Geotechnical Engineering Report

Center Street, Main Street to 100 West
Logan, Utah
June 14, 2019
Terracon Project No. 61185154

Prepared for:
J-U-B Engineer, Inc.
Logan, UT

Prepared by:
Terracon Consultants, Inc.
Midvale, Utah

June 14, 2019

Terracon
GeoReport

J-U-B Engineer, Inc.
1047 South 100 West, Suite 180
Logan, UT 84321

Attn: Mr. John Powell, P.E.
P: (435) 713 9514
E: jpowell@jub.com

Re: Geotechnical Engineering Report
Center Street, Main Street to 100 West
Main Street to 100 West
Logan, Utah
Terracon Project No. 61185154

Dear Mr. Powell:

We have completed the Geotechnical Engineering services for the above referenced project. This study was performed in general accordance with the agreed upon Scope of Services summarized in this report. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning design and construction of pavements and sign structure foundations.

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.

PROFESSIONAL ENGINEER
No. 10712597-2202
JUSTIN M
KRIEG
6-14-19
STATE OF UTAH

Justin M. Krieg, P.E.
Geotechnical Project Engineer

Rick L. Chesnut, P.E., P.G.
Senior Principal

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 which direct the reader to that section and clicking on the ***GeoReport*** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

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INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the Center Street, Main Street to 100 West project to be located in Logan, Utah. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Excavation considerations
- Foundation design and construction
- Seismic site classification per IBC
- Pavement design and construction

The geotechnical engineering Scope of Services for this project included the advancement of three test borings to depths ranging from 10 to 20 feet below existing site grades. Due to dense gravel and cobbles, auger refusal was encountered at depths ranging from 6 to 8 feet for the three test borings. An additional test boring using ODEX drilling methods was completed to a depth of 20 feet.

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 in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration.

Item	Description
Parcel Information	See **Site Location**
Existing Improvements	The Center Street existing pavement section consists of approximately 5" of asphalt concrete (AC) over 8" of Portland cement concrete (PCC). Sidewalks and commercial buildings line both sides of the street.

Item	Description
Current Ground Cover	Center street surfacing is AC. The sidewalks and street gutters are PCC.
Existing Topography	0 to 3 percent slope.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. 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	Site plan, verbal and email communication with the client.
Project Description	Reconstruct Center Street and adjacent walkways along the street from Main Street to 100 West. This project will improve walkability, increase use of business frontage on Center Street, and enhance connectivity to downtown areas.
Proposed Structure	An archway sign structure across Center Street supported by a foundation that consists a 40-inch diameter drilled shaft with a 4 ft. X 8 ft. reinforce concrete cap.
Sign Structure Maximum Loads (provided by J.-U-B Engineers)	Drilled Shaft: ■ Vertical: 10 kips + weight of foundation ■ Lateral Shear: 5 kips ■ Moment: 70 kip-ft
Grading	Up to 2 feet of cut and 2 feet of fill will be required to develop final grade.
Pavements	Flexible (asphaltic concrete) pavement sections will be considered. Anticipated traffic is as follows: ■ Autos/light trucks: 4815 vehicles per day ■ Light delivery trucks and buses: 135 vehicles per week ■ Tractor-trailer trucks: <250 vehicles per day The pavement design period is 20 years. Anticipated traffic growth of 1.2% per year was used to determine future AADT.

GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
1	AC	Asphaltic Concrete
2	PCC	Portland Cement Concrete
3	Fill	Existing Fill - Poorly Graded Gravel
4	Silty Clayey Gravel	Silty Clayey Gravel (GC-GM) – loose
5	Silty Gravel	Silty Gravel with Sand (GM) - very dense, possible cobbles
6	Poorly Graded Sand	Poorly Graded Sand with Silt (SP)- loose to medium dense

Groundwater Conditions

Groundwater was only observed in boring B-4 while drilling at an approximate depth of 12 feet. Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors. 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.

GEOTECHNICAL OVERVIEW

Based on the results of our exploration the site appears suitable for the proposed construction, provided the recommendations presented in this geotechnical report are followed. The surface of the roadway consisted of approximately 5 inches of asphaltic concrete overlaying 8 inches of Portland cement concrete. Undocumented fill was encountered to a depth of approximately 2 feet below existing grades. We expect that the fill was placed during original construction of the site, however we have no construction records to indicate the degree of compaction control. In general, support of flatwork and pavements on or above existing fill soils involves risk for the owner that compressible fill or unsuitable material, within or buried by the fill will, not be discovered. Fill should be removed from below foundations. In pavement areas and flatwork areas, the existing fills may be evaluated during construction for re-use. If found to be suitable, the fill may be left in place below pavements and flatwork providing it is compacted to the requirements of this report.

The proposed archway sign structure may be supported on a drilled shaft with a 4 ft. x 8 ft. reinforced concrete cap. We recommend that the sign contractor review this report and the soil boring logs to become familiar with the conditions encountered and provide appropriate equipment to complete the shaft excavation to the design depth while maintaining stability of the excavation walls and bottom. The **Deep Foundations** section addresses support of the archway sign structure on drilled shaft foundations. Due to very dense granular soils with cobbles, drilling the shaft may be difficult and will require temporary casing to prevent the excavation from collapsing.

Native soils below the fill (silty clayey gravel with sand) may become unstable during construction especially if exposed to excessive moisture and construction traffic. Removal of soft or deflecting soils and replacement with properly placed and compacted Structural Fill may be necessary during site preparation.

Geotechnical engineering recommendations for foundation systems and other earth-connected phases of the project are outlined below. The recommendations contained in this report are based upon the results of data presented herein, engineering analyses, and our current understanding of the proposed project.

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

EARTHWORK

Earthwork is anticipated to include 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

The site was paved during the time of field work. All asphalt, concrete and other site improvements should be stripped in the proposed sign foundation and pavement areas. Any undocumented fill, debris, loose, soft, or frozen soil and other deleterious materials encountered during construction should be removed from beneath the sign foundations and pavement areas.

Following the removal of these materials, the exposed native coarse-grained soils in flatwork and pavement areas should be prepared by scarifying to a depth of 8 inches, moisture-conditioning as necessary and compacting to the requirements of this report. Loose, deflecting or otherwise unsuitable conditions, identified during proofrolling should be removed and replaced with compacted Structural Fill. Backfill of excavations should be completed using properly placed and compacted Structural Fill.

Although evidence of underground facilities such as septic tanks, cesspools, basements, and utilities was not observed during the site reconnaissance, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed, and the excavation thoroughly cleaned prior to backfill placement and/or construction.

Fill Material Types

Pea gravel or other similar non-cementitious poorly graded materials should not be used as fill or backfill without the prior approval of the geotechnical engineer. Fill material should meet the following requirements:

Fill Type [1]	Application	Requirements		
		Gradation		Plasticity
		Size	Percent finer by weight (Foundations)	
Structural Fill	Required for all fill under foundations, floor slabs, and pavements	3 inch No. 4 Sieve No. 200 Sieve	100 35-60 15 max	Liquid limit 30 max Plasticity Index 6 max

1. All fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to the geotechnical engineer for evaluation.
2.

Fill Compaction Requirements

Structural Fill should meet the following compaction requirements.

ITEM	DESCRIPTION
Fill Lift Thickness	8-inches or less in loose thickness
Compaction	95% of the material's maximum dry density (modified Proctor - ASTM D 1557)
Moisture Content	Within 2% of optimum moisture content as determined by the modified Proctor test at the time of placement and compaction

If cobbles are encountered in the scarified native subgrade and a modified Proctor test cannot be completed, a vibratory compactor should compact the surface until it is firm and unyielding. Terracon should be contacted to observe and approve the compaction effort.

Utility Trench Backfill

All trench excavations should be made with sufficient working space to permit construction, including backfill placement and compaction. If utility trenches are backfilled with relatively clean granular material, they should be capped with at least 18 inches of cohesive fill in non-pavement areas to reduce the infiltration and conveyance of surface water through the trench backfill.

Grading and Drainage

Positive drainage away from structures and pavements should be provided during construction and maintained throughout the life of the proposed project. Infiltration of surface water into excavations should be prevented during construction. Water permitted to pond next to structures and pavements can result in greater soil movements than those discussed in this report. These greater movements can result in cracked slabs and pavements. Estimated movements described in this report are based on effective drainage for the life of structures and pavements and cannot be relied upon if effective drainage is not maintained. Surface drainage should be collected and discharged far away from the structures and pavements to prevent wetting of the foundation soils.

Earthwork Construction Considerations

Shallow excavations for the proposed pavement and flatwork areas are anticipated to be accomplished with conventional construction equipment. Additional effort will be required in deeper excavations such as utilities or for the drilled shaft foundations. In these areas, the contractor should review the information contained in this report and provide appropriate equipment to advance excavations to the design depths.

Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of pavements or flatwork. 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 freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to floor slab 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.

Very Dense gravel with some cobbles and possible boulders were encountered during the field exploration at the archway sign location. Difficult excavating and potential sloughing soil conditions may be encountered. The individual contractor(s) is responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom.

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.

DEEP FOUNDATIONS

Drilled Shaft Design Parameters

The proposed archway sign structure may be supported on drilled shaft foundations with a 4 ft. by 8 ft. concrete cap. Design and construction recommendations are provided in the following sections.

Drilled Shaft Design Parameters

Soil parameters to be used in the design of the drilled shaft foundations are included in the tables below. The values included in the table were estimated based on the observed soil conditions during our field exploration, visual classifications, and presumptive values for similar materials. Note that the soil parameters are not intrinsic values of the soil, and they depend on the state of the soil (density, depositional history, water content, etc.) and the loading conditions, among other factors.

The soil parameters presented in the tables are intended to be used in the design of drilled shaft foundations at the site, assuming soil conditions are similar to those encountered during our field exploration. The applicability of these soil parameters for other uses should be discussed with the geotechnical engineer.

The allowable end bearing pressure, skin friction, and horizontal constant of subgrade reaction for the depth intervals are summarized in the following tables. The allowable end bearing pressure and skin friction values presented are based on a factor of safety of 3. Also, the allowable skin friction to resist both vertical downward loads and uplift forces assume bored shafts having concrete cast in direct contact with adjacent soil.

The depth of the shafts should be determined by the structural engineer following lateral analysis of the shaft(s). We recommend that the shafts extend to a minimum depth of 11 feet. Greater depths may be required to resist overturning, uplift or downward forces inducted by the structure. The contribution of the upper 36 inches of the soil profile to pier capacities should be neglected due to the potential freeze-thaw, wet-dry cycles and any other disturbance in this zone that could further loosen the soil around the foundation. We estimate that settlement of drilled pier foundations bearing in the loose sand soils will be less than one inch.

Subsurface Unit	Depth Interval (ft)	Soil Data[1]					P-Y Curve Soil Model	Allowable Drilled Shaft Unit Capacity (ksf) [2,3]	
		Effective Unit Weight (pcf)	Shear Strength Parameters Ø	Shear Strength Parameters C (ksf)	Subgrade Modulus k (pci)	Static Strain ε_{50} – Soil		Tip	Skin
Fill	0 – 3	125	30	--	0	--	Sand (Reese)	--	--
Silty Clayey Gravel	3 - 4	120	30	--	30	--	Sand (Reese)	--	0.12
Silty Gravel	4 - 10	130	33	--	180	--	Sand (Reese)	7.5	0.40
Poorly Graded Sand	10 - 12	122	29	--	40	--	Sand (Reese)	2.0	0.26
Poorly Graded Sand	12 - 20	60	29	--	30	--	Sand (Reese)	2.0	0.30

1. The Soil Data values presented herein represent ultimate values; no factor of safety has been included. The designer should incorporate appropriate factors of safety in his or her design.
2. Allowable Drilled Shaft Unit Capacity values presented herein are based on a factor of safety of 3.

Subsurface Unit	Depth Interval (ft)	Soil Data[1]						P-Y Curve Soil Model	Allowable Drilled Shaft Unit Capacity (ksf) [2,3]	
		Effective Unit Weight (pcf)	Shear Strength Parameters		Subgrade Modulus k (pci)	Static Strain ε_{50} – Soil			Tip	Skin
			Ø	C (ksf)						

3. Based on a 40" shaft diameter

Allowable pier capacity in compression (Q_{allow}) can be calculated by the following equation:

$$Q_{allow} = (Q)\pi(d^2)/4 + \pi \sum_{i=1}^{n} (s_d)(d)(t_i) \quad \text{[pounds]}$$

Where:
- Q = allowable bearing pressure (psf)
- d = drilled shaft diameter (ft)
- s_d = allowable skin friction in compression (psf)
- t_i = i^{th} soil layer thickness in contact with pier (ft)
- i = individual layer
- n = total number of layers
- s_u = allowable skin friction in uplift (psf)

The first and second terms in the above equation represent allowable end bearing and skin friction components of the drilled capacity, respectively. The allowable uplift capacity can be calculated by substituting s_u for s_d in the second term of the equation, neglecting the end bearing component and adding the weight of the pier.

Tensile reinforcement should extend to the bottom of shafts subjected to uplift loading. Buoyant unit weights of the soil and concrete should be used in the calculations below the highest anticipated groundwater elevation.

We anticipate that the sign will be supported by one drilled shaft with a 4-foot-wide by 8-foot-long concrete cap on each side of Center Street. The concrete cap must structurally transfer the entire load of the sign structure to the drilled shaft and not the underlying soil to minimize possible settlement of utilities below the sign foundations. If multiple drilled shafts are used, we should be contacted to revise our design recommendations to account for shaft interaction.

Drilled Shaft Construction Considerations

Following drilling, soft, loose, or disturbed soil should be removed from the bottom of the shaft prior to placement of concrete. Temporary casing will be required to maintain stability of the excavation walls. Construction of drilled shafts should only be performed by contractors experienced in installation of this type of foundation.

Reinforcing-steel and concrete should be placed inside the temporary casing. The casing should be pulled as the concrete is placed to provide final contact between the soil and the concrete.

To facilitate pier construction, reinforcing-steel and concrete should be ready and on site, and concrete should be available within very short periods of time for placement as the drilled shaft excavation is completed.

Concrete should be placed into the excavation through without free-falling more than 5 feet. An uninterrupted supply and placement of concrete should be performed to produce a monolithic drilled shaft.

To ensure the concrete cap doesn't transfer loads to soils underlying the cap and cause settlement of nearby utilities, void forms may be used to form the base of the concrete cap extending beyond the limits of the drilled shaft.

The drilled shaft installation process should be performed under the direction of the Geotechnical Engineer. The Geotechnical Engineer should document the shaft installation process including soil/rock and groundwater conditions encountered, consistency with expected conditions, and details of the installed shaft.

Drilled Shaft Construction Considerations

The borings encountered loose to very dense granular soils and relatively shallow groundwater. To prevent collapse of the sidewalls and/or to control groundwater seepage, the use of temporary steel casing and/or slurry drilling procedures may be required for construction of the drilled shaft foundations. Significant seepage could occur in case of excavations penetrating water-bearing sandy soil layers. The drilled shaft contractor and foundation design engineer should be informed of these risks.

A full-depth temporary steel casing may be required to stabilize the sides of the shaft excavations. Difficult drilling conditions should be expected within the very dense gravel layer from approximately four feet to ten feet deep. If casing is removed during concrete placement, care should be exercised to maintain concrete inside the casing at a sufficient level to resist earth and hydrostatic pressures present on a casing exterior. Water or loose soil should be removed from the bottom of the drilled shafts prior to placement of the concrete.

Care should be taken to not disturb the sides and bottom of the excavation during construction. The bottom of the shaft excavation should be free of loose material before concrete placement.

Concrete should be placed as soon as possible after the foundation excavation is completed, to reduce potential disturbance of the bearing surface.

“Wet” shafts should be constructed by slurry displacement techniques. In this process, the shaft excavation is filled with approved polymer-based slurry to counter-balance the hydraulic forces below the water level and stabilize the wall of the shaft. Concrete would then be placed using a tremie extending to within 6 inches of the shaft base of the slurry-filled excavation. The tremie remains inserted several feet into the fresh concrete as it displaces the slurry upward and until placement is complete. The slurry should have a sand content no greater than 1% at the time concrete placement commences. The maximum unit weight of the slurry should be established in consultation with Terracon.

Concrete for "dry" drilled shaft construction should have a slump of about 5 to 7 inches. Concrete should be directed into the shaft utilizing a centering chute. Concrete for "wet" shaft construction would require higher slump concrete.

While withdrawing casing, care should be exercised to maintain concrete inside the casing at a sufficient level to resist earth and hydrostatic pressures acting on the casing exterior. Arching of the concrete, loss of seal and other problems can occur during casing removal and result in contamination of the drilled shaft. These conditions should be considered during the design and construction phases. Placement of loose soil backfill should not be permitted around the casing prior to removal.

The drilled shaft installation process should be performed under the direction of the Geotechnical Engineer. The Geotechnical Engineer should document the shaft installation process including soil/rock and groundwater conditions encountered, consistency with expected conditions, and details of the installed shaft.

SEISMIC CONSIDERATIONS

Based on the results of our exploration, the subsurface soil profile is best represented by Site Class D according to Chapter 20 of ASCE 7 in accordance with the 2015 IBC. The National Seismic Hazard Map database was searched to identify the peak ground acceleration (PGA) and spectral accelerations for 0.2 second (Ss) and 1.0 second (S1) periods for a 2% probability of exceedance (PE) in 50 years at the project site for site class B. These values should be adjusted for site effects, using appropriate site class factors from the 2015 IBC.

DESCRIPTION	VALUE
Site Class[1]	D[2]
Site Latitude	N 41.7313°
Site Longitude	W -111.8362°
S_o PGA	0.427 g
S_s Spectral Acceleration for a Short Period	0.979 g
S_1 Spectral Acceleration for a 1-Second Period	0.312 g
F_a Site Coefficient for a Short Period	1.109
F_v Site Coefficient for a 1-Second Period	1.776

1. Note: In general accordance with the *2015 IBC,* Section 1613.2.2.
2. Note: Chapter 20 of ASCE 7-10 requires a site soil profile determination extending to a depth of 100 feet for seismic site classification. The current scope does not include the required 100-foot soil profile determination. Borings extended to a maximum depth of 21 ½ feet, and this seismic site class definition considers that encountered soils continues below the maximum depth of the subsurface exploration. Additional exploration to deeper depths would be required to confirm the conditions below the current depth of exploration.

Based on reviewed liquefaction maps the site is in a low potential zone. Based on the subsurface conditions, the potential for liquefaction induced settlement is negligible.

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

Pavement sections were developed using AASHTO (1993) design methodology and traffic volumes described in the **Project Description**. Design traffic and estimated 18-kip Equivalent Single Axle Loads (ESAL) are summarized in the following table.

Section	Design ESALs[1]
Center Street	5,203,000

1. Design ESALs calculated from traffic provided by J-U-B Engineers Inc.

Subgrade support was estimated from a laboratory prepared California Bearing Ratio (CBR) test results of the on-site, silty clayey gravel with sand sampled. This test result is presented in the **Exploration Results** section of this report. A subgrade California Bearing Ratio (CBR) of 5 was used for the asphaltic concrete pavement design.

Pavement Section Thicknesses

The following table provides options for the design AC pavement section:

Traffic Area	Pavement Section			
	Asphaltic Concrete	Aggregate Base	Granular Borrow	Total Thickness
Center Street	6.0	6.0	12.0	24.0

Pavement Drainage

The performance of all pavements can be enhanced by minimizing excess moisture which can reach the subgrade soils. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. The following recommendations should be considered at minimum:

- Pavements should be sloped to provide rapid drainage of surface water;
- The pavement subgrade should be graded to provide positive drainage within the granular base section;
- Site grading at a minimum 2 percent grade away from the pavements;
- Compaction of any utility trenches for landscaped areas to the same criteria as the pavement subgrade;
- Sealing all landscaped areas in, or adjacent to pavements to minimize or prevent moisture migration to subgrade soils;
- Placing compacted backfill against the exterior side of curb and gutter; and,

- Placing curb, gutter and/or sidewalk directly on subgrade soils without the use of base course materials

Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program. Preventive maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment.

Pavement sections have not been designed to support construction traffic. Construction traffic should not be allowed on pavement subgrades or completed pavement sections except for that required to deliver and place pavement section materials.

Preventive 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 first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements. Prior to implementing any maintenance, additional engineering observation is recommended to determine the type and extent of preventive maintenance. Even with periodic maintenance, some movements and related cracking may still occur, and repairs may be required.

CORROSIVITY

Analytical laboratory tests were completed at the water treatment plant location. Results of the testing are provided below.

RESULTS OF CHEMICAL REACTIVITY LABORATORY TESTS

Sample	Depth (ft)	pH	Resistivity (ohm-cm)	Sulfates (mg/kg)	Chlorides (mg/kg)
B-1	2.0	10.3	717	126	265

An aggressive subsurface environment where corrosion can deteriorate the buried steel over their design life can generally be identified by soil resistivity and pH tests. The following criteria for corrosive soil are specified in AASHTO LRFD Section 10.7.5.

- Electrical resistivity less than 2,000 ohm-cm

- pH less than 5.5
- pH between 5.5 and 8.5 in soils with high organic content

On-site soils at Center Street are considered aggressive to buried steel based on laboratory test results. Based on the test results and ACI manuals, sulfate exposure to concrete appears to be negligible. Type II cement may be used for concrete applications.

GENERAL COMMENTS

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 this 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 immediately notified 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.

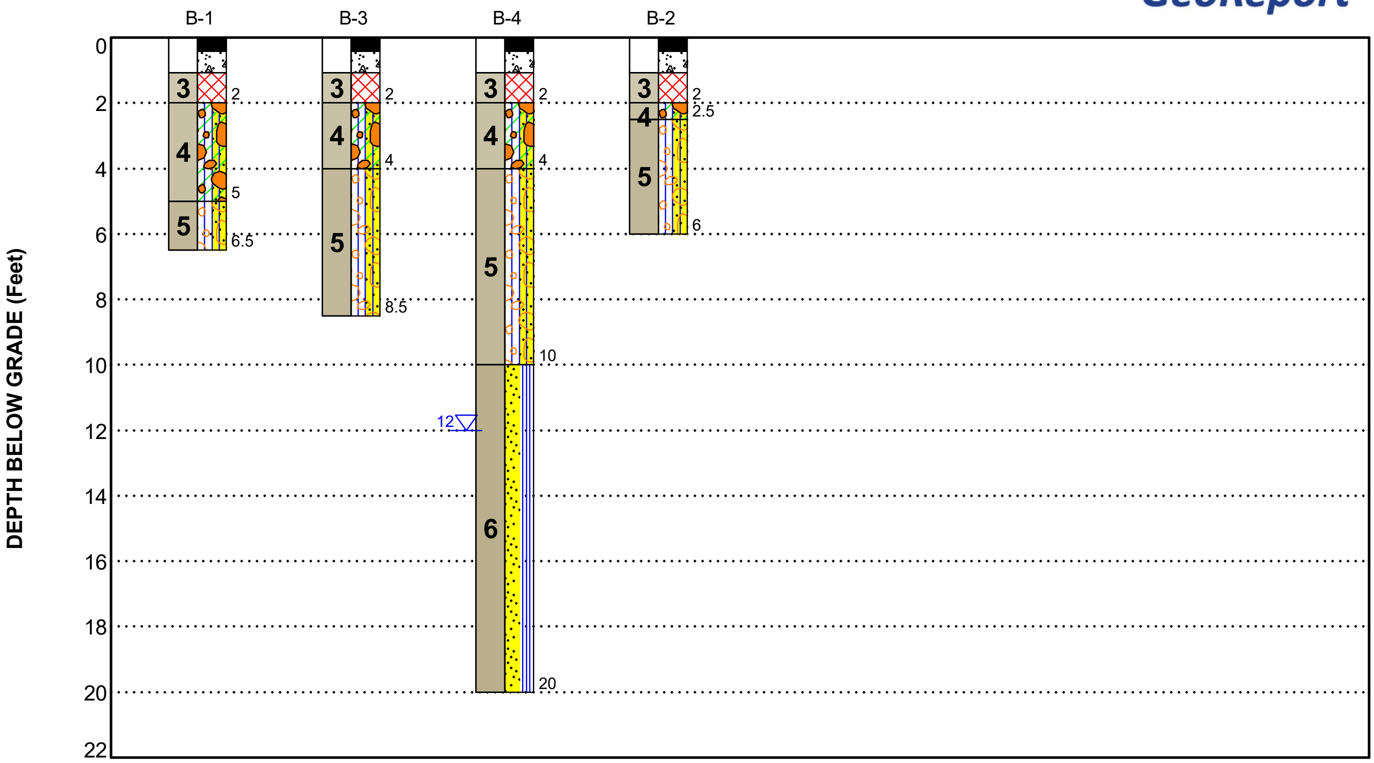
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation 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.

FIGURES

Contents:

GEOMODEL

Center Street; Main Street to 100 West ■ Logan, UT
1/22/2019 ■ Terracon Project No. 61185154



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

LEGEND

Asphalt
Concrete
Fill
Silty Clayey Gravel with Sand
Silty Gravel with Sand
Poorly-graded Sand with Silt

Model Layer	Layer Name	General Description
1	AC	Asphalt Concrete
2	PCC	Portland Cement Concrete
3	Fill	Existing Fill- Poorly Graded Gravel
4	Silty Clayey Gravel	Silty Clayey Gravel (GC-GM)- loose
5	SIlty Gravel	Silty Gravel with Sand (GM)- very dense
6	Poorly Graded Sand	Poorly Graded Sand with SIlt- loose to medium dense

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.

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.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

Number of Borings	Boring Depth (feet)	Planned Location
1	10 or auger refusal	pavement
1	15 or auger refusal	pavement / percolation test
1	20 or refusal	archway sign
1	20 (ODEX)	archway sign

Boring Layout and Elevations: Unless otherwise noted, Terracon personnel provided the boring layout. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±10 feet). If elevations and a more precise boring layout are desired, we recommend borings be surveyed following completion of fieldwork.

Subsurface Exploration Procedures: We advanced the borings with a track-mounted rotary drill rig using continuous flight augers hollow stem augers or ODEX. Four samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion. Pavements were patched with cold-mix asphalt and/or pre-mixed concrete, as appropriate.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were 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 reviewed the field data and assigned laboratory tests to 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 were 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 and Rock by Mass
- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- ASTM D1883 Standard Test Method for California Bearing Ratio

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

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Center Street, Main Street to 100 West ■ Logan, Utah

June 14, 2019 ■ Terracon Project No. 61185154

Terracon GeoReport

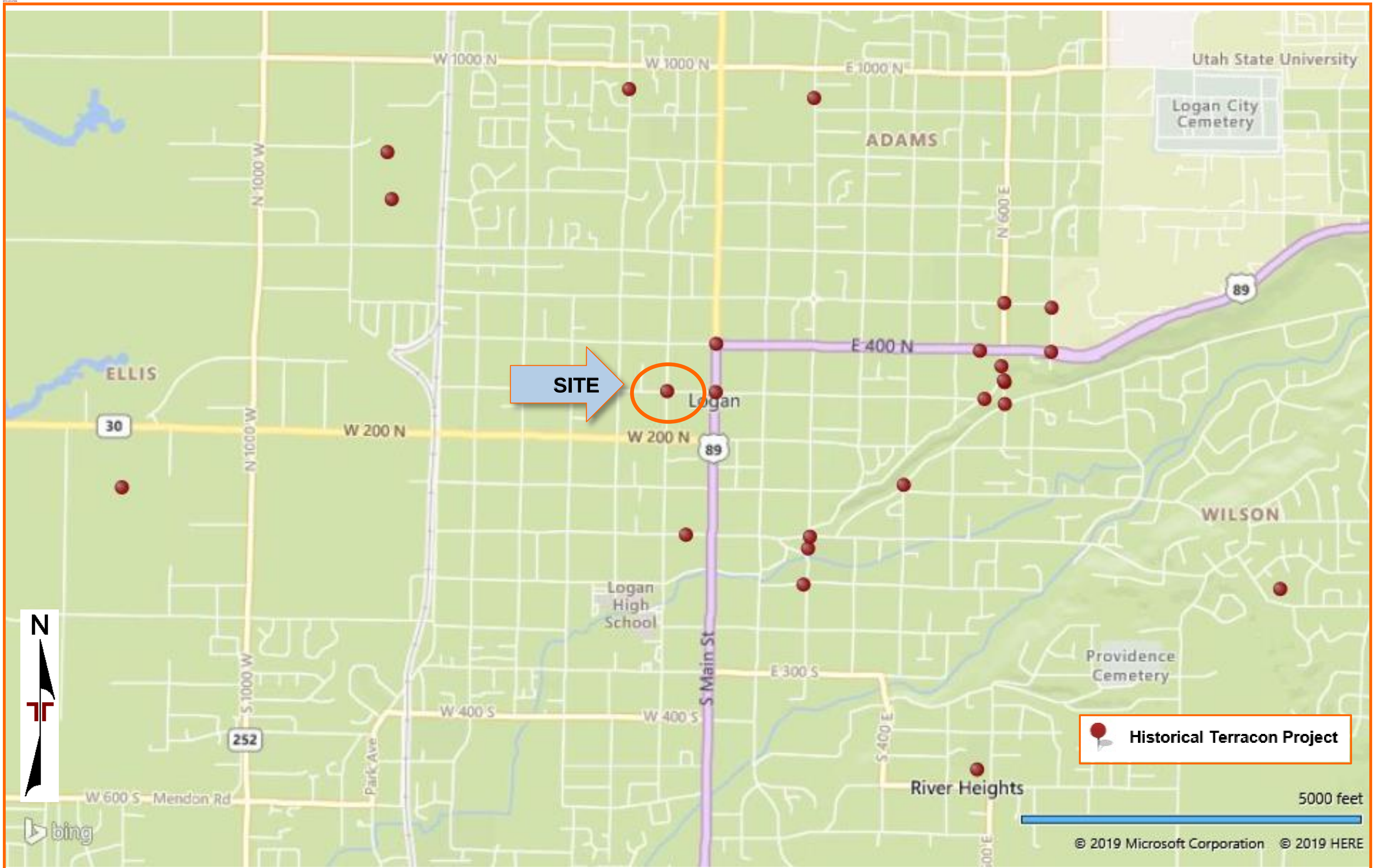


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Center Street, Main Street to 100 West ■ Logan, Utah

June 14, 2019 ■ Terracon Project No. 61185154

Terracon GeoReport

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

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: Center Street; Main Street to 100 West

**CLIENT: J-U-B ENGINEERS, Inc.
Logan, UT**

**SITE:
Logan, UT**

LOCATION See Exploration Plan

Latitude: 41.7314° Longitude: -111.8371°

MODEL LAYER	DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1	0.4	**ASPHALT**, approx. 5 inches									
2	1.1	**PORTLAND CEMENT CONCRETE**, approx. 8 inches									
3	2.0	**FILL - POORLY GRADED GRAVEL** , brown									
4	5.0	**SILTY CLAYEY GRAVEL WITH SAND (GC-GM)**, dark brown, loose				0	2-2-4 N=6	8		22-15-7	24
5	6.5	**SILTY GRAVEL WITH SAND (GM)**, brown, very dense, possible cobbles and boulders	5			4	20-39-33 N=72	3			
		Auger Refusal at 6.5 Feet									

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

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Backfilled with auger cuttings and 1' cement cutting mix, capped with asphalt

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 not encountered

Terracon
6949 S High Tech Dr, Ste 100
Midvale, UT

Boring Started: 11-19-2018	Boring Completed: 11-19-2018
Drill Rig: Geoprobe	Driller: DPS
Project No.: 61185154	

BORING LOG NO. B-2

PROJECT: Center Street; Main Street to 100 West

CLIENT: J-U-B ENGINEERS, Inc.
Logan, UT

SITE:
Logan, UT

LOCATION See Exploration Plan

Latitude: 41.7313° Longitude: -111.8355°

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1		0.4	**ASPHALT**, approx. 5 inches									
2		1.1	**PORTLAND CEMENT CONCRETE**, approx. 8 inches									
3		2.0	**FILL - POORLY GRADED GRAVEL**									
4		2.5	**SILTY CLAYEY GRAVEL WITH SAND (GC-GM)**, dark brown, loose									
5		6.0	**SILTY GRAVEL WITH SAND (GM)**, brown, very dense, possible cobbles and boulders				3	8-50/-3"	3			
				5					2		19-16-3	13

Auger Refusal at 6 Feet

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

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Backfilled with auger cuttings and 1' cement cutting mix, capped with asphalt

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 not encountered

Terracon
6949 S High Tech Dr, Ste 100
Midvale, UT

Boring Started: 11-19-2018	Boring Completed: 11-19-2018
Drill Rig: Geoprobe	Driller: DPS
Project No.: 61185154	

BORING LOG NO. B-3

PROJECT: Center Street; Main Street to 100 West

CLIENT: J-U-B ENGINEERS, Inc.
Logan, UT

SITE:
Logan, UT

LOCATION See Exploration Plan

Latitude: 41.7313° Longitude: -111.8362°

MODEL LAYER	DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1	0.4	**ASPHALT**, approx. 5 inches									
2	1.1	**PORTLAND CEMENT CONCRETE**, approx. 8 inches									
3	2.0	**FILL - POORLY GRADED GRAVEL**									
4	4.0	**SILTY CLAYEY GRAVEL WITH SAND (GC-GM)**, dark brown, loose			X	3	1-1-4 N=5	6			
5	8.5	**SILTY GRAVEL WITH SAND (GM)**, trace clay, brown, dense to very dense, possible cobbles and boulders	5		X	11	21-18-16 N=34	2		21-16-5	
					X	6	25-31-30 N=61				

Auger Refusal at 8.5 Feet

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

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Backfilled with auger cuttings and 1' cement cutting mix, capped with asphalt

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 not encountered

Terracon
6949 S High Tech Dr, Ste 100
Midvale, UT

Boring Started: 11-19-2018	Boring Completed: 11-19-2018
Drill Rig: Geoprobe	Driller: DPS
Project No.: 61185154	

BORING LOG NO. B-4

PROJECT: Center Street; Main Street to 100 West

CLIENT: J-U-B ENGINEERS, Inc.
Logan, UT

SITE:
Logan, UT

LOCATION See Exploration Plan

Latitude: 41.7313° Longitude: -111.8362°

MODEL LAYER	DEPTH	DESCRIPTION
1	0.4	**ASPHALT**, approx. 5 inches
2	1.1	**PORTLAND CEMENT CONCRETE**, approx. 8 inches
3	2.0	**FILL - POORLY GRADED GRAVEL**, with cobbles up to 3 inches in diameter
4	4.0	**SILTY CLAYEY GRAVEL WITH SAND (GC-GM)**, dark brown, loose
5	10.0	**SILTY GRAVEL WITH SAND (GP)**, trace clay, brown to gray, very dense, possible cobbles and boulders
6	20.0	**POORLY GRADED SAND WITH SILT (SP)**, trace clay, brown and gray, loose to medium dense
		Boring Terminated at 20 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (Inches)	FIELD TEST RESULTS	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
8.5–10		X	11	22-23-15 N=38	2		NP	0
12	▽							
13.5–15		X	20	1-3-4-4 N=7	26		NP	6
18.5–20		X	24	3-4-7-4 N=11	26			

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

Hammer Type: Automatic

Advancement Method:
Odex

Abandonment Method:
Backfilled with auger cuttings and 1' cement cutting mix, capped with asphalt

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

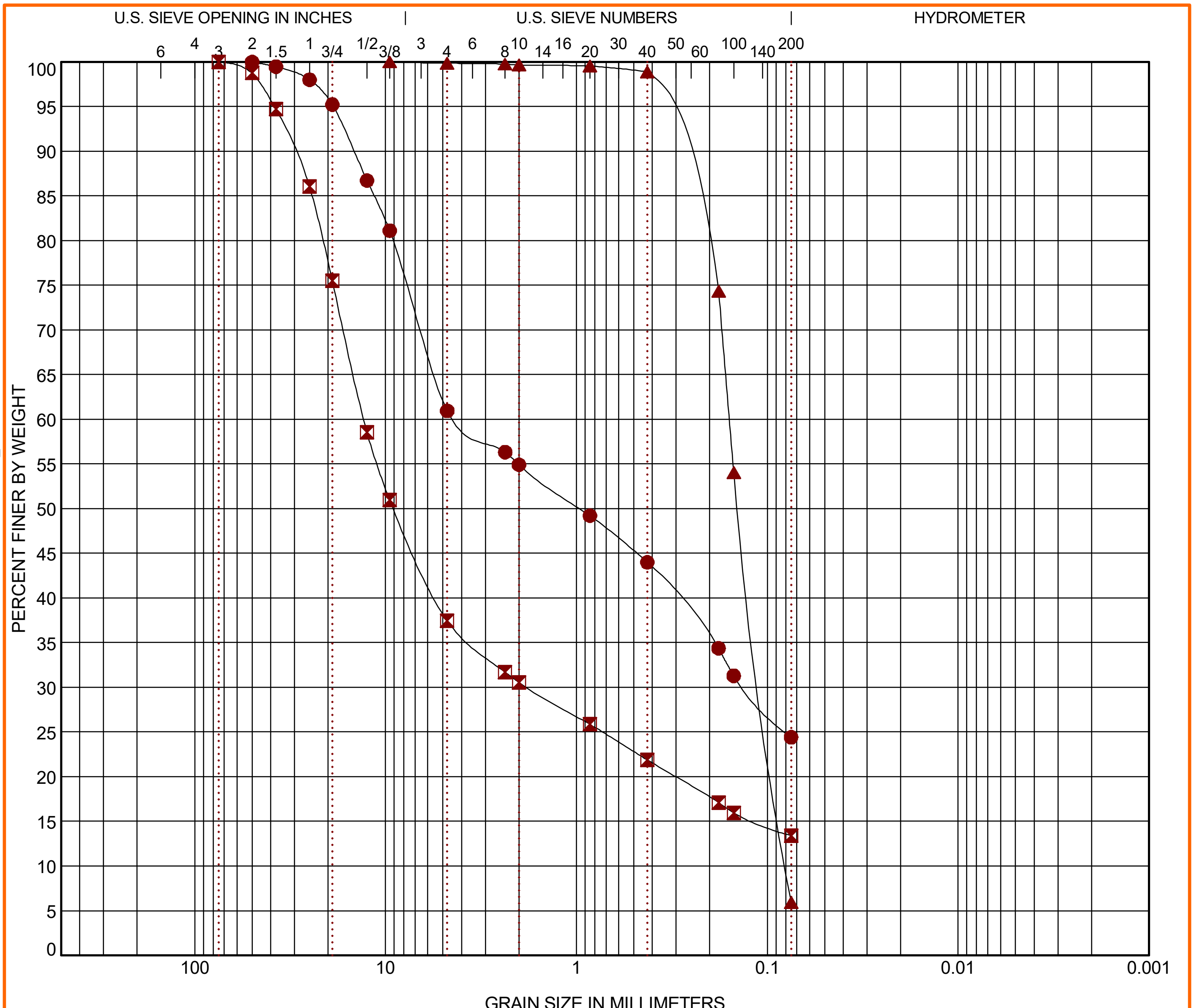
▽ *12' While Drilling*

Terracon
6949 S High Tech Dr, Ste 100
Midvale, UT

Boring Started: 01-15-2019	Boring Completed: 01-15-2019
Drill Rig: Geoprobe	Driller: DPS
Project No.: 61185154	

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring ID	Depth	USCS Classification	AASHTO Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-1	2 - 5	SILTY, CLAYEY GRAVEL with SAND (GC-GM)	A-2-4 (0)	8	22	15	7		
⊠	B-2	4 - 6	SILTY GRAVEL with SAND (GM)	A-1-a (0)	2	19	16	3		
▲	B-4	13 - 15	POORLY GRADED SAND with SILT (SP-SM)	A-3 (0)	26	NP	NP	NP	0.89	1.99

	Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-1	2 - 5	50	4.119	0.132		39.1	36.5		24.4	
⊠	B-2	4 - 6	75	12.964	1.81		62.6	24.1		13.4	
▲	B-4	13 - 15	9.5	0.158	0.106	0.08	0.1	93.9		5.9	

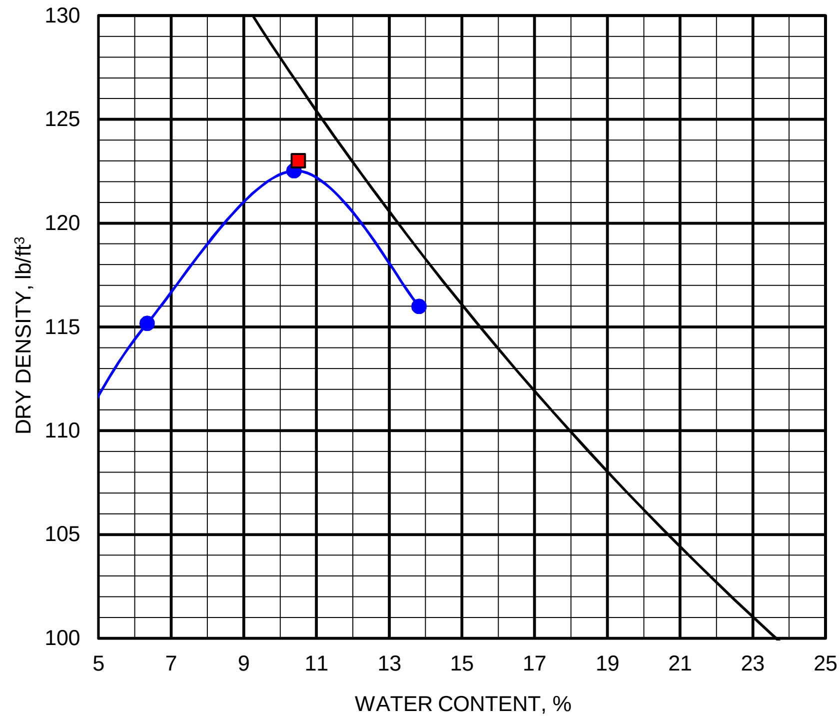
PROJECT: Logan Center Street; Main Street to 100 West	Terracon 6949 S High Tech Dr, Ste 100 Midvale, UT	PROJECT NUMBER: 61185154
SITE: 100 West Center Street Logan, UT		CLIENT: J-U-B ENGINEERS, Inc. Logan, UT

GRADATION RESULTS

SIEVE SIZE	PERCENT PASSING
1-1/2"	**100**
1"	**97**
3/4"	**96**
3/8"	**90**
No. 4	**82**
No. 8	**78**
No. 10	**78**
No. 16	**76**
No. 20	**75**
No. 30	**74**
No. 40	**72**
No. 50	**71**
No. 80	**68**
No. 100	**67**
No. 200	**59**

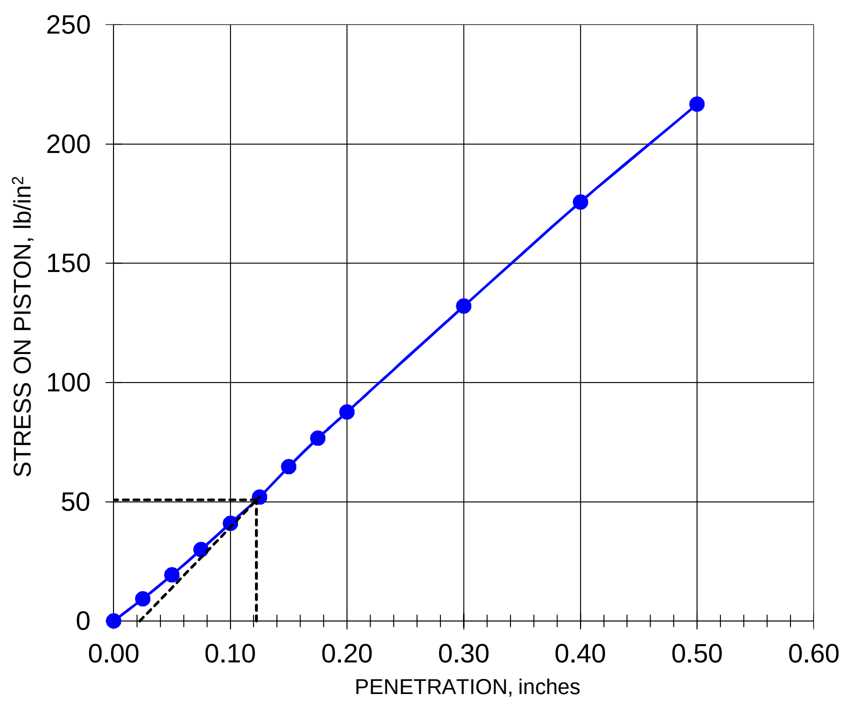
Liquid Limit: 22
Plasticity Index: 7

Maximum Dry Density, lb/ft^3: **123** Test Method: **ASTM D 1557**
Optimum Moisture, %: **10.5** (ZERO AIR VOIDS FOR SPECIFIC GRAVITY OF 2.58)



CALIFORNIA BEARING RATIO

Dry Density,	
Before Soaking, lb/ft^3:	**124.1**
After Soaking, lb/ft^3:	**123.3**
Relative Compaction, %:	**101**
Moisture Content,	
Before Compaction, %:	**9.4**
Top 1-inch After Soaking, %:	**12.8**
Average After Soaking, %:	**12.5**
Surcharge Weight, lb:	**10**
Soaking Period, hr:	**96**
Swell, %:	**-0.1**
CBR Value, %:	**5.1**



SAMPLE - IDENTIFICATION
B-1 @ 2.0-5.0

CLASSIFICATION
Silty Clayey Gravel with Sand (GC-GM)

Terracon

GRADATION, MOISTURE-DENSITY AND CALIFORNIA BEARING RATIO TEST RESULTS

Project Name: **Center Street, Main St. to 100 West Design**
Location: **B-1 @ 2-5'**
Project No.: **61185154**
Date: **1/21/2019**

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Bulk	Shelby Tube	Split Spoon
Rock Core	Macro Core	Modified California Ring Sampler
Grab Sample	No Recovery	Modified Dames & Moore Ring Sampler

WATER LEVEL

- Water Initially Encountered
- Water Level After a Specified Period of Time
- Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
N	N value
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, psf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 500	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	500 to 1,000	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	1,000 to 2,000	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	2,000 to 4,000	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	4,000 to 8,000	15 - 30	19 - 42
			Hard	> 8,000	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Terracon

UNIFIED SOIL CLASSIFICATION SYSTEM

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]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]	GW	Well-graded gravel [F]
			$Cu < 4$ and/or [Cc<1 or Cc>3.0] [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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]	SW	Well-graded sand [I]
			$Cu < 6$ and/or [Cc<1 or Cc>3.0] [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” line [J]	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 ≥ 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 ≥ 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 ≥ 30% plus No. 200 predominantly sand, add “sandy” to group name.

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

[N] PI ≥ 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.