

## **APPENDIX E3**

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### **EIR LEVEL GEOTECHNICAL FEASIBILITY INVESTIGATION**



**GEOTECHNICAL GROUP, INC.**

Soil Engineering ▲ Geology ▲ Environmental

**EIR LEVEL GEOTECHNICAL  
FEASIBILITY INVESTIGATION  
GATEWAY AT GRAND TERRACE  
SPECIFIC PLAN AND HOMECOMING PROJECT  
CITY OF GRAND TERRACE  
SAN BERNARDINO COUNTY, CALIFORNIA**

**PROJECT NO. 33318C.1  
JULY 31, 2018**

Prepared For:

Lewis Management Corp.  
1156 N. Mountain Avenue  
Upland, California 91786

Attention: Mr. Steven Johnson



July 31, 2018

Lewis Management Corp.  
1156 N. Mountain Avenue  
Upland, California 91786

Project No. 33318C.1

Attention: Mr. Steven Johnson

Subject: EIR Level Geotechnical Feasibility Investigation, Gateway at Grand Terrace Specific Plan and Homecoming Project, Grand Terrace, San Bernardino County, California.

LOR Geotechnical Group, Inc. is pleased to present this report summarizing our Geotechnical Feasibility Study for the proposed mixed-use, commercial and residential development. This report was based upon a scope of services generally outlined in our Work Authorization Agreement dated June 26, 2018, and other written and verbal communications with you.

In summary, it is our opinion that the site can be developed from a geotechnical perspective, provided the recommendations presented in the attached report are incorporated into design and construction. Supplemental investigation of specific development areas is recommended as design planning is formalized. The following executive summary reviews some of the important elements of the project, however, this summary should not be solely relied upon.

To provide adequate support for the proposed structures, we recommend that a compacted fill mat be constructed beneath footings and slabs. The compacted fill mat will provide a dense, high-strength soil layer to all undocumented fill material and any loose alluvial materials should be removed from areas to receive engineered compacted fill. The data developed during this investigation indicates that average removal depths of approximately 2 to 6 feet below existing grades will be required within the majority of the site. However, deeper removals ranging from approximately 10 to 15 feet will be required within the drainage courses that traverse the central and northern portions of the property and undocumented fills are also present as stockpiles and as graded areas within portions of many of the parcels.

Soils with low expansion index and a negligible sulfate content soils were encountered on the site. In addition, our test results for a representative sample indicate a low to moderate R-value for pavement design.

**LOR Geotechnical Group, Inc.**



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## **INTRODUCTION**

During July of 2017, an EIR Level GEOTECHNICAL Feasibility Investigation was performed by LOR GEOTECHNICAL Group, Inc., for the Gateway at Grand Terrace Specific Plan and Homecoming Project which is a proposed master planned, mixed use development of 25 parcels of land generally located north of Main Street, west of Michigan Avenue, south of Commerce Way, and east of Interstate 215, in the City of Grand Terrace, California. The purpose of our investigation was to provide a technical evaluation of the geologic setting of the site and to provide feasibility level GEOTECHNICAL design recommendations for the proposed development. The scope of our services included:

- Review of available GEOTECHNICAL literature, reports, maps, and agency information pertinent to the study area;
- Geologic field reconnaissance mapping to verify the areal distribution of earth units and significance of surficial features as compiled from documents, literature, and reports reviewed;
- A limited subsurface field investigation to determine the general physical soil conditions pertinent to the proposed development;
- Laboratory testing of selected soil samples obtained during the field investigation;
- Development of general GEOTECHNICAL recommendations for site grading and foundation design; and
- Preparation of this report summarizing our findings, and providing conclusions and recommendations for site development.

The approximate location of the site is shown on the attached Index Map, Enclosure A-1, within Appendix A.

To orient our investigation at the site, a Preliminary Road Alignment and Ownership Exhibit was furnished for our use. This map identifies the 25 individual parcels that comprise the Gateway at Grand Terrace Specific Plan and Homecoming Project. A copy of this image has been utilized as a base for our GEOTECHNICAL Map, Enclosure A-2, in Appendix A.

## **PROJECT CONSIDERATIONS**

Information furnished to this firm indicates the project will consist of the construction of both apartment and single-family residences and commercial developments. Although specific information pertaining to the types of structures that will be built was unavailable at this



time, they are anticipated to mainly consist of one to two story residences, multi-level apartments of wood or metal frame construction with plaster veneer exterior. Commercial development may include concrete masonry type structures. Light to moderate foundation loads are anticipated with such structures. Grading plans were also not available at this time. It is likely that grading will entail fill placement within low-lying areas and the creation of gently sloping pad areas.

### **EXISTING SITE CONDITIONS**

The site consists of 25 parcels which are all interconnected and generally located north of Main Street, west of Michigan Avenue, south of Commerce Way, and east of Interstate 215 in the city of Grand Terrace, San Bernardino County, California. At the present time, the majority of the sites are undeveloped and consist of lightly disturbed, natural land. The remainder of the site contains a diverse mixture of developments and improvements. A brief summary of the existing parcel conditions is as follows. Parcel two, in the far northern portion, has both previously and currently been utilized as a staging area for adjacent freeway improvements and contains moderate to significant amounts of undocumented fill soils associated with past and current usage. Parcels 1, 5, 6, 11, 14 and 18 are located adjacent to the east side of Interstate 215. Each of these parcels is associated with Caltrans, electrical power transmission, the Riverside Canal, waterlines, sewer lines, and/or flood control/drainage. Parcel 10 is a self storage facility that includes several permanent structures as well as shipping containers. Parcels 4, 15, 16, 17, and 25 are small parcels that contain local water company water wells. Parcels 3, 7, 8, 9, and 17 are rural residential properties while parcel 20 is a railroad easement for Burlington Northern and Santa Fe that extends north along the east side of Taylor Street. Parcels 12, 19 and 21 are vacant fields, with past use and graded site conditions apparent within the southern part of Parcel 19 and the far southwest portion of parcel 21. Parcel 22 is an electrical substation that is in the process of being modernized. Parcel 23 is the site of the Riverside Canal Power Company. This industrial property was closed many years ago and is slowly being raised. Parcel 24 is the site of Cage Park which also closed many years ago and is in a state of disrepair.

Access to the northern portions of the site is from several paved roads that enter from the east. These include Commerce Way, De Berry Street, and Van Buren Street. Locked gates prevent access to the central portion of the property while Taylor Street enters the site off of Main Street and extends north approximately one-half mile. Overall, the site directs runoff to the west as well as toward local streets and both man-made and earthen drainage channels. Vegetation consists mostly of annual grasses and weeds with trees and brush

present locally along the drainage channels. Other, imported trees, including eucalyptus and olive, are also present locally.

Two, approximately 10-foot deep excavations are located within the southern portion of Parcel 19. These apparently were made sometime prior to 1955 to hold three large diameters, steel storage tanks that were onsite from at least the early 1950's through the late 1990's.

The site is bound by Interstate 215 on the northwest, by railroad tracks on the southwest, by Main Street on the south and by mixed residential and commercial properties on the northeast and east. Grand Terrace High School and associated ballfields are present to the south and east.

This firm previously conducted two separate Preliminary GEOTECHNICAL Investigations for some of the site parcels. These included Parcel 3 (LOR, 2017a) and Parcels 12, 19 and 21 (LOR, 2017b).

### **AERIAL PHOTOGRAPH ANALYSIS**

A search was conducted for available aerial photographs of the area on file at the San Bernardino County Flood Control and Transportation department aerial photography collection, by a geologist from this firm. The search found aerial photographs taken of the site and surrounding area at various times between 1938 and 2005.

The aerial photographs reviewed consisted of vertical aerial stereoscopic photograph pairs of varying scales. These photographs were viewed using stereoscopes with magnifications of 2X and 4X for three-dimensional enhancement. Cultural developments as well as geologic features were noted. A complete list of the San Bernardino County Flood Control and Transportation department photographs studied is given in the references at the back of this report. In addition, we reviewed imagery available from GOOGLE Earth (2018) and from Historic Aerials (NETRONLINE, 2018).

Review of the aerial imagery indicates that prior to the middle of the last century, much of the site was utilized for agricultural purposes. These included walnut and citrus groves and also dry farmed land. Commercial, residential, and light industrial development replaced some of the agricultural land after this time, but much of the agricultural land was simply cleared and left as vacant land. Interstate 215, to the northwest, was constructed during the late 1960's and early 1970's. Other than modification and demolition activities within

the areas of the substation and power plant, light alteration of the property during construction of the adjacent high school, and the addition of the self storage facility in the northern portion, the majority of the site has changed little since the 1970's. No evidence for the presence of faults traversing the site area or mass movement features were noted during our review of the photographs covering the site and nearby vicinity.

### **SUBSURFACE FIELD INVESTIGATION**

Our subsurface field exploration program was conducted on July 2<sup>nd</sup> and 3<sup>rd</sup> of 2018 and consisted of advancing 13 exploratory borings using a truck mounted Mobile B-61 drill rig equipped with 8-inch diameter hollow stem augers. The borings were drilled to depths ranging from approximately 21 to 51.5 feet below the existing ground surface. Relatively undisturbed in-place and bulk samples of the materials encountered were obtained and returned to our geotechnical laboratory for further testing and evaluation. The approximate locations of our exploratory borings are presented on the attached Geotechnical Map, Enclosure A-2, Appendix A.

Logs of the subsurface conditions encountered in the exploratory borings were maintained by a geologist from this firm. A detailed description of the field exploration program and boring logs is presented in Appendix B.

### **LABORATORY TESTING PROGRAM**

Selected soil samples obtained during the field investigation were subjected to laboratory testing to evaluate their physical and engineering properties. Laboratory testing included moisture content, dry density, laboratory compaction, direct shear, sieve analysis, expansion potential, Atterberg limits, R-Value, and soluble sulfate content. A detailed description of the laboratory testing program and the test results are presented in Appendix C.

### **GEOLOGIC CONDITIONS**

The site is located within the northeastern portion of the Riverside area which in turn lies within the northern end of the Perris Valley. The property is situated between the La Loma Hills to the west and the Box Springs Mountains to the east and southeast. This area is located on the Perris block within the northern Peninsular Ranges geologic province of southern California. While the Perris block is considered to be a relatively stable structural block, it is bounded by active faults. These include the Elsinore fault zone on the



southwest, the San Jacinto fault zone on the northeast, and the Cucamonga fault zone on the north. The Perris block is underlain predominately by a very large mass of crystalline igneous rocks of Cretaceous age and older metasedimentary and metavolcanic rocks.

The Perris block has a series of erosional surfaces, marked by low topographic relief and capped with unconsolidated alluvial sediments stripped from the surrounding highlands, such as the La Loma Hills and Box Springs Mountains. This region including and around the site was mapped by the California Division of Mines and Geology as being underlain by deposits of relatively well-indurated, reddish-brown, older alluvium (Morton and Miller, 2003, and Dibblee, 2003).

The nearest known active fault zone is the San Jacinto fault zone located approximately 3.7 kilometers (2.3 miles) to the northeast. Other major faults within the region include the San Andreas fault zone located approximately 16 kilometers (10 miles) to the northeast, the Cucamonga fault zone located approximately 20 kilometers (12.5 miles) to the northwest, and the Elsinore fault located approximately 31 kilometers (19.5 miles) to the southwest.

The site and the regional geologic setting are shown on Enclosure A-3, within Appendix A.

#### Site Geologic Conditions

The subject site is underlain by surficial topsoil and localized fill soils followed by thick older alluvial materials. Within the drainages that traverse the central and northern portions of the site, younger alluvial soils are present. The earth materials encountered during our site investigation are described in detail on the Boring Logs within Appendix B and are generally described as follows:

Undocumented Fill: Virtually all of subject site parcels contain some amount of undocumented fill soil material. The undocumented fill soils range from disced topsoil to imported fill soils up to and locally exceeding several feet in thickness. The several small parcels located adjacent to and southeast of Interstate 215 all have fill present as a result of installation of local improvements (electric transmission lines, the Riverside Canal, drainage ditches, railroad construction, waterlines and other underground utilities and/or freeway construction). Parcel 2 contains fill soils of variable thickness across virtually the entire parcel with the deepest fills likely associated with placement within and across former natural drainage courses. Parcel 13 also contains a considerable amount of

undocumented fill soils. These are in the form of numerous end dumped piles of imported soils. These piles range from a few to approximately 10 feet in height. Undocumented fills are also, of course, present adjacent to and beneath the other existing structural improvements including residences, the storage facility, the Riverside Canal Power Company property, and the electric power substation. Undocumented fill soils created during grading of local areas are also present within Parcel 19 and the southwest portion of Parcel 21.

Topsoil: Mantling the surface of the central portion of the site are topsoil materials that consist of silty sand. Topsoil materials are also present locally in the northeastern portion of the site where the land has not been significantly disturbed through past use. These soils average approximately 1.5 to 2 feet in thickness and are relatively loose.

Younger Alluvium: Relatively young alluvial soils are present within the main drainage courses that traverse the northern portion of the site from east to west. In some areas, particularly in the far northern portion (Parcels 2 and 3), the alluvial channels have been covered by undocumented fill soils. The younger alluvial materials consist mainly of loose to medium dense silty sand with well graded sand soils at depth. As encountered within our exploratory borings, these sediments were found to locally exceed 10 to 15 feet in thickness.

Older Alluvium: Older alluvium is present at shallow depth across the site and underlies the fill soils and younger alluvium. In general, the older alluvium consists of dense silty sand to stiff sandy silt in the near surface and generally becomes sandier with increase in depth. The dense silty sand and the sandy silt layers are typically massive and occasionally porous in the near surface. However, the porosity decreases below the first couple of feet and a blocky soil structure is evident in the deeper, denser materials.

#### Groundwater Hydrology

Groundwater was not encountered in any of our exploratory borings, nor was any groundwater seepage observed during our site reconnaissance. Regional studies by Carson and Matti (1985) indicate that the past depth to groundwater at the site is on the order of 100 to 120 feet beneath the site. Recent groundwater data for a well located just southeast of the intersection of Main Street and Taylor Street indicates that the depth to groundwater at that location ranged from 157 to 177 feet during the time period from October 2011 to March of 2016. According to the Western Municipal Water District and the San Bernardino Valley Water Conservation District Cooperative Well Measuring Program,

the depth to groundwater was approximately 160 to 170 feet in nearby wells during the fall of 2014. The anticipated groundwater flow direction below the site is anticipated to be to the southwest following the regional surface topography.

#### Surface Runoff

Current surface runoff of precipitation waters across the site is largely from the east to the west. Runoff occurs as sheetflow into the onsite drainage course and then offsite to the west.

#### Mass Movement

The majority of the site consists of relatively flat surfaces with gently sloping areas in between. Locally, along the drainage course in the west-central portion of the property, the slopes approach 2:1 (horizontal to vertical). However, considering the site geologic conditions and the overall gently sloping nature of the property, the potential for mass movement failures such as landslides or debris flows is considered very low. In addition, no loose, un-rooted rocks that could fall or topple and roll were noted to be present above at or above the site and the potential for rockfalls occurring at the site is also considered to be nil.

#### Faulting

No active or potentially active faults are known to exist at the subject site. In addition, the subject site does not lie within a current State of California Earthquake Fault Zone (Hart and Bryant, 1995). No evidence of faulting was noted during our field reconnaissance nor during our review of aerial photographs covering the property and immediate surrounding region. The closest known active fault is the San Jacinto fault zone, located approximately 3.7 kilometers (2.3 miles) to the northeast.

The San Jacinto fault zone is a sub-parallel branch of the San Andreas fault zone, extending from the northwestern San Bernardino area, southward into the El Centro region. This fault has been active in recent times with several large magnitude events. It is believed that the San Jacinto fault is capable of producing an earthquake magnitude on the order of 6.5 or greater. Other faults in the region include the San Andreas fault located approximately 16.0 kilometers (10.0 miles) to the northeast, the Cucamonga fault located approximately 20 kilometers (12.5 miles) to the northwest, and the Elsinore fault approximately 31 kilometers (19.5 miles) to the southwest.



The San Andreas fault is considered to be the major tectonic feature of California, separating the Pacific plate and the North American plate. While estimates vary, the San Andreas fault is generally thought to have an average slip rate on the order of 24mm/yr and capable of generating large magnitude events on the order of 7.5 or greater.

The Cucamonga fault is considered to be part of the Sierra Madre fault system which marks the southern boundary of the San Gabriel Mountains. This is a north dipping thrust fault which is believed to be responsible for the uplift of the San Gabriel Mountains. It is believed that the Cucamonga fault is capable of producing an earthquake magnitude on the order of 7.0.

The Elsinore fault zone is one of the largest in southern California. At its northern end it splays into two segments and at its southern end it is cut by the Yuba Wells fault. The primary sense of slip along the Elsinore fault is right lateral strike-slip. It is believed that the Elsinore fault zone is capable of producing an earthquake magnitude on the order of 6.5 to 7.5.

Recent and sometimes current standards of practice have included a discussion of all potential earthquake sources within a 100 kilometer (62 mile) radius. However, while there are other large earthquake faults within a 100 kilometer (62 mile) radius of the site, none of these are considered as relevant to the site as the faults described above, due to their greater distance and/or smaller anticipated magnitudes.

#### Historical Seismicity

In order to obtain a general perspective of the historical seismicity of the site and surrounding region, a search was conducted for seismic events at and around the area within various radii. This search was conducted utilizing the historical seismic search program by EPI Software, Inc. (Reeder, 2000). This program conducts a search of a user selected cataloged seismic events database, within a specified radius and selected magnitudes, and then plots the events onto an overlay map of known faults. For this investigation the database of seismic events utilized by the EPI program was obtained from the Southern California Seismic Network (SCSN) available from the Southern California Earthquake Center. At the time of our search the data base contained data from January 1, 1932 through December 2010.

In our first search, the general seismicity of the region was analyzed by selecting an epicenter map listing all events of magnitude 4.0 and greater, recorded since 1932, within

a 100 kilometer (62 mile) radius of the site, in accordance with guidelines of the California Division of Mines and Geology. This map illustrates the regional seismic history of moderate to large events. As depicted on Enclosure A-4, within Appendix A, the site lies within a relatively active region associated with the San Jacinto fault zone trending southeast to northwest. Of these events, the closest was a magnitude 4.7 located within one kilometer of the site.

In the second search, the micro seismicity of the area lying within a 10 kilometer (6.2 mile) radius of the site was examined by selecting an epicenter map listing events on the order of 1.0 and greater since 1978. In addition, only the "A" events, or most accurate events were selected. Caltech indicates the accuracy of the "A" events to be approximately 1 km. The result of this search is a map that presents the seismic history around the area of the site with much greater detail, not permitted on the larger map. The reason for limiting the events to the last approximately 40 years on the detail map is to enhance the accuracy of the map. Events recorded prior to the mid 1970's are generally considered to be less accurate due to advancements in technology. As depicted on this map, Enclosure A-5, the San Jacinto fault zone appears to be the source of numerous events.

In summary, the historical seismicity of the site entails numerous small to medium magnitude earthquake events occurring around the subject site, predominately associated with the presence of the San Jacinto fault. Any future developments at the subject site should anticipate that moderate to large seismic events could occur very near the site.

#### Secondary Seismic Hazards

Other secondary seismic hazards generally associated with severe ground shaking during an earthquake include liquefaction, seiches and tsunamis, earthquake induced flooding, landsliding and rockfalls, and seismic-induced settlement.

Liquefaction: The potential for liquefaction generally occurs during strong ground shaking within granular, loose sediments where the depth to groundwater is usually less than 50 feet. As the site is underlain at depth by dense, older alluvium; the upper, loose alluvial soils are anticipated to be replaced as engineered compacted fill; and the depth to groundwater is on the order of 100 feet or more, the possibility of liquefaction at the site is considered to be very low to nil.

Seiches/Tsunamis: The potential for the site to be effected by a seiche or tsunami (earthquake generated wave) is considered nil due to absence of any large bodies of water near the site.

Flooding (Water Storage Facility Failure): There are no large water storage facilities located on or near the site which could possibly rupture during an earthquake and affect the site by flooding.

Seismically-Induced Landsliding: Due to the low relief of the site and surrounding region, the potential for landslides to occur at the site is considered nil.

Rockfalls: The flat lying nature of the property and surrounding area and the absence of nearby rock outcrops precludes the potential for rockfalls occurring at the site.

Seismically-Induced Settlement: Settlement generally occurs within areas of loose, granular soils with relatively low density. Since the site is underlain by relatively dense (stiff), older alluvial materials, the potential for settlement is considered low. In addition, the remedial earthwork operations to be conducted for the development of the site will mitigate any surficial loose soil conditions.

### **SOILS AND SEISMIC DESIGN CRITERIA (California Building Code)**

Section 1613 of Chapter 16 of the 2016 California Building Code (CBC) contains the procedures and definitions for the calculations of the earthquake loads on structures and non structural components that are permanently attached to structures and their supports and attachments.

It should be noted that the classification of use and occupancy of all proposed structures at the site, and thus design requirements, shall be the responsibility of the structural engineer and the building official.

### **CBC Earthquake Design Summary**

The following earthquake design criteria have been formulated for the site utilizing the source referenced above. However, these values should be reviewed by the building official (Risk Category) and structural engineer and the final design should be performed by a qualified structural engineer familiar with the region.



<b>CBC 2016 SEISMIC DESIGN SUMMARY*</b>	
Site Location (USGS WGS84) 34.0258, -117.3299, Risk Category III	
Site Class Definition (Chapter 20 ASCE 7)	D
$S_s$ Mapped Spectral Response Acceleration at 0.2s Period, (Figure 1613.3.1(1))	1.756
$S_1$ Mapped Spectral Response Acceleration at 1s Period, (Figure 1613.3.3(2))	0.770
$F_a$ Short Period Site Coefficient at 0.2s Period, (Table 1613.3.3(1))	1.0
$F_v$ Long Period Site Coefficient at 1s Period, (Table 1613.3.3(2))	1.5
$S_{MS}$ Adjusted Spectral Response Acceleration at 0.2s Period, (eq .16-37)	1.756
$S_{M1}$ Adjusted Spectral Response Acceleration at 1s Period, (eq .16-38)	1.155
$S_{DS}$ Design Spectral Response Acceleration at 0.2s Period, (eq .16-39)	1.171
$S_{D1}$ Design Spectral Response Acceleration at 1s Period, (eq .16-40)	0.770
Seismic Design Category - Short Period (Table 1613.3.5(1))	E
Seismic Design Category - Long Period (Table 1613.3.5(2))	E
*Values obtained from U.S.G.S. online U.S. Seismic Design Maps tool	

## **CONCLUSIONS**

### **General**

This feasibility study provides a broad overview of the geotechnical and geologic factors which are expected to influence future site planning and development. On the basis of our review of available data, it is the opinion of LOR Geotechnical Group, Inc. that proposed development of the site for mixed use commercial and residential construction is feasible from a geotechnical standpoint, provided the recommendations presented in this report and subsequent reports are incorporated into design and implemented during grading and construction. Supplemental investigation to include in-depth review of aerial photographs and previous site usage, additional subsurface borings as well as sampling and laboratory testing, is recommended once development plans have been made available in order to confirm the findings of this and previous geotechnical reports and to make modifications to these reports, as necessary.

### Foundation Support

Based upon the field investigation and test data, it is our opinion that the younger alluvial soils and upper portions of the older alluvial soils, will not, in their present conditions, provide uniform and/or adequate support for the proposed structures. However, the removal and recompaction of these soils will create an acceptable solution.

To provide adequate support for the proposed structures, we recommend that a compacted fill mat be constructed beneath footings and slabs. This compacted fill mat will provide a dense, high-strength soil layer to uniformly distribute the anticipated foundation loads over the underlying soils. In addition, the construction of this compacted fill mat will allow for the removal of the existing unsuitable alluvial materials within the building pad areas.

### Soil Expansiveness

As noted by our explorations and testing, the majority of the site surficial soils consist of silty sands and sandy silts with a very low to low expansion potential. Although the site grading will likely involve relatively significant mixing and blending of the site materials and a reduction of the overall expansion potential of the fill soils, sandy silt soils of low expansion index will still remain beneath the fill in most areas and mitigation measures for expansive soils will be necessary. These measures are described in the Foundation Design, Building Area Slab-on-Grade, and Exterior Flatwork sections of this report.

Careful evaluation of on-site soils and any import fill for their expansion potential should be conducted during the grading operations.

### Geologic Mitigations

No special geologic mitigation methods other than the geotechnical recommendations provided in the following sections are deemed necessary at this time.

### Seismicity

Seismic ground rupture is generally considered most likely to occur along pre-existing active faults. Since no known faults are known to exist at or project into the site, the probability of ground surface rupture occurring at the site is considered nil.

Due to the site's close proximity to the San Jacinto fault zone, as described above, it is reasonable to expect a strong ground motion seismic event to occur during the lifetime of the proposed development on the site. Large earthquakes could occur on other faults in the general area, but because of their lesser anticipated magnitude and/or greater distance, they are considered less significant than the San Jacinto fault zone from a ground motion standpoint.

The effects of ground shaking anticipated at the subject site should be mitigated by the seismic design requirements and procedures outlined in Chapter 16 of the California Building Code. However, it should be noted that the current building code requires the minimum design to allow a structure to remain standing after a seismic event, in order to allow for safe evacuation. A structure built to code may still sustain damage which might ultimately result in the demolishing of the structure (Larson and Slosson, 1992).

## **RECOMMENDATIONS**

### **Geologic Recommendations**

Geotechnical review of grading and site development plans should be conducted as planning and development of the project advances to further address existing and potential geologic and geotechnical conditions, as necessary.

### **General Site Grading**

It is imperative that no clearing and/or grading operations be performed without the presence of a qualified geotechnical engineer. An on-site, pre-job meeting with the developer, the contractor, and soil engineer should occur prior to all grading related operations. Operations undertaken at the site without the geotechnical engineer present may result in exclusions of affected areas from the final compaction report for the project.

Grading of the subject site should be performed in accordance with the following recommendations as well as applicable portions of the California Building Code, and/or applicable local ordinances.

All areas to be graded should be stripped of significant vegetation and other deleterious materials. All existing non-structural and/or undocumented fill soils should be completely removed from all proposed structural areas, including areas of proposed flatwork and paved areas. Subsequent to removal of deleterious items to the satisfaction of the soils



engineer, the fill soils may then be placed as compacted fill. Underground utilities that are to be abandoned or relocated, as well as their associated trench backfill materials, should also be removed during site clearing and grading.

Cavities created by removal of subsurface obstructions should be thoroughly cleaned of loose soil, organic matter and other deleterious materials, shaped to provide access for construction equipment, and backfilled as recommended in the following Engineered Compacted Fill section of this report.

#### Initial Site Preparation

All undocumented fill material and any loose alluvial materials should be removed from structural areas and areas to receive engineered compacted fill. The data developed during this investigation indicates that removals on the order of approximately 2 to 6 feet will be required from areas underlain by older alluvium. Deeper removals will be required in the drainage areas that transverse the central and northern portions of the site and contain younger alluvium, with removals of 10 to 15 feet anticipated. The actual depths of removals should be further evaluated as site specific development areas are proposed and then verified during the grading operation by observation and/or in-place density testing. Removals should expose older alluvial materials with a relative in-situ compaction of at least 83 percent and/or an in-situ saturation of at least 85 percent.

In areas of proposed development where onsite sewage disposal systems may be present as related to past residential and/or commercial use, care should be taken during clearing and grading to search for and properly abandon related features such as septic tanks and seepage pits.

#### Preparation of Fill Areas

Prior to placing fill, the surfaces of all areas to receive fill should be scarified to a depth of 6 to 12 inches. The scarified soil should be brought to near optimum moisture content and recompact to a relative compaction of at least 90 percent (ASTM D 1557).

#### Preparation of Building Pad Areas

All footings should rest entirely upon a minimum of 24 inches of properly compacted fill material placed over competent native soils. In areas where the required fill thickness is not accomplished through the removal of the existing fill and/or loose native soils, the

footing areas should be further subexcavated to a depth of at least 24 inches below the proposed footing base grade, with the subexcavation extending at least 5 feet beyond the footing lines. Where removals in excess of 5 feet deep are required, the removal areas should extend laterally at a 1:1 ratio. The bottom of this excavation should then be scarified to a depth of at least 12 inches, brought to near optimum moisture content, and recompacted to at least 90 percent relative compaction (ASTM D 1557) prior to refilling the excavation to grade as properly compacted fill.

No structure should be placed across any areas where the ratio of the maximum depth of fill to minimum depth of fill is greater than a 3 to 1 ratio as measured from the bottom of the footing. For example, if one edge of the building pad of a cut-to-fill transition lot requires 10 feet of fill, then the cut portion of the lot should be over-excavated to a minimum of 3 feet below the footing elevations.

#### Engineered Compacted Fill

All fill materials should be free from organic matter and other deleterious materials. Unless approved by the geotechnical engineer, rock or similar irreducible material with a maximum dimension greater than 6 inches should not be buried or placed in building area fills (within two feet of the bottom of the footings), the upper one foot of road subgrade, or within trench backfill. Materials greater than 12 inches in diameter should be placed in approved disposal areas, typically 10 feet or more below proposed finish grade elevations.

Import soil materials, if required, should be inorganic, non-expansive granular soils free from rocks or lumps greater than 6 inches in maximum dimension. Sources for import fill should be approved by the geotechnical engineer prior to their use.

Fill should be spread in maximum 8-inch thick, uniform, loose lifts with each lift brought to near optimum moisture content and compacted to a relative compaction of at least 90 percent in accordance with ASTM D 1557. The upper 12 inches of areas to be paved should be compacted to at least 95 percent (ASTM D 1557).

Based upon the relative compaction of the younger alluvial soils determined during this investigation and the relative compaction anticipated for compacted fill soil, we estimate a compaction shrinkage factor of approximately 10 to 15 percent for the younger alluvium. The older alluvial soils are denser and removal and replacement of these soils should result in a compaction shrinkage factor of approximately 5 to 10 percent. Shrinkage factors

should be monitored during construction. If percentages vary, provisions should be made to revise final grades or adjust quantities of borrow or export.

Careful evaluation of on-site soils and any import fill for their expansion potential should be conducted during the grading operations.

#### Short-Term Excavations

Following the California Occupational and Safety Health Act (CAL-OSHA) requirements, excavations 5 feet deep and greater should be sloped or shored. All excavations and shoring should conform to CAL-OSHA requirements.

Short-term excavation 5 feet deep and greater shall conform to Title 8 of the California Code of Regulations, Construction Safety Orders, Section 1504 and 1539 through 1547. Based on our exploratory trenches and borings and our observations, it appears that the alluvial soils can be classified as Type C soils. Deviation from the standard short-term slopes are permitted using option 4, Design by a Registered Professional Engineer (Section 1541.1).

#### Slope Construction

Preliminary data indicates that cut and fill slopes should be constructed no steeper than two horizontal to one vertical. Fill slopes should be overfilled during construction and then cut back to expose fully compacted soil. A suitable alternative would be to compact the slopes during construction, then roll the final slopes to provide dense, erosion-resistant surfaces.

Where fills are to be placed against existing slopes steeper than five horizontal to one vertical, the fill should be properly keyed and benched into competent native materials. The key, constructed across the toe of the slope, should be a minimum of 12 to 15-feet wide, a minimum of two feet deep at the toe, and sloped back at two percent. Benches should be constructed at approximately two to four feet vertical intervals.

#### Slope Protection

Since the native materials are susceptible to erosion by running water, measures should be provided to prevent surface water from flowing over slope faces. Slopes at the project should be planted with a deep rooted ground cover as soon as possible after completion.



The use of succulent ground covers such as iceplant or sedum is not recommended. If watering is necessary to sustain plant growth on slopes, then the watering operation should be monitored to assure proper operation of the irrigation system and to prevent over watering.

### Foundation Design

If the site is prepared as recommended, the proposed residential structures may be safely founded on conventional shallow foundations, either individual spread footings and/or continuous wall footings, bearing on a minimum of 24 inches of engineered compacted fill placed over competent native materials. All foundations should have a minimum width of 12 inches and, because the site soils are of low expansion potential, should be established a minimum of 18 inches below lowest adjacent grade.

Footings at least 12 to 15 inches wide and placed at least 18 inches below the lowest adjacent final grade could be designed for a maximum soil bearing pressure of 2,100 psf for dead plus live loads.

The above values are net pressures; therefore, the weight of the foundations and the backfill over the foundations may be neglected when computing dead loads. The values apply to the maximum edge pressure for foundations subjected to eccentric loads or overturning. The recommended pressures apply for the total of dead plus frequently applied live loads, and incorporate a factor of safety of at least 3.0.

The allowable bearing pressures may be increased by one-third for temporary wind or seismic loading. The resultant of the combined vertical and lateral seismic loads should act within the middle one-third of the footing width. The maximum calculated edge pressure under the toe of foundations subjected to eccentric loads or overturning should not exceed the increased allowable pressure. Buildings should be setback from slopes as detailed on the California Building Code.

Resistance to lateral loads will be provided by passive earth pressure and base friction. For footings bearing against compacted fill, passive earth pressure may be considered to be developed at a rate of 300 pounds per square foot per foot of depth. Base friction may be computed at 0.30 times the normal load. Base friction and passive earth pressure may be combined without reduction. These values are for dead load plus live load and may be increased by one-third for wind or seismic loading.

Footings on low expansive soils should be reinforced with a minimum of two # 4 rebars, one near the top and one near the bottom of the footings.

Our recommendations to counteract expansive soil activity should be considered minimum and should be revised upon the completion of the site grading. More stringent parameters for design of foundations on expansive soils can be specified by a structural engineer experienced in these matters.

The above recommendations are subject to revision pending supplemental geotechnical investigation and/or review of development plans. Soil bearing pressure for the proposed commercial and residential structures may be provided at that time.

#### Post-Tension Design Parameters

For low expansive soils, we recommend that the planned buildings be supported on post-tensioned slab foundations resting on a minimum of 2.0 feet of engineered compacted fill placed over competent native materials.

- Allowable Soil Bearing Pressure,  $q_{allow}$ : 1,800 psf
- Edge Moisture Variation Distance,  $e_m$ :
  - Center Lift Loading Conditions: 9.0 ft
  - Edge Lift Loading Conditions: 6.0 ft
- Differential Swell,  $y_m$ :
  - Center Lift 0.23 in
  - Edge Lift 0.53 in
- Subgrade Soil Friction Coefficient,  $\mu$ : 0.30

The above design parameters were determined in accordance with Design of Post-Tensioned Slabs-on-Ground, third edition, published by the Post-Tensioning Institute. It should also be noted that the post-tension design parameters presented above are preliminary. It is understood that during the site rough grading some mixing and blending of the site soils will occur. Therefore, further testing and verification will be necessary to confirm that these conditions are indeed present at the conclusion of the site rough grading and that the post-tension design parameters presented above remain accurate.

### Settlement

Total settlement of individual foundations will vary depending on the width of the foundation and the actual load supported. Maximum settlement of shallow foundations designed and constructed in accordance with the preceding recommendations are estimated to be on the order of 0.5 inch. Differential settlements between adjacent footings should be about one-half of the total settlement. Settlement of all foundations is expected to occur rapidly, primarily as a result of elastic compression of supporting soils as the loads are applied, and should be essentially completed shortly after initial application of the loads.

### Building Area Slab-on-Grade

Concrete floor slabs should bear on a minimum of 24 inches of engineered compacted fill placed over competent native materials. The final pad surfaces should be rolled to provide smooth, dense surfaces upon which to place the concrete. Slab areas should be properly pre-soaked prior to pouring concrete. Slab areas should be pre-soaked to approximately 4 percent above the optimum moisture content to a minimum depth of 18 inches. Unless more stringent parameters are given by the structural engineer with expansive soil design experience, the slab thickness should be a minimum of 4 inches. Minimum slab reinforcement should consist of #3 rebars placed at a maximum spacing of 18 inches on center, each way.

Slabs to receive moisture-sensitive coverings should be provided with a moisture vapor barrier. This barrier may consist of an impermeable membrane. Two inches of sand over the membrane will reduce punctures and aid in obtaining a satisfactory concrete cure. The sand should be moistened just prior to placing of concrete. The slabs should be protected from rapid and excessive moisture loss which could result in slab curling. Careful attention should be given to slab curing procedures, as the site area is subject to large temperature extremes, humidity, and strong winds.

### Exterior Flatwork

To provide adequate support, exterior flatwork improvements should rest on a minimum of 12 inches of soil compacted to at least 90 percent (ASTM D 1557). Flatwork areas should be pre-soaked prior to pouring concrete to a minimum depth of 18 inches and to approximately 4 percent above the optimum moisture content. All sidewalks, patio slabs, and driveways with a minimum dimension greater than 5 feet should be reinforced with #3 rebars placed at a maximum spacing of 18 inches on



center, each way. Reinforcement for curbing should be one continuous #4 rebar at top and bottom. In addition, it is recommended that sidewalks, patio slabs, curbs, etc., have a thickness of at least 4 inches, with saw cuts every 10 feet or less. Driveways should be at least 5-inch thick, with saw cuts every 15 feet or less.

Flatwork surface should be sloped a minimum of 1 percent away from buildings and slopes, to approved drainage structures.

Again, the above recommendations to counteract low expansive soil activity should be considered minimum as determined by our preliminary findings and should be revised, as necessary, as based upon the results of additional testing conducted during, or near the completion of site grading.

#### Wall Pressures

The design of footings for retaining wall structures should be performed in accordance with the recommendations described earlier under Preparation of Building Pad Areas and Foundation Design. For design of retaining wall footings, the resultant of the applied loads should act in the middle one-third of the footing, and the maximum edge pressure should not exceed the basic allowable value without increase.

For design of retaining walls unrestrained against movement at the top, we recommend an equivalent fluid density of 45 pounds per cubic foot (pcf) be used. This assumes level backfill consisting of recompacted, non-expansive, native soils placed against the structures and within the back cut slope extending upward from the base of the stem at 35 degrees from the vertical or flatter.

Retaining walls subject to uniform surcharge loads within a horizontal distance behind the structure equal to the structural height should be designed to resist additional lateral loads equal to 0.3 times the surcharge load. Any isolated or line loads from adjacent foundations or vehicular loading will impose additional wall loads and should be considered individually.

As noted before, low expansive soils are present at the site. Since these materials have very low permeability, uncertain behavior, and exert higher lateral earth pressures on earth retaining structures than more granular soils, the onsite soils should not be used as wall backfills.

To avoid over stressing or excessive tilting during placement of backfill behind walls, heavy compaction equipment should not be allowed within the zone delineated by a 45 degree line extending from the base of the wall to the fill surface. The backfill directly behind the walls should be compacted using light equipment such as hand operated vibrating plates and rollers. No material larger than 3 inches in diameter should be placed in direct contact with the wall.

Wall pressures should be verified prior to construction, when the actual backfill materials and conditions have been determined. Recommended pressures are applicable only to level, properly drained, non-expansive backfill with no additional surcharge loadings. If inclined backfills are proposed, this firm should be contacted to develop appropriate active earth pressure parameters.

#### Preliminary Pavement Design

Testing and design for preliminary on-site pavements was conducted in accordance with the California Highway Design Manual. Based upon our preliminary sampling and testing, R-values for subgrade soils will range from about 10 to 30. Traffic Indices generally used for these kinds of developments, it appears that the structural sections tabulated below should provide satisfactory pavements for the subject improvements:

AREA	T.I.	DESIGN R-VALUE	PRELIMINARY SECTION
Typical Residential Collections	5.0	10	0.25' AC/0.75' AB
	6.0	10	0.25' AC/1.05' AB
	7.0	10	0.30' AC/1.25' AB
Typical Residential Collections	5.0	30	0.25' AC/0.45' AB
	6.0	30	0.25' AC/0.70' AB
	7.0	30	0.30' AC/0.85' AB
AC - Asphalt Concrete			
AB - Class 2 Aggregate Base			

The above structural sections are predicated upon 90 percent relative compaction (ASTM D 1557) of all utility trench backfills and 95 percent relative compaction (ASTM D 1557) of

the upper 12 inches of pavement subgrade soils and of any aggregate base utilized. In addition, the aggregate base should meet Caltrans specifications for Class 2 Aggregate Base.

In areas of the pavement which will receive high abrasion loads due to start-ups and stops, or where trucks will move on a tight turning radius, consideration should be given to installing concrete pads. Such pads should be a minimum of 0.5 foot thick concrete, with a 0.50 foot thick aggregate base. Concrete pads are also recommended in areas adjacent to trash storage areas where heavier loads will occur due to operation of trucks lifting trash dumpsters.

The recommended 0.5 feet thick portland cement concrete (PCC) pavement section should have a minimum modulus of rupture (MR) of 550 pounds per square inch (psi).

The portland cement concrete pavement section may be placed directly over the native subgrade prepared as described above and pre-soaked as indicated in this report. In addition, the concrete section should be reinforced as indicated within this report. Transverse joints should be sawcut in the pavement at approximately one quarter of slab thickness. Construction joints should be constructed such that adjacent sections butt directly against each other and are keyed into each other. Parallel pavement sections should also be keyed into each other.

It should be noted that all of the above pavement designs were based upon the results of preliminary sampling and testing, and should be verified by additional sampling and testing during construction when the actual subgrade soils are exposed. The actual design traffic index's for various roads should be supplied by the local controlling agency responsible for the roadways.

#### Sulfate Protection

The results of the soluble sulfate tests conducted on selected subgrade soils expected to be encountered at foundation levels are presented on Enclosure C. Based on the test results, it appears that there is a negligible to moderate sulfate exposure to concrete elements in contact with the on site soils per the 2016 CBC. This should be verified by additional sampling and testing when the actual finish and near finish surface soils are obtained.



### Supplemental Geotechnical Investigation and Plan Reviews

This feasibility study was conducted prior to the issuance of any site development or grading plans. Once these plans become available, we should review the plans in order to better define onsite geotechnical considerations. Supplemental geotechnical investigation will allow for additional site research, subsurface investigation, sampling and laboratory testing of the soils present within representative and/or key areas and help to identify any areas of geologic or geotechnical concern, such as expansion potential of the local onsite materials or the anticipated depths of removal across areas underlain by undocumented fill or alluvial sediments.

### Construction Monitoring

As mentioned above, post investigation services are an important and necessary continuation of geotechnical work associated with planning and development of this project. Once project plans and specifications have been reviewed by this firm, construction monitoring, including testing for on-site pavement design, should be performed during and after the site rough grading operations. During and/or near the completion of site grading, additional expansion index testing should be conducted to characterize selected areas and to develop lot specific recommendations for foundation design as related to the expansion potential of the graded site soils.

During construction, sufficient and timely geotechnical observation and testing should be provided to correlate the findings of this investigation, and possible supplemental investigation, with the actual subsurface conditions exposed during construction. Items requiring observation and testing include, but are not necessarily limited to, the following:

1. Site preparation-stripping and removals.
2. Excavations, including approval of the bottom of excavation prior to filling.
3. Scarifying and recompacting prior to fill placement.
4. Subgrade preparation for pavements and slabs-on-grade.
5. Placement of engineered compacted fill and backfill, including approval of fill materials and the performance of sufficient density tests to evaluate the degree of compaction being achieved.
6. Foundation excavations, including footings.

### **TIME LIMITATIONS**

The findings of this report are valid as of this date. Changes in the condition of a property can, however, occur with the passage of time, whether they be due to natural processes or the work of man on this or adjacent properties. In addition, changes in the Standards-of-Practice and/or Governmental Codes may occur. Due to such changes, the findings of this report may be invalidated wholly or in part by changes beyond our control. Therefore, this report should not be relied upon after a significant amount of time without a review by LOR Geotechnical Group, Inc. verifying the suitability of the conclusions and recommendations.

### **LIMITATIONS**

This report contains geotechnical conclusions and recommendations developed solely for use by Lewis Management Corp., and their designates for the purposes described earlier. It may not contain sufficient information for other uses or the purposes of other parties. The contents should not be extrapolated to other areas or used for other facilities without consulting LOR Geotechnical Group, Inc.

The recommendations are based on interpretations of the subsurface conditions concluded from information gained from subsurface explorations, and a surficial site reconnaissance. The interpretations may differ from actual subsurface conditions, which can vary horizontally and vertically across the site. Due to possible subsurface variations, all aspects of field construction addressed in this report should be observed and tested by the project geotechnical consultant.

If parties other than LOR Geotechnical Group, Inc. provide construction monitoring services, they must be notified that they will be required to assume responsibility for the geotechnical phase of the project being completed by concurring with the recommendations provided in this report or by providing alternative recommendations.

The report was prepared using generally accepted geotechnical engineering practices under the direction of a state licensed geotechnical engineer. No warranty, expressed or implied, is made as to conclusions and professional advice included in this report. Any persons using this report for bidding or construction purposes should perform such independent investigations as deemed necessary to satisfy themselves as to the surface and subsurface conditions to be encountered and the procedures to be used in the performance of work on this project.

Lewis Management Corp.  
July 31, 2018

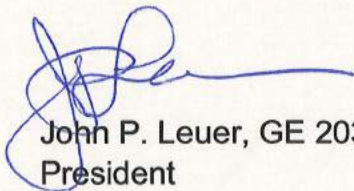
Project No. 33318C.1

## **CLOSURE**


It has been a pleasure to assist you with this project. We look forward to being of further assistance to you as construction begins.

Should you have any questions regarding this report, please do not hesitate to contact this office at your convenience.

Respectfully submitted,  
**LOR Geotechnical Group, Inc.**



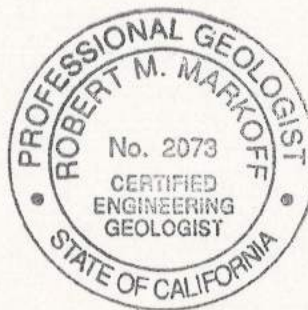
John P. Leuer, GE 2030  
President



Robert M Markoff, CEG 2073  
Engineering Geologist

RMM:JPL/ss

Distribution: Addressee (4) and PDF Steven.Johnson@lewismc.com





## REFERENCES

California Building Standards Commission and International Conference of Building Officials, 2016, California Building Code, 2016 Edition.

California Department of Water Resources, Groundwater Level Data, <http://www.water.ca.gov>

CHJ Consultants, 2016, Geotechnical Investigation, Grand Terrace High School Solar Project, 21810 Main Street, Grand Terrace, California, Job No. 15627-3, Dated January 11, 2016.

Dibblee, T.W., Jr., 2003, Geologic Map of the Riverside East/South ½ of San Bernardino South Quadrangles, Dibblee Geology Center Map #DF-109.

Fife, D.L., Rodgers, D.A., Case, G.W., Chapman, R.H., and Sprotte, E.C., 1976, Geologic Hazards in Southwestern San Bernardino County, California; California Division of Mines and Geology Special Report 113.

Hart, E.W. and W.A. Bryant, 1997, Fault-rupture Hazard Zones in California, California Dept. of Conservation Division of Mines and Geology Special Publication 42.

John R. Byerly, 2005, Final Geotechnical Investigation, Proposed Colton High School No. 3, North Side of Main Street, East Side of Taylor Street, Grand Terrace, California, File No.: 5-11335, Dated September 15, 2005.

Larson, R., and Slosson, J., 1992, The Role of Seismic Hazard Evaluation in Engineering Reports, in Engineering Geology Practice in Southern California, AEG Special Publication Number 4, pp 191-194.

LOR Geotechnical Group, Inc., 2017a, Preliminary Geotechnical Investigation, APN's: 1167-161-03 & -04, Grand Terrace, San Bernardino County, California, Project No. 33318B.1, Draft Report, dated February 6, 2017.

LOR Geotechnical Group, Inc., 2017b, Preliminary Geotechnical Investigation, APN's: 1167-151-22, -68, -71, & -74, Grand Terrace, San Bernardino County, California, Project No. 33318B.1, Draft Report, dated February 15, 2017.

Matti J.C. and Carson, S.E., 1985, Contour Map Showing Minimum Depth to Groundwater, Upper Santa Ana River Valley, California, 1973-1979, USGS Miscellaneous Field Studies Map MF-1802.

## **REFERENCES cont'd**

Morton, D.M., and Miller, F.K., 2003, Preliminary Geologic Map of the San Bernardino 30' X 60' Quadrangle, California, United States Geological Survey Open-File Report 03-293.

Norris, R.M. and R.W. Webb, 1990, Geology of California, Second Edition, John Wiley & Sons, New York.

Reeder, W., 2000, Earthquake Plotting Program, EPI Software.

United States Department of Agriculture, 2013, National Resources Conservation Service, Web Soil Survey, National Cooperative Soil Survey, Online Data.

U.S.G.S., 2016, U.S. Seismic Design Maps, [earthquake.usgs.gov/designmaps/us/application.php](http://earthquake.usgs.gov/designmaps/us/application.php).

Western Municipal Water District and the San Bernardino Valley Water Conservation District, Cooperative Well Measuring Program, Fall, 2014.

**AERIAL PHOTOGRAPHS**  
(SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT)

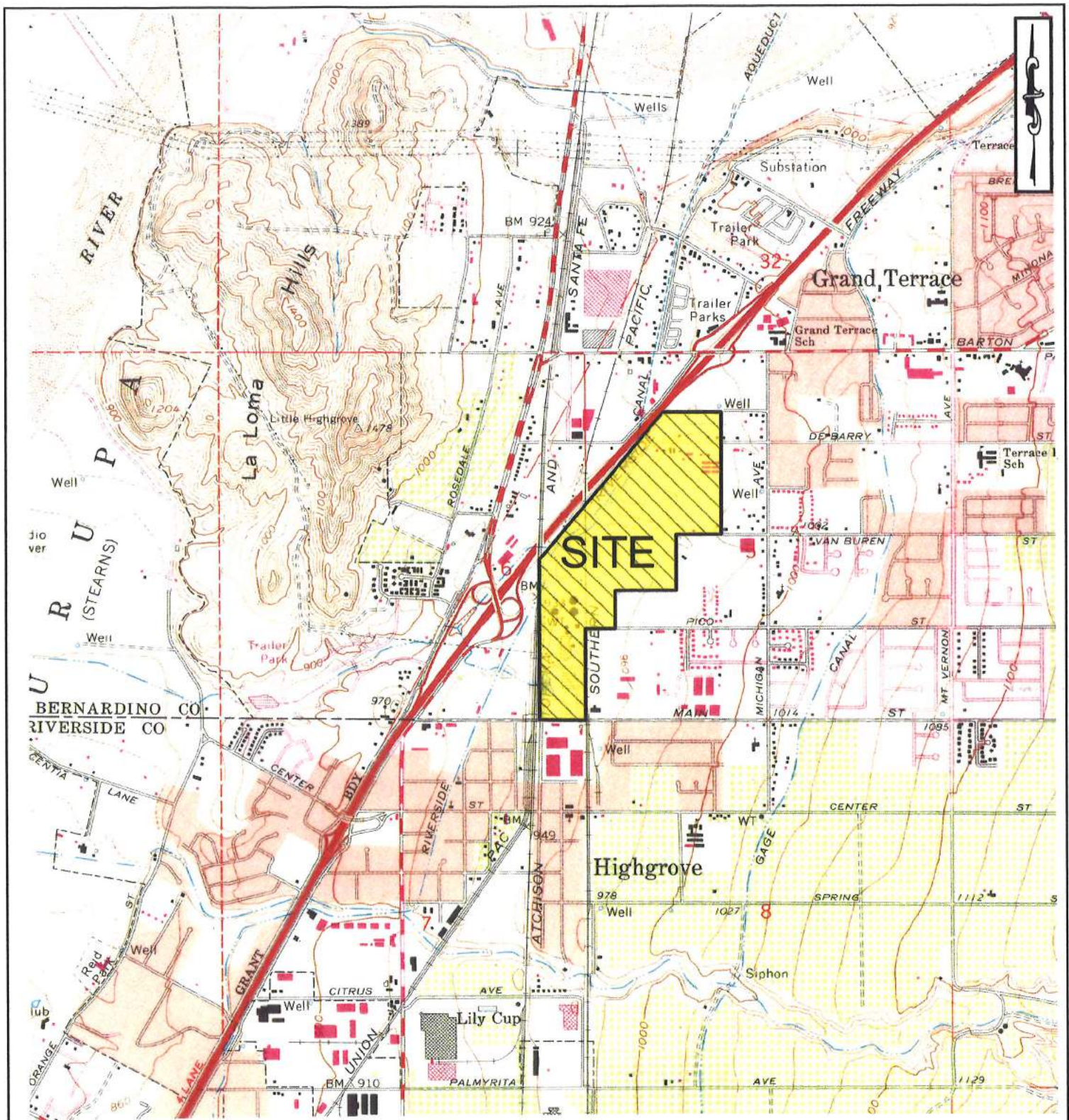
DATE	FLIGHT NO.	PHOTO NO(S).	SCALE
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6/3/1938	AXL/AXM 41-63	78-70	1" = 1,000'
8/9/1938	AXM-62	28 & 29	1" = 1,000'
11/18/1955	F-34	2-101 & 2-102, 8-24 & 8-25	1" = 2,000'
2/1/1969	C-293	100 & 101	1" = 2,000'
2/1969	C-295	96	1" = 2,000'
10/30/1972	C-194	72 & 73	1" = 2,000'
1/21/1978	C-279	51 & 52	1" = 2,000'
2/25/1986	C-450	53 & 54	1" = 2,000'
7/1/1991	C-487	69 & 70	1" = 2,000'
4/20/1996	C-528	76, 77 & 78	1" = 2,000'
6/15/2001	C-541	88, 89, & 90	1" = 2,000'
1/19/2005	C-553	9-43, 9-44 & 9-45	1" = 1,000'



## **APPENDIX A**

### **Index Map, Plate, Regional Geologic Map, and Historical Seismicity Maps**





## INDEX MAP

**PROJECT:** THE GATEWAY AT GRAND TERRACE, GRAND TERRACE CALIFORNIA

**PROJECT NO.:** 33318C.1

**CLIENT:** LEWIS MANAGEMENT CORP

**ENCLOSURE:** A-1

**LOR Geotechnical Group, Inc.**

**DATE:** JULY 2018

**SCALE:** 1" = 2,000'



Legend

- ◆ (B-13) - APPROXIMATE LOCATION OF EXPLORATORY BORING (THIS INVESTIGATION)
- ◆ (B-7) - APPROXIMATE LOCATION OF EXPLORATORY BORING (LOR, 2017, A & B)
- ◆ (T-14) - APPROXIMATE LOCATION OF EXPLORATORY TRENCH (LOR, 2017, A & B)
- ◆ (I-4) - APPROXIMATE LOCATION OF INFILTRATION TEST (LOR, 2017, B)

PROJECT NO.: 33318C.1  
DATE: JULY 2018

CLIENT: LEWIS MANAGEMENT CORP  
PROJECT: THE GATEWAY AT GRAND TERRACE SPECIFIC PLAN AND HOMECOMING PROJECT

SCALE: 1" = 200'

LOR Geotechnical Group, Inc.  
ENCLOSURE A-2

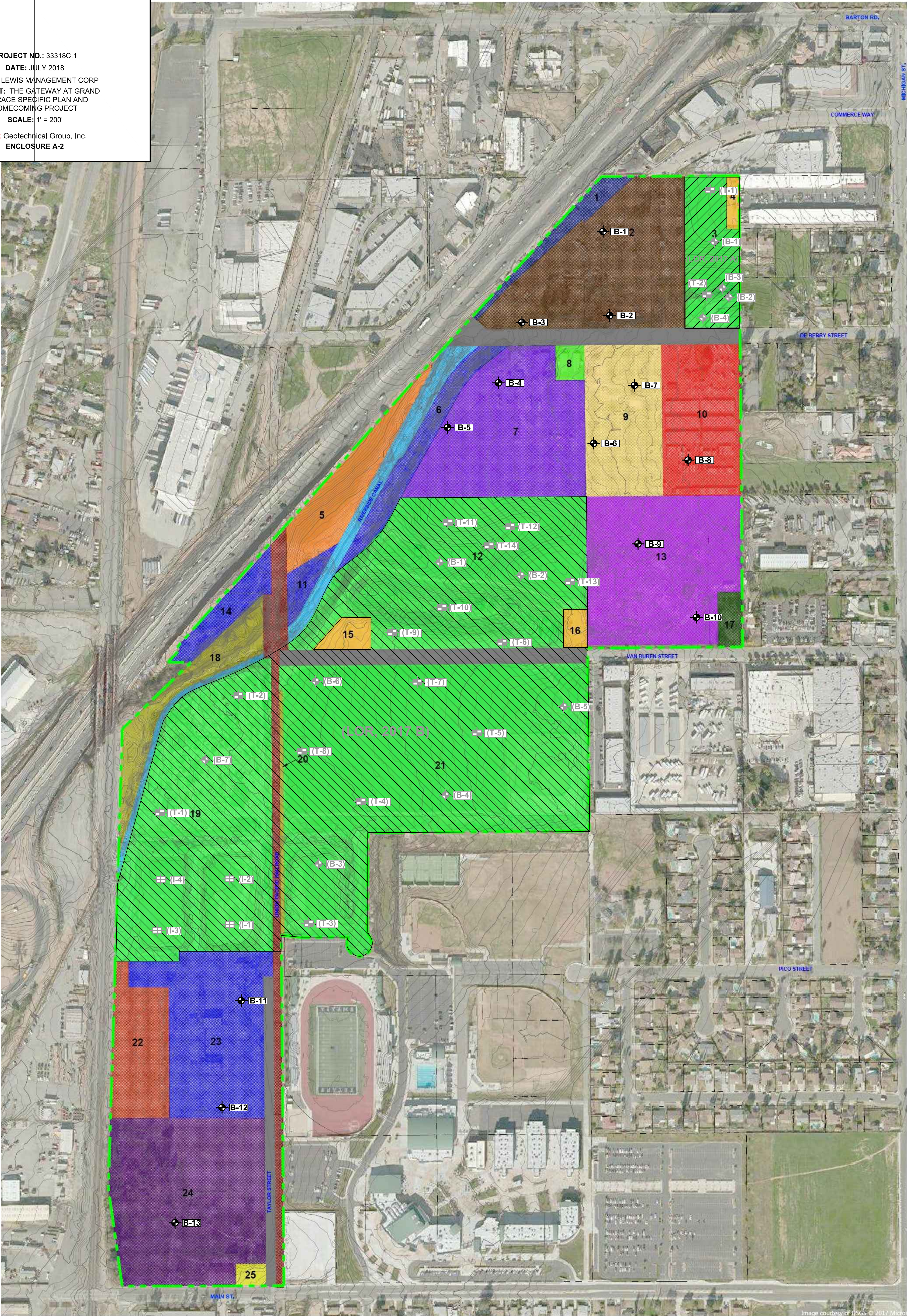
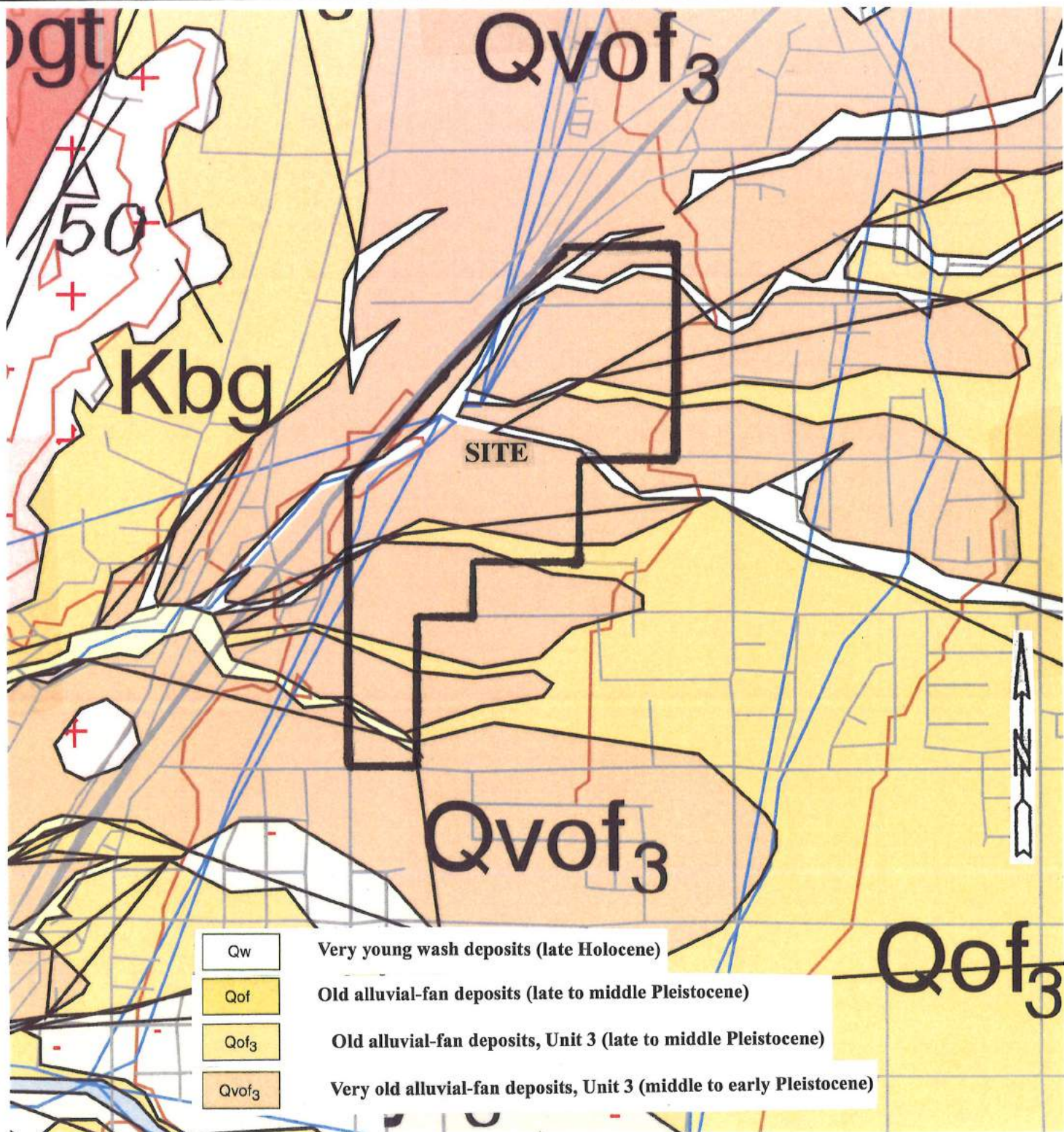


Image courtesy of USGS © 2017 Micro

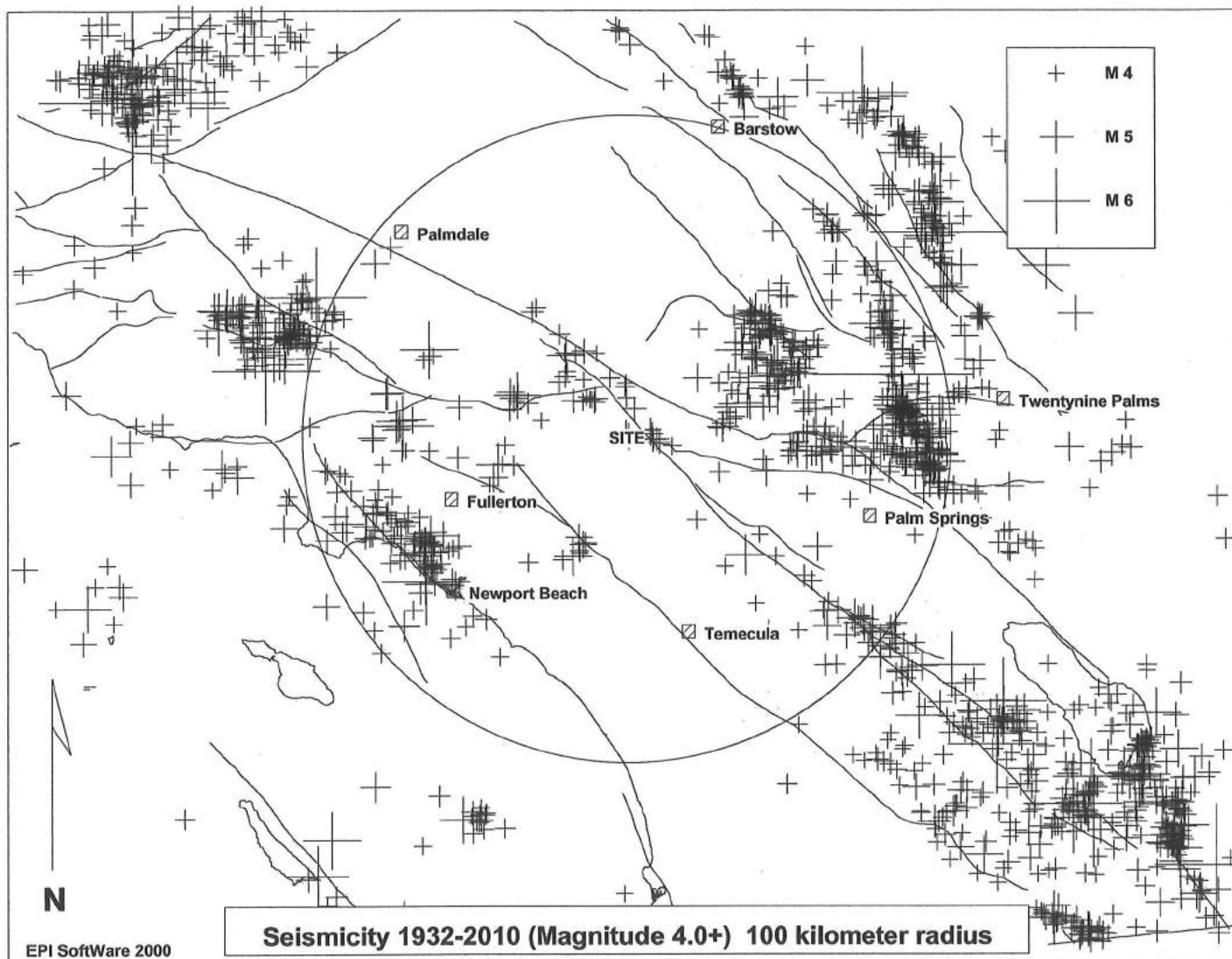
1" = 200'  
100 0 200 400 600





## REGIONAL GEOLOGIC MAP (Morton & Miller, 2003)

PROJECT:	THE GATEWAY AT GRAND TERRACE, GRAND TERRACE CALIFORNIA	PROJECT NO.:	33318C.1
CLIENT:	LEWIS MANAGEMENT CORP	ENCLOSURE:	A-3
LOR Geotechnical Group, Inc.		DATE:	JULY 2018
		SCALE:	1" = 1,250'



**SITE LOCATION:** 34.0258 LAT. -117.3299 LONG.

**MINIMUM LOCATION QUALITY:** C

**TOTAL # OF EVENTS ON PLOT:** 1500

**TOTAL # OF EVENTS WITHIN SEARCH RADIUS:** 576

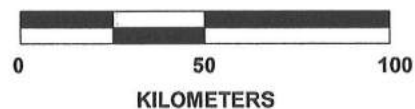
**MAGNITUDE DISTRIBUTION OF SEARCH RADIUS EVENTS:**

4.0- 4.9 : 516  
 5.0- 5.9 : 55  
 6.0- 6.9 : 4  
 7.0- 7.9 : 1  
 8.0- 8.9 : 0

**CLOSEST EVENT:** 4.7 ON SUNDAY, FEBRUARY 23, 1936 LOCATED APPROX. .8 KILOMETER OF THE SITE

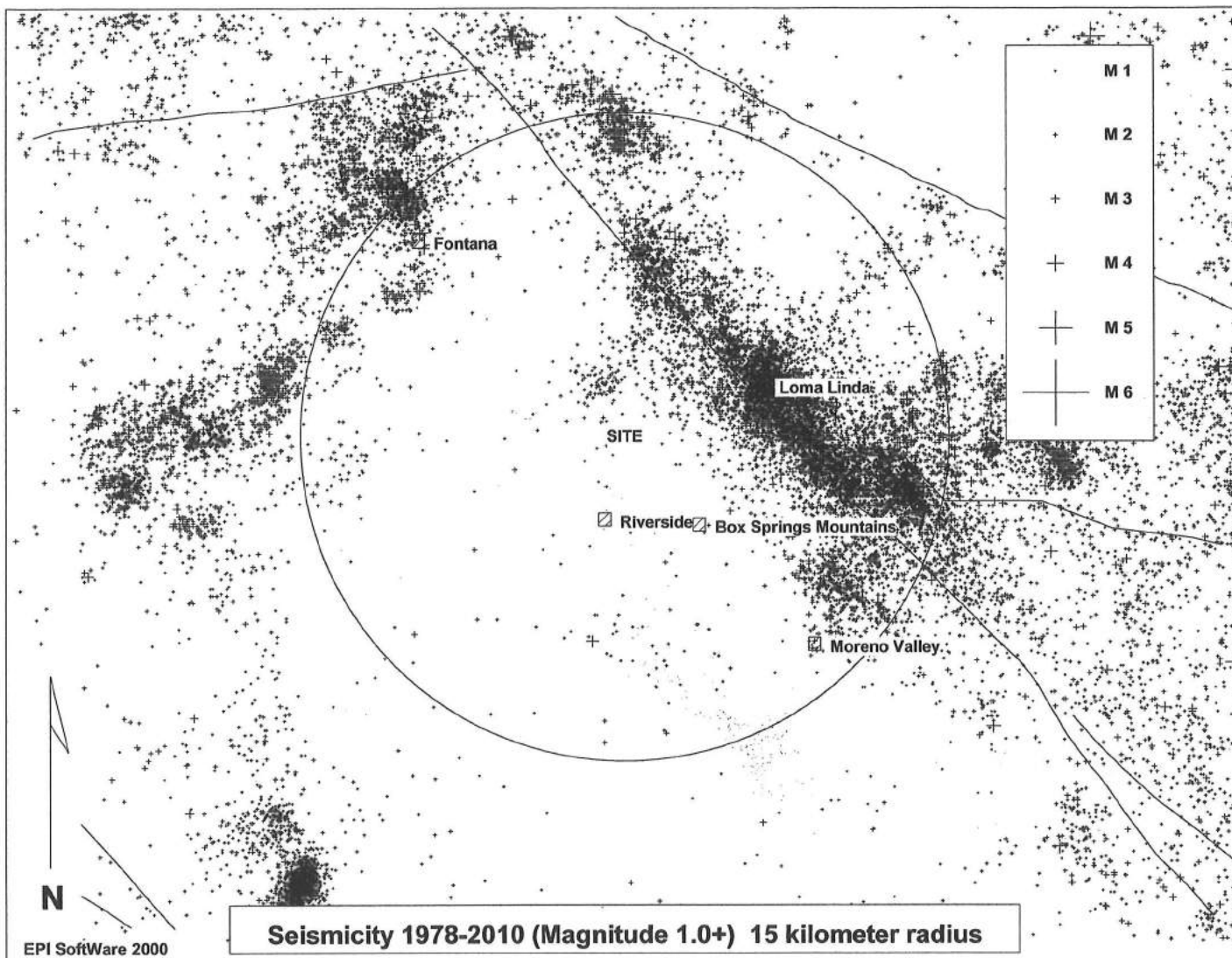
**LARGEST 5 EVENTS:**

7.3 ON SUNDAY, JUNE 28, 1992 LOCATED APPROX. 84 KILOMETERS EAST OF THE SITE  
 6.4 ON SATURDAY, MARCH 11, 1933 LOCATED APPROX. 75 KILOMETERS SOUTHWEST OF THE SITE  
 6.3 ON SUNDAY, JUNE 28, 1992 LOCATED APPROX. 50 KILOMETERS NORTHEAST OF THE SITE  
 6.1 ON THURSDAY, APRIL 23, 1992 LOCATED APPROX. 93 KILOMETERS EAST OF THE SITE  
 6.0 ON SATURDAY, DECEMBER 04, 1948 LOCATED APPROX. 92 KILOMETERS EAST OF THE SITE



**ENCLOSURE A-4**





**SITE LOCATION:** 34.0258 LAT. -117.3299 LONG.

**MINIMUM LOCATION QUALITY:** A

**TOTAL # OF EVENTS ON PLOT:** 19389

**TOTAL # OF EVENTS WITHIN SEARCH RADIUS:** 9089

**MAGNITUDE DISTRIBUTION OF SEARCH RADIUS EVENTS:**

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 3.0- 3.9 : 86  
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 5.0- 5.9 : 0  
 6.0- 6.9 : 0  
 7.0- 7.9 : 0  
 8.0- 8.9 : 0

**CLOSEST EVENT:** 2.4 ON FRIDAY, JULY 10, 1992 LOCATED APPROX. .2 KILOMETER OF THE SITE

**LARGEST 5 EVENTS:**

4.6 ON WEDNESDAY, OCTOBER 02, 1985 LOCATED APPROX. 7 KILOMETERS EAST OF THE SITE  
 4.5 ON FRIDAY, JANUARY 09, 2009 LOCATED APPROX. 9 KILOMETERS NORTH OF THE SITE  
 4.5 ON WEDNESDAY, MARCH 11, 1998 LOCATED APPROX. 9 KILOMETERS EAST OF THE SITE  
 4.4 ON THURSDAY, JANUARY 06, 2005 LOCATED APPROX. 14 KILOMETERS NORTHWEST OF THE SITE  
 4.4 ON MONDAY, FEBRUARY 21, 2000 LOCATED APPROX. 7 KILOMETERS NORTHEAST OF THE SITE



**ENCLOSURE A-5**



## **APPENDIX B**

### **Field Investigation Program and Boring Logs**

## **APPENDIX B**

### **FIELD INVESTIGATION**

#### **Subsurface Exploration**

The site was investigated on July 2<sup>nd</sup> and 3<sup>rd</sup> of 2018 and consisted of advancing 13 exploratory borings to depths of between 21.0 and 51.5 feet below the existing ground surface. The approximate locations of our borings are shown on Enclosure A-2, within Appendix A.

The drilling exploration was conducted using a Mobile B-61 drill rig equipped with 8-inch diameter hollow stem augers. The soils encountered within the borings were continuously logged by a geologist from this firm who created detailed logs of the borings, obtained undisturbed, as well as disturbed, soil samples for evaluation and testing, and classified the soils by visual examination in accordance with the Unified Soil Classification System.

Relatively undisturbed samples of the subsoils were obtained at a typical maximum interval of 5 feet. The relatively undisturbed samples were recovered by using a California split barrel sampler of 2.50-inch inside diameter and 3.25-inch outside. The sampler was driven by a 140-pound automatic trip hammer dropped from a height of 30 inches. The number of hammer blows required to drive the sampler into the ground the final 12 inches were recorded and further converted to an equivalent SPT N-values which are included in the boring logs.

The undisturbed soil samples were retained in brass sample rings of 2.42 inches in diameter and 1.00 inch in height, and placed in sealed plastic containers. Disturbed soil samples were obtained at selected levels within the borings and placed in sealed containers for transport to our geotechnical laboratory.

All samples obtained were taken to our laboratory for storage and testing. Detailed logs of the trenches and boring are presented on the enclosed Trench and Boring Logs, Enclosures B-1 through B-13. A Boring Log Legend and Soil Classification Chart are presented on Enclosures B-i and B-ii, respectively.

## CONSISTENCY OF SOIL

## SAMPLE KEY

### SANDS

#### SPT BLOWS

#### CONSISTENCY

0-4	Very Loose
4-10	Loose
10-30	Medium Dense
30-50	Dense
Over 50	Very Dense

### COHESIVE SOILS

#### SPT BLOWS

#### CONSISTENCY

0-2	Very Soft
2-4	Soft
4-8	Medium
8-15	Stiff
15-30	Very Stiff
30-60	Hard
Over 60	Very Hard

#### Symbol

#### Description



INDICATES CALIFORNIA  
SPLIT SPOON SOIL  
SAMPLE

INDICATES BULK SAMPLE

INDICATES SAND CONE  
OR NUCLEAR DENSITY  
TEST

INDICATES STANDARD  
PENETRATION TEST (SPT)  
SOIL SAMPLE

## TYPES OF LABORATORY TESTS

- 1 Atterberg Limits
- 2 Consolidation
- 3 Direct Shear (undisturbed or remolded)
- 4 Expansion Index
- 5 Hydrometer
- 6 Organic Content
- 7 Proctor (4", 6", or Cal216)
- 8 R-value
- 9 Sand Equivalent
- 10 Sieve Analysis
- 11 Soluble Sulfate Content
- 12 Swell
- 13 Wash 200 Sieve

## **BORING LOG LEGEND**

PROJECT:	THE GATEWAY AT GRAND TERRACE	PROJECT NO.: 33318C.1
CLIENT:	LEWIS MANAGEMENT CORP.	ENCLOSURE: B-i
LOR Geotechnical Group, Inc.		DATE: JULY 2018



## SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS  MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS  MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS  (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES  (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS  MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS  (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES  (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS  MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS  LIQUID LIMIT LESS THAN 50			ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS  LIQUID LIMIT GREATER THAN 50			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

## PARTICLE SIZE LIMITS

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE	
12"	3"	3/4"	No. 4	No. 10	No. 40	200	
(U.S. STANDARD SIEVE SIZE)							

## SOIL CLASSIFICATION CHART

PROJECT	THE GATEWAY AT GRAND TERRACE	PROJECT NO.	33318C.1
CLIENT:	LEWIS MANAGEMENT CORP.	ENCLOSURE:	B-ii
LOR Geotechnical Group, Inc.		DATE:	JULY 2018

# LOG OF BORING B-1

TEST DATA							DESCRIPTION
DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY	
0							
	31	9, 10	4.4	120.2		SM	@ 0 feet, <b>FILL: Crushed asphalt and aggregate base, dry, loose.</b> @ 0.5 feet, <b>OLDER ALLUVIUM: SILTY SAND</b> , approximately 10% coarse grained sand, 20% medium grained, 25% fine grained sand, 45% silty fines, brown to reddish-brown, damp, medium dense.
5	50		4.4	123.8			@ 5 feet, includes off-white calcium carbonate stringers.
	50		3.7	125.2			@ 7 feet, less calcium carbonate.
10	63		8.4	122.5			@ 10 feet, increase in fine grained sand content.
						SP	@ 12 feet, <b>POORLY GRADED SAND</b> , approximately 5% coarse grained sand, 20% medium grained sand, 70% fine grained sand, 5% silty fines, reddish-brown, damp, medium dense.
15	20		3.0	112.3			
						SM	@ 17 feet, <b>SILTY SAND</b> , approximately 15% medium grained sand, 50% fine grained sand, 35% silty fines, reddish-brown, damp to moist, dense.
20	83 for 8"		9.2	115.5			
							END OF BORING
							Fill to 0.5'
							No groundwater
							No bedrock
25							
30							

PROJECT: The Gateway at Grand Terrace

PROJECT NUMBER: 33318C.1

CLIENT: Lewis Management Corp.

ELEVATION:

**LOR** GEOTECHNICAL GROUP INC.

DATE DRILLED: July 2, 2018

EQUIPMENT: Mobile B-61

HOLE DIA.: 8" ENCLOSURE: B-1

# LOG OF BORING B-2

TEST DATA						
DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY
0						
22			8.1	114.3		
		3, 7, 11				
5	10		6.7	109.8		
	11	2	5.3	106.3		
10	10		6.6	105.0		
15	39		7.9	115.1		
20	72		5.0	106.6		
25	79 for 11"		8.4	117.5		
30						

## DESCRIPTION

@ 0 feet, **FILL**: Crushed asphalt and aggregate base, loose, dry.  
 @ 0.5 feet, **ALLUVIUM**: SANDY SILT, approximately 5% coarse grained sand, 10% medium grained sand, 25% fine grained sand, 60% silty fines, dark brown, moist, soft to firm.

@ 7 feet, slightly finer grained and reddishb-brown in color.

@ 14± feet, **OLDER ALLUVIUM**: SILTY SAND, approximately 5% coarse grained sand, 20% medium grained sand, 50% fine grained sand, 25% silty fines, reddish-brown, damp, dense.

@ 20 feet, lighter brown, sandier.

@ 25 feet, finer grained, increase in silt content.

**END OF BORING**

Fill to 0.5'  
 No groundwater  
 No bedrock

PROJECT: The Gateway at Grand Terrace

CLIENT: Lewis Management Corp.

**LOR** GEOTECHNICAL GROUP INC.

PROJECT NUMBER: 33318C.1

ELEVATION:

DATE DRILLED: July 2, 2018

EQUIPMENT: Mobile B-61

HOLE DIA.: 8" ENCLOSURE: B-2



# LOG OF BORING B-3

TEST DATA							
DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY	U.S.C.S.
0							
	13	8, 9, 10	954.8	10.5			ML
5	27		5.9	111.6			
	59		4.9	122.3			
10	73 for 10"		5.4	113.6			
							SM
15	48		3.1	117.2			
20	79 for 11"		6.0	126.0			
25							

## DESCRIPTION

- @ 0 feet, FILL: SANDY SILT with organics, upper tilled soil layer.
- @ 0.5± feet, approximately 5% coarse grained sand, 5% medium grained sand, 15% fine grained sand, 75% silty fines, brown, damp, soft.
- @ 4± feet, OLDER ALLUVIUM: SANDY SILT, approximately 5% coarse grained sand, 15% medium grained sand, 25% fine grained sand, 55% silty fines, reddish-brown, moist, stiff.
- @ 7 feet, minor calcium carbonate as stringers.
- @ 10 feet, finer grained.
- @ 12.5± feet, SILTY SAND, approximately 5% coarse grained sand, 20% medium grained sand, 35% fine grained sand, 40% silty fines, reddish-brown, moist, dense.
- @ 15 feet, sandier, coarser grained.
- @ 20 feet, includes a trace of clay.

## END OF BORING

Fill to 0.5'  
No groundwater  
No bedrock

PROJECT: The Gateway at Grand Terrace

CLIENT: Lewis Management Corp.

**LOR** GEOTECHNICAL GROUP INC.

PROJECT NUMBER: 33318C.1





ELEVATION:

DATE DRILLED: July 2, 2018

EQUIPMENT: Mobile B-61

HOLE DIA.: 8" ENCLOSURE: B-3

# LOG OF BORING B-4

TEST DATA							LOG OF BORING B-4
DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY	
0							CL
18	1, 4, 11	7.3		112.9			<p>@ 0 feet, <u>OLDER ALLUVIUM</u>: CLAYEY SAND, approximately 5% coarse grained sand, 10% medium grained sand, 25% fine grained sand, 60% silty fines, reddish-brown, moist, medium dense.</p> <p>below 5± feet, very dense.</p> <p>@ 7 feet, lighter in color.</p>
5	60 for 9"	10.0		118.6			
	43 for 5"	8.7		121.3			
10	51	3.2		122.2			SM
15	48	7.1		117.2			@ 10 feet, SILTY SAND, approximately 5% coarse grained sand, 25% medium grained sand, 50% fine grained sand, 20% silty fines, brown, damp, dense.
20	72	5.7		117.9			@ 15 feet, slight increase in silt content.
25	74 for 10"	4.6		122.5			@ 20 feet, very dense.
30	79	6.5		123.9			@ 25 feet, sandier with local gravels, very dense.
35	97 for 8"	20.3		101.2			@ 30 feet, very dense.
40	118	4.1					@ 35 feet, siltier and light yellowish-brown in color.
45	74	7.8					@ 40 feet, slightly sandier.
50	71	16.3					@ 45 feet, increase in fine grained sand content.
55							@ 50 feet, siltier, grayish-brown.
							END OF BORING
							No fill No groundwater No bedrock

PROJECT:	The Gateway at Grand Terrace	PROJECT NUMBER:	33318C.1
CLIENT:	Lewis Management Corp.	ELEVATION:	
<b>LOR</b> GEOTECHNICAL GROUP INC.		DATE DRILLED:	July 2, 2018
		EQUIPMENT:	Mobile B-61
		HOLE DIA.: 8"	ENCLOSURE: B-4

# LOG OF BORING B-5

TEST DATA							DESCRIPTION
DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY	
0							
	52 for 9"	9, 10	5.8	112.9		ML	@ 0 feet, <u>OLDER ALLUVIUM</u> : SANDY SILT, approximately 5% coarse grained sand, 15% medium grained sand, 25% fine grained sand, 55% silty fines, reddish-brown, damp to moist, stiff to very stiff, upper 6 to 12 inches tilled.
5	68 for 11"		9.5	125.3			
	68		9.6	122.3			@ 7 feet, includes minor calcium carbonate.
10	41		6.8	115.8			@ 10 feet, sandier and coarser grained.
15	12		2.4	107.4		SW	@ 13± feet, <u>WELL GRADED SAND</u> , approximately 15% coarse grained sand, 35% medium grained sand, 45% fine grained sand, 5% silty fines, reddish-brown, damp, medium dense.
20	24		4.1	113.3		SM	@ 18 feet, <u>SILTY SAND</u> , approximately 15% coarse grained sand, 30% medium grained sand, 35% fine grained sand, 20% silty fines, brown, damp, medium dense.
25							

PROJECT: The Gateway at Grand Terrace

PROJECT NUMBER: 33318C.1

CLIENT: Lewis Management Corp.

ELEVATION:

**LOR** GEOTECHNICAL GROUP INC.

DATE DRILLED: July 2, 2018

EQUIPMENT: Mobile B-61

HOLE DIA.: 8" ENCLOSURE: B-5



# LOG OF BORING B-6

DEPTH IN FEET	TEST DATA						U.S.C.S.	DESCRIPTION
	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)		DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY	
0								
25	9, 10	5.6			117.1		ML	@ 0 feet, <b>OLDER ALLUVIUM: SANDY SILT</b> , approximately 5% coarse grained sand, 10% medium grained sand, 15% fine grained sand, 70% silty fines, damp, medium dense, upper 6 to 12 inches tilled.
5	13	7.8			113.6			@ 7 to 8 feet, gravels, hard drilling.
10	6	3.3	2		109.1		SP	@ 10± feet, <b>POORLY GRADED SAND</b> , approximately 5% coarse grained sand, 10% medium grained sand, 80% fine grained sand, 5% silty fines, brown, damp, loose to medium dense.
15	58	2.8			129.5			@ 15 feet, includes minor gravel.
20	92 for 9"	12.5			119.5			@ 20 feet, includes trace to minor amounts of clay, reddish-brown, very dense.
25								<b>END OF BORING</b> No fill No groundwater No bedrock
30								

PROJECT: The Gateway at Grand Terrace

PROJECT NUMBER: 33318C.1

CLIENT: Lewis Management Corp.

ELEVATION:

**LOR** GEOTECHNICAL GROUP INC.

DATE DRILLED: July 2, 2018

EQUIPMENT: Mobile B-61

HOLE DIA.: 8" ENCLOSURE: B-6

# LOG OF BORING B-7

TEST DATA							DESCRIPTION
DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY	
0							CL @ 0 feet, <u>OLDER ALLUVIUM</u> : SANDY CLAY, approximately 5% coarse grained sand, 15% medium grained sand, 25% fine grained sand, 55% silty to clayey fines, reddish-brown, damp, medium dense, upper 6 to 12 inches disturbed.
26	1, 3, 7, 9, 10, 11	6.6	114.6				
5	29	10.2	123.6				below 6± feet, slightly sandier, dense to very dense.
10	74	7.9	131.0				@ 10 feet, very dense, finer grained.
15	37	10.9	111.1				SM @ 14 feet, SILTY SAND, approximately 20% medium grained sand, 60% fine grained sand, 20% silty fines, brown, moist, dense.
20	72 for 9"	9.9	119.7				@ 20 feet, finer grained.
25	80 for 9"	6.8	105.3				@ 25 feet, increase in percentage of fine grained sand,
30	54 for 6"	8.3	110.6				@ 30 feet, fine grained, roughly equal parts of fine grained sand and silty fines, light yellowish-brown, very dense.
35							END OF BORING No fill No groundwater No bedrock

PROJECT: The Gateway at Grand Terrace

PROJECT NUMBER: 33318C.1

CLIENT: Lewis Management Corp.

ELEVATION:

**LOR** GEOTECHNICAL GROUP INC.

DATE DRILLED: July 2, 2018

EQUIPMENT: Mobile B-61

HOLE DIA.: 8" ENCLOSURE: B-7

# LOG OF BORING B-8

TEST DATA							U.S.C.S.	DESCRIPTION
DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY		
0								@ 0 feet, <b>FILL</b> : Asphalt grindings and base.
22			10.1	122.6			ML	@ 1± feet, <b>OLDER ALLUVIUM</b> : SANDY SILT, approximately 5% coarse grained sand, 15% medium grained sand, 25% fine grained sand, 55% silty to clayey fines, reddish-brown, damp to moist, stiff.
5	37		10.8	116.1			SM	@ 6 feet, <b>SILTY SAND</b> , approximately 5% coarse grained sand, 25% medium grained sand, 35% fine grained sand, 35% silty fines, reddish-brown, moist, dense.
10	46 for 6"		7.7	113.8				@ 10 feet, very dense.
15	72 for 9"		8.5	115.5				@ 15 feet, slightly sandier.
20	51 for 6"		10.6	102.2				@ 20 feet, very dense.
25								<b>END OF BORING</b>
30								No fill No groundwater No bedrock

PROJECT: The Gateway at Grand Terrace

PROJECT NUMBER: 33318C.1

CLIENT: Lewis Management Corp.

ELEVATION:

**LOR** GEOTECHNICAL GROUP INC.

DATE DRILLED: July 3, 2018

EQUIPMENT: Mobile B-61

HOLE DIA.: 8" ENCLOSURE: B-8



# LOG OF BORING B-9

TEST DATA							
DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY	U.S.C.S.
0							SM
17	17		7.8	106.1			
5	6		8.8	103.4			
21	21		8.5	121.4			
10	26		8.2	125.3			
15	22		4.9	117.6			
20	43		6.3	127.6			
25	46		7.6	129.2			
30	87 for 11"		2.9	113.5			
35							

## DESCRIPTION

@ 0 feet, FILL: SILTY SAND with GRAVEL, fine to coarse grained, dry, loose, includes minor cobble sized pieces of asphalt and concrete in upper 1± feet.

@ 3± feet, ALLUVIUM: SILTY SAND, approximately 15% medium grained sand, 50% fine grained sand, 35% silty fines, reddish-brown, moist, porous (to 1/8" diameter), loose.

@ 7± feet, OLDER ALLUVIUM: SILTY SAND, approximately 5% coarse grained sand, 20% medium grained sand, 40% fine grained sand, 35% silty fines, reddish-brown, moist, non-porous, medium dense.

@ 15 feet, sandier and includes occasional fine to coarse grained sand with fine gravel layers.

@ 20 feet, finer grained.

@ 25 feet, includes trace to minor amounts of clay.

@ 30 feet, very dense.

END OF BORING

No fill  
No groundwater  
No bedrock

PROJECT: The Gateway at Grand Terrace

PROJECT NUMBER: 33318C.1

CLIENT: Lewis Management Corp.

ELEVATION:

**LOR** GEOTECHNICAL GROUP INC.

DATE DRILLED: July 3, 2018

EQUIPMENT: Mobile B-61

HOLE DIA.: 8" ENCLOSURE: B-9

# LOG OF BORING B-10

TEST DATA							U.S.C.S.	DESCRIPTION
DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY		
0							ML	@ 0 feet, <u>OLDER ALLUVIUM</u> : SANDY SILT, approximately 5% coarse grained sand, 15% medium grained sand, 25% fine grained sand, 55% silty fines, reddish-brown, damp, stiff, upper 6 to 12 inches tilled.
5	43		4.9	117.6				@ 5 feet, slightly finer grained, stiff.
10	64		6.3	120.7			SP	@ 9± feet, <u>POORLY GRADED SAND</u> , approximately 5% coarse grained sand, and fine gravel, 15% medium grained sand, 75% fine grained sand, 5% silty fines, light brown, damp, medium dense.
15	34		17.0	112.8			SW	@ 14± feet, <u>WELL GRADED SAND</u> , approximately 10% fine gravel, 20% coarse grained sand, 30% medium grained sand, 35% fine grained sand, 5% silty fines, light brown, damp.
20	45		1.3	105.5			SM	@ 20 feet, includes occasional thin fine grained silty sand layers.
25	57		4.7	103.8				@ 23 feet, <u>SILTY SAND</u> , approximately 5% medium grained sand, 50% fine grained sand, 45% silty fines, light brown, damp, dense, contains occasional 1/2 to 1" diameter concretions.
30	65		12.0	106.6				END OF BORING No fill No groundwater No bedrock

PROJECT: The Gateway at Grand Terrace

PROJECT NUMBER: 33318C.1

CLIENT: Lewis Management Corp.

ELEVATION:

**LOR** GEOTECHNICAL GROUP INC.

DATE DRILLED: July 3, 2018

EQUIPMENT: Mobile B-61

HOLE DIA.: 8" ENCLOSURE: B-10

# LOG OF BORING B-11

TEST DATA							
DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY	U.S.C.S.
0							
19			5.1	108.5			SM
5	52 for 11"		5.8				
10	59		3.0	121.6			
15	79 for 10"		8.4	126.4			ML
20	89 for 9"		7.3	120.0			SM
25							
30							
<p><b>DESCRIPTION</b></p> <p>@ 0 feet, <b>FILL: SILTY SAND</b>, approximately fine to coarse grained sand, damp, loose to medium dense, 1/2 to 1" gravel in upper 6".</p> <p>@ 4± feet, <b>OLDER ALLUVIUM: SILTY SAND</b>, approximately 5% coarse grained sand, 15% medium grained sand, 40% fine grained sand, 40% silty fines, reddish-brown, moist, dense.</p> <p>@ 5 feet, rings disturbed.</p> <p>@ 10 feet, slightly sandier and coarser grained.</p> <p>@ 14± feet, <b>SANDY SILT</b>, approximately 10% medium grained sand, 35% fine grained sand, 55% silty fines, reddish-brown, moist, very stiff.</p> <p>@ 17± feet, <b>SILTY SAND</b>, approximately 5% fine gravel, 15% coarse grained sand, 25% medium grained sand, 30% fine grained sand, 25% silty fines, brown, damp, very dense.</p> <p><b>END OF BORING</b></p> <p>Fill to 4' No groundwater No bedrock</p>							

PROJECT: The Gateway at Grand Terrace

PROJECT NUMBER: 33318C.1

CLIENT: Lewis Management Corp.

ELEVATION:

**LOR** GEOTECHNICAL GROUP INC.

DATE DRILLED: July 3, 2018

EQUIPMENT: Mobile B-61

HOLE DIA.: 8" ENCLOSURE: B-11



# LOG OF BORING B-12

TEST DATA							DESCRIPTION
DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY	
0							SM
19			5.3				@ 0 feet, FILL: Crushed and broken concrete.
5	36	3, 7, 9, 10, 11	7.5	127.9			@ 0.5± feet, SILTY SAND, fine to coarse grained sand, brown, damp, loose to medium dense.
10	66		9.2	121.4			@ 2 feet, rings disturbed.
15	68 for 11"		8.0	129.0			@ 4 feet, OLDER ALLUVIUM: SILTY SAND, approximately 5% coarse grained sand, 15% medium grained sand, 35% fine grained sand, 45% silty fines, reddish-brown, moist, dense.
20	45		5.7	123.8			@ 10 feet, slightly sandier.
25	54		8.7	122.9			@ 20 feet, much sandier, approximately 10% coarse grained sand, 30% medium grained sand, 45% fine grained sand, 15% silty fines.
30	81 for 9"		12.9	113.5			@ 25 feet, slight increase in silt content.
35	110		10.0				@ 30 feet, approximately 5% medium grained sand, 50% fine grained sand, 45% silty fines.
40	80		7.4				@ 35 feet, sandier.
45	98		9.4				@ 40 feet, fine to coarse grained sand with occasional thin silty/clayey layers.
50	78		5.4				@ 45 feet, includes minor local gravel.
55							@ 50 feet, fine to coarse grained, less silt.
END OF BORING							
Fill to 4'							
No groundwater							
No bedrock							

PROJECT: The Gateway at Grand Terrace

PROJECT NUMBER: 33318C.1

CLIENT: Lewis Management Corp.

ELEVATION:

**LOR** GEOTECHNICAL GROUP INC.

DATE DRILLED: July 3, 2018

EQUIPMENT: Mobile B-61

HOLE DIA.: 8" ENCLOSURE: B-12

# LOG OF BORING B-13

TEST DATA							
DEPTH IN FEET	SPT BLOW COUNTS	LABORATORY TESTS	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	SAMPLE TYPE	LITHOLOGY	U.S.C.S.
0							SM
27			5.5	113.7			
5	28		5.0	120.6			
10	74		4.1	122.5			
15	66		3.1	104.9			SW
20	42		2.8	108.4			
25	53		2.7	111.2			
30							

## DESCRIPTION

@ 0 feet, OLDER ALLUVIUM: SILTY SAND, approximately 5% coarse grained sand, 10% medium grained sand, 40% fine grained sand, 45% silty fines, brown, damp, medium dense, upper 6 to 12 inches tilled.

@ 5 feet, slightly porous (to 1/16" in diameter).

@ 10 feet, coarser grained, includes minor gravel.

@ 14± feet, WELL GRADED SAND, approximately 5% fine gravel, 15% coarse grained sand, 35% medium grained sand, 40% fine grained sand, 5% silty fines, light brown, damp, dense.

@ 20 feet, clean sand.

@ 25 feet, again, clean sand.

## END OF BORING

Fill to 1±'  
No groundwater  
No bedrock

PROJECT: The Gateway at Grand Terrace

CLIENT: Lewis Management Corp.

**LOR** GEOTECHNICAL GROUP INC.

PROJECT NUMBER: 33318C.1

ELEVATION:

DATE DRILLED: July 3, 2018

EQUIPMENT: Mobile B-61

HOLE DIA.: 8" ENCLOSURE: B-13

## **APPENDIX C**

### **Laboratory Testing Program and Test Results**



## **APPENDIX C**

### **LABORATORY TESTING**

#### General

Selected soil samples obtained from the borings were tested in our geotechnical laboratory to evaluate the physical properties of the soils affecting foundation design and construction procedures. Laboratory testing included moisture content, dry density, laboratory compaction, direct shear, sieve analysis, expansion potential, Atterberg limits, R-Value, and soluble sulfate content. Descriptions of the laboratory tests are presented in the following paragraphs.

#### Moisture-Density Tests

The moisture content and dry density information provides an indirect measure of soil consistency for each stratum, and can also provide a correlation between soils on this site. The dry unit weight and field moisture content were determined for selected undisturbed samples, in accordance with ASTM D 2937 and 2922, and ASTM D 2216, respectively, and the results are shown on the Boring Logs, Enclosures B-1 through B-13 for convenient correlation with the soil profile.

#### Laboratory Compaction

Selected soil samples were tested in the laboratory to determine compaction characteristics using the ASTM D 1557 compaction test method. The results are presented in the following table:

<b>LABORATORY COMPACTION</b>				
<b>Boring Number</b>	<b>Sample Depth (feet)</b>	<b>Soil Description (U.S.C.S.)</b>	<b>Maximum Dry Density (pcf)</b>	<b>Optimum Moisture Content (percent)</b>
B-2	4 - 7	(ML) Sandy Silt	131.0	10.0
B-7	2 - 6	(ML) Sandy Silt	131.5	10.5
B-12	4 - 7	(SM) Silty Sand	134.0	7.0

### Direct Shear Tests

Shear tests are performed with a direct shear machine in general accordance with ASTM D 3080 at a constant rate-of-strain (usually 0.05 inches/minute). The machine is designed to test a sample partially extruded from a sample ring in single shear. Samples are tested at varying normal loads in order to evaluate the shear strength parameters, angle of internal friction and cohesion. Samples are tested in remolded condition (90 percent per ASTM D 1557) and soaked, according to conditions expected in the field.

The results of the shear tests are presented in the following table:

DIRECT SHEAR TESTS				
Boring Number	Sample Depth (feet)	Soil Description (U.S.C.S.)	Apparent Cohesion (psf)	Angle of Internal Friction (degrees)
B-2	4 - 7	(ML) Sandy Silt	540	27
B-7	2 - 6	(ML) Sandy Silt	300	24
B-12	4 - 7	(SM) Silty Sand	160	31

### Expansion Index Tests

Remolded samples are tested to determine their expansion potential in accordance with the Expansion Index (EI) test. The test is performed in accordance with the Uniform Building Code Standard 18-2. The test results are presented in the following table:

EXPANSION INDEX TESTS				
Boring Number	Sample Depth (feet)	Soil Description	Expansion Index (EI)	Expansion Potential
B-4	2 - 5	(CL) Sandy Clay	40	Low
B-7	2 - 6	(CL) Sandy Clay	24	Low
Expansion Index:      0-20              21-50              51-90              91-130 Very low              Low              Medium              High				

### Atterberg Limits

This report was prepared concurrently with a related site located a short distance to the north. The most conservative fine-graded sample from the two sites was tested for Atterberg limits in accordance with ASTM D 4318. The results of this test are presented on Enclosure C-1.

### Sieve Analysis

A quantitative determination of the grain size distribution was performed for selected samples in accordance with the ASTM D 422 laboratory test procedure. The determination is performed by passing the soil through a series of sieves, and recording the weights of retained particles on each screen. The results of the sieve analyses are presented graphically on Enclosures C-2 and C-3.

### Consolidation Test

The apparatus used for the consolidation tests (odometer) is designed to test a one-inch high portion of the undisturbed soil sample as contained in a sample ring. Porous stones and filler paper are placed in contact with the top and bottom of the specimen to permit the addition or release of water. Loads are applied to the test specimen in specified increments, and the resulting axial deformations are recorded. The results are plotted as log of axial pressure versus consolidation or compression, expressed as strain or sample height.

Samples are tested at field and greater-than field moisture contents. The results are shown on Enclosures C-4 and C-5.

### Sand Equivalent

The sand equivalent of selected soils were evaluated using the California Sand Equivalent Test Method, Caltrans Number 217. The results of the sand equivalent tests are presented with the grain size distribution analyses on Enclosures C-2 and C-3.

### R-Value Test

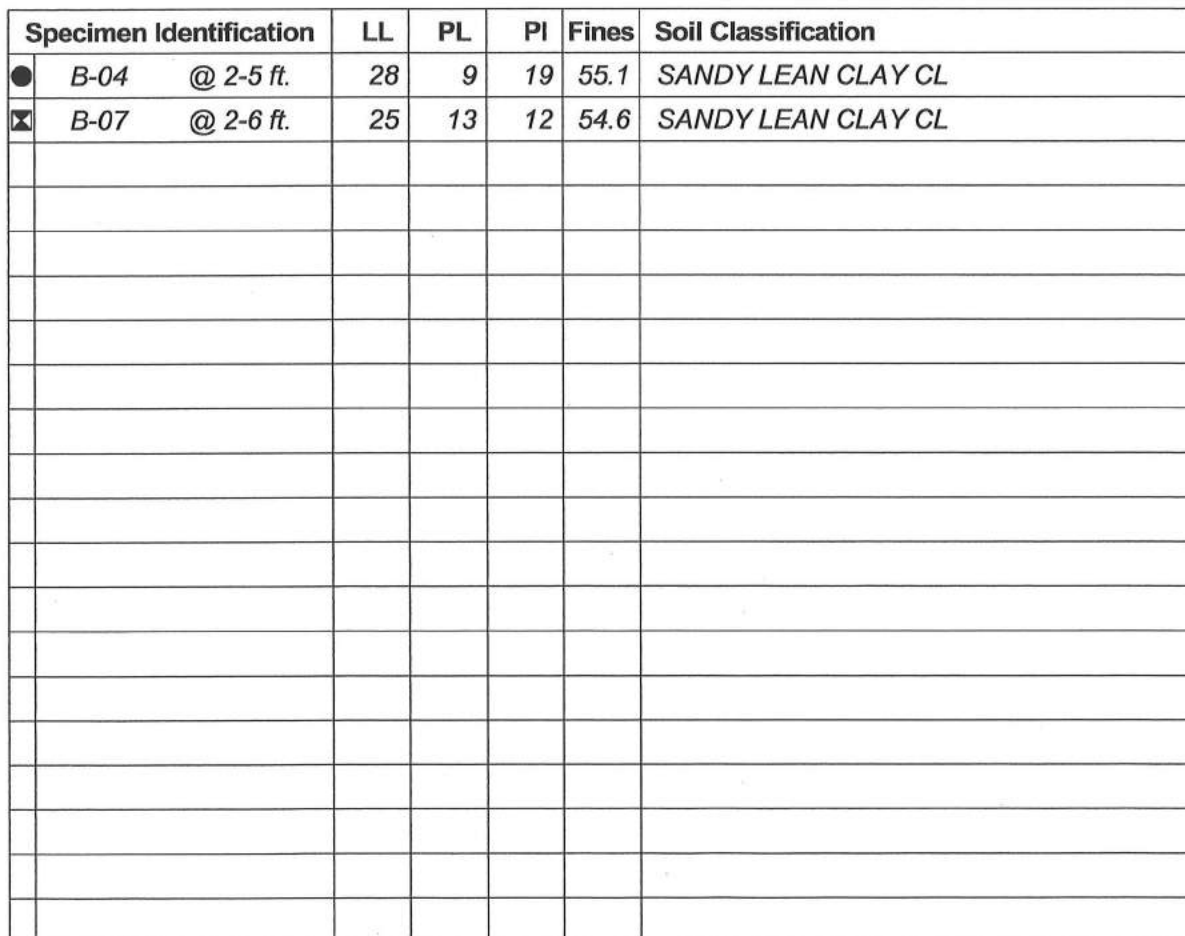
Soil samples were obtained at probable pavement subgrade level and sieve analysis and sand equivalent tests were conducted. Based on these indicator tests, a selected soil sample was tested to determine its R-value using the California R-Value Test Method, Caltrans Number 301. The results of the sieve analysis, sand equivalent, and R-value tests are presented on Enclosures C-2 and C-3.

### Soluble Sulfate Content Tests

The soluble sulfate content of selected subgrade soils was evaluated. The concentration of soluble sulfates in the soils was determined by measuring the optical density of a barium sulfate precipitate. The precipitate results from a reaction of barium chloride with water extractions from the soil samples. The measured optical density is correlated with readings on precipitates of known sulfate concentrations. The test results are presented on the following table:

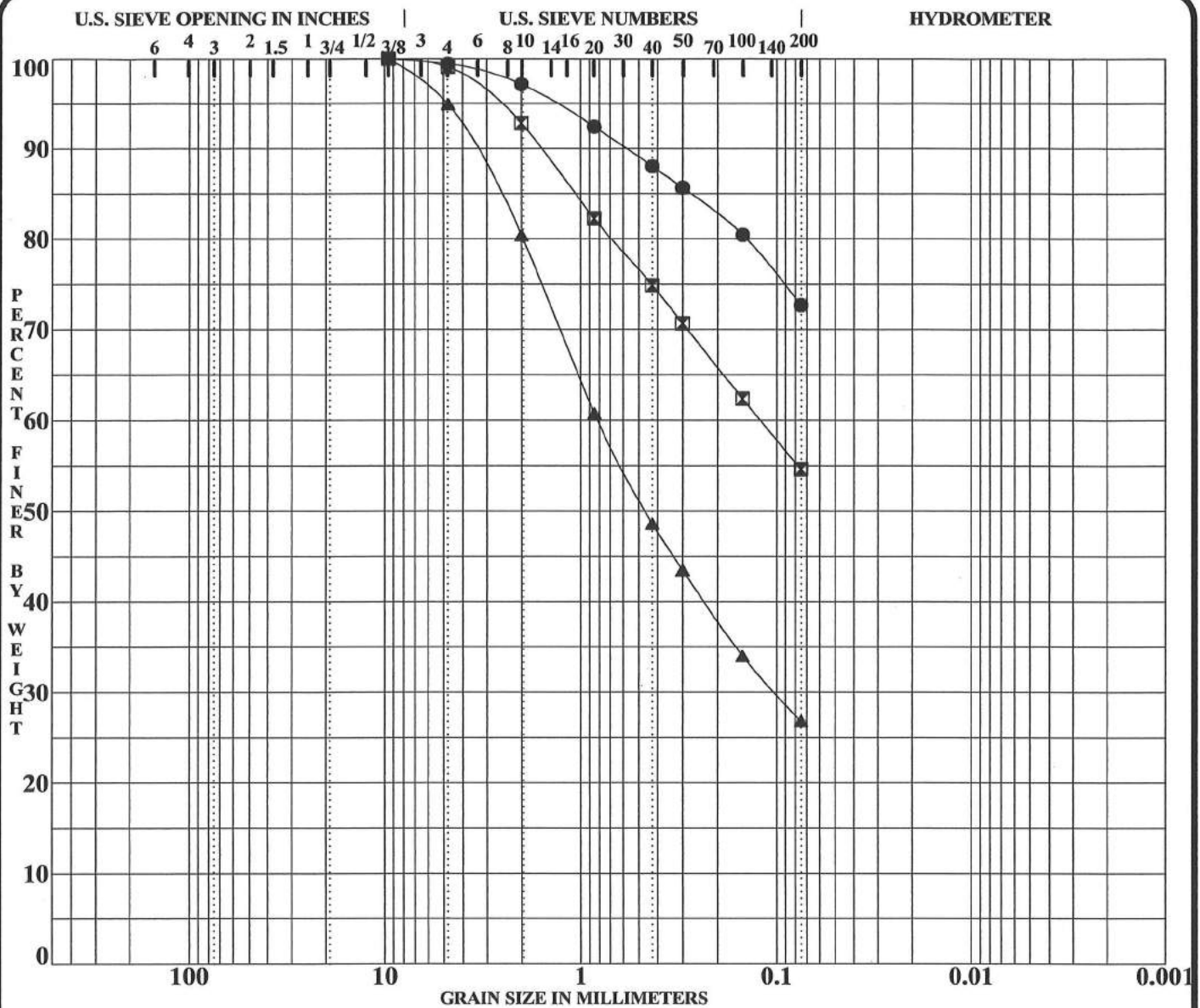
<b>SOLUBLE SULFATE CONTENT TESTS</b>			
<b>Boring Number</b>	<b>Sample Depth (feet)</b>	<b>Soil Description</b>	<b>Sulfate Content (percent by weight)</b>
B-2	4 - 7	(ML) Sandy Silt	<0.1
B-4	2 - 5	(CL) Sandy Clay	<0.1
B-7	2 - 6	(CL) Sandy Clay	<0.1
B-12	4 - 7	(SM) Silty Sand	<0.1

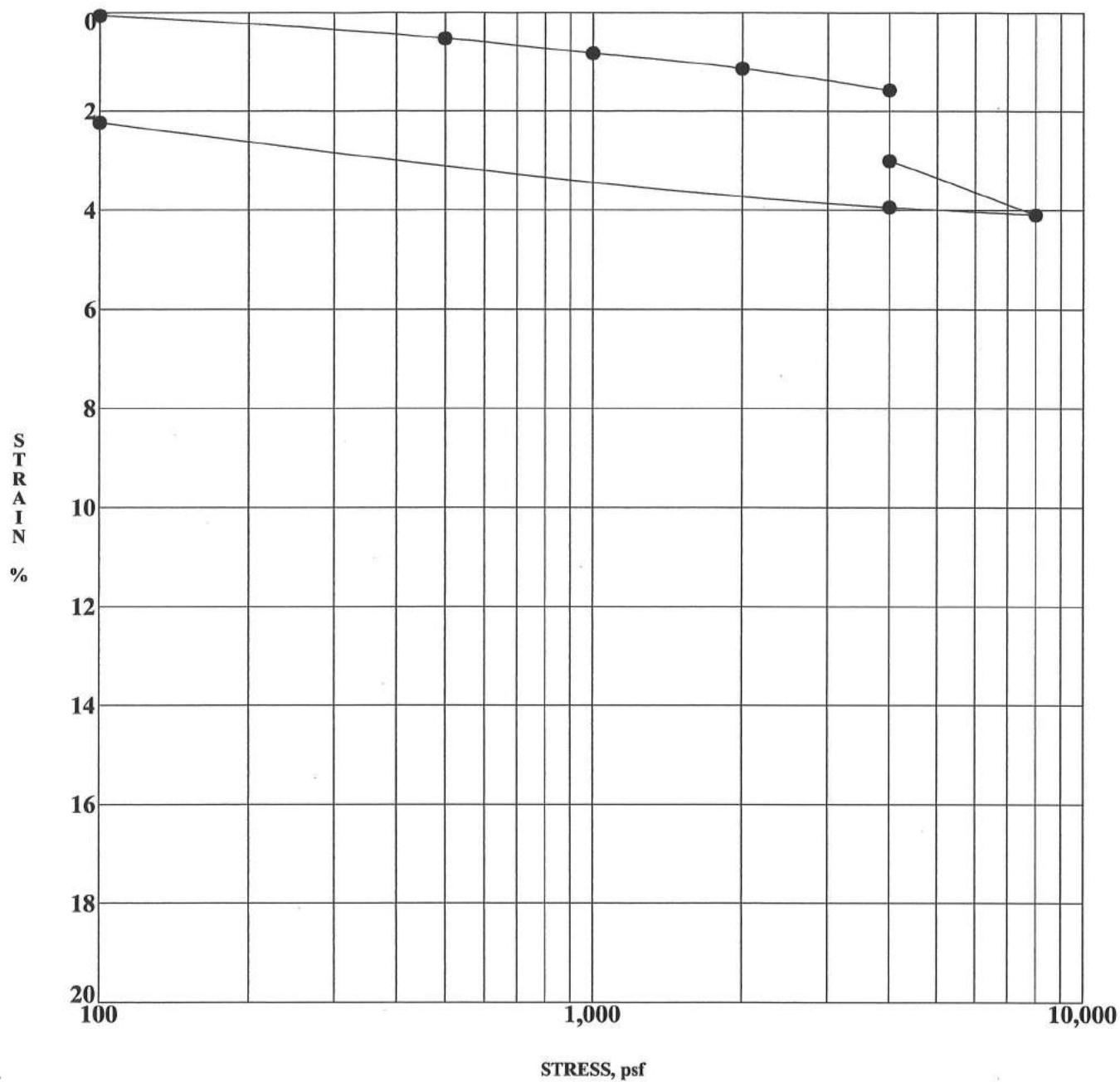




**ENCLOSURE C-1**







Specimen I.D.	Classification	DD	MC%
● B-02 @ 7 ft	(ML) Sandy Silt	111	5

PROJECT The Gateway at Grand Terrace

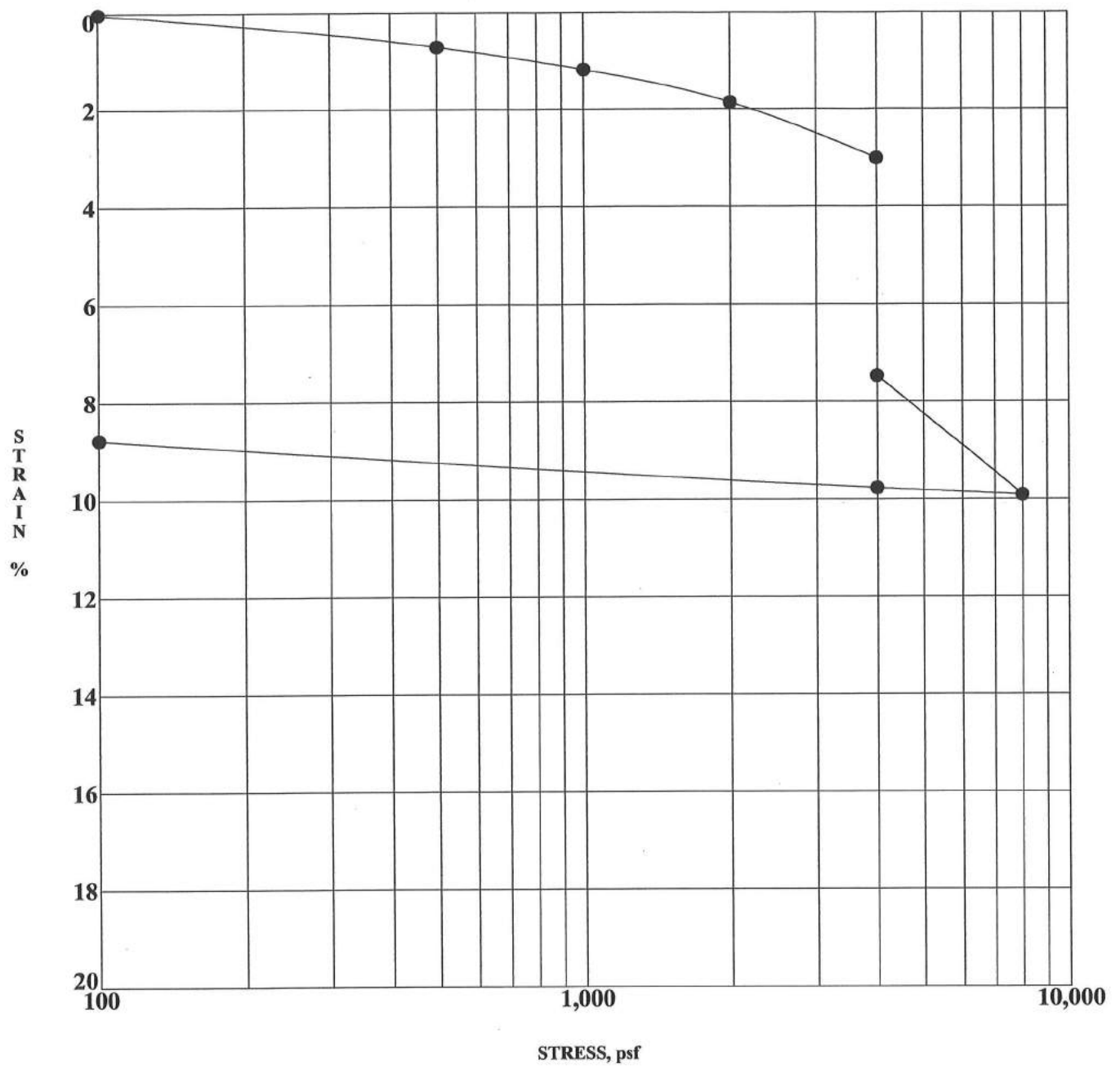
PROJECT NO. 33318C.1

DATE 7/18/18

**CONSOLIDATION TEST**  
LOR Geotechnical Group, Inc.

ENCLOSURE C-4





Specimen I.D.	Classification	DD	MC%
● B-06 @ 10 ft	(SP) Poorly Graded Sand	101	3

PROJECT The Gateway at Grand Terrace

PROJECT NO. 33318C.1

DATE 7/18/18

CONSOLIDATION TEST  
LOR Geotechnical Group, Inc.

ENCLOSURE C-5