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PRELIMINARY GEOTECHNICAL ENGINEERING STUDY

Smithfield Development

About 400 North 300 East
Smithfield, Utah

CMT PROJECT NO. 900068

FOR:
Neighborhood Housing Solutions
195 Golf Course Road, Suite 1
Logan, Utah 84321

June 18, 2020

CMT ENGINEERING
LABORATORIES

June 18, 2020

Mr. Jake Williams
Neighborhood Housing Solutions
195 Golf Course Road, Suite 1
Logan, Utah 84321

Subject: Preliminary Geotechnical Engineering Study
Smithfield Development
About 400 North 300 East
Smithfield, Utah
CMT Project No. 900068

Mr. Smith:

Submitted herewith is the report of our preliminary geotechnical engineering study for the subject site. This report contains the results of our preliminary 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 May 22, 2020, a CMT Engineering Laboratories (CMT) field engineer was on-site and supervised the excavation of 10 test pits extending to depths of about 10 to 12 feet below the existing ground surface. Soil samples were obtained during the field operations and subsequently transported to our laboratory for further testing and observation.

Based upon the results of our preliminary study, conventional spread and/or continuous footings may be utilized to support the proposed structures, provided the recommendations in this report are followed. A detailed discussion of design and construction criteria is presented in this report.

We appreciate the opportunity to work with you at this stage of the project. CMT offers a full range of Geotechnical Engineering, Geological, Material Testing, Special Inspection services, and Phase I and II Environmental Site Assessments. With 9 offices throughout Utah, Idaho and Arizona, our staff is capable of efficiently serving your project needs. 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

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1.0 INTRODUCTION

1.1 General

CMT Engineering Laboratories (CMT) was retained to conduct a preliminary geotechnical subsurface study for the Smithfield Development, an approximate 98-acre proposed residential subdivision. The site is located near 400 North 300 East in Smithfield, Utah, as shown in the **Vicinity Map** below. We understand that as the development plans are further defined, CMT will be retained to provide final geotechnical recommendations based on additional subsurface exploration and analyses.

VICINITY MAP

1.2 Objectives, Scope and Authorization

The objectives and scope of our study were planned in discussions among Mr. Jake Williams of Neighborhood Housing Solutions and Ms. Lindsey Bradshaw and Mr. Andrew Harris of CMT Engineering Laboratories (CMT). In general, the objectives of this study were to define and evaluate the subsurface soil and groundwater conditions at the site, and provide appropriate foundation, earthwork, pavement and seismic recommendations to be utilized in the design and construction of the proposed development.

In accomplishing these objectives, our scope of work has included performing field exploration, which consisted of the excavating/logging/sampling of 10 test pits, performing laboratory testing on representative samples of the subsurface soils encountered in the test pits, and conducting an office program, which consisted of correlating available data, performing engineering analyses, and preparing this summary report. This scope of work was authorized by returning a signed copy of our proposal dated March 2, 2020 and executed on March 3, 2020

1.3 Description of Proposed Construction

We understand that the proposed residential development will include single-family residences, townhome, and duplex residences. Structures are likely to be conventional wood frame construction founded on concrete footings, possibly with basements. Maximum continuous wall and column loads for the structures are anticipated to be 1,000 to 4,000 pounds per lineal foot and 15,000 to 75,000 pounds, respectively. If the loading conditions are different than we have projected, please notify us so that any appropriate modifications to our conclusions and recommendations contained herein can be made.

Pavements at the site are projected to include asphalt paved residential streets and parking areas. Traffic is projected to consist of a light volume of automobiles and pickup trucks, one or two daily medium-weight delivery trucks, a weekly garbage truck, and an occasional fire truck.

Site development will require some earthwork in the form of minor cutting and filling. A site grading plan was not available at the time of this report, but we project that maximum cuts and fills may be on the order of 2 to 3 feet. If deeper cuts or fills are planned, CMT should be notified to provide additional recommendations, if needed.

1.4 Executive Summary

Proposed residences can likely be supported upon conventional spread and continuous wall foundations. The most significant geotechnical aspects regarding site development include the following:

1. Sandy/gravelly soils, with roots and organic material (topsoil) on the surface of the site up to 2.5 feet in thickness, which will require removal beneath footing and floor slab areas, and proper preparation below pavement areas;
2. Subsurface natural soils at the site predominately consist of various GRAVELS (GC, GM, GP-GM, GP), with an occasional layer of CLAY (CL);

3. Groundwater was not encountered to the maximum depth explored of approximately 12 feet below the existing site grades. However, historic groundwater seepage and springs have been documented within the eastern portion of the property;
4. Some of the natural CLAY (CL) soils visually contained pinholes and, as confirmed by consolidation/collapse tests, are moisture sensitive (potentially collapsible) with measured collapse of about 5%; and
5. Foundations and floor slabs may be placed on suitable, undisturbed natural gravel soils or on properly placed and compacted structural fill extending to suitable, undisturbed natural soils.

CMT must assess that non-engineered fill, topsoil, potentially collapsible soils, debris, disturbed or unsuitable soils have been removed and that suitable soils have been encountered prior to placing site grading fills, footings, slabs, and pavements.

In the following sections, detailed discussions pertaining to the site and subsurface descriptions, geologic/seismic setting, earthwork, foundations, lateral resistance, lateral pressure, floor slabs, and pavements are provided.

2.0 FIELD EXPLORATION

In order to define and evaluate the subsurface soil and groundwater conditions 10 test pits were excavated with a backhoe at the site to depths of approximately 10 to 12 feet below the existing ground surface. Locations of the test pits are shown on **Figure 1, Site Plan**, included in the Appendix. The field exploration was performed under the supervision of an experienced member of our geotechnical staff.

Representative soil samples were collected by obtaining disturbed "grab" samples of the natural gravel soils and cutting relatively undisturbed "block" samples of the subsurface clay soils (where encountered) from within each test pit. The samples were sealed in plastic bags prior to transport to the laboratory.

The subsurface soils encountered in the test pits were logged and described in general accordance with ASTM[1] D-2488. Soil samples were collected as described above, and were classified in the field based upon visual and textural examination. These field classifications were supplemented by subsequent examination and testing of select samples in our laboratory. Graphical representations of the subsurface conditions encountered are presented on each individual Test Pit Log, **Figures 2 through 11**, included in the Appendix. A Key to Symbols defining the terms and symbols used on the logs, is provided as **Figure 12** in the Appendix.

3.0 LABORATORY TESTING

Selected samples of the subsurface soils were subjected to various laboratory tests to assess pertinent engineering properties, as follows:

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[1] American Society for Testing and Materials

1. Moisture Content, ASTM D-2216, Percent moisture representative of field conditions
2. Dry Density, ASTM D-2937, Dry unit weight representing field conditions
3. Gradation Analysis, ASTM D-1140/C-117, Grain Size Analysis
4. One Dimension Consolidation, ASTM D-2435, Consolidation properties

To provide data necessary for our settlement analyses and assess potential moisture sensitivity, a collapse/consolidation test was performed on a representative sample of the subsurface clay soil encountered in test pit TP-2. Based upon data obtained from the consolidation test, the clay soils at this site are moderately over-consolidated, moderately compressible under additional loading, and have a collapse potential of approximately 5% at a load of 1,000 psf when water was added (see the **Lab Summary Table** below). Detailed results of the consolidation tests are maintained within our files and can be transmitted to you, if so desired.

Laboratory test results are presented on the test pit logs (**Figures 2 through 11**) and in the following Lab Summary table:

LAB SUMMARY TABLE

TEST	DEPTH	SAMPLE	SOIL	MOISTURE	DRY DENSITY	GRADATION			COLLAPSE (-)/
PIT	(feet)	TYPE	CLASS	CONTENT(%	(pcf)	GRAV.	SAND	FINES	EXPANSION(+)
TP-1	6	Block	CL	20		14	29	57	
TP-2	3.5	Block	CL	18	90			87	-5%
	7.5	Block	CL	16		27	8	65	
TP-3	3	Bag	GP-GM	2		77	17	6	
TP-7	5	Bag	GP	1		91	7	2	
TP-8	4	Bag	GM	5		62	25	13	
TP-9	3	Bag	GM	10		46	16	38	
TP-10	4.5	Bag	GM	9		47	10	43	

4.0 GEOLOGIC & SEISMIC CONDITIONS

4.1 Geologic Setting

The subject site is located in the east-central portion of Cache Valley in northern Utah at an elevation between approximately 4,675 and 4,845 feet above sea level. The Cache Valley is a deep, sediment-filled basin that is part of the Middle Rocky Mountain Physiographic Province. The valley is bordered by the Bear River Range on the east and the Wellsville Mountains on the west. The valley is located within the Intermountain Seismic Belt, a zone of ongoing tectonism and seismic activity extending from southwestern Montana to southwestern Utah. The Cache Valley is a fault-block valley (Graben) structurally bound on the east by the west-dipping East Cache Fault Zone and on the west by the east-dipping West Cache Fault Zone. Tectonic displacement along these faults has resulted in the relative down-drop of the valley in relation to the uplift of the bounding mountain ranges (horsts) on the east and west.

Much of northwestern Utah, including the Cache Valley, was also previously covered by the Pleistocene age Lake Bonneville. The Great Salt Lake, located to the southwest of the valley, is a remnant of this ancient fresh water lake. Lake Bonneville reached a high-stand elevation of between approximately 5,160 and 5,200 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 by almost 300 feet relatively fast 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 Cache Valley was deposited as lacustrine sediments during both the transgressive (rise) and regressive (fall) phases of Lake Bonneville. These sediments were deposited over thick sequences of older Quaternary and Tertiary age, pre-Lake Bonneville deposits within the valley.

The geology of the USGS Smithfield, Utah 7.5 Minute Quadrangle, that includes the location of the subject site, has been mapped by Lowe and Galloway[2]. The surficial geology underlying most of the site is mapped as “Deltaic deposits” (Map Unit Qd3) dated as upper Pleistocene. On the northwest margin of the site the geology is mapped as “Lacustrine offshore deposits” (Map Unit Qlf3/Qlf4) dated as upper Pleistocene. On the northwestern portion of the site Unit Qlf3/Qlf4 is overlain by “Alluvial-fan deposits” (Unit Qaf1) dated as Holocene that have been deposited at the mouths of several small ravines on the site. Unit Qd3 is described in the referenced mapping as “Cobbles to fine sand deposited when Lake Bonneville stood at the Provo Shoreline.” Unit Qlf3/Qlf4 is described in the mapping as fine sand, silt, and clay deposited when Lake Bonneville stood at the Bonneville (4) and Provo (3) shorelines.” Unit Qaf1 is described as “Boulders to clay” on the referenced map. Refer to the **Geologic Map**, shown below.

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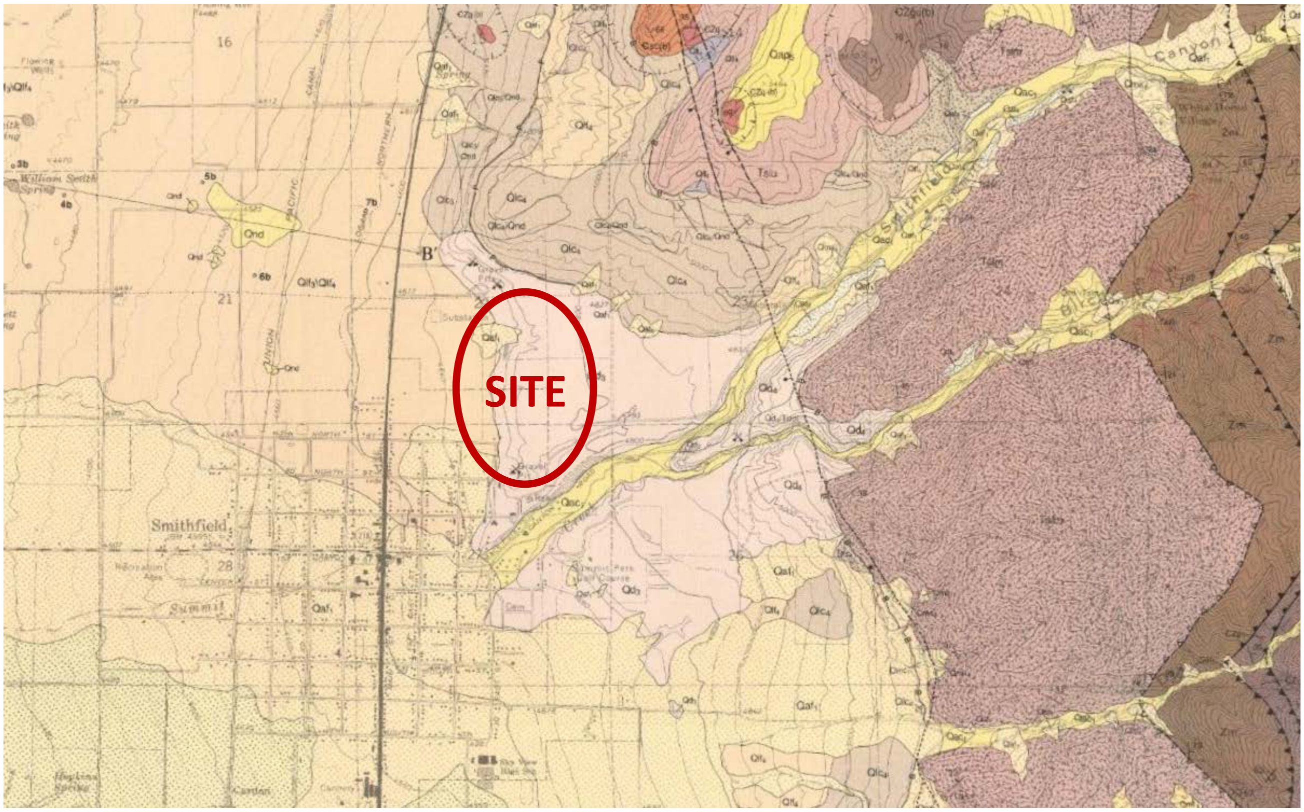
[2] Lowe, M. and Galloway, C.L., 1993, Provisional Geologic Map of the Smithfield Quadrangle, Cache County, Utah; Utah Geological Survey Map 143, Scale 1:24,000.



GEOLOGIC MAP

4.2 Faulting

No surface fault traces are shown on the referenced geologic map crossing, adjacent to, or projecting toward the subject site. The nearest mapped active fault is the Central Segment of the East Cache Fault Zone approximately 5.7 miles to the south-southeast.

4.3 Seismicity

4.3.1 Site Class

Utah has adopted the International Building Code (IBC) 2018, which determines the seismic hazard for a site based upon 2014 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). For site class definitions, IBC 2018 Section 1613.2.2 refers to Chapter 20, Site Classification Procedure for Seismic Design, of ASCE[3] 7-16. Given the subsurface soils encountered at the site in our explorations, which only extended to a maximum depth of about 12 feet, it is our opinion the site best fits Site Class D – Stiff Soil Profile (without data, or default), which we recommend for seismic structural design.

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[3] American Society of Civil Engineers

4.3.2 Seismic Design Category

The 2014 USGS mapping utilized by the IBC provides values of peak ground, short period and long period accelerations for the Site Class B/C boundary and 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 Seismic Design Categories in the International Residential Code (IRC 2018 Table R301.2.2.1.1) are based upon the Site Class as addressed in the previous section. For Site Class D at site grid coordinates of 41.8990 degrees north latitude and -111.8215 degrees west longitude, **S_{DS}** is 0.811 and the **Seismic Design Category** is D_1.

4.3.2 Ground Motions

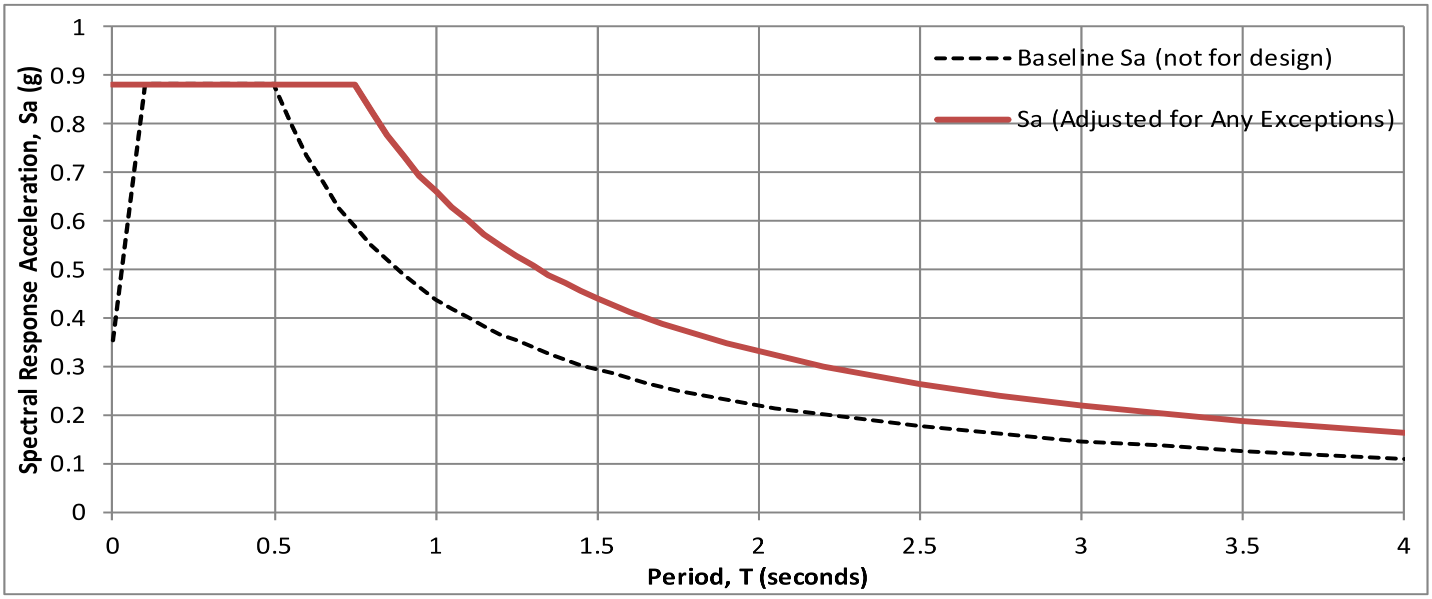
The following table summarizes the peak ground, short period and long period accelerations for the MCE event, and incorporates appropriate soil correction factors and any possible exceptions for a Site Class D soil profile (see response spectrum below):

SPECTRAL ACCELERATION VALUE, T	SITE CLASS B/C BOUNDARY [mapped values] (g)	SITE COEFFICIENT	SITE CLASS D* [adjusted for site class effects] (g)	MULTI-PLIER	DESIGN VALUES (g)
Peak Ground Acceleration	PGA = **0.437**	F_{pga} = 1.200	PGA_M = 0.524	1.000	PGA_M = 0.524
0.2 Seconds (Long Period Acceleration)	S_S = **1.103**	F_a = 1.200	S_{MS} = 1.324	0.667	S_{DS} = 0.882
	(exceptions, if any)	F_a = (N/A)	S_{MS} = (N/A)	0.667	S_{DS} = (N/A)
1.0 Second (Long Period Acceleration)	S_1 = **0.336**	F_v = N/A	S_{M1} = N/A	0.667	S_{D1} = N/A
	(exceptions, if any)	F_v = (1.964)	S_{M1} = (0.660)	0.667	S_{D1} = (0.440)

NOTES:

Site Class D Without Data (Default)

1. T_L = 8 seconds
2. Site Class: **D**
3. Have data to verify? **no**
4. **ASCE 7-16 requires Site Specific Ground Motion Hazard Analysis (S1 ≥ 0.2), OR Can Use Exception 2**



4.3.3 Liquefaction

Liquefaction is defined as the condition when saturated, loose, sandy 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.

The site is located within an area designated by the Utah Geologic Survey[4] as having “Very Low” liquefaction potential. This represents a less than 5% probability that within a 100-year period an earthquake strong enough to cause liquefaction will occur.

A special liquefaction study was not performed for this site. In our opinion, the subsurface conditions we encountered support the mapped very low liquefaction potential designation.

4.4 Other Geologic Hazards

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 debris flow, stream flooding, or rock fall hazard area.

5.0 SITE CONDITIONS

5.1 Surface Conditions

At the time the test pits were excavated the site predominately consisted of open agricultural fields/pasture. A few mature trees were present along the edges of the fields and in the northwest portion of the site. Unimproved roadways and pathways were observed throughout the property. A somewhat steep, high, west facing slope was observed on the northwest portion and along the western margin of the south half of the overall site. A dry pond was located on the northwest portion of the site. Based upon aerial photos readily available online dating back to 1993, the site has remained relatively unchanged since that time. There are some single-family residential structures to the south southwest and southeast, but much of the site is surrounded by undeveloped land (see **Vicinity Map** in **Section 1.1** above).

5.2 Subsurface Soils

At the locations of the test pits we encountered approximately 6 to 30 inches of sandy/gravelly soils with roots and organics (topsoil) on the surface.

Natural soils were observed beneath the topsoil and disturbed soils, consisting predominately of GRAVEL with varying amounts of clay, silt, sand, and cobbles (GC, GM, GP-GM, GP), and a few layers of CLAY (CL), with varying amounts of sand and gravel, extending to the maximum depth explored of approximately 12 feet.

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[4] Utah Geological Survey, "Liquefaction-Potential Map for Cache Valley, Cache County, Utah," Utah Geological Survey Public Information Series 79, August 1994. https://ugspub.nr.utah.gov/publications/public_information/pi-79.pdf

The natural gravel soils were slightly moist, light brown to gray in color, and estimated to be in a loose to dense state. These soils are projected to exhibit moderately high strength and low compressibility characteristics.

The clay soils were slightly moist, light brown to gray in color, and estimated to have stiff consistency. Some of these layers also exhibited a pinhole structure, a typical visual indication of potentially moisture sensitive (collapsible) soils. A collapse/consolidation test of a representative sample of these soils exhibited moderate over consolidation and strength characteristics, as well as a moderately high potential for collapse when wetted.

For a more descriptive interpretation of subsurface conditions, please refer to the test pit logs, **Figures 2 through 11**, which graphically represent the subsurface conditions encountered. The lines designating the interface between soil types on the logs generally represent approximate boundaries - in situ, the transition between soil types may be gradual.

5.3 Groundwater

Groundwater was not encountered at the time of our field explorations within the maximum depth explored of about 12 feet below the existing ground surface. However, historic groundwater seepage and springs have been documented within the eastern portion of the property. Therefore, groundwater is not likely to be encountered during construction for most of the development, but could be encountered on the eastern portion of the site.

Groundwater levels can fluctuate seasonally as well as in response to numerous other factors such as heavy precipitation, irrigation of neighboring land, and other unforeseen factors. The detailed evaluation of these and other factors, which may be responsible for ground water fluctuations, is beyond the scope of this study.

5.4 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 between or beyond the exploratory locations.

Also, when logging and sampling of the test pits was completed, the test pits were backfilled with the excavated soils but minimal to no effort was made to compact these soils and no compaction testing was performed. Thus, the test pit backfill is considered non-engineered fill and settlement of the backfill in the test pits over time should be anticipated.

6.0 SITE PREPARATION AND GRADING

6.1 General

All deleterious materials should be stripped from the site prior to commencement of construction activities. This includes vegetation, topsoil, loose and disturbed soils, etc. Based upon the conditions observed in the test pits there is topsoil on the surface of the site which we estimated to be about 6 to 30 in thickness. When stripping and grubbing, topsoil should be distinguished by the apparent organic content and not solely by color; thus we estimate that topsoil stripping will need to include the upper 6 to 12 inches. However, given the past agricultural uses of the site, the upper 12 to 15 inches may have been disturbed during farming.

Also, where trees or large shrubs are present, or were present, large roots and/or root balls may extend deeper.

The potentially collapsible soils may remain in pavement areas if:

1. The upper 12 inches is removed, the exposed subgrade is scarified and re-compacted as described above, and the removed 12 inches is replaced with structural fill meeting the specification given in the table in **Section 6.4** below.
2. No more than 3 feet of subsequent overlying site grading fills are installed above any remaining sequence of potentially collapsible soils;
3. Any planned subsurface detention systems are installed well away and down gradient from nearby structures, and preferably below any remaining sequence of potentially collapsible clay soils; and
4. Adequate site drainage is maintained to reduce the potential for subsurface soil saturation.
5. The owner accepts the risk that some settlement of pavement areas could occur if the underlying potentially collapsible soils become wetted, which could result in minor to significant maintenance.

The site should be observed by a CMT geotechnical engineer to assess that suitable natural soils have been exposed and any deleterious materials, loose and/or disturbed soils have been removed, prior to placing site grading fills, footings, slabs, and pavements.

Fill placed over large areas to raise overall site grades can induce settlements in the underlying natural soils. If more than 3 feet of site grading fill is anticipated over the natural ground surface, we should be notified to assess potential settlements and provide additional recommendations as needed. These recommendations may include placement of the site grading fill far in advance to allow potential settlements to occur prior to construction.

6.2 Temporary Excavations

Excavations deeper than 8 feet are not anticipated at the site. Groundwater was not encountered within the depths explored, about 10 to 12 feet at the time of our field explorations, and thus is not anticipated to be encountered in excavations during development.

The natural soils encountered at this site predominantly consisted of gravel. For sandy/gravelly (cohesionless) soils, temporary construction excavations not exceeding 4 feet in depth should be no steeper than one-half horizontal to one vertical (0.5H:1V). For excavations up to 8 feet and above groundwater, side slopes should be no steeper than one horizontal to one vertical (1H:1V). Excavations encountering saturated cohesionless soils will be very difficult to maintain, and will require very flat side slopes and/or shoring, bracing and dewatering.

In clayey (cohesive) soils, temporary construction excavations not exceeding 4 feet in depth may be constructed with near-vertical side slopes. Temporary excavations up to 8 feet deep, above or below groundwater, may be constructed with side slopes no steeper than one-half horizontal to one vertical (0.5H:1V).

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 Permanent/Cut Slopes

There are sloping areas on the western portion of the site. Site grading plans were not provided to us. Generally we recommend that existing slopes not be steepened in any way by either adding soil at the crest, or by cutting at the toe. Generally, permanent cut and fill slope should be graded no steeper than about 2.5 horizontal to one vertical (2.5H:1V) to be considered stable without retaining walls or other means of lateral resistance. If steeper cut and fill slopes are required to facilitate development plans, retaining walls or other means of reinforcement may be required. CMT must be allowed to review grading plans and assess slope stability and provide additional recommendations for slope stability and or retaining walls, etc., if needed.

6.4 Fill Material

Following are our recommendations for the various fill types we anticipate will be used at this site:

FILL MATERIAL TYPE	DESCRIPTION | RECOMMENDED SPECIFICATION
Structural Fill	Placed below structures, flatwork and pavement. Well-graded sand/gravel mixture, with maximum particle size of 4 inches, a minimum 70% passing 3/4-inch sieve, a minimum 15% passing and a maximum 30% passing the No. 200 sieve, and a maximum Plasticity Index of 10.
Site Grading Fill	Placed over larger areas to raise the site grade. Sandy to gravelly soil, with a maximum particle size of 6 inches, a minimum 70% passing 3/4-inch sieve, and a maximum 50% passing No. 200 sieve.
Non-Structural Fill	Placed below non-structural areas, such as landscaping. On-site soils or imported soils, with a maximum particle size of 8 inches, including silt/clay soils not containing excessive amounts of degradable/organic material (see discussion below).
Stabilization Fill	Placed to stabilize soft areas prior to placing structural fill and/or site grading fill. Coarse angular gravels and cobbles 1 inch to 8 inches in size. May also use 1.5-inch to 2.0-inch gravel placed on stabilization fabric, such as Mirafi RS280i, or equivalent (see **Section 6.7**).

On-site gravel soils may be suitable for use as structural fill, if processed to meet the requirements given above, and may also be used as site grading fill and as non-structural fill.

On-site clay soils may be used as non-structural fill, but are also inherently more difficult to work with in proper moisture conditioning (they are very sensitive to changes in moisture content), requiring very close moisture control during placement and compaction. This will be very difficult, if not impossible, during wet and cold periods of the year.

All fill material should be approved by a CMT geotechnical engineer prior to placement.

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 to at least the following percentages of the maximum dry density as determined by ASTM D-1557 (or AASHTO[5] T-180) in accordance with the following recommendations:

LOCATION	TOTAL FILL THICKNESS (FEET)	MINIMUM PERCENTAGE OF MAXIMUM DRY DENSITY
Beneath an area extending at least 4 feet beyond the perimeter of structures, and below flatwork and pavement (applies to structural fill and site grading fill) extending at least 2 feet beyond the perimeter	0 to 5 5 to 8	95 98
Site grading fill outside area defined above	0 to 5 5 to 8	92 95
Utility trenches within structural areas	--	96
Roadbase and subbase	-	96
Non-structural fill	0 to 5 5 to 8	90 92

Structural fills greater than 8 feet thick are not anticipated at the site. For best compaction results, we recommend that the moisture content for structural fill/backfill be within 2% of optimum. Field density tests should be performed on each lift as necessary to verify that proper compaction is being achieved.

6.6 Utility Trenches

For the bedding zone around the utility, we recommend utilizing sand bedding fill material that meets current APWA[6] requirements.

All utility trench backfill material below structurally loaded facilities (foundations, floor slabs, flatwork, parking lots/drive areas, etc.) should be placed at the same density requirements established for structural fill in the previous section.

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[5] American Association of State Highway and Transportation Officials

[6] American Public Works Association

Above the bedding zone, where the potentially collapsible natural clay soils are encountered, we recommend that utility trench backfill have a minimum 20% fines, to reduce permeability (refer to **Section 6.4** above). In addition, utilities should be installed as close to the bottom of the potentially collapsible soils as reasonably possible.

Most utility companies and local governments are requiring Type A-1a or A-1b (AASHTO Designation) soils (sand/gravel soils with limited fines) be used as backfill over utilities within public rights of way, and the backfill be compacted over the full depth above the bedding zone to at least 96% of the maximum dry density as determined by AASHTO T-180 (ASTM D-1557). Some of the natural gravel soils at this site may meet these specifications.

Where the utility does not underlie structurally loaded facilities and public rights of way, on-site fill and natural soils may be utilized as trench backfill above the bedding layer, provided are properly moisture conditioned and compacted to the minimum requirements stated above in **Section 6.5**.

6.7 Stabilization

The natural clay soils at this site will likely be susceptible to rutting and pumping. The likelihood of disturbance or rutting and/or pumping of the existing natural soils is a function of the load applied to the surface, as well as the frequency of the load. Consequently, rutting and pumping can be minimized by avoiding concentrated traffic, minimizing the load applied to the surface by using lighter equipment and/or partial loads, by working in drier times of the year, or by providing a working surface for the equipment. Rubber-tired equipment particularly, because of high pressures, promotes instability in moist/wet, soft soils. If rutting or pumping occurs, traffic should be stopped and the disturbed soils should be removed and replaced with stabilization material. Typically, a minimum of 18 inches of the disturbed soils must be removed to be effective. However, deeper removal is sometimes required.

To stabilize soft subgrade conditions (if encountered), a mixture of coarse, clean, angular gravels and cobbles and/or 1.5- to 2.0-inch clean gravel should be utilized, as indicated above in **Section 6.4**. Often the amount of gravelly material can be reduced with the use of a geotextile fabric such as Mirafi RS280i or equivalent. Its use will also help avoid mixing of the subgrade soils with the gravelly material. After excavating the soft/disturbed soils, the fabric should be spread across the bottom of the excavation and up the sides a minimum of 18 inches. Otherwise, it should be placed in accordance with the manufacturer’s recommendation, including proper overlaps. The gravel material can then be placed over the fabric in compacted lifts as described above.

7.0 FOUNDATION RECOMMENDATIONS

The following preliminary recommendations have been developed on the basis of the previously described project characteristics, including the maximum loads discussed in **Section 1.3**, the subsurface conditions observed in the field and the laboratory test data, and standard geotechnical engineering practice.

7.1 Foundation Design

Based on our geotechnical engineering analyses, the proposed residential structures may likely be supported upon conventional spread and/or continuous wall foundations placed on suitable, undisturbed natural gravel soils and/or on structural fill extending to suitable natural soils. Footings may be designed using a net bearing pressure of 2,000 psf.

The term “net bearing pressure” refers to the pressure imposed by the portion of the structure located above lowest adjacent final grade, thus the weight of the footing and backfill to lowest adjacent final grade need not be considered. The allowable bearing pressure may be increased by 1/3 for temporary loads such as wind and seismic forces.

We also recommend the following:

1. Continuous footing widths should be maintained at a minimum of 18 inches.
2. Spot footings should be a minimum of 24 inches wide.

7.2 Foundation Installation

Under no circumstances shall foundations be placed directly on non-engineered fill, on potentially collapsible soils, on topsoil with organics, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. Where footings would otherwise be placed on potentially collapsible soils, we recommend the collapsible soils be completely removed or over-excavated a minimum 36 inches, whichever is less, and replaced with properly compacted structural fill. If other unsuitable soils as described above are encountered, they must be completely removed and replaced with properly compacted structural fill.

Deep, large roots may be encountered where trees and larger bushes are located or were previously located at the site; such large roots should be removed. The base of footing excavations should be observed by a CMT geotechnical engineer to confirm that suitable bearing soils have been exposed.

All structural fill should meet the requirements for such, and should be placed and compacted in accordance with **Section 6** above. The width of structural replacement fill below footings should be equal to the width of the footing plus 1 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 2 feet, the fill replacement width should be 4 feet, centered beneath the footing.

The minimum thickness of structural fill below footings should be equivalent to one-third the thickness of structural fill below any other portion of the foundations. For example, if the maximum depth of structural fill is 6 feet, all footings for the new structure should be underlain by a minimum 2 feet of structural fill.

We also recommend the following:

1. Exterior footings subject to frost should be placed at least 30 inches below final grade.
2. Interior footings not subject to frost should be placed at least 16 inches below grade.

7.3 Estimated Settlement

Foundations designed and constructed in accordance with our recommendations could experience some settlement, but we anticipate that total settlements of footings founded as recommended above will not exceed 1 inch, with differential settlements on the order of 0.5 inches over a distance of 25 feet. We expect approximately 50% of the total settlement to initially take place during construction.

7.4 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 0.40 for natural gravel soils and structural fill may be utilized for design. Passive resistance provided by properly placed and compacted structural fill above the water table may be considered equivalent to a fluid with a density of 350 pcf. A combination of passive earth resistance and friction may be utilized if the friction component of the total is divided by 1.5.

8.0 LATERAL EARTH PRESSURES

We project that basement walls up to 8 feet tall will be constructed at this site. The lateral earth pressure values given below anticipate that native gravel soils and/or structural fill will be used as backfill material, placed and compacted in accordance with the recommendations presented herein. If other soil types will be used as backfill, we should be notified so that appropriate modifications to these values can be provided, as needed.

The lateral pressures imposed upon subgrade facilities will depend upon the relative rigidity and movement of the backfilled structure. For rigid basement walls that are not more than 10 inches thick, sand/gravel backfill may be designed using an at-rest equivalent fluid pressure of 55 pcf (psf/ft). This value assumes that the soil surface behind the wall is horizontal and that the backfill within 3 feet of the wall will be compacted with hand-operated compacting equipment.

For seismic loading of rigid basement walls up to 8 feet tall, we recommend using a uniform (rectangular) at-rest lateral pressure of 125 psf for design.

9.0 FLOOR SLABS

Floor slabs may be established upon suitable, undisturbed, natural gravel soils and/or on structural fill extending to suitable natural soils (same as for foundations). Under no circumstances shall floor slabs be established directly on potentially collapsible soils, or any topsoil, 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, we recommend that floor slabs be directly underlain by at least 4 inches of “free-draining” fill, such as “pea” gravel or 3/4-inch to 1-inch minus, clean, gap-graded gravel. To help control normal shrinkage and stress cracking, the floor slabs may have the following features:

1. Adequate reinforcement for the anticipated floor loads with the reinforcement continuous through interior floor joints;
2. Frequent crack control joints; and
3. Non-rigid attachment of the slabs to foundation walls and bearing slabs.

10.0 DRAINAGE RECOMMENDATIONS

10.1 Surface Drainage

Some of the on-site near-surface clay soils are potentially collapsible when subjected to water, thus it is very important to the long-term 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 each structure should be sloped to provide drainage away from the foundations. In the gravel soils we recommend a minimum slope of 4 inches in the first 10 feet away from the structure, but where the clay soils are present a minimum slope of 6 inches is recommended. This slope should be maintained throughout the lifetime of 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. Landscape sprinklers should be aimed away, and in areas of clay soils maintained a distance of 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 that may become evident during construction.

10.2 Foundation Subdrains

Groundwater was not encountered within the depths we explored. Also, the majority of the subsurface soils are defined as relatively free-draining ‘Group 1’ soils by the international Residential Code (IRC). Based upon these conditions it is our opinion that foundations subdrains are not needed within this development. If groundwater is encountered at this site during development CMT should be notified to revise these recommendations if appropriate.

11.0 PAVEMENTS

All pavement areas must be prepared as discussed above in **Section 6.1**, particularly the surficial non-engineered fill. Under no circumstances shall pavements be established over topsoil, un-prepared non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water.

In roadway areas and other pavement areas, subsequent to stripping and/or surface preparation, and prior to the placement of pavement materials, the exposed subgrade must be proof rolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. If excessively soft or otherwise unsuitable soils are encountered, we recommend they be removed to a minimum of 18 inches below the subgrade level and replaced with structural fill.

We anticipate the natural gravel soils will exhibit fair to good pavement support, but the natural clay soils will exhibit poor pavement support characteristics when saturated or nearly saturated. Based on our laboratory testing experience with similar soils, our pavement design utilized a California Bearing Ratio (CBR) of 3 for the natural clay soils, and 8 for the natural gravel soils.

Given the projected traffic as discussed above in **Section 1.3**, the following pavement sections are recommended for the given ESAL's (18-kip equivalent single-axle loads) per day:

MATERIAL	PAVEMENT SECTION THICKNESS (inches)			
	PARKING AREAS (3 ESAL'S per day)		ROADS & DRIVE AREAS (8 ESAL'S per day)	
Subgrade	**Gravel**	**Clay**	**Gravel**	**Clay**
Asphalt	**3**	**3**	**3**	**3**
Concrete	**--**	**--**	**--**	**--**
Road-Base	**8**	**4**	**10**	**6**
Subbase	**0**	**6**	**0**	**8**
Total Thickness	**11**	**13**	**13**	**17**

Untreated base course (UTBC) should conform to city specifications, or to 1-inch-minus UDOT specifications for A–1-a/NP, and have a minimum CBR value of 70%. Material meeting our specification for structural fill can be used for subbase, as long as the fines content (percent passing No. 200 sieve) does not exceed 15%. Roadbase and subbase material should be compacted as recommended above in **Section 6.4**. Asphalt material generally should conform to APWA requirements, having a ½-inch maximum aggregate size, a 75-gyration Superpave mix containing no more than 15% of recycled asphalt (RAP) and a PG58-28 binder.

12.0 QUALITY CONTROL

We recommend that CMT be retained to as part of a comprehensive quality control testing and observation program. With CMT on-site we can help facilitate implementation of our recommendations and address, in a timely manner, any subsurface conditions encountered which vary from those described in this report. Without such a program CMT cannot be responsible for application of our recommendations to subsurface conditions which may vary from those described herein. This program 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 (Modified Proctor, ASTM D-1557) tests should be requested by the contractor immediately after delivery of any fill materials. The maximum density information should then be used for field density tests on each lift as necessary to ensure that the required compaction is being achieved.

12.3 Excavations

All excavation procedures and processes should be observed by a geotechnical engineer from CMT or their representative. In addition, for the recommendations in this report to be valid, all backfill and structural fill placed in trenches and all pavements should be density tested by CMT. We recommend that freshly mixed concrete be tested by CMT in accordance with ASTM designations.

13.0 LIMITATIONS

The recommendations provided herein were developed by evaluating the information obtained from the subsurface explorations and soils encountered therein. The exploration logs reflect the subsurface conditions only at the specific location at the particular time designated on the 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.

APPENDIX

SUPPORTING DOCUMENTATION

Smithfield Development About 400 North 300 East, Smithfield, Utah	CMT ENGINEERING LABORATORIES			Figure: 1
	Site Plan	Date:	21-May-20	
		Job #	900068	

Smithfield Development

Test Pit Log

TP-1

About 400 North 300 East, Smithfield, Utah

Equipment: Rubber Tire Backhoe
Surface Elev. (approx):

Total Depth: 10'
Water Depth: (see Remarks)

Date: 5/22/20
Job #: 900068

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0	▩	Fill: Light brown silt with roots										
1 2 3 4 5	▦	Brown Silty to Sandy GRAVEL (GM), slightly moist loose (estimated)										
6 7 8 9	▨	Gray Sandy CLAY (CL) with gravel, slightly moist stiff (estimated)										
6			▮	1	20		14	29	57			
9			◢	2								
10		END AT 10'										
11 12 13 14												

Remarks: Groundwater not encountered during excavation.

Figure:

2

CMT ENGINEERING LABORATORIES

Excavated By: Owner Provided
Logged By: Owen K
Page: 1 of 1

Smithfield Development

Test Pit Log

TP-2

About 400 North 300 East, Smithfield, Utah

Equipment: Rubber Tire Backhoe
Surface Elev. (approx):

Total Depth: 12'
Water Depth: (see Remarks)

Date: 5/22/20
Job #: 900068

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0		Fill: Brown silty sandy gravel with roots										
1												
2		Light Brown Gravelly CLAY (CL), some sand, cobbles and pinholes, slightly moist stiff (estimated)	◢	3								
3			▮	4	18	90			87			
4		grades reddish-brown										
5												
6												
7			▮	5	16		27	8	65			
8												
9		grades with more gravel, less clay										
10		Clayey GRAVEL (GC), slightly moist dense (estimated)										
11			▮	6								
12		END AT 12'										
13												
14												

Remarks: Groundwater not encountered during excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Owner Provided
Logged By: Owen K

Page: 1 of 1

Figure:
3

Smithfield Development

Test Pit Log

TP-3

About 400 North 300 East, Smithfield, Utah

Equipment: Rubber Tire Backhoe
Surface Elev. (approx):

Total Depth: 10'
Water Depth: (see Remarks)

Date: 5/22/20
Job #: 900068

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0	▨	Fill: Light brown silt with roots										
		Light Brown Poorly Graded GRAVEL with silt (GP-GM) and sand, cobbles, slightly moist loose (estimated)										
3			◣	7	2		77	17	6			
8			◣	8								
10		END AT 10'										

Remarks: Groundwater not encountered during excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Owner Provided
Logged By: Owen K

Figure: 4

Smithfield Development

Test Pit Log

TP-4

About 400 North 300 East, Smithfield, Utah

Equipment: Rubber Tire Backhoe
Surface Elev. (approx):

Total Depth: 10'
Water Depth: (see Remarks)

Date: 5/22/20
Job #: 900068

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0		Fill: Brown gravel with cobbles and roots										
			◣	9								
1		Gray Poorly Graded GRAVEL with silt (GP-GM) and sand, slightly moist loose (estimated)										
2												
3												
4												
5												
6												
7												
8												
9												
			◣	10								
10		END AT 10'										
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Owner Provided
Logged By: Owen K
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Figure:
5

Smithfield Development

Test Pit Log

TP-5

About 400 North 300 East, Smithfield, Utah

Equipment: Rubber Tire Backhoe
Surface Elev. (approx):

Total Depth: 10'
Water Depth: (see Remarks)

Date: 5/22/20
Job #: 900068

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0		Fill: Brown silty gravel with some roots										
1												
		Gray Fine Poorly Graded GRAVEL with silt (GP-GM), slightly moist loose (estimated)										
2												
3												
4												
5												
6		grades with cobbles										
7												
8												
9												
10		END AT 10'										
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

Figure:
6

CMT ENGINEERING LABORATORIES

Excavated By: Owner Provided
Logged By: Owen K
Page: 1 of 1

Smithfield Development

Test Pit Log

TP-6

About 400 North 300 East, Smithfield, Utah

Equipment: Rubber Tire Backhoe
Surface Elev. (approx):

Total Depth: 10'
Water Depth: (see Remarks)

Date: 5/22/20
Job #: 900068

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Gradation Sand %	Gradation Fines %	Atterberg LL	Atterberg PL	Atterberg PI
0		Fill: Light brown gravel with some sand and roots										
1												
2												
		Light Brown Poorly Graded GRAVEL with silt (GP-GM), sand, and cobbles, slightly moist loose (estimated)										
3												
4												
5												
6												
7		grades with calicite and oxidation moist										
			◢	11								
8												
9			◢	12								
10		END AT 10'										
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Owner Provided
Logged By: Owen K
Page: 1 of 1

Figure:
7

Smithfield Development

Test Pit Log

TP-7

About 400 North 300 East, Smithfield, Utah

Equipment: Rubber Tire Backhoe
Surface Elev. (approx):

Total Depth: 10'
Water Depth: (see Remarks)

Date: 5/22/20
Job #: 900068

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0	▨	Fill: Brown silty sandy with gravel and roots										
1	▨											
2	░	Gray Poorly Graded GRAVEL (GP) with cobbles, some sand, trace silt, slightly moist loose (estimated)										
3	░											
4	░											
5	░		◢	13	1		91	7	2			
6	░											
7	░											
8	░											
9	░											
10		END AT 10'										
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Owner Provided
Logged By: Owen K

Page: 1 of 1

Figure:
8

Smithfield Development

Test Pit Log

TP-8

About 400 North 300 East, Smithfield, Utah

Equipment: Rubber Tire Backhoe
Surface Elev. (approx):

Total Depth: 10'
Water Depth: (see Remarks)

Date: 5/22/20
Job #: 900068

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0		Fill: Brown silty gravel with roots										
1												
		Light Brown Silty GRAVEL (GM) with sand, slightly moist loose (estimated) grades gray with cobbles										
2												
3												
4			◣	14	5		62	25	13			
5												
6												
7												
8												
9												
10		END AT 10'										
11												
12												
13												
14												

Remarks: Groundwater not encountered during excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Owner Provided
Logged By: Owen K
Page: 1 of 1

Figure:
9

Smithfield Development

Test Pit Log

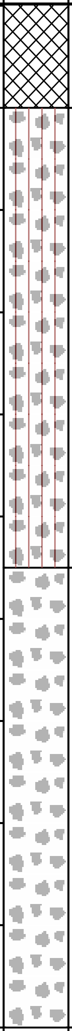
TP-9

About 400 North 300 East, Smithfield, Utah

Equipment: Rubber Tire Backhoe
Surface Elev. (approx):

Total Depth: 10'
Water Depth: (see Remarks)

Date: 5/22/20
Job #: 900068



Depth (ft)	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation Gravel %	Sand %	Fines %	Atterberg LL	PL	PI
0	Fill: Brown silty sand with some gravel and roots										
1	Light Brown Silty GRAVEL (GM) with sand, slightly moist very dense (estimated)										
2											
3	loose (estimated)	◢	15	10		46	16	38			
4											
5		◢	16								
6	Light Brown Poorly Graded GRAVEL (GP) with sand, slightly moist loose (estimated)										
7											
8											
9											
10	END AT 10'										
11											
12											
13											
14											

Remarks: Groundwater not encountered during excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Owner Provided
Logged By: Owen K
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Figure:
10

Smithfield Development

Test Pit Log

TP-10

About 400 North 300 East, Smithfield, Utah

Equipment: Rubber Tire Backhoe
Surface Elev. (approx):

Total Depth: 10'
Water Depth: (see Remarks)

Date: 5/22/20
Job #: 900068

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation			Atterberg		
							Gravel %	Sand %	Fines %	LL	PL	PI
0 1		Fill: Brown silty sand with gravel and roots										
2 3		Gray Poorly Graded GRAVEL (GP) with sand, slightly moist loose (estimated)										
4		Gray Silty GRAVEL (GM) with sand, cobbles, slightly moist dense (estimated)	◣	17	9		47	10	43			
5 6 7 8 9												
10 11 12 13 14		END AT 10'										

Remarks: Groundwater not encountered during excavation.

CMT ENGINEERING LABORATORIES

Excavated By: Owner Provided
Logged By: Owen K
Page: 1 of 1

Figure:
11

Smithfield Development

About 400 North 300 East, Smithfield, Utah

Key to Symbols

Date: 5/22/20
Job #: 900068

Depth (ft)	GRAPHIC LOG	Soil Description	Sample Type	Sample #	Moisture (%)	Dry Density(pcf)	Gradation ⑧ Gravel %	 Sand %	 Fines %	Atterberg ⑨ LL	 PL	 PI
①	②	③	④	⑤	⑥	⑦						

COLUMN DESCRIPTIONS

① **Depth (ft.):** Depth (feet) below the ground surface (including groundwater depth - see water symbol below).

② **Graphic Log:** Graphic depicting type of soil encountered (see ② below).

③ **Soil Description:** Description of soils encountered, including Unified Soil Classification Symbol (see below).

④ **Sample Type:** Type of soil sample collected at depth interval shown; sampler symbols are explained below-right.

⑤ **Sample #:** Consecutive numbering of soil samples collected during field exploration.

⑥ **Moisture (%):** Water content of soil sample measured in laboratory (percentage of dry weight of sample).

⑦ **Dry Density (pcf):** The dry density of a soil measured in laboratory (pounds per cubic foot).

⑧ **Gradation:** Percentages of Gravel, Sand and Fines (Silt/Clay), obtained from lab test results of soil passing the No. 4 and No. 200 sieves.

⑨ **Atterberg:** Individual descriptions of Atterberg Tests are as follows:

LL = Liquid Limit (%): Water content at which a soil changes from plastic to liquid behavior.

PL = Plastic Limit (%): Water content at which a soil changes from liquid to plastic behavior.

PI = Plasticity Index (%): Range of water content at which a soil exhibits plastic properties (= Liquid Limit - Plastic Limit).

STRATIFICATION	
Description	**Thickness**
Seam	Up to ½ inch
Lense	Up to 12 inches
Layer	Greater than 12 in.
Occasional	1 or less per foot
Frequent	More than 1 per foot

MODIFIERS
Trace
<5%
Some
5-12%
With
> 12%

MOISTURE CONTENT
Dry: Absence of moisture, dusty, dry to the touch.
Moist: Damp / moist to the touch, but no visible water.
Saturated: Visible water, usually soil below groundwater.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)

MAJOR DIVISIONS			USCS SYMBOLS	②	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 sieve size.	**GRAVELS** The coarse fraction retained on No. 4 sieve.	**CLEAN GRAVELS** (< 5% fines)	GW	▨	Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
			GP	▨	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
		GRAVELS WITH FINES (≥ 12% fines)	GM	▨	Silty Gravels, Gravel-Sand-Silt Mixtures
			GC	▨	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS The coarse fraction passing through No. 4 sieve.	**CLEAN SANDS** (< 5% fines)	SW	▨	Well-Graded Sands, Gravelly Sands, Little or No Fines
			SP	▨	Poorly-Graded Sands, Gravelly Sands, Little or No Fines
		SANDS WITH FINES (≥ 12% fines)	SM	▨	Silty Sands, Sand-Silt Mixtures
			SC	▨	Clayey Sands, Sand-Clay Mixtures
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 sieve size.	**SILTS AND CLAYS** Liquid Limit less than 50%		ML	▨	Inorganic Silts and Sandy Silts with No Plasticity or Clayey Silts with Slight Plasticity
			CL	▨	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
			OL	▨	Organic Silts and Organic Silty Clays of Low Plasticity
	SILTS AND CLAYS Liquid Limit greater than 50%		MH	▨	Inorganic Silts, Micacious or Diatomacious Fine Sand or Silty Soils
			CH	▨	Inorganic Clays of High Plasticity, Fat Clays
			OH	▨	Organic Silts and Organic Clays of Medium to High Plasticity
HIGHLY ORGANIC SOILS			PT	▨	Peat, Soils with High Organic Contents

Note: Dual Symbols are used to indicate borderline soil classifications (i.e. GP-GM, SC-SM, etc.).

SAMPLER SYMBOLS

◨	Block Sample
◪	Bulk/Bag Sample
⧗	Modified California Sampler 3.5" OD, 2.42" ID
⧗	D&M Sampler
▯	Rock Core
◩	Standard Penetration Split Spoon Sampler
▥	Thin Wall (Shelby Tube)

WATER SYMBOL

▽	Encountered Water Level
▼	Measured Water Level

(see Remarks on Logs)

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.

CMT ENGINEERING LABORATORIES

Figure:
12