REPORT
GEOTECHNICAL STUDY
PROPOSED SINGLE-FAMILY HOME
LOTS 28 AND 29 EASTWOOD ESTATES NO. 10
ABOUT 5973 SOUTH 2950 EAST
NEAR OGDEN, WEBER COUNTY, UTAH

Submitted To:

Herbert Christian
1368 Eagle Court
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Submitted By:

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September 9, 2015

Job No. 1931-01N-15

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Mr. Herbert Christian
1368 Eagle Court
Windsor, Colorado 80550

Re: Report
Geotechnical Study
Proposed Single-Family Home
Lots 28 and 29 Eastwood Estates No. 10
About 5973 South 2950 East
Near Ogden, Weber County, Utah
(41.1537 N; -111.9072 W)

1. INTRODUCTION

1.1 GENERAL

This report presents the results of our geotechnical study performed for the proposed home on Lots 28 and 29 of the Eastwood Estates No. 10 development located at about 5973 South 2950 East near Ogden in Weber County, Utah. The general location of the site with respect to major roadways, as of 2014, is presented on Figure 1, Vicinity Map. A more detailed aerial view of the site showing the existing roadways and improvements is presented on Figure 2, Site Plan. The locations of the borings drilled in conjunction with this study are also presented on Figure 2.

1.2 OBJECTIVES AND SCOPE

The objectives and scope of our study were planned in discussions between Mr. Herbert Christian, Mr. Mark Babbitt of Great Basin Engineering, and Mr. Andrew Harris of GSH Geotechnical, Inc. (GSH).

In general, the objectives of this study were to:

1. Define and evaluate the subsurface soil and groundwater conditions across the site.

2. Provide appropriate foundation, earthwork, and slope stability recommendations as well as geoseismic information to be utilized in the design and construction of the proposed home.

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

1. A field program consisting of the excavating, logging, and sampling of 3 test pits.

2. A laboratory testing program.

3. An office program consisting of the correlation of available data, engineering analyses, and the preparation of this summary report.

1.3 AUTHORIZATION

Authorization was provided by returning a signed copy of our Professional Services Agreement No. 15-0644N dated June 24, 2015 and executed July 3, 2015.

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, projected groundwater conditions, 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 project consists of constructing a single-family residence on Lots 28 and 29 of the Eastwood Estates No. 10 development located at about 5973 South 2950 East near Ogden in Weber County, Utah. Construction will likely consist of reinforced concrete footings and basement foundation walls supporting 1 to 3 wood-framed levels above grade with some stone, brick, or stucco veneer. Projected maximum column and wall loads are on the order of 10 to 50 kips and 1 to 3 kips per lineal foot, respectively.

Site development will require a moderate amount of earthwork in the form of site grading. We estimate in general that maximum cuts and fills to achieve design grades will be on the order of 2 to 5 feet. Larger fills and cuts may be required at isolated areas and should be engineered accordingly to maintain stability of the slopes at the site.

3. INVESTIGATIONS

3.1 FIELD PROGRAM

In order to define and evaluate the subsurface soil and groundwater conditions at the site, 2 borings were drilled to depths of about 52.0 to 102.0 feet below existing grade within the proposed home location. The borings were drilled using a truck-mounted drill rig equipped with air-rotary and a downhole hammer (Odex). Locations of the borings 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, samples of the typical soils encountered were obtained for subsequent laboratory testing and examination. The soils were classified in the field based upon visual and textural examination. These classifications have been supplemented by subsequent inspection and testing in our laboratory. Detailed graphical representation of the subsurface conditions encountered is presented on Figures 3A through 3C, Boring Log. 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) and a 2.0-inch outside diameter, 1.38-inch inside diameter drive sampler (SPT) were utilized in the subsurface soil sampling. The blow counts recorded on the boring logs were those required to drive the sampler 12 inches with a 140-pound hammer dropping 30 inches.

Following completion of drilling operations, 1.25-inch diameter slotted PVC pipe was installed in Boring B-1 and B-2 in order to provide a means of monitoring potential groundwater fluctuations. The borings were backfilled with auger cuttings.

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, Atterberg limits, full and partial gradation, and direct shear tests. The following paragraphs describe the tests and summarize the test data.

3.2.2 Moisture and Density

To provide index parameters and to correlate other test data, moisture and density tests were performed on selected samples. The results of these tests are presented on the boring logs, Figures 3A and 3B.

3.2.3 Atterberg Limit Tests

To aid in classifying the soils, Atterberg limit tests were performed on s sample of the onsite soils. Results of the test are tabulated below:

Boring No.	Depth (feet)	Liquid Limit (percent)	Plastic Limit (percent)	Plasticity Index (percent)	Soil Classification
B-2	90.5	33	19	14	SC

3.2.4 Full and Partial Gradation Test

Gradation tests were performed to aid in classifying soils. The tests results are tabulated below:

Boring No.	Depth (feet)	Soil Type	Percent Passing													
			4”	3”	2”	1 ½”	1”	3/4”	1/2”	3/8”	No. 4	No. 10	No. 20	No. 40	No. 100	No. 200
B-1	10.5	SP/SM	---	---	---	---	---	---	100	79	63	42	25	17	9	5.9
B-1	30.5	SP/SM	---	---	---	---	---	---	---	---	---	---	---	---	---	6.6
B-1	40.5	SP/SM	---	---	---	---	---	---	---	---	---	---	---	---	---	9.6
B-2	10.5	GP	---	---	---	---	100	60	--	46	30	20	13	9	5	3.2
B-2	25.5	GP/GM	---	---	---	---	---	---	---	---	---	---	---	---	---	8.6
B-2	40.5	GP/GM	---	---	---	---	100	79	---	45	35	27	19	14	8	5.9
B-2	70.5	SP/SM	---	---	---	---	---	---	---	---	---	---	---	---	---	11.8
B-2	90.5	SC	---	---	---	---	---	---	---	---	---	---	---	---	---	24.8

3.2.5 Laboratory Direct Shear Test

To determine the shear strength of the soils encountered at the site, laboratory direct shear tests were performed on each of 2 remolded samples of the site soils. The results of the tests are tabulated below:

Boring No.	Depth (feet)	Soil Type	Remolded Moisture Content (percent)	Remolded Dry Density (pcf)	Internal Friction Angle (degrees)	Apparent Cohesion (psf)
B-2	75.5	SP	12	89	36	75
B-2	85.5	SC	12	89	36	300

4. SITE CONDITIONS

4.1 GEOLOGIC SETTING

A geologic hazards evaluation study[1] dated September 1, 2015 was prepared for the subject property by Western Geologic, LLC, and a copy of that report is included in the attached Appendix.

4.2 SURFACE

The subject property consist of two vacant, irregular shaped lots located at about 5973 South 2950 East near Ogden in Weber County, Utah. The topography slopes downward to the west/southwest at grades of 1.4H:1V to 8H:1V (Horizontal:Vertical), with an overall change in elevation of about 140 feet across the site. Vegetation at the site consists primarily of native weeds, grasses, and a number of mature trees, particular over the slope area. The site is bordered on north and south residential development, by 2950 East to the east, and by Melanie Lane to the west.

4.3 SUBSURFACE SOIL

Subsurface conditions encountered at the boring locations were relatively consistent across the site. At the boring locations, topsoil and disturbed soils were encountered at the surface to about 2 to 3 inches below existing grades. Natural soils were encountered beneath the topsoil and disturbed soils to the full depth penetrated, about 52.0 to 102.0 feet, and consisted of fine and coarse gravel with fine to coarse sand and varying amounts of silt, fine to coarse sand with varying amounts of fine and coarse gravel and varying amounts of silt and clay, and occasional mixtures of these soils.

The natural sand and gravel soils encountered were medium dense to very dense, slightly moist to moist, brown to reddish brown to gray in color, and will generally exhibit moderately high strength and low compressibility characteristics under the anticipated loading.

For a more detailed description of the subsurface soils encountered, please refer to Figures 3A and 3B, Boring Log. The lines designating the interface between soil types on the test pit logs generally represent approximate boundaries. In-situ, the transition between soil types may be gradual.

4.4 GROUNDWATER

During and subsequent to drilling, groundwater was not encountered at the boring locations to depths of 102.0 feet. Groundwater is anticipated to be at significant depths in the area.

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[1] "Report, Geologic Hazards Evaluation, Eastwood Estates Lots 28 and 29, 5973-5995 South 2950 East, Ogden, Weber County, Utah," Western Geologic, LLC, September 1, 2015.

5. DISCUSSIONS AND RECOMMENDATIONS

5.1 SUMMARY OF FINDINGS

The results of our analyses indicate that the proposed structure may be supported upon conventional spread and/or continuous wall foundations established upon suitable natural soils or granular structural fill extending to suitable natural soils.

The most significant geotechnical aspect of the site is maintaining stability of the slope at the rear of the property.

All non-engineered fills (if encountered) must be removed to suitable natural soils below building foundations. The existing non-engineered fills may remain in flexible pavement and slab areas if they are properly prepared, as discussed in this report and subsequent overlying site grading fills are no more than 3 feet in total thickness.

The on-site soils may be re-utilized as structural site grading fill if they meet the requirements for such, as stated herein. However, it must be noted that from a handling and compaction standpoint, soils containing high amounts of fines (silts and clays) are very sensitive to changes in moisture content and will require very close moisture control during placement and compaction. <u>This will be very difficult, if not impossible, during wet and cold periods of the year.</u>

A geotechnical engineer from GSH will need to verify that all fill material (if encountered) and topsoil/disturbed soils have been completely removed and/or properly prepared and suitable natural soils encountered prior to the placement of structural site grading fills, floor slabs, footings, foundations, or rigid pavements.

In the following sections, detailed discussions pertaining to earthwork, foundations, lateral pressure and resistance, floor slabs, slope stability, 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 surface vegetation (if encountered), topsoil (if encountered), loose surficial fill piles, and any other deleterious materials from beneath an area extending out at least 3 feet from the perimeter of the proposed building and 2 feet beyond pavements and exterior flatwork areas.

All non-engineered fills must be removed below all foundations. In situ, non-engineered fills may remain below floor slabs and pavements if free of debris and deleterious materials, less than 4 feet in thickness, and if properly prepared. Proper preparation will consist of the scarification of the upper 12 inches below asphalt concrete (flexible pavement) and 24 inches below rigid pavement/floor slabs followed by moisture preparation and re-compaction to the requirements of structural fill. The thicker sequence of prepared soils below slabs/rigid pavements would require the temporary removal of 12 inches of fill soils, scarifying, moisture conditioning, and recompacting the underlying 12 inches and backfilling with 12 inches of compacted suitable fills.

Even with proper preparation, pavements/slabs established overlying non-engineered fills may encounter some long-term movements unless the non-engineered fills are completely removed. Installing reinforcement in slabs over fills may help reduce potential displacement cracking.

It must be noted that from a handling and compaction standpoint, onsite soils containing high amounts of fines (silts and clays) are inherently more difficult to rework and 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.

Subsequent to stripping and prior to the placement of structural site grading fill, pavements, driveway, and parking slabs on grade, the prepared subgrade must be proofrolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. If excessively soft or loose soils are encountered, they must be removed to a maximum depth of 2 feet and replaced with structural fill. Beneath footings, all loose and disturbed soils must be totally removed. Fill soils must be handled as described above.

Surface vegetation, construction/demolition debris, and other deleterious materials shall generally be removed from the site. Topsoil, although unsuitable for utilization as structural fill, may be stockpiled for subsequent landscaping purposes.

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

5.2.2 Excavations

For granular (cohesionless) soils, construction excavations above the water table, not exceeding 4 feet, shall be no steeper than one-half horizontal to one vertical (½H:1V). For excavations up to 10 feet, in granular soils and above the water table, the slopes shall be no steeper than one horizontal to one vertical (1H:1V). Excavations encountering saturated cohesionless soils will be very difficult and will require very flat sideslopes and/or shoring, bracing and dewatering. Excavations deeper than 8 feet are not anticipated at the site.

Temporary excavations up to 10 feet deep in fine-grained cohesive soils (if encountered), above or below the water table, may be constructed with sideslopes no steeper than one-half horizontal to one vertical (½H:1V).

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

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

5.2.3 Structural Fill

Structural fill will be required as site grading fill, as backfill over foundations and utilities, and possibly as replacement fill beneath some footings. All structural fill must be free of sod, rubbish, construction debris, frozen soil, and other deleterious materials.

Structural site grading fill is defined as fill placed over fairly large open areas to raise the overall site grade. The maximum particle size within structural site grading fill should generally not exceed 4 inches; although, occasional particles up to 6 to 8 inches may be incorporated provided that they do not result in "honeycombing" or preclude the obtainment of the desired degree of compaction. In confined areas, the maximum particle size should generally be restricted to 2.5 inches.

On-site granular soils may be re-utilized as structural site grading fill if they do not contain construction debris or deleterious material and meet the requirements of structural fill. However, due to the percentage of rock larger than 3/4 –inches in the gravelly soils at the site, placement and compaction would have to be verified by full time observation as inplace density testing with a nuclear densometer would be unfeasible. Fine-grained soils (clays/silts) are not recommended as structural fill.

Only granular soils are recommended in confined areas such as utility trenches, below footings, etc. Generally, we recommend that all imported granular structural fill consist of a well-graded mixture of sands and gravels with no more than 20 percent fines (material passing the No. 200 sieve) and less than 30 percent retained on the 3/4 inch sieve. The plasticity index of import fine-grained soil shall not exceed 18 percent.

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

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

5.2.4 Fill Placement and Compaction

All 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 ASTM[2] D-1557 (AASHTO[3] T-180) compaction criteria in accordance with the table below:

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Beneath an area extending at least 5 feet beyond the perimeter of the structure	0 to 10	95
Site Grading Fills outside area defined above	0 to 5	90
Site Grading Fills outside area defined above	5 to 10	95
Trench Backfill	--	96
Pavement granular base/subbase	--	96

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 shall consist of the removal of all loose or disturbed soils.

If utilized for stabilizing fill, coarse gravel and cobble mixtures 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 shall be adequately compacted so that the “fines” are “worked into” the voids in the underlying coarser gravels and cobbles.

5.2.5 Utility Trenches

All utility trench backfill material below structurally loaded facilities (flatwork, floor slabs, roads, etc.) shall be placed at the same density requirements established for structural fill. If the surface of the backfill becomes disturbed during the course of construction, the backfill shall be proofrolled and/or properly compacted prior to the construction of any exterior flatwork over a

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

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 must 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-1-a/A-1-b (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.

The natural or imported silt/clay soils are not recommended for use as trench backfill, particularly in structurally loaded areas.

5.3 SLOPE STABILITY

5.3.1 Parameters

The properties of the sand soils at this site were estimated using the results of our laboratory testing, published correlations, and our experience with similar soils. Based on tests performed by the Bureau of Reclamation[4], poorly graded clean sands and sand-gravel mixtures have an internal friction angle ranging from 36 to 38 degrees and clayey sands have an internal friction angle ranging from 28 to 34 degrees and a cohesion varying from 120 to 360 pounds per square foot. Accordingly, we estimated the following parameters for use in the stability analyses:

Accordingly, we estimated the following parameters for use in the stability analyses:

Material	Internal Friction Angle (degrees)	Apparent Cohesion (psf)	Unit Weight (pcf)
Sand/Gravel	35	75	120
Clayey Sand	36	250	115

For the seismic (pseudostatic) analysis, a peak horizontal ground acceleration of 0.495*g* after adjusting for Site Class C was obtained for site (grid) locations of 41.1537 degrees latitude (north) and 111.9072 degrees longitude (west). To model sustained accelerations at the site, one-half of this value is typically employed. Accordingly, a value of 0.25g was used as the pseudostatic coefficient for the stability analysis.

[4] U.S. Bureau of Reclamation, 1987, "Design Standards No. 13, Embankment Dams," Denver, Colorado.

5.3.2 Stability Analyses

We evaluated the global stability of the existing slope using the computer program *SLIDE*. This program uses a limit equilibrium (Simplified Bishop) method for calculating factors of safety against sliding on an assumed failure surface and evaluates numerous potential failure surfaces, with the most critical failure surface identified as the one yielding the lowest factor of safety of those evaluated. We analyzed the following configuration based on cross-sections provided in the referenced geologic study (see appendix for cross-section information and locations):

- A relatively flat roadway followed by an approximately 15-foot high slope inclined at approximately 1V:2H (Vertical:Horizontal) grading to an approximately 40-foot high slope inclined at approximately 1V:1.4H (Vertical:Horizontal) grading to an approximately 10-foot high slope inclined at about 1V:7.5H (Vertical:Horizontal) grading to an approximately 10-foot high slope inclined at about 1V:4.5H (Vertical:Horizontal) grading to an approximately 25-foot high slope inclined at about 1V:1.8H (Vertical:Horizontal) grading to an approximately 22-foot high slope inclined at about 1V:2.5H (Vertical:Horizontal) grading to an approximately 23-foot high slope inclined at about 1V:8H (Vertical:Horizontal) where the proposed home will be located grading to a relatively flat area for the upper roadway. To simulate the load imposed on the slope by the proposed home, a load of 2,000 pounds per square foot was modeled at 15 feet from the crest of the slope.

Typically, the required minimum factors of safety are 1.5 for static conditions and 1.0 for seismic (pseudostatic) conditions. The results of our analyses indicate that the existing slope configuration with the addition of the proposed home will meet both these requirements provided our recommendations are followed. The slope stability data are included as Figure 5 and 6, attached.

Note that slope movements or even failure can occur if the slope soils are undermined or become saturated. Therefore, we recommend that irrigation lines not be placed on the slope. Surface drainage at the bottom and top of the slope must also be directed to prevent ponding at the toe or crest of the slope. The property owner and the owner’s representatives must be made aware of the risks should these or other conditions occur that could saturate or erode/undermine the slope soils.

5.4 SPREAD AND CONTINUOUS WALL FOUNDATIONS

5.4.1 Design Data

The proposed structure may be supported upon conventional spread and continuous wall foundations established upon suitable natural soils and/or structural fill extending to suitable natural 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	- 16 inches
Minimum Recommended Width for Isolated Spread Footings	- 24 inches
Recommended Net Bearing Pressure for Real Load Conditions	- 2,000 pounds per square foot
Bearing Pressure Increase for Seismic Loading	- 50 percent

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

5.4.2 Installation

Footings shall not be installed upon soft or disturbed soils, non-engineered fill, construction debris, frozen soil, or within ponded water. If the granular structural fill upon which the footings are to be established become disturbed, it shall be recompacted to the requirements for structural fill or be removed and replaced with structural fill.

The width of structural fill, where placed below footings, shall extend laterally at least 6 inches beyond the edges of the footings in all directions for each foot of fill thickness beneath the footings. For example, if the width of the footing is 2 feet and the thickness of the structural fill beneath the footing is 2.0 feet, the width of the structural fill at the base of the footing excavation would be a total of 4.0 feet, centered below the footing.

5.4.3 Settlements

Maximum settlements of foundations designed and installed in accordance with recommendations presented herein and supporting maximum anticipated loads as discussed in Section 2, Proposed Construction, are anticipated to be 1 inch or less.

Approximately 40 percent of the quoted settlement should occur during construction.

5.5 LATERAL RESISTANCE

Lateral loads imposed upon foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footings and the supporting soils. In determining frictional resistance, a coefficient of 0.30 should be utilized for foundations placed over natural soils and 0.40 for foundations placed over structural fill. 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.

5.6 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. The above values assume that the surface of the soils slope behind the wall is no steeper than 4 horizontal to 1 vertical and that the granular fill within 3 feet of the wall will be compacted with hand-operated compacting equipment.

For seismic loading, a uniform pressure shall be added. The uniform pressures based on different wall heights are provided in the following table:

Wall Height (feet)	**Seismic Loading Active Case (psf)**	**Seismic Loading Moderately Yielding (psf)**
4	25	55
6	40	85
8	55	115

5.7 FLOOR SLABS

Floor slabs may be established upon suitable natural soils and/or upon structural fill extending to suitable natural soils. Under no circumstances shall floor slabs be established over non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. In order to provide a capillary break and facilitate curing of the concrete, it is recommended that floor slabs be directly underlain by 4 inches of "free-draining" fill, such as "pea" gravel or three-quarters- to one-inch minus clean gap-graded gravel.

Settlement of lightly loaded floor slabs (average uniform pressure of 200 pounds per square foot or less) is anticipated to be less than 1/4 inch.

5.8 SUBDRAINS

5.8.1 General

Groundwater was not encountered at the site, however we recommend that the perimeter foundation subdrains be installed as indicated below.

5.8.2 Foundation Subdrains

Foundation subdrains should consist of a 4-inch diameter perforated or slotted plastic or PVC pipe enclosed in clean gravel. The invert of a subdrain should be at least 2 feet below the top of the lowest adjacent floor slab. The gravel portion of the drain should extend 2 inches laterally and below the perforated pipe and at least 1 foot above the top of the lowest adjacent floor slab. The gravel zone must be installed immediately adjacent to the perimeter footings and the foundation walls. To reduce the possibility of plugging, the gravel must be wrapped with a geotextile, such as Mirafi 140N or equivalent. Above the subdrain, a minimum 4-inch-wide zone of "free-draining" sand/gravel should be placed adjacent to the foundation walls and extend to within 2 feet of final grade. The upper 2 feet of soils should consist of a compacted clayey cap to reduce surface water infiltration into the drain. As an alternative to the zone of permeable sand/gravel, a prefabricated "drainage board," such as Miradrain or equivalent, may be placed adjacent to the exterior below-grade walls. Prior to the installation of the footing subdrain, the below-grade walls should be dampproofed. The slope of the subdrain should be at least 0.3 percent. The gravel placed around the drain pipe should be clean 0.75-inch to 1.0-inch minus gap-graded gravel and/or "pea" gravel. The foundation subdrains can be discharged into the area subdrains, storm drains, or other suitable down-gradient location.

We recommend final site grading slope away from the structures at a minimum 2 percent for hard surfaces (pavement) and 5 percent for soil surfaces within the first 10 feet from the structures.

5.9 GEOSEISMIC SETTING

5.9.1 General

Utah municipalities have adopted the International Building Code (IBC) 2012. The IBC 2012 code determines the seismic hazard for a site based upon 2008 mapping of bedrock accelerations prepared by the United States Geologic Survey (USGS) and the soil site class. The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points).

The structure must be designed in accordance with the procedure presented in Section 1613, Earthquake Loads, of the IBC 2012 edition.

5.9.2 Faulting

Based upon our review of available literature, no active faults are known to pass through the site. The nearest active fault is the Wasatch Fault Zone Weber Section, approximately 600 feet west of the proposed building area.

5.9.3 Soil Class

For dynamic structural analysis, the Site Class C – Very Dense Soil and Soft Rock Profile as defined in Chapter 20 of ASCE 7 (per Section 1613.3.2, Site Class Definitions, of IBC 2012) can be utilized.

5.9.4 Ground Motions

The IBC 2012 code is based on 2008 USGS mapping, which provides values of short and long period accelerations for the Site Class B boundary for the Maximum Considered Earthquake (MCE). This Site Class B boundary represents average bedrock values for the Western United States and must be corrected for local soil conditions. The following table summarizes the peak ground and short and long period accelerations for the MCE event and incorporates the appropriate soil amplification factor for a Site Class C soil profile. Based on the site latitude and longitude (41.5265 degrees north and -111.8022 degrees west, respectively), the values for this site are tabulated on the following page.

Spectral Acceleration Value, T	Site Class B Boundary [mapped values] (% g)	Site Coefficient	Site Class C [adjusted for site class effects] (% g)	Design Values (% g)
Peak Ground Acceleration	49.5	F_a = 1.000	49.5	33.0
0.2 Seconds (Short Period Acceleration)	S_S = 123.8	F_a = 1.000	S_{MS} = 123.8	S_{DS} = 82.5
1.0 Second (Long Period Acceleration)	S_1 = 47.0	F_v = 1.330	S_{M1} = 62.5	S_{D1} = 41.7

5.9.5 Liquefaction

The site is located in an area that has been identified by the Utah Geologic Survey as having "very low" liquefaction potential. Liquefaction is defined as the condition when saturated, loose, finer-grained sand-type soils lose their support capabilities because of excessive pore water pressure which develops during a seismic event. Clay soils, even if saturated, will generally not liquefy.

Liquefaction of the site soils is not anticipated during the design seismic event due to the medium dense to very dense and unsaturated nature of the granular soils observed at the site.
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5.10 SITE OBSERVATIONS

As stated previously, prior to placement of foundations, floor slabs, pavements, and site grading fills, a geotechnical engineer from GSH must verify that all non-engineered fill materials, topsoil, and disturbed soils have been removed and/or properly prepared and suitable subgrade conditions encountered. Additionally, GSH must observe fill placement and verify in-place moisture content and density of fill materials placed at the site.

5.11 CLOSURE

If you have any questions or would like to discuss these items further, please feel free to contact us at (801) 393-2012.

Respectfully submitted,

GSH Geotechnical, Inc.

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State of Utah No. 740456
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Reviewed by:

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AMH/MSH:mmh

Encl. Figure 1, Vicinity Map
Figure 2, Site Plan
Figures 3A and 3B, Boring Logs
Figure 4, Key to Boring Log (USCS)
Figures 5 and 6, Stability Results
Appendix

Addressee (Email)

HERBERT CHRISTIAN
JOB NO. 1931-01N-15

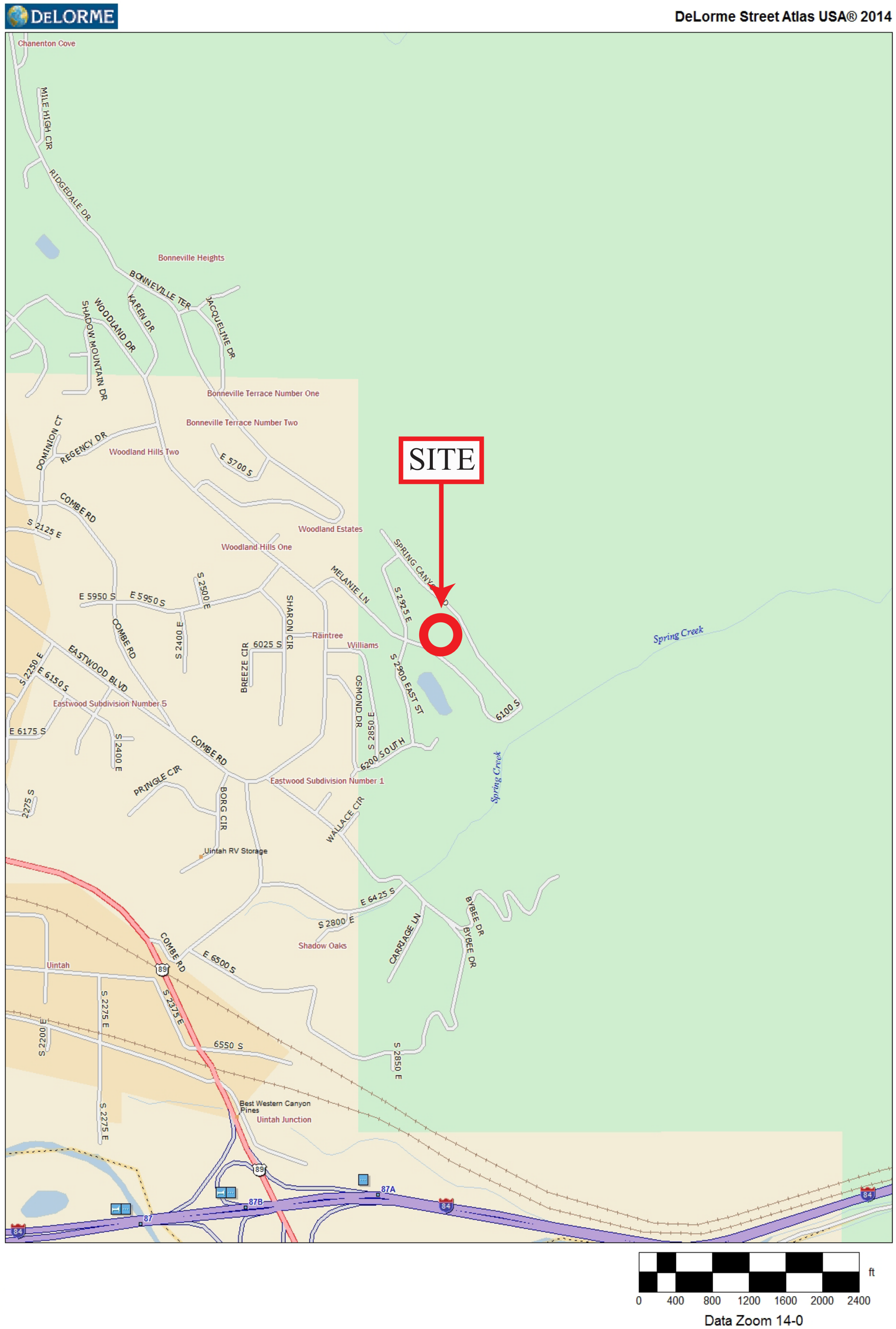


FIGURE 1
VICINITY MAP

GSH

REFERENCE:
DELORME STREET ATLAS

HERBERT CHRISTIAN
JOB NO. 1931-01N-15

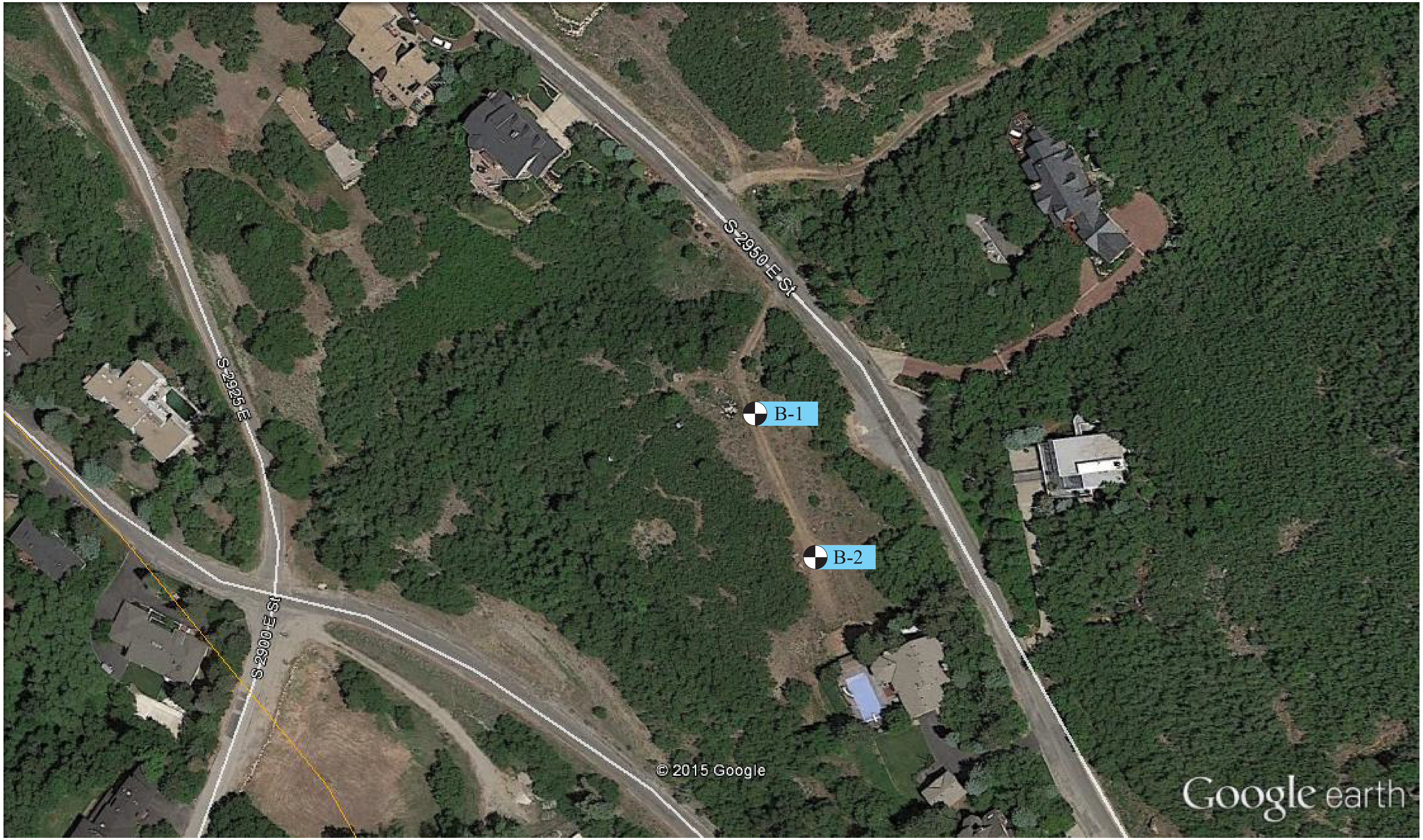


FIGURE 2
SITE PLAN

GSH

REFERENCE:
ADAPTED FROM AERIAL PHOTOGRAPH
DOWNLOADED FROM GOOGLE EARTH
IMAGERY DATE: JUNE 4, 2013

NOT TO SCALE

GSH

BORING LOG

BORING: B-1

CLIENT: Herbert Christian | PROJECT NUMBER: 1931-01N-15

PROJECT: Lots 28 and 29 Eastwood Estates No. 10 | DATE STARTED: 7/22/15 | DATE FINISHED: 7/22/15

LOCATION: Lots 28 and 29 Eastwood Estates No. 10, Weber County, Utah | GSH FIELD REP.: RG

DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger | HAMMER: Automatic | WEIGHT: 140 lbs | DROP: 30"

GROUNDWATER DEPTH: Not Encountered (7/22/15), Not Encountered (7/29/15) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface									
	SM GM	SILTY FINE AND COARSE GRAVEL with fine to coarse sand; occasional cobbles; major roots (topsoil) to 2"; brown	0								slightly moist loose to 2" very dense
				50/4"							
			5								
				45							dense
	SP SM	FINE TO COARSE SAND with some fine and coarse gravel; brown	10								moist medium dense
				20		2		6			
	GP SP	FINE AND COARSE GRAVEL with fine to coarse sand; some silt; brown	15								slightly moist dense
				91							
	GP	FINE AND COARSE GRAVEL with some fine to coarse sand; trace silt; brown	20								slightly moist very dense
				50/5"							
		grades with occasional cobbles up to 8" in diameter	25								

See Subsurface Conditions section in the report for additional information.

FIGURE 3A

BORING LOG

BORING: B-1

CLIENT: Herbert Christian | PROJECT NUMBER: 1931-01N-15

PROJECT: Lots 28 and 29 Eastwood Estates No. 10 | DATE STARTED: 7/22/15 | DATE FINISHED: 7/22/15

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		grades with occasional cobbles up to 8" in diameter	25								
				50/4"							
	SP SM	SILTY FINE TO COARSE SAND with some fine and coarse gravel; brown	30								slightly moist very dense
				68		1		7			
		grades with occasional cobbles up to 3" in diameter	35	109							moist
			40								dense
				45		3		10			
		grades with occasional fine and coarse gravel	45								medium dense
				56		3	116				
	SP	FINE TO COARSE SAND with some fine and coarse gravel; some silt; brown	50								very moist medium dense
				49							

See Subsurface Conditions section in the report for additional information.

FIGURE 3A
(continued)

BORING LOG

BORING: B-1

CLIENT: Herbert Christian PROJECT NUMBER: 1931-01N-15

PROJECT: Lots 28 and 29 Eastwood Estates No. 10 DATE STARTED: 7/22/15 DATE FINISHED: 7/22/15

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		End of Exploration at 52.0' No groundwater encountered at time of drilling Installed 1.25" diameter slotted PVC pipe to 50.5'	52								
			55								
			60								
			65								
			70								
			75								

See Subsurface Conditions section in the report for additional information.

FIGURE 3A
(continued)

BORING LOG

BORING: B-2

CLIENT: Herbert Christian | PROJECT NUMBER: 1931-01N-15

PROJECT: Lots 28 and 29 Eastwood Estates No. 10 | DATE STARTED: 7/22/15 | DATE FINISHED: 7/22/15

LOCATION: Lots 28 and 29 Eastwood Estates No. 10, Weber County, Utah | GSH FIELD REP.: RG

DRILLING METHOD/EQUIPMENT: 3-3/4" ID Hollow-Stem Auger | HAMMER: Automatic | WEIGHT: 140 lbs | DROP: 30"

GROUNDWATER DEPTH: Not Encountered (7/22/15), Not Encountered (7/29/15) | ELEVATION: ---

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
		Ground Surface									
	SM GM	SILTY FINE TO COARSE SAND with some fine and coarse gravel; major roots (topsoil) to 2"; brown	0								slightly moist loose to 2" dense
				36							
			5								
				31							
	GP	FINE AND COARSE GRAVEL with fine to coarse sand; some silt; brown	10								slightly moist dense
				36		1		3			
	GP	FINE AND COARSE GRAVEL with fine to coarse sand; some silt; brown	15								slightly moist very dense
				113		1	103				
		grades with occasional cobbles									
	GM	SILTY FINE AND COARSE GRAVEL with some fine to coarse sand; brown	20								slightly moist very dense
				50/5"							
		grades with occasional boulders up to 2' in diameter									
	GP	FINE AND COARSE GRAVEL	25								

See Subsurface Conditions section in the report for additional information.

FIGURE 3B

GSH	**BORING LOG** Page: 2 of 4	**BORING: B-2**

CLIENT: Herbert Christian | PROJECT NUMBER: 1931-01N-15

PROJECT: Lots 28 and 29 Eastwood Estates No. 10 | DATE STARTED: 7/22/15 | DATE FINISHED: 7/22/15

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
	GP GM	FINE AND COARSE GRAVEL with some fine to coarse sand; some silt; gray	25								slightly moist very dense
				50/4"		0		9			
			30								moist
				50/4"							
			35								medium dense
				45							
			40								very dense
				82		1		6			
	GP	FINE AND COARSE GRAVEL with fine to coarse sand; brown	45								moist medium dense
				55							
	SP	FINE TO COARSE SAND with some fine and coarse gravel; trace silt; brown	50								moist medium dense
				26							

See Subsurface Conditions section in the report for additional information.

FIGURE 3B (continued)

GSH	BORING LOG	BORING: B-2
	Page: 3 of 4	

CLIENT: Herbert Christian | PROJECT NUMBER: 1931-01N-15

PROJECT: Lots 28 and 29 Eastwood Estates No. 10 | DATE STARTED: 7/22/15 | DATE FINISHED: 7/22/15

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
			52								
	GP	FINE AND COARSE GRAVEL with fine to coarse sand; trace silt; brown	55								moist very dense
				109		2	103				
		grades with some silt	60								slightly moist
				50/2"							
			65								moist
				100+							
	SP SM	FINE TO COARSE SAND with some fine and coarse gravel; some silt; brown	70								moist dense
				36		5		12			
	SP	FINE TO COARSE SAND with some fine and coarse gravel; some silt; reddish-brown	75								moist medium dense
				56							
		grades with occasional layers of clayey fine to coarse sand up to 4" thick; reddish-brown									

See Subsurface Conditions section in the report for additional information.

FIGURE 3B
(continued)

BORING LOG

BORING: B-2

CLIENT: Herbert Christian

PROJECT NUMBER: 1931-01N-15

PROJECT: Lots 28 and 29 Eastwood Estates No. 10

DATE STARTED: 7/22/15 DATE FINISHED: 7/22/15

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSING 200	LIQUID LIMIT (%)	PLASTICITY INDEX	REMARKS
			79								
			80	50/4"							very dense
	SC	CLAYEY FINE TO COARSE SAND occasional fine and coarse gravel; reddish-brown	85	99							moist dense
		grades with occasional layers of fine sandy clay up to 4" thick	90	63		12		25	33	14	very dense
			95	100/5"							
	SP	FINE TO COARSE SAND with some silt; brown	100	50/5"							moist very dense
		End of Exploration at 102.0' No groundwater encountered at time of drilling Installed 1.25" diameter slotted PVC pipe to 102.0'	105								

See Subsurface Conditions section in the report for additional information.

FIGURE 3B
(continued)

CLIENT: Herbert Christian
PROJECT: Lots 28 and 29 Eastwood Estates No. 10
PROJECT NUMBER: 1931-01N-15

KEY TO BORING LOG

WATER LEVEL	USCS	DESCRIPTION	DEPTH (FT.)	BLOW COUNT	SAMPLE SYMBOL	MOISTURE (%)	DRY DENSITY (PCF)	% PASSSING 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 measured groundwater table. See symbol below.

② **USCS:** (Unified Soil Classification System) Description of soils encountered; typical symbols are explained below.

③ **Description:** Description of material encountered; may include color, moisture, grain size, density/consistency,

④ **Depth (ft.):** Depth in feet below the ground surface.

⑤ **Blow Count:** Number of blows to advance sampler 12" beyond first 6", using a 140-lb hammer with 30" 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 dryweight of

⑧ **Dry Density (pcf):** The density of a soil measured in laboratory; expressed in pounds per cubic foot.

⑨ **% Passing 200:** Fines content of soils sample passing a No. 200 sieve; expressed as a percentage.

⑩ **Liquid Limit (%):** Water content at which a soil changes from plastic to liquid behavior.

⑪ **Plasticity 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. May include other field and laboratory test results using the following abbreviations:

CEMENTATION:	MODIFIERS:	MOISTURE CONTENT (FIELD TEST):
Weakly: Crumbles or breaks with handling or slight finger pressure.	**Trace** <5%	**Dry:** Absence of moisture, dusty, dry to the touch.
Moderately: Crumbles or breaks with considerable finger pressure.	**Some** 5-12%	**Moist:** Damp but no visible water.
Strongly: Will not crumble or break with finger pressure.	**With** > 12%	**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 (USCS)

MAJOR DIVISIONS			USCS SYMBOLS	TYPICAL DESCRIPTIONS
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 sieve size.	**GRAVELS** More than 50% of coarse fraction retained on No. 4 sieve.	**CLEAN GRAVELS** (little or no 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 (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-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 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 o f 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, Humus, Swamp Soils with High Organic Contents

Note: Dual Symbols are used to indicate borderline soil classifications.

STRATIFICATION:

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

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

WATER SYMBOL

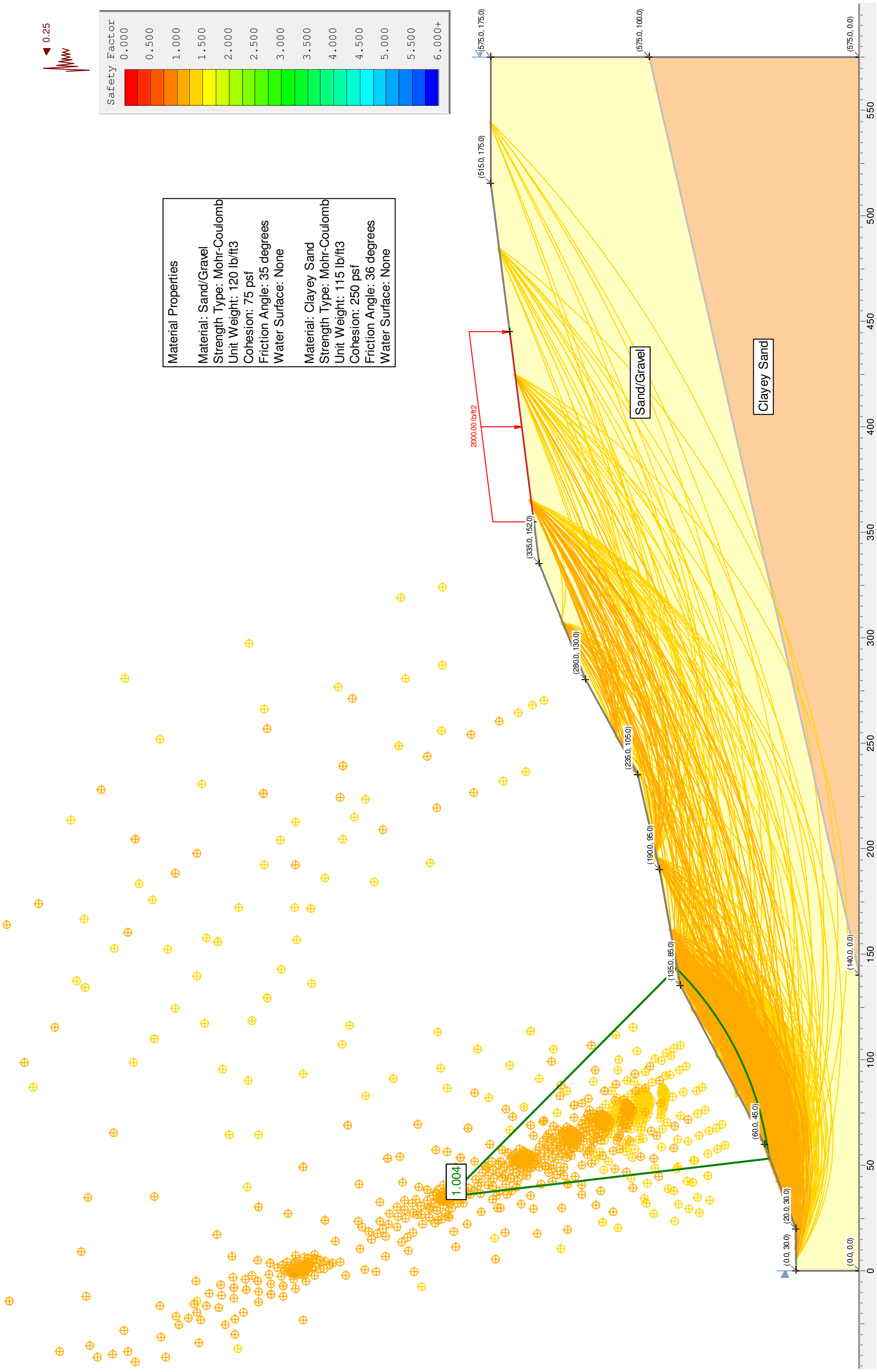
Water Level

FIGURE 4

GSH

STABILITY RESULTS

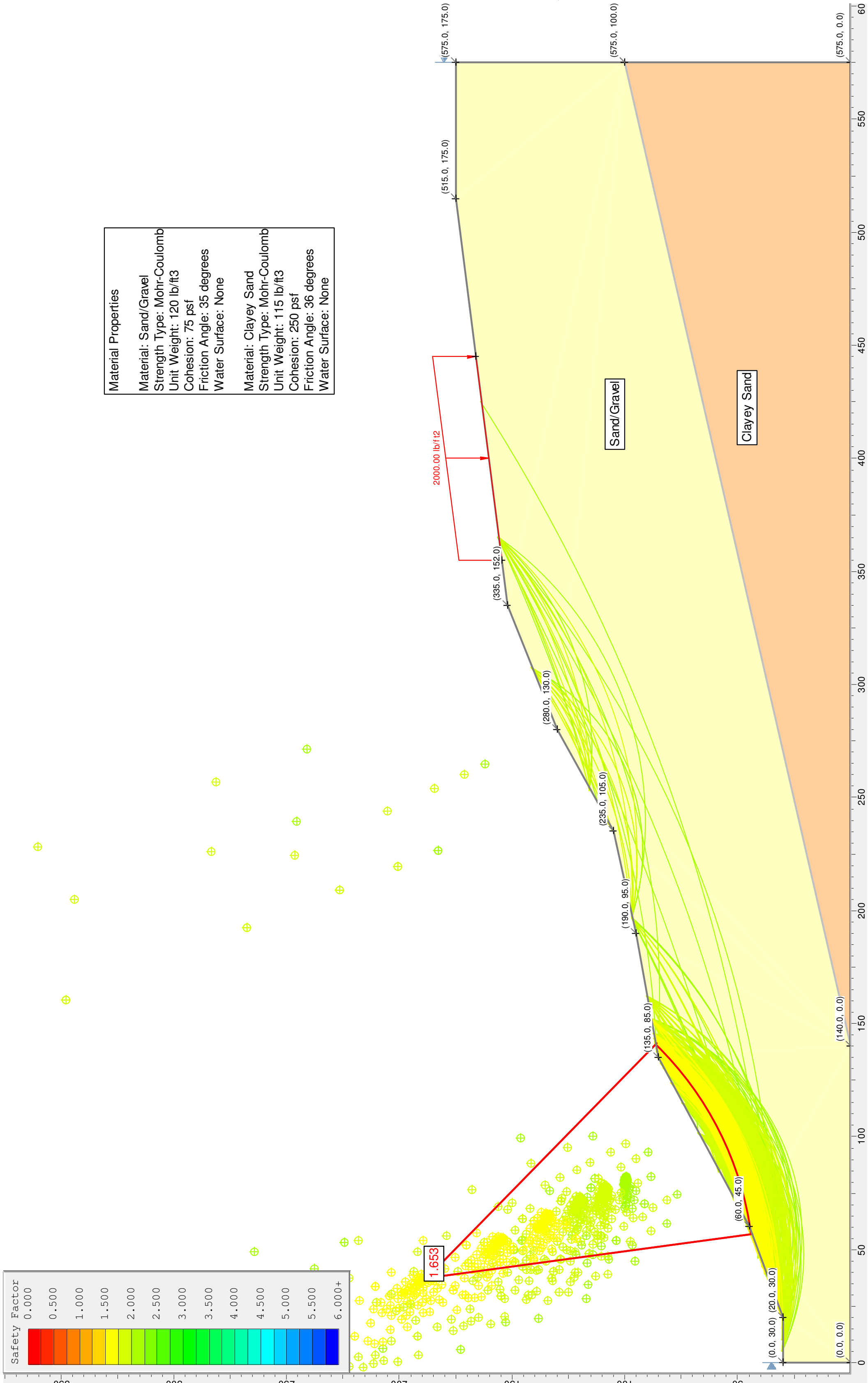
LOTS 28 & 29 EASTWOOD ESTATES NO. 10, WEBER COUNTY



PROJECT NO.: 1931-01N-15	GSH	FIGURE NO.: 6

STABILITY RESULTS

LOTS 28 & 29 EASTWOOD ESTATES NO. 10, WEBER COUNTY



PROJECT NO.: 1931-01N-15	GSH	**FIGURE NO.:** 5