REPORT
GEOTECHNICAL STUDY
PROPOSED UVU CLASSROOM BUILDING
UVU CAMPUS
OREM, UTAH

Submitted To:

State of Utah DFCM
4110 State Office Building
Salt Lake City, Utah 84114

Submitted By:

GSH Geotechnical, Inc.
473 West 4800 South
Salt Lake City, Utah 84123

February 15, 2013

Job No. 0128-095-13

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Job No. 0128-095-13

State of Utah DFCM
4110 State Office Building
Salt Lake City, Utah 84114

Attention: Mr. Kurt Baxter

Gentlemen:

Re: Report
Geotechnical Study
Proposed UVU Classroom Building
UVU Campus
Orem, Utah

1. INTRODUCTION

1.1 GENERAL

This report presents the results of our geotechnical study performed at the site of the proposed UVU Classroom Building, which is located within the north parking lot at the north end of campus. The general location of the overall site with respect to major topographic features and existing facilities, as of 1994 and 1998, is presented on Figure 1, Vicinity Map. A more detailed layout of the overall site showing the proposed building footprint, roadways and parking is presented on Figure 2, Site Plan. The locations of the five borings drilled in conjunction with this study are also presented on Figure 2.

During the course of this study, many of the discussions and recommendations summarized herein were presented verbally and by email to representatives of the design team.

1.2 OBJECTIVES AND SCOPE

The objectives and scope of the study were planned in discussions between Mr. Kurt Baxter of Utah DFCM and Alan Spilker of GSH Geotechnical Consultants, Inc. (GSH).

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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 earthwork, foundation, and pavement recommendations and geoseismic information to be utilized in the design and construction of the proposed structure.

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

1. A field program consisting of the drilling, logging, and sampling of five exploration borings to depths of 40 to 41 feet.

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.

1.3 AUTHORIZATION

Authorization was provided verbally by Mr. Kurt Baxter of DFCM based on the Professional Services Agreement No. 13-0130 dated January 24, 2013.

1.4 PROFESSIONAL STATEMENTS

Supporting data upon which our recommendations are based are presented in subsequent sections of this report. Recommendations presented herein are governed by the physical properties of the soils encountered in the exploration borings from this study, projected groundwater conditions from this study, and the layout and design data discussed in Section 2, Proposed Construction, of this report. If subsurface conditions other than those described in this report are encountered and/or if design and layout changes are implemented, GSH must be informed so that our recommendations can be reviewed and amended, if necessary.

Our professional services have been performed, our findings developed, and our recommendations prepared in accordance with generally accepted engineering principles and practices in this area at this time.

2. PROPOSED CONSTRUCTION

The proposed classroom building will consist of 4 to 5 stories above grade constructed of concrete frame and light steel construction. Maximum column and wall loads are projected to be on the order of 900 to 1200 kips and 6 to 8 kips per lineal foot, respectively. Maximum floor loads are projected to be on the order of 100 to 150 pound per square foot.

Cuts and fills associated with general site grading are expected to be minimal on the order of 1 to 2 feet.

3. SITE INVESTIGATIONS

3.1 FIELD PROGRAM

In order to define and evaluate the subsurface soil and groundwater conditions across the site, 5 borings were drilled to depths of 40.5 to 41.0 feet with a truck-mounted drill rig equipped with hollow-stem augers. Locations of the borings drilled in conjunction with this study are presented on Figure 2.

The field portion of our study was under the direct control and continual supervision of an experienced member of our geotechnical staff. During the course of the drilling operations, a continuous log of the subsurface conditions encountered was maintained. In addition, relatively undisturbed samples of the typical soils penetrated were obtained for subsequent laboratory testing and examination. The soils were classified in the field based upon visual and textural examination. These classifications were later supplemented by subsequent inspection and testing in our laboratory. Detailed graphical representation of the subsurface conditions encountered during this study is presented on Figures 3A through 3E. Soils were classified in accordance with the nomenclature described on Figure 4, Key to Boring Log (USCS).

A 3.25-inch outside diameter, 2.42-inch inside diameter drive sampler (Dames & Moore) was utilized in the majority of the subsurface sampling at the site. Additionally, a 2.0-inch outside diameter, 1.38-inch inside diameter drive sampler (SPT) was utilized at select locations and depths. The blow counts recorded on the boring logs were those required to drive the identified sampler 12 inches with a 140-pound hammer dropping 30 inches.

Following completion of drilling operations, one and one-quarter-inch diameter slotted PVC pipe was installed in each boring in order to provide a means of monitoring the groundwater fluctuations.

3.2 LABORATORY TESTING

3.2.1 General

In order to provide data necessary for our engineering analyses, a laboratory testing program was performed. The program included moisture, density, and consolidation. The following paragraphs describe the tests and summarize the test data.

3.2.2 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 undisturbed samples. The results of these tests are presented on the boring logs, Figures 3A through 3E.

3.2.3 Consolidation Tests

To provide data necessary for our settlement analyses, a consolidation test was performed on each of 7 representative samples of the fine-grained soils encountered at the exploration borings.

Test data available indicates that the finer-grained soils are moderate to moderately highly over-consolidated. The soils will exhibit moderate compressibility characteristics when loaded below the preconsolidation pressure. Detailed results of the tests are maintained within our files and can be provided, upon your request.

4. SITE CONDITIONS

4.1 SURFACE

The proposed classroom building will be located within an existing asphalt paved parking area at the north end of campus. The north and east perimeters are surrounded by College Drive. Existing multi-story campus buildings exist to the south with asphalt paved parking to the west.

4.2 SUBSURFACE SOIL

The soil conditions encountered at the borings, to the depths explored, are relatively similar. Asphalt concrete blankets the site across the surface at each boring location ranging from 3.0 to 4.5 inches thick supported on 5.0 to 7.0 inches of aggregate base. Below the pavement section in Borings B-2 and B-5, there exists a layer of sand with trace to some silt fill extending to depths of 3 to 4 feet below the surface. This sand fill is medium dense, moist, brown, and likely placed in a controlled manner as site grading fill for pavement support. However, unless the compaction of these fill meets with the compaction criteria stated herein, it must be considered as non-engineered fill below the building area.

Below the pavement section in Borings B-1, B-3, and B-4, and below the sand fills in Borings B-2 and B-5, natural soils consist primarily of silty and sandy clay with occasional to numerous silty/clayey sand layers ranging from 1/8 inch up to 6 inches thick. Within this primarily clay sequence, there are layers of sand with varying silt and clay content ranging in thickness from 2 to 12 feet encountered between 10 and 40 feet at the boring locations.

The natural clay soils are medium stiff to very stiff, moist to saturated, brown, and moderate to moderately highly over-consolidated and will exhibit moderate compressibility characteristics when loaded below the over-consolidation pressure. The natural sand soils are loose to medium

dense, moist to saturate, brown, and will exhibit high strength and low compressibility characteristics under the design loading.

The lines designating the interface between soil types on the boring logs generally represent approximate boundaries. In-situ, the transition between soil types may be gradual.

Static groundwater was measured 6 days following drilling in Borings B-1 through B-3 and B-5 at depths ranging from 11.1 to 13.5 feet below the ground surface.

Seasonal and longer-term groundwater fluctuations on the order of 1 to 2 feet are projected, with the highest seasonal levels generally occurring during the late spring and early summer months.

5. DISCUSSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

The results of our study show 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. More heavily loaded footings will require varying thickness of granular replacement fills to control settlements.

Some fills were encountered below existing pavements ranging to depths of 2 to 4 feet below grade. These fills consist of sands with varying silt content and were likely placed with some level of compaction as site grading fills. However, to remain below the building, they must have available past compaction documentation or be compaction tested in-place prior to major earthwork activities. Test results must comply with the compaction requirements stated later in this report to be considered as engineered fill.

Static groundwater was measured in the borings between 11.1 and 13.5 feet below the surface and is not anticipated to conflict with construction.

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

5.2 EARTHWORK

5.2.1 Site Preparation

Initial site preparation will consist of the removal of the existing pavements, non-engineered fills, and any deleterious materials extending out a minimum of 5 feet from the edge of new structures and flatwork. The edges of the existing pavements to be removed should be saw-cut to facilitate new pavement replacement jointing.

A roughly 2- to 4-foot thick layer of fill comprised of sand with trace to some silt was encountered below the pavement section in Borings B-2 and B-5, located within the eastern portion of the site. This fill is projected to be structural site grading fill associated with initial construction of the exiting pavements. However, past documentation or in-place density tests must be taken on the fill soils prior to the beginning of major construction to verify that these fills have been property placed and compacted if left beneath the building and/or flatwork. If test results indicate a minimum of 95 percent of the maximum dry density, as determined by the AASHTO[1] T-180 (ASTM[2] D-1557) compaction criteria, then these fills may be considered for design as natural suitable subgrade. Otherwise the fills would be considered as non-engineered fills and must be either recompacted in lifts to the requirements for structural fill or completely removed and subsequently replaced with imported structural fill.

Additional areas with fill may be identified during construction. Should this be the case, these fills shall be explored and tested as stated above.

Subsequent to stripping and prior to the placement of floor slabs, structural site grading fill, and pavements, the exposed subgrade must be proofrolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. If excessively soft or otherwise unsuitable soils are encountered beneath proposed footings, they must be removed. If unsuitable soils below footings extend deeper than 2 feet, GSH must be notified to make further recommendations, as necessary. In pavement, floor slab, and outside flatwork areas, unsuitable soils should be removed to a maximum depth of 2 feet and replaced with compacted granular structural fill.

5.2.2 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 10 feet deep in fine-grained cohesive soils, above or below the water table, may be constructed with sideslopes no steeper than three-quarter horizontal to one vertical. Excavations deeper than 10 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. For excavations up to 10 feet in granular soils and above the water table, the slopes should be no steeper than one horizontal to one vertical. Excavations encountering saturated cohesionless soils will be very difficult and will require very flat sideslopes and/or shoring, bracing and dewatering.

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.

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1 American Association of State Highway and Transportation Officials
2 American Society for Testing and Materials

To minimize disturbance to the underlying soils, it is our recommendation that footings be excavated with a smooth-lip bucket.

5.2.3 Structural Fill

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 fill placed over relatively large open areas to raise the overall grade. For structural site grading fill, the maximum particle size should generally 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 on-site soils may be re-utilized as structural site grading fill provided they meet the requirements stated herein. However, it should be noted that unless moisture control is maintained near optimum, utilization of the natural or imported *fine-grained clay* soils as structural site grading fill will be very difficult, if not impossible, during wet and cold periods of the year. Additionally, the fine-grained soils are presently high in moisture and would require drying prior to recompacting.

Only granular soils are recommended as structural fill below footings and in confined areas, such as around foundations and within utility trenches. The maximum particle size within structural fill placed within confined areas should generally be restricted to 2 inches.

Imported granular structural fill should consist of a fairly well-graded mixture of sand and gravel with less than 20 percent fines. The plasticity index of imported fine-grained soils must not exceed 15 percent.

To stabilize soft subgrade conditions, a mixture of coarse gravels and cobbles and/or 1.5- to 2.0-inch gravel (stabilizing fill) should be utilized.

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.

5.2.4 Fill Placement and Compaction

Coarse gravel and cobble mixtures (stabilizing fill), if utilized, should 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 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 should be adequately placed and compacted so that the "fines" are "worked into" the voids in the underlying coarser gravels and cobbles.

All other structural fill shall be placed in lifts not exceeding 8 inches in loose thickness. Structural fills shall be compacted in accordance with the percent of the maximum dry density as determined by the AASHTO[3] T-180 (ASTM[4] D-1557) compaction criteria in accordance with the following table:

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Beneath an area extending at least 5 feet beyond the perimeter of the structure	0 to 10	95
Outside area defined above	0 to 5	90
Outside area defined above	5 to 10	95
Pavement base/subbase	--	95

Structural fills greater than 10 feet thick are not anticipated at the site.

Subsequent to stripping and prior to the placement of structural site grading fill, the subgrade shall be prepared as discussed in Section 5.2.1, Site Preparation, of this report. In confined areas, subgrade preparation should consist of the removal of all loose or disturbed soils.

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.

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

5.2.5 Utility Trenches

All utility trench backfill material below structurally loaded facilities (flatwork, floor slabs, paved areas, etc.) should be placed to the same material and density requirements established for structural fill.

If the surface of the backfill becomes disturbed during the course of construction, the backfill should be proofrolled and/or properly compacted prior to the construction of any exterior flatwork over a backfilled trench. Proofrolling may 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 should 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.

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. We recommend that as the major utilities continue onto the site that these compaction specifications are followed.

Fine-grained cohesive soils, such as the natural on-site silty clays, are not recommended for use as trench backfill.

5.3 SPREAD AND CONTINUOUS WALL FOUNDATIONS

5.3.1 Design Data

The results of this study indicate that the proposed structure may be supported upon conventional spread and continuous wall foundations. To control settlement associated with significantly higher column and wall loads, varying thicknesses of granular structural fill will be required beneath the footings. Foundation recommendations presented herein are governed by the finer-grained soils. For design, the following parameters are provided:

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	- 3,000 pounds per square foot*
Bearing Pressure Increase for Seismic Loading	- 50 percent

* See Section 5.3.3, Settlements, of this report for thickness of granular structural fill required under higher loaded footings.

The term "net bearing pressure" refers to the pressure imposed by the portion of the structures 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.

5.3.2 Installation

Under no circumstances should the footings be installed over non-engineered fills, loose or disturbed soils, sod, rubbish, frozen soil, or other deleterious materials. If unsuitable soils are encountered, they must be removed and replaced with suitable granular fill. The width of replacement fill should be equal to the width of the footing plus one foot for each foot of fill thickness. If granular fills become loose, they must be recompacted to the requirements of structural fill before the footings are poured.

Foundations requiring replacement fill near the groundwater may require temporary dewatering. This must be considered by the contractor during the bidding process.

5.3.3 Settlements

Settlements of foundations designed and installed in accordance with the above criteria and recommendations supporting the loads as discussed in Section 2, Proposed Construction, can be controlled to within one-half to five-eighths of an inch.

Bearing Pressure (psf)	Foundations	Loading	Minimum Thickness of Replacement Granular Structural Fill (feet)	Projected Ultimate Settlements (inches)
3,000	Spread	Up to 400 kips	0.0	½ to 1
3,000	Spread	400+ to 700 kips	1.5	¾ to 1
3,000	Spread	700+ to 1000 kips	2.0	¾ to 1
3,000	Spread	1,000+ to 1200 kips	2.5	¾ to 1
3,000	Wall	Up to 8 kips/foot	0.0	¼ to ¾

Settlements will occur rapidly with 50 to 60 percent of the projected settlements occurring during construction.

5.4 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 should be utilized. 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. Below the water table, this granular soil should be considered equivalent to a fluid with a density of 150 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.

5.5 LATERAL PRESSURES

The lateral pressure parameters, as presented within this section, are for backfills which will consist of drained granular 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), granular backfill may be considered equivalent to a fluid with a density of 35 pounds per cubic foot in computing lateral pressures. For more rigid walls (moderately yielding), generally not exceeding 8 feet in height, granular backfill may be considered equivalent to a fluid with a density of 45 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 60 pounds per cubic foot. The above values assume that the

surface of the soils slope behind the wall is at a maximum of 4H:1V and that the granular fill within 3 feet of the wall will be compacted with hand-operated compacting equipment.

For seismic loading of retaining walls/below-grade walls, the uniform lateral pressures tabulated below, 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	25	50	75
6	35	75	115
8	45	100	155

5.6 AT-GRADE SLABS

Floor slabs may be established upon, suitable undisturbed natural soils and/or upon structural fill extending to suitable natural soils. Topsoil is not considered suitable. To provide a capillary break, 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. Settlements of lightly to moderately loaded floor slabs are anticipated to be minor. Exterior flatwork should be supported on 4 inches of aggregate base course.

5.7 PAVEMENTS

Associated pavements for this project will consist of patching areas of the existing parking lot which have been removed or disturbed during construction, as well as some new pavements. The existing parking lot pavements at the boring locations consist of roughly:

3.0 to 4.5 inches	Asphalt concrete
5.0 to 7.0 inches	Aggregate base course

Pavement use is anticipated to continue as a light vehicle parking area. Projected traffic will consist of a moderate volume of automobiles and light trucks with occasional medium-weight trucks and no heavy weight trucks. For design purposes, a 4 per day equivalent 18-kip axle load is considered.

Therefore, it is recommended that the patched areas and new parking pavements be constructed with a minimum section of:

3.0 inches	Asphalt concrete
8.0 inches	Aggregate base course
Over	Properly prepared suitable natural subgrade or site grading structural fill

For dumpster pads and concrete aprons/loading areas, we recommend a pavement section consisting of 6.5 inches of Portland cement concrete, over 4.0 inches of aggregate base course, over properly prepared natural subgrade or site grading structural fills.

Construction of rigid pavement/exterior slabs should be in sections 10 to 12 feet in width with construction or expansion joints or one-quarter depth saw-cuts on no more than 12-foot centers. Saw-cuts must be completed within 24 hours of the "initial set" of the concrete and should be performed under the direction of the concrete paving contractor. The concrete should have a minimum 28-day unconfined compressive strength of 4,000 pounds per square inch and contain 6 percent ±1 percent air-entrainment.

5.8 GEOSEISMIC SETTING

5.8.1 General

Utah municipalities have adopted the International Building Code (IBC) 2009. The IBC 2009 code determines the seismic hazard for a site based upon 2002 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).

The structures must be designed in accordance with the procedure presented in Section 1613, Earthquake Loads, of the IBC 2009 edition.

5.8.2 Faulting

Based upon our review of available literature, no active faults are known to pass through or immediately adjacent to the site. The nearest active fault is the Wasatch Fault, approximately 3 miles east of the site. The Wasatch Fault Zone is considered capable of generating earthquakes as large as magnitude 7.3[5].

[5] Arabasz, W.J., Pechmann, J.C., and Brown, E.D., 1992, Observational seismology and the evaluation of earthquake hazards and risk in the Wasatch Front area, Utah, in Gori, P.L., and Hays, W.W., eds., Assessment of regional earthquake hazards and risk along the Wasatch Front, Utah: U.S. Geological Survey Professional Paper 1500-D, 36 p.

5.8.3 Soil Class

For dynamic structural analysis, the Site Class D - Stiff Soil Profile as defined in Table 1613.5.2, Site Class Definitions, of the IBC 2009 can be utilized.

5.8.4 Ground Motions

The IBC 2009 code is based on 2002 USGS mapping, which provides values of short and long period accelerations for the Site Class B-C boundary for the Maximum Considered Earthquake (MCE). This Site Class B-C boundary represents a hypothetical bedrock surface and must be corrected for local soil conditions. The following table summarizes the peak ground and short and long period accelerations for a MCE event and incorporates a soil amplification factor for a Site Class D soil profile in the second column. Based on the site latitude and longitude (40.2817 degrees north and 111.7176 degrees west, respectively), the values for this site are tabulated below:

Spectral Acceleration Value, T Seconds	**Site Class B-C Boundary [mapped values] (% g)**	**Site Class D [adjusted for site class effects] (% g)**
Peak Ground Acceleration	46.1	46.1
0.2 Seconds, (Short Period Acceleration)	$S_S = 115.2$	$S_{MS} = 119.7$
1.0 Seconds (Long Period Acceleration)	$S_1 = 48.4$	$S_{M1} = 73.4$

The IBC 2009 code design accelerations (S_{DS} and S_{D1}) are based on multiplying the above accelerations (adjusted for site class effects) for the MCE event by two-thirds.

5.8.5 Liquefaction

The site is located in an area that has been identified by the Utah Earthquake Preparedness Information Center Utah Division of Comprehensive Emergency Management for Utah County as having “Moderate” 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 not liquefy during a major seismic event.

Due to the majority of the soils encountered consisting of silty/sandy clays, as well as the blow counts within the sand layers, our analysis indicates that liquefaction is not likely to occur at the site during a design seismic event.

Calculations were performed using the procedures described in the 2008 Soil Liquefaction During Earthquakes Monograph by Idriss and Boulanger[6].

If you have any questions or would like to discuss these items further, please feel free to contact us at (801) 685-9190.

Respectfully submitted,

GSH Geotechnical, Inc.

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

Reviewed by:

Alan D. Spilker, P.E.
State of Utah No. 334228
President/Senior Geotechnical Engineer

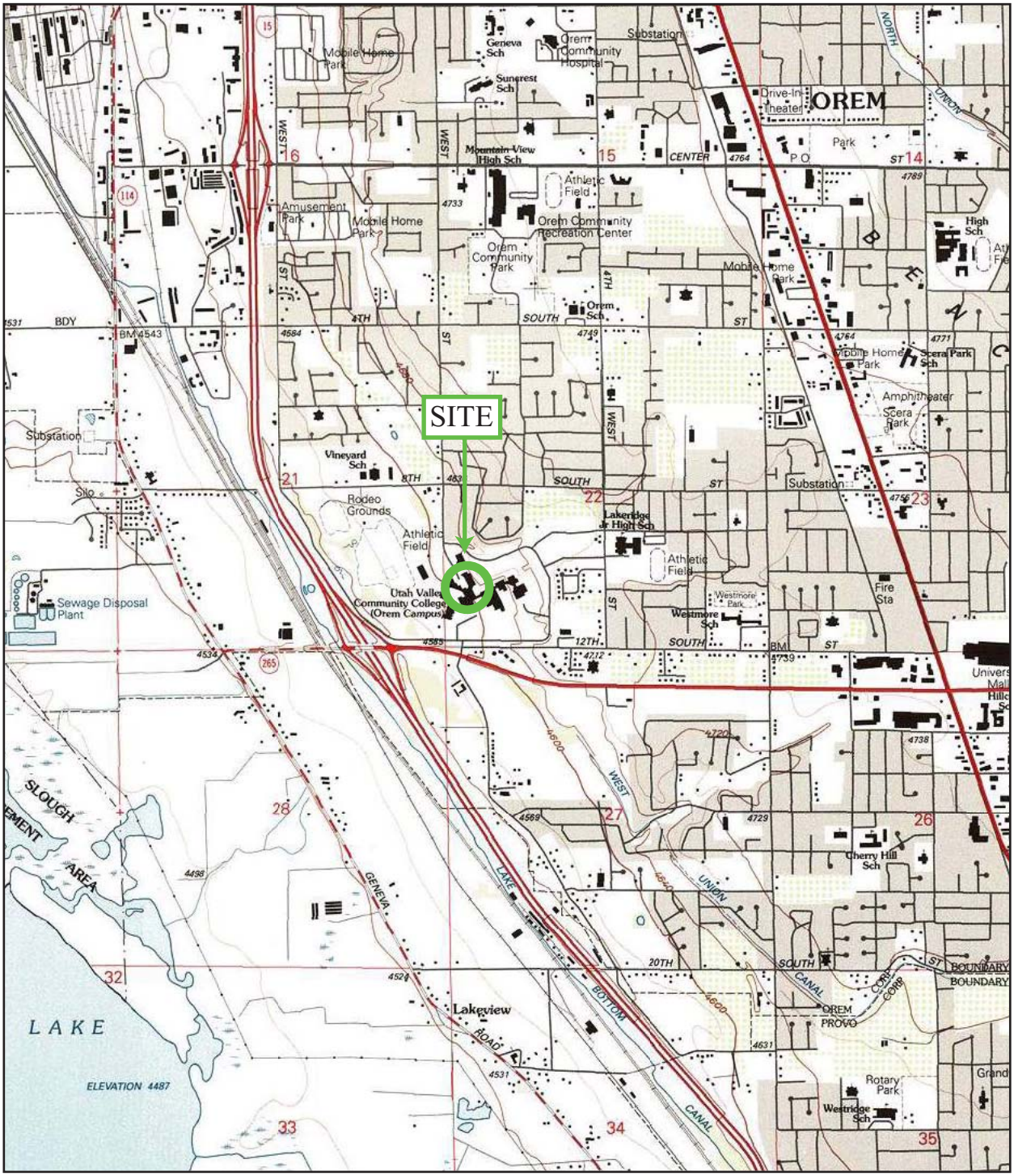
BNR/ADS:jh

Encl.	Figure	1,	Vicinity Map
	Figure	2,	Site Plan
	Figures	3A	through 3E, Log of Borings
	Figure	4,	Key to Boring Log (USCS)

Addressee (3 + email)

[6] Idriss, I. M., and Boulanger, R. W. (2008), Soil liquefaction during earthquakes: Monograph MNO-12, Earthquake Engineering Research Institute, Oakland, CA, 261 pp.

STATE OF UTAH, DFCM
JOB NO. 0128-095-13



SCALE IN FEET

1000 0 1000 2000

FIGURE 1
VICINITY MAP

REFERENCE:
USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE MAPS
ENTITLED "OREM, UTAH" DATED 1994 AND
"PROVO, UTAH" DATED 1998

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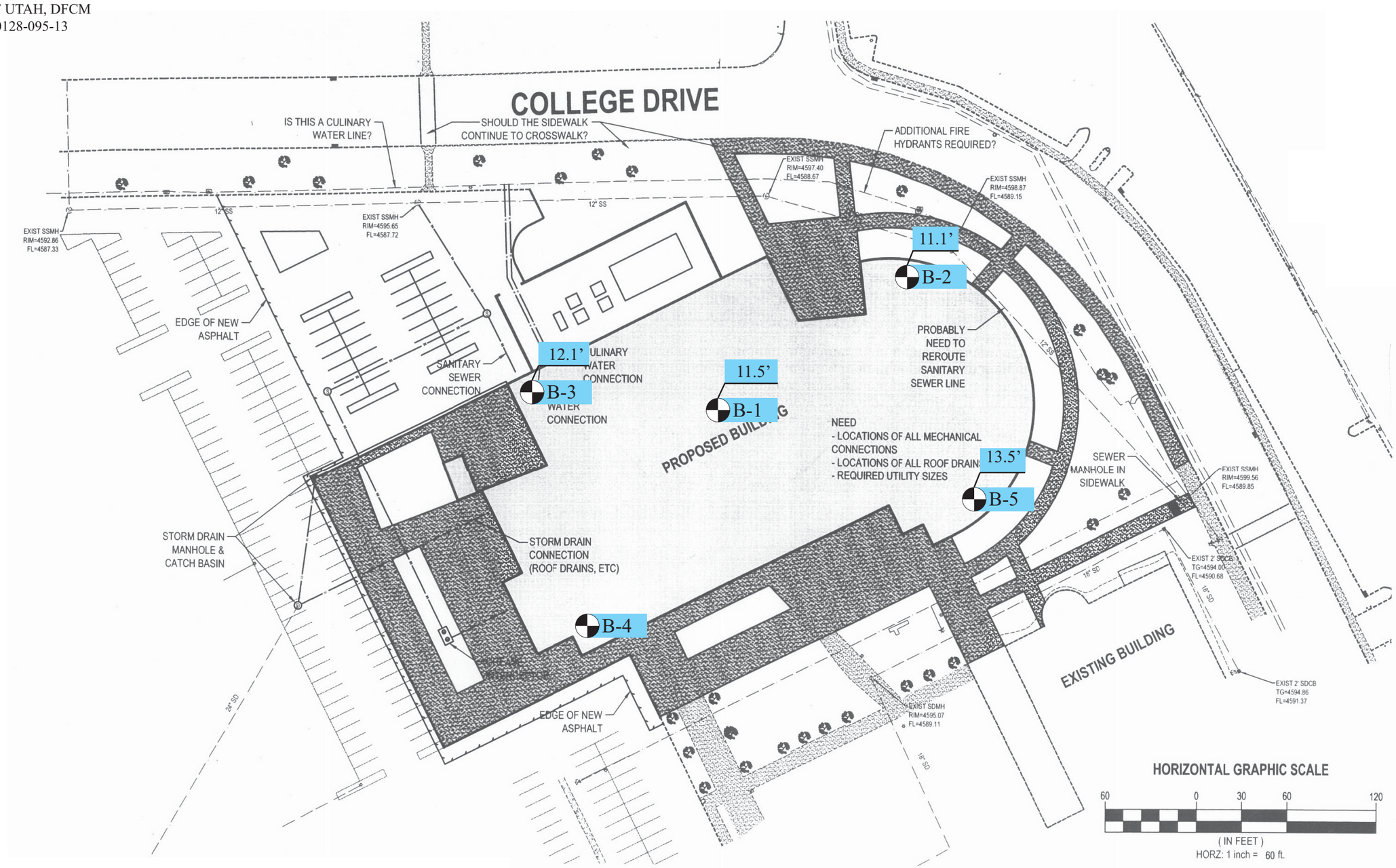
STATE OF UTAH, DFCM
JOB NO. 0128-095-13



KEY:

Groundwater depth 2/1/13

REFERENCE:
ADAPTED FROM DRAWING ENTITLED
"UVU CLASSROOM BUILDING, C200SP"
BY CRSA METHOD STUDIO, DATED SEPTEMBER 27, 2012

FIGURE 2
SITE PLAN

GSH

GSH

BORING LOG

BORING: B-1

CLIENT: State of Utah, DFCM
PROJECT NUMBER: 0128-095-13
PROJECT: UVU Classroom Building
DATE STARTED: 01/26/13
LOCATION: UVU Campus, Orem, Utah
DATE FINISHED: 01/26/13 **GSH Field Rep.:** RAG
DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger
HAMMER: Automatic **WEIGHT:** 140 lbs **DROP:** 30"
GROUNDWATER DEPTH: 11.5' (02/01/13)
ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0								
		3.5" ASPHALT									
		5.0" ROADBASE									
	CL	**SILTY CLAY** with some fine sand; brown									moist very stiff
				12		15.7	112				
		grades with some oxidation mottling	5	12		29.7	87				
				11		32.8	87				
			10	29		30.2	90				
▼	SM	**SILTY FINE SAND** brown									
	CL	**SILTY CLAY** with layers up to 1" thick of sand; brown									
	SM	**SILTY FINE SAND** brown	15	24							saturated
	CL	**SILTY SAND** with interbedded layers of sand up to 3" thick; brown									saturated
			20	24		24.4	102				very stiff
		grades with sand layers up to 5" thick									
		unrecoverable	25	19							

See Subsurface Conditions section in the report for additional information.

FIGURE 3A

BORING LOG

BORING: B-1

CLIENT: State of Utah, DFCM
PROJECT NUMBER: 0128-095-13
PROJECT: UVU Classroom Building
DATE STARTED: 01/26/13

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
			25								
	SM	**SILTY SAND** with clay; brown		28		27.1	96				saturated
	CL	**SILTY CLAY** brown	30	29		27.2	98				saturated
	SM	**SILTY FINE SAND** with numerous interbedded layers up to 3” thick of clay; brown with some oxidation mottling	35	15							saturated loose
	CL	**SILTY CLAY** with numerous layers up to 1” thick of fine sand; brown with oxidation mottling	40	8							saturated medium stiff
		End of exploration at 40.5’. Installed 1-1/4” diameter slotted PVC pipe to 40.5’.	45 50								

See Subsurface Conditions section in the report for additional information.

FIGURE 3A (cont’d)

GSH

BORING LOG

BORING: B-2

CLIENT: State of Utah, DFCM
PROJECT NUMBER: 0128-095-13
PROJECT: UVU Classroom Building
DATE STARTED: 01/26/13
LOCATION: UVU Campus, Orem, Utah
DATE FINISHED: 01/26/13 **GSH Field Rep.:** RAG
DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger
HAMMER: Automatic **WEIGHT:** 140 lbs **DROP:** 30"
GROUNDWATER DEPTH: 11.1' (2/1/13)
ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0								
		3.5" ASPHALT									
		7.0" ROADBASE									
	SP/SM FILL	**FINE TO COARSE SAND, FILL** with trace to some silt, trace to some gravel; gray-brown									moist medium dense
				34		16.3	116				
	CL	**SILTY CLAY** with some fine sand; brown									moist stiff
			5	18		22.3	101				
		grades with some oxidation mottling									
				9		33.4	87				very moist to saturated medium stiff
			10	10		33.9	86				very moist to saturated
	SP/SM	**FINE SAND** with trace to some silt; brown									
			15	37							saturated
	CL	**SILTY CLAY** with occasional layers less than 1" thick of silty sand; brown with some oxidation mottling									
			20	6							saturated medium stiff
		grades with layers up to 5" thick of silty sand	25	3							soft

See Subsurface Conditions section in the report for additional information.

FIGURE 3B

BORING LOG

BORING: B-2

CLIENT: State of Utah, DFCM
PROJECT NUMBER: 0128-095-13
PROJECT: UVU Classroom Building
DATE STARTED: 01/26/13

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
			25								
		grades with layers up to 4” thick of silty fine sand	30	15							
	SM	**SILTY FINE SAND** with occasional layers less than 1” thick of silty clay; brown with some oxidation mottling	35	17							
	CL	**SILTY CLAY** with some fine sand and with occasional layers up to 6” thick of silty fine sand; brown with oxidation mottling	40	13							
		End of exploration at 40.5’. Installed 1-1/4” diameter slotted PVC pipe to 40.5’.	45 50								

See Subsurface Conditions section in the report for additional information.

FIGURE 3B
(cont’d)

GSH

BORING LOG

BORING: B-3

CLIENT: State of Utah, DFCM
PROJECT NUMBER: 0128-095-13
PROJECT: UVU Classroom Building
DATE STARTED: 01/26/13
LOCATION: UVU Campus, Orem, Utah
DATE FINISHED: 01/26/13 **GSH Field Rep.:** RAG
DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger
HAMMER: Automatic **WEIGHT:** 140 lbs **DROP:** 30"
GROUNDWATER DEPTH: 12.1' (02/01/13)
ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0								
		4.5" ASPHALT									
		7.0" ROADBASE									
	CL	**SILTY CLAY** with some fine sand; brown with oxidation mottling									moist stiff
				14		29.4	91				
			5	25		31.0	88				very stiff
		grades with numerous interbedded layers of silty sand		11		27.8	86				very moist stiff
	SM	**SILTY FINE SAND** with numerous thin layers of silty clay; brown	10	22		24.8	99				very moist to saturated
▼	CL	**SILTY CLAY** with some fine sand and occasional layers up to 3" thick of silty fine sand; brown									
			15	12							saturated stiff
		grades with occasional layers up to 1" thick of silty fine sand	20	8							
		grades with layers up to 3" thick of silty sand	25	9							

See Subsurface Conditions section in the report for additional information.

FIGURE 3C

BORING LOG

BORING: B-3

CLIENT: State of Utah, DFCM
PROJECT NUMBER: 0128-095-13
PROJECT: UVU Classroom Building
DATE STARTED: 01/26/13

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
			25								
			30	11							
		grades with numerous layers of clayey/silty sand	35	12							
		sand layers grade out	40	8							
		End of exploration at 40.5'. No groundwater encountered at time of drilling. Installed 1-1/4" diameter slotted PVC pipe to 40.5'.	45 50								

See Subsurface Conditions section in the report for additional information.

FIGURE 3C
(cont'd)

GSH

BORING LOG

BORING: B-4

CLIENT: State of Utah, DFCM
PROJECT NUMBER: 0128-095-13
PROJECT: UVU Classroom Building
DATE STARTED: 01/27/13
LOCATION: UVU Campus, Orem, Utah
DATE FINISHED: 01/27/13 **GSH Field Rep.:** RAG
DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger
HAMMER: Automatic **WEIGHT:** 140 lbs **DROP:** 30"
GROUNDWATER DEPTH: 19.0' (01/27/13)
ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0								
		3.0" ASPHALT									
		7.0" ROADBASE									
	CL	**SILTY CLAY** with trace fine sand; brown									moist hard
				89							
			5	22							very stiff
		grades with occasional layers up to 1/8" thick of fine sand		10		34.4	85				medium stiff
			10	10		34.1	87				
		grades with occasional layers up to 4" thick of silty sand	15	9							stiff
▼											saturated
			20	12							
		grades with layers up to 3" thick of silty sand	25	6							medium stiff

See Subsurface Conditions section in the report for additional information.

FIGURE 3D

GSH

BORING LOG

BORING: B-4

CLIENT: State of Utah, DFCM
PROJECT NUMBER: 0128-095-13
PROJECT: UVU Classroom Building
DATE STARTED: 01/26/13

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
			25								
	SC/ CL	**CLAYEY SAND/SANDY CLAY** with numerous layers up to 1/2" thick of silty clay									
			30	0							saturated very loose/very soft
			35	1							
			40	7							medium stiff
	CL	**FINE SANDY CLAY** with some silt									
		End of exploration at 41.0'. Installed 1-1/4" diameter slotted PVC pipe to 41.0'.	45								
			50								

See Subsurface Conditions section in the report for additional information.

FIGURE 3D (cont'd)

GSH

BORING LOG

BORING: B-5

CLIENT: State of Utah, DFCM
PROJECT NUMBER: 0128-095-13
PROJECT: UVU Classroom Building
DATE STARTED: 01/27/13
LOCATION: UVU Campus, Orem, Utah
DATE FINISHED: 01/27/13 **GSH Field Rep.:** RAG
DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger
HAMMER: Automatic **WEIGHT:** 140 lbs **DROP:** 30"
GROUNDWATER DEPTH: 13.0' (01/27/13) 13.5' (02/01/13)
ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface	0								
		3.5" ASPHALT									
		7.0 ROADBASE									
	SP FILL	**FINE TO MEDIUM SAND, FILL** with trace silt and clay and fine gravel; gray		49							moist medium dense
	CL	**SILTY CLAY** with trace fine sand; gray	5	26		26.7	96				moist very stiff
		grades with numerous layers up to 1/2" thick of silty fine sand		19		27.9	93				stiff
			10	10		32.1	90				medium stiff very moist to saturated
▼											saturated
			15	4							soft
			20	4							
			25	10							medium stiff

See Subsurface Conditions section in the report for additional information.

FIGURE 3E

BORING LOG

BORING: B-5

CLIENT: State of Utah, DFCM
PROJECT NUMBER: 0128-095-13
PROJECT: UVU Classroom Building
DATE STARTED: 01/26/13

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
			25								
		grades with numerous layers up to 1/4” thick of silty fine sand	30	13							saturated stiff
			35	18							
			40	13							
		End of exploration at 41.0’. Installed 1-1/4” diameter slotted PVC pipe to 41.0’.	45								
			50								

See Subsurface Conditions section in the report for additional information.

FIGURE 3E
(cont’d)

PROJECT: UVU Classroom Building
PROJECT LOCATION: UVU Campus, Orem, Utah
PROJECT NUMBER: 0128-095-13

KEY TO BORING LOG

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12

COLUMN DESCRIPTIONS

1. **Water Level**: Depth to measure groundwater table. See symbol below.
2. **USCS**: Graphic depiction of subsurface material encountered; typical symbols are explaned below.
3. **Description**: Description of material encountered; may include color, moisture, grain size, and density/consistency.
4. **Depth (ft.)**: Depth in feet below the ground surface.
5. **Blow Count**: Number of blows required to advance sampler (12 inches) beyond first. using a 140-lb hammer with a 30 inch drop.
6. **Sample Symbol**: Type of soil sample collected at depth interval shown; sampler symbols are explained below.
7. **Moisture (%)**: Water content of soil sample measured in laboratory; expressed as percentage of dry weight of specimen.
8. **Dry Density (pcf)**: The density of a soil measured in laboratory; expressed as pounds per cubic foot.
9. **% Passing 200:** Fines content of soil sample passing a No. 200 sieve measured in laboratory, expressed as a percentage.
10. **Liquid Limit (%):** Water content at which a soil changes from plastic to liquid behavior.
11. **Placsticity Index (%):** Range of water content at which a soil exhibits plastic properties.
12. **Remarks**: Comments and observations regarding drilling or sampling made by driller or field personnel. Other field and laboratory test results; using the following abbreviations:

CEMENTATION

Weakly: Crumbles or breaks with handling of slight finger pressure.
Moderately: Crumbles or breaks with considerable finger pressure.
Strongly: Will not crumble or break with finger pressure.

MODIFIERS

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

MOISTURE CONTENT (FIELD TEST)

Dry: Absence of moisture, dusty, dry to the touch.
Moist: Damp but no visible water.
Saturated: Visible water, usually soil below water table.

Descriptions and stratum lines are interpretive; field descriptions may have been modified to reflect lab test results. Descriptions on the logs apply only at the specific boring locations and at the time the borings were advanced; they are not warranted to be representative of subsurface conditions at other locations or times.

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			SYMBOLS Graph	SYMBOLS Letter	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS More than 50% of No. 200 sieve size.	GRAVELS More than 50% of coarse fraction retained in No. 4 sieve.	CLEAN GRAVELS (little or no fines)		GW	Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
				GP	Poorly-Graded Gravel, Gravel-Sand Mixtures, Little or No Fines
		GRAVELS WITH FINES (appreciable amount of fines)		GM	Silty Gravels, Gravel-Sand-Silt Mixtures
				GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	SANDS More than 50% of coarse fraction passing through No. 4 sieve.	CLEAN SANDS (little or no fines)		SW	Well-Graded Sands, Gravelly Sands, Little or No Fines
				SP	Poorly Graded Sands, Gravelly Sands, Little or No Fines
		SANDS WITH FINES (appreciable amount of fines)		SM	Silty Sands, Sand-Clay Mixtures
				SC	Clayey Sands, Sand-Clay Mixtures
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 sieve size.	SILTS AND CLAYS Liquid limit less than 50%			ML	Inorganic Silts and Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with Slight Plasticity
				CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
				OL	Organic Silts and Organic Silty Clays of Low Plasticity
	SILTS AND CLAYS Liquid limit greater than 50%			MH	Inorganic Silts, Micacious or Diatomacious Fine Sand or Silty Soils
				CH	Inorganic Clays of High Plasticity, Fat Clays
				OH	Organic Clays of Medium to High Plasticity, Organic Silts
HIGHLY ORGANIC SOILS				PT	Peat, Humus, Swamp Soils with High Organic Contents

Note: Dual Symbols are used to indicate borderline soil classifications

STRATIFACTION

DESCRIPTION	THICKNESS
Seam	up to 1/8"
Layer	1/8" - 12"

STRATIFACTION

Occasional: One or less per 6" of thickness.
Numerous: More than one per 6" of thickness.

TYPICAL SAMPLER GRAPHIC SYMBOLS

- Bulk/Bag Sample
- Standard Penetration Split Spoon Sampler
- Rock Core
- No Recovery
- 3.25" OD 2.42" ID D&M Sampler
- 3.0" OD 2.42" ID D&M Sampler
- California Sampler
- Thin Wall

LOG KEY SYMBOLS

- Water Level

FIGURE 4

GSH