Geotechnical Engineering Study
Proposed Shunk Property Residential Development

11800 South 4000 West
Riverton, Utah
(40.5364° N. 111.9873° W.)

PREPARED FOR:

Urban Land Group
1084-9 Willow Wind Drive
Farmington, Utah 84025

PREPARED BY:

CMT Engineering Laboratories

CMT Project No. 9460

March 21, 2017

OK

CMT ENGINEERING LABORATORIES

March 21, 2017

Urban Land Group
Attention: Mr. Ron Martinez
1084-9 Willow Wind Drive
Farmington, Utah 84025

Subject: Geotechnical Engineering Study
Proposed Shunk Property Residential Development
CMT Project No. 9460

Mr. Martinez:

Submitted herewith is the report of our geotechnical engineering study for the subject site. This report contains the results of our findings and an engineering interpretation of the results with respect to the available project characteristics. It also contains recommendations to aid in the design and construction of the earth related phases of this project.

On February 28, 2017, a CMT Engineering Laboratories (CMT) engineer was on-site and supervised the excavation of six test pits extending to depths of approximately 13 feet below the existing grade. Soil samples were obtained during the field operations and subsequently transported to our laboratory for further testing.

Based on the findings of the subsurface exploration, the upper 3.0 to 6.0 feet of natural clay soils at the test pit locations exhibit moderate to low strength and moderate to moderately high compressibility characteristics for foundations bearing on them. The depth of these soils is anticipated to vary across the site both laterally and with depth. A detailed discussion of our findings and design and construction criteria is presented in this report.

We appreciate the opportunity to work with you on this project. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (801) 870-6730.

Sincerely,
CMT Engineering Laboratories

LICENSED PROFESSIONAL ENGINEER #276476 BRYAN N ROBERTS STATE OF UTAH

Bryan N. Roberts, P.E.
State of Utah No. 276476
Senior Geotechnical Engineer

Reviewed by:

Andrew M. Harris
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Senior Geotechnical Engineer

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1.0 INTRODUCTION

1.1 General

CMT Engineering Laboratories (CMT) was retained by Urban Land Group to conduct a geotechnical subsurface study for the planned residential subdivision development located at about 11800 South 4000 West in Riverton, Utah. (See **Figures 1 and 2** in the Appendix).

The purpose of this study was to provide an assessment of the subsurface soil conditions at the site and provide recommendations for design and construction of the proposed residences. Our scope of work included supervising the excavation of six test pits at the site, collecting samples of the subsurface soils from the test pits, performing laboratory tests, evaluating field and laboratory test data, and preparing this report which summarizes our findings.

1.2 Objectives and Scope

The objectives and scope of our study were planned in discussions between Mr. Ron Martinez of Urban Land Group and Mr. Andrew Harris of CMT Engineering Laboratories (CMT).

In general, the objectives of this study were to:

1. Define and evaluate the subsurface soil and groundwater conditions across the site.
2. Provide appropriate foundation, earthwork, and pavement recommendations and geoseismic information to be utilized in the design and construction of the proposed development.

In accomplishing these objectives, our scope has included the following:

1. A field program consisting of the excavating, logging, and sampling of 6 test pits.
2. A laboratory testing program.
3. An office program consisting of the correlation of available data, engineering analyses, and the preparation of this summary report.

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1.3 Authorization

Authorization was provided by returning a signed copy of our Proposal dated February 21, 2017.

2.0 EXECUTIVE SUMMARY

Our analysis indicates that the proposed structures may be supported upon conventional spread and continuous wall foundations established upon suitable natural soils and/or structural fill extending to suitable natural soils.

The most significant geotechnical aspects of the site are

1 The poorly consolidated, fine grained soils encountered within about the upper 3.0 to 6.0 feet at the test pit locations.
2 The upper about 12 inches is comprised of topsoil as well as loose/disturbed soils/non-engineered fills from past agricultural activities and weathering.

At the test pit locations, the upper approximately 3.0 to 6.0 feet of natural clay/silt soils contained trace pinholes, varied from poorly to moderately consolidated, and based on consolidation testing some of the soils tested are moderately-highly compressible when saturated and/or exhibited low pre-consolidation pressure (translating to low strength, high compressibility and relatively poor to moderate engineering characteristics in their present state). Some variation both laterally and with depth of the above described fine grained surficial soils must be anticipated. Incorporating basement/sublevels may be prudent to get below the relatively low strength surficial soils.

Below about 6.0 feet from the surface, the natural clay soils increase in density, with pinholes grading out, and are likely to exhibit moderate strength and compressibility characteristics. Natural sand and gravel soils were encountered below the surficial clay soils within the test pits at depths of about 6.0 to 9.0 feet below the ground surface and extending to the full depth penetrated, about 13.0 feet. The natural sand and gravel soils will exhibit moderately high strength and low compressibility characteristics under planned loading. Groundwater was not encountered during the excavation period within the maximum depth penetrated, about 13.0 feet.

The upper about 12 inches of topsoil/disturbed soils much be removed below buildings and pavements. CMT must verify that all topsoil, disturbed, or unsuitable soils have been removed and or properly prepared and that suitable soils have been encountered prior to placing site grading fills, footings, slabs, and pavements.

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The on-site soils, including any non-engineered fills and excavated poorly consolidated silt and clay soils, may be re-utilized as structural site grading fill if they meet the requirements for such, and can be adequately re-compacted as stated herein. However, it must be noted that from a handling and compaction standpoint, soils containing high amounts of fines (silts and clays) are inherently difficult to properly moisture condition and re-compact and remain stable and are very sensitive to changes in moisture content requiring very close moisture control and relatively thin lifts during placement and compaction. Recompacting of these soils will be very difficult, if not impossible, during wet and cold periods of the year.

In the following sections, detailed discussions pertaining to site description and geoseismic setting, earthwork, foundations, lateral resistance, lateral pressure, floor slabs, and pavements are provided.

3.0 DESCRIPTION OF PROPOSED CONSTRUCTION

A residential subdivision is planned for the approximate 9.9-acre site. Structures are to be of wood-framed construction and founded on concrete spread footings with basements. Projected maximum column and wall loads are on the order of 10 to 25 kips and 1 to 3 kips per lineal foot, respectively.

New residential roadways will be part of the development. It is anticipated that the residential streets will be constructed of asphalt pavement with relatively light projected traffic that includes primarily passenger vehicles, daily delivery trucks, daily school buses, and an occasional semi-tractor/trailer combination.

Site development will require a moderate amount of earthwork in the form of site grading. We estimate in general that maximum cuts and fills to achieve design grades will be on the order of 2 to 3 feet. Larger cuts and fills may be required in isolated areas.

4.0 FIELD EXPLORATION AND SITE CONDITIONS

4.1 Field Exploration

The subsurface soil conditions were explored by excavating six test pits across the site at the approximate locations shown on **Figure 2** in the Appendix. The test pits extended to depths of approximately 13.0 feet below the existing ground surface. During the course of the excavating operations, a continuous log of the subsurface conditions encountered was maintained. In addition, samples of the typical soils encountered were obtained for subsequent laboratory

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testing and examination. Representative soil samples were placed in sealed plastic bags and containers prior to transport to the laboratory. The soils were classified in the field based upon visual and textural examination. These classifications have been supplemented by subsequent inspection and testing in our laboratory. Detailed graphical representation of the subsurface conditions encountered is presented on Figures 3 through 8, Test Pit Log. In addition, a Key to Symbols defining the terms and symbols used on the logs, is provided as **Figure 9** in the Appendix.

Following completion of excavating and logging, each test pit was backfilled. Although an effort was made to compact the backfill with the excavator bucket, the backfill was not placed in uniform lifts and compacted to a specific density and therefore must be considered as non-engineered backfill. Settlement of the backfill with time is likely to occur.

4.2 General Geology

The subject site is located in the south-west portion of the Salt Lake Valley in north-central Utah. The site sits at an elevation of approximately 4,656 feet above sea level. The Salt Lake Valley is a deep, sediment-filled basin that is part of the Basin and Range Physiographic Province. The valley was formed by extensional tectonic processes during the Tertiary and Quaternary geologic time periods. The valley is bordered by the Wasatch Mountain Range on the east and the Oquirrh Mountains on the west. The Salt Lake Valley is located within the Intermountain Seismic Belt, a zone of ongoing tectonism and seismic activity extending from southwestern Montana to southwestern Utah. The active (evidence of movement in the last 10,000 years) Wasatch Fault Zone is part of the Intermountain Seismic Belt and extends from southeastern Idaho to central Utah along the western base of the Wasatch Mountain Range.

Much of northwestern Utah, including the Salt Lake Valley, was also previously covered by the Pleistocene age Lake Bonneville. The Great Salt Lake, located to the northwest of the valley, is a remnant of this ancient fresh water lake. Lake Bonneville reached a high-stand elevation of approximately 5,092 feet above sea level at between 18,500 and 17,400 years ago. Approximately 17,400 years ago, the lake breached its basin in southeastern Idaho and dropped relatively fast, by almost 300 feet, as water drained into the Snake River. Following this catastrophic release, the lake level continued to drop slowly over time, primarily driven by drier climatic conditions, until reaching the current level of the Great Salt Lake. Shoreline terraces formed at the high-stand elevation of the lake and several subsequent lower lake levels are visible in places on the mountain slopes surrounding the valley. Much of the sediment within the Salt Lake Valley was deposited as lacustrine sediments during both the transgressive (rise) and regressive (fall) phases of Lake Bonneville.

The geology of the USGS Midvale, Utah 7.5 Minute Quadrangle, that includes the location of the subject site, has been mapped by Davis[1]. The surficial geology at the location of the subject site and adjacent properties is mapped as "Fine-grained lacustrine deposits of the Bonneville lake cycle" (Map Unit Qlf) dated to be late Pleistocene. Unit Qlf is described in the mapping as "Transgressive and regressive, deep-water sediments; brown, dark-brown, grayish-brown, and gray calcareous, laminated silt, clayey silt, and sandy silt; commonly contains isolated pebbles, cobbles, and thin lenses of sand and gravel that were deposited by ice-rafting (dropstones) and turbidity flows." No fill has been mapped at the location of the site on the geologic map.

No surface fault traces are shown on the referenced geologic map crossing or projecting toward the subject site. No landslide deposits or features, including lateral spread deposits, are mapped on or adjacent to the site. The site is not located within a known or mapped potential stream flooding, debris flow, or rockfall hazard area.

4.2 Site Surface Conditions

The site consists of a rectangular shaped parcel of undeveloped land, that has been utilized for agricultural purposes. Based upon aerial photos dating back to 1993 that are readily available on the internet, the site appears to have been open and vacant since at least that time. The upper about 12 inches is loose/disturbed from past disking and contains major roots/topsoil. The site is bordered to the north by 11800 South, the east by 4000 West, and by similar open farmed land to the south and west. The site is relatively flat and about 2 to 3 feet lower than surrounding roads.

4.3 Subsurface Soils

The subsurface soil conditions encountered within the test pits completed across the site were relatively similar. The observed subsurface soils were predominately natural clay and silt soils extending from the surface to depths of about 6.0 to 8.5 feet below the surface. The upper about 12 inches were disturbed/highly weathered and contained major roots/topsoil. Below the surficial clay soils, natural sand and gravel with varying silt content was encountered extending to the full depth penetrated, about 13.0 feet.

In general, the natural clays were moist, medium stiff to stiff, light to dark brown in color. The upper 3.0 to 6.0 feet of natural clays contained trace pinholes, were generally poorly consolidated, and were relatively light weight. These soils generally exhibit low pre-consolidation pressure, low strength, and moderate to moderately highly compressibility

[1]Davis, F.D., 2000, Geologic Map of the Midvale Quadrangle, Salt Lake County, Utah; Utah Geological Survey Map 177, Scale 1:24,000.

characteristics. Below about 6.0 feet from the surface, the natural clay soils increase in density, with pinholes grading out, and are likely to exhibit moderate strength and compressibility characteristics

The natural sand and gravel soils encountered were generally medium dense, moist, light brown to brown, and will exhibit moderately high strength and low compressibility characteristics.

For a more detailed description of the subsurface soil conditions, please refer to Figures 3 through 8, Test Pit Logs. The lines designating the interface between soil types on the test pit logs generally represent approximate boundaries. In-situ, the transition between soil types may be gradual.

4.4 Groundwater

Groundwater was not encountered within the depths penetrated, about 13.0 feet, at the time of the field work. Groundwater levels can fluctuate as much as 1.5 to 2.0 feet seasonally. Numerous other factors such as heavy precipitation, irrigation of neighboring land, and other unforeseen factors, may also influence ground water elevations at the site. The detailed evaluation of these and other factors, which may be responsible for ground water fluctuations, is beyond the scope of this study.

4.5 Site Subsurface Variations

Based on the results of the subsurface explorations and our experience, variations in the continuity and nature of subsurface conditions should be anticipated. Due to the heterogeneous characteristics of natural soils, care should be taken in interpolating or extrapolating subsurface conditions beyond the exploratory locations. Seasonal fluctuations in ground water conditions may also occur.

In addition, once the subsurface explorations were completed the test pits were backfilled with the excavated soils but little effort was made to compact these soils. Settlement of the backfill in the test pits over time should be anticipated and caution should be exercised when constructing over these locations.

4.6 Seismic Setting

4.6.1 General

Utah municipalities have adopted the International Building Code (IBC) 2015. The IBC 2015 code determines the seismic hazard for a site based upon 2008 mapping of bedrock accelerations prepared by the United States Geologic Survey (USGS) and the soil site class. The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points).

4.6.2 Faulting

Based upon our review of available literature, no active faults are known to pass through the site. The nearest mapped active fault trace is the Salt Lake City section of the Wasatch Fault located about 8 miles to the east.

4.6.3 Soil Class

For dynamic structural analysis, the Site Class D – Stiff Soil Profile as defined in Chapter 20 of ASCE 7 (per Section 1613.3.2, Site Class Definitions, of IBC 2015) can be utilized based on subsurface soil conditions encountered within the depths penetrated.

4.6.4 Ground Motions

The 2008 USGS mapping provides values of short and long period accelerations for the Site Class B boundary for the Maximum Considered Earthquake (MCE). This Site Class B boundary represents average bedrock values for the Western United States and must be corrected for local soil conditions. The following table summarizes the peak ground and short and long period accelerations for the MCE event and incorporates the appropriate soil amplification factor for a Site Class D soil profile. Based on the site latitude and longitude (40.5364 degrees north and -111.9873 degrees west, respectively), the values for this site are tabulated on the following page.

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Spectral Acceleration Value, T	Site Class B Boundary [mapped values] (% g)	Site Coefficient	Site Class D [adjusted for site class effects] (% g)	Design Values (% g)
Peak Ground Acceleration	45.3	$F_a = 1.047$	47.5	31.7
0.2 Seconds (Short Period Acceleration)	$S_S = 113.3$	$F_a = 1.047$	$S_{MS} = 118.6$	$S_{DS} = 79.1$
1.0 Second (Long Period Acceleration)	$S_1 = 37.6$	$F_v = 1.648$	$S_{M1} = 62$	$S_{D1} = 41.3$

4.6.5 Liquefaction

The site is located in an area that has been identified by Salt Lake County as having a "very low" liquefaction potential. Liquefaction is defined as the condition when saturated, loose, granular soils lose their support capabilities because of excessive pore water pressure, which develops during a seismic event. Clayey soils, even if saturated, will generally not liquefy during a major seismic event.

Liquefaction of the site soils within the depths penetrated, 13.0 feet, is not anticipated during the design seismic event due to the lack of free water or saturated soil conditions, and the medium dense to dense nature of the granular soils observed at the site; however the liquefaction susceptibility of the underlying soils (deeper than our explorations) is unknown and would require further investigation to quantify.

5.0 LABORATORY TESTING

5.1 Laboratory Examination

In order to provide data necessary for our engineering analyses, a laboratory testing program was completed. The program included moisture, density, partial and full gradation, Atterberg limits, collapse-consolidation and California Bearing Ratio (CBR) tests. The following paragraphs describe the tests and summarize the test data.

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5.1.1 Moisture and Density Tests

To aid in classifying the soils and to help correlate other test data, moisture and density tests were performed on selected samples. The results of these tests are presented on the test pit logs, Figures 3 through 8.

5.1.2 Moisture and Density Tests

Full and partial gradation tests were performed to aid in classifying soils. The tests results are tabulated below.

Test Pit No.	Depth (Feet)	Percent Passing Sieve									Soil Classification
		1"	3/4"	1/2"	3/8"	No. 4	No. 10	No. 40	No. 100	No. 200	
TP-1	11	77	62	43	35	22	17	14	9	5.9	GP-GM
TP-2	10	100	100	99	98	97	96	92	83	71.4	CL*
TP-3	9	65	61	57	55	50	47	42	38	30.8	SM-GM
TP-4	8	100	100	100	100	98	97	95	88	74.7	CL*
TP-5	12	53	45	32	23	13	9	6	3	2.3	GP
TP-6	10	73	54	44	38	28	22	16	11	8.3	GP-GM

* 4- to 8- inch clay layer within general sand and gravel soil sequence.

5.1.1 Atterberg Limit Tests

To aid in classifying the soils, an Atterberg limit test was performed on a sample of the fine-grained cohesive soils. Results of the test are tabulated below:

Test Pit No.	Depth (feet)	Liquid Limit (percent)	Plastic Limit (percent)	Plasticity Index (percent)	Soil Classification
TP-2	4	46	25	21	CL
TP-3	5	40	23	17	CL
TP-5	1	33	21	12	CL
TP-6	2.5	38	21	17	CL

5.1.2 Collapse-Consolidation Tests

To provide data necessary for our settlement analyses, a collapse-consolidation test was performed on each of 3 representative samples of the near-surface clay soils encountered in the exploration test pits.

The collapse portion of the test was performed in accordance with the following procedure:

1. Load sample at in-situ moisture content to specific axial pressure.
2. Measure and record axial deflection.
3. Saturate sample.
4. Measure and record resulting collapse.

The test results are tabulated below:

Test Pit No	Depth (feet)	Soil Classification	Natural Dry Density (pcf)	Natural Moisture Content (percent)	Axial Load When Saturated (psf)	Collapse (-) (percent)
TP-2	4.0	CL	77	25.1	250	0.37
TP-3	5.0	CL	80	18.8	250	0.1
TP-6	2.5	CL	84	24.3	250	0.0

Following the collapse portion of the testing the samples were normally loaded throughout th testing procedure. The results of the tests indicate that although there was minor to no collapse under the load tested, the natural fine grained soils within the upper about 3.0 to 6.0 feet, exhibit high compressibility characteristics and low to moderate pre-consolidation pressure. In general, the deeper clay soils, exhibit moderate strength and compressibility characteristic.

Detailed results of these tests are maintained within our files and can be transmitted to you, upon your request.

5.1.1 Compaction Test

A compaction (standard Proctor) test was performed in accordance with the (ASTM[2] D-698) specifications. The test was performed in order to determine maximum dry density and optimum moisture content of a representative sample of the near-surface silty clay with trace gravel obtained from Test Pit TP-3. The data was then used in preparation of the California Bearing Ratio (CBR) test sample. This soil type will be the primary subgrade soil within pavement areas. The results of the compaction test are presented below:

Test Pit No.	Depth (feet)	Soil Classification	Optimum Moisture Content (percent)	Maximum Dry Density (pcf)
TP-3	1-1.5	CL	14.1	116.7

5.1.1 California Bearing Ratio (CBR) Test

To determine subgrade characteristics and to provide data for design of the proposed pavements, a California Bearing Ratio (CBR) test was performed on the representative sample of silty clay with trace gravel obtained from near surface at Test Pit TP-3. The test was performed in accordance with the Utah Department of Transportation Procedure 8-9-22 "California Bearing Ratio Soil" as presented in the Utah State Department of Highways Manual of Instruction, Part 8, Materials. The results of the CBR tests are presented below:

Soil Classification	CL		
Before Soaking	Dry Density	112.7	pcf
	Moisture Content	13.5	percent
After Soaking	Surcharge	10	psf
	Swell	3.93	percent
CBR	Surcharge	10	psf
	At 0.1" penetration	5.4	percent
	At 0.2" penetration	5.3	percent

2 American Society for Testing and Materials

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6.0 SITE PREPARATION AND GRADING

6.1 Site Preparation

Initial site preparation will consist of the removal of surface vegetation, topsoil, any other deleterious materials, non-engineered fills if encountered, and loose/disturbed surface soils from beneath an area extending out at least 4 feet from the perimeter of the proposed buildings and 2 feet beyond pavements and exterior flatwork areas. This may require the removal of up to 12 inches due to past agricultural activities, and weathered soils at the site. Deeper removal sequences may be required in isolated areas.

Subsequent to the above operations and prior to the placement of footings, structural site grading fill, or floor slabs, the exposed natural subgrade must be proofrolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. If any loose, soft, or disturbed zones are encountered, they must be completely removed in footing and floor slab areas and replaced with granular structural fill. In pavement areas, unsuitable soils encountered during recompaction and proofrolling must be removed to a maximum depth of 2 feet and replaced with compacted granular structural fill.

Due to the easily disturbed nature of the native clays, stabilization may be required prior to placement of footings, floor slabs, pavements, or structural fills. This will especially be true during periods of precipitation, and within areas of construction traffic.

A representative of CMT must verify that suitable natural soils and/or proper preparation of existing soils have been encountered/met prior to placing site grading fills, footings, slabs, and pavements.

6.2 Temporary Excavations

Temporary construction excavations in cohesive soil, not exceeding 4 feet in depth and above or below the groundwater table, may be constructed with near-vertical sideslopes. Temporary excavations up to 8 feet deep in fine-grained cohesive soils, above or below the water table, may be constructed with sideslopes no steeper than one-half horizontal to one vertical (0.5H:1V). Excavations deeper than 8 feet are not anticipated at the site.

For granular (cohesionless) soils, construction excavations above the water table, not exceeding 4 feet, should be no steeper than one-half horizontal to one vertical (0.5H:1V). For excavations up to 8 feet, in granular soils and above the water table, the slopes should be no steeper than one horizontal to one vertical (1H:1V). Excavations encountering saturated cohesionless soils will be very difficult and will require very flat sideslopes and/or shoring, bracing and dewatering.

To reduce disturbance of the natural soils during excavation, it is recommended that smooth edge buckets/blades be utilized.

All excavations must be inspected periodically by qualified personnel. If any signs of instability or excessive sloughing are noted, immediate remedial action must be initiated. All excavations should be made following OSHA safety guidelines.

6.3 Structural Fill Material

Structural fill is defined as all fill which will ultimately be subjected to structural loadings, such as imposed by footings, floor slabs, pavements, etc. Structural fill will be required as backfill over foundations and utilities, as site grading fill, and possibly as replacement fill below footings. All structural fill must be free of sod, rubbish, topsoil, frozen soil, and other deleterious materials.

Structural site grading fill is defined as structural fill placed over relatively large open areas to raise the overall grade. For structural site grading fill, the maximum particle size shall not exceed 4 inches; although, occasional larger particles, not exceeding 8 inches in diameter, may be incorporated if placed randomly in a manner such that "honeycombing" does not occur and the desired degree of compaction can be achieved. The maximum particle size within structural fill placed within confined areas shall be restricted to 2 inches.

On-site soils, may be re-utilized as structural site grading fill if they meet the requirements of such. However, re utilization of the native fine grained silt/clay soils as structural site grading fill will require significant care and preparation to assure appropriate moisture levels during placement and compaction. This may be extremely difficult especially during periods of precipitation or during colder periods of the year. Further, thin loose lifts will likely be required to obtain adequate compaction.

We recommend imported granular structural fill consist of a fairly well graded mixture of sand and gravel with between 15 to 30 percent fines (clays and silts) to reduce permeability and no more than 30 percent retained on the 0.75-inch sieve.

To stabilize soft subgrade conditions (if encountered) or where structural fill is required to be placed closer than 1.0 foot above the water table at the time of construction, a mixture of coarse angular gravels and cobbles and/or 1.5- to 2.0-inch gravel (stabilizing fill) should be utilized. It may also help to utilize a stabilization fabric, such as Mirafi 600X or equivalent, placed on the native ground if 1.5- to 2.0-inch gravel is used as stabilizing fill.

Non-structural site grading fill is defined as all fill material not designated as structural fill and may consist of any cohesive or granular soils not containing excessive amounts of degradable material.

6.4 Utility Trenches

All utility trench backfill material below structurally loaded facilities (flatwork, floor slabs, roads, etc.) shall be placed at the same density requirements established for structural fill. If the surface of the backfill becomes disturbed during the course of construction, the backfill shall be proofrolled and/or properly compacted prior to the construction of any exterior flatwork over a backfilled trench. Proofrolling shall be performed by passing moderately loaded rubber tire-mounted construction equipment uniformly over the surface at least twice. If excessively loose or soft areas are encountered during proofrolling, they shall be removed to a maximum depth of 2 feet below design finish grade and replaced with structural fill.

Most utility companies and City-County governments are now requiring that Type A-1a or A-1b (AASHTO Designation – basically granular soils with limited fines) soils be used as backfill over utilities within public right away. These organizations are also requiring that in public roadways the backfill over major utilities be compacted over the full depth of fill to at least 96 percent of the maximum dry density as determined by the AASHTO T-180 (ASTM D-1557) method of compaction.

In private areas, natural soils may be re-utilized as trench backfill over the bedding layer provided that they are properly moisture prepared and compacted to the minimum requirements stated in section 6.5 Fill Placement and Compaction below.

6.5 Fill Placement and Compaction

The various types of compaction equipment available have their limitations as to the maximum lift thickness that can be compacted. For example, hand operated equipment is limited to lifts of about 4 inches and most "trench compactors" have a maximum, consistent compaction depth of about 6 inches. Large rollers, depending on soil and moisture conditions can achieve compaction at 8 to 12 inches. The full thickness of each lift should be compacted

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to at least the following percentages of the maximum dry as determined by the ASTM[3] D-1557(AASHTO[4] T-180) compaction criteria in accordance with the table below:

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Beneath an area extending at least 4 feet beyond the perimeter of the structure and 2 feet beyond pavements	0 to 8	95
Site grading fills outside area defined above	0 to 5	90
Site grading fills outside area defined above	5 to 8	95
Utility trenches within structural areas	--	96
Roadbase/Subbase	-	96

Structural fills greater than 8 feet thick are not anticipated at the site. We recommend for best compaction results that the moisture content for structural fill/backfill be within 2 percent of optimum.

Subsequent to stripping and prior to the placement of structural site grading fill, the subgrade shall be prepared as discussed in Section 6.1, Site Preparation, of this report. In confined areas, subgrade preparation should consist of the removal of all loose or disturbed soils.

The natural clay soils could be susceptible to rutting and pumping particularly during wet periods of the year. To stabilize soft soil conditions, coarse angular gravel and cobble mixtures (stabilizing fill) may be utilize and shall be end-dumped, spread to a maximum loose lift thickness of 15 inches, and compacted by dropping a backhoe bucket onto the surface continuously at least twice. As an alternative, the stabilizing fill may be compacted by passing moderately heavy construction equipment or large self-propelled compaction equipment at least twice. Subsequent fill material placed over the coarse gravels and cobbles shall be adequately compacted so that the "fines" are "worked into" the voids in the underlying coarser gravels and cobbles. Utilization of a filter fabric, such as Mirafi 600X or equivalent, over soft subgrade may also be advantageous.

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3 American Society for Testing and Materials
4 American Association of State Highway and Transportation Officials

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Non-structural fill may be placed in lifts not exceeding 12 inches in loose thickness and compacted by passing construction, spreading, or hauling equipment over the surface at least twice.

Field density tests should be performed on each lift as necessary to verify that compaction is being achieved.

7.0 LATERAL EARTH PRESSURES

Buildings may or may not include full depth sublevels. For subgrade levels and retaining walls up to approximately 8 feet, the following discussion is provided. The lateral pressure parameters, as presented within this section, are for backfills which will consist of drained on-site soil, placed and compacted in accordance with the recommendations presented herein.

The lateral pressures imposed upon subgrade facilities will, therefore, be basically dependent upon the relative rigidity and movement of the backfilled structure. For active walls, such as retaining walls which can move outward (away from the backfill), backfill may be considered equivalent to a fluid with a density of 45 pounds per cubic foot in computing lateral pressures. For more rigid walls (moderately yielding), backfill may be considered equivalent to a fluid with a density of 55 pounds per cubic foot. For very rigid non-yielding walls, granular backfill should be considered equivalent to a fluid with a density of at least 65 pounds per cubic foot. The above values assume that the surface of the soils slope behind the wall is horizontal and that the fill within 3 feet of the wall will be compacted with hand-operated compacting equipment.

For seismic loading of retaining/below-grade walls, the following uniform lateral pressures, in pounds per square foot (psf), should be added based on wall depth and wall case.

Uniform Lateral Pressures			
Wall Height (Feet)	**Active Pressure Case (psf)**	**Moderately Yielding Case (psf)**	**At Rest/Non-Yielding Case (psf)**
4	26	53	79
6	39	79	119
8	52	105	159

The given values for design are based on the natural clay soils remaining in place behind walls. If the natural clay soils will be excavated and other soils placed as backfill, we recommend that this office review the materials and determine if the above design earth pressures are still appropriate.

8.0 FOUNDATION RECOMMENDATIONS

The following recommendations have been developed on the basis of the previously described project characteristics, the subsurface conditions observed in the field, the laboratory test data, as well as common engineering practice.

8.1 Foundation Recommendations

The results of our analyses indicate that the proposed structures may be supported upon conventional spread and/or continuous wall foundations established upon suitable natural soils or granular structural fill extending to suitable natural soils. For design, with respect to the proposed construction and anticipated loading given in Section 3.0, Description of Proposed Construction, the following parameters are recommended:

Minimum Recommended Depth of Embedment for Frost Protection	- 30 inches
Minimum Recommended Depth of Embedment for Non-frost Conditions	- 15 inches
Recommended Minimum Width for Continuous Wall Footings	- 18 inches
Minimum Recommended Width for Isolated Spread Footings	- 24 inches
Recommended Net Bearing Pressure for Real Load Conditions on suitable Natural Clay Soil	- 1,200 pounds per square foot
Recommended Net Bearing Pressure for Real Load Conditions and Footings Established on: Natural Sand and Gravel Soils or a Minimum 1.5 feet of Granular Structural Replacement Fill Extending to Suitable Natural Soils	- 2,000 pounds per square foot

Bearing Pressure Increase for Seismic Loading	- 30 percent

The term "net bearing pressure" refers to the pressure imposed by the portion of the structure located above lowest adjacent final grade. Therefore, the weight of the footing and backfill to lowest adjacent final grade need not be considered. Real loads are defined as the total of all dead plus frequently applied live loads. Total load includes all dead and live loads, including seismic and wind.

8.2 Installation

Under no circumstances shall the footings be established upon non-engineered fills, loose or disturbed soils, topsoil, sod, rubbish, potentially collapsible soils, construction debris, other deleterious materials, frozen soils, or within ponded water. If unsuitable soils are encountered, they must be completely removed and replaced with compacted structural fill.

The width of structural replacement fill below footings should be equal to the width of the footing plus one foot for each foot of fill thickness. For instance, if the footing width is 2 feet and the structural fill depth beneath the footing is 1.5 feet, the fill replacement width should be 3.5 feet, centered beneath the footing.

8.3 Estimated Settlement

Foundations designed and constructed in accordance with our recommendations could experience some settlement, but we anticipate that settlement of footings founded as recommended above will be 1 inch or less. We expect approximately 50 percent of initial settlement to take place during construction.

8.4 Lateral Resistance

Lateral loads imposed upon foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footings and the supporting soils. In determining frictional resistance, a coefficient of 0.30 should be utilized for natural soils and 0.40 for granular structural fills. Passive resistance provided by properly placed and compacted granular structural fill above the water table may be considered equivalent to a fluid with a density of 300 pounds per cubic foot.

A combination of passive earth resistance and friction may be utilized provided that the friction component of the total is divided by 1.5.

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9.0 FLOOR SLABS

Floor slabs may be established upon suitable natural soils and/or upon structural fill extending to suitable natural soils. Under no circumstances shall floor slabs be established over non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water.

In order to facilitate curing of the concrete, it is recommended that floor slabs be directly underlain by at least 4 inches of "free-draining" fill, such as "pea" gravel or three-quarters to one-inch minus clean gap-graded gravel.

10.0 DRAINAGE RECOMMENDATIONS

It is important to the longterm performance of foundations and floor slabs that water not be allowed to collect near the foundation walls and infiltrate into the underlying soils. We recommend the following:

1. All areas around structures should be sloped to provide drainage away from the foundations. Where possible we recommend a minimum slope of 6 inches in the first 10 feet away from the structure.

2. All roof drainage should be collected in rain gutters with downspouts designed to discharge at least 10 feet from the foundation walls or well beyond the backfill limits, whichever is greater.

3. Adequate compaction of the foundation backfill should be provided. We suggest a minimum of 90% of the maximum laboratory density as determined by ASTM D-1557. Water consolidation methods should not be used under any circumstances.

4. Sprinklers should be aimed away and kept at least 4 feet from the foundation walls. The sprinkling systems should be designed with proper drainage and be well-maintained. Over watering should be avoided.

5. Other precautions may become evident during construction.

11.0 PAVEMENTS

The natural clay soils are anticipated to exhibit poor pavement support when saturated. We anticipate light traffic volumes and that vehicle types will be typical for residential construction,

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except during the build out phase when heavy trucks will be much more frequent. Our pavement design is based upon an estimated California Bearing Ratio (CBR) of 5 for the natural clay soils and a daily equivalent single axle load (ESAL) of 7.0.

Table 1: Pavement Design

Material	Pavement Section Thickness (in)
Asphalt	3
Road-Base	6
Subbase	5
Total Thickness	14
OR	
Asphalt	3
Road-Base	10
Subbase	---
Total Thickness	13

*Subgrade should be proof-rolled

Prior to placing subbase, the subgrade must be properly prepared as outlined in Section 6.0 Site Preparation and Grading of this report. Subbase shall consist of a granular soil meeting a minimum CBR or 30 percent. Roadbase/Untreated base course (UTBC) should conform to city or 1"-minus UDOT specifications and have a CBR value greater than 70 percent. Asphalt should conform to the standard city or UDOT specification.

The asphalt pavement should be compacted to 96% of the maximum density for the asphalt material. Roadbase and subbase material shall be compacted as outlined in section 6.5 Fill Placement and Compaction of this report.

12.0 QUALITY CONTROL

Our recommendations in this report are based on the assumption that adequate quality control testing and observations will be conducted by CMT during construction to verify compliance. This may include but not necessarily be limited to the following:

12.1 Field Observations

Observations should be completed during all phases of construction such as site preparation, foundation excavation, structural fill placement and concrete placement.

12.2 Fill Compaction

Compaction testing by CMT is required for all structural supporting fill materials. Maximum Dry Density (Proctor-ASTM 1557) tests should be requested by the contractor immediately after delivery of any granular fill materials. The maximum density information should then be used for field density tests on each lift as necessary to insure that the required compaction is being achieved.

12.3 Quality Control

All excavation procedures and processes should be observed by a geotechnical engineer from CMT. In addition, all backfill and structural fill placed in trenches and all pavements should be density tested by CMT.

13.0 LIMITATIONS

The recommendations provided herein were developed by evaluating the information obtained from the test pit and site exploration. The test pit data reflects the subsurface conditions only at the specific locations at the particular time designated on the test pit logs. Soil and ground water conditions may differ from conditions encountered at the actual exploration locations. The nature and extent of any variation in the explorations may not become evident until during the course of construction. If variations do appear, it may become necessary to re-evaluate the recommendations of this report after we have observed the variation.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

We appreciate the opportunity to be of service to you on this project. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (801) 870-6730. To schedule materials testing, please call (801) 381-5141.

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Appendix

Shunk Property

4000 W 11800 S, Riverton, Utah

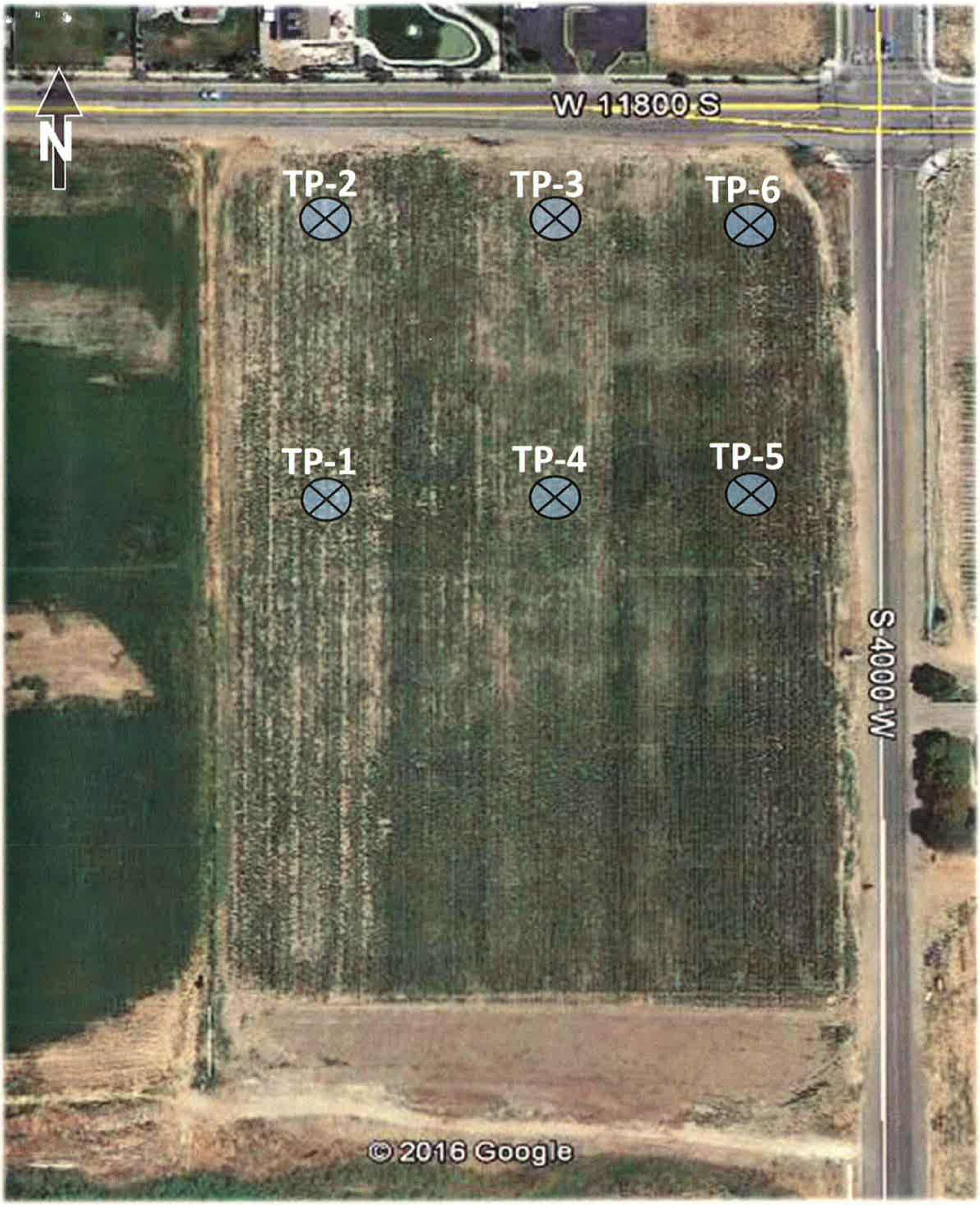
CMT ENGINEERING LABORATORIES

Site Map

Date: 28-Feb-17

Job # 9460

Figure: 1



Shunk Property

4000 W 11800 S, Riverton, Utah

CMT ENGINEERING LABORATORIES

Site Map

Date: 28-Feb-17
Job # 9460

Figure: 2

Shunk Property

4000 W 11800 S Riverton, Utah

Test Pit Log

TP-1

Type: Rubber Tire Back hoe
Surface Elev. (approx):

Total Depth: 13.0
Water Level:

Date: 2/28/2017
Job #: 9460

Depth (ft.)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Gradation: Gravel %	Gradation: Sand %	Gradation: Fines %	Atterberg: LL	Atterberg: PL	Atterberg: PI	Dry Density
0		TOPSOIL: dark brown CLAY (CL) trace sand. Recently tilled. moist and soft										
		Dark brown CLAY (CL) trace sand and gravel, some pinholes.										
2												
		moist and stiff		1	23							86
4												
6		Tan/light brown Clayey SAND (SC) w/ gravel moist and medium dense										
		Light brown GRAVEL and SAND (GM-SM) w/ oxidized clayey silt layers (4-8") one every 1-3'. moist and medium dense		2								
8												
10		Light brown Sandy GRAVEL (GP-GM), some silt										
		moist and medium dense		3	5	78	16	6				
12												
		End at 13.0'										
14												

Remarks: Groundwater wasn't encountered in the excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Todd Nelson
Logged By: Nate Pack

Figure: 3

Shunk Property

4000 W 11800 S Riverton, Utah

Test Pit Log

TP-2

Type: Rubber Tire Back hoe
Surface Elev. (approx):

Total Depth: 13.0
Water Level:

Date: 2/28/2017
Job #: 9460

Depth (ft.)	Soil Description	Sample Type	Sample #	Moisture (%)	Gradation: Gravel %	Gradation: Sand %	Gradation: Fines %	Atterberg: LL	Atterberg: PL	Atterberg: PI	Dry Density
0	TOPSOIL: dark brown CLAY (CL) trace sand. Recently tilled. moist and soft										
	Dark brown CLAY (CL) trace sand and gravel.										
4	-grades brown in color, silty w/ calcium, some pinholes. moist and stiff		4	25				46	25	21	77
	Light brown/tan CLAY and SILT (CL-ML), some pinholes.										
6	moist and stiff		5								
	Light brown GRAVEL and SAND (GM-SM) w/ oxidized clayey silt layers (4-8") one every 1-3'.										
10	-tested sample of clayey silt layer moist and medium dense		6	18	3	26	71				
13	End at 13.0'										

Remarks: Groundwater wasn't encountered in the excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Todd Nelson
Logged By: Nate Pack

Figure: 4

Shunk Property

4000 W 11800 S Riverton, Utah

Test Pit Log

TP-3

Type: Rubber Tire Back hoe
Surface Elev. (approx):

Total Depth: 13.0
Water Level:

Date: 2/28/2017
Job #: 9460

Depth (ft.)	Soil Description	Sample Type	Sample #	Moisture (%)	Gradation: Gravel %	Gradation: Sand %	Gradation: Fines %	Atterberg: LL	Atterberg: PL	Atterberg: PI	Dry Density
0	TOPSOIL: dark brown CLAY (CL) trace sand. Recently tilled. moist and soft										
	Dark brown CLAY (CL) trace gravel, calcium and pinholes. moist and stiff		7								
	-grades brown in color, silty w/ calcium.										
	moist and stiff		8	19				40	23	17	80
6	Brown/oxidized Silty SAND (SM) w/ gravel.										
	Light brown Silty GRAVEL with sand (GM) and oxidized clayey silt layers (4-8") one every 1-3'. moist and medium dense		9	5	50	19	31				
13	End at 13.0'										

Remarks: Groundwater wasn't encountered in the excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Todd Nelson
Logged By: Nate Pack

Figure: 5

Shunk Property

4000 W 11800 S Riverton, Utah

Test Pit Log

TP-4

Type: Rubber Tire Back hoe
Surface Elev. (approx):
Total Depth: 13.0
Water Level:
Date: 2/28/2017
Job #: 9460

Depth (ft.)	Soil Description	Sample Type	Sample #	Moisture (%)	Gravel %	Sand %	Fines %	LL	PL	PI	Dry Density
0	TOPSOIL: dark brown silty CLAY (CL) trace sand. Recently tilled. moist and soft										
	Dark brown Silty CLAY (CL) trace sand and gravel, some pinholes.										
	moist and stiff		10	18							
4	-thin gravel layer at 4'										
6	Light brown GRAVEL and SAND (GM-SM) w/ oxidized clayey silt layers (4-8") one every 1-3'. moist and medium dense										
8	-tested sample of clayey silt layer		2	19	2	23	75				
13	End at 13.0'										

Remarks: Groundwater wasn't encountered in the excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Todd Nelson
Logged By: Nate Pack

Figure: 6

Shunk Property

4000 W 11800 S Riverton, Utah

Test Pit Log

TP-5

Type: Rubber Tire Back hoe
Surface Elev. (approx):

Total Depth: 13.0
Water Level:

Date: 2/28/2017
Job #: 9460

Depth (ft.)	Soil Description	Sample Type	Sample #	Moisture (%)	Gradation: Gravel %	Gradation: Sand %	Gradation: Fines %	Atterberg: LL	Atterberg: PL	Atterberg: PI	Dry Density
0	TOPSOIL: dark brown silty CLAY (CL) trace sand. Recently tilled. moist and soft										
	Dark brown silty CLAY (CL) trace sand and gravel. moist and stiff		12	22				33	21	12	
2											
	Light brown/gray CLAY and SILT (CL-ML)										
4											
6	moist and stiff		13								
	Light brown GRAVEL and SAND (GM-SM).										
8											
10											
	Light brown GRAVEL (GP), some sand w/ oxidized clayey silt layers (4-8") one every 1-3'.										
12	slightly moist and loose		14	2	87	11	2				
	End at 13.0'										
14											

Remarks: Groundwater wasn't encountered in the excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Todd Nelson
Logged By: Nate Pack

Figure: 7

Shunk Property

4000 W 11800 S Riverton, Utah

Test Pit Log

TP-6

Type: Rubber Tire Back hoe
Surface Elev. (approx):
Total Depth: 13.0
Water Level:
Date: 2/28/2017
Job #: 9460

Depth (ft.)	Soil Description	Sample Type	Sample #	Moisture (%)	Gravel %	Sand %	Fines %	LL	PL	PI	Dry Density
0	TOPSOIL: dark brown silty CLAY (CL) trace sand. Recently tilled.										
	Dark brown silty CLAY (CL) trace sand and gravel, trace pinholes.										
2											
	moist and stiff		15	24				38	21	17	84
	-grades to gray/light brown/orange in color, with sand and silty lenses, no pinholes.										
4											
6	moist and firm/stiff		16	3							
8	Light brown GRAVEL and SAND (GM-SM) w/ oxidized clayey silt layers (4-8") one every 1-3'.										
10	Light brown Sandy GRAVEL (GP-GM), some silt										
	slightly moist, medium dense		17	3	72	20	8				
12											
	End at 13.0'										
14											

Remarks: Groundwater wasn't encountered in the excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Todd Nelson
Logged By: Nate Pack

Figure: 8

KEY TO SYMBOLS

Symbol Description

Strata symbols

- Topsoil
- Low plasticity clay
- Clayey sand/ Low plasticity clay
- Silty sand and gravel
- Poorly graded gravel with silt
- Silty low plasticity clay
- Silty sand
- Silty gravel
- Poorly graded gravel

Soil Samplers

- Block sample

Symbol Description

- Bulk/Grab sample

Notes:

1. The results of laboratory tests on the samples collected are shown on the logs at the respective sample depths.

2. The subsurface conditions represented on the logs are for the locations specified. Caution should be exercised if interpolating between or extrapolating beyond the exploration locations.

3. The information presented on each log is subject to the limitations, conclusions, and recommendations presented in this report.

Figure 9