**REPORT**
**GEOTECHNICAL STUDY**
**LOT 42R SUMMIT AT SKI LAKES NO.11**
**6763 EAST VIA CORTINA STREET**
**HUNTSVILLE, UTAH**

Submitted To:

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October 16, 2016

Job No. 2206-01N-16

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Mr. Craig Wagstaff
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Re: Report
Geotechnical Study
Lot 42R Summit at Ski Lakes No.11
6763 East Via Cortina Street
Huntsville, Weber County, Utah
(41.2429° N; 111.7856° W)

# 1. INTRODUCTION

## 1.1 GENERAL

This report presents the results of our geotechnical study performed for the proposed single-family residence planned for Lot 42R Summit at Ski Lakes No.11, to be located at 6763 East Via Cortina Street in Huntsville, 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 existing roadway and improvements is presented on Figure 2, Site Plan. The locations of the borings drilled and the test pits and trench excavated 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. Craig Wagstaff 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 drilling, logging, and sampling of 1 exploration boring, and the excavating, logging, and sampling of 2 test pits and 1 trench.

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. 16-0658N dated June 23, 2016.

## 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 and test pits/trench, 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 the subject property located at 6763 East Via Cortina Street in Huntsville, Utah. Construction will likely consist of spread 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 25 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 10 feet. Larger cuts and fills may be required in isolated areas.

## 3. INVESTIGATIONS

### 3.1 FIELD PROGRAM

In order to define and evaluate the subsurface soil and groundwater conditions at the site, 1 boring was drilled to a depth of about 51.5 feet below existing grade. The boring was drilled using a truck-mounted drill rig equipped with hollow-stem augers. The boring was terminated at the aforementioned depths due to practical refusal in bedrock. Additionally, 2 test pits and 1 trench were excavated to depths of about 6.0 to 13.0 feet below existing grade. The test pits and trench was excavated using a track-mounted excavator. The boring, test pit, and trench locations 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 and excavating operations, a log of the subsurface conditions encountered was maintained. In addition, relatively undisturbed and small disturbed 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 representations of the subsurface conditions encountered within the boring are presented on Figure 3A, Boring Log. Soils were classified in accordance with the nomenclature described on Figure 4, Key to Boring Log (USCS). Additional information related to the subsurface conditions encountered in the test pits and trench are presented on the test pit and trench logs within the project geological study, contained within the appendix of this report.

A 3.0-inch outside diameter, 2.42-inch inside diameter drive sampler (Dames & Moore) was utilized for subsurface sampling at select locations. The blow counts recorded on the boring logs were those required to drive the samplers 12 inches with a 140-pound hammer dropping 30 inches.

A 2.42-inch inside diameter thin-wall drive sampler was utilized in the subsurface sampling within the test pits and trench at the site.

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

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

## 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 performing moisture content, density, partial gradation, Atterberg limits, consolidation, and direct shear tests on representative subsurface soil samples. The following paragraph describes the tests and summarizes 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 log, Figure 3A.

### 3.2.3 Partial Gradation Tests

To aid in classifying the granular soils, a partial gradation test was performed. Results of the test are tabulated below:

| Boring/ Test Pit No. | Depth (feet) | Percent Passing No. 200 Sieve | Soil Classification |
|---|---|---|---|
| B-1 | 25.0 | 6.4 | SP/SM |
| B-1 | 35.0 | 17.8 | SM |
| B-1 | 40.0 | 23.2 | SM |
| TP-1 | 13.0 | 26.3 | SC |
| TP-2 | 2.0 | 24.3 | SC |

### 3.2.4 Atterberg Limit Tests

To aid in classifying the soils, Atterberg limit tests were performed on samples of the fine-grained cohesive soils. Results of the test are tabulated below:

| Boring/Test Pit/Trench No. | Depth (feet) | Liquid Limit (percent) | Plastic Limit (percent) | Plasticity Index (percent) | Soil Classification |
|---|---|---|---|---|---|
| B-1 | 20.0 | 50 | 26 | 24 | CL/CH |
| TP-1 | 4.0 | 38 | 15 | 23 | CL |
| TR-1 | 4.0 | 38 | 18 | 20 | CL |

### 3.2.5 Consolidation Tests

To provide data necessary for our settlement analyses, consolidation tests were performed on each of 2 representative samples of the clay soils encountered at the site. The data obtained from the tests were used to calculate foundation movements which could occur from the anticipated foundation loadings. Based upon data obtained from the consolidation tests, the clay soils will exhibit slightly moderate to moderate strength and moderate to moderately high compressibility characteristics under the anticipated loadings. Detailed results of the tests are maintained within our files and can be transmitted to you, upon your request.

### 3.2.6 Laboratory Direct Shear Test

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

| Boring No. | Depth (feet) | Soil Type | In-Situ Moisture Content (percent) | Dry Density (pcf) | Internal Friction Angle (degrees) | Apparent Cohesion (psf) |
|---|---|---|---|---|---|---|
| B-1 | 10.0 | CL | 29 | 80 | 30 | 490 |
| B-1 | 22.5 | SM | 23 | 98 | 31 | 775 |
| B-1 | 27.5 | CL/ML | 24 | 85 | 39 | 245 |

## 4. SITE CONDITIONS

### 4.1 GEOLOGIC SETTING

A geological study[1] dated October 13, 2016 was prepared for the subject property by GSH Geotechnical, Inc., and a copy of that report is included in the attached Appendix.

### 4.2 SURFACE

The subject property is a rectangular shaped parcel located at 6763 East Via Cortina Street in Huntsville, Utah. The topography of the site has a slope downward to the south with an overall change in elevation of about 105 feet across the site. The surface of the site is vegetated with native grasses, weeds, and sagebrush. The site is bordered on the north and south by Via Cortina Street, and on the east and west by similar vacant residential lots.

[1] "Report, Geological Study, Single-Family Home Development Lot, Lot 42R Summit at Ski Lake No.11, 6763 East Via Cortina, Huntsville, Weber County, Utah," GSH Geotechnical, Inc., GSH Job No. 2206-01N-16, October 14, 2016.

## 4.3 SUBSURFACE SOIL

Subsurface conditions encountered at the boring, test pit, and trench locations were relatively consistent. At the test pit and trench locations, topsoil and disturbed soils were encountered at the surface extending to about 6 to 12 inches below existing site grades. At the boring location, non-engineered fill material consisting of clayey sand was encountered from the surface extending to about 7.5 feet below existing site grades. Natural soils were encountered to the full depth penetrated, about 6.0 to 51.5 feet, and consisted of clayey silt, silty clay with varying fine to coarse sand content, fine to coarse sand with varying clay and silt content, weathered siltstone/claystone and sandstone bedrock, and occasional mixtures of these soils.

The natural clay soils encountered were medium stiff to hard, dry to moist, yellowish-brown to dark brown in color, and will generally exhibit moderate strength and compressibility characteristics under the anticipated loading.

The natural sand soils encountered were dense to very dense, moist, yellowish-brown to brown 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, Boring Log, and the test pit and trench logs contained within the appendix of this report. The lines designating the interface between soil types on the test pit logs generally represent approximate boundaries. In-situ, the transition between soil types may be gradual.

## 4.4 GROUNDWATER

Groundwater was not encountered during our field investigation in the boring, test pits, or trenches. Stabilized groundwater levels were measured in boring B-1 and groundwater was not encountered. Seasonal and longer-term groundwater fluctuations of 1 to 2 feet should be anticipated. The highest seasonal levels will generally occur during the late spring and summer months. Irrigation on this and surrounding properties may also create additional seasonal groundwater fluctuations.

# 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 a minimum of 18 inches of granular structural fill extending to suitable natural soils.

The most significant geotechnical aspects of the site are the surficial non-engineered fill soils, the moderate strength characteristics of the clay soils, and maintaining stability of the slopes at the site.

Maintaining stability of the slopes at the site is critical to construction at the site. A subdrain system must be installed upslope of the home to reduce the potential for surface water infiltration, as discussed further within this report. A foundation subdrain must be constructed for all exterior foundations.

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 inherently difficult to rework as they 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 qualified geotechnical engineer from GSH will need to verify that all fill material topsoil and loose/disturbed soils have been completely removed 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, 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, topsoil, and other deleterious materials from beneath an area extending out at least 3 feet from the perimeter of the proposed building, pavements, and exterior flatwork areas.

Additional site preparation will consist of the removal of existing non-engineered fills from an area extending out at least 3 feet from the perimeter of residential structures and 1 foot beyond rigid pavements.

Non-engineered fills may remain in asphalt pavement and sidewalk areas as long as they are properly prepared. Below rigid pavements non-engineered fills must be removed. Additionally, the surface of any existing engineered fills must be prepared prior to placing additional site grading fills.

Proper preparation shall consist of scarifying, moisture conditioning, and re-compacting the upper 12 inches to the requirements for structural fill. Fine-grained soils will require that very close moisture control be maintained for recompacting, which will be very difficult, if not impossible, to recompact during wet and cold periods of the year. As an option to proper preparation and recompaction, the upper 12 inches of non-engineered fill (where encountered) may be removed and replaced with granular subbase over proofrolled subgrade. Even with proper preparation, pavements established overlying non-engineered fills may encounter some long-term movements unless the non-engineered fills are completely removed.

Subsequent to stripping and prior to the placement of structural site grading fill, pavements, driveway and garage 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 soft, loose, and disturbed soils must be totally removed. Non-engineered fills shall be handled as described above.

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

#### 5.2.2 Excavations

For granular (cohesionless) soils, construction excavations above the water table, not exceeding 4 feet, should be no steeper than one-half horizontal to one vertical (0.5H:1V). For excavations up to 10 feet, in granular soils and above the water table, the slopes should be no steeper than one horizontal to one vertical (1H:1V). Excavations encountering saturated cohesionless soils will be very difficult and will require very flat sideslopes and/or shoring, bracing and dewatering. Excavations deeper than 10 feet are not anticipated at the site.

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 one-half horizontal to one vertical (0.5H: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.

The on-site fine-grained 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 inherently difficult to rework as they are very sensitive to changes in moisture content and will require very close moisture control during placement and compaction. This will be very difficult, if not impossible, during wet and cold periods of the year.

Only granular soils are recommended in confined areas such as utility trenches, below footings, etc. Generally, we recommend that all imported 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 imported structural fill should 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 |

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

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 should 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.

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 should 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.) should 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 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-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 soils at this site were estimated using the results of our laboratory testing, published correlations, and our experience with similar soils. Accordingly, we estimated the following parameters for use in the stability analyses:

| Material | Internal Friction Angle (degrees) | Apparent Cohesion (psf) | Saturated Unit Weight (pcf) |
|---|---|---|---|
| Clayey Sand/Sandy Clay | 29 | 250 | 115 |
| Bedrock | 35 | 200 | 120 |

For the seismic analysis, a peak horizontal ground acceleration of 0.263 using IBC 2015 guidelines and adjusted for Site Class effects (for Site Class D soils) was obtained for site (grid) locations of 41.2429 degrees latitude (north) and 111.7856 degrees longitude (west). To model sustained accelerations at the site, one-half of this value is typically used. Accordingly, a value of 0.132 was used as the pseudostatic coefficient in the seismic analyses.

### 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 configurations based on the cross-section provided in the referenced geological study (see geological study in appendix for cross-section information and location):

- Cross-section A-A' consisted of slopes ranging from about nearly flat to about 3H:1V (Horizontal:Vertical) with an overall change in elevation of up to about 105 feet. To simulate the load imposed on the slope by the proposed home, a load of 1,500 psf was modeled over the proposed building areas. In addition, a phreatic surface was included in our analyses to account for potential perched groundwater conditions developing above the bedrock.

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 configurations will meet both these requirements provided our recommendations are followed (see Figures 5 and 6).

Slope movements or even failure can occur if the slope soils are undermined or become saturated. Groundwater was not encountered during the course of our field investigation; however saturation of the slope soils can adversely affect the stability of the slope. Measures must be implemented to control groundwater levels and reduce the potential for saturation of the soils at the site. Surface drainage at the bottom and top of the slope should be directed to prevent ponding at the toe or crest of the slope. A subdrain system (cut-off drain system) across the slope is recommended to control groundwater levels and reduce the potential for infiltration of surface water at the site, as discussed further in Section 5.8, Subdrains. Landscape irrigation on this and surrounding areas may also create additional seasonal groundwater fluctuations. The limitations of landscape irrigation at the site are discussed further in Section 5.9, Site Irrigation. The property owner and the owner's representatives should be made aware of the risks should these or other conditions occur that could saturate or erode/undermine the slope soils.

Changes to the grading at the site and any retaining walls must be properly engineered to maintain stability of the slopes. GSH must review the final grading plans for the project prior to initiation of any construction.

## 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 a minimum of 18 inches structural fill extending to suitable natural soils. For design, the parameters on the following page 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 | - 1,500 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 becomes 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 0.40 should be utilized 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 40 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 50 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 should be added. The uniform pressures based on different wall heights are provided in the table below:

| 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 facilitate construction and 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 minimal.

The top of floor slabs must be established a minimum of 3 feet above measured static groundwater levels.

## 5.8 SUBDRAINS

### 5.8.1 General

We recommend that the perimeter foundation subdrains and a cutoff drain above the home and above the cutoff walls 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.

#### 5.8.3 Cutoff Drain

To reduce potential infiltration of surface water and groundwater into the subsurface soils at the site, a cutoff drain should be installed upslope of the home. Final location of the required cutoff drains must be reviewed by GSH prior to construction. The drain should consist of a perforated 4-inch minimum diameter pipe wrapped in fabric and placed near the bottom of a minimum 24 inch wide trench excavated to bedrock and lined in filter fabric. The pipe should daylight at one or both ends of the drain and discharge to an appropriate drainage device or area. Clean gravel up to 2 inches in maximum size, with less than 10 percent passing the No. 4 sieve and less than 5 percent passing the No. 200 sieve, should be placed around the drain pipe. A fabric, such as Mirafi 140N or equivalent, should be placed between the clean gravel and the adjacent soils. A zone of clean gravel wrapped in fabric at least 24 inches wide should also extend above the drain, to within 2 feet of the ground surface, with fabric placed over the top of the gravel. The upper 2 feet of soils should consist of a compacted clayey cap to reduce surface water infiltration into the drain.

### 5.9 SITE IRRIGATION

Proper site drainage is critical to maintaining slope stability at the site. Saturation of soils at the site may result in slope movement or failure. Therefore, we recommend that no irrigation lines should be placed on the slope below the home. Landscaping at the site should be planned to utilize drought resistant plants that require minimal watering. Plants or lawn may be placed on the slope, with plants watered using direct drip systems targeted only for each plant, and any lawn areas watered using sprinklers placed a minimum of 30 feet from the slope. Overwatering should be strictly avoided. The surface of the site should be graded to prevent the accumulation or ponding of surface water at the site. The property owner and the owner's representatives should be made aware of the risks should these or other conditions occur that could saturate or erode/undermine the slope soils.

To reduce the potential for saturation of the site soils, overwatering at the site should be strictly avoided. Watering at the site should be limited to a maximum equivalent rainfall of 0.5 inches per week. Irrigation at the site should be strictly avoided during periods of natural precipitation.

## 5.10 GEOSEISMIC SETTING

### 5.10.1 General

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

The structure must be designed in accordance with the procedure presented in Section 1613, Earthquake Loads, of the IBC 2015 edition.

### 5.10.2 Faulting

Based upon our review of available literature, no active faults are known to pass through the site. The nearest active fault is the Weber Section of the Wasatch Fault, approximately 7.4 miles west of the site. The Wasatch Fault Zone is considered capable of generating earthquakes as large as magnitude 7.3[4].

### 5.10.3 Soil Class

For dynamic structural analysis, the Site Class D – Stiff Soil Profile as defined in Chapter 20 of ASCE 7 (per Section 1613.3.2, Site Class Definitions, of IBC 2012) can be utilized.

### 5.10.4 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 (41.2447 degrees north and -111.8005 degrees west, respectively), the values for this site are tabulated on the following page.

[4] 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.

| Spectral Acceleration Value, T | Site Class B Boundary [mapped values] (% g) | Site Coefficient | Site Class D [adjusted for site class effects] (% g) | Design Values (% g) |
|---|---|---|---|---|
| Peak Ground Acceleration | 34.1 | $F_a$ = 1.159 | 39.5 | 26.3 |
| 0.2 Seconds (Short Period Acceleration) | $S_S$ = 83.4 | $F_a$ = 1.159 | $S_{MS}$ = 98.9 | $S_{DS}$ = 65.9 |
| 1.0 Second (Long Period Acceleration) | $S_1$ = 28.1 | $F_v$ = 1.824 | $S_{M1}$ = 52.5 | $S_{D1}$ = 35 |

### 5.10.5 Liquefaction

The site is located in an area that has been identified by the Utah Geologic Survey as having "moderate" 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.

Calculations were performed using the procedures described in the 2008 Soil Liquefaction During Earthquakes Monograph by Idriss and Boulanger[5] and the 2014 Soil Liquefaction During Earthquakes Monograph by Idriss and Boulanger Boulanger[6]. Our evaluation indicates liquefaction of near-surface soils encountered at the site within the depths penetrated are not anticipated during the design seismic event due to the unsaturated soil conditions encountered at the site.

## 5.11 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 fills, topsoil, and disturbed/loose soils have been removed 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 Idriss, I. M., and Boulanger, R. W. (2008), Soil liquefaction during earthquakes: Monograph MNO-12, Earthquake Engineering Research Institute, Oakland, CA, 261 pp.

6 Boulanger, R. W. and Idriss, I. M. (2014), "CPT and SPT Based Liquefaction Triggering Procedures." Report No. UCD/CGM-14/01, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, CA, 134 p.

## 5.12 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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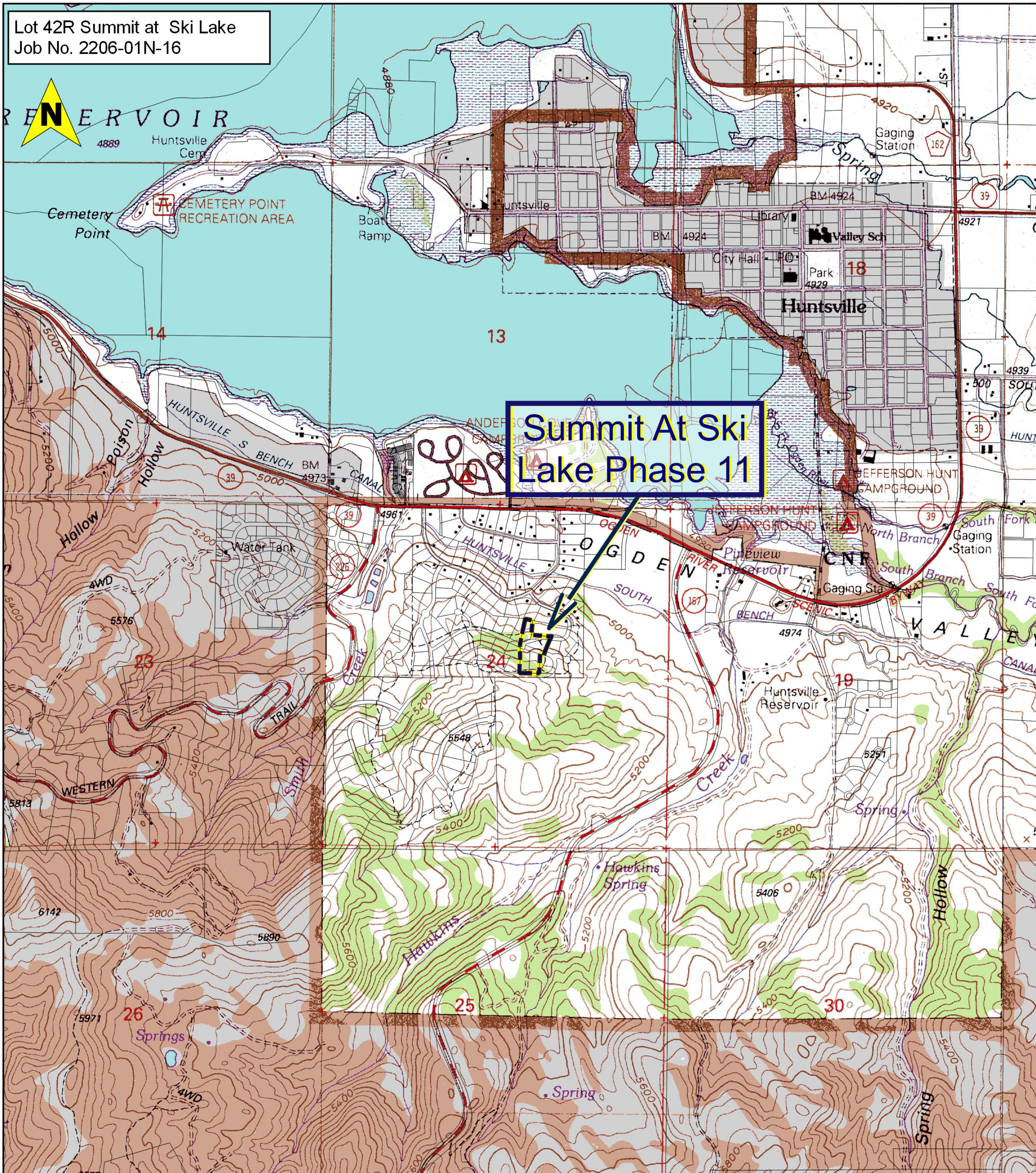
AMH/MSH:mmh

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

Addressee (email)




Base:
1998 7.5 Minute USGS Toporgraphic Maps Titled
Snowbasin, Utah, and Huntsville, Utah.

0 1000 2000 3000 4000 ft

1:24,000

**FIGURE 1**
**VICINITY MAP**

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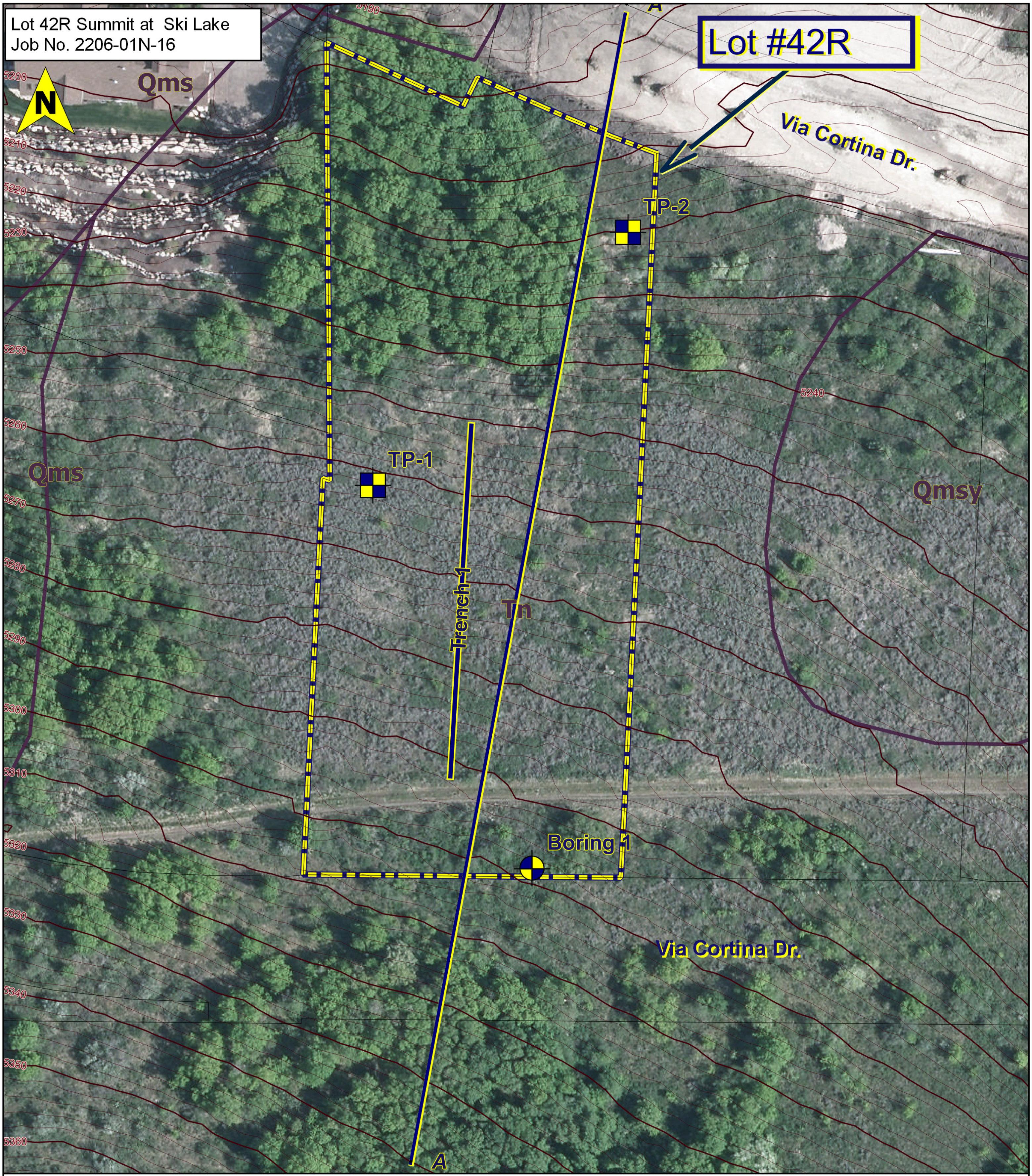


Base:
2012 6-inch Color HRO Orthoimagery, from Utah AGRC; http://gis.utah.gov/
Elevation:
2006 2.0m Geoprocessed LiDAR from Utah AGRC; http://gis.utah.gov/

0 60 120 ft
1:720

**FIGURE 2**
**SITE PLAN**

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# BORING LOG



## BORING: B-1

CLIENT: Craig Wagstaff — PROJECT NUMBER: 2206-01N-16

PROJECT: Lot 42R Summit at Ski Lake No.11 — DATE STARTED: 7/13/16 — DATE FINISHED: 7/13/16

LOCATION: 6763 East Viacortina Street, Huntsville, Weber County, Utah — GSH FIELD REP.: JM

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

GROUNDWATER DEPTH: Not Encountered (7/13/16) — ELEVATION: ---

| WATER LEVEL | USCS | DESCRIPTION | DEPTH (FT.) | BLOW COUNT | SAMPLE SYMBOL | MOISTURE (%) | DRY DENSITY (PCF) | % PASSSING 200 | LIQUID LIMIT (%) | PLASTICITY INDEX | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ground Surface** | 0 | | | | | | | | |
| | CL FILL | SILTY CLAY, FILL<br>with trace fine to medium sand; trace organics; dark brown | | | | | | | | | slightly moist<br>stiff |
| | | | | 15 | X | 15 | 82 | | | | |
| | | | 5 | 20 | X | 23 | 93 | | | | moist |
| | CL | SILTY CLAY<br>with trace fine to medium sand; brown | | | | | | | | | moist<br>stiff |
| | | | | 15 | X | 25 | 91 | | | | |
| | CL | CLAYSTONE/SILTSTONE<br>with some fine to mediun sand; light brown | | | | | | | | | moist<br>hard |
| | | | 10 | 84 | X | 38 | 77 | | | | |
| | | | | 50+ | X | | | | NP | NP | |
| | | | 15 | 50+ | X | 32 | 83 | | | | |
| | | | | 50+ | X | | | | | | |
| | | | 20 | 50+ | X | | | | 50 | 24 | |
| | SM | SILTY FINE TO MEDIUM SAND/WEATHERED SANDSTONE<br>brown | | | | | | | | | moist<br>very dense |
| | | | | 89 | X | | | | | | |
| | SP | FINE TO MEDIUM SAND | 25 | | X | | | | | | |

See Subsurface Conditions section in the report for additional information.

CLIENT: Craig Wagstaff | PROJECT NUMBER: 2206-01N-16

PROJECT: Lot 42R Summit at Ski Lake No.11 | DATE STARTED: 7/13/16 | DATE FINISHED: 7/13/16

| WATER LEVEL | USCS | DESCRIPTION | DEPTH (FT.) | BLOW COUNT | SAMPLE SYMBOL | MOISTURE (%) | DRY DENSITY (PCF) | % PASSING 200 | LIQUID LIMIT (%) | PLASTICITY INDEX | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | SP | FINE TO MEDIUM SAND<br>with trace silt; yellowish-brown | 25 | 79 | X | 14 | | 94 | | | moist<br>dense |
| | CL | CLAY<br>with trace fine sand; brown | | 50+ | X | | | | | | moist<br>hard |
| | SM | SILTY FINE SAND/WEATHERED SANDSTONE<br>brown | 30 | 50+ | X | | | | | | moist<br>dense |
| | | | | 50+ | X | | | | | | |
| | SP | FINE TO MEDIUM SAND/WEATHERED SANDSTONE<br>with trace silt; brown | 35 | 88 | X | 22 | 101 | 18 | | | moist<br>very dense |
| | SM | SILTY FINE TO MEDIUM SAND/WEATHERED SANDSTONE<br>brown | | 50+ | X | | | | | | moist<br>very dense |
| | | | 40 | 50+ | X | 18 | | 23 | | | |
| | | | | 50+ | X | | | | | | |
| | | | 45 | 50+ | X | 26 | 88 | | | | |
| | SM | FINE TO COARSE SILTY SAND/WEATHERED SANDSTONE<br>brown | | 76 | X | | | | | | moist<br>very dense |
| | SM | SILTY FINE TO MEDIUM SAND/WEATHERED SANDSTONE<br>yellowish-brown | 50 | 85 | X | 21 | 95 | | | | moist<br>very dense |
| | | End of Exploration at 51.5' | | | | | | | | | |

See Subsurface Conditions section in the report for additional information.

FIGURE 3A
(continued)

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# BORING LOG



## BORING: B-1

CLIENT: Craig Wagstaff | PROJECT NUMBER: 2206-01N-16

PROJECT: Lot 42R Summit at Ski Lake No.11 | DATE STARTED: 7/13/16 | DATE FINISHED: 7/13/16

| WATER LEVEL | USCS | DESCRIPTION | DEPTH (FT.) | BLOW COUNT | SAMPLE SYMBOL | MOISTURE (%) | DRY DENSITY (PCF) | % PASSING 200 | LIQUID LIMIT (%) | PLASTICITY INDEX | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No groundwater encountered at time of drilling<br>Installed 1.25" diameter slotted PVC pipe to 50.0' | 52 | | | | | | | | |
| | | | 55 | | | | | | | | |
| | | | 60 | | | | | | | | |
| | | | 65 | | | | | | | | |
| | | | 70 | | | | | | | | |
| | | | 75 | | | | | | | | |

See Subsurface Conditions section in the report for additional information.

FIGURE 3A
(continued)

| | |
|---|---|
| CLIENT: Craig Wagstaff<br>PROJECT: Lot 42R Summit at Ski Lake No.11<br>PROJECT NUMBER: 2206-01N-16 | **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**

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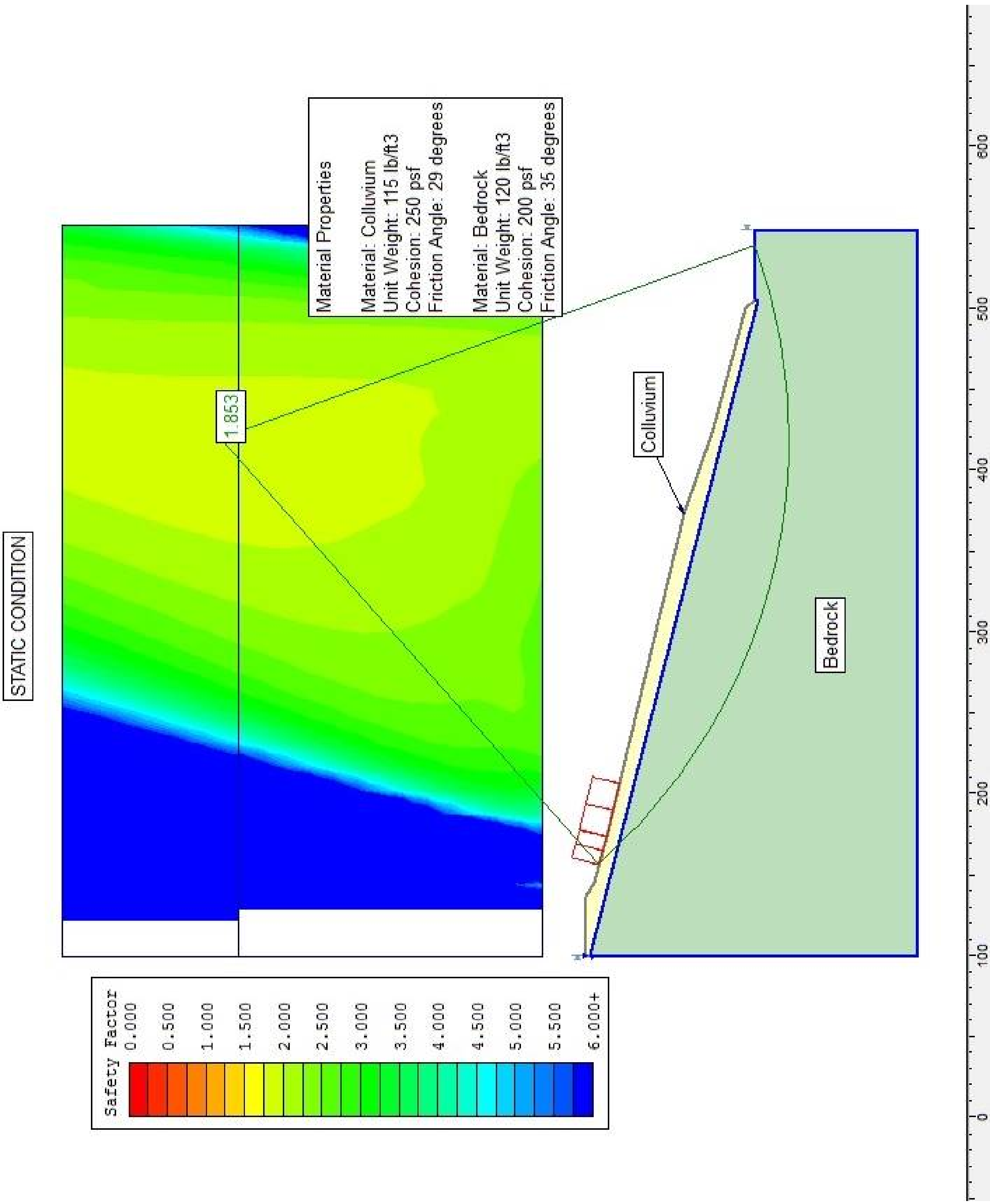
# STABILITY RESULTS

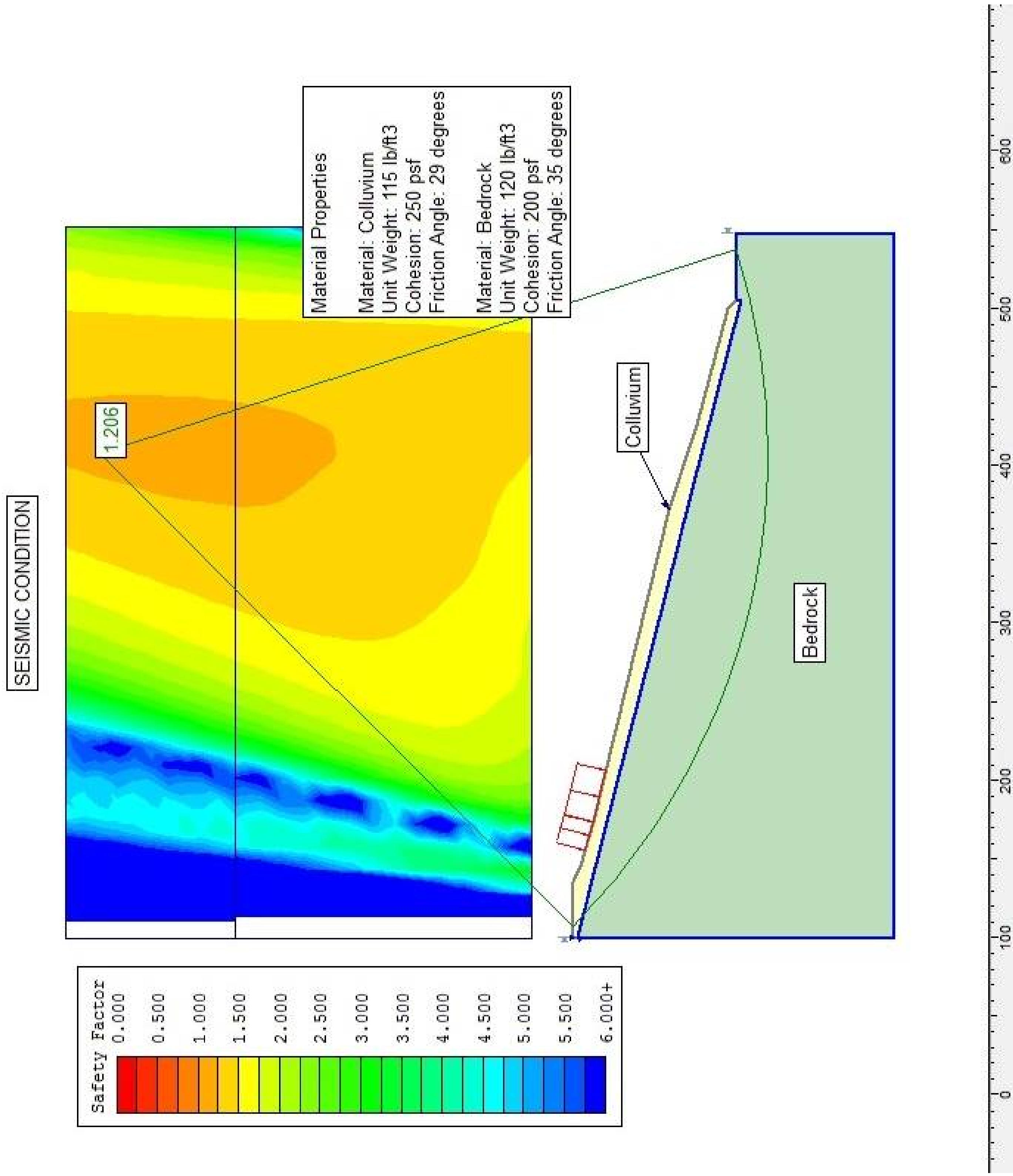
## LOT 42R SUMMIT AT SKI LAKE NO.11




**PROJECT NO.:** 2206-01N-16 | GSH | **FIGURE NO.:** 5

# STABILITY RESULTS

## LOT 42R SUMMIT AT SKI LAKE NO.11




| PROJECT NO.: 2206-01N-16 | GSH | FIGURE NO.: 6 |
|---|---|---|