Geotechnical Engineering Report

Limonite Avenue Widening

Jurupa Valley, California

August 30, 2018

Terracon Project No. CB185061

Prepared for:

City of Jurupa Valley

Jurupa Valley, California

Prepared by:

Terracon Consultants, Inc.

Colton, California

August 30, 2018

City of Jurupa Valley
8930 Limonite Avenue
Jurupa Valley, California 92509-5019

Attn: Mr. Chase Keys – Assistant Engineer
P: (951) 332 6464
E: ckeys@jurupavalley.org

Re: Geotechnical Engineering Report
Limonite Avenue Widening
Limonite Avenue, between Bain Street and Homestead Street
Jurupa Valley, California
Terracon Project No. CB185061

Dear Mr. Keys:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with Terracon Proposal No. PCB185061 dated May 22, 2018. This report presents the findings of the subsurface exploration and provides geotechnical recommendations for the street pavement and the design and construction of the proposed box culvert.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

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REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks that direct the reader to that section, and clicking on the logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

REPORT SUMMARY

Topic [1]	Overview Statement [2]
Project Description	The project consists of widening approximately 3,850 linear feet of Limonite Avenue between Bain Street and Homestead Street, east of Van Buren Boulevard in Jurupa Valley, CA. Two additional traffic lanes are anticipated to be added to the existing two lanes. Final design of the roadway has not been completed, but it is anticipated that most of the alignment will require that the existing roadway be completely demolished and fully rebuilt. Some areas may only have outside lanes added; those areas will be determined at the time of final design. A raised center median with curb and gutter, a multi-purpose path, and an equestrian trail are also included in this project.
Geotechnical Characterization	■ Undocumented fill up to 4 feet deep. ■ Loose silty sand up to 35 feet deep ■ Layer of soft silt from 15 feet to 20 feet ■ Medium dense silty sand from 35 to 40 feet and dense to very dense silty sand below 40 feet ■ Groundwater was encountered between 28 and 32 feet ■ Due to the shallow levels of groundwater, liquefaction hazard potential is high.
Earthwork	Canal sediments, existing fill, and disturbed native soils should be removed Subgrade surfaces should be proof-rolled prior to placement of fill
Shallow Foundations	Shallow foundations will be sufficient. Allowable bearing pressure = 2,000 lbs/sq ft Foundations should rest upon 24” of compacted class 2 permeable material Expected settlements: < 1 inch total, < ¾ inch differential Detect and remove zones of fill as noted in **Earthwork.**
Pavements	With subgrade prepared as noted in **Earthwork** Asphalt: ■ Major Highway: 0.55’ HMA[3]/1.30’ Class 2 AB[4] Concrete: ■ Major Highway: 0.70’ PCC[5]/0.70’ Class 2 AB
General Comments	This section contains important information about the limitations of this geotechnical engineering report.

1. If the reader is reviewing this report as a pdf, the topics above can be used to access the appropriate section of the report by simply clicking on the topic itself.
2. This summary is for convenience only. It should be used in conjunction with the entire report for design purposes.
3. HMA = hot mix asphalt
4. AB = aggregate base
5. PCC = Portland Cement Concrete

Geotechnical Engineering Report

Limonite Avenue Widening
Limonite Avenue, between Bain Street and Homestead Street
Jurupa Valley, California
Terracon Project No. CB185061
August 30, 2018

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed road widening to be located at Limonite Avenue, between Bain Street and Homestead Street in Jurupa Valley, California. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions and historic high groundwater
- 2016 California Building Code (CBC) seismic design parameters
- Liquefaction potential
- Seismic settlement
- Lateral earth pressures
- Subgrade preparation/earthwork recommendations
- Recommendations for preliminary pavement section design

The geotechnical engineering scope of services for this project included the advancement of nine test borings to depths ranging from approximately 6-1/2 to 41-1/2 feet below existing site grades.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs and as separate graphs in the **Exploration Results** section of this report.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The roadway project is along Limonite Avenue, between Bain Street and Homestead Street in Jurupa Valley, California. The total length of the roadway for this project is approximately 3,850 feet. (See **Site Location**)
Existing Improvements	The alignment consists of a two-lane asphalt road surrounded by residential and commercial buildings.
Current Ground Cover	Asphalt paved two lane road with concrete curb and gutters.
Existing Topography	The alignment has gentle slopes (>10:1) to both the east and west. The center portion of the alignment is at the lowest elevation and is approximately 25 to 30 feet lower in elevation than either the west or east end of the alignment.

Historic Aerial Photo Examination

Historic imagery dating from 1948 was examined for past site usage. From 1948 to 1967 the alignment was developed as a 2 lane, asphalt paved road with a few structures to the south. The remainder of the surrounding area was developed as agriculture. From 1967 to 1994 the property alignment went from being developed for agriculture use to being developed as dairy farms. By 1994, the property to the north had been developed with large farms and rural homes. From 1994 to 2014, the property around Limonite Avenue has remained rural housing, agriculture and dairy farms.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed in the project planning stage. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	Project information was furnished to us via an email dated May 10, 2018, by Steve Loriso for a request of scope of proposed geotechnical investigation. We have identified some of the parameters listed as assumed or unknown in our proposal. Those remain highlighted below in this table.

Item	Description
Project Description	The project consists of widening approximately 3,850 linear feet of Limonite Avenue between Bain Street and Homestead Street, east of Van Buren Boulevard in Jurupa Valley, CA. Two additional traffic lanes are anticipated to be added to the existing two lanes. Final design of the roadway has not been completed, but it is anticipated that most of the alignment will require that the existing roadway be completely demolished and fully rebuilt. Some areas may only have outside lanes added; those areas will be determined at the time of final design. A raised center median with curb and gutter, a multi-purpose path, and an equestrian trail are also included in this project.
Proposed Structures	No building structures. Culvert box
Finished Floor Elevation	Near existing elevation.
Maximum Loads	■ Culvert Mat: 2,000 pounds per square foot (psf) ■ Wing Walls: 2,000 psf
Grading/Slopes	Anticipated slopes near culvert
Below Grade Structures	We understand that a box culvert is planned to be installed within the project alignment, west of Beach Street (near station 37+50). The culvert is approximately 10 feet below the existing roadway.
Free-Standing Retaining Walls	None.
Pavements	Per city engineer, the street class and traffic index (TI) are as follows: ■ Major Highway: TI=9.0
Estimated Start of Construction	Unknown.

GEOTECHNICAL CHARACTERIZATION

Geologic Setting

The site is located on the Cucamonga Plain in the west-central portion of the San Bernardino Valley, a structural basin within the Peninsular Ranges Geomorphic Province. This portion of the valley is bounded on the north by the San Gabriel Mountains of the Transverse Ranges and on the south by Jurupa Hills of the Perris Block. The Cucamonga Plain is formed by coalesced alluvial fans emanating from the San Gabriel Mountains. Published geologic mapping by Morton & Miller (2006) show the site is underlain by alluvial and aeolian deposits of Holocene and late- to middle-Pleistocene age.

Fault Rupture Potential: The alignment is not located within an Alquist-Priolo Earthquake Fault Zone (APZ) designated by the State of California for active faults. The closest APZ boundary, designated for the Lake Elsinore Fault zone (Chino segment), is located approximately 9.5-miles west-southwest of the site. Known faults or fault-related features are not located within the site;

therefore, the potential for fault rupture within the site is considered low.

Subsurface Profile

We have developed a general characterization of the subsurface soil and groundwater conditions based upon our review of the data and our understanding of the geologic setting and planned construction. A summary of the subsurface profile can be seen on our GeoModel, located in our **Exploration Results**.

The geotechnical characterization forms the basis of our geotechnical calculations and evaluation of site preparation, foundation options and pavement options. As noted in **General Comments**, the characterization is based upon widely spaced exploration points across the site, and variations are likely.

Groundwater Conditions

Groundwater conditions encountered during our investigation are included in our GeoModel. Groundwater-level fluctuations occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

Historic Groundwater Conditions

The site is located in Section 22 of Township 2 South, Range 6 West, in the Chino sub-basin of the Upper Santa Ana Valley groundwater basin. Depth-to-groundwater data in the vicinity of the site are available from the State of California Department of Water Resources (2017) and other groundwater studies. These data are summarized in the following tables:

Summary of Groundwater Data					
Well/Data Source	**Date Measured**	**Measuring Point Elevation (feet)**	**Depth to Water (feet) Well/Site**	**Distance from Site (miles)**	**Source**
02S06W28C001S	1/1/2001	669.760	64.83	3/4 miles W	DWR (2018)
	7/20/2010		64.22		
	4/4/2018		65.77		
Contour Map	1985	--	30	--	Carson & Matti (1985)

GEOTECHNICAL OVERVIEW

The subsurface soils of the site are described in the **Geotechnical Characterization** section. Based upon our field investigation and test data, it is our opinion that the upper existing soils will not, in their present condition, provide uniform or adequate support for the proposed box culvert. Based on review of our exploratory boring logs, variable in situ conditions may be present. These conditions may cause unacceptable differential and/or overall settlement upon application of the anticipated foundation loads.

The pavement subgrade should be proof-rolled with an adequately loaded vehicle such as a fully loaded tandem axle dump truck. The proposed box culvert should be supported on a minimum of 24 inches (2 feet) of Class 2 permeable material per the Caltrans Standard Specifications (2015), Section 68. Prior to placement of the permeable material, all canal sediments, existing fill soils, and any soil disturbed during demolition and construction should be removed from the box culvert area to expose undisturbed native soils. Additional site preparation recommendations including subgrade improvement and fill placement are provided in the **Earthwork** section.

The **Shallow Foundations** section addresses support of the box culvert bearing on engineered fill. Recommendations for pavement designs are provided in **Pavements** section.

The **General Comments** section provides an understanding of the report limitations.

SEISMIC CONSIDERATIONS

Seismic Design Parameters

The seismic design parameters for buildings and other structures are based on seismic design category and mapped acceleration parameters modified for ASCE 7-10 (soil profile). The seismic design parameters, according to the 2016 California Building Code (CBC) are provided in the following table.

Description	Value
2016 California Building Code Site Classification (CBC) [1]	D [2]
Site Latitude	33.9755
Site Longitude	-117.4994
Mapped Spectral Acceleration Parameters [3]	S_S = 1.50 and S_1 = 0.60
Site Coefficients [3]	F_A = 1.0 and F_V = 1.5

Description	Value
Adjusted Maximum Considered Earthquake Spectral Response Parameters Design Spectral Acceleration Parameters[3]	SM_S = 1.50 and SM_1 = 0.90
Design Spectral Acceleration Parameters[3]	SD_S = 1.00 and SD_1 = 0.60
Geometric Mean Peak Ground Acceleration[3]	0.5g
De-aggregated Magnitude	8.1

1. Seismic site classification in general accordance with the 2016 California Building Code, which refers to ASCE 7-10.
2. The 2016 California Building Code (CBC) uses a site profile extending to a depth of 100 feet for seismic site classification. Borings at this site were extended to a maximum depth of 41-1/2 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth.
3. These values were obtained using online seismic design maps and tools provided by the USGS (https://earthquake.usgs.gov/designmaps/us/application.php)

LIQUEFACTION AND SEISMIC SETTLEMENT

The theory and methodology of liquefaction potential, seismic settlement evaluations and surface manifestation are described in **Theory and Methodology of Liquefaction and Seismic Settlement** in the **Supporting Information** section.

Liquefaction Potential

According to the County of Riverside General Plan (2018), the site is within an area identified as having a potential for liquefaction.

Due to the potential for the presence of shallow groundwater beneath the site (28 feet) and the loose state of soils encountered, the liquefaction potential of the site has been evaluated based on the procedures and corrections recently summarized by Idriss and Boulanger (2008). A historic high groundwater depth of 30 feet bgs was utilized to calculate the liquefaction potential in the area. The recommended design PGA of 0.50g and a deaggregated earthquake magnitude (M_w) of 8.1 were utilized as input into the liquefaction analysis program GeoSuite©, version 2.4 (Yi, 2018).

Liquefaction potential was evaluated for the soil profiles encountered in exploratory borings using an SPT sampler. The results of liquefaction potential evaluations are shown in Exhibits D-1. Our calculation indicates that liquefaction could occur in a layer at depths ranging from approximately 30 to 35 feet bgs based on SPT data.

Seismic Settlement

Liquefaction-induced settlement was evaluated following the procedures used for liquefaction potential (Idriss and Boulanger, 2008). The seismic settlement of dry sands was evaluated based on UCLA volumetric strain material model (VSMM) (Duku et al. 2008; Yee et al. 2014; Stewart, 2014).

Seismic settlement was estimated using soil profile generalized from exploratory boring B-5. The geometric mean peak ground acceleration (PGA) of 0.50g and a deaggregated earthquake magnitude (M_w) of 8.1 were utilized as input into the liquefaction analysis program GeoSuite©, version 2.4 (Yi, 2018). The results of seismic settlement evaluations are shown in Exhibits D-1.

Our analysis indicates that seismic settlement (including liquefaction-induced settlement and dry sand settlement) could be on the order of approximately 1.3 inch.

Surface Manifestation of Liquefaction

Both the liquefaction potential index (LPI) and liquefaction severity number (LSN) were calculated for all soil profiles. The LPI indicates that the liquefaction risk of the site is "high". The site exhibits little expression of liquefaction as per the LSN index (Tonlin & Taylor, 2013). Overall, it is the opinion of this firm that the site may exhibit moderate risk of surface manifestation, most possibly exhibit as surface settlement.

SHALLOW FOUNDATIONS

We understand that the proposed box culvert will be of typical cut and cover design, and will consist of a lengthening of the existing box culvert at the site. Geotechnical design parameters for shallow foundations supporting the box culvert and associated wing walls are presented separately in the sections below.

If the site has been prepared in accordance with the requirements noted in **Earthwork**, the following design parameters are applicable for shallow foundations.

Box Culvert

Based on the soil conditions encountered during our field exploration, the proposed box culvert should be supported on a minimum of 24 inches (2 feet) of Class 2 permeable material per the Caltrans Standard Specifications (2015), Section 68. Prior to placement of the permeable material, all canal sediments, existing fill soils, and any soil disturbed during demolition and construction should be removed from the box culvert area to expose undisturbed native soils.

If fine-grained materials (silts or clays) are encountered during excavation of the box culvert, a Subgrade Separation Geotextile filter fabric should be placed at the base and sides of the excavation prior to placement of the permeable material. The Separation Geotextile may consist of Mirafi 140N or equivalent and should extend a minimum of three feet above the top of the excavation to allow for partially wrapping of the top of the permeable material after placement. The Separation Geotextile Fabric serves to confine the compacted fill materials during placement, and is not necessary in high permeability granular subgrades such as sands and gravels.

The layer of Class 2 permeable material should extend laterally from the edges of the proposed box culvert at least a distance equal to 2/3 the depth of the compacted fill below the bottom of the culvert (i.e. extend laterally 16 inches beyond the edges of the box culvert for a fill depth of 24 inches below the bottom of the box). The Class 2 permeable material that is placed beneath the proposed footing elevation shall follow compaction recommendations presented in the **Earthwork**.

If soft and/or wet subgrade conditions are encountered, these soils should be excavated and replaced or repaired in accordance with Caltrans Standard Specifications for Highway Construction (2015).

Box Culvert Design Parameters

Item	Description
Box Culvert Foundation	Box Culvert Floor (Mat Foundation)
Required Bearing Stratum [3]	Minimum 24" of compacted Class 2 permeable material supported on undisturbed native soils
Net Allowable Bearing pressure [1, 2]	2,000 psf
Presumptive bearing capacity for service limit state for settlement of approximately 1 inch or less	1,200 psf
Ultimate Passive Resistance [4] **(equivalent fluid pressures)**	350 psf
Ultimate Coefficient of Sliding Friction [5]	Precast concrete: 0.50
Estimated Total Settlement from Structural Loads [2]	Less than about 1 inch

Item	Description

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. These bearing pressures can be increased by 1/3 for transient loads unless those loads have been factored to account for transient conditions. Values assume that exterior grades are no steeper than 20% within 10 feet of structure.
2. Values provided are for maximum loads noted in **Project Description**.
3. Unsuitable or soft soils should be over-excavated and replaced per the recommendations presented in the **Earthwork**.
4. Use of passive earth pressures requires the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neatly against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face. A factor of safety of 2.0 is recommended.
5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Should be neglected for foundations subject to net uplift conditions. A factor of safety of 1.5 is recommended.

Differential settlement of the structure is anticipated to be approximately equal to ½ to ¾ of the total settlement. Differential settlement in directions both longitudinal and transverse to the box culvert should be anticipated below the box culvert.

Wing Wall Foundations

Based on the soil conditions encountered during our field exploration, we recommend the proposed wing walls be founded on spread foundations bearing on 24 inches of native soils recompacted as engineered fill. Prior to placement of the engineered fill, all canal sediments, existing fill, and disturbed native soils should be removed from the foundation areas.

If fine-grained materials (silts or clays) are encountered during excavation of the box culvert, a Subgrade Separation Geotextile should be placed at the base and sides of excavations for the footings for the wing walls prior to placing the Aggregate for Untreated Base. The Separation Geotextile may consist of Mirafi 140N or equivalent and should be extended a minimum of three feet above the top of the excavation to allow for partially wrapping of the top of the crushed aggregate after placement. The Separation Geotextile Fabric serves to confine the compacted fill materials during placement, and is not necessary in high permeability granular subgrades such as sands and gravels.

Engineered fill should extend laterally from the foundation edges at least a distance equal to 2/3 of the depth of the compacted fill below the footing base elevation. Engineered fill shall follow compaction recommendations presented in the **Earthwork**.

Wing Wall Design Parameters

Item	Description
Wing Wall Foundation	Conventional shallow spread footings
Required Bearing Stratum [3]	Minimum 24" of compacted engineered fill

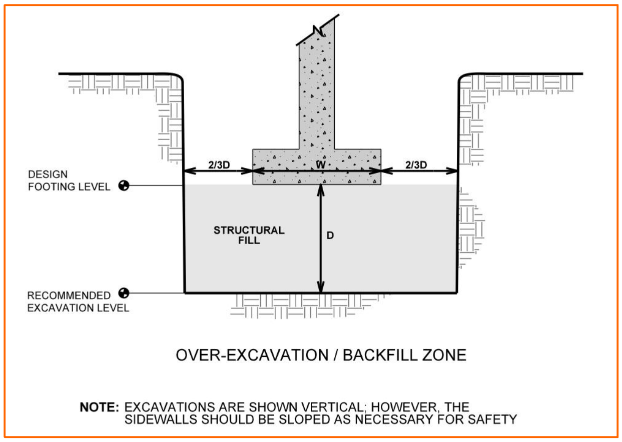
Item	Description
Minimum Foundation Dimensions	24 inches
Net Allowable Bearing pressure [1, 2]	2,000 psf
Minimum embedment depth	12 inches
Ultimate Passive Resistance [4] **(equivalent fluid pressures)**	350 psf
Ultimate Coefficient of Sliding Friction [5]	0.50
Estimated Total Settlement from Structural Loads [2]	Less than about 1 inch

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. An appropriate factor of safety has been applied. These bearing pressures can be increased by 1/3 for transient loads unless those loads have been factored to account for transient conditions. Values assume that exterior grades are no steeper than 20% within 10 feet of structure.
2. Values provided are for maximum loads noted in **Project Description**.
3. Unsuitable or soft soils should be over-excavated and replaced per the recommendations presented in the **Earthwork**.
4. Use of passive earth pressures requires the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neatly against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face. A factor of safety of 2.0 is recommended.
5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Should be neglected for foundations subject to net uplift conditions. A factor of safety of 1.5 is recommended.

Foundation Construction Considerations

As noted in **Earthwork**, the footing excavations should be evaluated under the direction of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

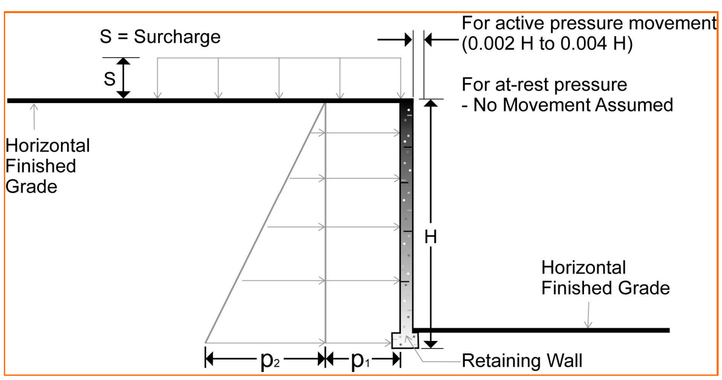
Over-excavation for engineered fill placement below the wing wall footings should be conducted as shown below. The over-excavation should be backfilled up to the footing base elevation, with engineered fill placed, as recommended in the **Earthwork** section.



LATERAL EARTH PRESSURES

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls (unless stated).



Lateral Earth Pressure Design Parameters				
Earth Pressure Condition [1]	Coefficient for Backfill Type [2]	Surcharge Pressure [3, 4, 5] p_1 (psf)	Effective Fluid Pressures (psf) [2, 4, 5]	
			Unsaturated [6]	Submerged [6]
Active (K_a)	0.43	(0.43)S	(50)H	---
At-Rest (K_o)	0.56	(0.56)S	(65)H	---
Passive (K_p)	2.60	---	(300)H	---

1. For active earth pressure, wall must rotate about base, with top lateral movements 0.002 H to 0.004 H, where H is wall height. For passive earth pressure, wall must move horizontally to mobilize resistance.
2. Uniform, horizontal backfill using on-site material, compacted to at least 90 percent of the ASTM D 1557 maximum dry density, rendering a maximum unit weight of 114 pcf.
3. Uniform surcharge, where S (psf) is surcharge pressure.
4. Loading from heavy compaction equipment is not included.
5. No safety factor is included in these values.
6. In order to achieve “unsaturated” conditions, follow guidelines in **Subsurface Drainage for Below Grade Walls** below. “Submerged” conditions are recommended when drainage behind walls is not incorporated into the design.

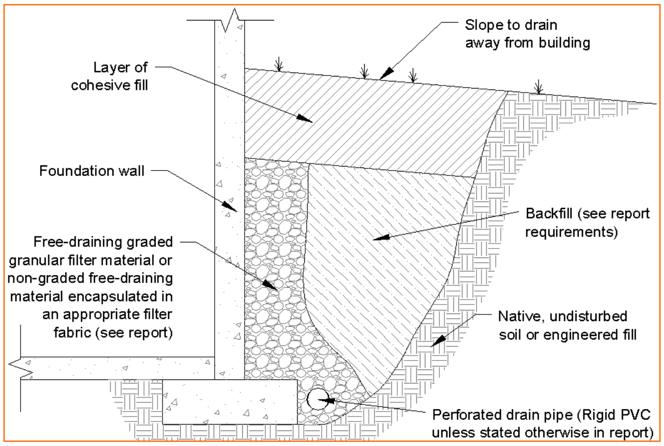
Backfill placed against structures should consist of granular soils or low-plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 and 60 degrees from vertical for the active and passive cases, respectively.

For walls 10 feet high or less, a uniform construction surcharge load of 72 psf or an alternative traffic surcharge load of 100 psf should be applied in addition to active earth pressure. If the wall is higher than 10 feet, a uniform construction surcharge load of 72 psf or an alternative traffic surcharge load of 100 psf should be applied only up to 10 feet. The resulting additional surcharge pressure should be applied to the wall as a rectangular distribution, from top to bottom, or 10 feet, whichever is smaller.

These values should be verified prior to construction when the backfill materials and conditions have been determined. These values are applicable only to level, properly drained backfill with no additional surcharge loadings and do not include a factor of safety other than conservative modeling of the soil strength parameters. If inclined backfills are proposed, this firm should be contacted to develop appropriate active earth pressure parameters. If import material is to be utilized for backfill, an engineer from this firm should verify the backfill has equivalent or superior strength values.

Subsurface Drainage for Below Grade Walls

A perforated rigid plastic drain line installed behind the base of walls and extends below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around a below-grade building area or exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 5 percent passing the No. 200 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used. A pre-fabricated drainage structure is a plastic drainage core or mesh that is covered with filter fabric to prevent soil intrusion and is fastened to the wall prior to placing backfill.

PAVEMENTS

General Pavement Comments

Pavement designs are provided for the traffic conditions and pavement life conditions as noted in **Project Description** and in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs, noted in this section, must be applied to the site, which has been prepared as recommended in the **Earthwork** section.

Pavement Design Parameters

Design of asphalt concrete (AC) pavements is based on the procedures outlined in the Caltrans "Highway Design Manual for Safety Roadside Rest Areas" (Caltrans, 2016). Design of Portland Cement Concrete (PCC) pavement sections were designed using PCA “Thickness Design for Concrete Highway and Street Pavements.”

R-value testing was performed on a sample mixed from near-surface bulk samples from boring Nos. B-1 and B-8. The test result indicates an R-value of 15 (See **Exploration Results**). A modulus of rupture of 600 psi was used for pavement concrete. The structural sections are predicated upon proper compaction of the utility trench backfills and the subgrade soils as prescribed by in **Earthwork**, with the upper 12 inches of subgrade soils and all aggregate base material brought to a minimum relative compaction of 95 percent in accordance with ASTM D 1557 prior to paving. The aggregate base should meet Caltrans requirements for Class 2 base.

It should be noted that the 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.

At the direction of the City of Jurupa Valley, the proposed Limonite Avenue is classified as a major highway. Therefore, a Traffic Index (TI) of 9.0 was utilized in the pavement design for this project.

Pavement Section Thicknesses

The following table provides options for AC and PCC sections:

Asphalt Concrete Design			
Usage / Traffic Index (TI)	Thickness (feet)		
	AC Thickness [1]	Aggregate Base Thickness AB [1]	Total Pavement Thickness
Major Highway / TI = 9.0	0.55	1.30	1.85

1. All materials should meet the current California Department of Transportation (Cal Trans) Standard Specifications for Highway and Bridge Construction.

Portland Cement Concrete Design			
Usage / Traffic Index (TI)	Thickness (feet)		
	PCC Thickness	Aggregate Base Thickness AB	Total Pavement Thickness
Major Highway / TI = 9.0	0.70	0.70	1.40

Recommended structural sections were calculated based on assumed TIs and our preliminary sampling and testing.

Terracon does not practice traffic engineering. We recommend that the project civil engineer or traffic engineer verify that the TIs and ADTT traffic indices used are appropriate for this project.

Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the granular subbase.

Based on the possibility of shallow and/or perched groundwater, we recommend installing a pavement subdrain system to control groundwater, improve stability, and improve long term pavement performance.

The pavement surfacing and adjacent sidewalks should be sloped to provide rapid drainage of surface water. Water should not be allowed to pond on or adjacent to these grade-supported slabs since this could saturate the subgrade and contribute to premature pavement or slab deterioration.

The pavement surfacing and adjacent sidewalks should be sloped to provide rapid drainage of surface water.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an ongoing pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the priority when implementing a pavement maintenance program. Additional engineering observation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to paved areas should slope down from the edges at a minimum 2%.
- Subgrade and pavement surfaces should have a minimum 2% slope to promote proper surface drainage.
- Install below pavement drainage systems surrounding areas anticipated for frequent wetting.
- Install joint sealant and seal cracks immediately.

- Seal all landscaped areas in or adjacent to pavements to reduce moisture migration to subgrade soils.
- Place compacted, low permeability backfill against the exterior side of curb and gutter.
- Place curb, gutter and/or sidewalk directly on clay subgrade soils rather than on unbound granular base course materials.

EARTHWORK

Earthwork will include clearing and grubbing, demolition, excavations, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria as necessary to render the site in the state considered in our geotechnical engineering evaluation for foundations and pavements.

Site Preparation

Prior to placing fill, existing vegetation and root mat should be removed. Complete stripping and removal of existing pavements and aggregate base should be performed in the proposed roadway areas.

Site preparation for the proposed box culvert extension may include partial demolition of the existing box culvert or wing walls. All canal sediments, existing fill, and disturbed native soils should be removed from the box culvert foundation areas.

The pavement subgrade should be proof-rolled with an adequately loaded vehicle such as a fully loaded tandem axle dump truck. The proof-rolling should be performed under the direction of the Geotechnical Engineer. Areas excessively deflecting under the proof-roll should be delineated and subsequently addressed by the Geotechnical Engineer. Such areas should either be removed or modified by stabilizing. Excessively wet or dry material should either be removed or moisture conditioned and recompacted.

Fill Material Types

Fill required to achieve design grade should be classified as structural fill and general fill. Structural fill is material used below or within 10 feet of structures, pavements or constructed slopes. General fill is material used to achieve grade outside of these areas. The on-site soils should provide adequate quality fill material provided they are free from organic matter and other deleterious materials. Rocks or similar irreducible material with a maximum dimension greater than 8 inches should not be buried or placed in fills.

Import fill, if utilized, should be inorganic, non-expansive granular soils free from rocks or lumps greater than 3 inches in maximum dimension and should meet the following material property requirements.

Gradation	Percent Passing (ASTM C 136)
3-inches	100
No. 4 Sieve	50 to 100
No. 200 Sieve	< 40
Index	**Value**
Liquid Limit	30 (max)
Plasticity Index	15 (max)
Maximum Expansive Index [1]	20 (max)

1. ASTM D 4829.

The contractor shall notify the Geotechnical Engineer of import sources sufficiently ahead of their use so that the sources can be observed and approved as to the physical characteristic of the import material. For all import material, the contractor shall also submit current verified reports from a recognized analytical laboratory indicating that the import has a "not applicable" (Class S0) potential for sulfate attack based upon current ACI criteria and is "mildly corrosive" to ferrous metal and copper. The reports shall be accompanied by a written statement from the contractor that the laboratory test results are representative of all import material that will be brought to the job.

Fill Compaction Requirements

Structural and general fill should meet the following compaction requirements.

Item	Structural Fill	General Fill
Maximum Lift Thickness	8 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 to 6 inches in loose thickness when hand-guided equipment (i.e., jumping jack or plate compactor) is used	Same as structural fill
Minimum Compaction Requirements [1]	95% of max. within 1 foot of finished pavement subgrade 90% of max. below shallow foundations, below slabs, and more than 1 foot below finished pavement subgrade	90% of maximum
Water Content Range [1]	Granular: -2% to +2% of optimum	As required to achieve min. compaction requirements

1. Maximum density and optimum water content as determined by the modified proctor test (ASTM D 1557).
2. .

Grading and Drainage

Exposed ground should be sloped and maintained at a minimum five (5) percent away from the roadway. After roadway construction, final grades should be verified to document effective drainage has been achieved.

Earthwork Construction Considerations

Shallow excavations for the proposed box culvert are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of floor slabs. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over or adjacent to construction areas should be removed. If the subgrade desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to the box culvert construction.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, “Excavations” and its appendices, and in accordance with any applicable local, and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

Construction Observation and Testing

The earthwork efforts should be monitored under the direction of the Geotechnical Engineer. Monitoring should include documentation of adequate removal of vegetation and top soil, proof-rolling, and mitigation of areas delineated by the proof-roll to require mitigation.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 5,000 square feet in pavement areas. One density and water content test should be performed for each 1 foot of backfill, for every 250 linear feet of compacted utility trench backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated under the direction of the Geotechnical Engineer. In the event that unanticipated conditions are encountered, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

CORROSIVITY

The table below lists the results of laboratory soluble sulfate, soluble chloride, electrical resistivity, and pH testing. The values may be used to estimate potential corrosive characteristics of the on-site soils with respect to contact with the various underground materials which will be used for project construction.

Corrosivity Test Results Summary						
Boring	Sample Depth (feet)	Soil Description	Soluble Sulfate (percent)	Soluble Chloride (percent)	Electrical Resistivity (Ω-cm)	pH
B-4	1.0 – 5.0	SM	162	43	2,231	9.08

Results of soluble sulfate testing indicate samples of the on-site soils tested possess moderate sulfate concentrations when classified in accordance with Table 4.3.1 of the ACI Design Manual. Concrete should be designed in accordance with the provisions of the ACI Design Manual, Section 318, Chapter 4. To improve sulfate resistance of concrete in severe sulfate exposure when Type V cement is not available, the following should be considered:

- Use of Type I-II modified cement for sulfate resistance
- Cement should have a tricalcium aluminate content of not more than 8 percent.
- Concrete mixture should contain at least 20 percent Class F fly ash.
- Provide air-entrainment of 4 to 7 percent by volume.
- Lower the water to cement ratio to 0.4 to 0.45.

REFERENCES

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Geotechnical References

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Yi, F., 2018, GeoSuite©, version 2.4 - A Comprehensive Package for Geotechnical and Civil Engineers, GeoAdvanced, http://geoadvanced.com/.

Aerial Imagery Examined

Google Earth, 2018, web-based software application, aerial imagery dated May 31, 1994; May 21, 2002; November 13, 2003; October 10, 2005; January 30, 2006; April 12, 2007; March 9, 2011; June 7, 2012.

Netroline, aerial imagery dated 1938, 1959. 1967, 1968, 1978, 1980, 2005, historicaerials.com; accessed August 2018.

GENERAL COMMENTS

As the project progresses, we address assumptions by incorporating information provided by the design team, if any. Revised project information that reflects actual conditions important to our services is reflected in the final report. The design team should collaborate with Terracon to confirm these assumptions and to prepare the final design plans and specifications. Such collaboration facilitates the incorporation of our opinions related to implementation of our geotechnical recommendations. Any information conveyed prior to the final report is for informational purposes only and should not be considered or used for decision-making purposes.

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather.

The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in the final report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be notified immediately so that we can provide evaluation and supplemental recommendations.

Our scope of services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet) [1]	Locations [2]
7	6-1/2 feet	Pavement
2	41-1/2 feet	Planned box culvert

1. Below ground surface
2. See **Exploration Plan**

Boring Layout and Elevations: Unless otherwise noted, Terracon personnel provide the boring layout. Coordinates are obtained with a handheld GPS unit (estimated horizontal accuracy of about ±20 feet) and approximate elevations are obtained from Google Earth.

Subsurface Exploration Procedures: We advance the borings with a truck-mounted drill rig using hollow-stem augers. Both a standard penetration test (SPT) sampler (2-inch outer diameter and 1-3/8-inch inner diameter) and a modified California ring-lined sampler (3-inch outer diameter and 2-3/8-inch inner diameter) are utilized in our investigation. The penetration resistance is recorded on the boring logs as the number of hammer blows used to advance the sampler in 6-inch increments (or less if noted). The samplers are driven with an automatic hammer that drops a 140-pound weight 30 inches for each blow. After the required seating, samplers are advanced up to 18 inches, providing up to three sets of blowcounts at each sampling interval. The sampling depths, penetration distances, and other sampling information are recorded on the field boring logs. The recorded blows are raw numbers without any corrections for hammer type (automatic vs. manual cathead) or sampler size (ring sampler vs. SPT sampler). Relatively undisturbed and bulk samples of the soils encountered are placed in sealed containers and returned to the laboratory for testing and evaluation.

We observe and record groundwater levels during drilling and sampling. For safety purposes, all borings are backfilled with auger cuttings after their completion. Pavements, are patched with cold-mix asphalt.

Our exploration team prepares field boring logs as part of the drilling operations. These field logs include visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs are prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviews the field data and assigns various laboratory tests to better understand the engineering properties of the various soil strata as necessary for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods are applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil by Mass
- ASTM D7263 Standard Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens
- ASTM D6913 Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
- ASTM D1140 Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing
- ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort
- ASTM D3080/D3080M Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions
- ASTM D2419 Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
- ASTM D2844 Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils

The laboratory testing program often includes examination of soil samples by an engineer. Based on the material's texture and plasticity, we describe and classify the soil samples in accordance with the Unified Soil Classification System.

SITE LOCATION AND EXPLORATION PLANS

SITE LOCATION and NEARBY GEOTECHNICAL DATA

Limonite Avenue Widening ■ Jurupa Valley, California

August 30, 2018 ■ Terracon Project No. CB185061

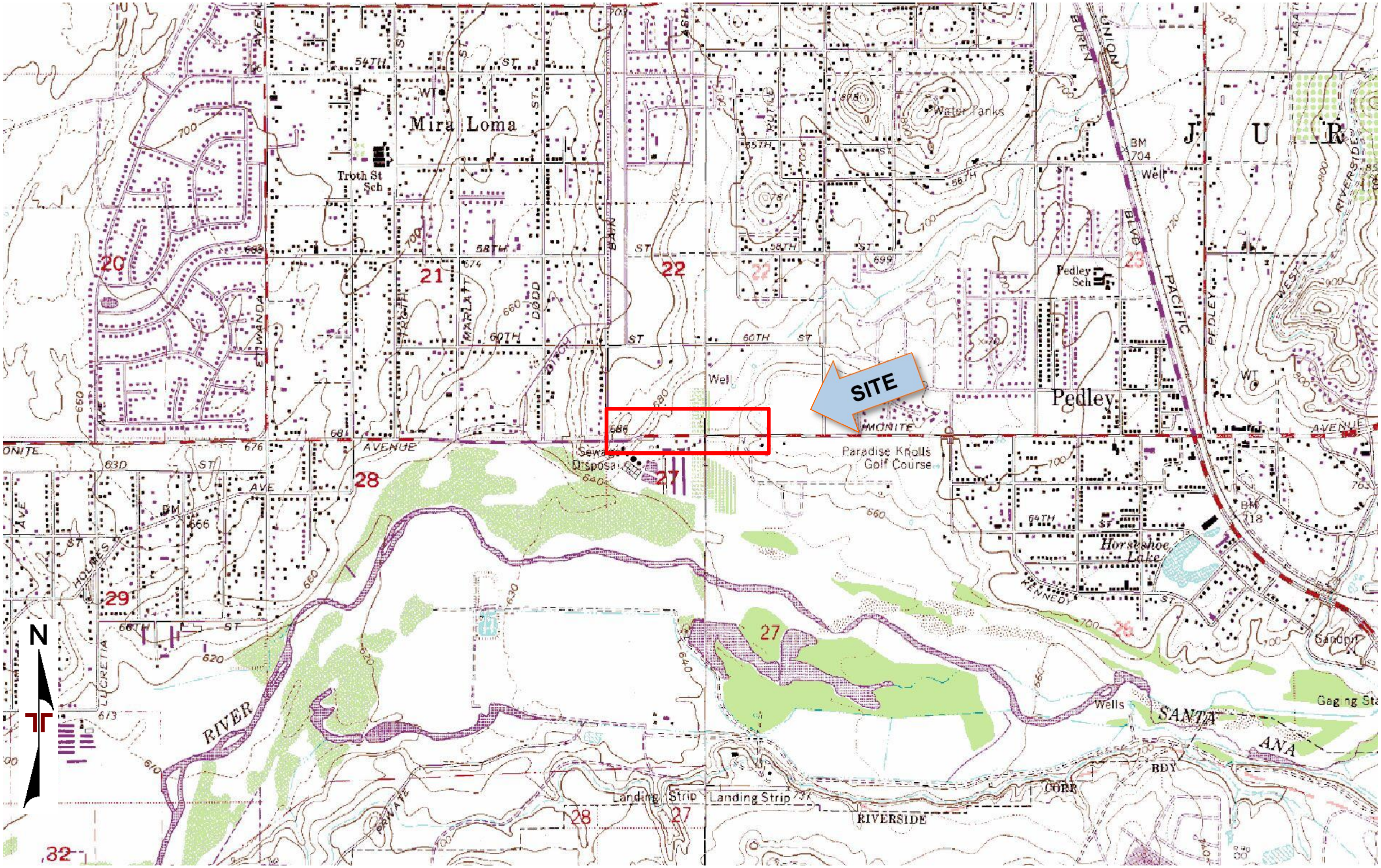


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY
QUADRANGLES INCLUDE: CORONA NORTH, CA (1/1/1981) and RIVERSIDE WEST, CA (1/1/1980).

EXPLORATION PLAN

Limonite Avenue Widening ■ Jurupa Valley, California
August 30, 2018 ■ Terracon Project No. CB185061

Terracon GeoReport

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

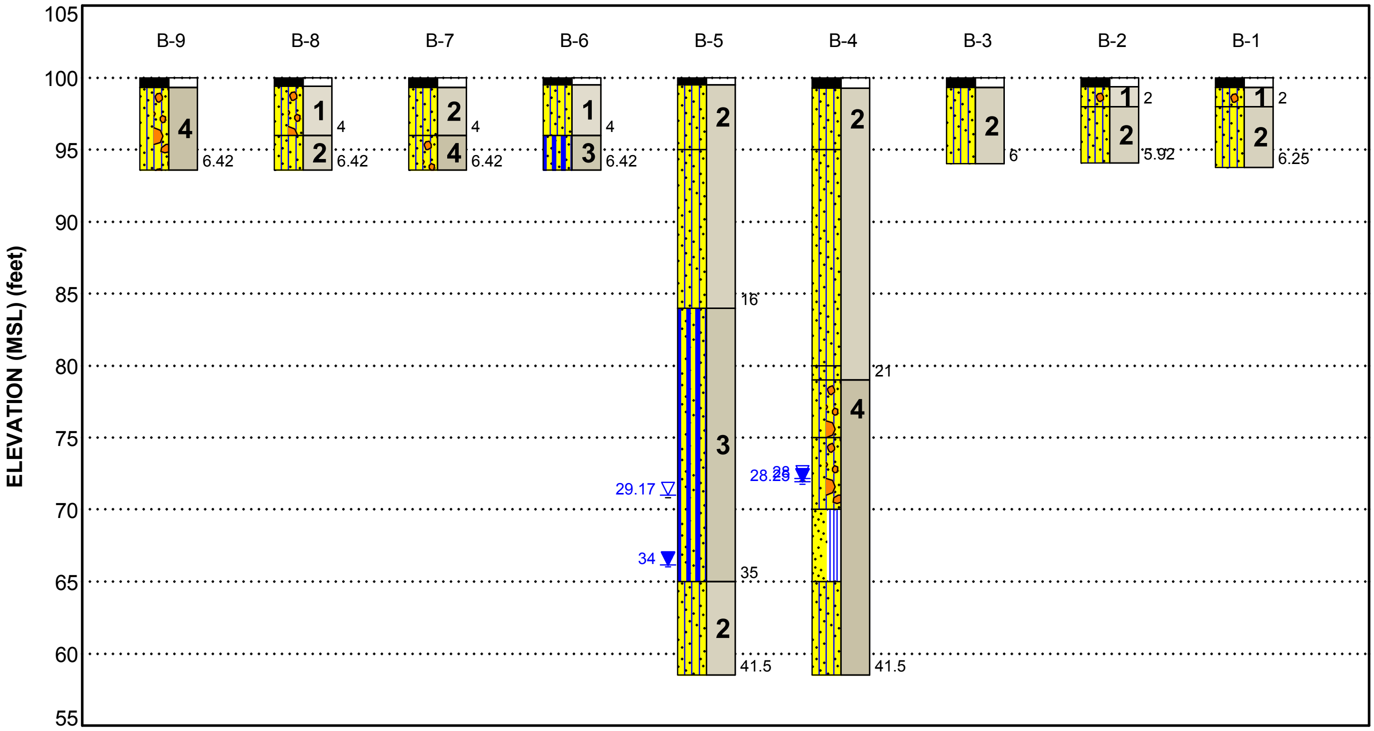
MAP PROVIDED BY BING MAPS

EXPLORATION RESULTS

GEOMODEL

Limonite Avenue Widening ■ Jurupa Valley, CA
8/30/2018 ■ Terracon Project No. CB185061

Terracon GeoReport



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Description	General Description
1	**Fill**	Undocumented Fill
2	**Silty Sand**	Silty Sand, fine to coarse grained sand, some lenses of gravel
3	**Sandy Silt**	Sandy Silt, fine to medium grained sand
4	**Sand and Gravel**	Silty Sand with Gravel, fine to coarse grained sand

LEGEND

USCS Soil Classification

- Asphalt
- Silty Sand with Gravel
- Silty Sand
- Poorly-graded Sand with Silt
- Sandy Silt

- First Water Observation
- Second Water Observation
- Third Water Observation

Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

NOTES:

Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.
Numbers adjacent to soil column indicate depth below ground surface.

BORING LOG NO. B-1

PROJECT: Limonite Avenue Widening

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA

SITE: Limonite Avenue
Jurupa Valley, CA

LOCATION See Exploration Plan

Latitude: 33.9755° Longitude: -117.496°

Approximate Surface Elev: 695 (Ft.) +/-

GRAPHIC LOG	MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAND EQUIVALENCE	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	PERCENT FINES
		0.7	**ASPHALT**, 8.5" thick	694.5+/-									
	1	2.0	**FILL - SILTY SAND WITH GRAVEL (SM)**, fine to coarse grained, brown, gravel to 1"	693+/-				6	15-17-16		8	125	
	2	6.3	**SILTY SAND (SM)**, fine to medium grained, reddish brown	689+/-						14	7		40
					5			6	17-35-50/3"		10	117	

Boring Terminated at 6.25 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
Hammer Weight/Drop Distance/Sampler Diameter: 140 lbs./30 in./3.25 in. O.D.

Advancement Method:
8" hollow-stem auger

Abandonment Method:
Boring backfilled with auger cuttings and capped with asphalt upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
1355 E Cooley Dr, Ste C
Colton, CA

Boring Started: 07-26-2018	Boring Completed: 07-26-2018
Drill Rig: CME 75	Driller: 2R
Project No.: CB185061	

BORING LOG NO. B-2

PROJECT: Limonite Avenue Widening

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA

SITE: Limonite Avenue
Jurupa Valley, CA

LOCATION See Exploration Plan

Latitude: 33.9755° Longitude: -117.497°

Approximate Surface Elev: 692 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAND EQUIVALENCE	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	PERCENT FINES
	0.7	**ASPHALT**, 7.5" thick	691.5+/-									
1	2.0	**FILL - SILTY SAND WITH GRAVEL (SM)**, fine to coarse grained, brown, gravel to 1"	690+/-				6	3-7-28		13	112	
2		**SILTY SAND (SM)**, fine to coarse grained, reddish brown								7		
	5.9		686+/-	5			6	35-50/5"		8	121	

Boring Terminated at 5.92 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
Hammer Weight/Drop Distance/Sampler Diameter: 140 lbs./30 in./3.25 in. O.D.

Advancement Method:
8" hollow-stem auger

Abandonment Method:
Boring backfilled with auger cuttings and capped with asphalt upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
1355 E Cooley Dr, Ste C
Colton, CA

Boring Started: 07-26-2018 | Boring Completed: 07-26-2018
Drill Rig: CME 75 | Driller: 2R
Project No.: CB185061

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL CB185061 LIMONITE AVENUE W.GPJ TERRACON_DATATEMPLATE.GDT 8/15/18

BORING LOG NO. B-3

PROJECT: Limonite Avenue Widening

**CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA**

**SITE: Limonite Avenue
Jurupa Valley, CA**

LOCATION See Exploration Plan

Latitude: 33.9755° Longitude: -117.4986°

Approximate Surface Elev: 677 (Ft.) +/-

GRAPHIC LOG	MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAND EQUIVALENCE	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	PERCENT FINES
		0.7	**ASPHALT**, 8" thick	676.5+/-									
	2		**SILTY SAND (SM)**, fine to medium grained, reddish brown					6	32-50/5"		11	111	
										17	11		29
		6.0		671+/-	5			6	29-50/6"		16	114	

Boring Terminated at 6 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
Hammer Weight/Drop Distance/Sampler Diameter: 140 lbs./30 in./3.25 in. O.D.

Advancement Method:
8" hollow-stem auger

Abandonment Method:
Boring backfilled with auger cuttings and capped with asphalt upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
1355 E Cooley Dr, Ste C
Colton, CA

Boring Started: 07-25-2018	Boring Completed: 07-25-2018
Drill Rig: CME 75	Driller: 2R
Project No.: CB185061	

BORING LOG NO. B-4

PROJECT: Limonite Avenue Widening

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA

SITE: Limonite Avenue
Jurupa Valley, CA

LOCATION See Exploration Plan

Latitude: 33.9755° Longitude: -117.4992°

Approximate Surface Elev: 662 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAND EQUIVALENCE	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	PERCENT FINES
	0.8	**ASPHALT**, 8.75" thick	661.5+/-									
2	5.0	**SILTY SAND (SM)**, fine to coarse grained, brown, trace clay, trace gravel to 1"	657+/-				6	11-18-22		11	113	
										9		
2	20.0	**SILTY SAND (SM)**, fine to coarse grained, brown, trace clay	642+/-	5			6	7-11-12		9	114	
										10		
				10			6	5-7-17		12	111	
				15			6	13-22-30		13	119	
2	21.0	**SILTY SAND (SM)**, fine to medium grained, orangish brown	641+/-	20			6	8-14-17		6	102	
4	25.0	**SILTY SAND WITH GRAVEL (SM)**, fine to medium grained, orangish brown, gravel to 1"	637+/-	25								

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
Hammer Weight/Drop Distance/Sampler Diameter: 140 lbs./30 in./3.25 in. O.D.

Advancement Method:
8" hollow-stem auger

Abandonment Method:
Boring backfilled with auger cuttings and capped with asphalt upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater encountered at 28'

Terracon
1355 E Cooley Dr, Ste C
Colton, CA

Boring Started: 07-25-2018	Boring Completed: 07-25-2018
Drill Rig: CME 75	Driller: 2R
Project No.: CB185061	

BORING LOG NO. B-4

PROJECT: Limonite Avenue Widening

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA

SITE: Limonite Avenue
Jurupa Valley, CA

LOCATION See Exploration Plan

Latitude: 33.9755° Longitude: -117.4992°

Approximate Surface Elev: 662 (Ft.) +/-

GRAPHIC LOG	MODEL LAYER	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAND EQUIVALENCE	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	PERCENT FINES
	4	**SILTY SAND WITH GRAVEL (SM)**, fine to medium grained, light brown, gravel to 2"				6	9-11-17		2	124	
				▽							
		30.0 — 632+/-	30								
	4	**POORLY GRADED SAND WITH SILT (SP-SM)**, fine to coarse grained, light brown				6	12-20-32		12	119	
		35.0 — 627+/-	35								
	4	**SILTY SAND (SM)**, fine to medium grained, brown				6	13-26-50/5"		17	114	
			40			6	20-32-50/6"		19	108	
		41.5 — 620.5+/-									
		Boring Terminated at 41.5 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
Hammer Weight/Drop Distance/Sampler Diameter: 140 lbs./30 in./3.25 in. O.D.

Advancement Method:
8" hollow-stem auger

Abandonment Method:
Boring backfilled with auger cuttings and capped with asphalt upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *Groundwater encountered at 28'*

Terracon
1355 E Cooley Dr, Ste C
Colton, CA

Boring Started: 07-25-2018	Boring Completed: 07-25-2018
Drill Rig: CME 75	Driller: 2R
Project No.: CB185061	

BORING LOG NO. B-5

PROJECT: Limonite Avenue Widening

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA

SITE: Limonite Avenue
Jurupa Valley, CA

LOCATION See Exploration Plan

Latitude: 33.9755° Longitude: -117.4995°

Approximate Surface Elev: 658 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
	0.5	**ASPHALT**, 6" thick	657.5+/-
2	5.0	**SILTY SAND (SM)**, fine to coarse grained, light to medium brown	653+/-
2	15.0	**SILTY SAND (SM)**, fine to coarse grained, light to medium brown, trace clay	643+/-
3	20.0	**SILT (ML)**, brown, trace clay	638+/-
2		**SILTY SAND (SM)**, fine grained, strong brown, trace clay	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAND EQUIVALENCE	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	PERCENT FINES
1.0–2.5			6	5-6-5 N=11		8		
2.5–5.0					21			22
5.0–6.5			6	4-4-4 N=8		8		47
10.0–11.5			6	5-3-3 N=6				
15.0–16.5			6	2-2-2 N=4				96
20.0–21.5			6	2-3-4 N=7				47

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
Hammer Weight/Drop Distance/Sampler Diameter: 140 lbs./30 in./2.0 in. O.D.

Advancement Method:
8" hollow-stem auger

Abandonment Method:
Boring backfilled with auger cuttings and capped with asphalt upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *At completion of drilling*

Terracon
1355 E Cooley Dr, Ste C
Colton, CA

Boring Started: 07-25-2018	Boring Completed: 07-25-2018
Drill Rig: CME 75	Driller: 2R
Project No.: CB185061	

BORING LOG NO. B-5

PROJECT: Limonite Avenue Widening

**CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA**

**SITE: Limonite Avenue
Jurupa Valley, CA**

LOCATION See Exploration Plan

Latitude: 33.9755° Longitude: -117.4995°

Approximate Surface Elev: 658 (Ft.) +/-

GRAPHIC LOG	MODEL LAYER	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAND EQUIVALENCE	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	PERCENT FINES
	2	**SILTY SAND (SM)**, fine grained, strong brown, trace clay *(continued)*			X	6	1-1-2 N=3				
			30		X	6	1-2-3 N=5				
				∇							
		35.0 — 623+/-	35								
	2	**SILTY SAND (SM)**, fine to medium grained, reddish brown			X	6	5-7-11 N=18				
			40		X	6	10-22-32 N=54				
		41.5 — 616.5+/-									
		Boring Terminated at 41.5 Feet									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
Hammer Weight/Drop Distance/Sampler Diameter: 140 lbs./30 in./2.0 in. O.D.

Advancement Method:
8" hollow-stem auger

Abandonment Method:
Boring backfilled with auger cuttings and capped with asphalt upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

∇ *At completion of drilling*

Terracon
1355 E Cooley Dr, Ste C
Colton, CA

Boring Started: 07-25-2018	Boring Completed: 07-25-2018
Drill Rig: CME 75	Driller: 2R
Project No.: CB185061	

BORING LOG NO. B-6

PROJECT: Limonite Avenue Widening

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA

SITE: Limonite Avenue
Jurupa Valley, CA

LOCATION See Exploration Plan

Latitude: 33.9756° Longitude: -117.5002°

Approximate Surface Elev: 655 (Ft.) +/-

GRAPHIC LOG	MODEL LAYER	DEPTH / DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAND EQUIVALENCE	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	PERCENT FINES
		0.5 **ASPHALT**, 6" thick	654.5+/-									
	1	**FILL - SILTY SAND (SM)**, fine to coarse grained, reddish brown, trace gravel to 1"					6	9-11-32		8	114	
										8		
		4.0	651+/-									
	3	**SANDY SILT (ML)**, fine to medium grained, reddish brown		5			6	8-8-11		13	88	
		6.5	648.5+/-									

Boring Terminated at 6.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
Hammer Weight/Drop Distance/Sampler Diameter: 140 lbs./30 in./3.25 in. O.D.

Advancement Method:
8" hollow-stem auger

Abandonment Method:
Boring backfilled with auger cuttings and capped with asphalt upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
1355 E Cooley Dr, Ste C
Colton, CA

Boring Started: 07-26-2018	Boring Completed: 07-26-2018
Drill Rig: CME 75	Driller: 2R
Project No.: CB185061	

BORING LOG NO. B-7

PROJECT: Limonite Avenue Widening

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA

SITE: Limonite Avenue
Jurupa Valley, CA

LOCATION See Exploration Plan

Latitude: 33.9756° Longitude: -117.5018°

Approximate Surface Elev: 655 (Ft.) +/-

GRAPHIC LOG	MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAND EQUIVALENCE	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	PERCENT FINES
		0.7	**ASPHALT**, 8" thick	654.5+/-									
	2		**SILTY SAND (SM)**, fine to medium grained, reddish brown					6	5-4-4		5	107	
											5		30
		4.0		651+/-									
	4		**SILTY SAND WITH GRAVEL (SM)**, fine to coarse grained, reddish brown, gravel to 1"		5			6	15-22-37		2		
		6.5		648.5+/-									

Boring Terminated at 6.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
Hammer Weight/Drop Distance/Sampler Diameter: 140 lbs./30 in./3.25 in. O.D.

Advancement Method:
8" hollow-stem auger

Abandonment Method:
Boring backfilled with auger cuttings and capped with asphalt upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

Terracon
1355 E Cooley Dr, Ste C
Colton, CA

Boring Started: 07-26-2018

Boring Completed: 07-26-2018

Drill Rig: CME 75

Driller: 2R

Project No.: CB185061

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL CB185061 LIMONITE AVENUE W.GPJ TERRACON_DATATEMPLATE.GDT 8/15/18

BORING LOG NO. B-8

PROJECT: Limonite Avenue Widening

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA

SITE: Limonite Avenue
Jurupa Valley, CA

LOCATION See Exploration Plan

Latitude: 33.9754° Longitude: -117.5036°

Approximate Surface Elev: 662 (Ft.) +/-

GRAPHIC LOG	MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAND EQUIVALENCE	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	PERCENT FINES
		0.6	**ASPHALT**, 7" thick	661.5+/-									
	1		**FILL - SILTY SAND WITH GRAVEL (SM)**, fine to coarse grained, brown, gravel to 1"					6	19-25-25		7	116	
		4.0		658+/-						16	7		29
	2		**SILTY SAND (SM)**, fine to medium grained, reddish brown to brown		5			6	9-8-11		5	103	
		6.5		655.5+/-									

Boring Terminated at 6.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
Hammer Weight/Drop Distance/Sampler Diameter: 140 lbs./30 in./3.25 in. O.D.

Advancement Method:
8" hollow-stem auger

Abandonment Method:
Boring backfilled with auger cuttings and capped with asphalt upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Not encountered

1355 E Cooley Dr, Ste C
Colton, CA

Boring Started: 07-26-2018	Boring Completed: 07-26-2018
Drill Rig: CME 75	Driller: 2R
Project No.: CB185061	

BORING LOG NO. B-9

PROJECT: Limonite Avenue Widening

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA

SITE: Limonite Avenue
Jurupa Valley, CA

LOCATION See Exploration Plan

Latitude: 33.9753° Longitude: -117.5049°

Approximate Surface Elev: 680 (Ft.) +/-

Graphic Log	Model Layer	Depth	Material Description	Elevation (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Sand Equivalence	Water Content (%)	Dry Unit Weight (pcf)	Percent Fines
		0.7	**ASPHALT**, 8" thick	679.5+/-									
	4		**SILTY SAND WITH GRAVEL (SM)**, fine to coarse grained, gravel to 1"					6	9-15-29		14	116	
										15	7		33
		6.5		673.5+/-	5			6	11-24-40		11	119	

Boring Terminated at 6.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic
Hammer Weight/Drop Distance/Sampler Diameter: 140 lbs./30 in./3.25 in. O.D.

Advancement Method:
8" hollow-stem auger

Abandonment Method:
Boring backfilled with auger cuttings and capped with asphalt upon completion.

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

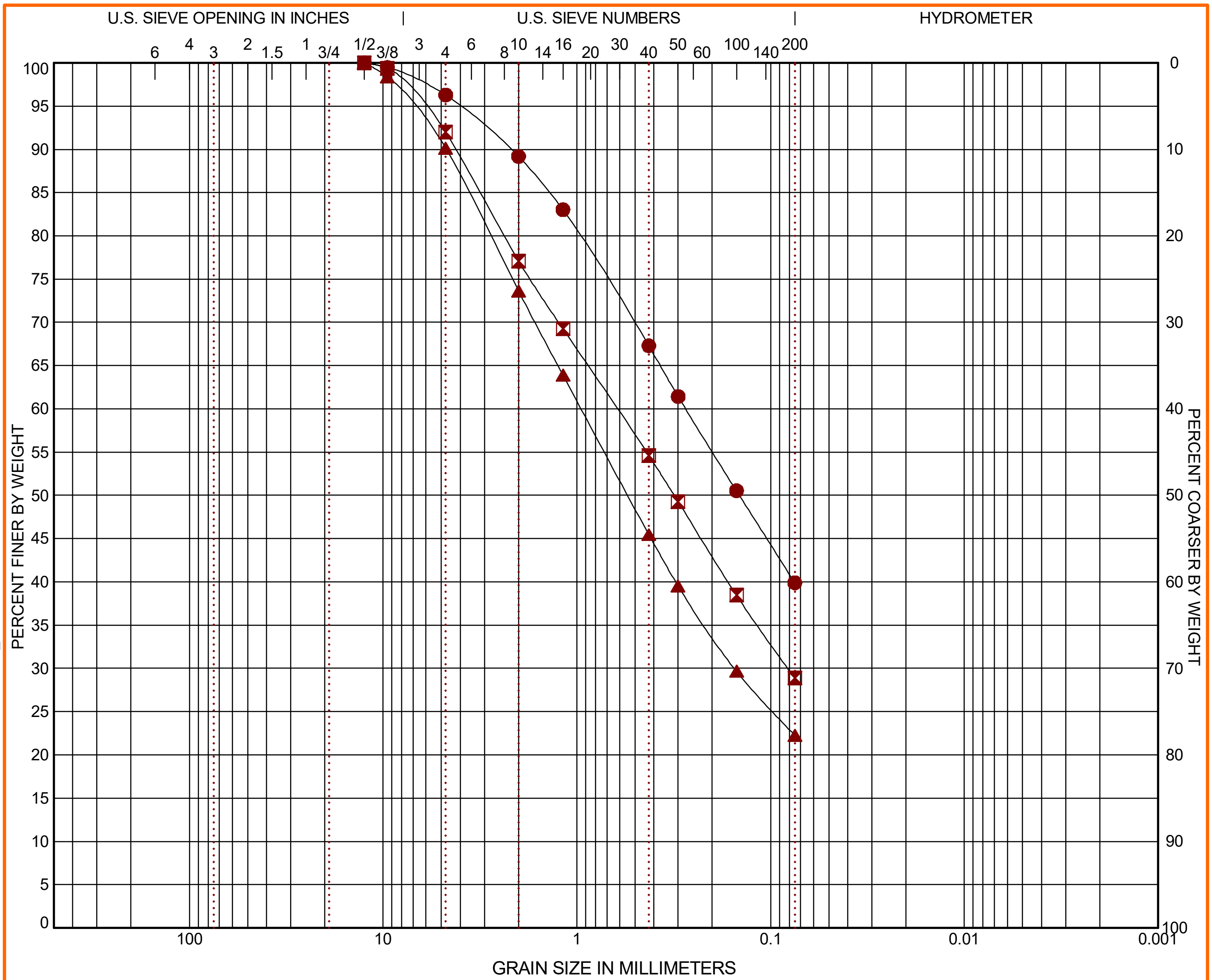
WATER LEVEL OBSERVATIONS

1355 E Cooley Dr, Ste C
Colton, CA

Boring Started: 07-26-2018	Boring Completed: 07-26-2018
Drill Rig: CME 75	Driller: 2R
Project No.: CB185061	

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-1	1 - 5	0.0	3.7	56.4		39.9		SM
⊠	B-3	1 - 5	0.0	8.0	63.1		28.9		SM
▲	B-5	1 - 5	0.0	9.9	67.9		22.3		SM

GRAIN SIZE

	●	⊠	▲
D_{60}	0.274	0.619	0.95
D_{30}		0.081	0.154
D_{10}			

COEFFICIENTS

	●	⊠	▲
C_C			
C_U			

●		⊠		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
1/2"	100.0	1/2"	100.0	1/2"	100.0
3/8"	99.47	3/8"	99.37	3/8"	98.4
#4	96.28	#4	92.0	#4	90.15
#10	89.18	#10	77.11	#10	73.64
#16	83.03	#16	69.26	#16	63.92
#40	67.29	#40	54.61	#40	45.46
#50	61.43	#50	49.27	#50	39.51
#100	50.53	#100	38.45	#100	29.66
#200	39.89	#200	28.86	#200	22.27

SOIL DESCRIPTION

●	SILTY SAND (SM)
⊠	SILTY SAND (SM)
▲	SILTY SAND (SM)

REMARKS

●	
⊠	
▲	

PROJECT: Limonite Avenue Widening

SITE: Limonite Avenue
Jurupa Valley, CA

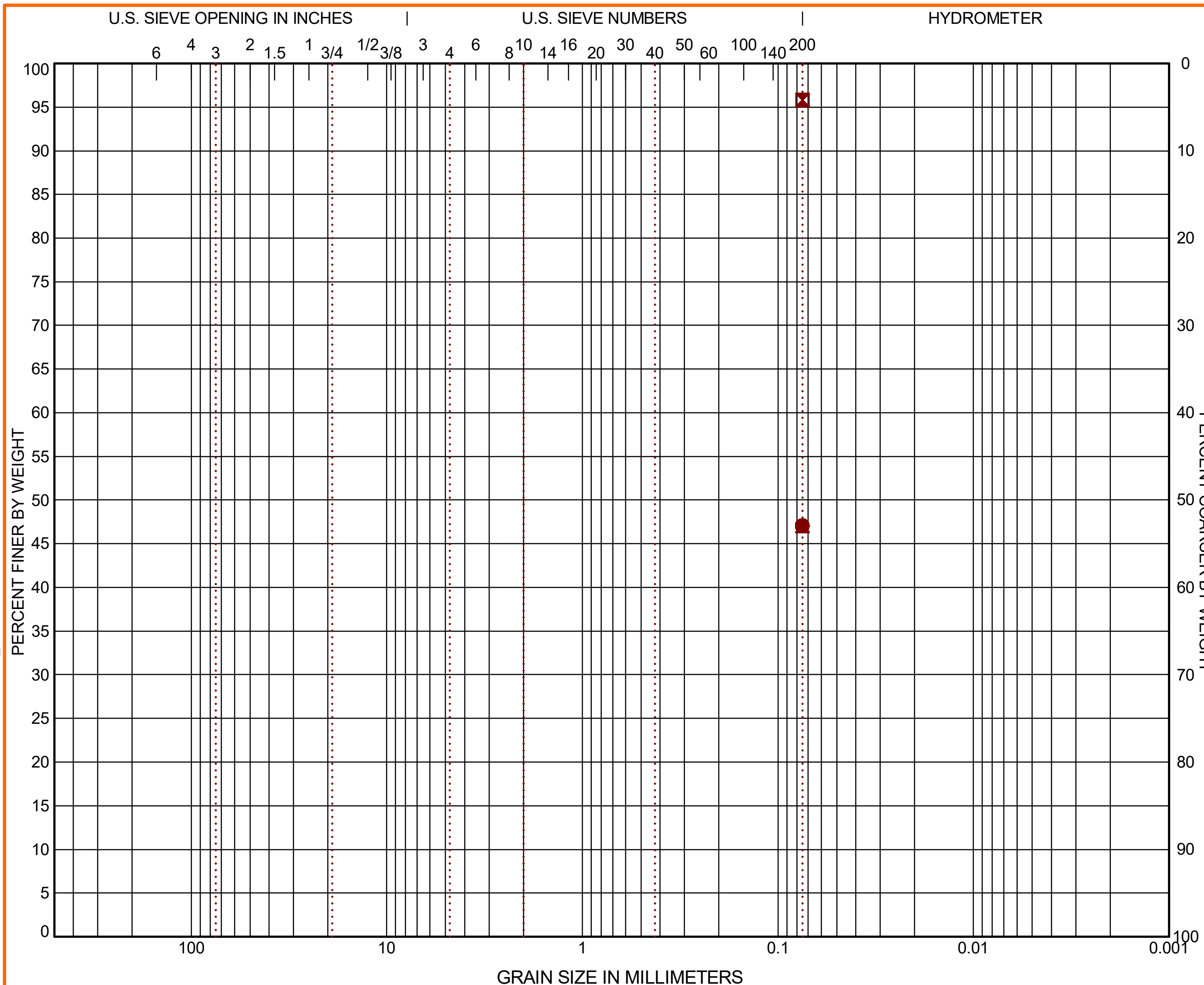
Terracon
1355 E Cooley Dr, Ste C
Colton, CA

PROJECT NUMBER: CB185061

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-5	5 - 6.5					47.1		
⊠	B-5	15 - 16.5					95.8		
▲	B-5	20 - 21.5					46.9		

GRAIN SIZE

	●	⊠	▲
D_{60}			
D_{30}			
D_{10}			

COEFFICIENTS

	●	⊠	▲
C_C			
C_U			

●		⊠		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
#200	47.08	#200	95.81	#200	46.92

SOIL DESCRIPTION

●	
⊠	
▲	

REMARKS

●	
⊠	
▲	

PROJECT: Limonite Avenue Widening

SITE: Limonite Avenue
Jurupa Valley, CA

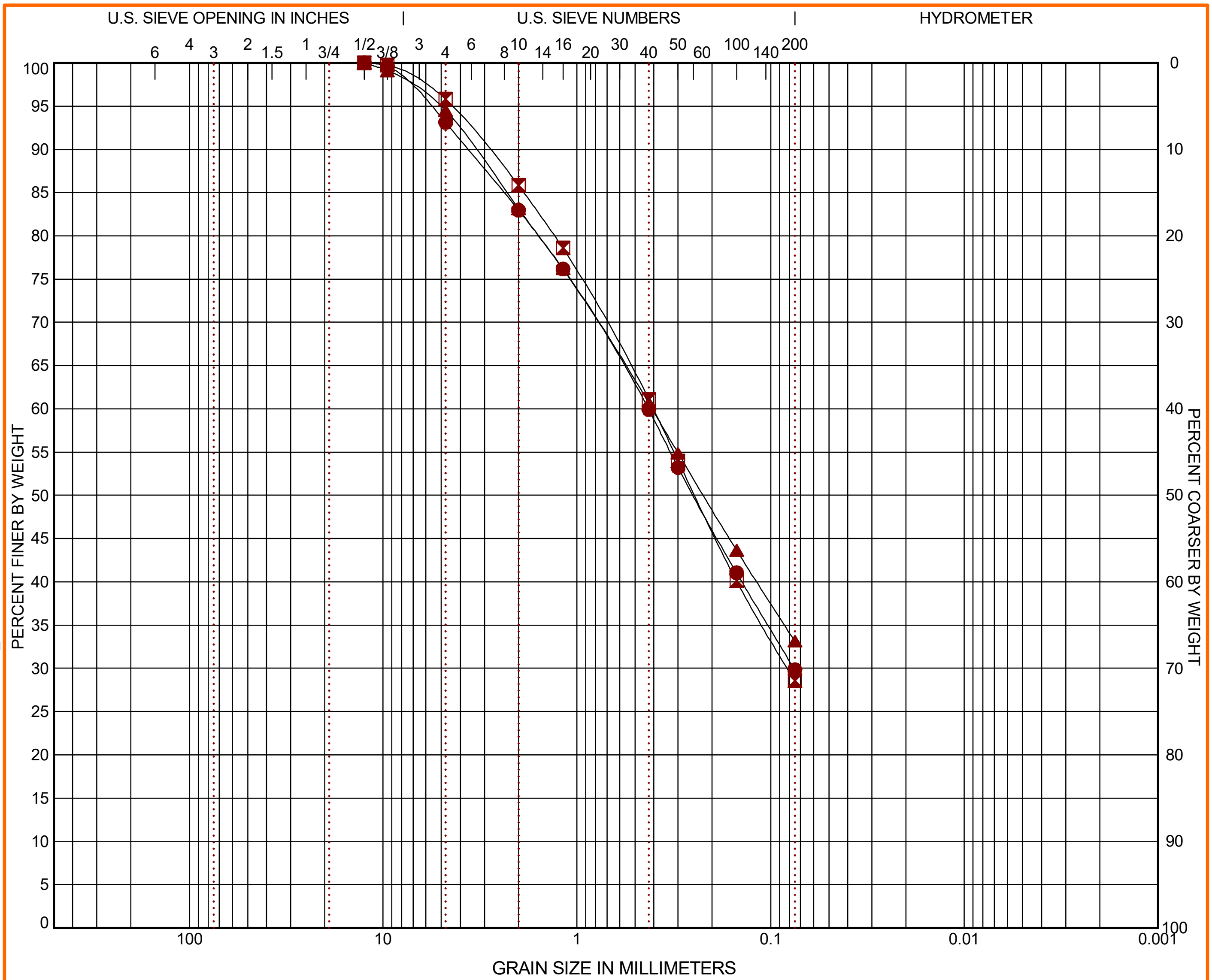
Terracon
1355 E Cooley Dr, Ste C
Colton, CA

PROJECT NUMBER: CB185061

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-7	1 - 5	0.0	6.9	63.3		29.9		SM
⊠	B-8	1 - 5	0.0	4.2	67.3		28.5		SM
▲	B-9	1 - 5	0.0	5.5	61.4		33.1		SM

GRAIN SIZE

	●	⊠	▲
D_{60}	0.427	0.403	0.409
D_{30}	0.076	0.082	
D_{10}			

COEFFICIENTS

	●	⊠	▲
C_C			
C_U			

● Sieve	● % Finer	⊠ Sieve	⊠ % Finer	▲ Sieve	▲ % Finer
1/2"	100.0	1/2"	100.0	1/2"	100.0
3/8"	99.59	3/8"	99.74	3/8"	99.1
#4	93.12	#4	95.8	#4	94.52
#10	82.97	#10	85.82	#10	83.14
#16	76.16	#16	78.58	#16	76.23
#40	59.92	#40	61.08	#40	60.65
#50	53.21	#50	53.98	#50	54.86
#100	41.05	#100	40.11	#100	43.67
#200	29.85	#200	28.55	#200	33.15

SOIL DESCRIPTION

●	SILTY SAND (SM)
⊠	SILTY SAND (SM)
▲	SILTY SAND (SM)

REMARKS

●	
⊠	
▲	

PROJECT: Limonite Avenue Widening

SITE: Limonite Avenue
Jurupa Valley, CA

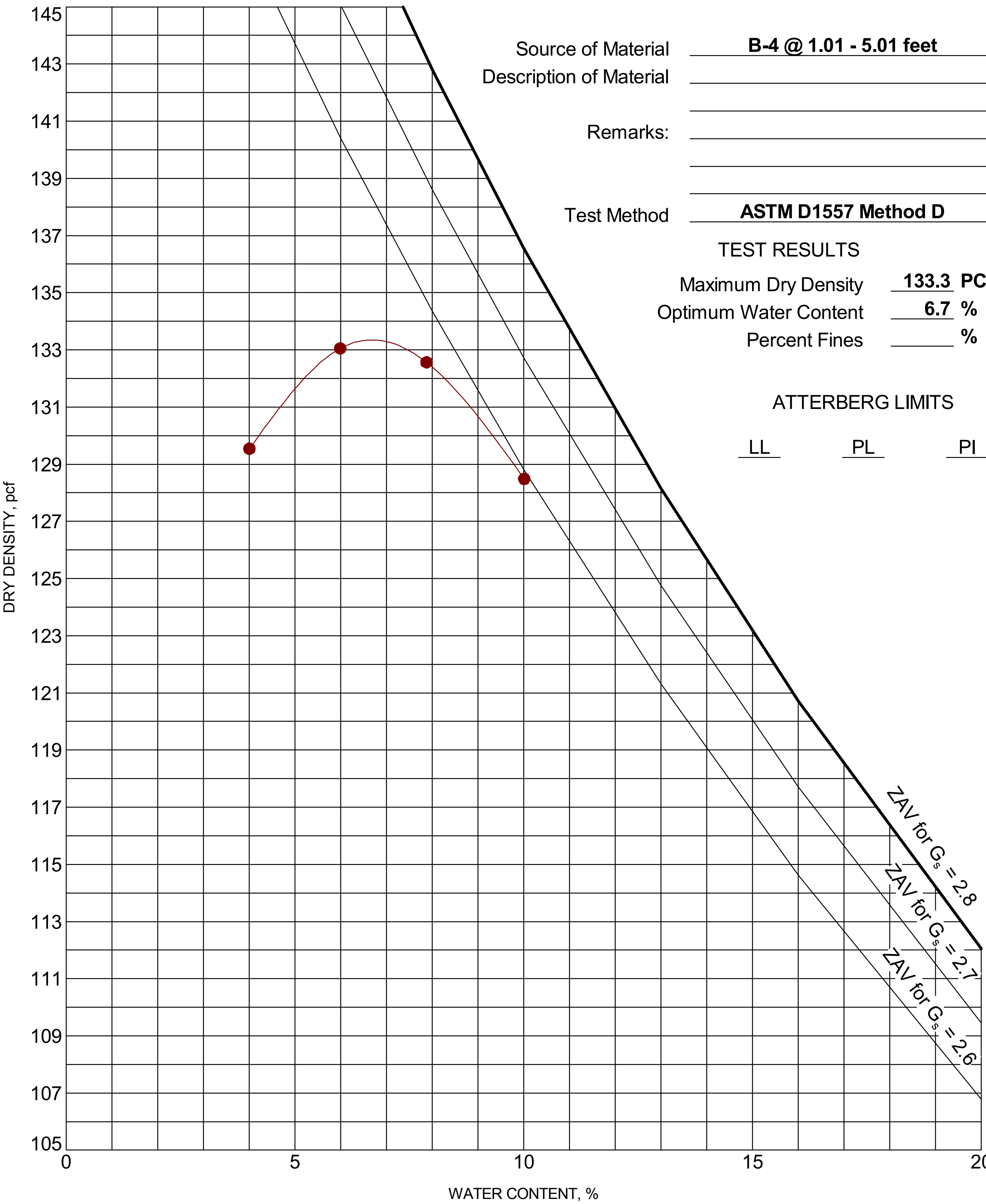
Terracon
1355 E Cooley Dr, Ste C
Colton, CA

PROJECT NUMBER: CB185061

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material: **B-4 @ 1.01 - 5.01 feet**

Description of Material:

Remarks:

Test Method: **ASTM D1557 Method D**

TEST RESULTS

Maximum Dry Density **133.3 PCF**

Optimum Water Content **6.7 %**

Percent Fines **%**

ATTERBERG LIMITS

LL	PL	PI

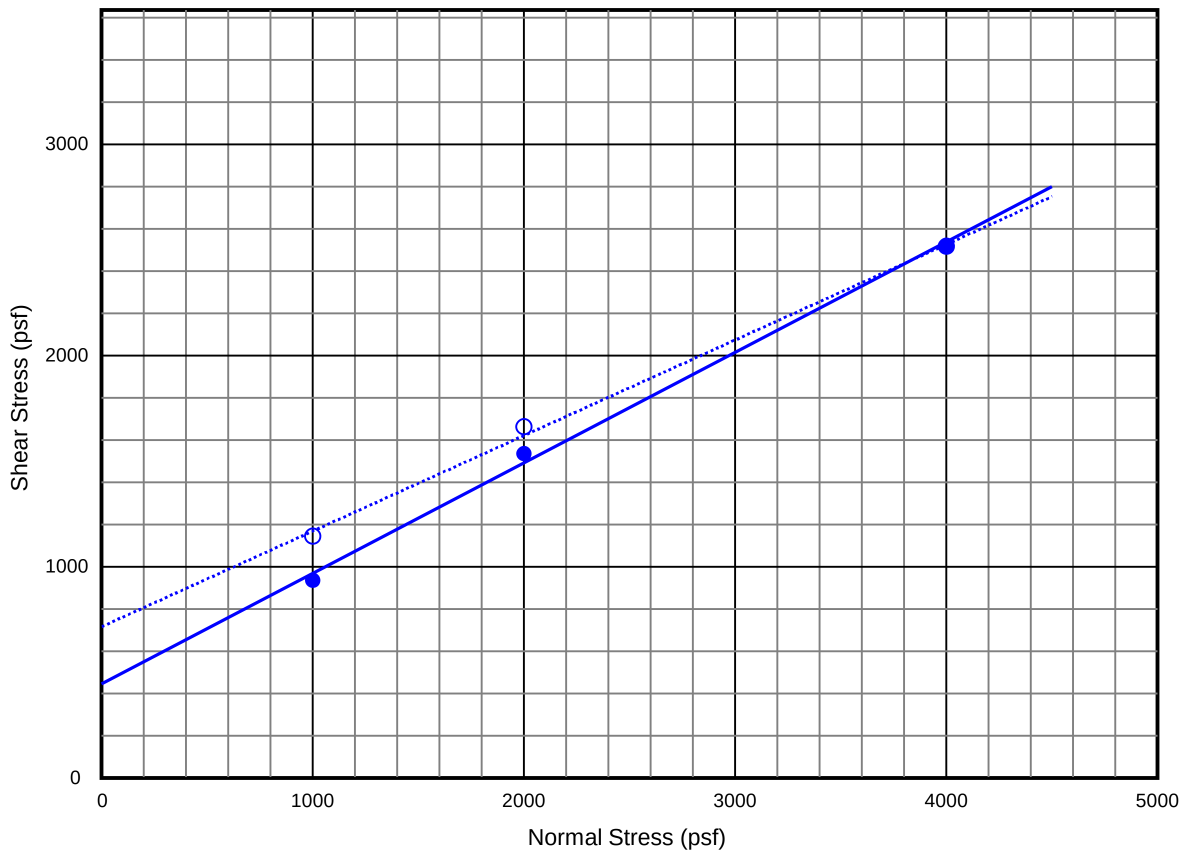
PROJECT: Limonite Avenue Widening

SITE: Limonite Avenue
Jurupa Valley, CA

Terracon
1355 E Cooley Dr, Ste C
Colton, CA

PROJECT NUMBER: CB185061

CLIENT: City of Jurupa Valley CA
Jurupa Valley, CA



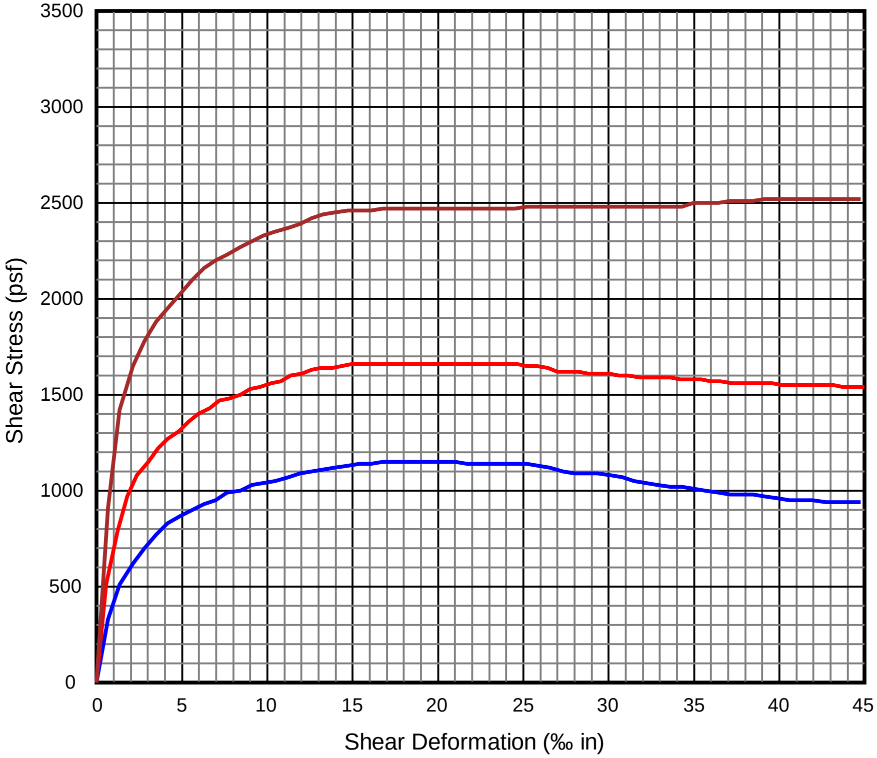
	Boring No.	Depth (ft)	γ_d (pcf)	w (%)	C_{pk} (psf)	ϕ_{pk} (°)	C_{rs} (psf)	ϕ_{rs} (°)
●	4	10	111.0	12.0	718.1	24.4	445.1	27.6
	(SM) Silty Sand / Undisturbed							

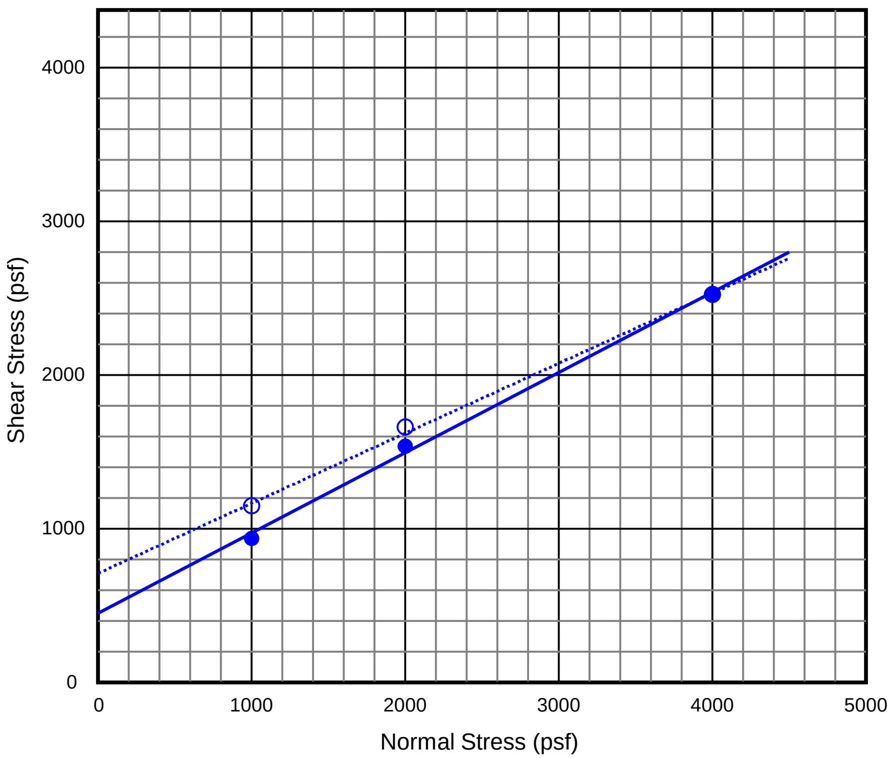
N:\Projects\2018\CB185061\Working Files\Laboratory-Field Data-Boring Logs\LabSuite_CB185061.csv

Terracon

DIRECT SHEAR TESTS (ASTM D3080)					
Project:	Limonite Avenue Widening				
Location:	Jurupa Valley, CA				
Job Number:	CB185061	Engineer:	RH	Enclosure:	N/A-1

Prepared at 8/15/2018 6:56:55 AM





	Boring No.	Depth (ft)	USCS	γ_d (pcf)	w (%)	C_{pk} (psf)	ϕ_{pk} (°)	C_{rs} (psf)	ϕ_{rs} (°)
●	4	10	(SM) Silty Sand / Undisturbed	111.0	12.0	718.1	24.4	445.1	27.6

DIRECT SHEAR TESTS (ASTM D3080)

Project:	Limonite Avenue Widening		
Location:	Jurupa Valley, CA		
Job Number:	CB185061	Engineer:	RH
Enclosure:	N/A-2		

N:\Projects\2018\CB185061\Working Files\Laboratory-Field Data-Boring Logs\LabSuite_CB185061.csv

Prepared at 8/15/2018 6:56:55 AM

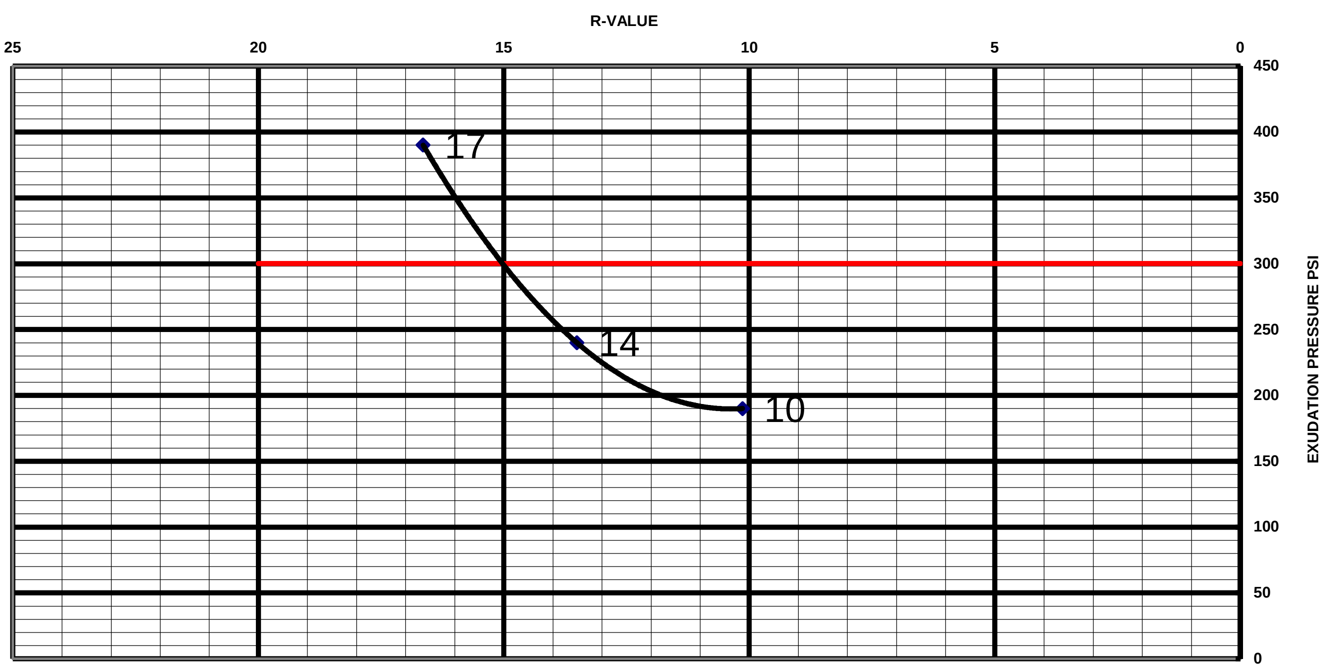
Job No. CB185061
Date. 8/7/2018

LAB0RATORY RECORD OF TESTS MADE ON BASE, SUBBASE, AND BASEMENT SOILS

CLIENT: City of Jurupa Valley
PROJECT LOCATION: Limonite Ave. Widening
R-VALUE # : 1A
T.I. :

	A	B	C	D
COMPACTOR AIR PRESSURE P.S.I.	75	100	150	
INITIAL MOISTURE %	6.4	6.4	6.4	
WATER ADDED, ML	60	50	40	
WATER ADDED %	5.5	4.6	3.7	
MOISTURE AT COMPACTION %	11.9	11.0	10.1	
HEIGHT OF BRIQUETTE	2.53	2.52	2.49	
WET WEIGHT OF BRIQUETTE	1156	1156	1157	
DENSITY LB. PER CU.FT.	123.7	125.2	127.9	
STABILOMETER PH AT 1000 LBS.	58	55	51	
2000 LBS.	132	128	122	
DISPLACEMENT	4.70	4.00	3.90	
R-VALUE	10	14	17	
EXUDATION PRESSURE	190	240	390	
THICK. INDICATED BY STAB.	0.00	0.00	0.00	
EXPANSION PRESSURE	5	15	24	
THICK. INDICATED BY E.P.	0.17	0.50	0.80	

EXUDATION CHART



R-Value: **15**

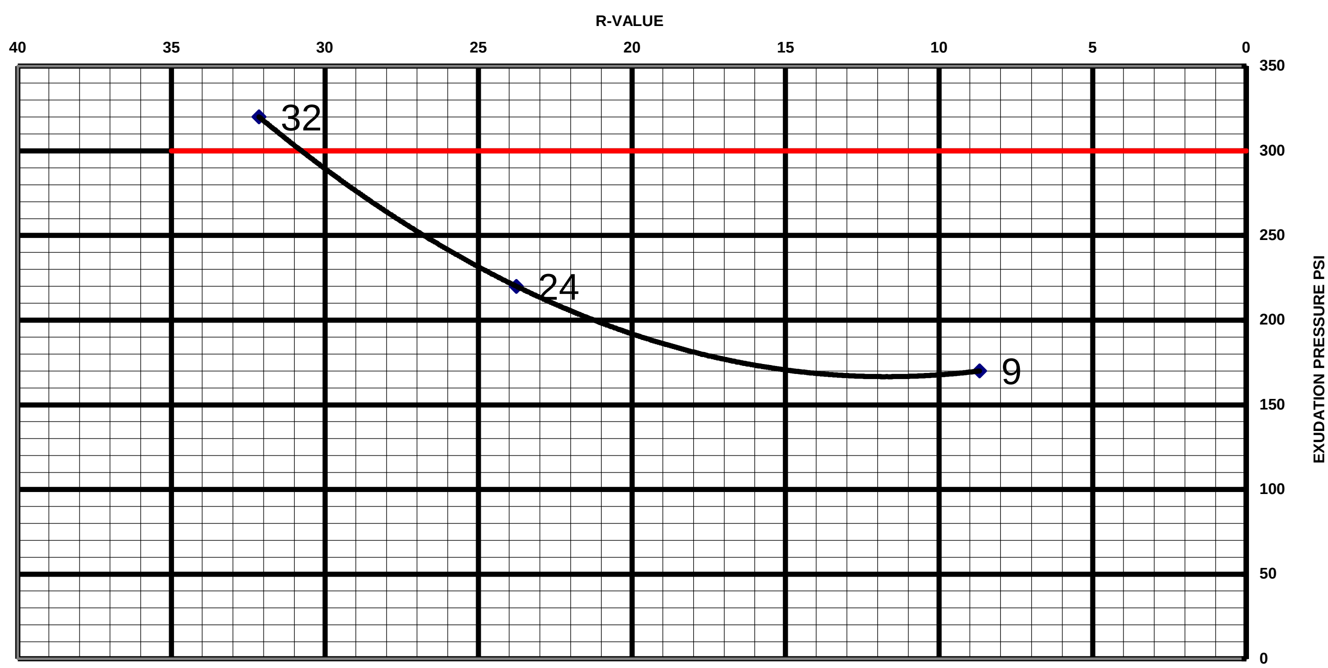
Job No. CB185061
Date. 8/7/2018

LAB0RATORY RECORD OF TESTS MADE ON
BASE, SUBBASE, AND BASEMENT SOILS

CLIENT: **City of Jurupa Valley**
PROJECT **Limonite Ave. Widening**
LOCATION:
R-VALUE # : **8A**
T.I. :

	A	B	C	D
COMPACTOR AIR PRESSURE P.S.I.	75	100	175	
INITIAL MOISTURE %	7.3	7.3	7.3	
WATER ADDED, ML	40	30	20	
WATER ADDED %	3.7	2.8	1.9	
MOISTURE AT COMPACTION %	11.0	10.1	9.2	
HEIGHT OF BRIQUETTE	2.49	2.47	2.46	
WET WEIGHT OF BRIQUETTE	1156	1157	1156	
DENSITY LB. PER CU.FT.	126.7	128.9	130.4	
STABILOMETER PH AT 1000 LBS.	61	49	43	
2000 LBS.	134	105	92	
DISPLACEMENT	5.10	4.20	3.90	
R-VALUE	9	24	32	
EXUDATION PRESSURE	170	220	320	
THICK. INDICATED BY STAB.	0.00	0.00	0.00	
EXPANSION PRESSURE	0	0	0	
THICK. INDICATED BY E.P.	0.00	0.00	0.00	

EXUDATION CHART



R-Value: **31**

CHEMICAL LABORATORY TEST REPORT

Project Number: CB185061
Service Date: 08/03/18
Report Date: 08/07/18
Task:

750 Pilot Road, Suite F
Las Vegas, Nevada 89119
(702) 597-9393

Client

City of Jurupa Valley CA
Jurupa Valley, CA

Project

Limonite Avenue Widening

Sample Submitted By: Terracon (CB) **Date Received:** 8/1/2018 **Lab No.: 18-0965**

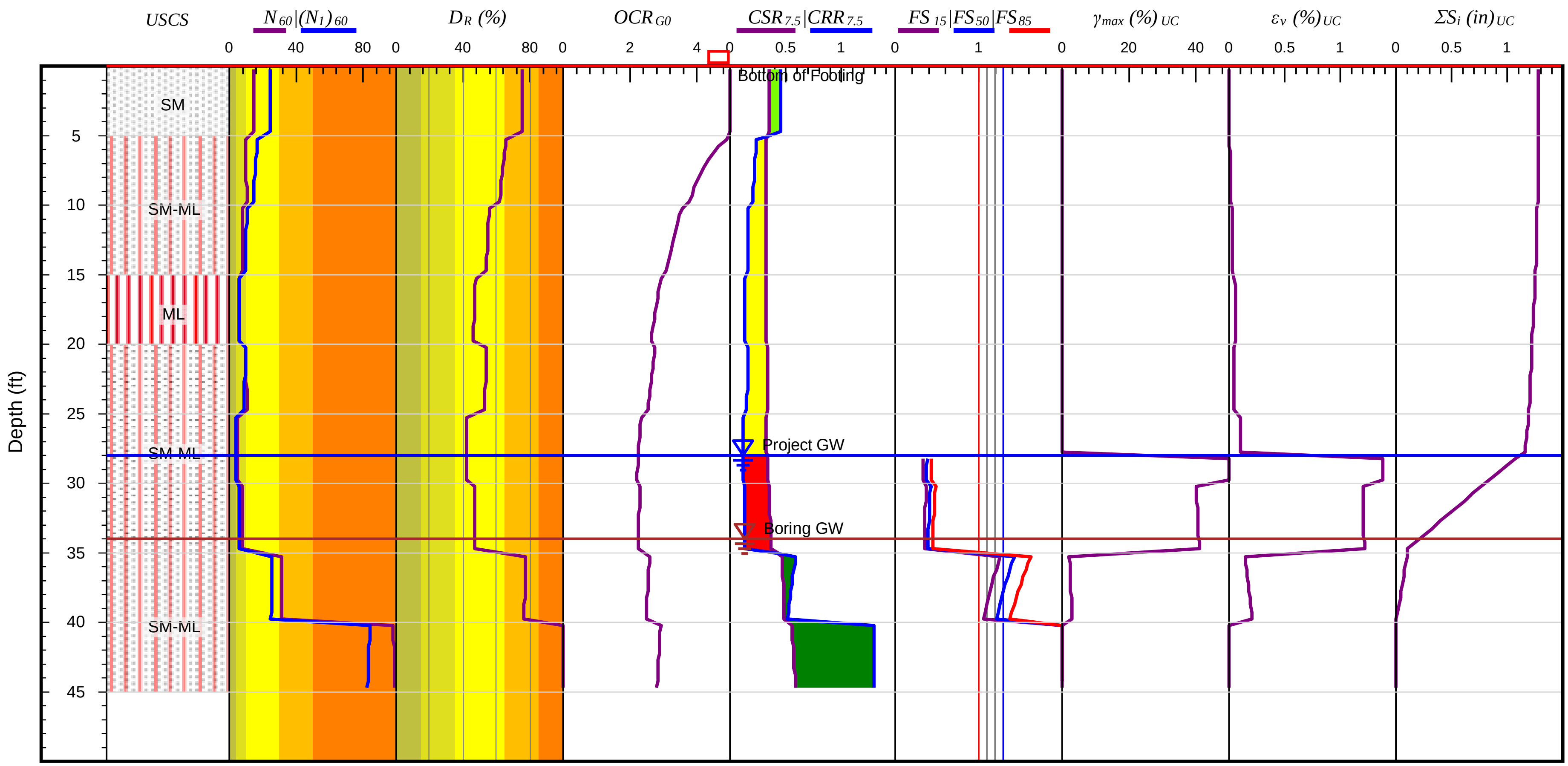
Results of Corrosion Analysis

Sample Number	4A
Sample Location	B-4
Sample Depth (ft.)	1.0-5.0
pH Analysis, ASTM G 51	9.08
Water Soluble Sulfate (SO4), ASTM C 1580 (mg/kg)	162
Chlorides, ASTM D 512, (mg/kg)	43
Resistivity (As Received), ASTM G 57, (ohm-cm)	11640
Resistivity (Saturated), ASTM G 57, (ohm-cm)	2231

Analyzed By: Trisha Campo

Trisha Campo
Chemist

GEOTECHNICAL CALCULATIONS



SM

ML

SM-ML

Earthquake & Groundwater Information:
Magnitude = 8.1
Max. Acceleration = 0.5 g
Project GW = 28 ft
Maximum Settlement = 1.28 in
Settl. at Bottom of Footing = 1.28 in

Liquefaction: Boulanger & Idriss (2010-16)
Settl.: [dry] UCLA (2008-14); [sat] Idriss & Boulanger (2008)
Lateral spreading: Idriss & Boulanger (2008)
M correction: [Sand] Boulanger & Idriss(2004)
σv correction: Idriss & Boulanger (2008)
Stress reduction: Idriss & Boulanger (2008)

Terracon

Seismic Settlement Potential - SPT Data

Project:	Limonite Avenue Widening				
Location:	Limonite Avenue, Jurupa Valley, California				
Job Number:	CB185061	Boring No.:	B-5	Exhibit:	D-1

J:\2018\CB185061\Working Files\Calculations-Analyses\GeoSuite_CB185061_B-5.csv

SUPPORTING INFORMATION

THEORY AND METHODOLOGY OF LIQUEFACTION AND SEISMIC SETTLEMENT

Liquefaction Potential

Liquefaction is a process in which strong ground shaking causes saturated soils to lose their strength and behave as a fluid. Ground failure associated with liquefaction can result in severe damage to structures. Soil types susceptible to liquefaction include sand, silty sand, sandy silt and silt, as well as soils having a plasticity index (PI) less than 7 (Boulanger and Idriss, 2006). Loose soils with a PI less than 12 and moisture content greater than 85 percent of the liquid limit are also susceptible to liquefaction (Bray and Sancio, 2006). For sandy soils, the geologic conditions for increased susceptibility to liquefaction are: 1) shallow groundwater (generally less than 50 feet in depth), 2) the presence of unconsolidated sandy alluvium, typically Holocene in age, and 3) strong ground shaking. All three of these conditions must be present for liquefaction to occur.

For clayey soils, recent studies indicate that deposits of clays and plastic silts (i.e., cohesive soils) have also experienced failure during earthquakes (Idriss and Boulanger, 2008). This kind of failure is called cyclic softening. "The term cyclic softening is used in reference to strength loss and deformation in clays and plastic silts, while the term liquefaction is used in reference to strength loss and deformation in saturated sands and other cohesionless soils. As such, the terms cyclic softening and liquefaction can also be used in reference to the engineering procedures that have been developed for these respective soil types" (Idriss and Boulanger, 2008).

Liquefaction potential can usually be evaluated based on the SPT, CPT or shear wave velocity data and using the simplified procedure described by Seed and Idriss (1982), Seed and others (1985), modified in the 1996 National Center for Earthquake Engineering Research (NCEER) and 1998 NCEER/National Science Foundation (NSF) workshops (Youd and Idriss, 2001), and as recently summarized by Idriss and Boulanger (2008). The method of evaluating liquefaction potential consists of comparing the cyclic stress ratio (CSR) developed in the soil by the earthquake motion to cyclic resistance ratio (CRR), which will cause liquefaction of the soil for a given number of cycles. In the simplified procedure, the CSR developed in the soil is calculated from a formula that incorporates ground surface acceleration, total and effective stresses in the soil at different depths (which in turn are related to the location of the groundwater table), non-rigidity of the soil column and a number of simplifying assumptions.

For sandy soils, the CRR that will cause liquefaction is related to the relative density of the soil, expressed in terms of SPT blowcounts $(N_1)_{60}$ (Seed and Idriss, 1982; Seed and others, 1985; Youd and Idriss, 2001; Idriss and Boulanger, 2008), cone penetration resistance (q_{c1N}) (Robertson and Wride, 1998; Youd and Idriss, 2001; Idriss and Boulanger, 2008) or shear wave velocity (V_{s1}) (Andrus and Stokoe, 2000; Youd and Idriss, 2001; Andrus and others, 2004), all normalized for an effective overburden pressure of 1 ton per square foot and corrected to equivalent clean sand resistance. For clayey soils, the CRR is related to cyclic undrained shear strength ratio, s_u/σ_{vc}' (Idriss and Boulanger, 2008). All of these methods are incorporated into a liquefaction and seismic settlement program, GeoSuite©, version 2.4 (Yi, 2018).

Seismic Settlement

Prediction of seismic-induced settlement is also very important. Seismic-induced settlement includes settlement that occurs both in dry sands and saturated sands (California Geological Survey, 2008). Severe seismic shaking may cause dry sands to densify, resulting in settlement expressed at the ground surface. Seismic settlement in dry soils generally occurs in loose sands and silty sands, with cohesive and fine-grained soils being less prone to significant settlement. For saturated soils, significant settlement is anticipated if the soils exhibit liquefaction during seismic shaking.

The methods for evaluating seismic settlement in saturated sands can generally be classified into two groups. The method for the first group was developed during the 1970s and 1980s, generally based on the relationship between cyclic stress ratio, $(N_1)_{60}$, and volumetric strain (Silver and Seed, 1971; Lee and Albaisa, 1974; and Tokimatsu and Seed, 1987). The method for the second group was developed in the early 1990s with the paper by Ishihara and Yoshimine (1992) as the first publication in the category, modified and improved by various researchers (Robertson and Wride, 1998; Yoshimine et al., 2006; Idriss and Boulanger, 2008; and Yi, 2010), and is generally based on the relationship between volumetric strain and the factor of safety for liquefaction. Idriss and Boulanger (2008) modified the methods to incorporate both SPT and CPT data. Yi (2010) modified the methods to incorporate shear wave velocity data.

Research related to the estimation of dry sand settlement during earthquake excitation was initiated in the early 1970s by Silver and Seed (1971), followed by the works of several researchers (Seed and Silver, 1972; Pyke et al., 1975; Tokimatsu and Seed, 1987; and Pradel, 1998). A simplified method of evaluating earthquake-induced settlements in dry, sandy soils based on the Tokimatsu and Seed procedure has been developed by Pradel (1998) and is recommended by Martin and Lew (1999) as one of the standard methods for the estimation of earthquake-induced settlements of dry sands in California.

In recent years, serious research was performed by the University of California, Los Angeles (Duku et al. 2008; Yee et al. 2014; Stewart, 2014), and a new volumetric strain material model (VSMM) was proposed. The new UCLA VSMM was developed based on a series of laboratory test results and is able to consider the effects of overburden pressure, fines contents and degree of saturation. This new model was utilized for a new based-isolated new hospital, Loma Linda University Medical Center Campus Transformation Project, and approved by California's Office of Statewide Health Planning and Development (OSHPD).

All of these methods generally utilize SPT data. Utilizing the test results of Silver and Seed (1971), Yi extended the application of the procedures for both CPT (Yi, 2010a) and V_s data (Yi, 2010b, 2010c). These methods are also incorporated into a liquefaction and seismic settlement program, GeoSuite©, version 2.4 (Yi, 2018).

Surface Manifestation of Liquefaction

Ishihara (1985) published a paper containing observations on the protective effect that an upper layer of non-liquefied material had against the manifestation of liquefaction at the ground surface. The paper contained graphs that plotted thickness of the upper non-liquefied layer (H_1) and the thickness of underlying liquefied material (H_2). The maximum acceleration is 400 to 500 gal in Ishihara's graph. The term "surface manifestation" is utilized to describe liquefaction-induced surface damage.

A quantitative method using an index called the liquefaction potential index (LPI) was developed and presented by Iwasaki (1978, 1982). The LPI is defined as:

$$LPI = \int_{0}^{20} F_1 W(z) dz$$

where W(z) = 10 – 0.5z, F_1 = 1 - FS for FS < 1.0, F_1 = 0 for FS > 1.0 and z is the depth below the ground surface in meters. The LPI presents the risk of liquefaction damage as a single value with the following indicators of liquefaction-induced damage:

LPI Range and Damage	
LPI Range	**Damage**
LPI = 0	Liquefaction risk is very low.
0 < LPI ≤ 5	Liquefaction risk is low.
5 < LPI ≤ 15	Liquefaction risk is high.
LPI > 15	Liquefaction risk is very high.

The most recent development for quantitative descriptions of liquefaction-induced surface damage, called "liquefaction vulnerability", was made by Tonkin & Taylor (2013) after the Christchurch earthquakes occurred between 2010 and 2011 and was based on field observations and analyses of approximately 7,500 cone penetrometer test (CPT) investigations. A new index, the liquefaction severity number (LSN), was proposed and defined as:

$$LSN = \int \frac{\varepsilon_v}{z} dz$$

where ε_v is the calculated volumetric densification strain in the subject layer from Zhang et al. (2002) and z is the depth to the layer of interest in meters below the ground surface. The typical behaviors of sites with a given LSN are summarized in following table.

LSN Ranges and Observed Land Effects	
LSN Range	**Predominant Performance**
0 – 10	Little to no expression of liquefaction, minor effects
10 – 20	Minor expression of liquefaction, some sand boils
20 – 30	Moderate expression of liquefaction, with sand boils and some structural damage
30 – 40	Moderate to severe expression of liquefaction, settlement can cause structural damage
40 – 50	Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlement of structures
>50	Severe damage, extensive evidence of liquefaction at surface, severe total and differential settlements affecting structures, damage to services

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UNIFIED SOIL CLASSIFICATION SYSTEM

Limonite Avenue Widening ■ Jurupa Valley, California

August 30, 2018 ■ Terracon Project No. CB185061

Terracon GeoReport

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ³ 4 and 1 £ Cc £ 3 [E]	GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ³ 6 and 1 £ Cc £ 3 [E]	SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A"	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ³ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ³ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ³ 30% plus No. 200 predominantly sand, add "sandy" to group name.

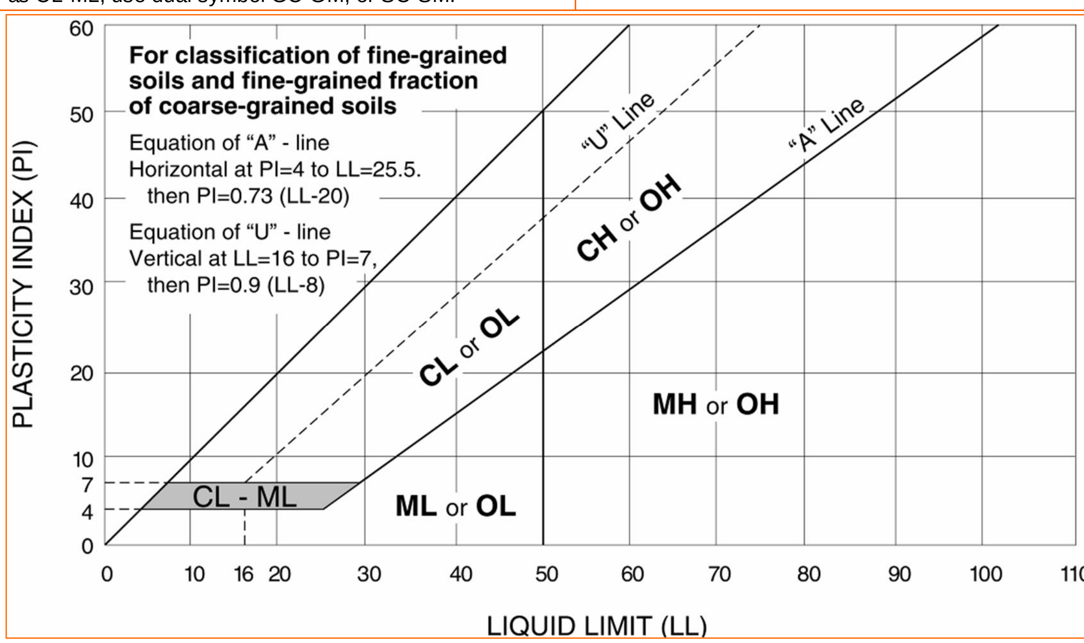
[M] If soil contains ³ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ³ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



DESCRIPTION OF ROCK PROPERTIES

WEATHERING	
Term	**Description**
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

STRENGTH OR HARDNESS		
Description	**Field Identification**	**Uniaxial Compressive Strength, psi (MPa)**
Extremely weak	Indented by thumbnail	40-150 (0.3-1)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (1-5)
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	700-4,000 (5-30)
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	4,000-7,000 (30-50)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (50-100)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (100-250)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>250)

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		**Bedding Spacing (May Include Foliation or Banding)**	
Description	**Spacing**	**Description**	**Spacing**
Extremely close	< ¾ in (<19 mm)	**Laminated**	< ½ in (<12 mm)
Very close	¾ in – 2-1/2 in (19 - 60 mm)	**Very thin**	½ in – 2 in (12 – 50 mm)
Close	2-1/2 in – 8 in (60 – 200 mm)	**Thin**	2 in – 1 ft. (50 – 300 mm)
Moderate	8 in – 2 ft. (200 – 600 mm)	**Medium**	1 ft. – 3 ft. (300 – 900 mm)
Wide	2 ft. – 6 ft. (600 mm – 2.0 m)	**Thick**	3 ft. – 10 ft. (900 mm – 3 m)
Very Wide	6 ft. – 20 ft. (2.0 – 6 m)	**Massive**	> 10 ft. (3 m)

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0-degree angle.

ROCK QUALITY DESIGNATION (RQD) [1]	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

1. The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009 Technical Manual for Design and Construction of Road Tunnels – Civil Elements

WEATHERING	
Fresh	Rock fresh, crystals bright, few joints may show slight staining. Rock rings under hammer if crystalline.
Very slight	Rock generally fresh, joints stained, some joints may show thin clay coatings, crystals in broken face show bright. Rock rings under hammer if crystalline.
Slight	Rock generally fresh, joints stained, and discoloration extends into rock up to 1 in. Joints may contain clay. In granitoid rocks some occasional feldspar crystals are dull and discolored. Crystalline rocks ring under hammer.
Moderate	Significant portions of rock show discoloration and weathering effects. In granitoid rocks, most feldspars are dull and discolored; some show clayey. Rock has dull sound under hammer and shows significant loss of strength as compared with fresh rock.
Moderately severe	All rock except quartz discolored or stained. In granitoid rocks, all feldspars dull and discolored and majority show kaolinization. Rock shows severe loss of strength and can be excavated with geologist's pick.
Severe	All rock except quartz discolored or stained. Rock "fabric" clear and evident, but reduced in strength to strong soil. In granitoid rocks, all feldspars kaolinized to some extent. Some fragments of strong rock usually left.
Very severe	All rock except quartz discolored or stained. Rock "fabric" discernible, but mass effectively reduced to "soil" with only fragments of strong rock remaining.
Complete	Rock reduced to "soil". Rock "fabric" no discernible or discernible only in small, scattered locations. Quartz may be present as dikes or stringers.

HARDNESS (for engineering description of rock – not to be confused with Moh's scale for minerals)	
Very hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows of geologist's pick.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach hand specimen.
Moderately hard	Can be scratched with knife or pick. Gouges or grooves to ¼ in. deep can be excavated by hard blow of point of a geologist's pick. Hand specimens can be detached by moderate blow.
Medium	Can be grooved or gouged 1/16 in. deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1-in. maximum size by hard blows of the point of a geologist's pick.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.
Very soft	Can be carved with knife. Can be excavated readily with point of pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.

Joint, Bedding, and Foliation Spacing in Rock [1]

Spacing	Joints	Bedding/Foliation
Less than 2 in.	Very close	Very thin
2 in. – 1 ft.	Close	Thin
1 ft. – 3 ft.	Moderately close	Medium
3 ft. – 10 ft.	Wide	Thick
More than 10 ft.	Very wide	Very thick

1. Spacing refers to the distance normal to the planes, of the described feature, which are parallel to each other or nearly so.

Rock Quality Designator (RQD) [1]

RQD, as a percentage	Diagnostic description
Exceeding 90	Excellent
90 – 75	Good
75 – 50	Fair
50 – 25	Poor
Less than 25	Very poor

1. RQD (given as a percentage) = length of core in pieces 4 inches and longer / length of run

Joint Openness Descriptors

Openness	Descriptor
No Visible Separation	Tight
Less than 1/32 in.	Slightly Open
1/32 to 1/8 in.	Moderately Open
1/8 to 3/8 in.	Open
3/8 in. to 0.1 ft.	Moderately Wide
Greater than 0.1 ft.	Wide

References: American Society of Civil Engineers. Manuals and Reports on Engineering Practice - No. 56. Subsurface Investigation for Design and Construction of Foundations of Buildings. New York: American Society of Civil Engineers, 1976. U.S. Department of the Interior, Bureau of Reclamation, Engineering Geology Field Manual.