feet (Southern California Earthquake Data Center 2006).

4.1.6 Northridge Blind Thrust Fault

The Northridge Blind Thrust Fault (NBTF) (a.k.a. Pico Thrust Fault) is a south dipping blind thrust fault. It is part of the Oak Ridge Fault (ORF), an extensive fault system, which is approximately 55 miles long and dips to the south at less than a 45 degree angle. It is proposed that the ORF curves from an east to west strike to an east to southeast strike that mimics changes in strike along the pre-Saugus Frew and Torrey Faults. The long term slip rate on the ORF is about 3.5 to 6 mm per year (Southern California Earthquake Data Center 2006). The NBTF is interpreted as the eastern blind continuation of the ORF, and the south slip movement along this portion was responsible for damage caused by the Moment Magnitude 6.7 Northridge Earthquake of 1994. This earthquake measured 6.7 on the moment magnitude scale and was one of the most destructive earthquakes in U.S. history.

4.2 Seismicity and Ground Shaking

The Study area is located within the seismically active area of southern California. Approximately 30 earthquakes happen each day, most of which register a Richter magnitude below 2.0. The last appreciable earthquake in the Los Angeles area was in January 1994 when the Northridge Earthquake hit the San Fernando Valley with a Richter magnitude of 6.7 (USGS 2012). The attached Table 3 is a summary of significant historical or larger magnitude earthquakes in the vicinity of the ARBOR Reach.

Ground shaking is the primary cause of earthquake damage in southern California. Structures on poorly consolidated and thick soils typically incur more damage than buildings on consolidated soils and bedrock. As discussed above, the majority of the Study area is on such soils. Damages to the surrounding areas as well as to the structures and features built as part of the project are to be expected following a major earthquake.

The intensity of the ground shaking is related to the magnitude of the earthquake, type of fault, depth of the earthquake, and distance of the site from the epicenter. Areas near major active faults generally experience stronger seismic shaking more frequently. The Study area can be assumed to experience strong seismic shaking, since it is in an area of high seismic activity and near several active faults. The Los Angeles District has utilized the USGS models to estimate the intensity of the ground motions that should be expected to be imparted on the ARBOR Reach and its foundation. These models are found online and available to the public. The USGS 2008 National Seismic Hazards Mapping Program (NSHMP) Probabilistic Seismic Hazard Assessment (PSHA) Interactive De-aggregations web site is located at https://geohazards.usgs.gov/deaggint/2008/. The following summary of site peak ground accelerations (PGAs) can be expected at the upstream end, the downstream end, and the approximate midpoint of the ARBOR Reach:

Estimated Ground Motions along the ARBOR Reach				
Return Period (years)	**Probability of Exceedance (PE)**	**Estimated PGA[1] (g)**		
		Upstream End (34.153°N, 118.326°W)	**Downstream End (34.048°N, 118.230°W)**	**Approximate Midpoint (34.111°N, 118.262°W)**
144	50% in 100 years (OBE)	0.28	0.25	0.29
475	10% in 50 years (MDE)	0.52	0.47	0.59
950	10% in 100 years	0.69	0.64	0.81
2475	2% in 50 years (MCE)	0.97	0.92	1.14

[1] Utilizes 0.0 seconds spectral acceleration, at the recommendation of the model developers, so as to most closely equate the results to PGA. Assumed Vs30=760 m/s

4.3 Liquefaction and Lateral Spreading

The greatest seismic induced damage risk (as opposed to the direct damage caused by ground shaking) to the Study area and the project is due to earthquake induced liquefaction of soils. Liquefaction is caused when the ground shakes wet granular soil and changes it to an unstable liquid state. Areas with high groundwater, saturated loose sands, and silty sands within 50 feet of the ground surface, and are in close proximity to active faulting are most susceptible to liquefaction. Lateral spreading is similar to liquefaction in that it is the deformation of shallow sloping ground towards an open face during a seismic event.

Regions in the Study area with high liquefaction and lateral spread potential include the majority of lowland areas along the LA River and tributaries. In addition, there is high liquefaction potential along the foothills of the Santa Monica Mountains in Sub-Reaches 1-3, along the base of the Elysian and Repetto Hills in Sub-Reaches 4-6, and along the base of the Elysian Hills in Sub-Reaches 7 and 8. These high liquefaction potential areas are all shown on the Liquefaction Potential Maps, Figures 12 through 20 and have been published by the California Department of Conservation Mines and Geology (CDCMG). Impacts of liquefaction and lateral spread will need to be addressed for all potential modifications.

4.4 Landslides

Landslides are a natural hazard throughout southern California, especially within steep terrain underlain by relatively weak soil materials. Factors that affect slope failure are angle, substrate, climate (e.g. precipitation), and seismic shaking. Hillside areas of Los Angeles have geologic and topographic conditions that are conducive to the development of landslides. Landslides can also be triggered by seismic events, causing the soils to lose their stability and possibly to liquefy. Debris flows due to prolonged and heavy precipitation are more localized in small gullies (large ditches or small valleys caused by an advanced stage of channel erosion). These are typically shallow landslides, where the surface material becomes saturated and begins to flow downhill, taking vegetation and buildings with it. Debris flows are known to start on slopes as low as 15 degrees, but are more likely to develop on steeper slopes.

Within the Study area, landslide potential occurs along the eastern Santa Monica Mountains (Sub-Reaches 1-6), Elysian Hills (Sub-Reaches 4-8), and Repetto Hills (Sub-Reaches 4-6). It is anticipated that the alternatives will not affect or disturb any known or potential landslide hazard areas. However, considerations will need to be made for evaluation of landslides during design.

5.0 GROUNDWATER

The groundwater in the Study area is encountered in the shallow subsurface at depths from 15 to 30 feet along the upper banks of the LA River and at depths of river bottom (ground surface within the channel). The direction of the groundwater flow is from northwest to southeast in the general downstream direction of the LA River. The groundwater occurs within a shallow unconfined aquifer that is regionally extensive and is found throughout San Fernando and the Los Angeles Basins. This aquifer is fed from the surrounding runoff of both Basins, as well as man-made recharge areas in the San Fernando Basin. The water table surface of this shallow aquifer is shown as contours on the Water Table Contour Maps, Figures 6 through 11. This surface was estimated based on water level data accumulated from shallow piezometers and observation wells installed in support of geotechnical investigations by the USACE, City of LA and HTRW PRPs during the last 60 years.

5.1 Dewatering

The groundwater in the Study area will be affected more so during construction of the actual project than the time after it is built. This will occur in the case in which any groundwater is encountered and it interferes with future habitat construction activities of excavation, planting, etc. During the most likely case of excavation, this will require that groundwater be removed (dewatered) from the excavation(s) by bailing or by pumping out via temporary, dewatering wells. Because dewatering is temporary it should not affect the long term character nor deplete the quantity of the shallow groundwater. Therefore dewatering activities for the project should not impact or interrupt its overall use as a shallow water supply aquifer.

The dewatering activity will more likely affect the temporary movement of groundwater during its removal. This is usually not a cause for concern for construction projects in which the shallow aquifer is known to be uncontaminated with HTRW pollutants. However, there are numerous known (approximately 23) HTRW properties that are in or adjacent to the project Study area that may introduce HTRW contaminants into the groundwater during dewatering. Of these properties, the San Fernando Valley Superfund (SFVSS) site/property has the greatest impact to project dewatering activities because it is has already caused a regionally extensive amount of HTRW contamination to the shallow aquifer.

As previously mentioned, impacts to construction from routine dewatering of non-HTRW contaminated groundwater is straightforward and mainly involves removal and movement of dewatered groundwater back into (recharge) the surrounding aquifer or placement back into the nearest surface waters (LA River). This usually requires application only for a simple dewatering permit with California State and local regulatory agencies. The simple permit

outlines basic coordination planning and monitoring for such non-HTRW dewatering activities. For the aforementioned reasons, existing HTRW contaminated groundwater is more likely to be encountered during future construction activities for this project. As such, the impacts are more complicated and will likely require a complex dewatering permit that requires 401 certification and more extensive monitoring than the simple permit. In addition, it may also require close coordination/consultation and approval from the Los Angeles Regional Water Quality Control Board (LARWQCB) and may also require a waste discharge permit (WDR) tailored specifically to the planned discharge of the project dewatered groundwater.

The additional permitting requirements may require instead that any dewatered groundwater be stored and treated prior to final discharge back into the surrounding shallow groundwater aquifer or LA River. According to USACE Regulation, ER 1165-2-132, "Hazardous, Toxic and Radioactive Waste (HTRW) Guidance for Civil Works Projects", these activities are considered as HTRW response activities and are paid for at 100% non project cost, i.e. 100% of HTRW response cost is provided by the Sponsor.

5.2 Pumps and Wells

Pump and treat well technology is the current response method being employed to remediate the HTRW contaminants from the shallow aquifer. Numerous wells are deployed across the SFVSS and the nearest pump and treatment facility to the project is the Pollock Well Field. This facility is a series of wells located about less than 1 mile northwest from the Taylor Yard property, near the center of the project. This well field has been in operation for about 10 years and recovers a large portion of the HTRW contamination from SFVSS and is operated by the City of Los Angeles Public Works. The U.S. Environmental Protection Agency (U.S. EPA) is overseeing the management of SFVSS and the Pollock Well Field facility as well as other fields to ensure that they continue to properly remediate the HTRW contamination within the shallow aquifer. The migration pattern of HTRW contamination within the existing shallow groundwater aquifer caused by the SFVSS and the recovery of such contamination by the Pollock well field may also be impacted by the project after it is built. Several of the more likely impacts are as described in the following sections.

5.2.1 Application of Landscape Water During Operation and Maintenance

Future landscape water plans and budget for the habitat project may need to consider means for preventing potential interference with the ongoing pump and treat response for the SFVSS contaminated shallow aquifer. This is more likely to occur for any residual HTRW soil contamination left at the Taylor Yard property, because the vertical distance from this contamination to the shallow water aquifer is small. If landscape water is allowed to infiltrate freely through the soil at this property, it is has the potential to leach out residual HTRW soil

contaminants and directly transport them into the surrounding aquifer. However, the likelihood of this occurring will be low because of the following:

a. Much of the residual soil contamination will be removed from this property by the Sponsor as part of their required response activities for this project;

b. Other additional environmental engineering technologies such as impermeable barriers/covers, soil vapor extraction, localized pump and treat will also likely be deployed as part of the overall response as well; and

c. The shallow aquifer beneath Taylor Yard is already contaminated by HTRW and some of this has been attributed to leaching of residual HTRW contaminants from its soil. Much of this attributed contamination is co-mingled with contamination emanating from SFVSS and is currently successfully being remediated by the U.S. EPA pump and treat well system at the nearby Pollock well field.

Nevertheless, as part of operation and maintenance requirements, landscape water should be applied such that it doesn't infiltrate in amounts that will affect or alter the current mechanical transport (migration) of the SFVSS contaminated groundwater into the pump wells. The plans and budget also need to include prevention of the introduction or addition of any HTRW soil type contaminants into this aquifer. To prevent this, the habitat plans need to also include a water budget and provide potential remediation technologies if applicable. As mentioned, the Sponsor may likely employ impermeable barriers/covers or soil vapor extraction, etc. to remediate Taylor Yard, which would help alleviate any potential for localized soil leaching into the groundwater aquifer beneath the Taylor Yard property. All of these plans need to be reviewed and approved by primary regulatory agencies such as the LARWQWB.

5.2.2 Unique Habitat Project Designed Features Such as Wetlands

The construction of unique project features such as wetlands may need to incorporate or consider additional means for reducing, altering, or interfering with migration of the SFVSS contaminated groundwater plume. This needs to occur where the SFVSS underlies property that is planned for construction of the habitat footprint which is unique and has a direct connection to the LA River. This will occur for Taylor Yard, since it directly overlies SFVSS and does include a unique wetland footprint plan for most of the alternatives selected as part of this project. The likelihood of altering and interfering with the SFVSS plume is low because of the following:

a. As mentioned earlier, the Sponsor may likely employ active environmental engineering technologies such as barriers/cover, etc., that will also reduce and alter migration of the SFVSS contaminated plume;

b. Also as mentioned earlier, much of the SFVSS contaminated groundwater plume is currently successfully being remediated by the U.S. EPA pump and treat well system at the nearby Pollock Well Field. It is unlikely that built features such as wetlands will interfere with the success of this pump and treat system for Taylor Yard since this property is very close to the recovery forces (well radius of influence) of the Pollock Well Field. This will likely continue as long as the wells remain operating. According to EPA, the pump and treat response for Pollock and SFVSS will continue for approximately 10 to 20 years into the future, which will be ongoing beyond the date of final construction of the LA River project. Also, much of the higher concentrations of HTRW within the SFVSS plume are already successfully being captured directly near the Pollock and other pump and treatment well locations. As indicated on the 2010 SFVSS HTRW groundwater plume map (shown in the HTRW Survey Report, part of the HTRW Appendix), there are still portions of this plume that extend beyond the higher concentration areas of capture. These outlier areas contain lower HTRW concentrations from this plume. Because of this, it is likely that any migration of this plume through or around the project that is associated with unique features will be of lower concentrations; and

c. The construction of unique habitat features for this project should not interfere with or alter the existing pathways of migration of contaminated groundwater at SFVSS. This is because there are open bottom areas, plus an extensive system of weep holes/drains that already exist and that have been built into the LA River channel and levee. These devices were built around the 1940s for the purpose of relieving and draining the structure of any surrounding groundwater. They have continued to operate in this manner to this day. The presence of yet to be constructed unique habitat features such as wetlands should not interfere or alter the exiting migration of the SFVSS contaminated plume. This is because portions of the SFVSS HTRW contaminant plume have most likely already migrated through and beneath the LA River channel/levee, since this structure effectively already allows for groundwater seepage into the river.

The shallow groundwater and aquifer will remain unaffected without construction of the project. The SFVSS and HTRW contaminated portions of the shallow aquifer will remain unaffected with construction of the project and with construction of unique features of the project such as wetlands.

6.0 HTRW

There are known HTRW impacts to various properties within the Study area. There are 23 known properties that will have moderate to high HTRW impacts to the Study area project.

Taylor Yard G1, Taylor Yard G2 and SFVSS are the three known properties that have the highest HTRW impacts. This is because contamination in soil and groundwater is heavy and widespread at these properties and most or all of the various habitat feature footprints selected from the final array of project alternatives directly overlie these particular properties.

Nineteen (19) known properties have low HTRW impacts to the project. This is because contamination in soil and groundwater is not heavy, is fairly well contained and not widespread at these properties, and all of the habitat footprints are adjacent to but do not directly overlie these properties.

One additional property also has an unknown HTRW impact on the project. This property, the Piggyback Yard, is planned to be a major feature of the project. Piggyback Yard has potentially high levels of contamination based on its historical uses, although there are no public records available for that site, and as such, the impact to the project is unknown at the time of the study.

According to USACE regulation ER 1165-2-132, remediation of HTRW sites/properties should occur before project implementation or actual construction. This remediation is the responsibility of the project Sponsor and is not paid for by the project, i.e. it is at 100% of non-project cost, and in-kind project credit by the USACE cannot be given to the Sponsor. The ER definition for required remediation includes CERCLA HTRW, i.e any CERCLA hazardous substance. Hazardous substances include all RCRA type hazardous waste; Clean Air Act hazardous substances and hazardous air pollutants; Clean Water Act toxic pollutants; and Toxic Substance Control Act hazardous chemical substances or mixtures. On the whole, it includes Federal EPA and California State HTRW of all types that have been released into the soil, surface water, groundwater or air at the project site and that are currently regulated under environmental law. The exceptions are petroleum and natural gas products released into the environment at the project site, as these products are not CERCLA hazardous substances. These non-CERCLA hazardous substances may be removed/remediated and paid for by the project, as long as they are required to be removed/remediated according to any validly promulgated Federal, California State, or local regulation.

A large known amount of HTRW contaminated soil exists at the two Taylor Yard properties of G1 and G2. A large amount of known HTRW contaminated groundwater also resides beneath most of the Study project area and is part of the San Fernando Valley Superfund site/property. These are 3 of the 23 known HTRW contaminated properties described from the HTRW Survey Report that directly impact the project area. A smaller unknown amount of residual soil and groundwater contamination may also exist at the one Piggyback property and at or near the remaining 19 known properties that are near but outside the project footprint. It is possible, but less likely that unknown amount of soil and groundwater contamination will be encountered during construction of the project at the 19 properties. This is because most of the known

HTRW contamination has already been actively removed/remediated from these 188 sites, and any residual contamination is being monitored, and land use controls are in place, or it is being passively remediated, i.e. left to naturally attenuate. It is possible and more likely that unknown amounts of soil and groundwater contamination will be encountered during construction of the habitat footprint at Piggyback, because much of this property was one used as a railroad maintenance yard. Piggyback is likely to contain heavy HTRW contamination based on its historical similarity to Taylor Yard, which is heavily contaminated with HTRW and is also a high HTRW impact property to the project. However, there is no material evidence at this time to substantiate this; therefore, the overall HTRW impact of Piggyback is low for the project.

Regardless of its state, any residual CERCLA derived HTRW contamination encountered before or during construction must be must be removed/remediated by the Sponsor at 100% their cost. The primary regulatory agencies for the approval of the remediation of HTRW will be the California Department of Toxic Substance and Control (DTSC) or the Los Angeles Regional Water Quality Control Board (LARWQCB). Please see the HTRW Survey Report and HTRW Issue Paper, for more information on the HTRW issues.

There will also be construction activities that involve routine transport, use, and disposal of common hazardous materials, such as fuels (gasoline and diesel), oils and lubricants, and cleaners (e.g., solvents, corrosives, soaps, detergents). Accidental spills of such materials can occur around such activities; however, minor spills are not likely to have significant effects. Best Management Practices (BMPs) would be implemented to minimize potential for the public to come into contact with or be exposed to hazardous materials during the routine transport, use, or disposal of hazardous materials or as a result of an accidental release. Prior to the start of construction, the USACE will develop engineering specifications and plans, which will include a written Environmental Protection Plan (EPP). The EPP will also include a written Pollution Prevention Plan that outlines the actions needed to respond and remediate any unknown/ unexpected HTRW contamination or potential release of construction derived hazardous materials.

Existing known and unknown amounts of HTRW will remain throughout the Study area without the project. On-going and progressive remediation, monitoring and regulation of the 23 known HTRW properties by the current PRPs will continue to occur.

7.0 POTENTIAL PLAN ALTERNATIVES AND DESIGN CONSTRAINTS

Existing conditions have been discussed above and are presented in Table 1. Modifications to the existing conditions will consist of specific sub-measures that will alter the existing condition to meet project objectives. The sub-measures proposed at this time are listed in Table 2. Various sub-measures are combined within sub-reaches to comprise various alternative plans. Four plans

have been carried forward and are described in detail in other appendices. These four plans are presented in Table 2. A summary of the constraints discussed in sections below are summarized in table form in Table 4. Regardless of which sub-reach is being modified, the following geotechnical constraints and design considerations will need to be addressed:

a. Site specific exploration and testing of the materials on site will need to be performed. The exploration and testing will be conducted to develop design parameters, which will be used in structural design of the elements required by the selected sub-measures. The parameters developed will be used in the analysis and considerations for hydrostatic pressures, potential seepage gradients, internal erosion potential, slope stability, settlement, and other geotechnical design considerations outlined in the current design standards;

b. Utilities, transportation corridors, infrastructure facilities, residential and commercial structures and other features are in close proximity of the LA River channel. A detailed delineation and inventory of these features will need to be conducted. Potential impacts of channel modifications on these features will need to be evaluated during design;

c. Levees are present throughout the ARBOR Reach. Modifications to existing levees will need to maintain existing flood protection, be designed and constructed according to current standards, and follow current vegetation guidance under ETL 1110-2-571. As part of this study, a memorandum for record has been prepared with "Levee Condition Inspection and Issue Discussion" as the subject. This memorandum is included as Attachment 1;

d. Grading plans will need to be developed and reviewed during design stages in accordance with codes, standards, and practices;

e. Seismic design parameters will need to be developed during design stages for structural design;

f. Scour estimates have not been made at this time, but would have a significant impact on the design and construction. Scour could potentially put the foundation of structures at risk from undermining or direct flow impacts that have not been considered as part of this Study. Scour estimates, when determined, will need to be incorporated into the development of the design parameters mentioned above. Deepened foundations to accommodate a deep scour condition will result in a more robust structural design to accommodate increased lateral loading. The resulting increases in project cost could be

significant and are not presently accounted for in the costs. Currently, it is the assumption that scour issues would be able to be adequately addressed during design phases; and

g. The potential for unknown HTRW materials exist within the ARBOR Reach and may be encountered during design exploration as well as during construction.

7.1 Sub-Reach 1

Planned restoration actions and modifications within this sub-reach include habitat corridor construction and riparian planting on the right bank. No channel modifications are currently being considered at this time.

Other than those general issues mentioned above, the following constraints and design considerations impact this specific sub-reach:

a. Habitat Corridors will need to take into account potential impacts to the California State 134 Freeway (CA-134) from an easement and structural suitability standpoint;

b. Levees exist within this reach on both the right and left banks. It is currently the assumption that the levees will not be modified and that the planting will be done following policy guidance under ETL 1110-2-571 within this sub-reach; and

c. HTRW issues that will need to be addressed include existing Volatile Organic Compound (VOC/s) contamination associated with the Forest Lawn Cemetery. As the cemetery site is not within the project footprint, impacts from soil contamination are not anticipated. However, potential groundwater contamination may impact the project site as it is generally down gradient from contaminated areas and dewatering is likely during grading operations. This impact will need to be evaluated and if necessary addressed during design phases.

7.2 Sub-Reach 2

Planned restoration actions within this sub-reach include habitat corridor construction and riparian planting on the banks, a vertical wall from River Station (RS) RS-542+40 to 509+00 on the left bank (only in one alternative plan), planting of vines, and construction of a soft bottom.

Other than those general issues mentioned above, the following constraints and design considerations impact this specific sub-reach:

a. Habitat Corridors will need to take into account potential impacts to the CA-134 and Interstate 5 Freeway (I-5) from an easement and structural suitability standpoint. Currently, it is the assumption that these impacts will be evaluated during design phases;

b. Impacts to the bridge crossings of I-5 as a result of re-configuration of the channel associated with the vertical wall and scour will need to be considered. Currently, it is the assumption that the bridge impacts and scour will be evaluated during design phases;

c. The walls currently under consideration likely require counterfort or tieback designs. These designs will require extensive right of way, either temporary or permanent, and will need to be considered during design;

d. Levees exist within this reach on both the right and left banks. Modifications to existing levees will need to maintain existing flood protection, be designed and constructed according to current standards, and follow current vegetation guidance under ETL 1110-2-571; and

e. HTRW issues that will need to be addressed include existing VOC contamination associated with the Forest Lawn Cemetery. As the cemetery site is not within the project footprint, soil impacts from the contamination are not anticipated for the project. However, potential groundwater contamination may impact the project site as it is generally down gradient from the cemetery and dewatering operations are likely during site development. This impact will need to be evaluated and if necessary addressed during design phases.

7.3 Sub-Reach 3

Planned restoration actions within this sub-reach include daylighting of storm drains, expansion of the Verdugo Wash confluence (only in one alternative plan), and diversion of flows into side channels at Ferraro Fields. Daylighting of the storm drain connections would allow for habitat development at storm drain entrance to the river and eliminating closed pipes. The planned changes to Verdugo Wash include removal of the existing paved bottom and widening of the channel to create a soft bottom environment with vegetation. This drainage would extend upstream from the Verdugo Wash and the LA River and would extend downstream approximately 1,200 feet.

Other than those general issues mentioned above, the following constraints and design considerations impact this specific sub-reach:

a. Modifications will need to take into account potential impacts to the CA-134 and I-5 interchange, as well as surface streets and railroad crossings from an easement and structural suitability standpoint. Currently, it is the assumption that these impacts will be evaluated during design phases;

b. Impacts to the bride crossings of CA-134 as a result of re-configuration of the channel and scour will need to be considered. Currently, it is the assumption that these impacts and scour will be evaluated during design phases;

c. The walls currently under consideration, in several alternatives in the Verdugo Wash confluence, will likely require counterfort or tieback designs. These designs will require extensive right of way, either temporary or permanent, and these issues will need to be evaluated during design;

d. Levees exist within this reach on both the right and left banks. Modifications to existing levees will need to maintain existing flood protection, be designed and constructed according to current standards for seepage, settlement and stability according to EM 1110-2-1913, and follow current vegetation guidance under ETL 1110-2-571; and

e. HTRW issues that will need to be addressed include existing zinc and chromium contamination associated with the Former Hawkes Finishing site. As the finishing site is not within the footprint of the project site, impacts from soil contamination are not anticipated for the project. However, groundwater that is contaminated by these conditions may impact the project site. Dewatering and grading operations could aggravate these conditions. This impact will need to be evaluated and if necessary addressed during design phases.

7.4 Sub-Reach 4

Planned restoration actions within this sub-reach include daylighting of storm drains, riparian planting, and diversion of flows into side channels. Daylighting of the storm drain connections would allow for habitat development at storm drain entrance to the river and eliminating closed pipes.

Other than those general issues mentioned above, the following constraints and design considerations impact this specific sub-reach:

a. Modifications will need to take into account potential impacts to the I-5, as well as surface street crossings from an easement and structural suitability standpoint. This impact will not be a factor in alternative 13. Currently, it is the assumption that these impacts will be evaluated during design phases;

b. Impacts to the bride crossings of the Colorado Street Freeway Extension and Los Feliz Boulevard as a result of re-configuration of the channel and scour will need to be

considered. Currently, it is the assumption that these impacts and scour will be evaluated during design phases;

c. Levees exist within this reach on both the right and left banks. Modifications to existing levees will need to maintain existing flood protection, be designed and constructed according to current standards, and follow current vegetation guidance under ETL 1110-2-571; and

d. No direct HTRW issues are within this sub-reach, but the sub-reach may be impacted by upstream or downstream sites if dewatering operations change the local groundwater gradient. Similarly, impact to the sub-reach may occur if grading changes surficial drainage or exposes soils.

7.5 Sub-Reach 5

Planned restoration actions within this sub-reach include daylighting of storm drains and changes to the right and left banks. Daylighting of the storm drain connections would allow for habitat development at storm drain entrances to the river and elimination of closed pipes. The right bank of the channel would change from trapezoidal to vertical configuration for the entire sub-reach in alternatives 16 and 20. The left bank of the channel would change from trapezoidal to vegetated terraces from RS 356+22 to RS 286+05 in alternatives 16 and 20. The proposed terraces would be 12-feet wide by 4-feet deep and tie into the existing ground elevation at a 3:1 slope. The left bank would then transition from terraces to a vertical configuration from RS 286+05 to RS 271+89, and then transition back into the original design channel configuration starting at RS 274+78.29, before the channel passes under the Glendale Freeway in alternatives 16 and 20.

Other than those general issues mentioned above, the following constraints and design considerations impact this specific sub-reach:

a. Modifications will need to take into account potential impacts to the I-5, as well as surface street crossings from an easement and structural suitability standpoint. This impact will not be a factor in alternative 13. Currently, it is the assumption that these impacts will be evaluated during design phases;

b. The walls currently under consideration likely require counterfort or tieback designs, These designs will require extensive right of way, either temporary or permanent, and will need to be considered during design;

c. Proposed planting structures may require deep foundations depending upon information derived from scour and other hydraulic analyses. Currently, it is the assumption that these requirements will be evaluated during design phases;

d. Impacts to the bride crossings of Hyperion Avenue, Fletcher Drive, and the Glendale Freeway as a result of re-configuration of the channel and scour will need to be considered. Currently, it is the assumption that these impacts and scour will be evaluated during design phases;

e. Levees exist within this reach on both the right and left banks. Modifications to existing levees will need to maintain existing flood protection, be designed and constructed according to current standards, and follow current vegetation guidance under ETL 1110-2-571; and

f. HTRW issues that will need to be addressed include existing fuel contamination of soil associated with the Former Triangle Gas Station and fuel-solvent contamination of groundwater associated with the Chevron Gas Station. Directly downstream, the Taylor Yard G1 site has fuel-solvent & metals contamination of soils and groundwater. As the Taylor Yard G1 site is directly within the project habitat footprint, potential impacts from both soils and groundwater contamination remediation of soil contamination will need to be addressed as part of the project. These properties will also need to be remediated by the Sponsor prior to construction. Although response at the Taylor Yard sites is currently being addressed, the Sponsor would be 100% responsible for any additional remediation to reach land use levels necessary for the project. As the other gas station sites are not within the project footprint, a direct impact from soil contamination is not anticipated. However, groundwater that may migrate from these sites could impact the project site and dewatering, if necessary, is likely to aggravate this condition. These impacts will need to be addressed during design phases.

7.6 Sub-Reach 6

Planned restoration actions within this sub-reach include the following (note: items a and b are each representative of a different alternative):

a. A small terraced area is planned along the left bank with vegetation from RS 261+80 to RS 256+00; the channel is re-configured to take advantage of the Taylor Yard 'bowtie' parcel at RS 243+17, where the channel invert starts to widen into the left bank to a width of more than 100 feet before it contracts back to the original channel size at RS 201+76 and the eastern edge of the widened invert is sloped back up at a 4:1 slope to the original ground elevation;

b. A small terraced area is planned along the left bank with vegetation from RS 261+80 to RS 256+00; the channel is re-configured to take advantage of the Taylor Yard 'bowtie'

parcel at RS 243+17, where the channel invert starts to widen into the left bank to a width of more than 620 feet before it contracts back to the original channel size at RS 201+76 and the eastern edge of the widened invert is sloped back at a 3:1 slope to the original ground elevation approximately 15 feet from the railroad tracks; and

c. A small area of widening up to 300 feet to accommodate in channel geomorphology and vegetation along the left bank from RS 265+38 to RS 251+78.

Other than those general issues mentioned above, the following constraints and design considerations impact this specific sub-reach:

a. Modifications will need to take into account potential impacts to the I-5 crossing at the downstream end of the sub-reach, as well as surface streets and railroads adjacent to the channel from an easement and structural suitability standpoint. Currently, it is the assumption that these impacts will be evaluated during design phases;

b. Impacts to the bride crossings of I-5 as a result of re-configuration of the channel and scour will need to be considered. Currently, it is the assumption that these impacts and scour will be evaluated during design phases;

c. Proposed planting structures may require deep foundations depending upon information derived from scour and other hydraulic analyses. Currently, it is the assumption that these requirements will be evaluated during design phases; and

d. HTRW issues that will need to be addressed include existing fuel-solvent & metals contamination of soils and groundwater associated with the Taylor Yard G1 and G2 parcels, and fuel contamination of groundwater associated with the Shell Gas Station. Directly downstream, the San Fernando Consolidated Facility site has fuel contamination of groundwater. As the Taylor Yard G1 and G2 sites are directly within the project footprint, potential impacts of this contamination to dewatering and grading operations will need to be addressed and these properties will have to be remediated prior to construction by the Sponsor. Although these sites are currently being addressed by responsible parties, the Sponsor would be responsible for any additional remediation to reach land use levels necessary for the project. The other sites are not within the project footprint, soil impacts from the contamination are not anticipated for the project. However, these sites are generally up gradient from the project and groundwater flow from them could impact the project as shallow groundwater drains from construction excavations. These conditions could be aggravated by dewatering operations during site development. These impacts will need to be addressed during design phases.

7.7 Sub-Reach 7

Planned restoration actions within this sub-reach include reconfiguration of Arroyo Seco (in three alternative plans) and terracing along the banks by construction of several modifications. Concrete bottom and side slopes would be removed from the Arroyo Seco Channel. Four 4-foot deep terraces on the right bank from RS 102+15 to 97+99 would be added adjacent to the Cornfields site (in only one alternative plan). At Cornfields, the western edge of the terrace would be sloped back up to the original ground elevation. The elevation of the railroad is maintained on trestles from RS 102+15 to 98+98. Modifications to the channel would also include daylighted storm drain connections. Daylighting of the storm drain connections would allow for habitat development at storm drain entrances to the river and eliminate closed pipes.

Other than those general issues mentioned above, the following constraints and design considerations impact this specific sub-reach:

a. Modifications will need to take into account potential impacts to properties adjacent to the channel as well as surface street crossings from an easement and structural suitability standpoint. Currently, it is the assumption that these impacts will be evaluated during design phases;

b. Impacts to the bride crossings of North Figueroa Street, CA-110 Freeway, North Broadway Street, Spring Street, and North Main Street, and two rail lines as a result of re-configuration of the channel and scour will need to be considered. Currently, it is the assumption that these impacts and scour will be evaluated during design phases;

c. Proposed planting structures may require deep foundations depending upon information derived from scour and other hydraulic analyses. Currently, it is the assumption that these requirements will be evaluated during design phases;

d. Levees exist within this reach on both the right and left banks. Modifications to existing levees will need to maintain existing flood protection, be designed and constructed according to current standards, and follow current vegetation guidance under ETL 1110-2-571; and

e. HTRW issues that will need to be addressed within this sub-reach include: fuel contamination of groundwater associated with the San Fernando Consolidated facility, solvent and VOC contamination to soil and groundwater associated with the former Bortz Oil Company site (area a.k.a. Cornfields), and fuel contamination associated with the former Albian Dairy. Directly downstream, the former Manufacture Gas Plant site has PAH, metals, VOCs, and fuels contamination of groundwater and soils, and the Valspar

Corporation site has solvent contamination of groundwater. As these sites are not within the project footprint, soil impacts from the contamination are not anticipated. However, if groundwater flow from the contaminated sites is toward the project some impact from these contamination sources should be anticipated. If dewatering is necessary during construction, these impacts could be aggravated. These impacts will need to be addressed during design phases.

7.8 Sub-Reach 8

Planned restoration actions in this sub-reach include 3-foot deep terraces along the right bank within the extent of the LADWP parking lot and ties into the existing ground with a 3:1 slope (in two alternative plans). The terraced area would begin with one 3-foot deep terrace at RS 83+61 and end with seven 3-foot deep terraces at RS 68+38. The Los Angeles River channel would be re-configured in two alternative plans to take advantage of the Piggyback Yard parcel. At RS 69+93, the channel invert would start to widen into the left bank. The invert width would increase to more than 500 feet before it contracting back to the original channel size at RS 38+47. Within the Piggyback Yard extent, a bench up to 1000-feet wide would extend from RS 64+92 to RS 50+15. The bench would be established at approximately the 2-year water surface elevation and include marsh vegetation. The eastern edge of the bench would be sloped back up to the original ground elevation to a point about 1800 feet from the channel. The railroad would be trestled over the widened channel from RS 68+38 to RS 40+13. Modifications to the channel would also include daylighted storm drain connections.

Other than those general issues mentioned above, the following constraints and design considerations impact this specific sub-reach:

a. Modifications will need to take into account potential impacts to properties adjacent to the channel as well as surface street crossings from an easement and structural suitability standpoint. Currently, it is the assumption that these impacts will be evaluated during design phases;

b. Impacts to the bride crossings of two rail lines, East Ceasar Chavez Avenue, US Highway 101, and First Street as a result of re-configuration of the channel and scour will need to be considered. The railroad crossings may require temporary shoo fly trestles to allow for uninterrupted service to rail traffic. Currently, it is the assumption that these impacts and scour will be evaluated during design phases;

c. Levees exist within this reach on both the right and left banks. Modifications to existing levees in two alternative plans will need to maintain existing flood protection, be

designed and constructed according to current standards, and follow current vegetation guidance under ETL 1110-2-571; and

d. HTRW issues that will need to be addressed within this sub-reach include: fuel contamination associated with the former Albian Dairy, PAH, metals, VOCs, and fuels contamination of groundwater and soils associated the former Manufacture Gas Plant site, VOCs and metals contamination of soils and groundwater associated with the BNSF Tower Site, solvent contamination of groundwater associated with the Morton Intl Whittaker Corp. site, fuel contamination to soils and groundwater associated with the MTA site, fuel contamination of groundwater associated with the Chevron Gas Station site, fuel contamination of groundwater associated with the Gannett Outdoor Systems Inc. site, solvent contamination of soils and groundwater associated with the Infinity Outdoor Co. site, metals contamination to groundwater and soils associated with the Chromal Plating & Grinding Co. site, and solvent contamination of groundwater associated with the Valspar Corporation site. As these sites are not within the project footprint, soil impacts from the contamination are not anticipated. However, if groundwater flow from the contaminated sites is toward the project some impact from these contamination sources should be anticipated. If dewatering is necessary during construction, these impacts could be aggravated. These impacts will need to be addressed during design phases.

8.0 LIMITATIONS AND ASSUMPTIONS

The alternatives and restoration actions discussed within this appendix were under development at the time of the compilation of this Geotechnical Study and may not be representative of the final selected alternative.

As is common with feasibility studies, certain engineering investigations and preliminary design aspects are routinely assigned to future stages of study. As a result. some risk is associated with this approach, and has been documented in the risk register. These aspects include anticipated scour, construction easements and right-of-way considerations, and detailed potential HTRW impacts. The impacts of assigning these Study items to future stages of Study include the unanticipated need for new mitigation measures, re-evaluation of alternatives, and could have impact on final construction costs. For example, scour could potentially put the foundation of structures at risk from undermining or direct flow impacts that have not been considered as part of this Study. Scour estimates will need to be incorporated into the development of the design parameters mentioned above. Deepened foundations to accommodate a deep scour condition will result in a more robust structural design to accommodate increased lateral loading. The resulting increases in project cost could be significant and are not currently accounted for in the costs. It is

the current assumption that these aspects will be addressed in design phases and after the tentatively selected plan is determined.

All information contained within this Appendix is based on the information available to the project team, this information does not constitute all publically available data, and is presumed to be current to the date of the Geotechnical Study only.

As within any urbanized setting, the potential for undocumented fill, unknown utilities, and changing surface conditions exists. Future activities and studies will need to account for these conditions. Detailed studies could reveal subsurface conditions and issues not yet identified as part of this Study.

9.0 RECOMMENDATIONS FOR FUTURE STUDY AND PATH FORWARD

A thorough subsurface investigation will be required for any engineering design and should be in conformance with current investigation, analysis, and design standards. Efforts conducted during these studies may include subsurface exploration, well testing, data gathering, laboratory testing, and field mapping.

Significant coordination with multiple organizations and agencies as well as land and utility owners will be required for investigation and construction. A detailed breakdown of the selected alternative and the impacted properties should be made to focus investigation efforts.

10.0 REFERENCES

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Southern California Earthquake Data Center. 2012. Significant Earthquakes and Faults. Accessed August 2012 at www.data.scec.org/index.html.

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Table 1
Sub-Reach Descriptions

Sub-Reach	Upstream End	Downstream End	Approximate Length (miles)	Existing Channel Configuration	Areas of Opportunity
Reach 1	Pollywog Park/Headworks	Midpoint of Bette Davis Park	1.5	Rectangular (vertical concrete wall) channel with concrete bottom	Headworks, Pollywog Park, Bette Davis Park
Reach 2	Midpoint of Bette Davis Park	Upstream end of Ferraro Fields	0.73	Trapezoidal channel with grouted stone or concrete side slopes with soft bottom	Bette Davis Park
Reach 3	Upstream end of Ferraro Fields	Brazil Street	1	Trapezoidal channel with concrete side slopes transition into rectangular channel transition into rectangular channel all with concrete bottom	Ferraro Fields, the Burbank Western Channel, Glendale River Walk, Verdugo Wash, Griffith Park,
Reach 4	Brazil Street	Los Feliz Boulevard	1.78	Trapezoidal channel with grouted stone side slopes and soft bottom	Griffith Park, Atwater Park
Reach 5	Los Feliz Boulevard	Glendale Freeway (CA 2)	1.68	Trapezoidal channel with grouted stone and concrete side slopes and soft bottom	Atwater Park, the Bowtie and Taylor Yard,
Reach 6	Glendale Freeway (CA 2)	Interstate 5 (I-5)	2.4	Trapezoidal channel with grouted stone and concrete side slopes and soft bottom	Elysian Park,
Reach 7	Interstate 5 (I-5)	Main Street	1.1	Rectangular and trapezoidal channel with concrete side slopes and concrete bottom	Cornfields (LA State Historic Park), Elysian Park, Arroyo Seco, Downtown Los Angeles
Reach 8	Main Street	First Street	1.44	Trapezoidal channel with concrete side slopes and concrete bottom	Piggyback Yard (also known as Mission Yard), Downtown Los Angeles

Table 2
Los Angeles River Ecosystem Restoration
Sub-Measure Application in Alternative Plans 10, 13, 16, 20

Sub-measure	Reach 1		Reach 2		Reach 3		Reach 4		Reach 5		Reach 6		Reach 7		Reach 8	
	Left Bank	Right Bank	Left Bank	Right Bank	Left Bank	Right Bank	Left Bank	Right Bank	Left Bank	Right Bank	Left Bank	Right Bank	Left Bank	Right Bank	Left Bank	Right Bank
Riparian planting of habitat corridors		All	All	All	20	13, 16, 20	All	All	All	All	All	All			All	All
Expose/daylight stormdrain outlets					All	All	All	All	All	All			10, 20	10, 20		
Channel widening					20	20			16, 20		All	All	13, 16, 20	20	16, 20	
Create/rebuild channel geomorphology					13, 16, 20	13, 16, 20	All	All					13, 16, 20	20	16, 20	16, 20
Divert flows into side channels					13, 16, 20		All	All							16, 20	
Planting built into walls (boxes)											13, 16, 20	13, 16, 20				
Channel Bed Deepening															16, 20	16, 20
Terrace banks									16, 20		13, 16, 20	13, 16, 20	20	20	16, 20	16, 20
Bioengineer Channel Walls (vines)			20							16, 20			13, 16	13, 16		
Trapezoidal to vertical walls			20							16, 20						
Widen Tributaries					20											
Elevate Railroad													20	20	20	20

Table 3
Selected Historic Earthquakes of Southern California

Year	Date	Location	Time	Richter Magnitude	Mercalli Intensity	Casualties/Property Damage
1769	28-Jul	LA Area	--	6	VIII	No information.
1812	8-Dec	Los Angeles Area	3:00 PM	7	VII	40 deaths, Mission San Juan Capistrano severely to moderately damaged. Mission San Gabriel moderately damaged.
1827	24-Sep	Los Angeles Area	4:00 AM	5.5	--	No information.
1855	11-Jul	Los Angeles Area	4:15 AM	6	VIII	Bells of Mission San Gabriel were detached. 6 buildings damaged in LA.
1857	9-Jan	Fort Tejon	4:24 PM	7.9	IX	2 deaths; heavy property damage/loss.
1916	23-Oct	Tejon Pass Region	2:44 PM	5.3	--	No information.
1933	10-Mar	Long Beach	5:54 PM	6.4	IX	120 deaths; $50 million.
1941	21-Oct	Torrance-Gardena	10:57 PM	4.8	VII	No deaths; $100,000.
1941	14-Nov	Torrance-Gardena	12:42 AM	4.8	VIII	No deaths; $1 million.
1951	25-Dec	San Clemente Island	4:46 PM	5.9	--	No deaths; no appreciable damage.
1971	9-Feb	San Fernando	6:01 AM	6.6	--	65 deaths; $505 million.
1979	1-Jan	Malibu	3:15 PM	5.2	--	No deaths; minor damage.
1987	1-Oct	Whittier-Narrows	7:42 AM	5.9	--	8 deaths; $358 million.
1988	3-Dec	Pasadena	11:38 PM	5	--	No deaths; no appreciable damage.
1989	19-Jan	Malibu	10:38 PM	5	--	No deaths; slight damage.
1989	12-Jun	Montebello	9:57 AM	4.6	--	No deaths; no appreciable damage.
1991	28-Jun	Sierra Madre	7:44 AM	5.8	--	2 deaths; $40 million.
1994	17-Jan	Northridge	4:31 AM	6.7	--	61 deaths; est. $20 billion.
2001	9-Sep	SE of West Hollywood	4:59 PM	4.2	--	No deaths; moderate damage.
2005	16-Jun	Los Angeles Area	1:53 PM	4.4	--	No deaths; no appreciable damage
2007	9-Aug	Los Angeles Area	12:58 AM	4.4	--	No deaths; no appreciable damage
2008	29-Jul	Los Angeles Area	5:42 AM	5.5	--	No deaths; no appreciable damage
2009	9-Jan	Los Angeles Area	7:49 PM	4.5	--	No deaths; no appreciable damage
2009	18-May	Los Angeles Area	8:39 PM	4.7	--	No deaths; no appreciable damage

Source: USGS 2012

Table 4
Geotechnical Constaints and Considerations for Design

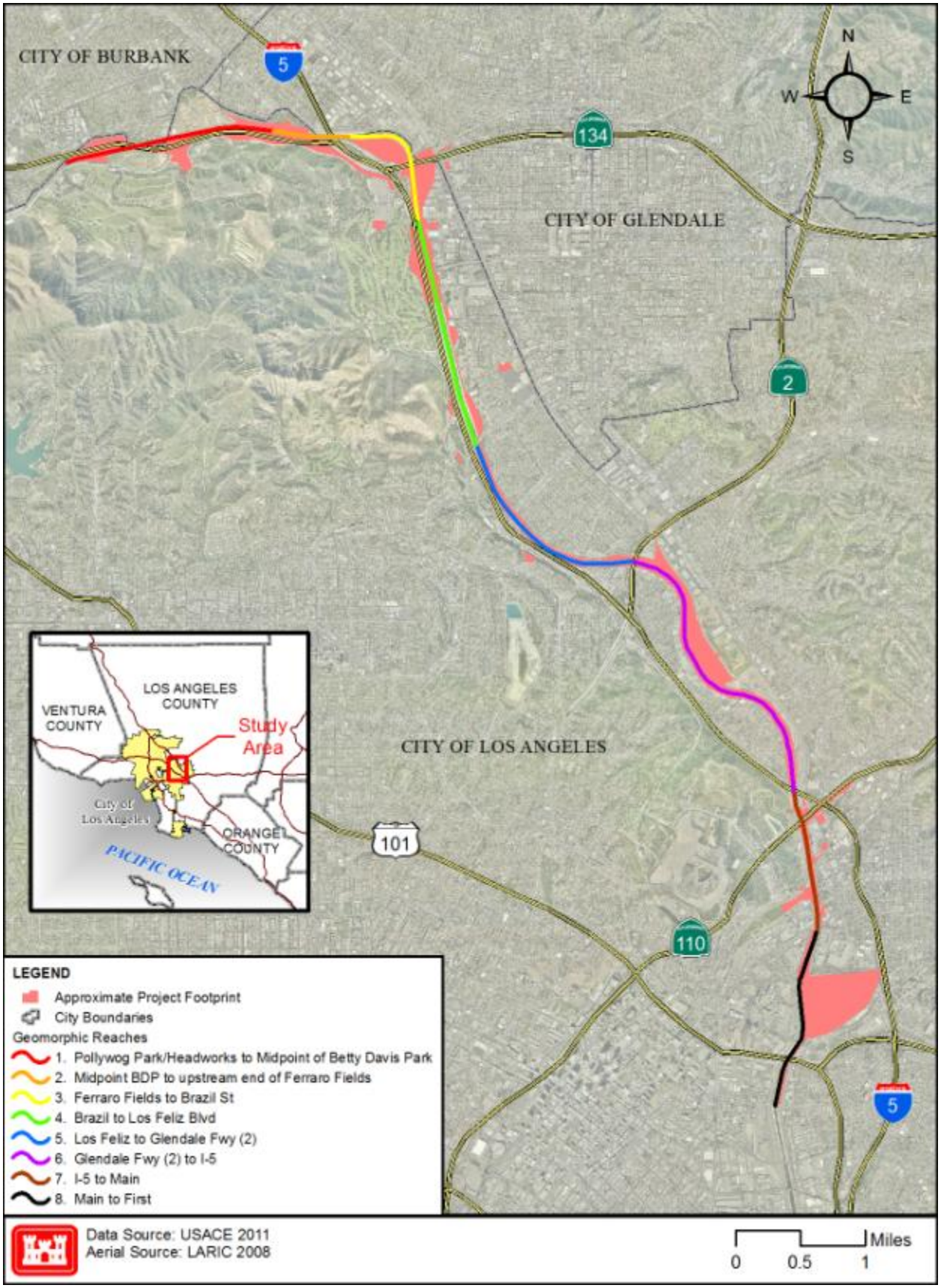
Sub-Reach	Geotechnical Discipline	Constraints and Considerations for Design
Sub-Reach1	Soils	For off bank grading, testing for soil compatibility, and grading operations will need to be conducted.
		Grading plans will need to be developed and reviewed. Habitat Corridors will need to take into account potential impacts to 134 Freeway.
		Habitat Corridors will need to take into account potential impacts to 134 Freeway.
	Levee Safety	Modifications to levees will need to maintain existing protection.
		Modifications are to be performed and designed according to current standards for levees, floodwalls, and channels.
		Vegetation must follow current vegetation guidance under ETL 1110-2-571.
	HTRW	Forest Lawn Cemetery (Open File CWQCB with VOC impact to groundwater) site may impact dewatering and grading operations and will need to be addressed.
Sub-Reach 2	Soils	Without scour estimate impact to design of wall can not be determined.
		Parameters for structural design will need to be determined.
		These walls will probably require counterfort or tieback designs which will require extensive right of way, either temporary or permanent, and will impact real-estate (estimate 45 feet permanent required behind the wall for anchors, probably less counterforts. An unknown amount for construction).
		Seismic design considerations will also need to be made during design as seismic deformation may require significant costs following an event for reconstruction.
		The I-5 crossing in this reach also has potential cost related issues. Scour could potentially put the bridge foundations at risk from undermining or direct flow impact that has not been considered.
		Foundation depths for both the walls and the potential underpinning of the I-5 Bridge could result in significant costs.
		For off bank grading, testing for soil compatibility, and grading operations will need to be conducted.
		Grading plans will need to be developed and reviewed.
		Habitat Corridors will need to take into account potential impacts to CA-134 and I-5 Freeways.
	Levee Safety	Modifications to levees will need to maintain existing protection.
		Modifications are to be performed and designed according to current standards for levees, floodwalls, and channels.
		Vegetation must follow current vegetation guidance under ETL 1110-2-571.
	HTRW	Forest Lawn Cemetery (Open File CWQCB with VOC impact to groundwater) site may impact dewatering and grading operations and will need to be addressed.
Sub-Reach 3	Soils	Without scour estimate impact to design of features can not be determined. In order to prevent potential undercutting, foundations for simple structures may be a required to be at significant depth and may be exorbitant cost for the proposed features.
		Parameters for structural design will need to be determined.
		Some of these features may require extensive right of way, either temporary or permanent, and will impact real-estate.
		Seismic design considerations will also need to be made during design as seismic deformation may require significant costs following an event for reconstruction.
		The CA-134 crossing in this reach also has potential cost related issues. Scour could potentially put the bridge foundations at risk from undermining or direct flow impact that has not been considered.
		Foundation depths for both features and the walls and the potential underpinning of the CA-134 Bridge could result in significant costs.
		Potential utility impacts (shoring, replacement, re-routing etc.) need to be evaluated and may pose significant cost.
	Levee Safety	Modifications to levees will need to maintain existing protection.
		Modifications are to be performed and designed according to current standards for levees, floodwalls, and channels.
		Vegetation must follow current vegetation guidance under ETL 1110-2-571.
	HTRW	Former Hawkes Finishing site (Open File CWQCB with Cr & Zn impact to soil) may impact dewatering and grading operations and will need to be addressed.

Table 4
Geotechnical Constaints and Considerations for Design

Sub-Reach	Geotechnical Discipline	Constraints and Considerations for Design
Sub-Reach 4	Soils	Without scour estimate impact to design of features can not be determined. In order to prevent potential undercutting, foundations for simple structures may be a required to be at significant depth and may be exorbitant cost for the proposed features.
		Parameters for structural design will need to be determined.
		Some of these features may require extensive right of way, either temporary or permanent, and will impact real-estate.
		Seismic design considerations will also need to be made during design as seismic deformation may require significant costs following an event for reconstruction.
	Levee Safety	Modifications to levees will need to maintain existing protection.
		Modifications are to be performed and designed according to current standards for levees, floodwalls, and channels.
		Vegetation must follow current vegetation guidance under ETL 1110-2-571.
	HTRW	None within reach but may be impacted by upstream or downstream sites if dewatering operations change the local groundwater gradient or grading changes surficial drainage or exposes soils.
Sub-Reach 5	Soils	Without scour estimate impact to design of wall can not be determined.
		These walls, directly adjacent to I-5 will probably require counterfort or tieback designs. That will require extensive right of way, either temporary or permanent, and will impact real-estate (estimate 45 feet permanent required behind the wall for anchors, probably less counterforts. An unknown amount for construction).
		Parameters for structural design will need to be determined.
		Seismic design considerations will also need to be made during design as seismic deformation may require significant costs following an event for reconstruction.
		The Glendale Freeway, Hyperion Avenue, and Los Feliz Blvd. crossings in this reach also have potential cost related issues. Scour could potentially put the bridge foundations at risk from undermining or direct flow impact that has not been considered.
		Foundation depths for both the walls and the potential underpinning of the bridges could result in significant costs.
	Levee Safety	Modifications to levees will need to maintain existing protection.
		Modifications are to be performed and designed according to current standards for levees, floodwalls, and channels.
		Vegetation must follow current vegetation guidance under ETL 1110-2-571.
	HTRW	Former Triangle Gas Station (Open File CWQCB with fuel impact to soil), Chevron Gas Station (Open File CWQCB with fuel-solvent impact to groundwater), and Taylor Yd G1 (Open case with DTSC with fuel-solvent & metals impact to soils and groundwater) directly downstream may impact dewatering and grading operations and will need to be addressed.
Sub-Reach 6	Soils	Without scour estimate impact to design of features can not be determined.
		In order to prevent potential undercutting, foundations for simple structures may be a required to be at significant depth and may be exorbitant cost for the proposed features.
		Parameters for structural design will need to be determined. Some of these features may require extensive right of way, either temporary or permanent, and will impact real-estate.
		Seismic design considerations will also need to be made during design as seismic deformation may require significant costs following an event for reconstruction.
		Potential slope stability issues will need to be evaluated on a case by case basis.
		Impacts to railroad tracks will need evaluation.
	Levee Safety	Modifications to levees will need to maintain existing protection.
		Modifications are to be performed and designed according to current standards for levees, floodwalls, and channels.
		Vegetation must follow current vegetation guidance under ETL 1110-2-571.
	HTRW	Taylor Yd G1 (Open case file with DTSC with fuel-solvent & metals impact to soils and groundwater), Taylor Yd G2 (Open case file with DTSC with fuel-solvent & metals impact to soils groundwater), Shell Gas Station (Open file with CWQCB with fuel impact to groundwater), Chevron Gas Station (Open file with CWQCB with fuel impact to groundwater), and San Fernando Consolidated Facility (Open file with CWQCB with fuel impact to groundwater downstream) may impact dewatering and grading operations and will need to be addressed.

Table 4
Geotechnical Constaints and Considerations for Design

Sub-Reach	Geotechnical Discipline	Constraints and Considerations for Design
Sub-Reach 7	Soils	Without scour estimate impact to design of features can not be determined. In order to prevent potential undercutting, foundations for simple structures may be a required to be at significant depth and may be exorbitant cost for the proposed features.
		Parameters for structural design will need to be determined.
		Some of these features may require extensive right of way, either temporary or permanent, and will impact real-estate.
		Seismic design considerations will also need to be made during design as seismic deformation may require significant costs following an event for reconstruction.
		Potential slope stability issues will need to be evaluated on a case by case basis.
		Impacts to railroad tracks will need evaluation.
	Levee Safety	Modifications to levees will need to maintain existing protection.
		Modifications are to be performed and designed according to current standards for levees, floodwalls, and channels.
		Vegetation must follow current vegetation guidance under ETL 1110-2-571.
	HTRW	San Fernando Consolidated facility (Open file with CWQCB with fuel impact to groundwater), former Bortz Oil Company ((area a.k.a. Cornfields)Open case file with DTSC and CWQCB with solvent-VOC impact to groundwater & soils), former Albian Dairy (Open file with CWQCB with fuel impact to groundwater), former Manufacture Gas Plant (Open case file with DTSC with PAH, metals, VOCs, fuels impact to groundwater and soils is downstream), and Valspar Corporation (Open file with CWQCB with solvent impact to groundwater downstream) may impact dewatering and grading operations and will need to be addressed.
Sub-Reach 8	Soils	Without scour estimate impact to design of features can not be determined. In order to prevent potential undercutting, foundations for simple structures may be a required to be at significant depth and may be exorbitant cost for the proposed features.
		Parameters for structural design will need to be determined.
		Some of these features may require extensive right of way, either temporary or permanent, and will impact real-estate
		Seismic design considerations will also need to be made during design as seismic deformation may require significant costs following an event for reconstruction.
		Potential slope stability issues will need to be evaluated on a case by case basis.
		Impacts to railroad tracks will need evaluation.
	Levee Safety	Modifications to levees will need to maintain existing protection.
		Modifications are to be performed and designed according to current standards for levees, floodwalls, and channels.
		Vegetation must follow current vegetation guidance under ETL 1110-2-571.
	HTRW	Former Albian Dairy (Open file with CWQCB with fuel impact to groundwater), former Manufacture Gas Plant (Open file with DTSC with PAH, metals, VOCs, fuels impact to groundwater and soils), BNSF Tower (Open file with CWQCB with VOCs, metals impact to soils and groundwater), former Manufacture Gas Plant (Open Case file with DTSC with solvent, VOCs, metals impact to groundwater and soils), Morton Intl Whittaker Corp Open file with CWQCB with solvent impact to groundwater), MTA Open file with CWQCB with fuel impact to groundwater and soils), Chevron Gas Station (Open file with CWQCB with fuel impact to groundwater), Gannett Outdoor Systems Inc (Open file with CWQCB with fuel impact to groundwater), Infinity Outdoor Co (Open file with CWQCB with solvent impact to groundwater and soils), . Chromal Plating & Grinding Co (Open file with CWQCB with metals impact to groundwater and soils), and Valspar Corp (Open file with CWQCB with solvent impact to groundwater) may impact dewatering and grading operations and will need to be addressed.



Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 1
ARBOR Reach and Sub-reaches

US Army Corps of Engineers
Los Angeles District
Geotech Branch


San Fernando Basin
Los Angeles Basin
Big Tujunga Creek
San Gabriel Mountains
Simi Hills
Bell Creek
Arroyo Calabasas
Aliso Creek
Pacoima Wash
Tujunga Wash
Los Angeles
Burbank
Verdugo Wash
Arroyo Seco
Pasadena
Santa Anita Cr.
Glendale
ARBOR Reach
Santa Monica Mountains
Los Angeles
Rio Hondo
Lynwood
Compton
Downey
Compton Creek
Pacific Ocean
Lakewood
Long Beach
About 50 miles (80 km) across

Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 3
Top of Bedrock Contour Map

US Army Corps of Engineers
Los Angeles District
Geotech Branch

Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 4
Top of Bedrock Contour Map

US Army Corps of Engineers
Los Angeles District
Geotech Branch

Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

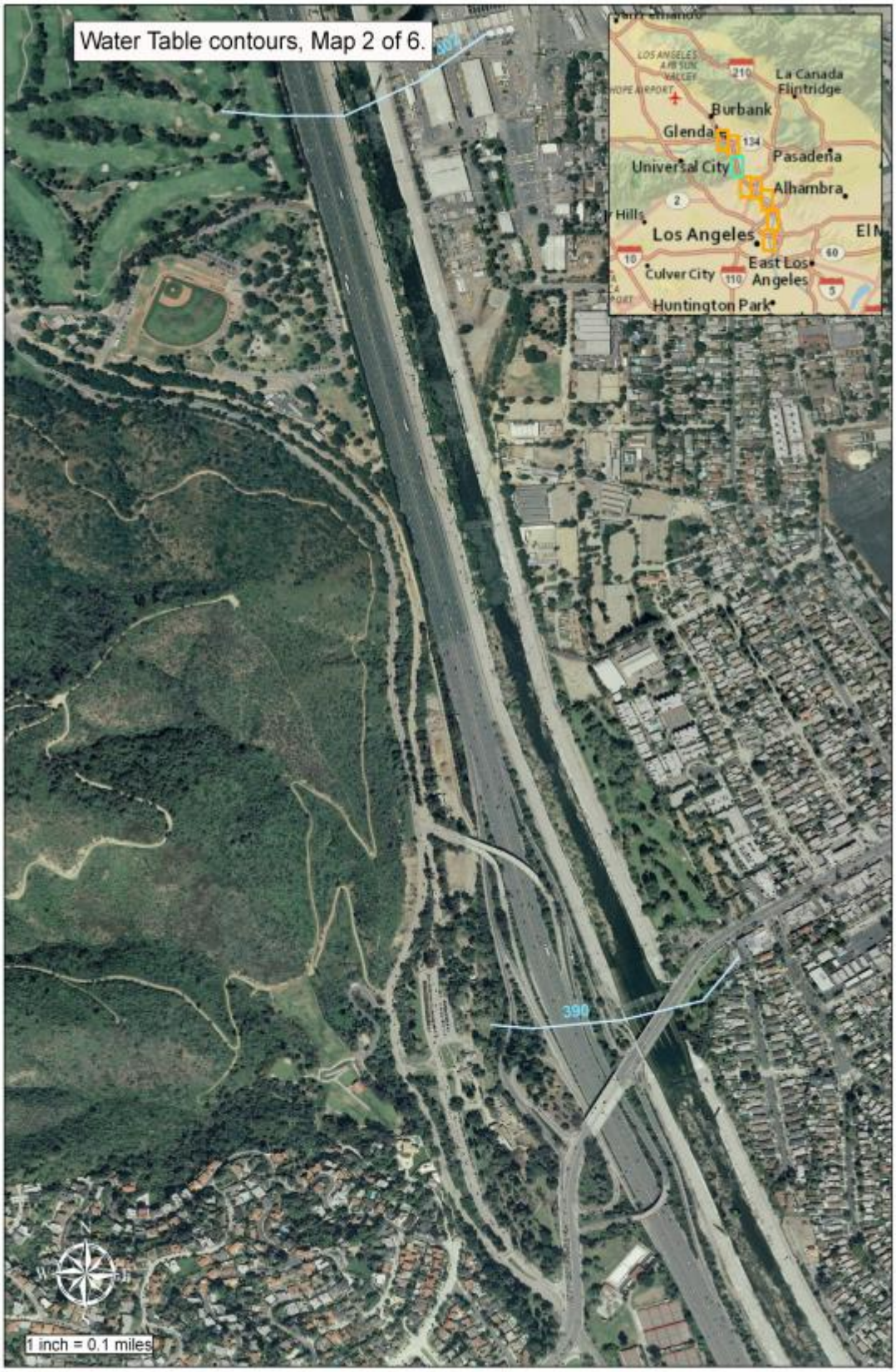
Figure 5
Top of Bedrock Contour Map

US Army Corps of Engineers
Los Angeles District
Geotech Branch

Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 6
Water Table Contour Map

US Army Corps of Engineers
Los Angeles District
Geotech Branch



Los Angeles River
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Geotechnical Feasibility Study

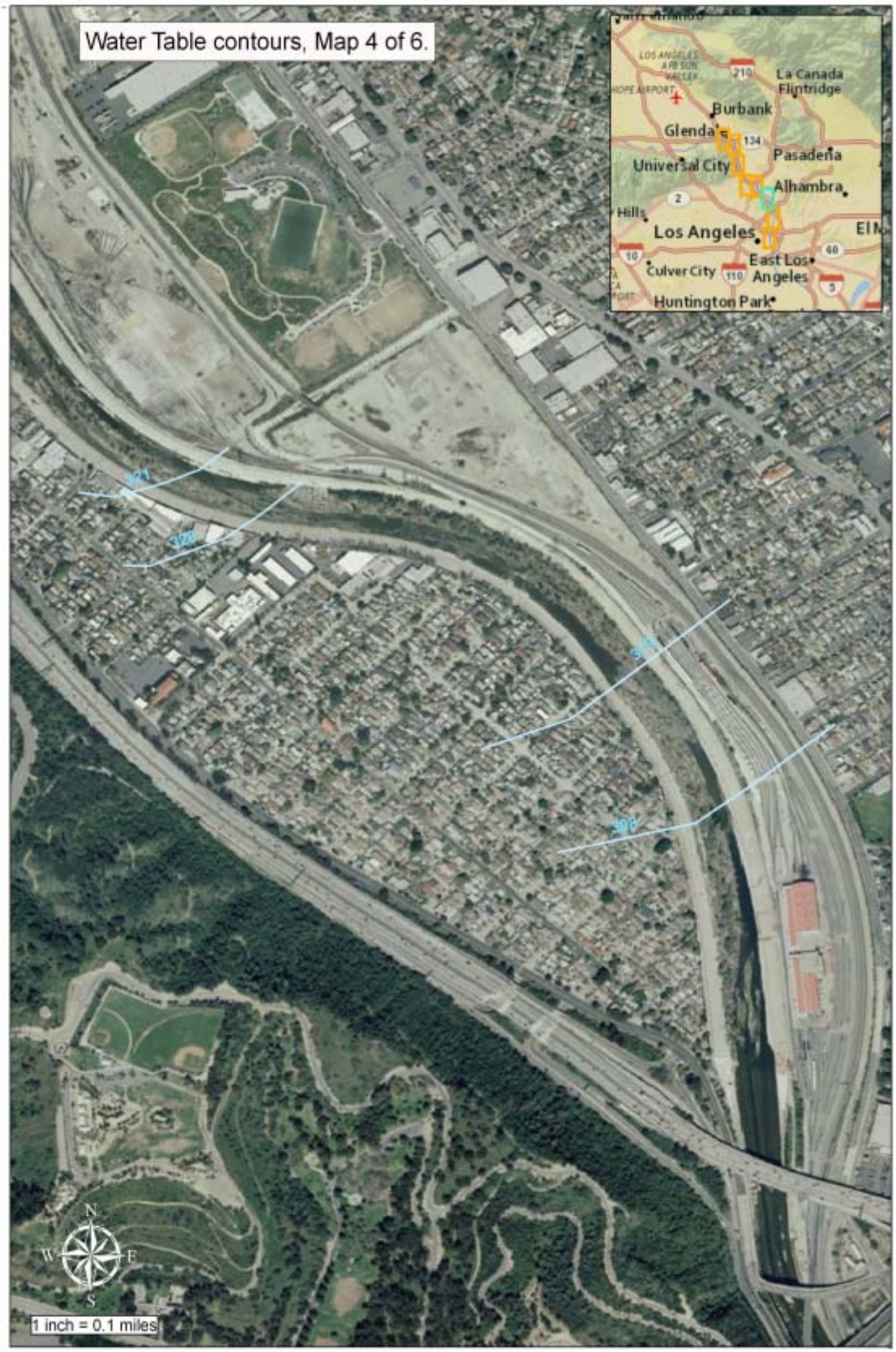
Figure 7
Water Table Contour Map

US Army Corps of Engineers
Los Angeles District
Geotech Branch

Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 8
Water Table Contour Map

US Army Corps of Engineers
Los Angeles District
Geotech Branch



Los Angeles River
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Geotechnical Feasibility Study

Figure 9
Water Table Contour Map

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Los Angeles District
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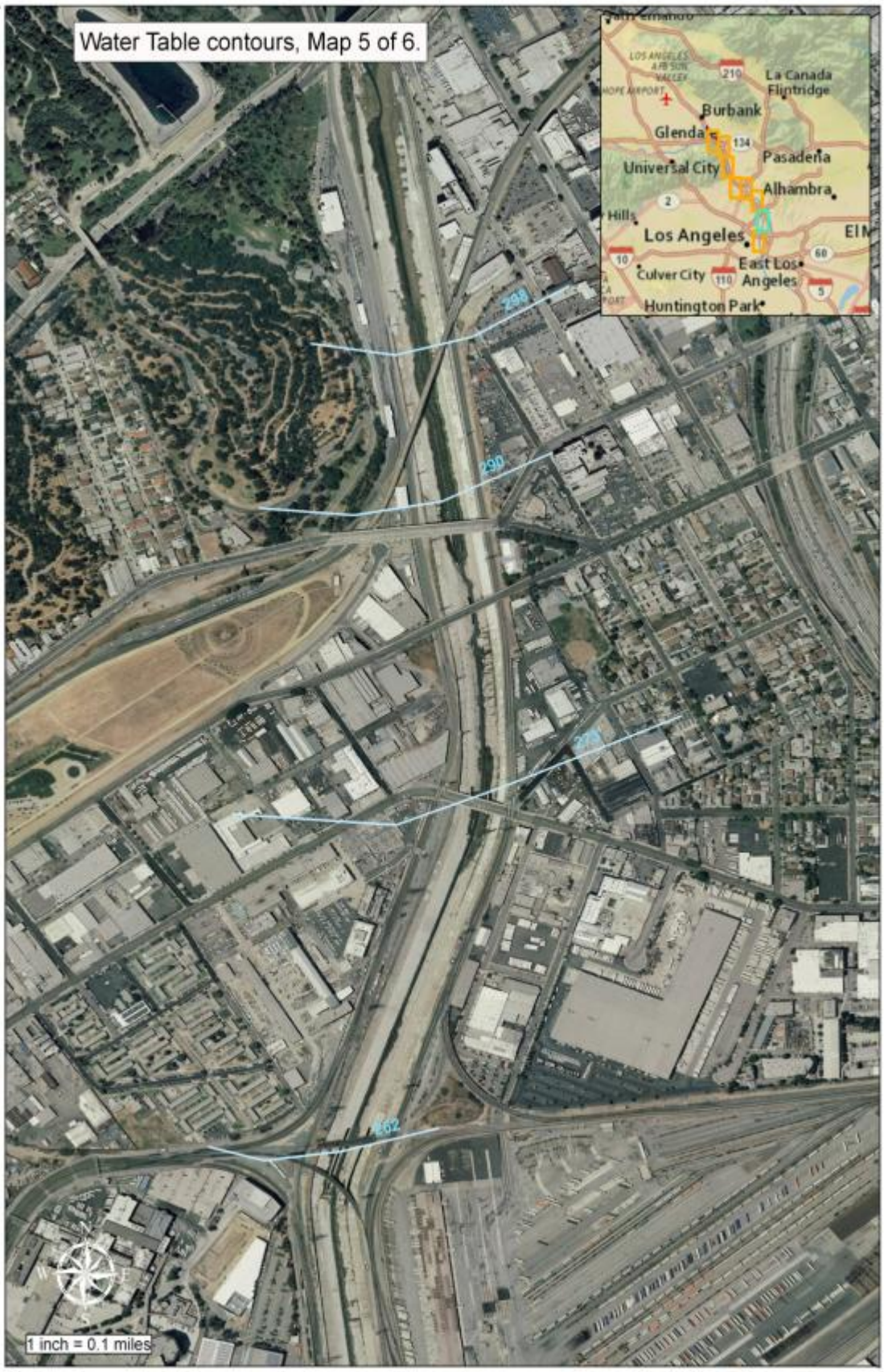

Los Angeles River
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Figure 10
Water Table Contour Map

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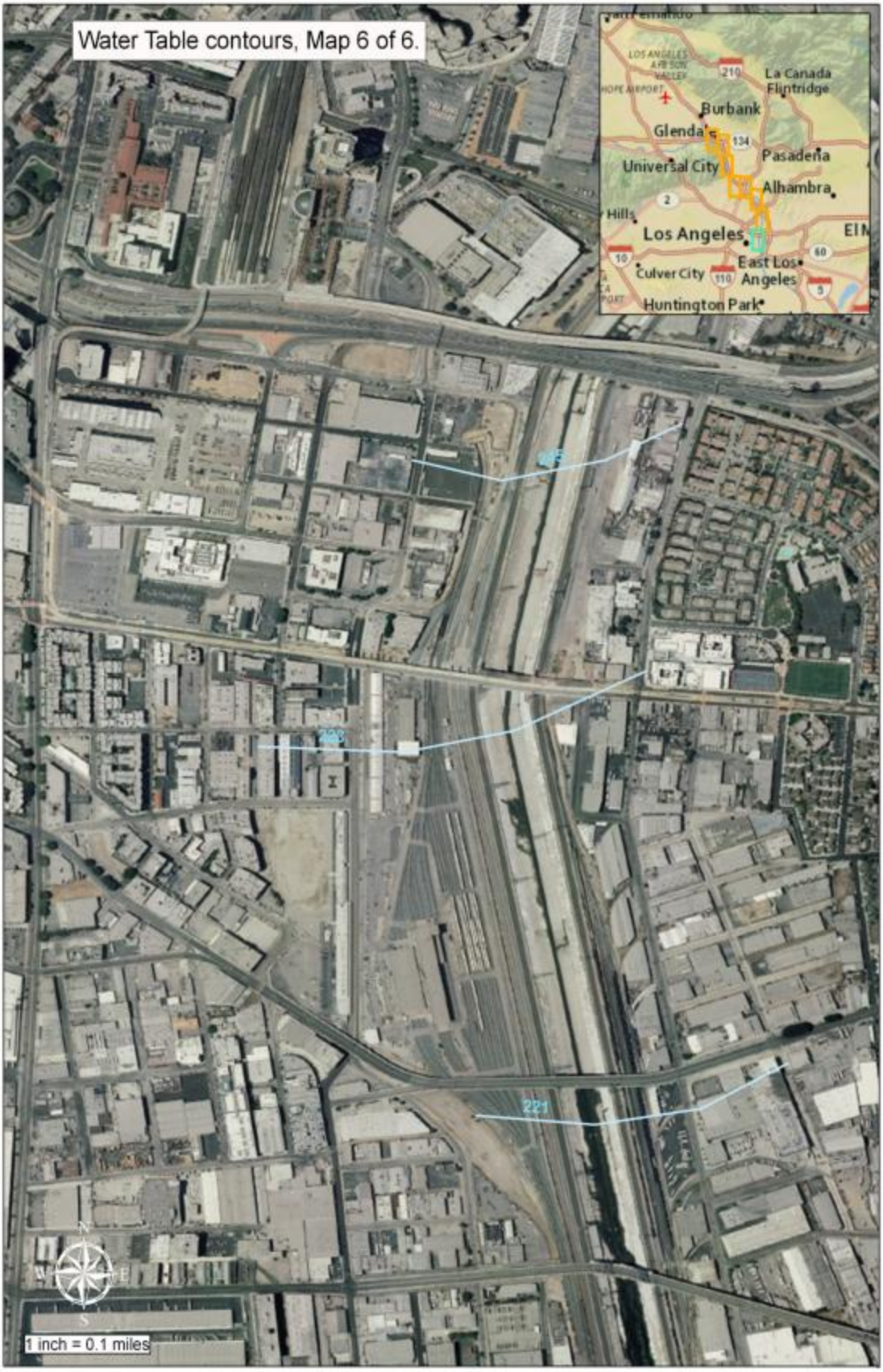

Los Angeles River
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Figure 11
Water Table Contour Map

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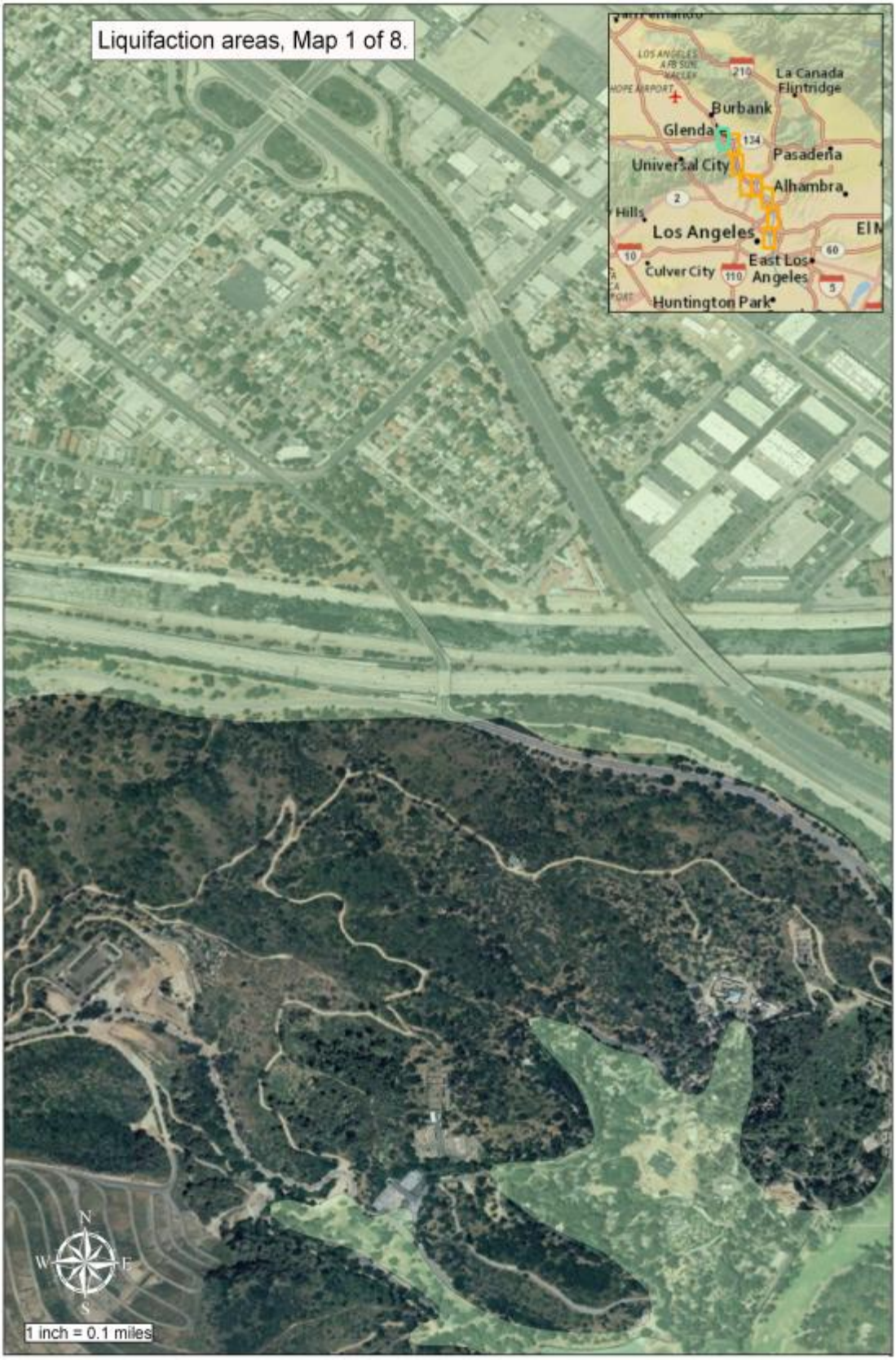

Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 12
Liquefaction Potential Map

US Army Corps of Engineers
Los Angeles District
Geotech Branch

Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 13
Liquefaction Potential Map

US Army Corps of Engineers
Los Angeles District
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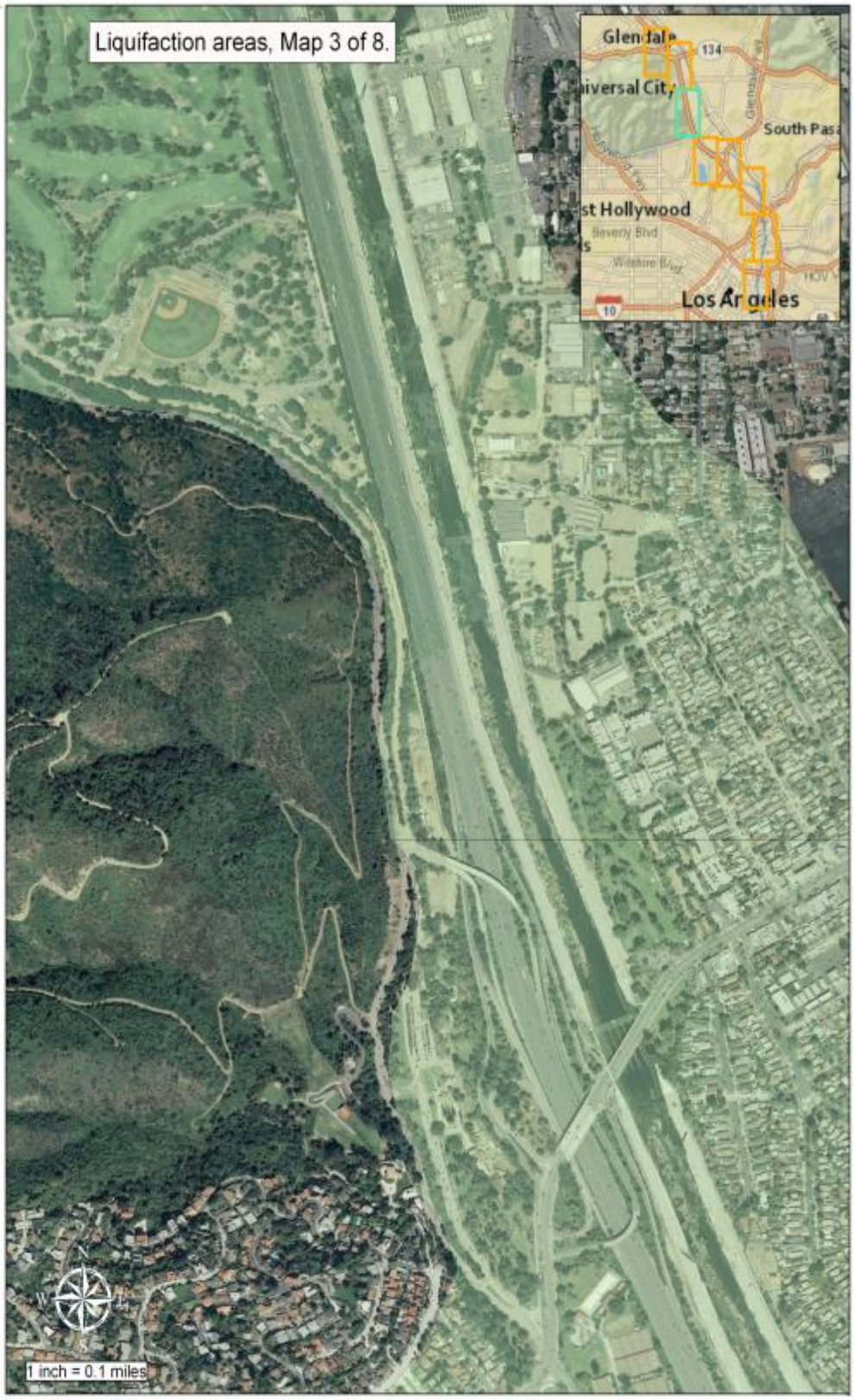
Liquifaction areas, Map 3 of 8.
Glendale
134
South Pasa
st Hollywood
Beverly Blvd
Wilshire Blvd
HOV
Los Angeles
10
1 inch = 0.1 miles


Liquifaction areas, Map 4of 8.
Glendale
134
South Pas
st Hollywood
Beverly Blvd
Wilshire Blvd
HOV
Los Angeles
10
1 inch = 0.1 miles


Liquifaction areas, Map 5 of 8.
Glendale
134
South Pas
st Hollywood
Beverly Blvd
Wilshire Blvd
HOV
Los Angeles
10
1 inch = 0.1 miles

Los Angeles River
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Figure 17
Liquefaction Potential Map

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Liquifaction areas, Map 6 of 8.
Glendale
134
South Pas
st Hollywood
Beverly Blvd
Wilshire Blvd
HOV
Los Angeles
10
1 inch = 0.1 miles

Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 19
Liquefaction Potential Map

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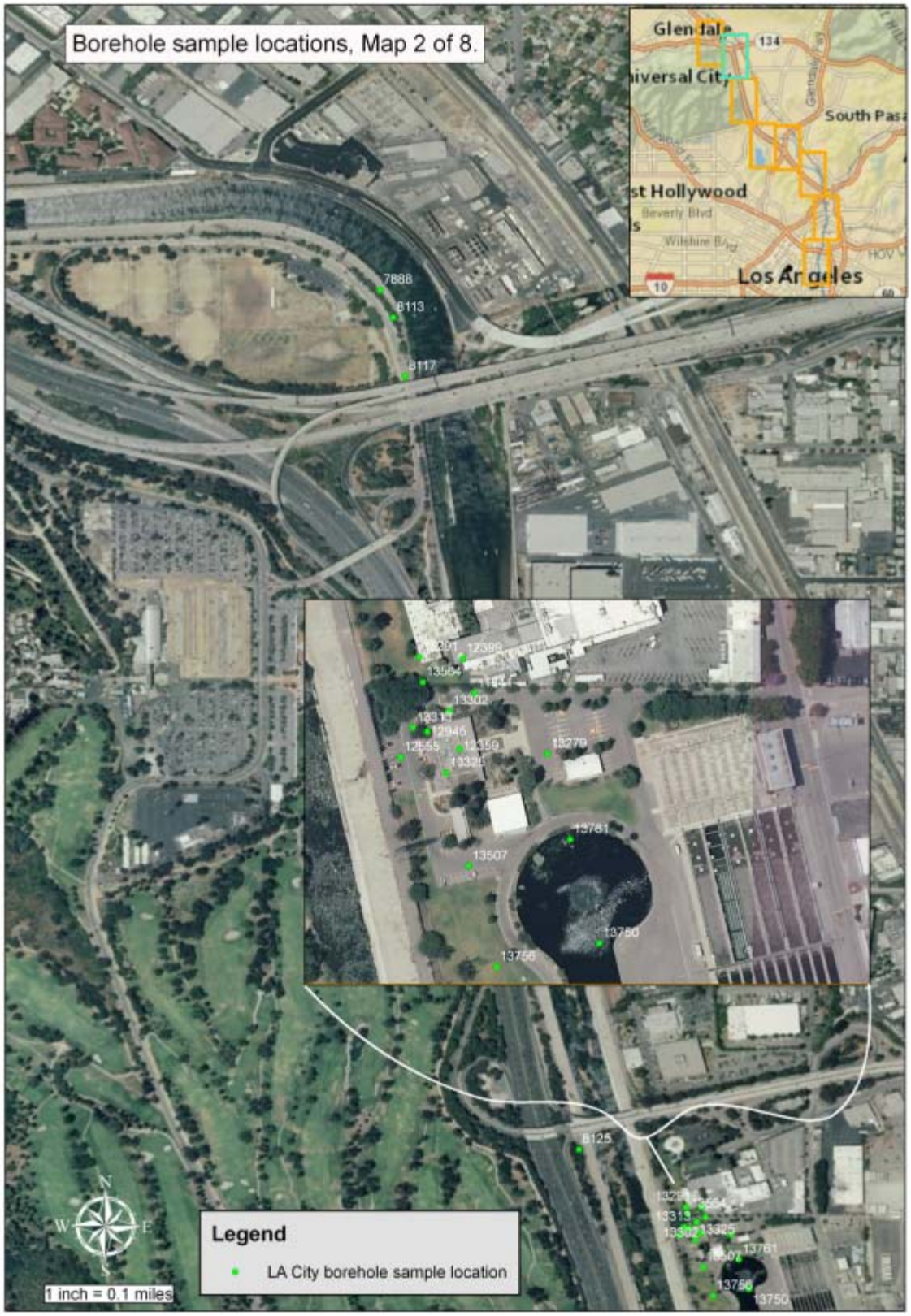
Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 20
Liquefaction Potential Map

US Army Corps of Engineers
Los Angeles District
Geotech Branch



Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 21
Borehole Location Map

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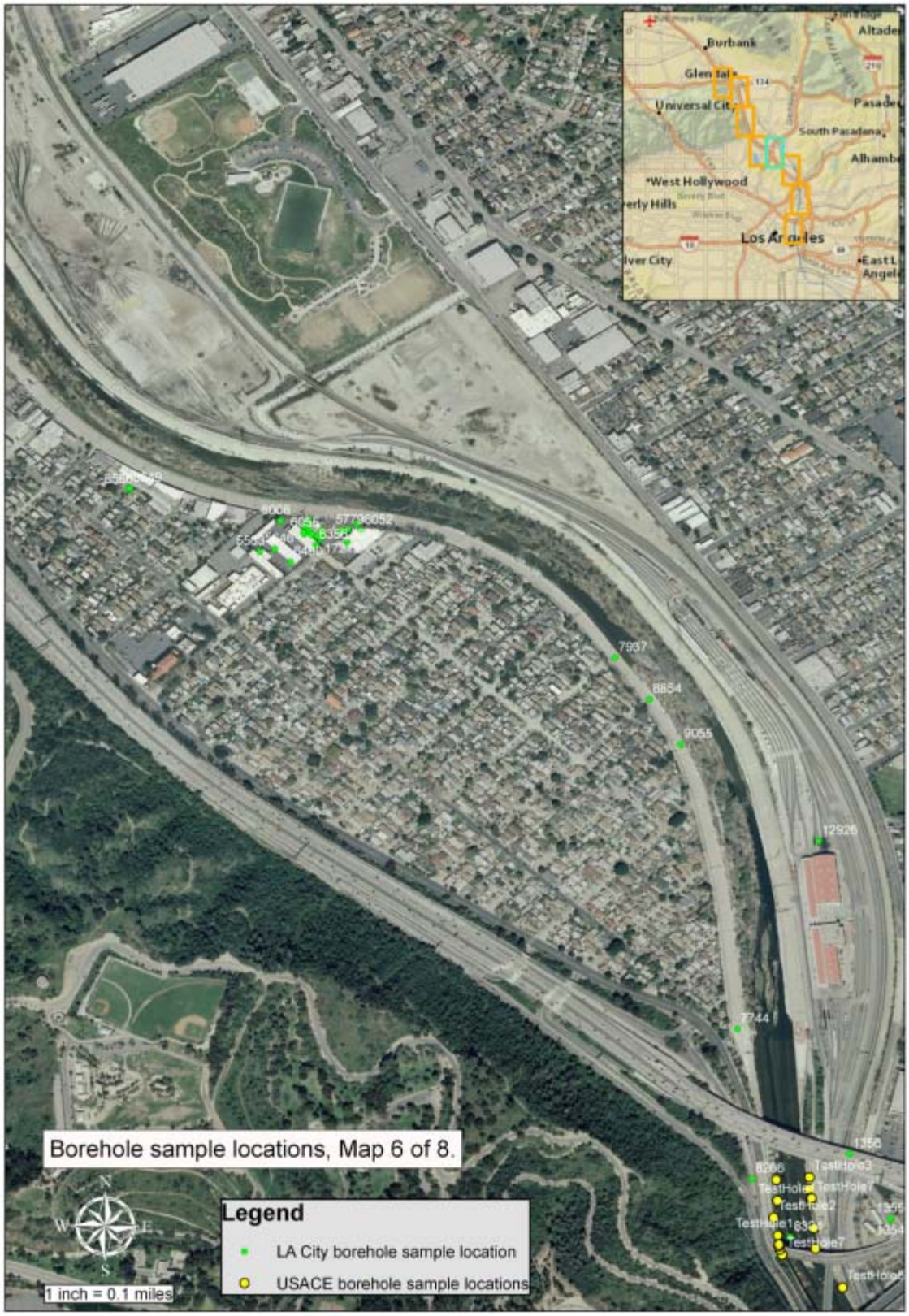
Burbank
Glendale
Universal City
South Pasadena
*West Hollywood
Los Angeles
Borehole sample locations, Map 3 of 8.
Legend
LA City borehole sample location
1 inch = 0.1 miles


Burbank
Glendale
Universal City
Pasadena
South Pasadena
Alhambra
West Hollywood
Beverly Hills
Los Angeles
Silver City
East L.A.
Borehole sample locations, Map 4 of 8.
Legend
LA City borehole sample location
1 inch = 0.1 miles


Burbank
Glendale
Universal City
Pasadena
South Pasadena
Alhambra
West Hollywood
Beverly Hills
Los Angeles
Culver City
East L.A.
8405
8284
6853
6692
Borehole sample locations, Map 5 of 8.
Legend
LA City borehole sample location
1 inch = 0.1 miles

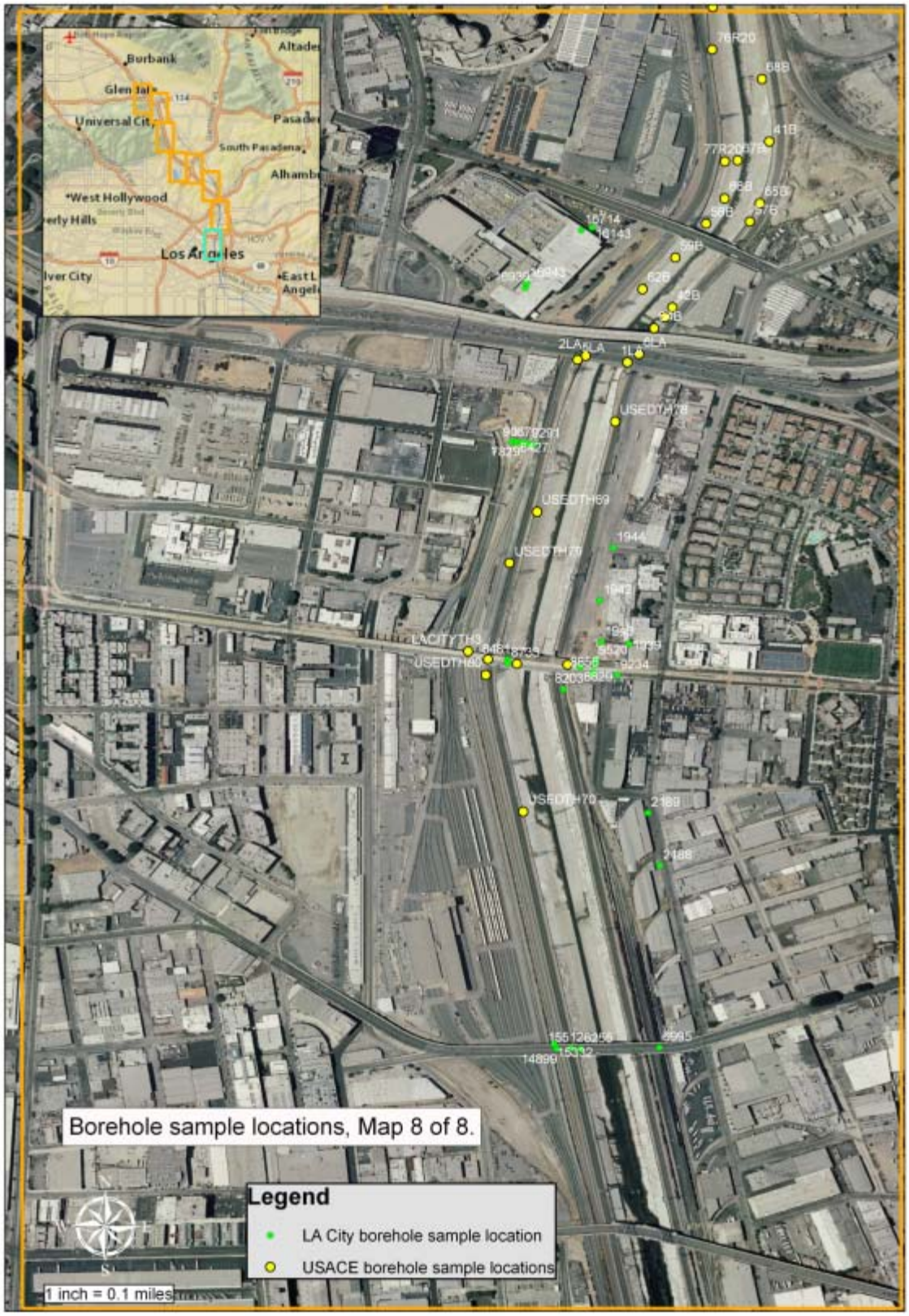


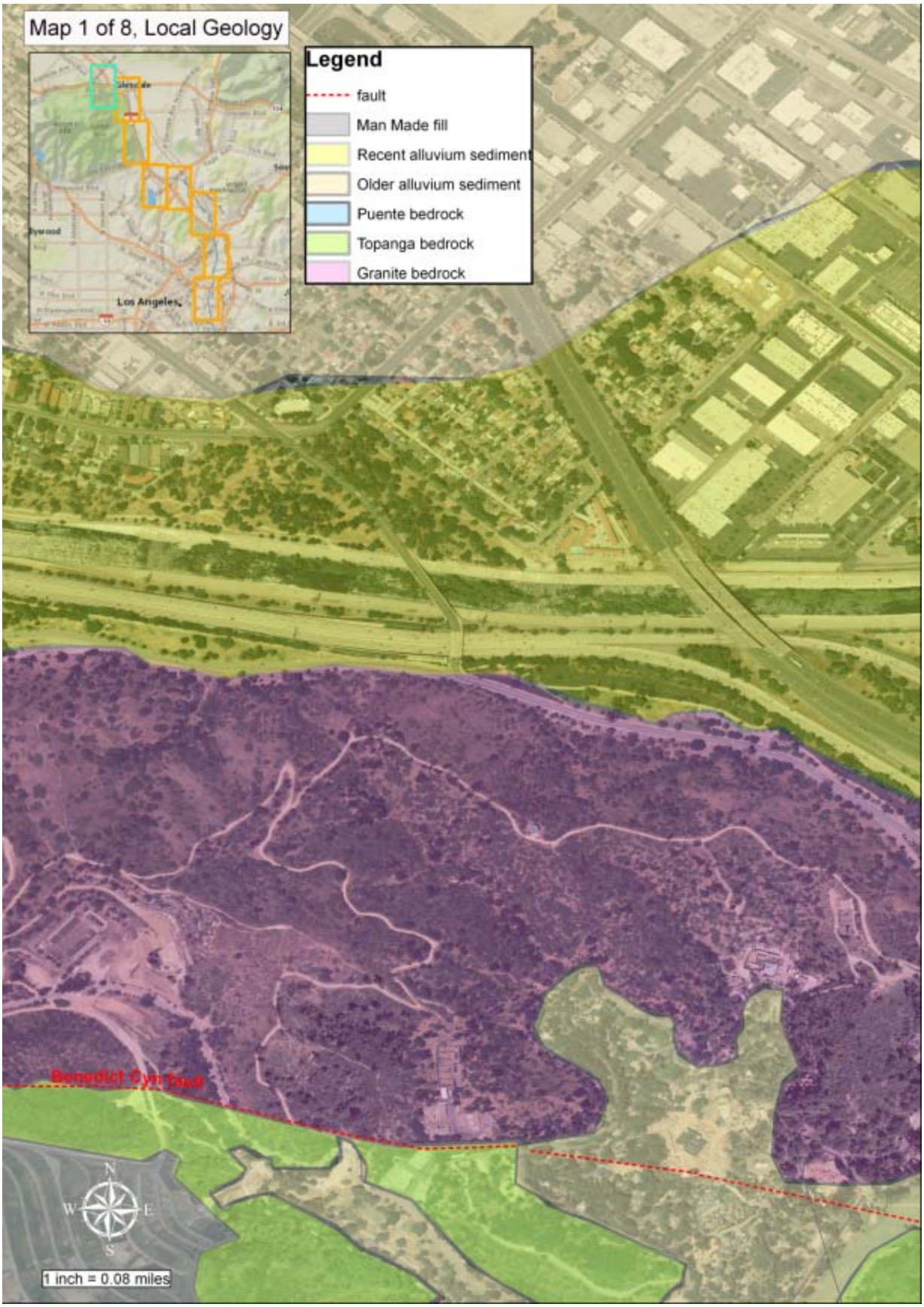
Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 25
Borehole Location Map

US Army Corps of Engineers
Los Angeles District
Geotech Branch


Burbank
Glendale
Universal City
South Pasadena
*West Hollywood
Los Angeles
Borehole sample locations, Map 7 of 8.
Legend
LA City borehole sample location
USACE borehole sample locations
1 inch = 0.1 miles

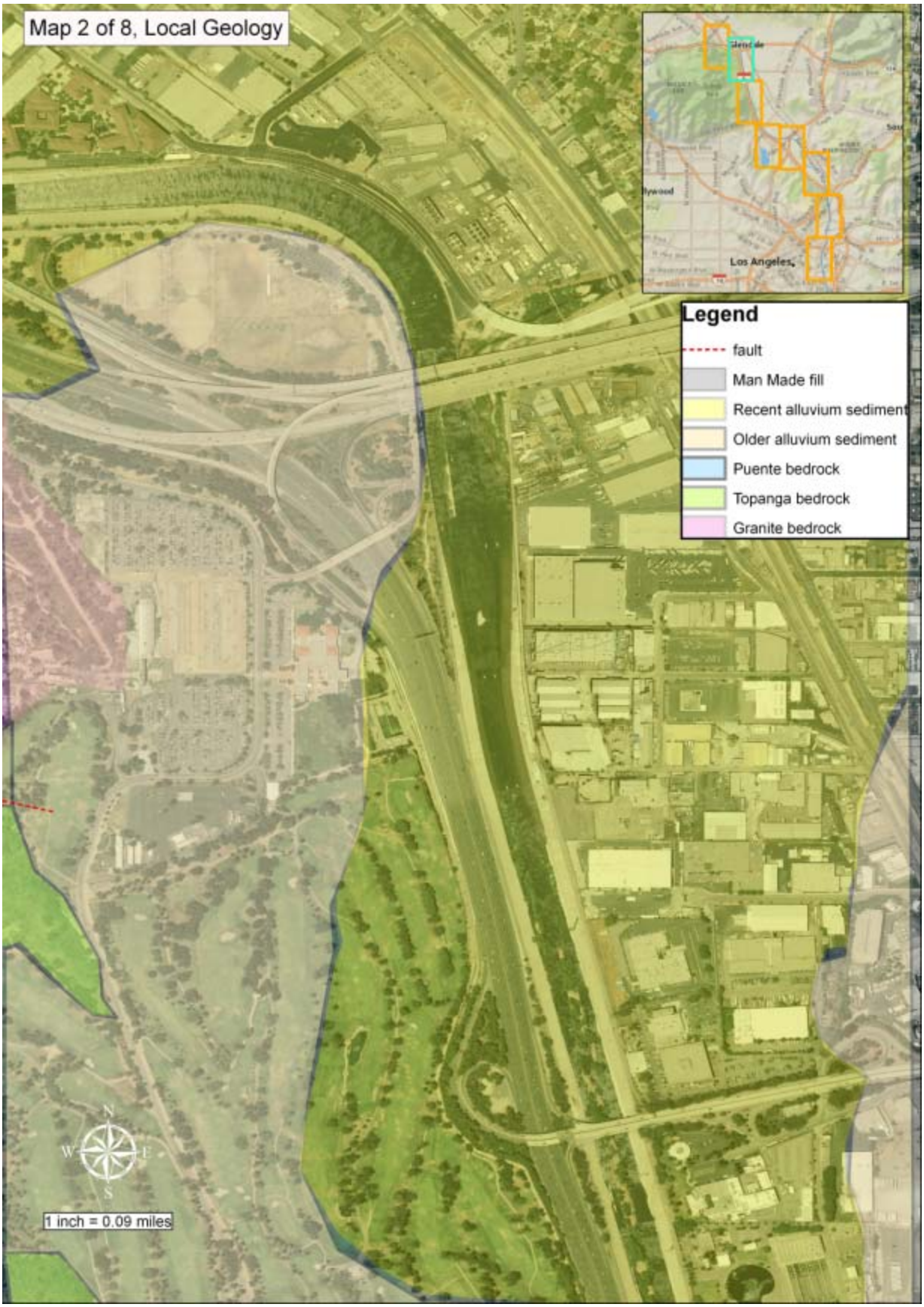

Burbank
Glendale
Universal City
South Pasadena
*West Hollywood
Los Angeles
Borehole sample locations, Map 8 of 8.
Legend
LA City borehole sample location
USACE borehole sample locations
1 inch = 0.1 miles



Los Angeles River Ecosystem Restoration Study Geotechnical Feasibility Study

Figure 28 Local Geology Map

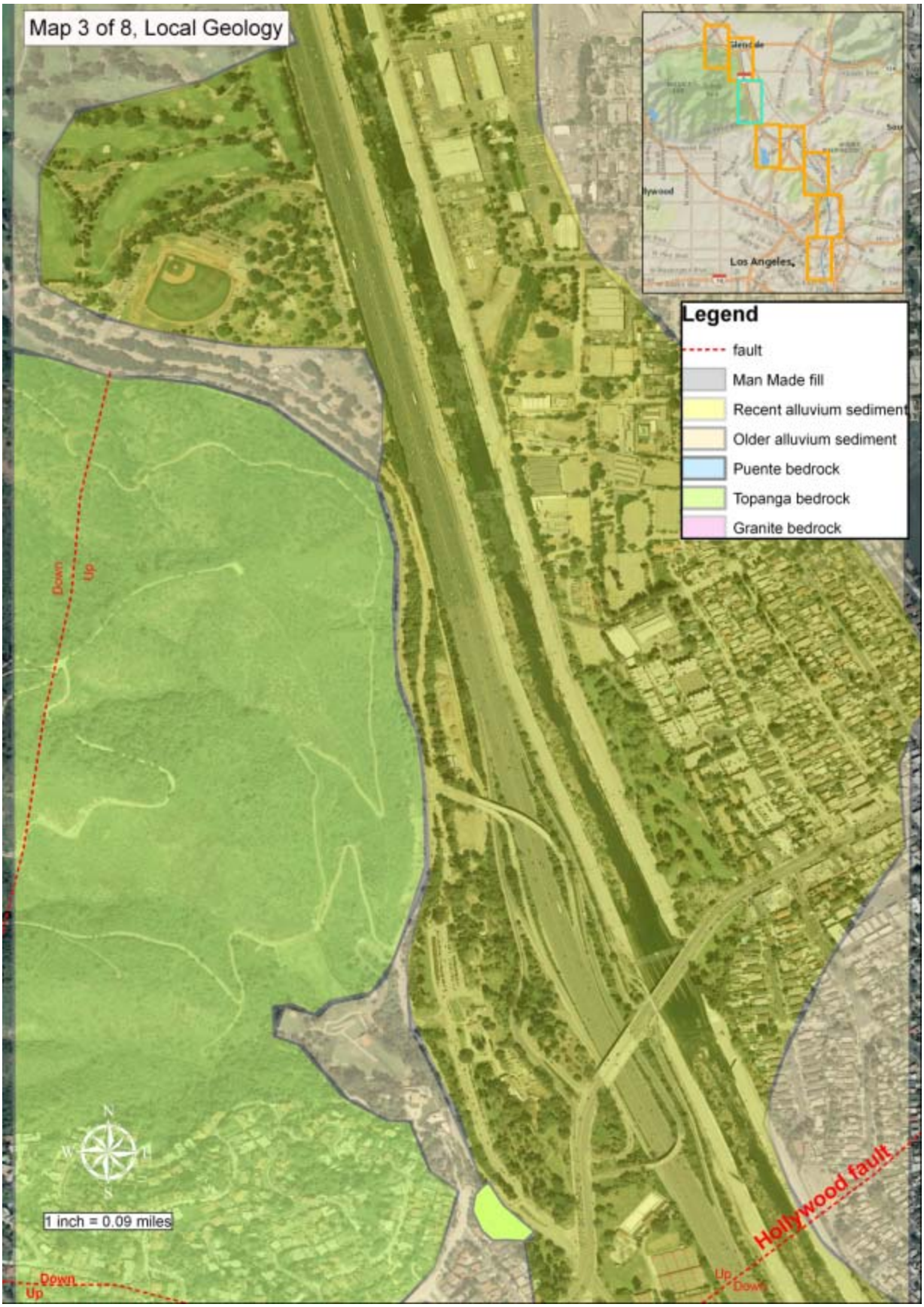
US Army Corps of Engineers Los Angeles District Geotech Branch



Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 29
Local Geology Map

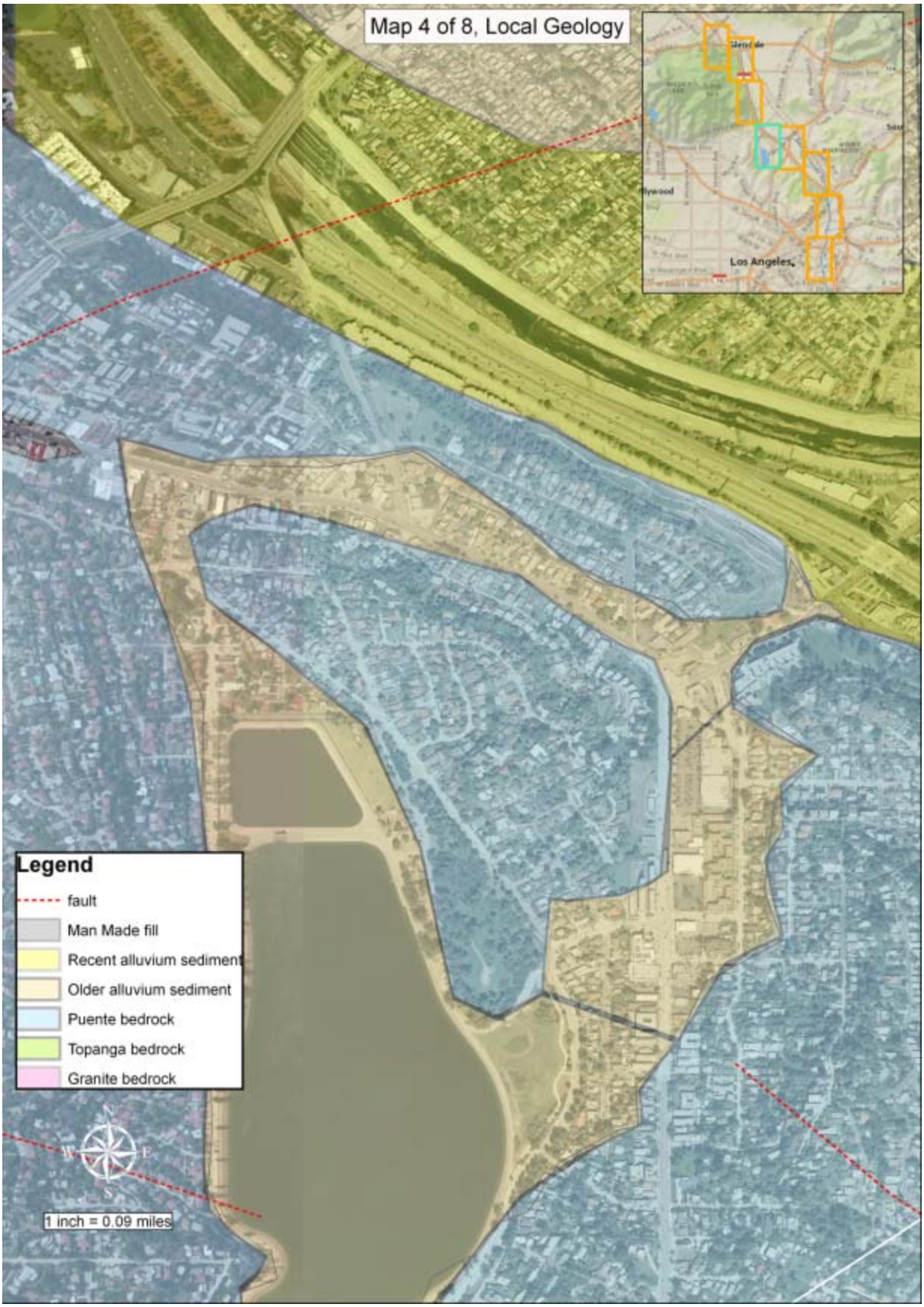
US Army Corps of Engineers
Los Angeles District
Geotech Branch



Los Angeles River Ecosystem Restoration Study Geotechnical Feasibility Study

Figure 30 Local Geology Map

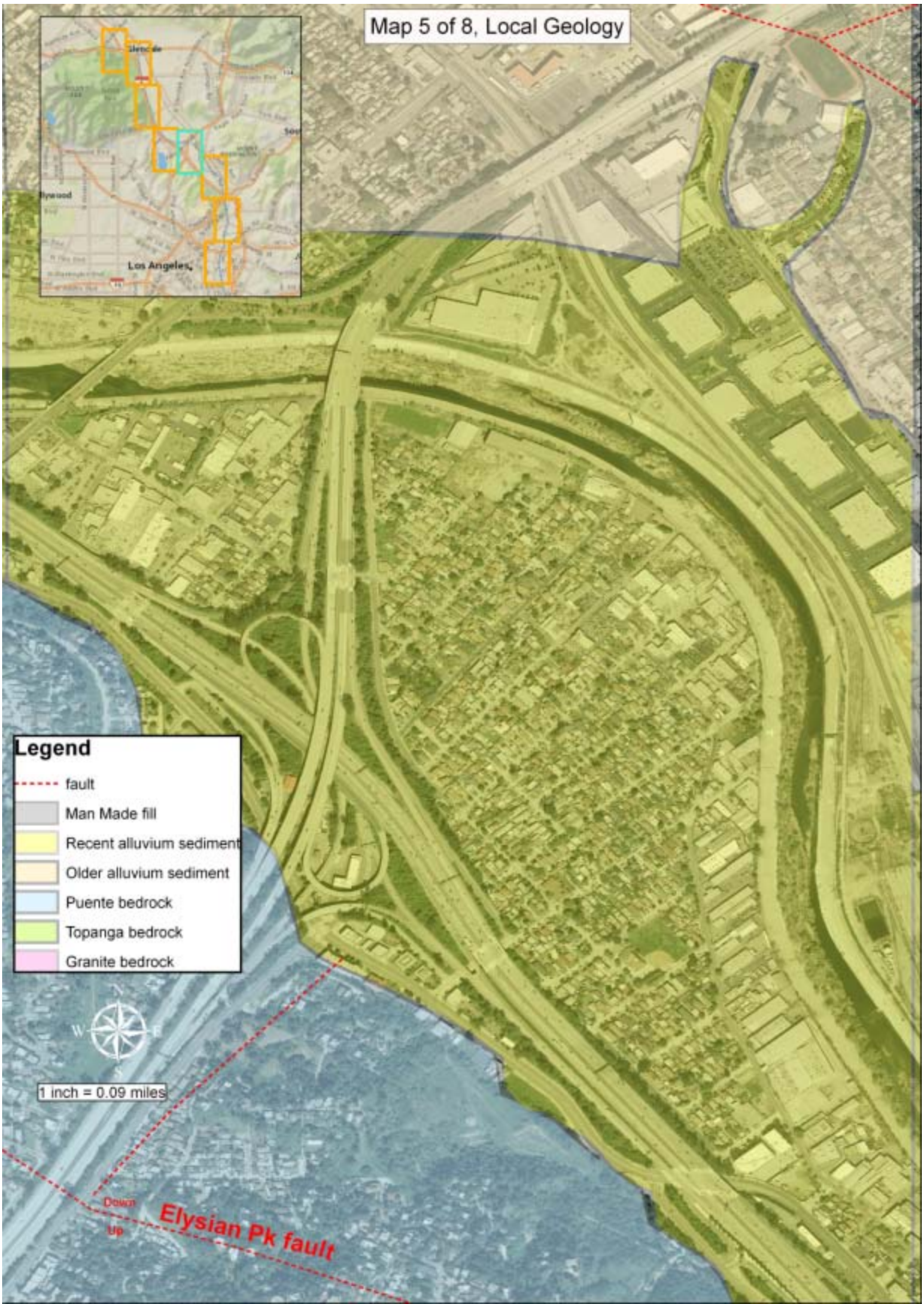
US Army Corps of Engineers Los Angeles District Geotech Branch



Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 31
Local Geology Map

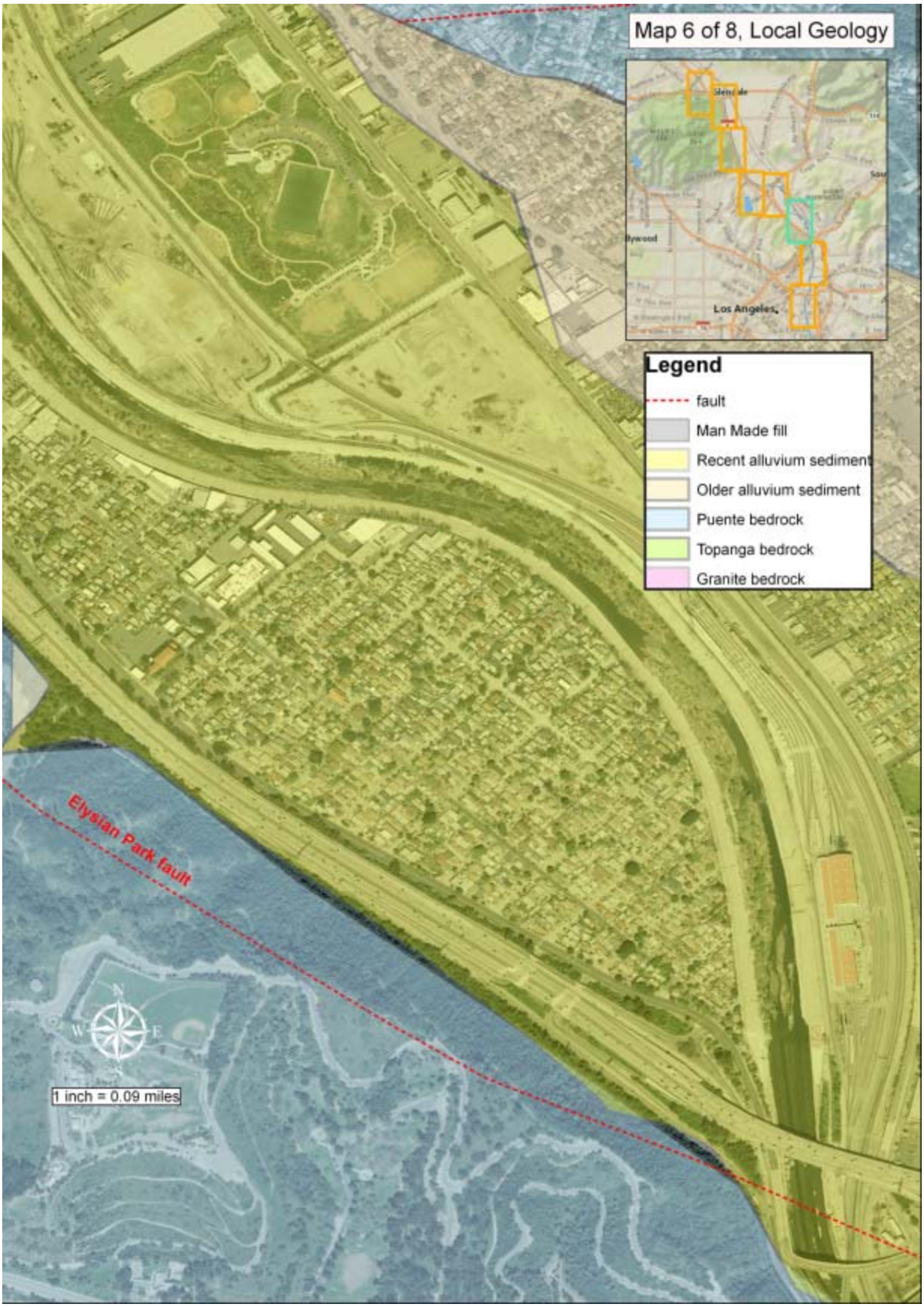
US Army Corps of Engineers
Los Angeles District
Geotech Branch



Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 32
Local Geology Map

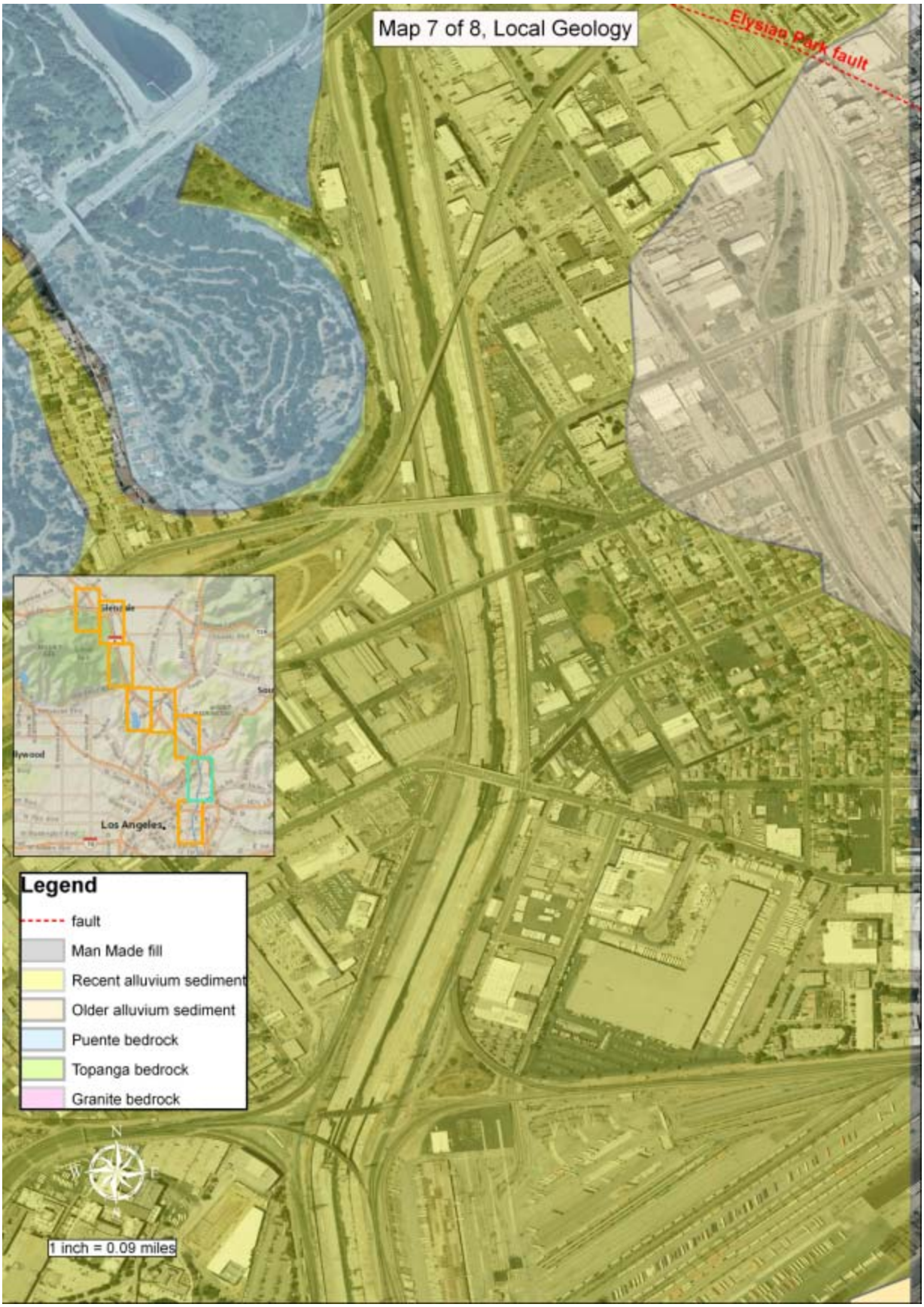
US Army Corps of Engineers
Los Angeles District
Geotech Branch

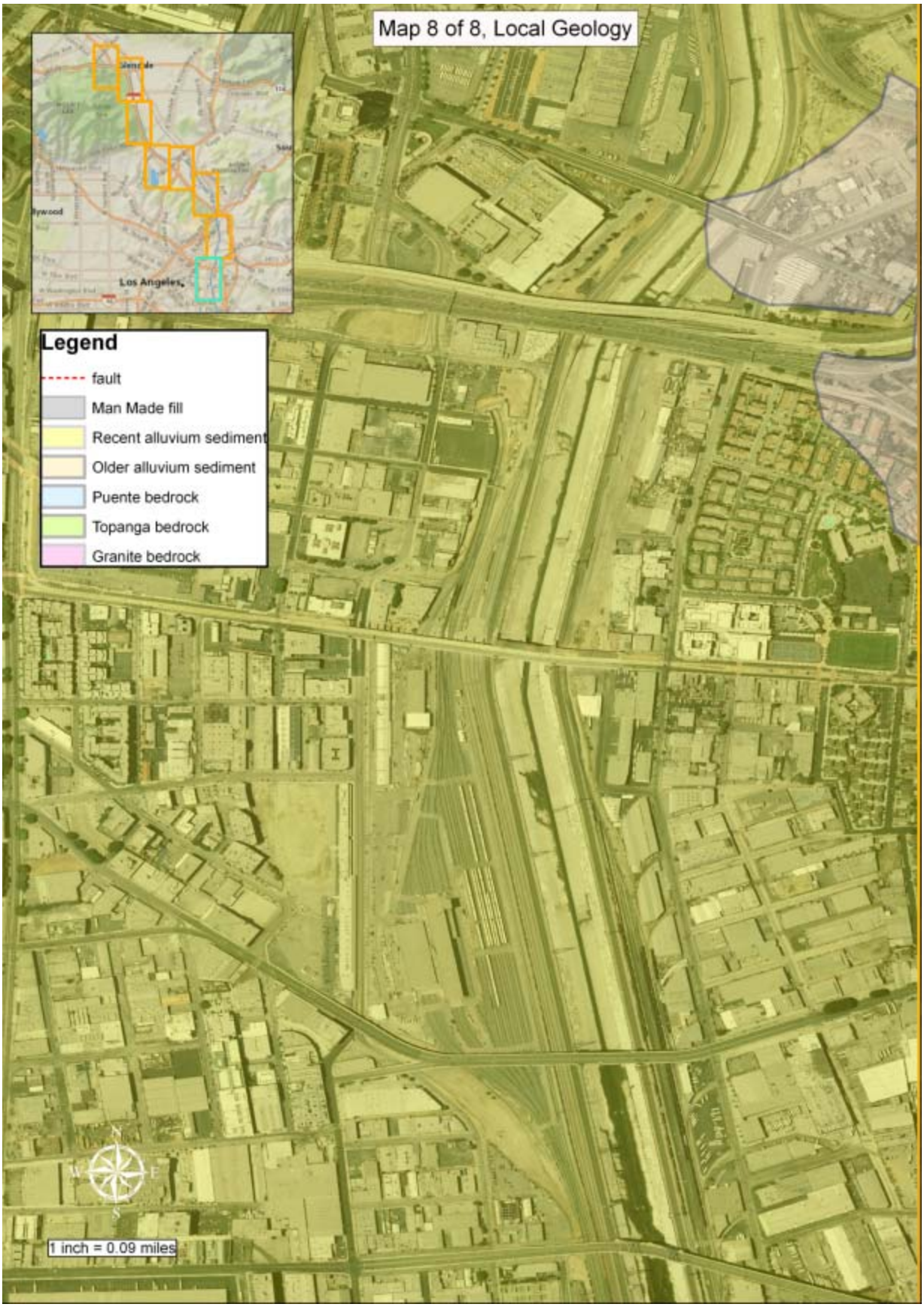


Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 33
Local Geology Map

US Army Corps of Engineers
Los Angeles District
Geotech Branch

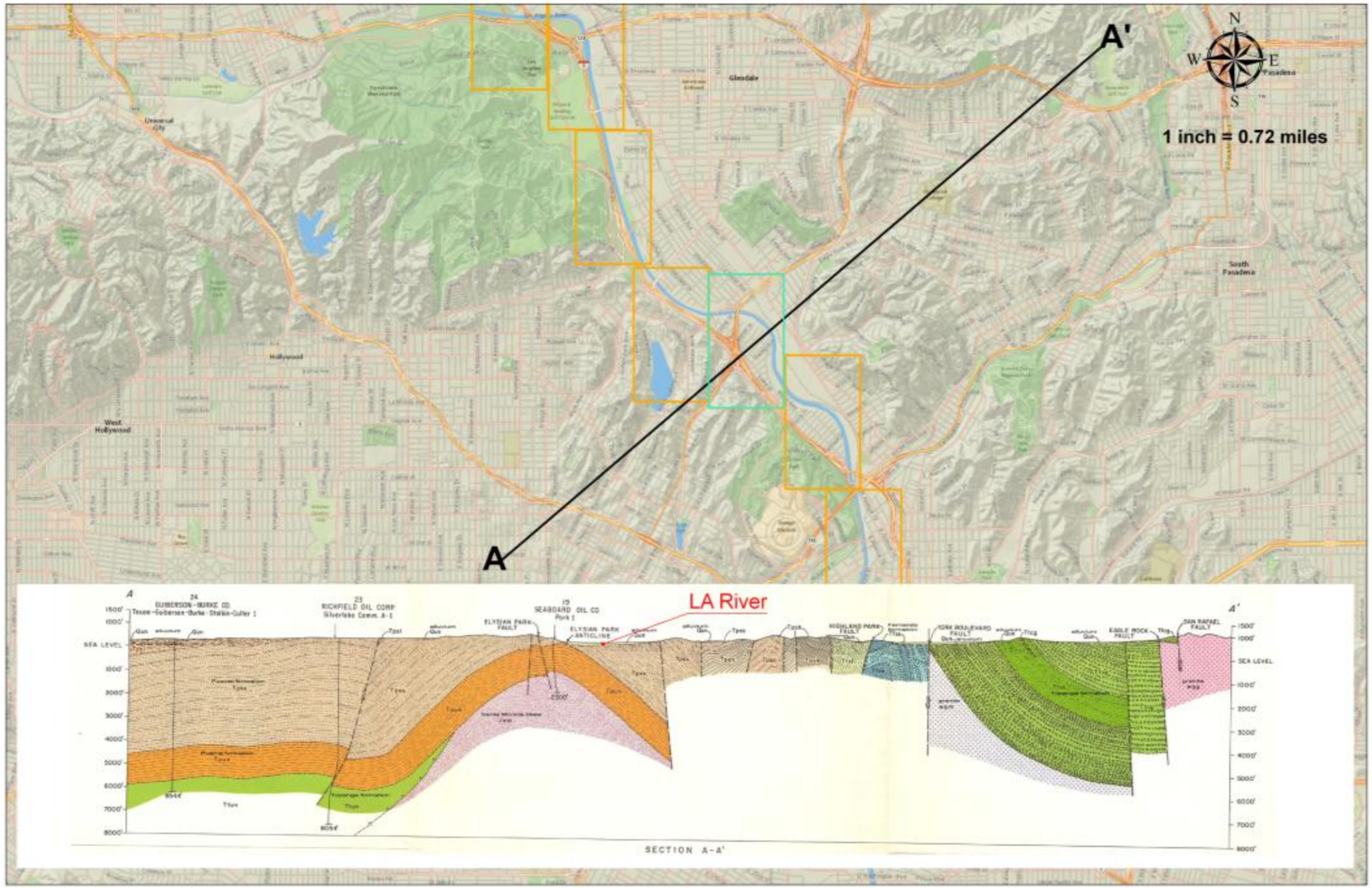

Map 7 of 8, Local Geology
Elysian Park fault
Los Angeles,
Legend
fault
Man Made fill
Recent alluvium sediment
Older alluvium sediment
Puente bedrock
Topanga bedrock
Granite bedrock
N
W
E
S
1 inch = 0.09 miles



Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 35
Local Geology Map

US Army Corps of Engineers
Los Angeles District
Geotech Branch



LA River Geologic Profile A to A'
"looking northwest"

Los Angeles River
Ecosystem Restoration Study
Geotechnical Feasibility Study

Figure 36
Local Geologic Cross Section

US Army Corps of Engineers
Los Angeles District
Geotech Branch

CESPL-ED-GD (1110) 10 May 2013

MEMORANDUM FOR RECORD

SUBJECT: Los Angeles River Ecosystem Restoration Study
Levee Condition Inspection and Issue Discussion

1. Reference:

ETL 1110-2-571, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures, 10 April 2009. Hereafter referred to as "the ETL".

2. General Background and Purpose:

a. As part of the Los Angeles River Ecosystem Restoration Study, the existing Los Angeles County Drainage Area (LACDA) flood risk management project within the study area along the Los Angeles River needed to be evaluated for areas that have leveed conditions. This memorandum is included as an attachment to the geotechnical portion of the study.

b. The National Levee Database (NLD) indicated that five levees are within the study area. These levees, known as LAR 2, LAR 3, LAR 5, LAR 6, and LAR 7, are depicted on Figure A1. This listing was made based on as-built documents and may not be reflective of current conditions.

c. Alternatives being studied as part of the ecosystem restoration will impact these levees by modifying or altering the original designed condition and will need to be designed and constructed in accordance with the latest guidance including but not limited to the ETL as referenced.

d. Existing field conditions of the levees were evaluated to determine if modifications had been made such that some river reaches were no longer levees in contrast to the conditions reflected in the NLD. Site visits were made on 23 and 25 October 2012 by Mr. Chris Spitzer of Soils Design and Materials Section, and Mr. Kelly Howard of the Operations and Maintenance Branch. The general conditions encountered, specifically whether a levee condition was present, are depicted on Figures A1 through A5. The locations and delineations of the conditions depicted on the figures are approximate.

e. Current assessment procedures for levees involve three steps. The steps can be generalized into 1) periodic inspection, 2) evaluation, and 3) delisting or deficiency correcting steps. Following construction of the levee, periodic inspection of the levee is to occur during which all deficiencies of the levee are noted and documented. Following the inspection, an evaluation of the deficiencies with respect to the Corps policies regarding vegetation, encroachments, and field conditions is made. From the evaluation, delisting recommendations or deficiency correcting actions are made. This procedure is independent of the ecosystem restoration project. It should be noted that the Los Angeles District is currently in the assessment process for the levees within the study area and actions regarding the levees will likely occur prior to completion of the ecosystem restoration project.

3. Observations:

Conditions were observed during the site visit and are described and depicted in the attached Photos. These conditions can be summarized in general as follows:

a. Landside conditions were observed as the landside was visually lower than the levee crest. As such, a levee condition still exists in these locations as delineated in the NLD. The approximate locations of these conditions are depicted in green on Figures A1 through A5.

b. Levee conditions were observed with limited overflow areas on the landside where drainage is directed immediately back to the river via storm drains (bathtub). The approximate locations of these conditions are depicted in yellow on Figures A1 through A5. These portions of the levee may have no residences or structures behind the crest and seemingly have no consequences.. However, if these portions were to overtop or fail, significant vehicular traffic impairment, property damage, or life loss could occur as a result. Additionally this failure may result in the shutdown of major thoroughfares (e.g. I-5) and significantly impact transportation and subsequently have significant economic impacts.

c. Landside encroachments (permitted or unpermitted) consisting of backfill or retaining walls that raised the adjoining property to a height at or above the levee crest were observed at several locations depicted in orange on Figures A1 through A5. This condition effectively makes these areas a non-levee condition. However, these areas and lengths may be required to function as part of a levee system (i.e. as a high ground tie in or hydraulically required for water surface elevations) and, if delisting is desired, will need to be evaluated on a case by case basis.

d. Landside encroachments (e.g., grading after as-builts) consisting of development that created a short leveed condition in order to provide interior drainage were observed on the right bank between LAR 2 and LAR 3. These locations are not shown on the map, but if they are part of new construction for the ecosystem restoration project, they will be evaluated for approval as if they were a levee.

4. Vegetation Guidance:

a. Existing vegetation issues were observed during the site visit. As stated above, these issues are being addressed by the assessment of the levees and not under the ecosystem restoration study. However, the study PDT needs to ensure that the features proposed under the study alternatives would be consistent with the vegetation guidance. The ETL applies to levees only and would not be applicable to channels that act as flood risk management structures except where engineering judgment dictates that such channel is an appurtenant structure to a levee. In addition, regardless of the ETL, if vegetation poses a threat to the integrity or maintainability of any flood risk management structure, such vegetation shall not be allowed in the design.

b. The ETL, in part, provides guidelines for maintaining levees, floodwalls,

embankment dams, and appurtenant structures free of vegetation other than grasses within a designated zone because "trees and other woody vegetation, such as shrubs and vines, can create both structural and seepage instabilities, prevent adequate inspection, and create obstacles to maintenance and flood-fighting/flood-control activities." Relevant figures from the ETL illustrating these VFZs are attached.

1. The ETL requires a vegetation free zone (VFZ) for levees as follows: "The vegetation-free zone is a three- dimensional corridor surrounding all levees, floodwalls, embankment dams, and critical appurtenant structures in all flood damage reduction systems. The vegetation-free zone applies to all vegetation except grass." The minimum width of such zone is the width of the levee, floodwall, or embankment dam, including all critical appurtenant structures, plus 15 feet on either side. Employing a lesser width of VFZ requires a variance unless the existing real estate rights do not provide the minimum width. Under specific site conditions, a greater width than the minimum may be required. (ETL, Sec. 2-2).
2. The ETL addresses environmental improvements and considerations for urban levees: "All levees must have effective and reliable erosion protection; the appropriate use of grasses is described in Paragraph 4-8. Where opportunities exist, environmental improvements should be considered. Project design shall address the following criteria: (1) Urban levees. Because levee projects have the potential to dominate these high-visibility landscapes, planting is often desirable, particularly in high-visibility locations, such as at and along major thoroughfares, parks, and waterfront developments." (ETL Sec 3).
3. The ETL addresses additional vegetation considerations for floodwalls as follows:
   "The minimum vegetation-free zone provides for access, but there are two additional areas of concern with respect to floodwalls. (1) Large trees can be a threat to project reliability. Planting design and maintenance must take into account the potential for overturning trees to damage floodwalls. (2) Planting design and maintenance must also take into account the three potential means by which tree roots may damage floodwalls." (ETL Sec 3).

5. Conclusions:

a. Based on visual observations, portions of the existing configuration no longer appear to meet the criteria of a levee condition and may be removed from the NLD at a future date. These areas will need to be accurately delineated in location and extent and ultimately approved as a non-levee condition by the District Levee

Safety Officer.

b. Portions that are listed and confirmed as levee through field observation have been noted as part of this effort. Any modifications by ecosystem restoration study to the levees will be made in accordance with current design practices and guidance pertaining to design and construction of levees.

6. PDT Approach to Leveed Conditions Under Alternatives in the Final Array:

Ecosystem restoration alternatives propose to modify the levees and/or include features adjacent to the levees. All modifications that are to be made to levee segments, will be in conformance with levee safety program policies. Discussion for each of the levee systems, the proposed measures, and their impacts to the levee are as follows:

a. Planting along each of the observed levee systems will conform to the ETL and design will conform to other levee guidance (including but not limited to EM 1110-2-1913 - Design and Construction of Levees).
b. All culvert daylighting will tie in to high ground for levee protection and will conform to the ETL, and design will conform to other Levee Guidance.
c. The Los Feliz Golf Course proposed diversion in the RIVER alternative (Alternative 20) would require the effective removal of the levee by using ungated pipes of restricted flow. As a result, property adjacent to the golf course may require flood reduction measure(s), which will be identified after Hydrology and Hydraulics analyses are performed during the F5 effort.
d. Proposed measures at the upstream end of LAR 6 in the RIVER alternative (Alternative 20) would remove portions of the levee toe by widening the river at the confluence of the river and Verdugo Wash. The resulting confluence will eliminate the need for a levee at the upstream end, create a tie-in with the adjacent landside topography, and will create a levee condition beginning at some location downstream of the confluence. Planting within this segment will conform to the ETL and other levee guidance.
e. Along LAR 3, in Griffith Park and Ferraro Fields, proposed diversions will result in a levee condition. This will require the new diversions/levees to conform to the ETL and design to conform to other levee guidance.
f. With respect to the segments that are listed in the NLD but were observed not to have levee conditions (portions of LAR 2 and LAR 5), the proposed project would treat them as levees subject to the ETL until delisting or HQUSACE direction that they can be treated as a non-levee condition. The application of the ETL would affect the type of vegetation that can be planted. The District has requested clarification from HQ about the application of the ETL for NLD-listed segments that do not have a levee condition. One direction from HQ stated that until LAR 5 and

LAR 2 are delisted, planting would need to conform to the ETL and design would need to conform to other Levee Guidance. HQ does not have a process for delisting yet, but this concern is being posed up the chain. Other HQ advisement has indicated that, if no levee condition exists, the ETL does not apply. This study is taking the approach that following levee assessment, if a portion of one of these levee reaches is determined to be a non-levee condition, as shown on Figures A1 through A5, then the ETL may not apply and a specified vegetation plan may be approved by the District Levee Safety Officer.

7. Current Levee Assessment Status

Currently the levees within the ARBOR Reach are being or are planned to be assessed in the next few years. Field inspection as part of the periodic inspection process was recently conducted for LAR 6. The Periodic Inspection Report is being prepared at this time for LAR 6. The other levees, LAR 2, LAR 3, LAR 5, and LAR 7, are scheduled to be inspected by 2016.

8. Limitations:

All of the above discussion is for planning and consideration purposes only. Further evaluation, analysis, and design will be required during future stages. In addition, conditions and guidance may change and may not be applicable at the time of design or during future studies.

Chris A. Spitzer, P.E.
Soils Design & Materials Section

Jody L. Fischer P.E.
Levee Safety Program Manager

Mark W. McLarty, C.E.G.
Geology & Investigation Section Chief

Encl: Selected Photos Showing Field Conditions
Relevant Figures from ETL 1110-2-571
Figures A1 through A5

CF: FAIRBANK (Dam Safety Program Manager
FARLEY (Geotechnical Branch)
LEIFIELD (Engineering Division)
BEAUCHAMP-HERNADEZ (Operations Branch)l

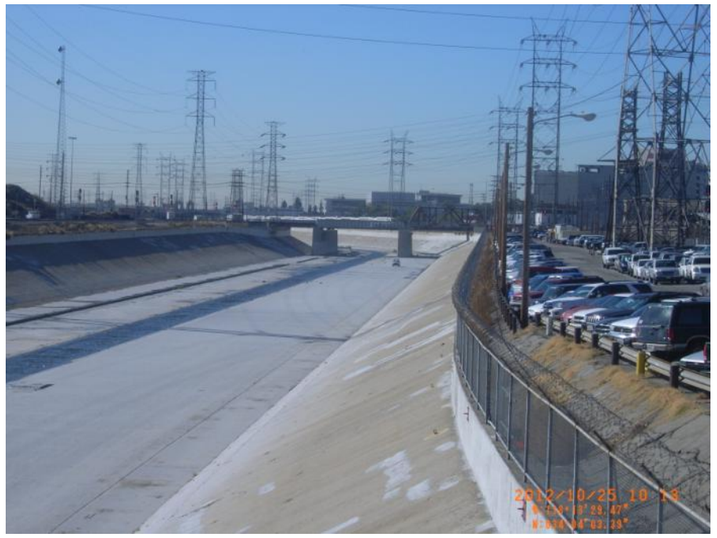


Photo 1: View looking downstream at N. Main Street. LAR 2 on right side. Not a levee condition. From top of wall and ascending slope approximately 5-feet in height with relatively level ground on landside.

Photo 2: View looking downstream at N. Main Street. LAR 5 on left side. Not a levee condition. Railroad embankment with ascending slope above top of wall. Photo 3 depicts landside condition further.

Photo 3: View looking downstream at N. Main Street. LAR 5 on right side. Not a levee condition. Ground in immediate foreground at approximately the same elevation of the wall depicted in Photo 2.

Photo 4: Looking upstream near downstream end of LAR 3. Not a levee condition. Ascending slope to high ground on landside. Vegetation would be within the VFZ if this portion is to remain listed as levee or is required for levee support upstream or downstream.

Photo 5: On crest of LAR 3 looking upstream. Not a levee condition. Although landside is slightly lower than crest. Flow would be directed along I-5 (on left) and the crest of the highway is above the crest of LAR 3.

Photo 6: Looking upstream along LAR 3 just upstream of Hyperion Ave. Not a levee condition. Grades for park are above crest.

Photo 7: Equestrian ramp and tunnel entrance. Note crest on right, highway on left. Tunnel and culvert at base of down-ramp in center.

Photo 8: Landside of tunnel culvert at end of tunnel in background. Tunnel height allows horse and rider to pass through without rider bending over. Note small wall in foreground as it is the same wall depicted in Photo 9.

Photo 9: Landside of tunnel looking upstream. Wall in foreground is the wall depicted in Photo 8. The building in background is at approximately same grade as top of tunnel.

Photo 10: Looking upstream on LAR 3 near Gene Autry Museum. Levee condition of approximately 2 to 4-feet exists and flow would be directed on I-5 and along levee. Southbound lanes are higher than northbound lanes.

Photo 11. At Ferraro Fields looking downstream on LAR 3. Levee condition beyond right of photo and vegetation on landside crest.

Photo 12: Equestrian undercrossing on landside of LAR 3. Photo taken at landside crest.

Photo 13: Landside of undercrossing on left side. Inlet of drain on right side.

Photo 15: Downstream of Riverside Drive looking downstream on LAR 7. Vegetation on landside.

Photo17: Looking upstream on LAR 7. Landside backfilled and not a levee condition.

Photo 14: Upstream end of LAR 3 looking downstream. Vegetation on landside.

Photo 16: Looking upstream on LAR 7. Levee condition and irrigation lines at riverside crest and across entire landside slope.I-5 in background.

Photo 18: Looking upstream on LAR 6. Vegetation on levee and cannot inspect toe with fence.

Photo 19: Atwater Park. Not a levee condition on LAR 6 but needed as levee conditions exist upstream and downstream.

Photo 21: Vegetation on landside and levee condition on LAR 6.

Photo 20: Los Feliz Golf Course. Vegetation on landside.

Photo 22: Taken in same vicinity of Photo 21 showing that this is a levee condition.

Figures from ETL 1110-2-571

The following figures (with ETL figure numbering) are from ETL 1110-2-571 and are representative of current or potential reconfiguration of the levees along the Los Angeles River.

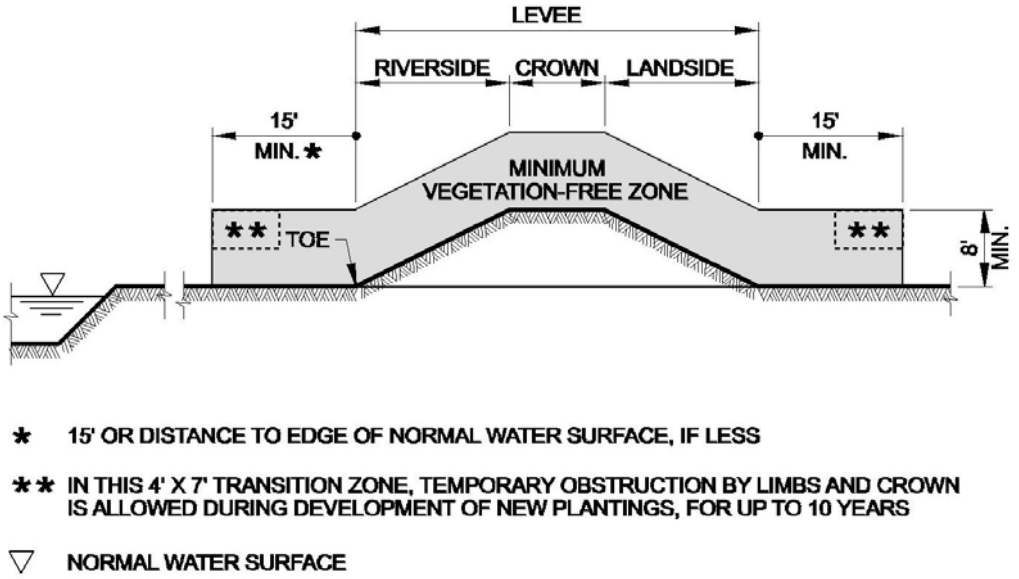


Figure 1: Levee Section – Basic

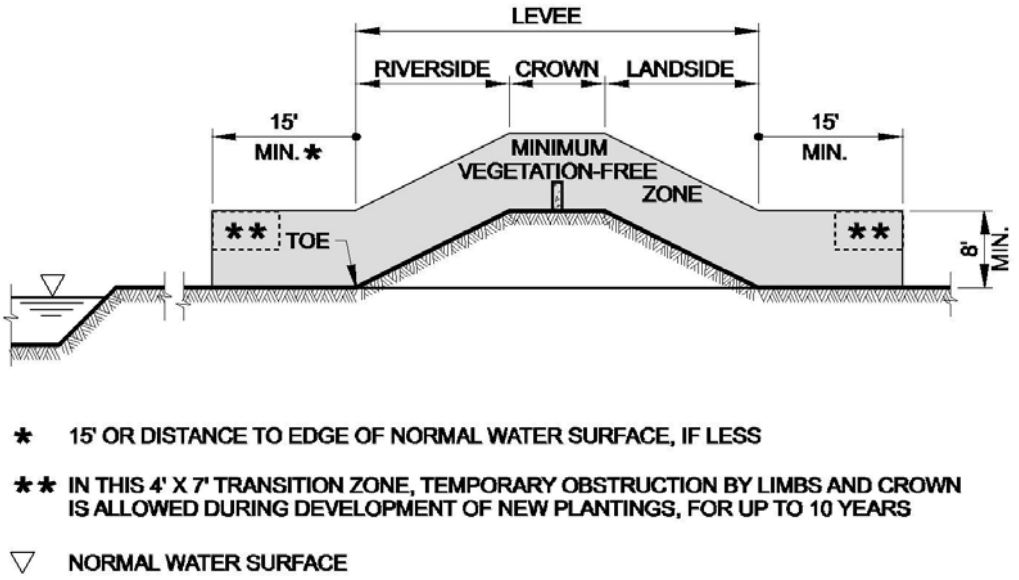
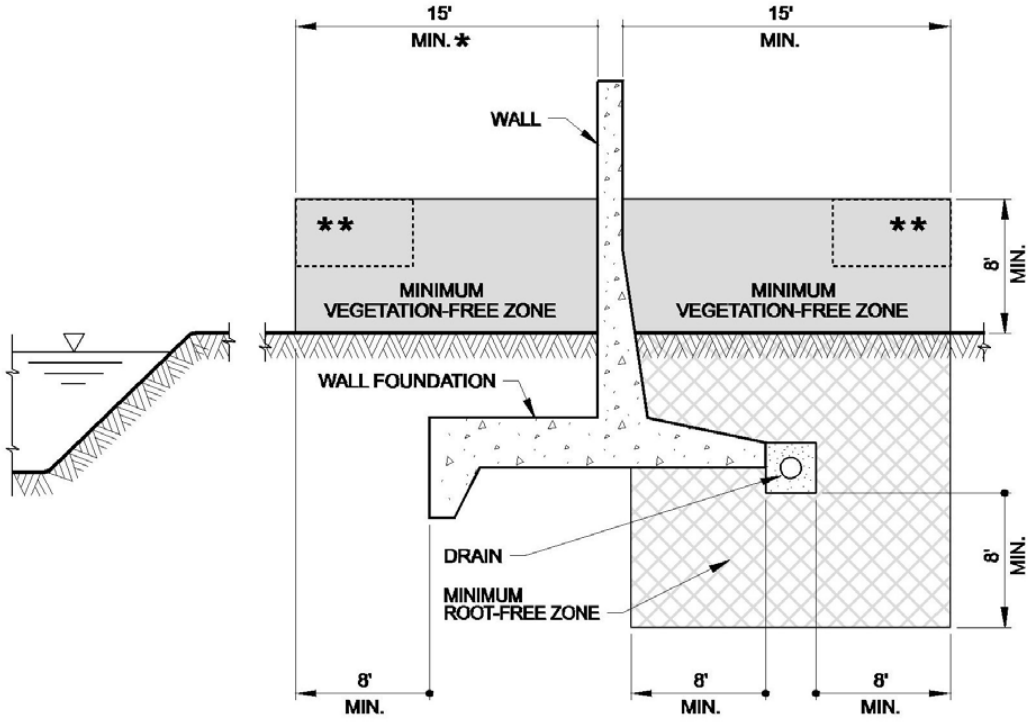


Figure 3: Levee Section – Basic, with Floodwall on Crown

Figures from ETL 1110-2-571



* 15' OR DISTANCE TO EDGE OF NORMAL WATER SURFACE, IF LESS

** IN THIS 4' X 7' TRANSITION ZONE, TEMPORARY OBSTRUCTION BY LIMBS AND CROWN IS ALLOWED DURING DEVELOPMENT OF NEW PLANTINGS, FOR UP TO 10 YEARS

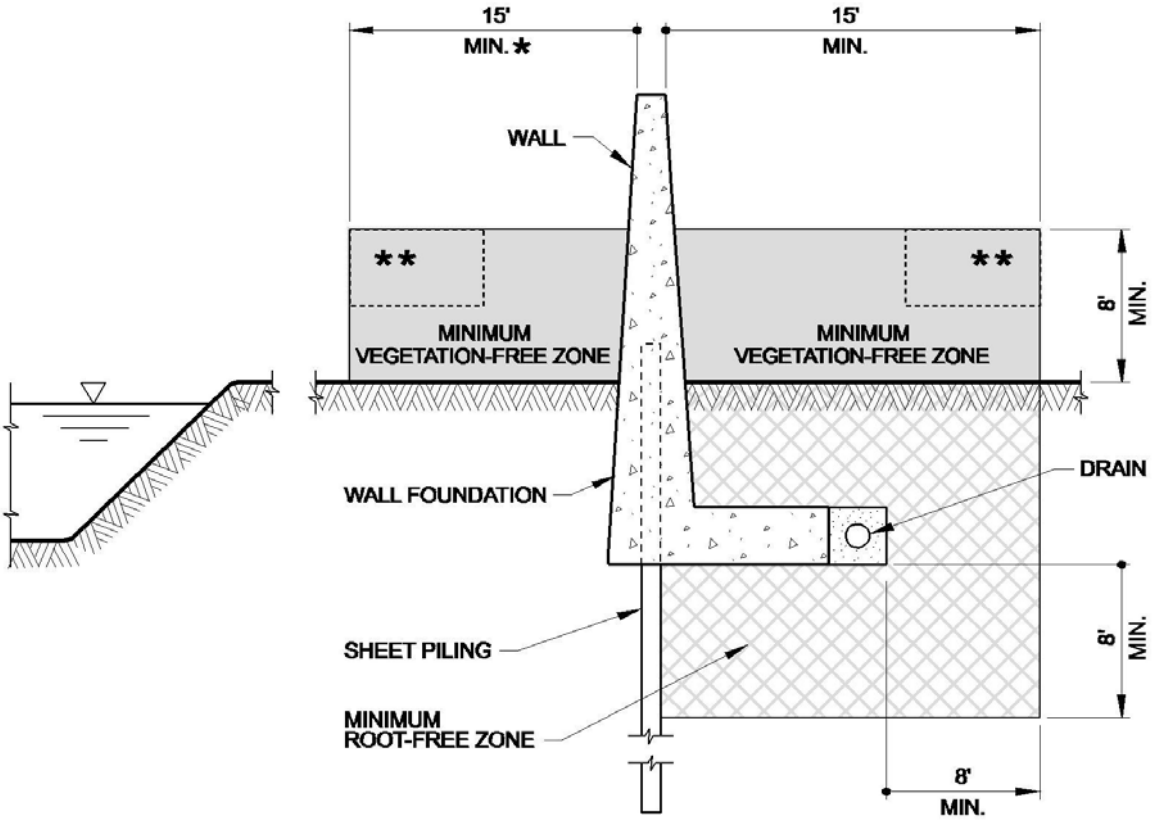
▽ NORMAL WATER SURFACE

NOTE: THE HORIZONTAL DIMENSION OF THE MINIMUM VEGETATION-FREE ZONE SHALL BE THE GREATER OF:

(A) THE 15-FOOT MINIMUM, AS DIMENSIONED ABOVE GRADE; OR
(B) AS DIMENSIONED FROM THE BELOW-GRADE STRUCTURE

Figure 17: Inverted-T Type Floodwall with Drain.

Figures from ETL 1110-2-571



* 15' OR DISTANCE TO EDGE OF NORMAL WATER SURFACE, IF LESS

** IN THIS 4' X 7' TRANSITION ZONE, TEMPORARY OBSTRUCTION BY LIMBS AND CROWN IS ALLOWED DURING DEVELOPMENT OF NEW PLANTINGS, FOR UP TO 10 YEARS

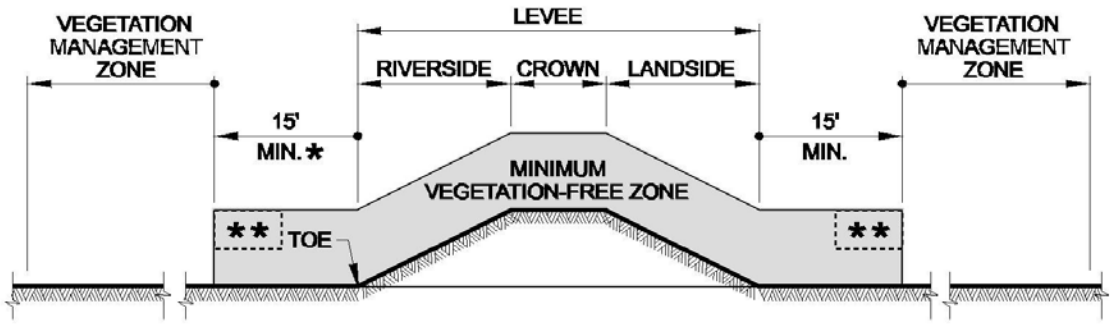
▽ NORMAL WATER SURFACE

NOTE: THE HORIZONTAL DIMENSION OF THE MINIMUM VEGETATION-FREE ZONE SHALL BE THE GREATER OF:

(A) THE 15-FOOT MINIMUM, AS DIMENSIONED ABOVE GRADE; OR
(B) AS DIMENSIONED FROM THE BELOW-GRADE STRUCTURE

Figure 19: Cantilever-I Type Sheet-Piling Floodwall with Drain.

Figures from ETL 1110-2-571



* 15' OR DISTANCE TO EDGE OF NORMAL WATER SURFACE, IF LESS

** IN THIS 4' X 7' TRANSITION ZONE, TEMPORARY OBSTRUCTION BY LIMBS AND CROWN IS ALLOWED DURING DEVELOPMENT OF NEW PLANTINGS, FOR UP TO 10 YEARS

▽ NORMAL WATER SURFACE

NOTES:

1. THE VEGETATION-MANAGEMENT ZONE ALLOWS FOR ACCESS, FOR THE PURPOSE OF INSPECTION, AND MODIFICATION OR REMOVAL OF ANY PLANT WHOSE LIMB, FOILAGE, OR ROOT BEHAVIORS BECOME A THREAT TO PROJECT RELIABILITY.
2. THE APPROPRIATE WIDTH OF THE VEGETATION-MANAGEMENT ZONE SHALL BE DETERMINED BY THE DESIGN TEAM: 35 FEET WILL BE SUFFICIENT IN MOST CASES.
3. THE VEGETATION-MANAGEMENT ZONE MAY BE ESTABLISHED BY EASEMENT.
4. THIS FIGURE SHOWS THE VEGETATION-MANAGEMENT ZONE IN THE CASE OF A LEVEE; HOWEVER, IT IS EQUALLY APPROPRIATE IN THE CASE OF ANY OTHER FLOOD DAMAGE REDUCTION STRUCTURE OR APPURTENANCE: IT'S USUAL RELATIONSHIP IS TO THE VEGETATION-FREE ZONE.

Figure 22: Vegetation-Management Zone.

Figures from ETL 1110-2-571

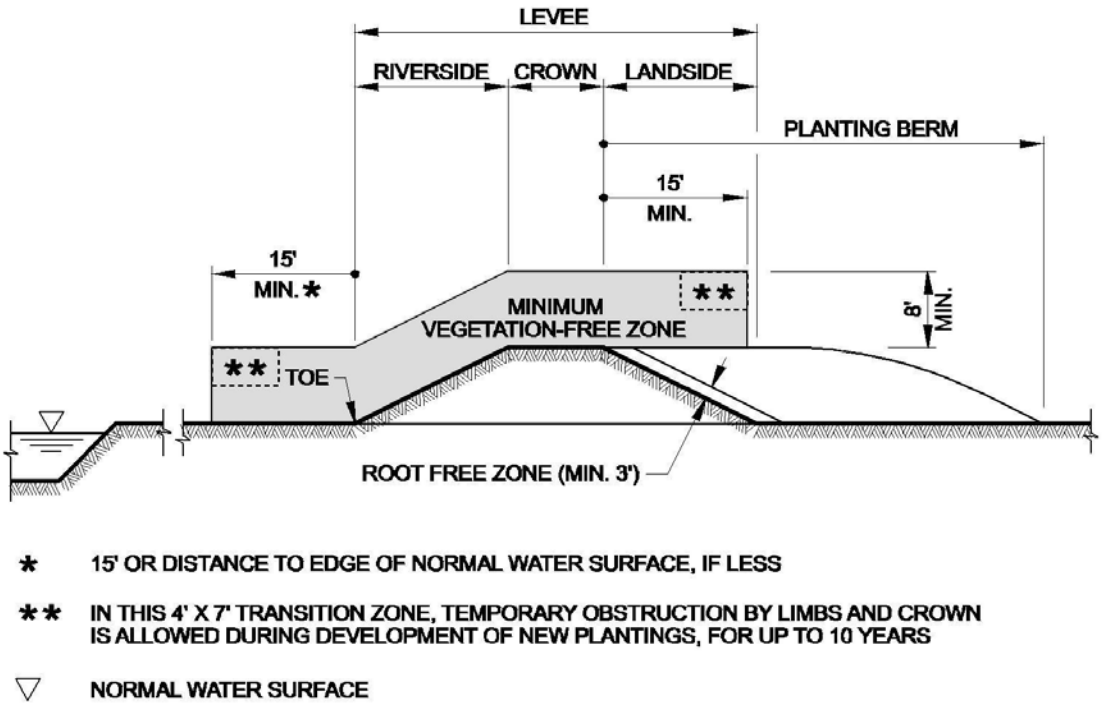
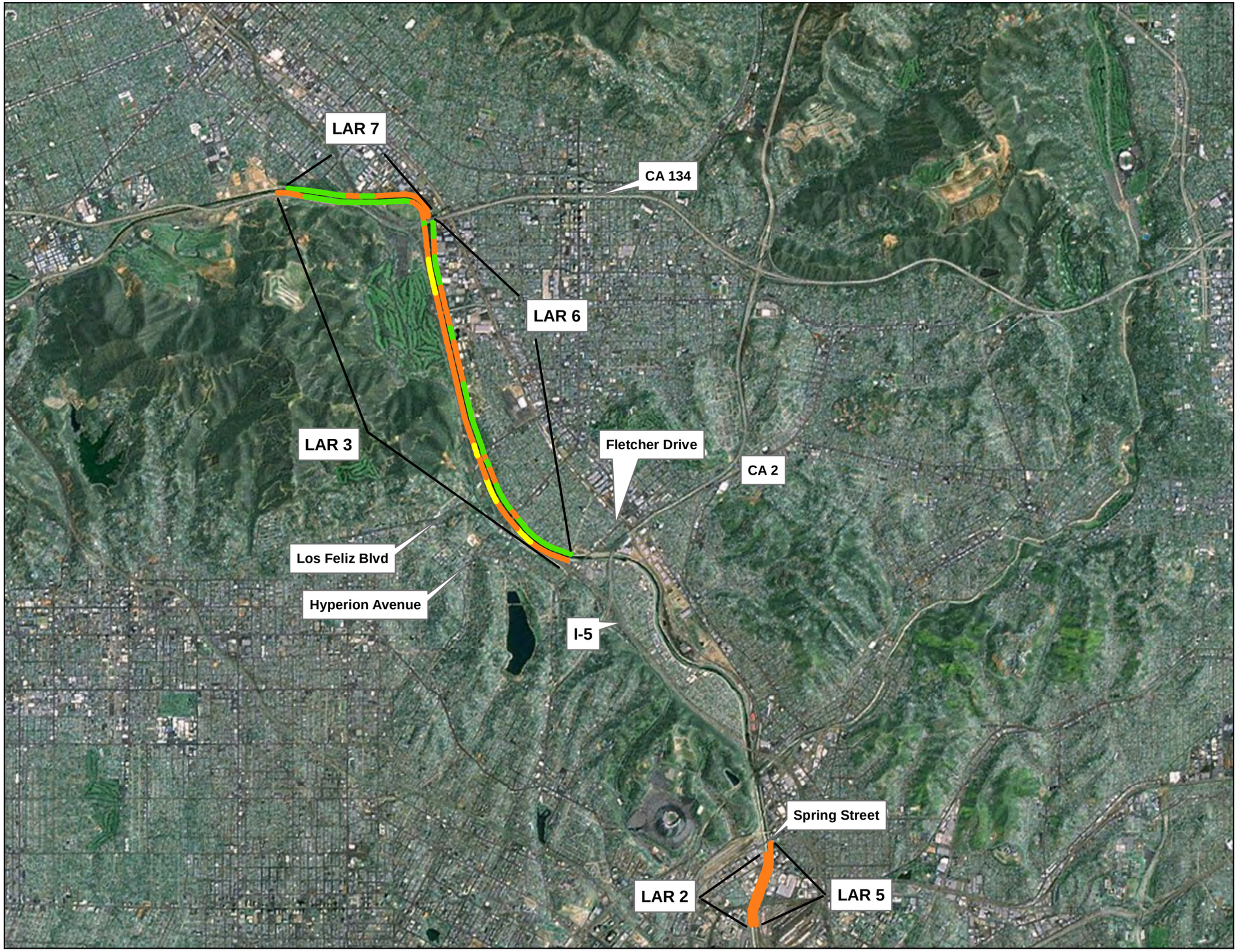
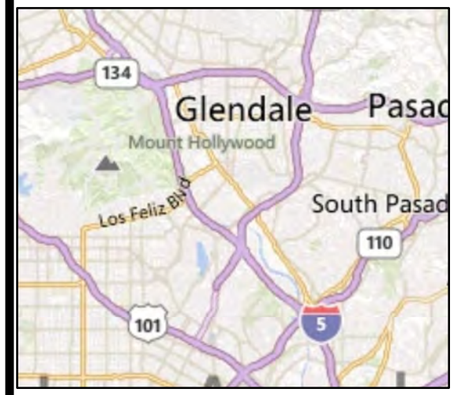


Figure 13: Levee Section with land side Planting Berm.





Legend

- Levee as indicated on plan and in field
- Not levee. Landside backfilled.
- Levees with bathtub condition

N

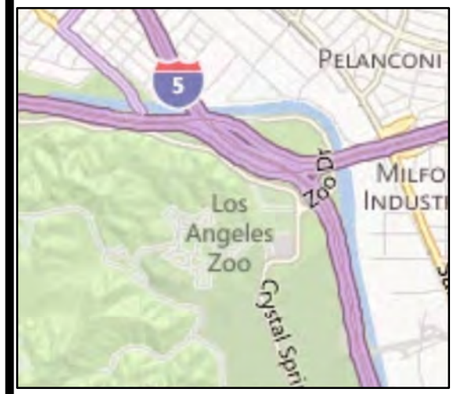
0 5,000 10,000 Feet

Los Angeles River Ecosystem Restoration Study

Levees LAR 2, LAR 3, LAR 5, LAR 6, and LAR 7 Field Levee Conditions

Figure A1

U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT



Legend

- Levee as indicated on plan and in field
- Not levee. Landside backfilled.
- Levees with bathtub condition

N

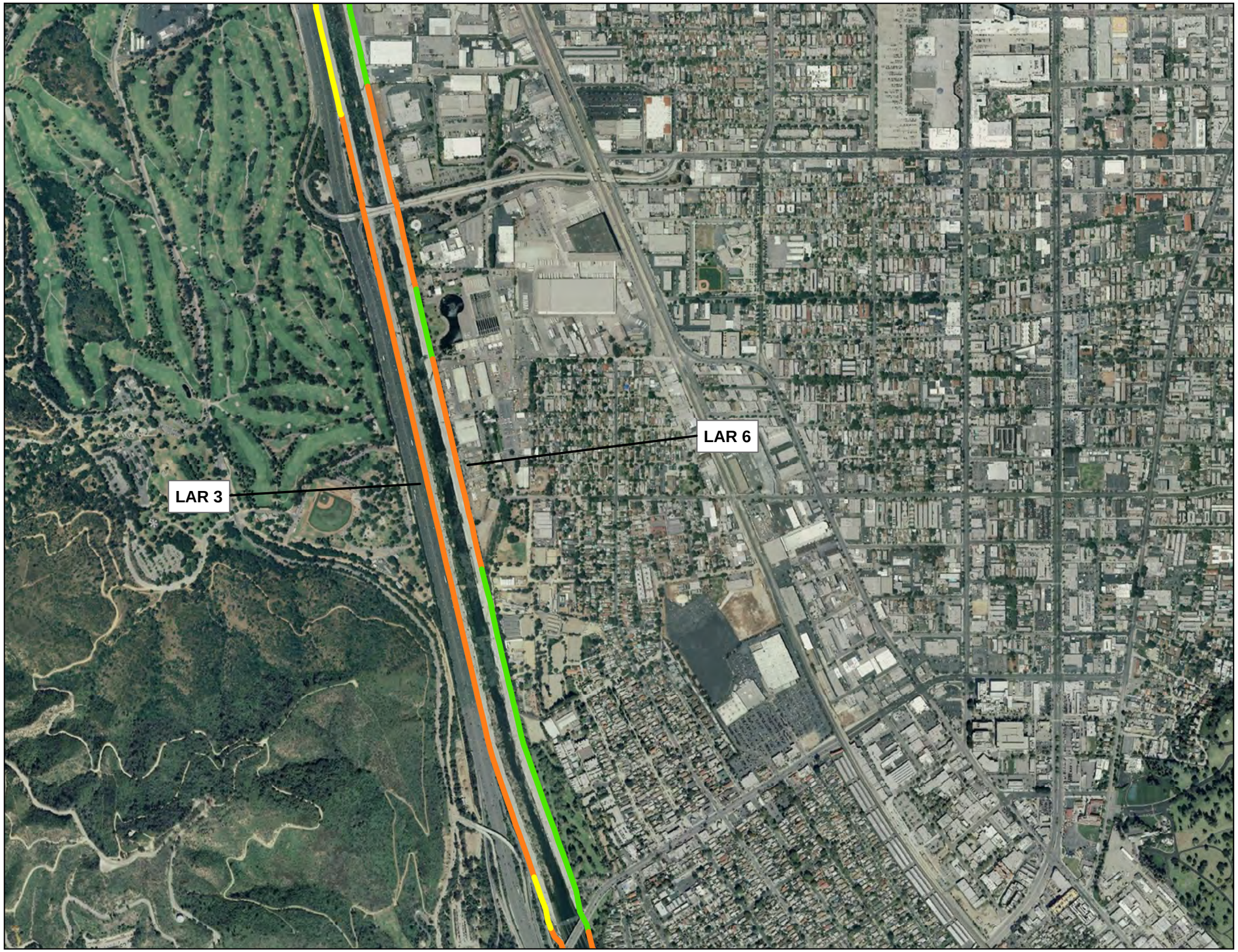
0 1,050 2,100 Feet

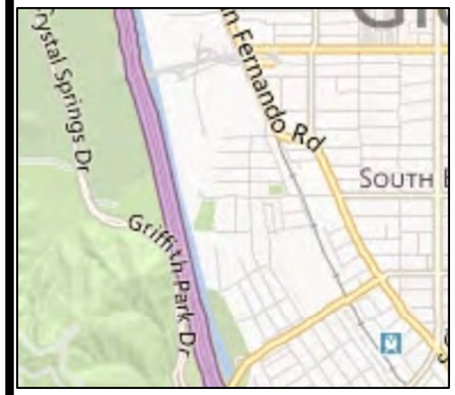
Los Angeles River Ecosystem Restoration Study

Levees LAR 2, LAR 3, LAR 5, LAR 6, and LAR 7 Field Levee Conditions

Figure A2

U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT





Legend

- Levee as indicated on plan and in field
- Not levee. Landside backfilled.
- Levees with bathtub condition

N

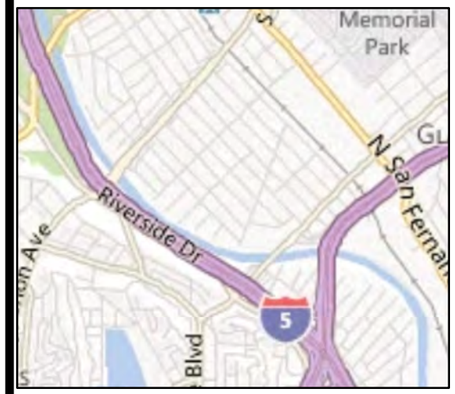
0 1,050 2,100 Feet

Los Angeles River Ecosystem Restoration Study

Levees LAR 2, LAR 3, LAR 5, LAR 6, and LAR 7 Field Levee Conditions

Figure A3

U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT



Legend

- Levee as indicated on plan and in field
- Not levee. Landside backfilled.
- Levees with bathtub condition

N

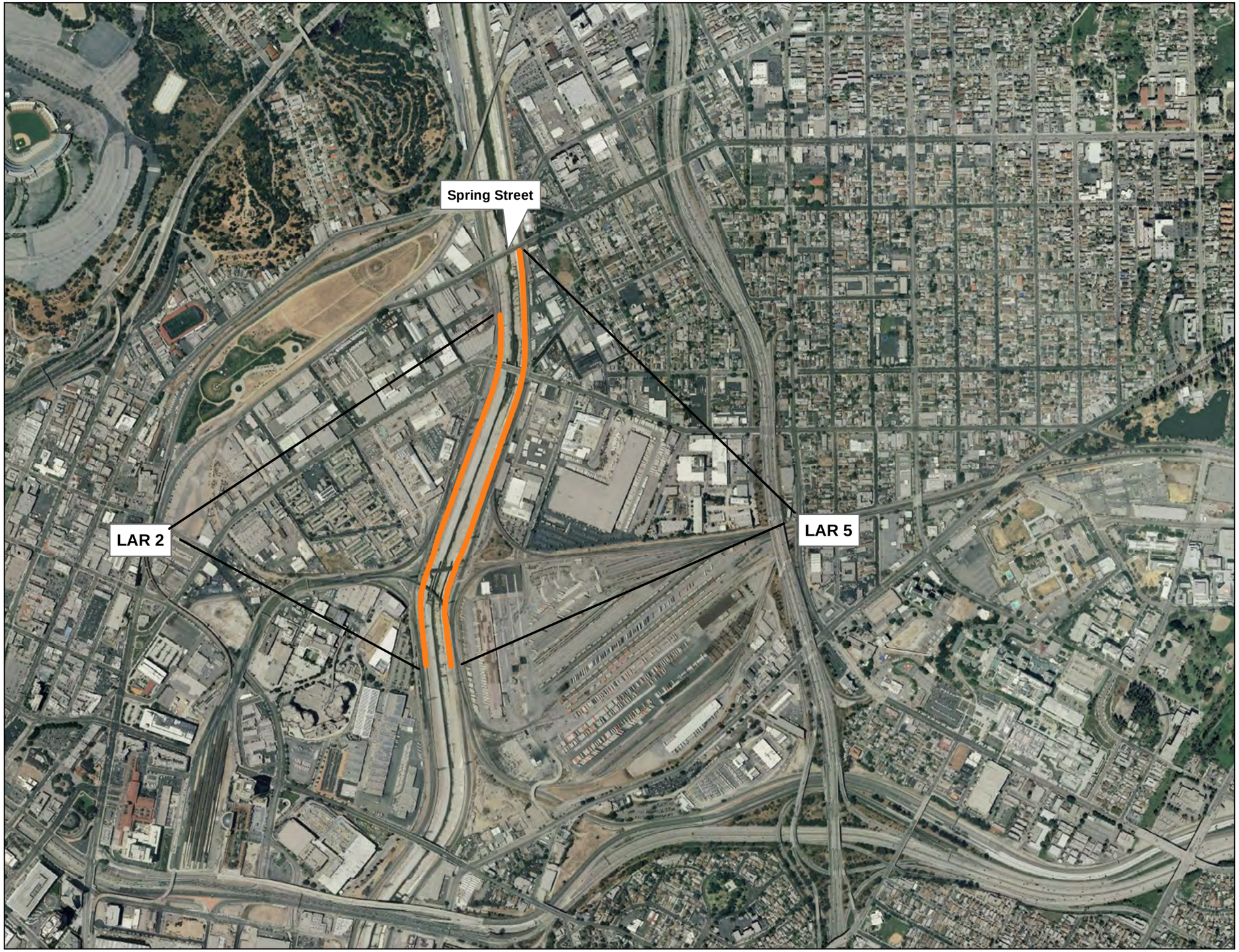
0 1,050 2,100 Feet

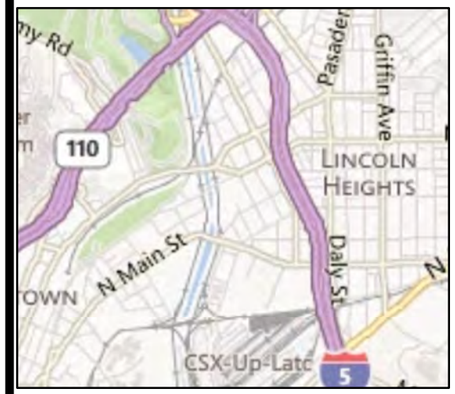
Los Angeles River Ecosystem Restoration Study

Levees LAR 2, LAR 3, LAR 5, LAR 6, and LAR 7 Field Levee Conditions

Figure A4

U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT





Legend

- Levee as indicated on plan and in field
- Not levee. Landside backfilled.
- Levees with bathtub condition

N

0 1,050 2,100 Feet

Los Angeles River Ecosystem Restoration Study

Levees LAR 2, LAR 3, LAR 5, LAR 6, and LAR 7 Field Levee Conditions

Figure A5

U.S. ARMY CORPS OF ENGINEERS LOS ANGELES DISTRICT