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**GEOTECHNICAL AND GEOLOGIC HAZARDS INVESTIGATION**  
**Bobcat Ridge Subdivision**  
**Summit Powder Mountain Resort**  
**Weber County, Utah**

IGES Project No. 01628-028

September 20, 2018

Prepared for:

**Summit Mountain Holding Group**



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## 1.0 INTRODUCTION

### 1.1 PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical and geologic hazard investigation conducted for the *Bobcat Ridge* project, part of the currently on-going expansion at the Powder Mountain Ski Resort in Weber County, Utah. The purpose of our investigation was to assess the nature and engineering properties of the subsurface soils at the project site and to provide recommendations for the design and construction of foundations, grading, and drainage. In addition, geologic hazards have been assessed for the property. The scope of work completed for this study included literature review, site reconnaissance, subsurface exploration, engineering analyses, and preparation of this report.

Our services were performed in accordance with our proposal to Summit Mountain Holding Group (Client), dated March 27, 2018. The recommendations presented in this report are subject to the limitations presented in the "Limitations" section of this report (Section 6.1).

### 1.2 PROJECT DESCRIPTION

Our understanding of the project is based primarily on our previous involvement with the Summit Powder Mountain Resort project, which included two geotechnical investigations for the greater 200-acre Powder Mountain Resort expansion project (IGES, 2012a and 2012b) and subsequent geotechnical consulting for a number of other aspects of the project.

The Summit Powder Mountain Resort expansion project is located southeast of SR-158 (Powder Mountain Road), south of previously developed portions of Powder Mountain Resort, in unincorporated Weber County, Utah. The project is accessed by Powder Ridge Road and Summit Pass Road.

The project site is located south of Phase 1C and 1D and west of the proposed Beach Club property, accessed by way of a southern extension of Summit Pass Road (see *Site Vicinity Map*, Figure A-1 in Appendix A). We understand that the project consists of developing an approximately 40-acre parcel to include 48 residential lots ranging in size from approximately 0.34 acres to 1.55 acres. The project will also include approximately 6,125 linear feet of new roadway, some of which will be private and some of which will be Weber County roadway, including approximately 960 feet of the southern extension of Summit Pass Road. The roadway is expected to be constructed with a series of relatively shallow cuts and fills. A single skier bridge is planned across the southern extension of Summit Pass Road, whereby a ski path will pass under the roadway. The residential units are anticipated to be assorted types of high-end vacation homes, likely multi-story residential structures; it is likely the structures will include a basement level, unless groundwater conditions preclude the practical construction of a basement.

## 2.0 METHODS OF STUDY

### 2.1 LITERATURE REVIEW

#### 2.1.1 Geotechnical

The earliest geotechnical report for the area is by AMEC (2001), which was a reconnaissance-level geotechnical and geologic hazard study. IGES later completed a geotechnical investigation for the Powder Mountain Resort expansion in 2012 (IGES, 2012a, 2012b). Our previous work included twenty-two test pits and one soil boring excavated at various locations across the 200-acre development; as a part of this current study, the logs from relevant nearby test pits and other data from our reports were reviewed. This includes a review of the geotechnical and geologic hazard investigations for the Beach Club property (IGES, 2017) and Village Lift (IGES, 2016).

#### 2.1.2 Geological

Several pertinent publications were reviewed as part of this assessment. Sorensen and Crittenden, Jr. (1979) provides 1:24,000 scale geologic mapping of the Huntsville Quadrangle, and Crittenden, Jr. (1972) provides 1:24,000 scale geologic mapping of the Brown's Hole Quadrangle. Coogan and King (2001) provide more recent geologic mapping of the area, but at a 1:100,000 scale. An updated Coogan and King (2016) regional geologic map (1:62,500 scale) provides the most recent published geologic mapping that covers the project area. Western Geologic (2012) conducted a reconnaissance-level geologic hazard study for the greater 200-acre Powder Mountain expansion project, including the Bobcat Ridge area. The Western Geologic (2012) study modified some of the potential landslide hazard boundaries that had previously been mapped at a regional scale (1:100,000) by Coogan and King (2001) and Elliott and Harty (2010). The corresponding United States Geological Survey (USGS) topographic maps for the Huntsville and Brown's Hole Quadrangles (2017) provide physiographic and hydrologic data for the project area. Regional-scale geologic hazard maps pertaining to landslides (Elliott and Harty, 2010; Colton, 1991), faults (Christenson and Shaw, 2008a; USGS and Utah Geological Survey (UGS), 2006), debris-flows (Christenson and Shaw, 2008b), and liquefaction (Christenson and Shaw, 2008c; Anderson et al., 1994) that cover the project area were also reviewed. The Quaternary Fault and Fold Database (USGS and UGS, 2006), was reviewed to identify the location of proximal faults that have had associated Quaternary-aged displacement.

Stereo-paired aerial imagery for the project site and recent and historic Google Earth imagery was also reviewed to assist in the identification of potential adverse geologic conditions. The aerial photographs reviewed are documented in the *References* section of this report.

#### 2.1.3 Hydrological

Due to the presence of wetlands near the project area, Bio-West performed a wetland delineation study to identify the limits of the wetland (Bio-West, 2018). Two distinct wetland areas were

identified in the study, though both areas were found to be entirely outside of the limits of disturbance for the Bobcat Ridge property.

## 2.2 FIELD INVESTIGATION

Site reconnaissance and site-specific geologic mapping was performed across the site prior to identifying the test pit locations, such that suspect geologic hazard areas could be appropriately investigated by subsurface methods. Subsurface soils were investigated by excavating 55 test pits at representative locations across the property. The approximate location of the test pits is illustrated on the *Geotechnical and Local Geology Map* (Figure A-2 in Appendix A). The soil types were visually logged at the time of our field work in general accordance with the *Unified Soil Classification System* (USCS). Soil classifications and descriptions are included on the test pit logs, Figures A-3 through A-57 in Appendix A. A key to USCS symbols and terminology is presented as Figure A-58, and a key to physical rock properties is presented as Figure A-59.

## 2.3 LABORATORY TESTING

Samples retrieved during the subsurface investigation were transported to the IGES laboratory for evaluation of engineering properties. Specific laboratory tests included:

- Atterberg Limits (ASTM D4318)
- Grain-Size Distribution (ASTM D6913)
- Fines Content (ASTM D1140)
- In situ Moisture Content & Dry Unit Weight (ASTM D7263, D2216)
- Unconfined Compressive Strength (ASTM D2166)
- Direct Shear (ASTM D3080)
- Ring Shear Test
- Soluble Sulfate, Soluble Chloride, pH and Resistivity

Results of the laboratory testing are discussed in this report and presented in Appendix B. Some test results, including moisture content, particle size distribution, and Atterberg Limits, have been incorporated into the test pit logs (Figures A-3 through A-57).



## 3.0 GEOLOGIC CONDITIONS

### 3.1 GENERAL GEOLOGIC SETTING

The Bobcat Ridge property is situated in the western portion of the northern Wasatch Mountains, approximately 4 miles north of Ogden Valley. The Wasatch Mountains contain a broad depositional history of thick Precambrian and Paleozoic sediments that have been subsequently modified by various tectonic episodes that have included thrusting, folding, intrusion, and volcanics, as well as scouring by glacial and fluvial processes (Stokes, 1987). The uplift of the Wasatch Mountains occurred relatively recently during the Late Tertiary Period (Miocene Epoch) between 12 and 17 million years ago (Milligan, 2000). Since uplift, the Wasatch Front has seen substantial modification due to such occurrences as movement along the Wasatch Fault and associated spurs, the development of the numerous canyons that empty into the current Salt Lake Valley and Utah Valley and their associated alluvial fans, erosion and deposition from Lake Bonneville, and localized mass movement events (Hintze, 1988).

The Wasatch Mountains, as part of the Middle Rocky Mountains Province (Milligan, 2000), were uplifted as a fault block along the Wasatch Fault (Hintze, 1988). Ogden Valley itself is a fault-bounded trough that was occupied by Lake Bonneville (Sorensen and Crittenden, Jr, 1979) before being cut through by the Ogden River and subsequently dammed to form the Pineview Reservoir.

The Wasatch Fault and its associated segments are part of an approximately 230-mile long zone of active normal faulting referred to as the Wasatch Fault Zone (WFZ), which has well-documented evidence of late Pleistocene and Holocene (though not historic) movement (Lund, 1990; Hintze, 1988). The faults associated with the WFZ are all normal faults, typically exhibiting block movement down to the west of the fault and up to the east. The WFZ is contained within a greater area of active seismic activity known as the Intermountain Seismic Belt (ISB), which runs approximately north-south from northwestern Montana, along the Wasatch Front of Utah, through southern Nevada, and into northern Arizona. In terms of earthquake risk and potential associated damage, the ISB ranks only second in North America to the San Andreas Fault Zone in California (Stokes, 1987).

The WFZ consists of a series of ten segments of the Wasatch Fault that each display different characteristics and past movement, and are believed to have movement independent of one another (UGS, 1996). The Bobcat Ridge property is located approximately 10 miles to the northeast of the Weber Segment of the north-south-trending Wasatch Fault, which is the closest documented Holocene-aged (active) fault to the property (USGS and UGS, 2006).

### 3.2 SURFICIAL GEOLOGY FROM LITERATURE

According to Sorensen and Crittenden, Jr. (1979) and Crittenden, Jr. (1972), the property is entirely underlain by the undivided Tertiary/Cretaceous Wasatch and Evanston Formations (TKwe),

described as “unconsolidated pale-red to greenish-red pebble, cobble, and boulder conglomerate. Forms boulder-covered slopes but does not crop out anywhere. Clasts are mainly Precambrian quartzite and are tan, gray, or purple; matrix is mainly poorly consolidated sand and silt.” A generalized bedding attitude near the property shows this unit striking due north and dipping 10 degrees to the east; this map forms the basemap for the *Regional Geology Map 1* (Figure A-60). Coogan and King (2001) produced a regional-scale geologic map that covered the property; this map shows most of the property to be entirely underlain by the Wasatch Formation, though the northern portion of the property is within deposits mapped as undivided mass-movement deposits, which “includes slides, slumps, and flows, as well as colluvium, talus, and alluvial fans that are mostly debris flows.” Western Geologic (2012) identified a number of landslide deposits contained within the Powder Mountain Resort expansion area, including some mapped within the Bobcat Ridge property boundary (*Regional Geology Map 2*, Figure A-61). While most of the property is located outside of mapped landslide deposits, Western Geologic (2012) maps the northwestern portion of the property as underlain by deposits mapped as “mixed slope colluvium, shallow landslides, and talus,” while a Holocene to Late Pleistocene landslide lobe is mapped in the northeastern part of the property, and a large Pleistocene landslide lobe is mapped across the southernmost portion of the property. Finally, Coogan and King (2016) updated their 2001 map, which shows the northern part of the property to largely be underlain by landslide deposits (unit Qms), though the rest of the property is mapped as being underlain by the Wasatch Formation (unit Tw) (*Regional Geology Map 3*, Figure A-62). Wasatch Formation bedrock in the area is shown to be striking approximately to the north-northeast, and dipping between 3 and 6 degrees to the east-southeast; additionally, according to this map, the property is just west of a north-south trending syncline<sup>1</sup>.

### 3.3 HYDROLOGY

The USGS topographic maps for the Huntsville and Brown’s Hole Quadrangles (2017) show that the Bobcat Ridge project area straddles a ridge, whereby the topographic gradient for the northern approximately one-half of the property slopes down to the northwest towards Lefty’s Canyon, while the southern approximately one-half of the property slopes down to the south towards Gertsen Creek (see Figure A-1). No active or ephemeral stream<sup>2</sup> drainages were observed on the property during the site reconnaissance. A spring is present near the northeastern portion of the property, noted on both the topographic map (Figure A-1) and by Western Geologic (2012; Figure A-61). This spring was observed in the field during the site reconnaissance, and was associated with a delineated wetland area of standing water and abundant hydrophilic plants, most notably *Juncus ensifolius* and mule’s ear vegetation (including both *Veratrum californicum* and *Wyethia amplexicaulis asteraceae*) (Bio-West, 2018). The delineated wetland areas identified by Bio-West

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<sup>1</sup> **Syncline:** A fold of which the core contains the stratigraphically younger rocks; it is generally concave upward. (AGI, 2005)

<sup>2</sup> **Ephemeral stream:** A stream or reach of a stream that flows briefly only in direct response to precipitation in the immediate locality and whose channel is at all times above the water table. (AGI, 2005)

(2018) is shown on Figure A-2. Additional mule's ear vegetation was observed downslope in the northwestern portion of the property (Lots 36 through 38), though this was not accompanied by standing water. Anomalous moist ground on a south-facing slope was observed in the southeastern portion of the property near the Lot 24/27 boundary, though this was not accompanied by either mule's ear vegetation or standing water.

Baseline groundwater depths for the Bobcat Ridge property are currently unknown, and are anticipated to fluctuate both seasonally and annually. At the time of our subsurface exploration, groundwater seepage was observed in 28 of the 55 test pits excavated, with seepage occurring as shallow as 3 feet below existing grade.

### 3.4 GEOLOGIC HAZARDS FROM LITERATURE

Based upon the available geologic literature, regional-scale geologic hazard maps that cover the Bobcat Ridge project area have been produced for landslide, fault, debris-flow, and liquefaction hazards. The following is a summary of the data presented in these regional geologic hazard maps.

#### 3.4.1 Landslides

Two regional-scale landslide hazard maps have been produced that cover the project area. Colton (1991) maps the property to be underlain by a south-trending landslide lobe in the southern part of the property and a northwest-trending landslide lobe in the northeastern part of the property, largely consistent with the landslides as delineated by Western Geologic (2012; see Figure A-61). Elliott and Harty (2010) shows deposits mapped as "Landslide undifferentiated from talus and/or colluvial deposits" across most of the northern portion of the property, with a large area mapped as "Landslide and/or landslide undifferentiated from talus, colluvial, rock-fall, glacial, and soil-creep deposits" in the southeastern portion of the property and a smaller area mapped in the north-central portion of the property. As noted above, both Western Geologic (2012) and Coogan and King (2016) map various landslide deposits on the slopes of the northern and southern portions of the property (see Figures A-61 and A-62).

#### 3.4.2 Faults

Neither Christensen and Shaw (2008a) nor the Quaternary Fault and Fold Database of the United States (USGS and UGS, 2006) show any Quaternary-aged (~2.6 million years ago to the present) faults to be present on or projecting towards the subject property. The Weber County Natural Hazards Overlay Districts defines an active fault to be "a fault displaying evidence of greater than four inches of displacement along one or more of its traces during Holocene time (about 11,000 years ago to the present)" (Weber County, 2015). The closest active fault to the property is the Weber Segment of the Wasatch Fault Zone, located approximately 10 miles southwest of the western margin of the property (USGS and UGS, 2006).

### 3.4.3 Debris Flows

Christensen and Shaw (2008b) does not show the project area to be located within a debris-flow hazard special study area.

### 3.4.4 Liquefaction

Anderson, et al. (1994) and Christensen and Shaw (2008c) both show the project area to be located in an area with very low potential for liquefaction.

## 3.5 REVIEW OF AERIAL IMAGERY

A series of aerial photographs that cover project area were taken from the UGS Aerial Imagery Collection and analyzed stereoscopically for the presence of adverse geologic conditions across the property. This included a review of photos collected from the years 1946, 1952, and 1963. A table displaying the details of the aerial photographs reviewed can be found in the *References* section at the end of this report.

No geologic lineaments or fault scarps were observed in the aerial photography on the subject property. Irregular topography, possibly coinciding with landslide deposits, were most pronounced in the northeastern portion of the property. A subdued bowl was observed in the southern part of the property, which could be indicative of an old landslide scarp; it is likely that this is the feature that was identified by Colton (1991), Elliott and Harty (2010), and Western Geologic (2012) used to delineate older (Pleistocene-aged) landslide deposits in this area. Immediately northwest of the property, a treeless linear swath of land was observed to extend downslope to Lefty's Canyon and likely represents an area of Holocene-aged landsliding.

Google Earth imagery of the property from between the years of 1993 and 2017 were also reviewed. The property appeared to remain largely unchanged across this time frame. A small pond along the preexisting two-track road that passes northwest-southeast across the middle of the property was observed to be present in the 1993 imagery. The subdued bowl in the southern part of the property was observed in the field; this bowl area is nearly devoid of trees. No definitive landslide deposits or other geological hazard features were noted on the property in the imagery. Most of the northern half of the project area was found to be densely covered in trees, though several open areas devoid of trees were readily observed. The southern half of the property contains more treeless ground, though where present, the tree clusters are dense. No bedrock exposures were observed to be present anywhere on the property, nor were any drainages observed on the property.

At the time of this report, no LiDAR data for the project area was available to be reviewed.

### 3.6 SEISMICITY

Following the criteria outlined in the 2015 International Building Code (IBC, 2015), spectral response at the site was evaluated for the *Maximum Considered Earthquake* (MCE) which equates to a probabilistic seismic event having a two percent probability of exceedance in 50 years (2PE50). Spectral accelerations were determined based on the location of the site using the *U.S. Seismic “DesignMaps” Web Application* (USGS, 2012/15); this software incorporates seismic hazard maps depicting probabilistic ground motions and spectral response data developed for the United States by the U. S. Geological Survey as part of NEHRP/NSHMP (Frankel et al., 1996). These maps have been incorporated into both *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures* (FEMA, 1997) and the *International Building Code* (IBC) (International Code Council, 2015).

**Table 3.6**  
**Short- and Long-Period Spectral Accelerations for MCE**

| Parameter   | Short Period<br>(0.2 sec)       | Long Period<br>(1.0 sec)        |
|---|---------------------------------|---------------------------------|
| MCE Spectral Response Acceleration (g)              | $S_S = 0.814$                   | $S_1 = 0.270$                   |
| MCE Spectral Response Acceleration Site Class C (g) | $S_{MS} = S_S F_a = 0.874$      | $S_{M1} = S_1 F_v = 0.413$      |
| Design Spectral Response Acceleration (g)           | $S_{DS} = S_{MS}^{2/3} = 0.583$ | $S_{D1} = S_{M1}^{2/3} = 0.275$ |

To account for site effects, site coefficients that vary with the magnitude of spectral acceleration and *Site Class* are used. Site Class is a parameter that accounts for site amplification effects of soft soils and is based on the average shear wave velocity of the upper 100 feet; based on our field exploration and our understanding of the geology in this area, the subject site is appropriately classified as Site Class C (*very dense soil/soft rock*). Based on IBC criteria, the short-period ( $F_a$ ) coefficient is 1.075 and the long-period ( $F_v$ ) site coefficient is 1.530. Based on the design spectral response accelerations for a *Building Risk Category* of I, II or III, the site’s *Seismic Design Category* is D. The short- and long-period *Design Spectral Response Accelerations* are presented in Table 3.6; a summary of the *Design Maps* analysis is presented in Appendix B. The *peak ground acceleration* (PGA) may be taken as  $0.4 \cdot S_{MS}$ .

### 3.7 GEOLOGIC HAZARD ASSESSMENT

Geologic hazard assessments are necessary to determine the potential risk associated with particular geologic hazards that are capable of adversely affecting a proposed development area. As such, they are essential in evaluating the suitability of an area for development and provide critical data in both the planning and design stages of a proposed development. The geologic

hazard assessment discussion below is based upon a qualitative assessment of the risk associated with a particular geologic hazard, based upon the data reviewed and collected as part of this investigation.

A “low” hazard rating is an indication that the hazard is either absent, is present in such a remote possibility so as to pose limited or little risk, or is not anticipated to impact the project in an adverse way. Areas with a low-risk determination for a particular geologic hazard do not require additional site-specific studies or associated mitigation practices with regard to the geologic hazard in question. A “moderate” hazard rating is an indication that the hazard has the capability of adversely affecting the project at least in part, and that the conditions necessary for the geologic hazard are present in a significant, though not abundant, manner. Areas with a moderate-risk determination for a particular geologic hazard may require additional site-specific studies, depending on location and construction specifics, as well as associated mitigation practices in the areas that have been identified as the most prone to susceptibility to the particular geologic hazard. A “high” hazard rating is an indication that the hazard is very capable of or currently does adversely affecting the project, that the geologic conditions pertaining to the particular hazard are present in abundance, and/or that there is geologic evidence of the hazard having occurred at the area in the historic or geologic past. Areas with a high-risk determination always require additional site-specific hazard investigations and associated mitigation practices where the location and construction specifics are directly impacted by the hazard. For areas with a high-risk geologic hazard, simple avoidance is often considered.

The following is a summary of the geologic hazard assessment for the Bobcat Ridge property.

### 3.7.1 Landslides/Mass Movement

The extant geologic literature for the property shows the site to contain, at least in part, mapped landslide deposits (Elliott and Harty, 2010; Western Geologic, 2012; Coogan and King, 2016). These are most notably present in the northernmost and southernmost portions of the property (see Figures A-61 and A-62). During the site reconnaissance, much of the northern part of the property was observed to contain irregular, though not hummocky, topography. What appeared to be landslide deposits associated a notable break in slope, hummocky topography, and a collection of boulders weathering out at the surface was commonly observed in the northern portions of the northernmost lots. In the southern portion of the southernmost lots, a small though conspicuous break in slope corresponding to what appeared to be the headscarp of the mapped Pleistocene-aged landslide deposits was observed.

In the subsurface, shallow landslide deposits and associated shear plane clay were observed in some test pits. The landslide deposits were typically less than 10 feet in depth, and heterogeneous units that appeared similar to the weathered Wasatch Formation. The landslide deposits were differentiated from the Wasatch Formation in that they were commonly mottled with a light gray

fat clay, were more clay-rich, contained pinhole voids, and generally contained a lower proportion of clasts than is common in the Wasatch Formation. Additionally, these units were frequently underlain by a light gray to dark reddish brown fat clay seam that was commonly slickensided and represented the shear plane for the landslide deposits. In some places, the landslide deposits were indistinct from the basal shear plane; in these cases, the landslide deposits are likely to have been deposited by an earthflow-type process as opposed to a translational or rotational slide.

The landslide deposits were most commonly and widely encountered on the gentler slopes (approximately 10:1 (H:V)) in the southern half of the property, overlain by a thin layer of colluvium and underlain by weathered Wasatch Formation. These deposits are collectively delineated as Landslide C on Figure A-2. The geomorphology of this area suggests that these are older (Pleistocene-aged) deposits. However, abundant associated shallow groundwater conditions perched upon the landslide deposit clays provide a setting that may be conducive to shallow sliding, despite the gentler slopes present in this part of the property.

In the northern half of the property shallow landslide deposits were less common and more variable, and differentiated into two distinct lobes noted as Landslide A and Landslide B on Figure A-2. In the northeastern part of the property (Landslide B), a treeless area coinciding with multiple breaks in slope believed to be landslide scarps was observed. Test pits in this area displayed landslide deposits consisting of a heterogeneous mixture of fat clay, sand, and gravel, and lacked a basal slide plane clay. These deposits are interpreted to have been a product of Holocene-aged earthflow-type landsliding. In the northwestern part of the property (Landslide A), a deeper light gray fat clay seam underlying what appeared to be weathered Wasatch Formation was most commonly observed in the test pits excavated in this area. No natural slickensides were observed to be present in this clay, though the clay exhibited a high plasticity and it was easy to produce mechanically-induced slickensides in this material. Though this clay was similar in appearance and character to the clay observed in the southern part of the property, in TP-1 the clay was found to be forming upon weathered micaceous shale bedrock of the Calls Fort Shale Member and represented an older landslide slide plane. As such, it is interpreted that where encountered in the northwestern portion of the property, this unit represents the uppermost, weathered portion of the Calls Fort Shale Member and has the potential to be reactivated as a shear plane, especially where shallow groundwater conditions are present in the area.

As shown on Figure A-2, the material overlying the deeper fat clay seam observed in the test pits in the northwestern part of the property may represent older (Pleistocene-aged) landslide deposits. Surficial geomorphology in this area suggests that these may be landslide deposits, though this material was observed in the test pits in this area to be very consistent with weathered Wasatch Formation as seen in other test pits across the property. It is possible that this material represents a largely intact block of Wasatch Formation that had moved as a translational slide along the deeper clay seam.

Given this data and the prevalence of shallow groundwater conditions across the property, the risk associated with landslide and mass movement hazards on the property is generally considered to be high for the lots in the northwestern and northeastern portions of the property, moderate to high for the lots in the southern portion of the property, moderate for the lots on the steeper slopes in the northern portion of the property, and low for the lots on the gentle terrain in the middle of the property.

### 3.7.2 Rockfall

Though the property is largely on a slope, no bedrock outcrops are exposed upslope of the property. As such, the rockfall hazard associated with the property is considered to be low.

### 3.7.3 Surface-Fault Rupture and Earthquake-Related Hazards

No faults are known to be present on or project across the property, and the closest active fault to the property is the Weber Segment of the WFZ, located approximately 10 miles to the west of the property (USGS and UGS, 2006). Given this information, the risk associated with surface-fault-rupture on the property is considered low.

The entire property is subject to earthquake-related ground shaking from a large earthquake generated along the active Wasatch Fault. Given the distance from the Wasatch Fault, the hazard associated with ground shaking is considered to be moderate. Proper building design according to appropriate building code and design parameters can assist in mitigating the hazard associated with earthquake ground shaking.

### 3.7.4 Liquefaction

The site is largely underlain by Wasatch Formation, a poorly consolidated sedimentary rock unit (conglomerate). Rock units such as these are not considered susceptible to liquefaction; as such, the potential for liquefaction occurring at the site is considered low.

### 3.7.5 Debris-Flows and Flooding Hazards

The property does not contain and is not located adjacent to any active or ephemeral drainages. Additionally, there are no debris-flow source areas upslope of the property, and the property is on a consistent slope downhill to the southwest. Given these conditions, the debris-flow and flooding hazard associated with the property is considered to be low.

### 3.7.6 Shallow Groundwater

Groundwater was encountered in 28 of the 55 test pits excavated as part of this investigation, with continuous seepage filling the test pits with standing water columns as much as 3 feet deep during logging efforts. These test pits were excavated in early to late June, and the groundwater level was likely to be at or near its annual high. Springs were observed near the northeastern part of the property, associated with a delineated wetland area containing standing water and abundant



hydrophilic vegetation. Though no standing water was observed elsewhere on the property (aside from a small man-made pond), other areas were noted to contain similar hydrophilic vegetation and have moist surficial soils. The groundwater seepage was as shallow as 3 feet below existing grade, and appears to coincide with the presence of the fat clay seams found both above and below the weathered Wasatch Formation. These clay seams are the likely reason for the persistent shallow groundwater conditions observed across the property, which act as aquitards that induce a localized perched groundwater condition.

Given the existing data, it is expected that groundwater levels will fluctuate both seasonally and annually, and the risk associated with shallow groundwater hazards is considered to be high. Spring thaw and runoff are likely to significantly contribute to elevated groundwater conditions. Shallow groundwater issues can be mitigated through appropriate grading measures, the installation of land drains, the construction of basements with foundation drains, and/or the avoidance of the construction of residences with basements, or some combination of the aforementioned.

## 4.0 GENERALIZED SITE CONDITIONS

### 4.1 SITE RECONNAISSANCE

Mr. Peter E. Doumit, P.G., C.P.G., and Mr. Bill Bragdon, P.G., of IGES conducted reconnaissance of the site and the immediate adjacent properties on May 23 and 29, 2018. The site reconnaissance was conducted with the intent to assess the general geologic conditions present across the property, with specific interest in those areas identified in the geologic literature and aerial imagery reviews as potential geologic hazard areas. Additionally, the site reconnaissance provided the opportunity to geologically map the surficial geology of the area. Figure A-2 is a site-specific geologic map of the Bobcat Ridge property and adjacent areas.

At the time of the site reconnaissance, the property was approximately bisected by a preexisting gravel road that passed from southwest to northeast across the property. The southern half of the property was observed to have a consistent, gentle topographic gradient down to the south-southwest with a slightly irregular, though not hummocky, surface. The northern half of the property was observed to have a steeper topographic gradient down to the northwest, with more irregular topography that was observed to be hummocky in places, especially in the northernmost portions of the property. Dense vegetation in the form of aspen trees and occasional pine trees was observed scattered across the property, but most was most prominent along the north-facing slopes in the northern part of the property. Strong soil creep was observed in the aspens in some places of the northernmost (downslope) part of the property. Treeless areas were generally found to be covered in grasses and small shrubs, and commonly contained subrounded to subangular cobbles and boulders of pale red to medium gray quartzite up to several feet in diameter; in rare cases, medium dark gray dolomite cobbles were observed at the surface. These rock clasts<sup>3</sup> are believed to be part of a surficial geologic unit considered to be colluvial deposits derived from weathered Wasatch Formation.

In the northeastern part of the property, an area containing springs emanating from the north-facing hillslope and associated standing water and common hydrophilic plants (mule's ear) was observed. Similar conditions were not found elsewhere on the property, though very moist ground was observed in the eastern side of Lot 27 (where TP-51 was later excavated), and mule's ear vegetation was observed in a couple small areas in Lots 36 through 38. A small man-made pond was observed adjacent to and north of the bisecting gravel road in between Lots 11 and 14.

No running water or ephemeral drainages were observed on the property at the time of the site visit. Possible landslide headscarps were observed both in the northern and southern portions of the property. The possible scarp in the southern part of the property was more subdued and

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<sup>3</sup> Clast: An individual constituent, grain, or fragment of a sediment or rock, produced by the mechanical or chemical disintegration or a larger rock mass. (AGI, 2005)

coincided with a transition to a large treeless and cobble-rich area further to the south. Multiple possible scarps were observed in the northern part of the property, coinciding with notable breaks in slope with downslope hummocky topography. These areas were subsequently assessed in the subsurface investigation.

## 4.2 SUBSURFACE CONDITIONS

Between June 6 and 26, 2018, 55 exploration test pits were excavated at representative locations across the property to characterize subsurface conditions for both the proposed lots and roadways (Figure A-2). The test pits were excavated to depths ranging between 5½ and 17 feet below existing grade with the aid of Caterpillar 315C and 320 tracked excavators. The test pits excavated to evaluate the roadways were excavated to between 5½ and 10 feet below existing grade, while the test pits excavated to evaluate the lots were excavated to between 10 and 17 feet below existing grade. TP-14, originally planned to be a roadway test pit, was not excavated due to its proposed location being within an area of standing water. Additionally, TP-53B was excavated to assess subsurface conditions in the area of a proposed ski bridge. Detailed logs for the test pits are presented in Figures A-3 through A-57. In general, seven distinct geologic units were encountered in the subsurface. The soil and moisture conditions encountered during our investigation are discussed in the following paragraphs.

### 4.2.1 Earth Materials

**A/B Soil Horizon:** This topsoil unit was found to be approximately 6 to 18 inches thick, present in all of the test pits. The unit was typically a grayish brown to light brown, medium stiff to loose, dry to slightly moist, sandy lean CLAY with gravel (CL), with gravel and larger-sized subrounded to subangular quartzite clasts comprising generally between 10 and 25% of the unit. The topsoil was found to contain abundant plant and tree roots, and was forming upon the underlying colluvium, shallow landslide, or Wasatch Formation units.

**Colluvium:** This unit was found to underlie the topsoil in most test pits, but was absent in TP-8, TP-10, TP-29, TP-40, TP-43 through TP-47, TP-49, and TP-51 through TP-53; most conspicuously absent from the test pits excavated in the southeastern part of the property. The unit was typically between 1 and 2 feet thick, but was as thin as 6 inches and as thick as 3 feet in places. The unit consisted of a dark yellowish brown to moderate yellowish brown, medium-stiff, moist, sandy lean CLAY with gravel (CL). Gravel and larger-sized subrounded quartzite clasts comprised generally approximately 30 to 40% of the unit, with individual clasts up to 4 feet in diameter and a typical mode clast size of 3 to 4 inches. Clasts were largely supported within a topsoil matrix that hosted common to abundant plant and tree roots. The unit may also include an alluvial component, as seen elsewhere on Powder Mountain.

**Wasatch Formation:** This unit was found in all but the southernmost test pits (except TP-50, in which it was observed), typically extending to the maximum depth of exploration in the test pits. The unit consisted of weakly consolidated conglomerate bedrock that had been largely

disaggregated into a heterogeneous, moderate reddish brown to dark reddish brown, dense to medium-dense, moist to wet mixture of clay, sand, and gravel that commonly classifies as a clayey GRAVEL with sand (GC). The unit was variable between test pits, grading to a clayey SAND with gravel (SC) and sandy lean CLAY with gravel (CL) in places, representing facies changes<sup>4</sup> within the Wasatch Formation. Gravel and larger-sized subrounded quartzite clasts typically comprised between 20 and 50% of the unit, with individual clasts up to 3 feet in diameter and a common mode clast size of between 1 to 3 inches. The sand component was generally fine- to medium-grained subangular quartzite grains, but was observed to be coarse-grained in places. Where coarser-grained sand was present, the unit exhibited a fine-grained brecciated<sup>5</sup> appearance. Muscovite mica flakes and black manganese oxide staining were observed within the unit in some test pits excavated in the southern portion of the property, as part of a very stiff, dark reddish brown sandy fat CLAY (CH) subunit that was observed to be devoid of slickensides.

Based on the data collected from the test pits, it appears that this unit across the Bobcat Ridge property contains three distinct subunits: an upper clayey GRAVEL with sand; a middle sandy fat CLAY with rare slickensides and common muscovite mica grains and manganese oxide staining; and a lower sandy fat CLAY that exhibits a fine-grained brecciated appearance. In general, the upper and middle subunits were encountered in the test pits excavated in the northern half of the property, while the middle and lower subunits were encountered in the test pits excavated in the southern half of the property.

**Shallow Landslide:** This unit was found to underlie the topsoil in the southernmost test pits (except TP-50), and was found underlying the colluvium unit in several of the northern test pits (TP-6, TP-7, TP-13, TP-20, TP-24, TP-25). The unit was typically between 1 and 3 feet thick, but was as thick as 7 feet in places (TP-49). The unit consisted of a mottled light brownish gray to moderate reddish brown to dark yellowish orange, medium-stiff, moist to wet, sandy fat CLAY with gravel (CH). Gravel and larger-sized subrounded to subangular quartzite clasts typically comprised between approximately 10 and 30% of the unit, with individual clasts up to 1 foot in diameter and a typical mode clast size of 1 to 2 inches. The unit was commonly identified by way of a highly heterogeneous appearance, being poorly sorted with common organic and manganese oxide smears, commonly exhibited pinhole voids, and either contained or was underlain by slickensided fat clay.

**Shear Plane:** This unit was observed in TP-1, TP-40, TP-41, TP-43, TP-44, TP-45, TP-46, TP-49, TP-51, and TP-52, immediately underlying the shallow landslide deposits. The unit was

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<sup>4</sup> **Facies change:** A lateral or vertical variation in the lithologic or paleontologic characteristics of contemporary sedimentary deposits. It is caused by, or reflects, a change in the depositional environment. (AGI, 2005)

<sup>5</sup> **Brecciated:** Converted into, characterized by, or resembling a breccia; especially said of a rock structure marked by an accumulation of angular fragments, or of an ore texture showing mineral fragments without notable rounding. (AGI, 2005)

typically between 1 and 6 feet thick, and consisted of a light gray to mottled light brownish gray and dark yellowish orange to dark reddish brown, medium-stiff, moist to wet, high plasticity sandy fat CLAY (CH). Most commonly, the unit was devoid of or contained few gravel and larger sized clasts, exhibited a glossy sheen and greasy feel, and contained occasional to common discontinuous slickensides and pinhole voids. The unit appeared similar to weathered Norwood Formation fat clays observed elsewhere in the Ogden Valley, though the Norwood Formation has not been mapped this far north. Ordinarily, this feature would be considered part of the overlying landslide unit; however, the characteristics of this material appears unique from the shallow landslide unit and the underlying bedrock units, thus this thin layer is considered as a separate unit for the purposes of this report.

**Deep Clay Seam:** This unit was found to underlie the Wasatch Formation primarily in the northwestern portion of the property, observed in TP-2, TP-3, TP-8 as a light gray to mottled light gray and dark reddish brown, stiff, moist to wet, high plasticity sandy fat CLAY (CH). In these test pits, the unit extended to the maximum depth of the exploration, being at least 7 feet thick in TP-8. Gravel and larger sized clasts were rare to absent. The seam exhibited a common fat clay glossy sheen, though natural slickensides were not observed. The unit looked very similar to the shear plane unit observed in the southern portion of the property, though at a different stratigraphic position. It is possible that the *shear plane* described above existed as the *deep clay seam* prior to movement; this suggests that while the *deep clay seam* does not currently show evidence of movement, the *deep clay seam* nonetheless may be particularly susceptible to movement under certain circumstances.

**Calls Fort Shale:** This unit was only observed in TP-1, identified at a depth of 8 feet below existing grade and extending to the maximum depth of exploration in this test pit. The unit consisted of dark yellowish orange to light greenish gray weathered shale bedrock that has been largely disaggregated to a dense, moist, silty, clayey GRAVEL (GM-GC), with gravel and larger sized angular shale clasts comprising between 50 and 60% of the unit. The shale clasts were observed to be finely bedded, have a greasy feel, and contained very fine-grained mica crystals (biotite and muscovite). The clay component of the unit was a fat clay, the product of decomposition of the shale bedrock.

#### 4.2.2 Groundwater

Groundwater was encountered in 28 of the 55 test pits (see Figure A-2), having been excavated in early to late June and likely at or near the annual high groundwater levels. Seepage was typically observed to be emanating from the sandy Wasatch Formation or shallow landslide deposits at depths as shallow as 3 feet below existing grade, but was also found in excess of 10 feet below existing grade. Continuous, persistent seepage in some test pits caused the pits to be filled with as much as 3 feet of water during the test pit logging. Notably, groundwater was shallowest in the

areas where the shallow landslide deposits were present, most especially in the southern half of the property.

#### 4.2.3 Strength of Earth Materials

To assess the shear strength of site soils for slope stability analysis, three direct shear tests (ASTM D3080) were performed on representative site soils. Two of the tests were performed on relatively ‘undisturbed’ tube samples of clayey soils, and one of the tests was performed on a remolded specimen of granular soil. The tests were conducted under drained conditions. The test results are summarized in Table 4.2.3; detailed test results are presented in Appendix B.

To assess the residual strength of clayey soils, a ring shear test (ASTM D6467) was completed on a remolded clay sample obtained from what was interpreted to be a landslide basal shear surface in TP-1. Residual shear strength values are required to model any pre-existing sheared earth material, typically isolated along a roughly planar surface along the base of a landslide. The tests were conducted under drained conditions. The test results are summarized in Table 4.2.3; detailed test results are presented in Appendix B.

**Table 4.2.3  
Summary of Soil Strength Testing**

| Sample          | Soil Type                    | Test         | Results   |
|-----------------|------------------------------|--------------|---|
| TP-3 @ 9.5 ft   | Fat CLAY (CH)<br>(clay seam) | Direct Shear | $\Phi=19^\circ$ , $c=587$ psf<br>LL=90 PI=54 Fines=82.3%          |
| TP-9 @ 8 ft     | Clayey GRAVEL<br>w/sand (GC) |              | $\Phi=31^\circ$ , $c=115$ psf (remold)<br>G:49.1% S:26.0% F:24.9% |
| TP-21 @ 5.5 ft  | Sandy Lean CLAY<br>(CL)      |              | $\Phi=29^\circ$ , $c=311$ psf<br>LL=32 PI=16                      |
| TP-1 @ 4 ft     | Fat CLAY (CH)<br>(clay seam) | Ring Shear   | $\Phi_r=14.4^\circ$ LL=126 PI=85<br>Fines=94.3%                   |
| TP-22 @ 10.5 ft | Fat CLAY (CH)                | Unconfined   | $S_u=907$ psf<br>LL=77 PI=58                                      |
| TP-40 @ 5.5 ft  | Fat CLAY (CH)                | Unconfined   | $S_u=1,302$ psf<br>LL=97 PI=74                                    |
| TP-52 @ 4.5 ft  | Fat CLAY (CH)                | Unconfined   | $S_u=4,400$ psf<br>LL=72 PI=54                                    |
| TP-49 @ 7.5 ft  | Fat CLAY (CH)                | UU           | $S_u=966$ psf<br>LL=95 PI=74                                      |

To evaluate the unconfined compressive strength of the prevailing clayey soils, one unconsolidated-undrained (UU) triaxial compression test (ASTM D2850) and three unconfined

compressive strength tests (ASTM D2166) were completed on relatively ‘undisturbed’ tube samples of clayey soils. These tests were completed to assess the *undrained shear strength* of the prevailing clay soils, which is correlated to the shear stress at failure. The test results are summarized in Table 4.2.3; detailed test results are presented in Appendix B.

### 4.3 STABILITY OF NATURAL SLOPES

#### 4.3.1 Slope Stability

The stability of the existing natural slopes has been assessed in accordance with methodologies set forth in Blake et al. 2002 and AASHTO LRFD for Bridge Design Specifications with respect to several representative cross-sections, illustrated on Figures D-1 through D-5 in Appendix D (the section is identified in plan-view on Figure A-2). The stability of the slopes was modeled using SLIDE, a computer application incorporating (among others) Spencer’s Method of analysis. Calculations for stability were developed by searching for the minimum factor of safety for a circular-type failure occurring through surficial soils and the underlying conglomerate bedrock, as well as a translational-type failure occurring along existing or potentially new landslide basal shear surfaces. Analysis was performed for both static and seismic (pseudo-static) cases.

Soil strength parameters were selected based primarily on soil strength testing, with due consideration for soil types observed, local experience, and correlation with index properties (Atterberg Limits, clay content). Based on this assessment, appropriate soil strength values were developed – the values selected are summarized in Table 4.3.1a.

**Table 4.3.1a  
Soil Strength Parameters**

| Earth Materials                 | Friction angle (degrees) | Cohesion (psf) | Unit Weight (pcf) |
|---------------------------------|--------------------------|----------------|-------------------|
| Calls Fort Shale (Cbc)          | 22                       | 3,000          | 135               |
| Wasatch Formation (Tw)          | 40                       | 100            | 125               |
| Landslide (Qls) mass            | 31                       | 115            | 129               |
| Landslide (Qls) <i>residual</i> | $\Phi_r=14.4^\circ$      |                | 129               |
| Colluvium/Alluvium (Qac)        | 34                       | 0              | 120               |
| Colluvium (Qc)                  | 36                       | 0              | 125               |

Groundwater, e.g. a piezometric groundwater surface, was encountered in about half of the test pits during our subsurface investigation; shallow groundwater (less than 10 feet below existing grade) was fairly common. Although assumed to be a ‘perched’ condition, since the depth of the groundwater cannot be known with certainty, the groundwater was assumed to be a piezometric surface where encountered. Estimated groundwater levels are shown on the geologic cross-sections in Appendix D; measured groundwater levels are presented on the test pit logs.

Pseudo-static (seismic screening) analysis of the proposed slope was performed in general conformance with Blake et al. 2002, ASCE 7-10 and AASHTO LRFD for Bridge Design Specifications. The design seismic event was taken as the ground motion with a 2 percent probability of exceedance in 50 years (2PE50). Based on information provided on the USGS website ground motion calculator, the Peak Ground Acceleration (PGA) associated with a 2PE50 event is estimated to be 0.35g. Half of the PGA, (0.175g), was taken as the horizontal seismic coefficient ( $k_h$ ) (Hynes and Franklin, 1984), and used in the pseudo-static seismic screen analysis. The results of the analyses have been summarized in Table 4.3.1b. Where the seismic factor-of-safety was less than 1.0, a simplified Newmark-type displacement analysis was performed in accordance with Bray and Travararou (2007). The purpose of this additional analysis is to estimate the potential magnitude of seismic slope movement. It is important to note that developers of this simplified approach to estimate displacement consider the results of these analyses to be indices of expected seismic performance and not predications of exact amount or location of slope displacement amount. In general, a maximum of 5 cm of slope deformation is considered acceptable from a design standpoint (Blake et al. 2002). The results of the slope deformation analysis are also presented in Table 4.31b; detailed analysis is presented in Appendix D. Where the minimum criteria does not meet the minimum acceptable standard, the value is shown in red (static: min. FS of 1.50, seismic: min. FS of 1.0, displacement: max. allowed of 5 cm).

**Table 4.3.1b  
Results of Slope Stability Analyses**

| Section | Static Factor of Safety | Pseudo-Static Factor of Safety | Estimated Slope Deformation (cm) |
|---------|-------------------------|--------------------------------|----------------------------------|
| A-A'    | 1.62                    | 0.91                           | 2.1                              |
| B-B'    | 2.11                    | 1.19                           | n/a                              |
| C-C'    | 1.22                    | 0.73                           | 6.4                              |
| D-D'    | 2.29                    | 0.89                           | 2.5                              |
| E-E'    | 2.08                    | 0.84                           | 3.4                              |

**Discussion:**

Section A-A' – this analysis indicates that Landslide A is stable under static conditions, but is likely unstable under seismic conditions. Slope deformation analysis indicates an estimated slope deformation of 2 cm. Nonetheless, considering the high groundwater and the particularly weak clay seam identified at depth, development within this landslide lobe is not recommended pending further study or mass grading including over-excavation through the basal shear plane of the landslide deposits to competent native materials for all improvements, including roadways.

Section B-B' – this analysis indicates that the slope is stable under both static and seismic conditions, largely owing to the presence of relatively competent Wasatch Formation bedrock. Although the analysis shows a portion of Landslide A as being stable, since this portion is attached



to the greater landslide mass, which is currently considered to be marginally stable, development within the lower reaches of Section B-B' (within the landslide deposits) should be avoided pending additional study. It should be noted that there are no lots within landslide deposits along Section B-B'.

Section C-C' – this analysis indicates a fairly low factor of safety for both static and seismic conditions, with slope deformation estimated to be in excess of 5 cm. Nevertheless, the landslide deposits within Landslide B (the young landslide deposits mapped within the northeastern part of the property) are relatively shallow, not exceeding 6 feet in depth and often shallower. Accordingly, development within the area covered by these landslide deposits is feasible, though complete over-excavation down to competent Wasatch Formation would be necessary for all improvements, including roadways.

Sections D-D' and E-E' – These sections delineate a broad, flat, shallow landslide mass that has translated on a seam of low-strength fat clay. Although the landslide mass is considered stable under static conditions (owing to the relatively subdued topography and low slope gradient), the landslide is nonetheless susceptible to re-activation under seismic conditions. Slope deformation analysis indicates estimated slope movements less than 5 cm; however, owing to the presence of shallow groundwater and a particularly low-strength clay seam that defines the basal shear of the landslide, development upon this landslide mass should be avoided unless remedial grading to disrupt the basal shear is performed across the entire building footprint for individual lots and for all roadways. Remedial grading may be challenging in some areas due to the presence of shallow groundwater.

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

### 5.1 GENERAL CONCLUSIONS

Based on the results of the literature review, site reconnaissance, subsurface investigation, and laboratory results, the subsurface conditions are considered suitable for most of the proposed development provided that the recommendations presented in this report are incorporated into the design and construction of the project. Limited areas of the project area should be avoided for development pending additional subsurface investigation and/or analysis and the development of a suitable geologic hazard mitigation plan.

Supporting data upon which the following recommendations are based have been presented in the previous sections of this report. The recommendations presented herein are governed by the physical properties of the earth materials encountered in the subsurface explorations. If subsurface conditions other than those described herein are encountered in conjunction with construction, and/or if design and layout changes are initiated, IGES must be informed so that our recommendations can be reviewed and revised as deemed necessary.

### 5.2 GEOLOGIC CONCLUSIONS AND RECOMMENDATIONS

Based upon the data collected and reviewed as part of the geologic hazard assessment, IGES makes the following conclusions regarding the geological hazards present at the Bobcat Ridge project area:

- **The Bobcat Ridge project area does have significant or imminent geological hazards that could adversely affect the development as currently proposed, in the form of landslide hazards and shallow groundwater conditions.**
- Shallow landslide deposits and an associated older (Pleistocene-aged) slide plane fat clay that was heavily slickensided was observed in test pits excavated in the southern portion of the property. Additionally, high plasticity clays were observed underlying the Wasatch Formation in the northwestern part of the property, though these were not found to be slickensided except in TP-1. Shallow landslide deposits were also observed in some test pits in the northeastern part of the property, though these were also not slickensided. Combined with the prevalent shallow groundwater conditions observed across the property, these subsurface conditions are conducive to slope instabilities in these areas that largely manifest as shallow, surficial landslides. As such, the landslide hazard is considered to be high for Lots 3, 8, 37 through 39, and 42; moderate to high for Lots 1, 2, 22 through 33, 36, and 43; moderate for Lots 4 through 7, 9, 12, 40, 41, 44 through 48; and low for Lots 10 through 21, 34, and 35. The hazard classifications are based upon a combination of subsurface data, existing topography, and the presence/absence of shallow groundwater conditions, and are applied without consideration to any mitigation effort (since remedial

grading or similar mitigation efforts could significantly reduce the hazard classification for some lots). These ratings have been applied conservatively to represent the most hazardous conditions for any given lot. Due to the fact that topographic conditions and likely subsurface conditions are laterally variable across individual lots, some of these hazard ratings could be reduced depending on where residences are to be specifically located on certain lots, or by way of remedial grading (see Figure A-63 and the Table of Lots in Appendix E).

- Shallow groundwater conditions (less than about 10 feet below existing grade) were observed in 28 of the 55 test pits, and wetland area containing a spring and standing water conditions was observed near the northeastern portion of the property. Because the test pits were excavated in June, groundwater levels were likely to be at or near their annual high. Shallow groundwater hazards are considered to be high for Lots 1, 2, 5, 7 through 10, 15 through 17, 19 through 21, and 23 through 42; moderate for Lots 3, 4, 11 through 13, 18, 22, and 43; and low for Lots 6, 14, and 44, through 48 (see Figure A-63 and the Table of Lots in Appendix E).
- Earthquake ground shaking is the only other identified hazard that may potentially affect all parts of the project area and is considered to pose a moderate risk.
- Rockfall, surface-fault-rupture, liquefaction, debris-flow, and flooding hazards are considered to be low for the property.

Given the conclusions listed above, IGES makes the following recommendations:

- Foundations and roadways should be placed on competent bedrock (Wasatch Formation or Calls Fort Shale), or structural fill extending to competent bedrock; this will require over-excavating within the building envelope or roadway to below the base of the shallow landslide deposits and shear plane (where present), as well as over-excavating below the base of the deeper high plasticity clay seam (where present). For the lots and roadway located within Landslide A, development is not currently recommended without significant landslide hazard mitigation efforts. It is recommended that landslide hazard mitigation entail additional studies to further delineate the landslide boundary and mass grading of both the building envelope and all of the landslide upslope of these lots. This applies to Lots 36 through 39, 42, and 43. For the lots and roadways located within Landslides B and C, over-excavation across the entire building footprints for each lot and roadway is recommended. This applies to Lots 2, 3, 4, 7, 8, 9, and 21 through 33 (see the Table of Lots in Appendix E). The over-excavation applies to the entire building footprint. In some areas, the depth of landslide deposits may preclude the practicality of over-excavation under a single home; therefore, mass-grading may be an appropriate alternative for some areas.

- An IGES geologist or geotechnical engineer should observe the foundation excavations to assess that the excavations have been taken to an appropriate depth, and to further evaluate for adverse geologic conditions.
- Given the presence of shallow groundwater conditions, residences without basements (on-grade structures) are recommended for those lots designated to have a high shallow groundwater hazard risk, unless groundwater remediation efforts are performed. This applies to Lots 1, 2, 5, 7 through 10, 15 through 17, 19 through 21, and 23 through 42 (see the Table of Lots in Appendix E). It is recommended that the groundwater hazard be remediated by way of the installation of a series of land drains at various locations upslope of the building envelope of these lots, and the incorporation of basement foundation drains for each individual lot (e.g. a ‘passive’ system that does not rely on a pump or other mechanical device). The location, orientation, length, and depth of the land drains should be coordinated by or with IGES.

## 5.3 EARTHWORK

### 5.3.1 General Site Preparation and Grading

Below proposed structures, fills, and man-made improvements, all vegetation, topsoil, debris and undocumented fill (if any) should be removed. Any existing utilities should be re-routed or protected in place. The exposed native soils should then be proof-rolled with heavy rubber-tired equipment such as a scraper or loader\*. Any soft/loose areas identified during proof-rolling should be removed and replaced with structural fill. All excavation bottoms should be observed by an IGES representative during proof-rolling or otherwise prior to placement of engineered fill to evaluate whether soft, loose, or otherwise deleterious earth materials have been removed, and to assess compliance with the recommendations presented in this report.

\*not required where bedrock is exposed in the foundation subgrade

### 5.3.2 Excavations

Soft, loose, or otherwise unsuitable soils beneath structural elements, hardscape or pavements may need to be over-excavated and replaced with structural fill. If over-excavation is required, the excavations should extend ½ foot laterally for every foot of depth of over-excavation. Excavations should extend laterally at least two feet beyond flatwork, pavements, and slabs-on-grade. Structural fill should consist of granular materials and should be placed and compacted in accordance with the recommendations presented in this report.

Prior to placing engineered fill, all excavation bottoms should be scarified to at least 6 inches, moisture conditioned as necessary at or slightly above optimum moisture content (OMC), and

compacted to at least 90 percent of the maximum dry density (MDD) as determined by ASTM D-1557 (Modified Proctor). Scarification is not required where bedrock is exposed.

### 5.3.3 Excavation Stability

The contractor is responsible for site safety, including all temporary trenches excavated at the site and the design of any required temporary shoring. The contractor is responsible for providing the "competent person" required by Occupational Safety and Health (OSHA) standards to evaluate soil conditions. For planning purposes, Soil Type C is expected to predominate at the site (sands and gravels), although Soil Type B (stiff clay) will be encountered locally. Close coordination between the competent person and IGES should be maintained to facilitate construction while providing safe excavations.

Based on OSHA guidelines for excavation safety, trenches with vertical walls up to 5 feet in depth may be occupied. Where very moist soil conditions or groundwater is encountered, or when the trench is deeper than 5 feet, we recommend a trench-shield or shoring be used as a protective system to workers in the trench. As an alternative to shoring or shielding, trench walls may be laid back at one and one-half horizontal to one vertical (1½H:1V) (34 degrees) in accordance with OSHA Type C soils – where stiff clays are exposed, the slope may be steepened to 1H:1V (45 degrees). Trench walls may need to be laid back at a steeper grade pending evaluation of soil conditions by the geotechnical engineer. Soil conditions should be evaluated in the field on a case-by-case basis. Large rocks exposed on excavation walls should be removed (scaled) to minimize rock fall hazards. Shallow groundwater was encountered at several locations – local dewatering may be necessary for some utility construction.

### 5.3.4 Structural Fill and Compaction

All fill placed for the support of structures, flatwork or pavements should consist of structural fill. Structural fill should consist of granular native soils, which may be defined as soils with less than 25% fines, 10-60% sand, and contain no rock larger than 4 inches in nominal size (6 inches in greatest dimension). Structural fill should also be free of vegetation and debris. All structural fill should be 1 inch minus material when within 1 foot of any base coarse material. Soils not meeting these criteria may be suitable for use as structural fill; however, such soils should be evaluated on a case by case basis and should be approved by IGES prior to use. Soils classifying as Fat CLAY (CH) should not be used for structural fill placed below pavements or structures. Fat clay can typically be identified as sticky, highly plastic clays with a glossy luster and a greasy texture.

All structural fill should be placed in maximum 4-inch loose lifts if compacted by small hand-operated compaction equipment, maximum 6-inch loose lifts if compacted by light-duty rollers, and maximum 8-inch loose lifts if compacted by heavy duty compaction equipment that is capable of efficiently compacting the entire thickness of the lift. Additional lift thickness may be allowed by IGES provided the Contractor can demonstrate sufficient compaction can be achieved with a

given lift thickness with the equipment in use. We recommend that all structural fill be compacted on a horizontal plane, unless otherwise approved by IGES. Structural fill underlying all shallow footings and pavements should be compacted to at least 95 percent of the MDD as determined by ASTM D-1557. **The moisture content should be at, or slightly above, the OMC for all structural fill.** Any imported fill materials should be approved prior to importing. Also, prior to placing any fill, the excavations should be observed by IGES to confirm that unsuitable materials have been removed. In addition, proper grading should precede placement of fill, as described in the General Site Preparation and Grading subsection of this report.

Specifications from governing authorities such as Weber County and/or special service districts having their own precedence for backfill and compaction should be followed where more stringent.

### 5.3.5 Oversize Material

Based on our observations, there is a significant potential for the presence of oversize materials (larger than 6 inches in greatest dimension). Large rocks, particularly boulders (>12 inches), may require special handling, such as segregation from structural fill, and disposal.

### 5.3.6 Utility Trench Backfill

Utility trenches should be backfilled with structural fill in accordance with Section 5.3.4 of this report. Utility trenches can be backfilled with the onsite soils free of debris, organic and oversized material. Prior to backfilling the trench, pipes should be bedded in and shaded with a uniform granular material that has a Sand Equivalent (SE) of 30 or greater. Pipe bedding should not be water-densified in-place (jetting). Alternatively, pipe bedding and shading may consist of clean ¾-inch gravel, or a similar material approved by IGES. Native granular earth materials can be used as backfill over the pipe bedding zone – however, soils classifying as Fat CLAY (CH) should not be used under pavements or structures. All utility trenches backfilled below pavement sections, curb and gutter, and hardscape, should be backfilled with structural fill compacted to at least 95 percent of the MDD as determined by ASTM D-1557. All other trenches should be backfilled and compacted to approximately 90 percent of the MDD (ASTM D-1557). However, in all cases the pipe bedding and shading should meet the design criteria of the pipe manufacturer. Specifications from governing authorities having their own precedence for backfill and compaction should be followed where they are more stringent.

## 5.4 FOUNDATION RECOMMENDATIONS

Based on our field observations and considering the presence of relatively competent native earth materials, we recommend that the footings for proposed homes be founded either *entirely* on competent native soils or *entirely* on structural fill. Native/fill transition zones are not allowed. Due to the presence of shallow landslide deposits, foundation excavations must extend below the landslide deposits and basal shear plane clay and into the competent Wasatch Formation below – this recommendation applies to the entire building envelope, not just the footings. Alternatively,

the foundations may be supported on structural fill extending to competent material below any identified landslide deposits (this alternative also applies to the entire building envelope). Estimated over-excavation for each lot is presented in the Table of Lots in Appendix E.

If landslide deposits or soft, loose, or otherwise deleterious earth materials are exposed in the footing excavations, then all footings must be deepened such that all footings bear on relatively uniform, competent native earth materials. Alternatively, the foundation excavation may be over-excavated a minimum of 2 feet below the bottom of proposed footings and replaced with structural fill, such that the footings bear entirely on a uniform fill blanket. We recommend that IGES assess the bottom of the foundation excavation prior to the placement of steel or concrete to identify the competent native earth materials as well as any unsuitable soils, transition zones, or landslide deposits. Additional over-excavation may be required based on the actual subsurface conditions observed.

Shallow spread or continuous wall footings constructed entirely on competent, *granular*, uniform native earth materials or on a minimum of 2 feet of *structural fill* may be proportioned utilizing a maximum net allowable bearing pressure of **2,800 pounds per square foot (psf)** for dead load plus live load conditions. The net allowable bearing value presented above is for dead load plus live load conditions. The minimum recommended footing width is 20 inches for continuous wall footings and 30 inches for isolated spread footings.

All conventional foundations exposed to the full effects of frost should be established at a minimum depth of 42 inches below the lowest adjacent final grade. Interior footings, not subjected to the full effects of frost (i.e., *a continuously heated structure*), may be established at higher elevations, however, a minimum depth of embedment of 12 inches is recommended for confinement purposes.

Foundation drains should be installed around below-ground foundations (e.g., basement walls) to minimize the potential for flooding from shallow groundwater, which may be present at various times during the year, particularly spring run-off.

Skier Bridge Foundations: We understand the skier bridge foundations will likely consist of conventional spread footings. Considering that the skier bridge foundation will be constructed approximately 20 feet below existing grade and will likely be placed in competent bedrock, a maximum net allowable bearing pressure of 4,600 psf for dead load plus live load conditions may be utilized for design.

## 5.5 SETTLEMENT

### 5.5.1 Static Settlement

Static settlements of properly designed and constructed conventional foundations, founded as described in Section 5.4, are anticipated to be on the order of 1 inch or less. Differential settlement is expected to be half of total settlement over a distance of 30 feet.

### 5.5.2 Dynamic Settlement

Dynamic settlement (or seismically-induced settlement) consists of dry dynamic settlement of unsaturated soils (above groundwater) and liquefaction-induced settlement (below groundwater). During a strong seismic event, seismically-induced settlement can occur within loose to moderately dense sandy soil due to reduction in volume during, and shortly after, an earthquake event. Settlement caused by ground shaking is often non-uniformly distributed, which can result in differential settlement.

Based on the subsurface conditions encountered, and considering the engineering characteristics of the prevailing Wasatch Formation bedrock, dynamic settlement arising from a MCE seismic event is expected to be low; for design purposes, settlement on the order of ½ inch over 40 feet may be assumed.

## 5.6 EARTH PRESSURES AND LATERAL RESISTANCE

Lateral forces imposed upon conventional foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footing and the supporting soils. In determining the frictional resistance against concrete, a coefficient of friction of 0.45 for sandy/gravelly native soils or structural fill should be used.

**Table 5.6  
Lateral Earth Pressure Coefficients**

| Condition       | Level Backfill               |                                | 2H:1V Backfill               |                                |
|-----------------|------------------------------|--------------------------------|------------------------------|--------------------------------|
|                 | Lateral Pressure Coefficient | Equivalent Fluid Density (pcf) | Lateral Pressure Coefficient | Equivalent Fluid Density (pcf) |
| Active (Ka)     | 0.307                        | 38.4                           | 0.468                        | 58.4                           |
| At-rest (Ko)    | 0.470                        | 58.8                           | 0.80                         | 85                             |
| Passive (Kp)    | 3.26                         | 407                            | —                            | —                              |
| *Seismic Active | 0.113                        | 14.2                           | 0.417                        | 52.1                           |

\* Based on Mononobe-Okabe

Ultimate lateral earth pressures from *granular* backfill acting against retaining walls, temporary shoring, or buried structures may be computed from the lateral pressure coefficients or equivalent fluid densities presented in Table 5.6. These lateral pressures should be assumed even if the backfill is placed in a relatively narrow gap between a vertical bedrock cut and the foundation wall. These coefficients and densities assume no buildup of hydrostatic pressures. The force of water should be added to the presented values if hydrostatic pressures are anticipated.



Clayey soils drain poorly and may swell upon wetting, thereby greatly increasing lateral pressures acting on earth retaining structures; this is particularly pertinent to soils classifying as Fat Clay (CH), which were encountered throughout the site. As such, clayey soils should not be used as retaining wall backfill. Backfill should consist of native granular soil with an Expansion Index (EI) less than 20.

Walls and structures allowed to rotate slightly should use the active condition. If the element is to be constrained against rotation (i.e., a basement wall), the at-rest condition should be used. These values should be used with an appropriate factor of safety against overturning and sliding. A value of 1.5 is typically used. Additionally, if passive resistance is calculated in conjunction with frictional resistance, the passive resistance should be reduced by  $\frac{1}{2}$ .

For seismic analyses, the *active* earth pressure coefficient provided in the table is based on the Mononobe-Okabe pseudo-static approach and only accounts for the dynamic horizontal thrust produced by ground motion. Hence, the resulting dynamic thrust pressure *should be added* to the static pressure to determine the total pressure on the wall. The pressure distribution of the dynamic horizontal thrust may be closely approximated as an inverted triangle with stress decreasing with depth and the resultant acting at a distance approximately 0.6 times the loaded height of the structure, measured upward from the bottom of the structure.

## 5.7 SLOPE GRADING RECOMMENDATIONS

### 5.7.1 General Specifications

The following generalized recommendations are for engineered slopes (cut slopes and fill slopes). Recommendations for grading of engineered slopes are intended to minimize the potential for future surficial failures. For purposes of this report, surficial failure includes excessive erosion, sloughing, slumping, mass wasting, rockfall, and similar relatively shallow failures. For engineered slopes taller than 6 feet, IGES should review the grading plans and evaluate the impact to local slope stability.

Engineered slopes should be no steeper than 2H:1V; steeper slopes (as steep as 1.5H:1V) may be allowed provided a reinforcement system that incorporates a HPTRM is utilized. Any slope reinforcement system should be designed by a qualified civil engineer (e.g. Western Excelsior *Extreme Armoring System*).

All fill slopes taller than about 5 feet should incorporate a *keyway* into the design, with a minimum depth of 2 feet and a minimum width of 8 feet.

### 5.7.2 Benching

Where fills are to be placed on ground with slopes steeper than 5H:1V, the ground should be stepped or benched. At a minimum, benches should be constructed every four (4) vertical feet. Benches shall be excavated a minimum lateral depth of four (4) feet into competent material or as otherwise recommended by IGES. However, the *lowest* bench should be excavated a minimum lateral depth of 8 feet into competent material (this measurement may include the keyway width for a fill slope).

### 5.7.3 Slope Protection

Slope planting and other measures should be provided immediately following construction. Slope protection polymers, straw wattles, and/or jute mesh should also be considered to limit the amount of erosion on slopes subject to erosion until landscaping and other permanent erosion protection measures are fully in place.

### 5.7.4 Earthwork Recommendations

In addition to the normal compaction procedures for structural fill specified in Section 5.3.4, compaction of fill slopes shall be accomplished by backrolling of slopes with sheepsfoot rollers at increments of 3 to 4 feet in fill elevation, or by other methods producing satisfactory results acceptable to IGES. As an alternative to slope compaction, slopes may be constructed 2 to 3 feet 'fat' and trimmed back using a bulldozer with a slope board or similar equipment. Upon completion of grading, relative compaction of the fill out to the slope face shall be at least 90 percent of the maximum dry density per ASTM D 1557 (modified Proctor).

## 5.8 CONCRETE SLAB-ON-GRADE CONSTRUCTION

To minimize settlement and cracking of slabs, and to aid in drainage beneath the concrete floor slabs, all concrete slabs should be founded on a minimum 4-inch layer of compacted gravel overlying properly prepared subgrade. The gravel should consist of free-draining gravel or road base with a 3/4-inch maximum particle size and no more than 5 percent passing the No. 200 mesh sieve. The layer should be compacted to at least 95 percent of the MDD as determined by ASTM D-1557.

All concrete slabs should be designed to minimize cracking as a result of shrinkage. Consideration should be given to reinforcing the slab with a welded wire fabric, re-bar, or fibermesh. Slab reinforcement should be designed by the structural engineer; however, as a minimum, slab reinforcement should consist of 4''×4'' W2.9×W2.9 welded wire mesh within the middle third of the slab. We recommend that concrete be tested to assess that the slump and/or air content is in compliance with the plans and specifications. We recommend that concrete be placed in general accordance with the requirements of the American Concrete Institute (ACI). A Modulus of Subgrade Reaction of **250 psi/inch** may be used for design. It should be noted that the Modulus of Subgrade Reaction is not a function of soil properties alone but is also influenced by other factors, including the width of the loaded area, the shape of the loaded area, and the specific location under

the slab. As such, the structural engineer should exercise care and engineering judgment when using the above stated value for design.

A moisture barrier (vapor retarder) consisting of 10-mil thick Visqueen (or equivalent) plastic sheeting should be placed below slabs-on-grade where moisture-sensitive floor coverings or equipment is planned. Prior to placing this moisture barrier, any objects that could puncture it, such as protruding gravel or rocks, should be removed from the building pad. Alternatively, the subgrade may be covered with 2 inches of clean sand.

## 5.9 MOISTURE PROTECTION AND SURFACE DRAINAGE

Surface moisture should not be allowed to infiltrate into the soils in the vicinity of the foundations. As such, design strategies to minimize ponding and infiltration near the structure should be implemented.

We recommend roof runoff devices be installed to direct all runoff a minimum of 10 feet away from foundations. The builder should be responsible for compacting the exterior backfill soils around the foundation, particularly around subterranean walls. Additionally, the ground surface within 10 feet of the structure should be constructed so as to slope a minimum of **five** percent away (2 percent is allowed if the ground surface within 10 feet is a relatively impermeable surface, such as a concrete slab). Pavement sections should be constructed to divert surface water off the pavement into storm drains, curb/gutter, or another suitable location.

For basements, IGES recommends a perimeter foundation drain be constructed in accordance with the 2012 or later International Residential Code (IRC).

## 5.10 PAVEMENT

### 5.10.1 Pavement Design

The near-surface soils generally consisted of fat clay (CH); furthermore, shallow groundwater has been noted across the site, and near-surface water has been identified locally. Accordingly, based on our observations, for pavement design we have modeled a CBR of 3. Anticipated traffic volumes were not available at the time this report was prepared; however, based on our understanding of the project development we assume traffic on the roadways would consist primarily of passenger cars with occasional heavy vehicles associated with construction, municipal waste collection, public transportation, fire trucks, and similar. The following pavement designs have been developed for a 20-year design life assuming a 0 percent annual growth rate, and our assumed equivalent single axle load (ESAL) of 200,000 ESALs for interior roadways. Based on the information obtained and the assumptions listed above, recommended pavement section alternatives are presented in Table 5.10.

**Table 5.10**  
**Pavement Design CBR 3.0 – Soft Surficial Soils, Clay**

| <b>Material Type</b>                      | <b>Option 1</b> | <b>Option 2</b> | <b>Option 3</b> |
|---|-----------------|-----------------|-----------------|
| <b>Asphalt Concrete Pavement (inches)</b> | 3.5             | 3.5             | 3.5             |
| <b>Untreated Road Base (inches)</b>       | 16              | 12              | 10              |
| <b>Subbase</b>                            | None            | None            | 14              |
| <b>*Stabilization Fabric</b>              | None            | Mirafi RS380i   | None            |

\*Stabilization fabric is placed between the subgrade and the road base.

The pavement section thicknesses presented in Table 5.10 assume that there is no mixing over time between the road base and the clayey subgrade. In order to minimize mixing or fines migration, and thereby prolong the life of the pavement section, we recommend that the owner give consideration to placing a filter fabric between the native soils and the road base, such as the **Mirafi 140N** or an IGES-approved equivalent.

During construction, a significant amount of heavy construction traffic occurs. Some distress may manifest on pavement sections during this initial construction time period. Maintenance may need to be performed after completion of construction.

As a minimum, the upper 4 inches of the fine-grained soils beneath all pavement sections should be reworked in-place and compacted to at least 93% of the MDD with the moisture content at or slightly above the OMC as determined by ASTM D-1557 (highly organic earth materials that appear to be topsoil should not be left in-place or be allowed to be mixed-in with the reworked soil). Asphalt has been assumed to be a high stability plant mix and base course material composed of crushed stone with a minimum CBR of 70. Road base should be compacted to a minimum density of 95 percent as determined by ASTM D-1557 (Modified Proctor). Asphalt should be compacted to a minimum of 96 percent of the Marshall maximum density. Asphalt and aggregate base material should conform to local requirements. Subbase should be a coarse, granular pit-run material with a minimum CBR of 30.

Where Portland Cement Concrete (PCC) pavements are planned, such as near trash enclosures or other areas expected to support heavy truck traffic, the pavement is recommended to be a minimum of 5 inches in thickness. Concrete pavement should be underlain by a minimum 6 inches of aggregate base course.

If conditions vary significantly from our stated assumptions, IGES should be contacted so we can modify our pavement design parameters accordingly.

### 5.10.2 Pavement Construction

The preceding pavement design options meet AASHTO design guidelines; however, where particularly soft, pumping subgrade is encountered, difficulty may be encountered during construction, particularly with respect to stabilization of the pavement subgrade. If soft, pumping soils or mobility problems arise during construction, one of the following options may be implemented:

- A. Where soft subgrade is encountered, Mirafi RS380i reinforcement or an engineer-approved equivalent can be placed between the soft subgrade and the subbase. *The subbase should be compacted in two lifts*; some pumping/deflection may be noticed during compaction of the first lift, however upon placement of the final lift the 12 inches of subbase over RS380i is expected to stabilize the subgrade.
- B. Stabilization of soft or pumping subgrade can also be accomplished by using a clean, coarse angular material worked into the soft subgrade. We recommend the material be greater than 3 inches in nominal diameter, but less than 6 inches. Alternately, a locally available pit-run gravel may be suitable but should contain a high percentage of particles larger than 3 inches diameter and have less than 5 percent fines (material passing the No. 200 Sieve). A pit-run gravel may not be as effective as a coarse, angular material in stabilizing the soft soils and will likely require more material be placed. The stabilization material should be worked (pushed) into the soft subgrade soils until a relatively firm and unyielding surface is established. Once a relatively firm and unyielding surface is achieved, the area may be brought to final design grade using structural fill. Other earth materials not meeting aforementioned criteria may also be suitable; however, such material should be evaluated on a case-by-case basis and should be approved by IGES prior to use.
- C. Where soft soils are encountered, the Contractor should consider compaction using static methods (e.g., wheel-rolling with heavy earth-moving equipment such as a loader or scraper). Compaction over soft soils using vibratory methods often proves to be marginally effective.

### 5.10.3 Frost Heave

The pavement designs presented in Table 5.10 do not take into account the deleterious effects of frost heave (positive volumetric strain of frozen soils). The prevailing near-surface soils generally consist of fat clay, which generally have a high moisture content and can be particularly susceptible to frost heave. Because the soils may be particularly susceptible to frost heave, the Owner may wish to consider placing a relatively frost-free material below the pavement section, e.g. a coarse subbase material with less than 20 percent fines content. Within the Summit Powder Mountain

area, the frost depth is generally taken as 42 inches for design; however, the actual frost depth could be less, or more, depending on location and whether snow removal is maintained throughout the winter since snow often acts to insulate the ground from very cold air. In roadways, frost depth can exceed this value, particularly in shady areas that receive little sun, since snow insulation is negligible due to snow removal.

The thickness of frost-free material added to the pavement section will be dependent upon the degree of risk of frost heave that is acceptable to the Owner – as a minimum, a distance of 24” from finish grade to the frost-susceptible soils would be prudent (total pavement section thickness of 24”, which would include asphalt, roadbase, and subbase combined). It should be noted that Option 3 from Table 5.10 would achieve this minimum. This would reduce, *but not eliminate* the risk associated with frost heave; the Owner may wish to consider additional thickness of frost-free material to further reduce the risk of reduced pavement life arising from frost heave.

## 5.11 SOIL CORROSION POTENTIAL

Laboratory testing of a representative soil sample indicated that the soil sample tested had a sulfate content of 5.8 ppm. Accordingly, the soils are classified as having a ‘low potential’ for deterioration of concrete due to the presence of soluble sulfate. As such, conventional Type II Portland cement may be used for all concrete in contact with site soils.

To evaluate the corrosion potential of ferrous metal in contact with onsite native soil a sample was tested for soil resistivity, soluble chloride and pH. The test indicated that the onsite soil tested has a minimum soil resistivity of 978 OHM-cm, soluble chloride content of 18.9 ppm and a pH of 4.2. Based on this result, the onsite native soil is considered to be *severely corrosive* to ferrous metal. To address the acidic soil conditions, we recommend a lower water/cement ratio, ~0.4, for reinforced concrete. The lower water/cement ratio will reduce permeability of the concrete and reduce the susceptibility of the reinforcing steel to acidic corrosion.

## 5.12 CONSTRUCTION CONSIDERATIONS

### 5.12.1 Over-Size Material

Large rocks (up to 48 inches in maximum dimension) were observed within the test pits; larger rocks may be present locally. As such, excavation of the lower levels may generate an abundance of over-size material that may require special handling, processing, or disposal.

### 5.12.2 Groundwater

Shallow groundwater was identified at many locations across the site. Depending on location, groundwater could adversely impact the proposed construction; groundwater could cause equipment mobility problems, and could cause localized excavation instability. In some areas, shallow groundwater presence could be a protracted or perennial condition, and would need to be dealt with accordingly via the installation of temporary or permanent land drains. The Contractor

should be aware that shoring and/or localized dewatering may be necessary during construction of the foundations, particularly during spring and early summer. The Table of Lots (Appendix E) indicates the anticipated groundwater condition for each individual lot.

Considering the wide-spread presence of shallow groundwater, the Owner may wish to consider the use of land drains to reduce the groundwater level over a broader area, which would serve to facilitate development and would improve slope stability across the site.

## 6.0 CLOSURE

### 6.1 LIMITATIONS

The concept of risk is a significant consideration of geotechnical analyses. The analytical means and methods used in performing geotechnical analyses and development of resulting recommendations do not constitute an exact science. Analytical tools used by geotechnical engineers are based on limited data, empirical correlations, engineering judgment and experience. As such the solutions and resulting recommendations presented in this report cannot be considered risk-free and constitute IGES's best professional opinions and recommendations based on the available data and other design information available at the time they were developed. IGES has developed the preceding analyses, recommendations and designs, at a minimum, in accordance with generally accepted professional geotechnical engineering practices and care being exercised in the project area at the time our services were performed. No warranties, guarantees or other representations are made.

The information contained in this report is based on limited field testing and understanding of the project. The subsurface data used in the preparation of this report were obtained largely from the explorations made for the Bobcat Ridge project. It is very likely that variations in the soil, rock, and groundwater conditions exist between and beyond the points explored. The nature and extent of the variations may not be evident until construction occurs and additional explorations are completed. If any conditions are encountered at this site that are different from those described in this report, IGES must be immediately notified so that we may make any necessary revisions to recommendations presented in this report. In addition, if the scope of the proposed construction or grading changes from those described in this report, our firm must also be notified.

This report was prepared for our client's exclusive use on the project identified in the foregoing. Use of the data, recommendations or design information contained herein for any other project or development of the site not as specifically described in this report is at the user's sole risk and without the approval of IGES, Inc. It is the client's responsibility to see that all parties to the project including the designer, contractor, subcontractors, etc. are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk.

We recommend that IGES be retained to review the final design plans, grading plans and specifications to determine if our engineering recommendations have been properly incorporated in the project development documents. We also recommend that IGES be retained to evaluate construction performance and other geotechnical aspects of the project as construction initiates and progresses through its completion.



## 6.2 ADDITIONAL SERVICES

The recommendations made in this report are based on the assumption that an adequate program of tests and observations will be made during the construction. IGES staff or other qualified personnel should be on site to verify compliance with these recommendations. These tests and observations should include at a minimum the following:

- Observations and testing during site preparation, earthwork and structural fill placement.
- Consultation as may be required during construction.
- Quality control on concrete placement to verify slump, air content, and strength.
- Quality control and testing during placement and compaction of asphalt.

We also recommend that project plans and specifications be reviewed by us to verify compatibility with our conclusions and recommendations. Additional information concerning the scope and cost of these services can be obtained from our office.

We appreciate the opportunity to be of service on this project. Should you have any questions regarding the report or wish to discuss additional services, please do not hesitate to contact us at your convenience at (801) 748-4044.

## 7.0 REFERENCES

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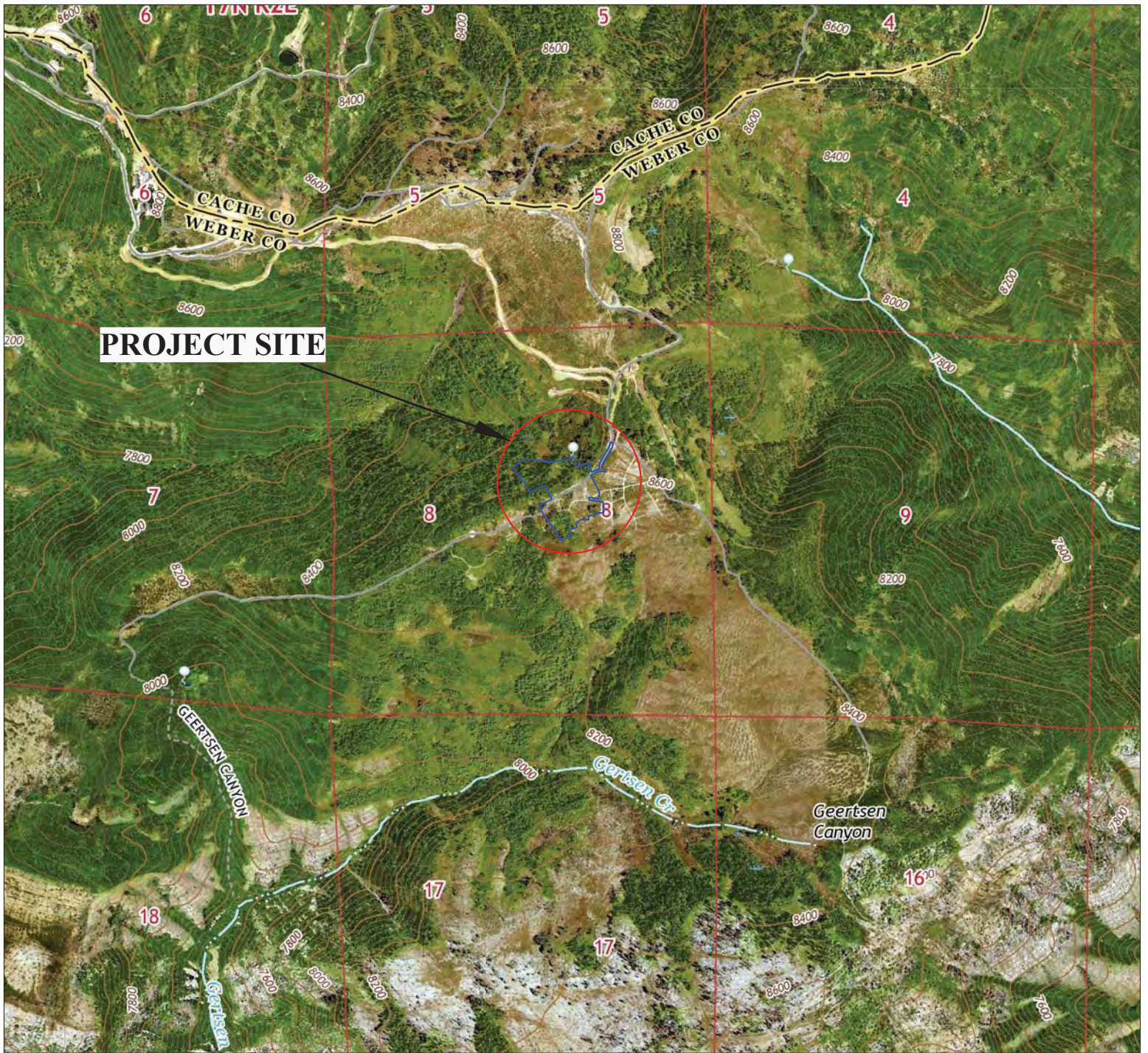
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### ***AERIAL PHOTOGRAPHS***

| <b>Data Set</b> | <b>Date</b>        | <b>Flight</b> | <b>Photographs</b> | <b>Scale</b> |
|-----------------|--------------------|---------------|--------------------|--------------|
| 1947 AAJ        | August 10, 1946    | AAJ_1B        | 88, 89, 90         | 1:20,000     |
| 1953 AAI        | September 14, 1952 | AAI_4K        | 34, 35, 36         | 1:20,000     |
| 1963 ELK        | June 25, 1963      | ELK_3         | 57, 58, 59         | 1:15,840     |

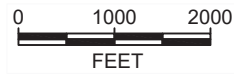
\*<https://geodata.geology.utah.gov/imagery/>

# **APPENDIX A**



**Base Maps:**

-USGS Brown's Hole, Huntsville, James Peak and Sharp Mountain 7.5-Minute Quadrangles (2017)



1" = 2000'



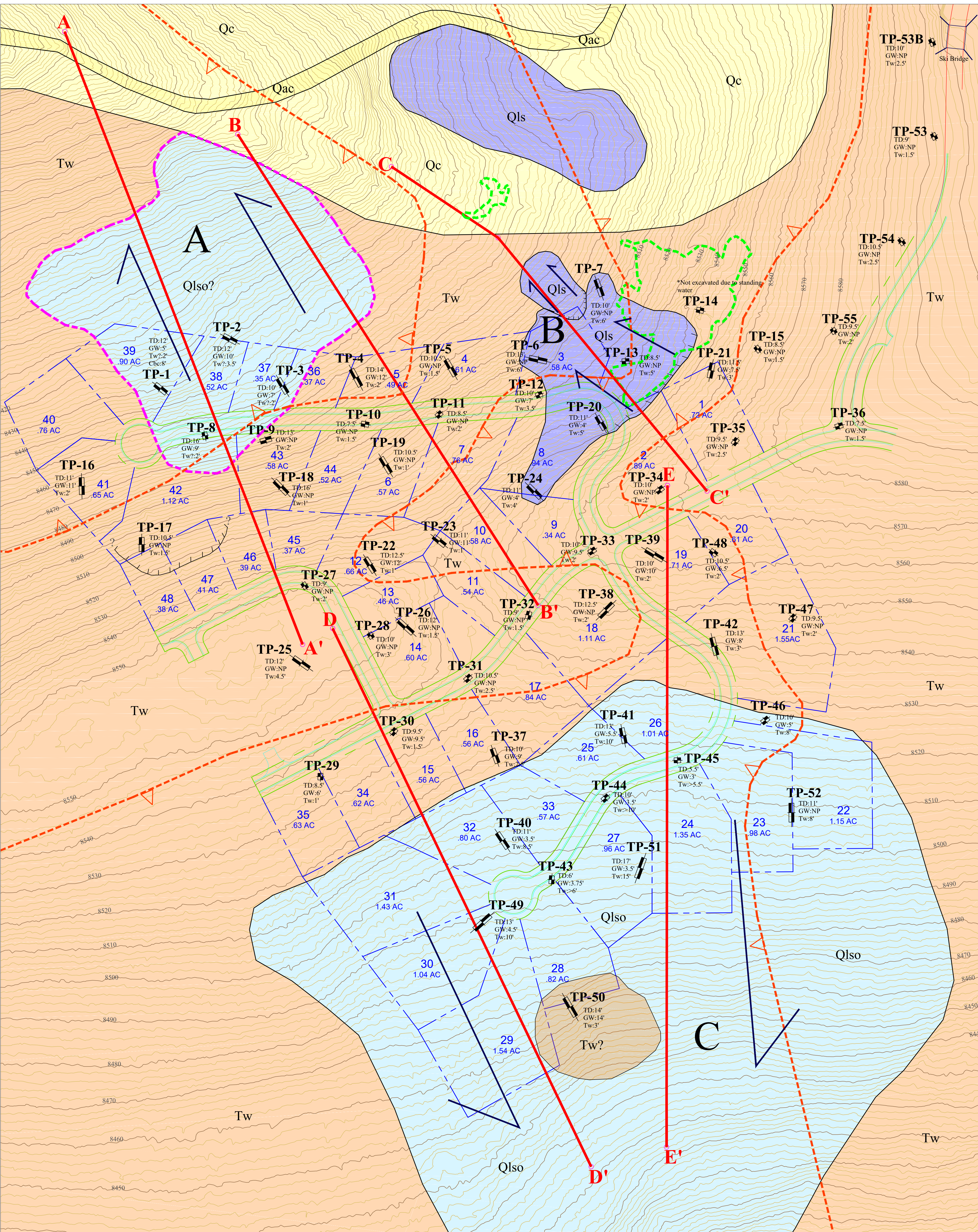
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Site Vicinity Map

Figure

A-1



**LEGEND**

- |   |   |  |  |
|---|---|--|--|
| <p><b>Basemap:</b></p> <p>-Bobcat Ridge Preliminary Plat, provided by Talisman Civil Consultants, dated 8-13-2018</p> <p>Contour Interval: 2'</p> <p>*All Geologic Contacts Approximate</p> | <p><b>Qac</b> Alluvial and Colluvial Deposits</p> <p><b>Qc</b> Colluvium</p> <p><b>Qls</b> Landslide Deposit (Holocene-aged)</p> <p><b>Qlso</b> Older landslide deposit (Pleistocene-aged)</p> <p>Project Boundary</p> <p>Deeper clay seam area; possible older landslide</p> <p>A= Landslide A</p> | <p><b>Tw</b> Wasatch Formation</p> <p>Test Pit Location</p> <p>Landslide Scarp; queried where uncertain</p> <p>Landslide direction of movement</p> <p>Area of Shallow Groundwater (~10' below existing grade)</p> <p>Triangle points in direction of groundwater</p> <p>B= Landslide B</p> <p>C= Landslide C</p> | <p>TD = Total depth</p> <p>GW = Groundwater depth (NP=Not Present)</p> <p>Tw = Depth to Wasatch Fm</p> <p>Cbe = Depth to Calls Fort Shale</p> <p>0 100 200 FEET</p> <p>1" = 100'</p> |
|---|---|--|--|



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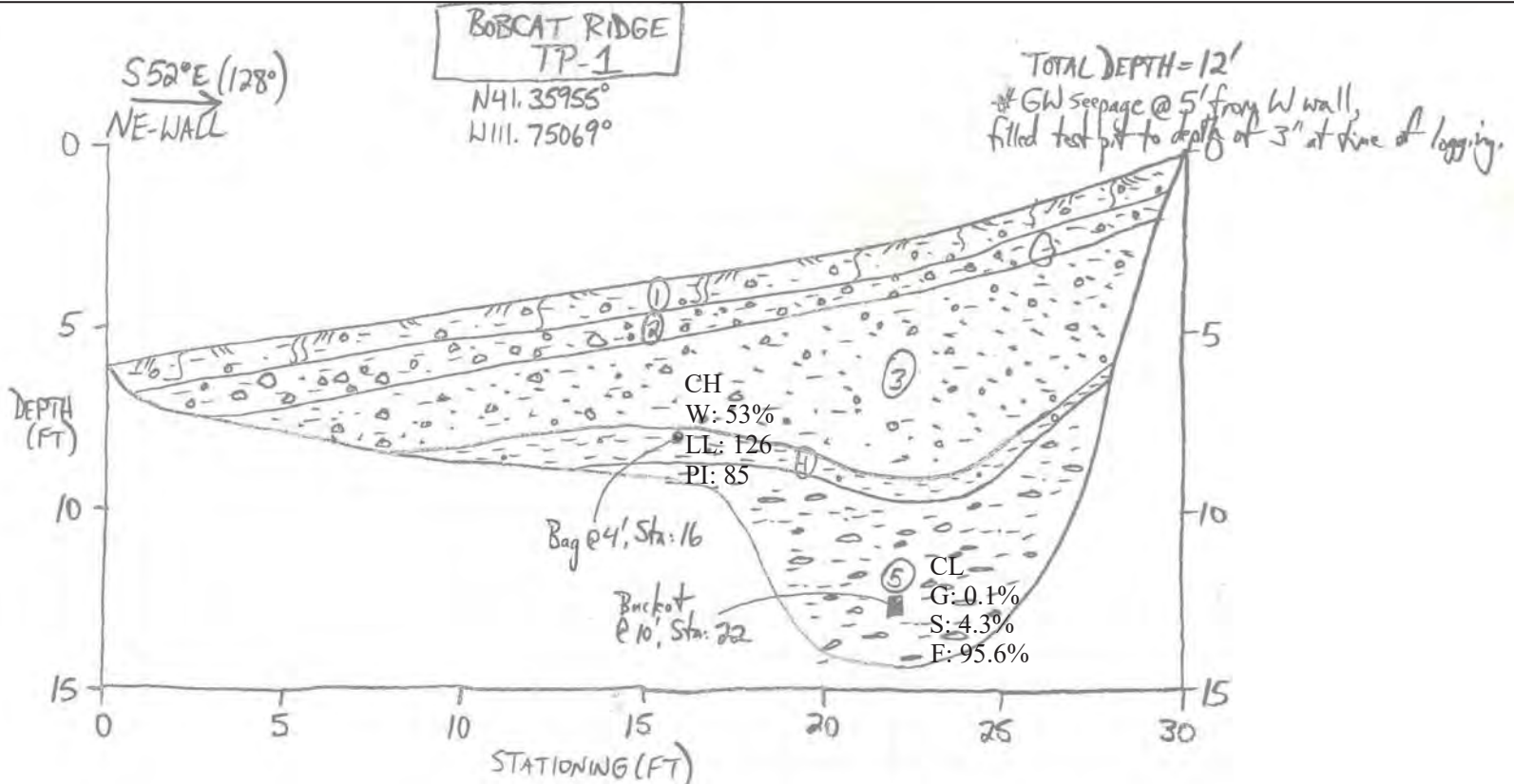
**Geotechnical and Local Geology Map**

**Figure A-2**

Project No. 01628-028

Date 6-22-18 by FE on  
Ckd by

1" = 5'  
H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; grayish brown (5Y  $\frac{3}{2}$ ) to brownish black (5YR  $\frac{7}{2}$ ) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular pale yellowish orange (10YR  $\frac{8}{2}$ ) to medium gray (N5) quartzite up to 8" in diameter, though mode clast size is ~1"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~6"-1' thick; grayish brown (5Y  $\frac{3}{2}$ ) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subangular to subrounded quartzite as above up to 1' in diameter, though mode clast size is ~2-4"; topsoil matrix; common to abundant plant and tree roots; unit thickens downslope to the north; gradational, irregular basal contact.

**3. Wasatch Formation?:** ~2-5' thick; moderate reddish brown (10R  $\frac{4}{2}$ ) to moderate yellowish brown (10YR  $\frac{4}{2}$ ) clayey SAND with gravel (SC), medium dense to dense, moist to wet, low plasticity fines, massive; gravel and larger sized clasts comprise ~20% of the unit, clasts are subrounded quartzite as above up to 5" in diameter, though mode clast size is ~1-2"; possibly shallow landslide deposits; occasional plant and tree roots; sharp, wavy basal contact.

**Old Slide Plane:** ~6"-1' thick; light gray (N7) to dark reddish brown (10R  $\frac{3}{2}$ ) fat CLAY (CH), stiff, moist, high plasticity, massive; gravel and larger sized clasts comprise ~5% of the unit; clasts are subrounded quartzite as above, up to 4" in diameter; uppermost ~3" is dark reddish brown and sandier, and may represent the lowermost portion of the Wasatch Formation though it grades quickly to fat clay; lower portion is very similar to light gray fat clay observed in other test pits, with blocky ped structures, mechanically-induced slickensides and appears similar to weathered Norwood Formation; sharp, wavy basal contact.

**5. Calls Fort Shale:** >5' thick; dark yellowish orange (10YR  $\frac{6}{2}$ ) to light greenish gray (5GY  $\frac{8}{2}$ ) highly weathered shale bedrock that has been disaggregated to a silty GRAVEL (GM), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~50-60% of the unit; clasts are all light greenish gray, angular, finely bedded shale that has greasy feel and fine-grained mica crystals; clay component is fat; density of unit increases with depth.



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**Figure**

**A-3**

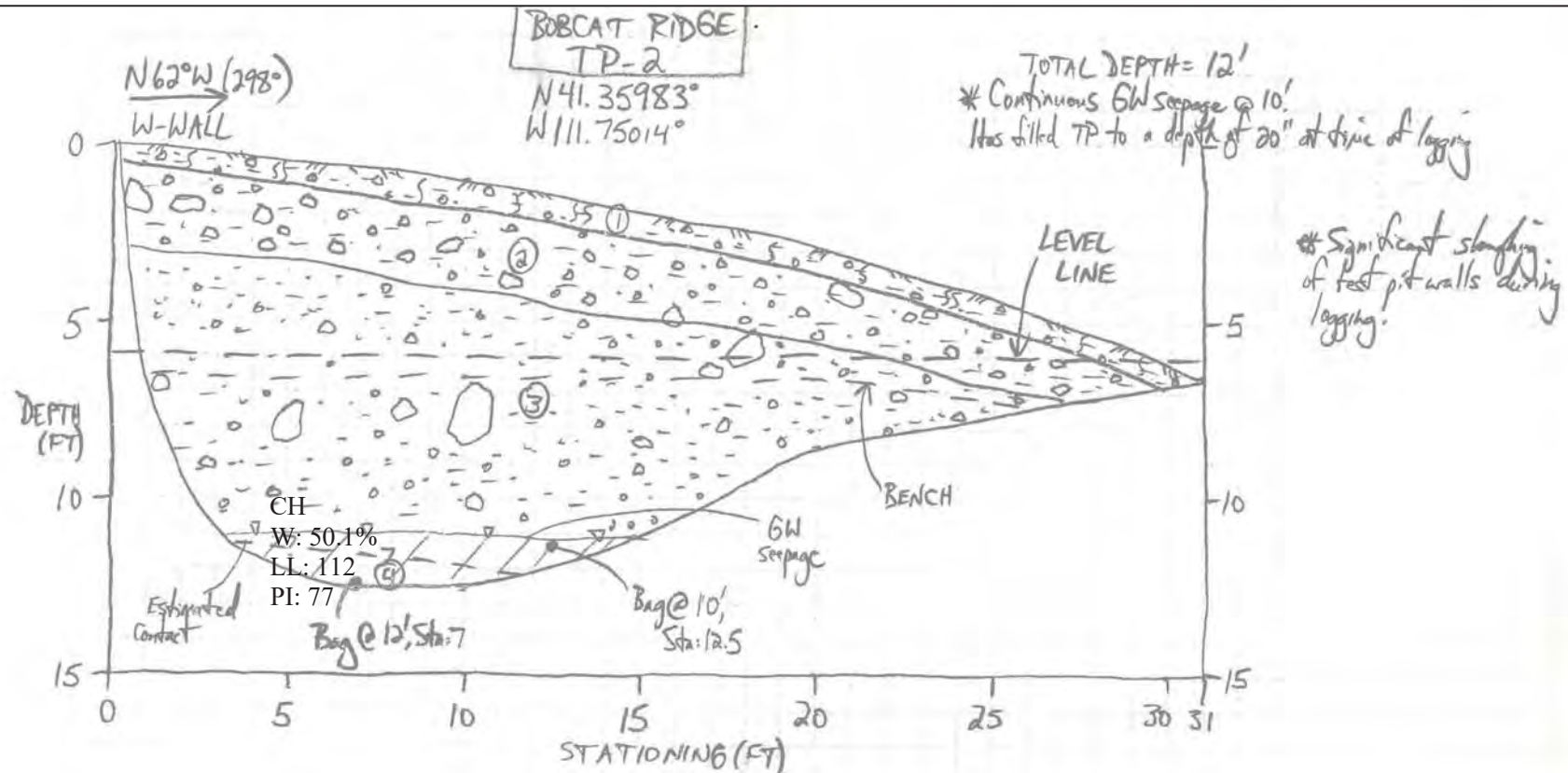
**TP-1 Log**



Project No. 01628-028

Date 6-21-18 by PED  
Ckd by on

1" = 5'  
H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6-10" thick; grayish brown (5Y 2/2) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular medium light gray (N6) to pale yellowish orange (10YR 8/6) quartzite up to 8" in diameter, though mode clast size is ~2-4"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~2-2.5' thick; dark yellowish brown (10YR 4/2) to grayish brown (5Y 2/2) sandy lean CLAY with gravel (CL) gradational to clayey GRAVEL (GC) with sand, medium stiff to loose, moist to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~40-50% of the unit; clasts are subangular to subrounded quartzite as above and also include moderate reddish orange (10R 6/6) sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~3-4"; topsoil matrix; common plant and tree roots; sharp, irregular basal contact.

**3. Wasatch Formation?:** ~8' thick; moderate reddish brown (10R 4/6) to dark yellowish orange (10YR 6/6) clayey SAND with gravel (SC), medium dense, moist to wet, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1.5' in diameter, though mode clast size is ~3-4"; becomes sandier and more orange with depth; possibly shallow landslide deposits; occasional to common plant and tree roots; sharp, planar basal contact.

**4. Clay Seam:** >2' thick; commonly mottled light gray (N7) to dark reddish brown (10R 2/2) fat CLAY (CH), stiff, wet, high plasticity, massive; devoid of clasts; common blocky ped structures; common fat clay sheen and easily mechanically slickensided but no natural slickensides observed; appears to be similar to deeper clay seen in TP-3.



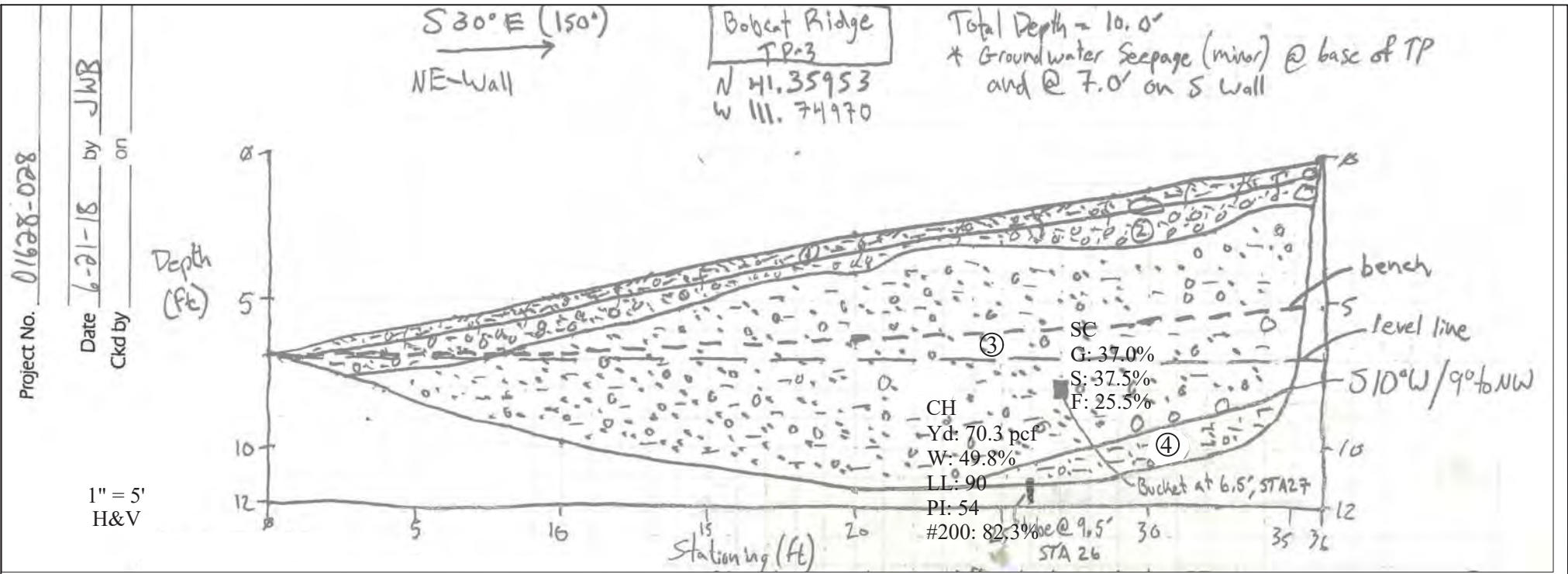
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Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Figure

A-4

TP-2 Log



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6" thick; grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular light gray (N7) quartzite up to ~1' in diameter, though mode clast size is ~1/2 to 1"; common plant roots; unit is significantly thicker on the southwestern wall; sharp, irregular basal contact.

**2. Colluvium:** ~6"-1.5' thick; grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are predominantly subrounded to subangular quartzite as above, though few dark yellowish orange (10YR 8/6) oxidized sandstone clasts; clasts are up to 1.5' in diameter, though mode clast size is ~1-3"; occasional plant roots; unit thickness varies dramatically, and unit is almost non-existent in places; sharp, irregular basal contact.

**3. Wasatch Formation?:** ~6-8' thick; moderate reddish brown (10R 4/6) to dark reddish brown (10R 3/4) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-40% of the unit; clasts are subrounded to subangular quartzite and sandstone as above; clasts are up to 10" in diameter, though mode clast size is ~2"; possible shallow landslide deposits; few plant roots; sharp, planar basal contact.

**4. Clay Seam:** >1.5' thick; mottled light gray (N7) and moderate reddish brown (10R 4/6) sandy fat CLAY (CH), stiff to very stiff, moist to wet, high plasticity, massive; gravel and larger sized clasts comprise ~5% of the unit; clasts are subangular to subrounded quartzite as above up to 1" in diameter, though mode clast size is <0.5"; unit looks like weathered Norwood Formation and is similar to the shear plane unit seen in test pits on the southernmost part of the Bobcat Ridge property; fat clay sheen, though no slickensides observed.



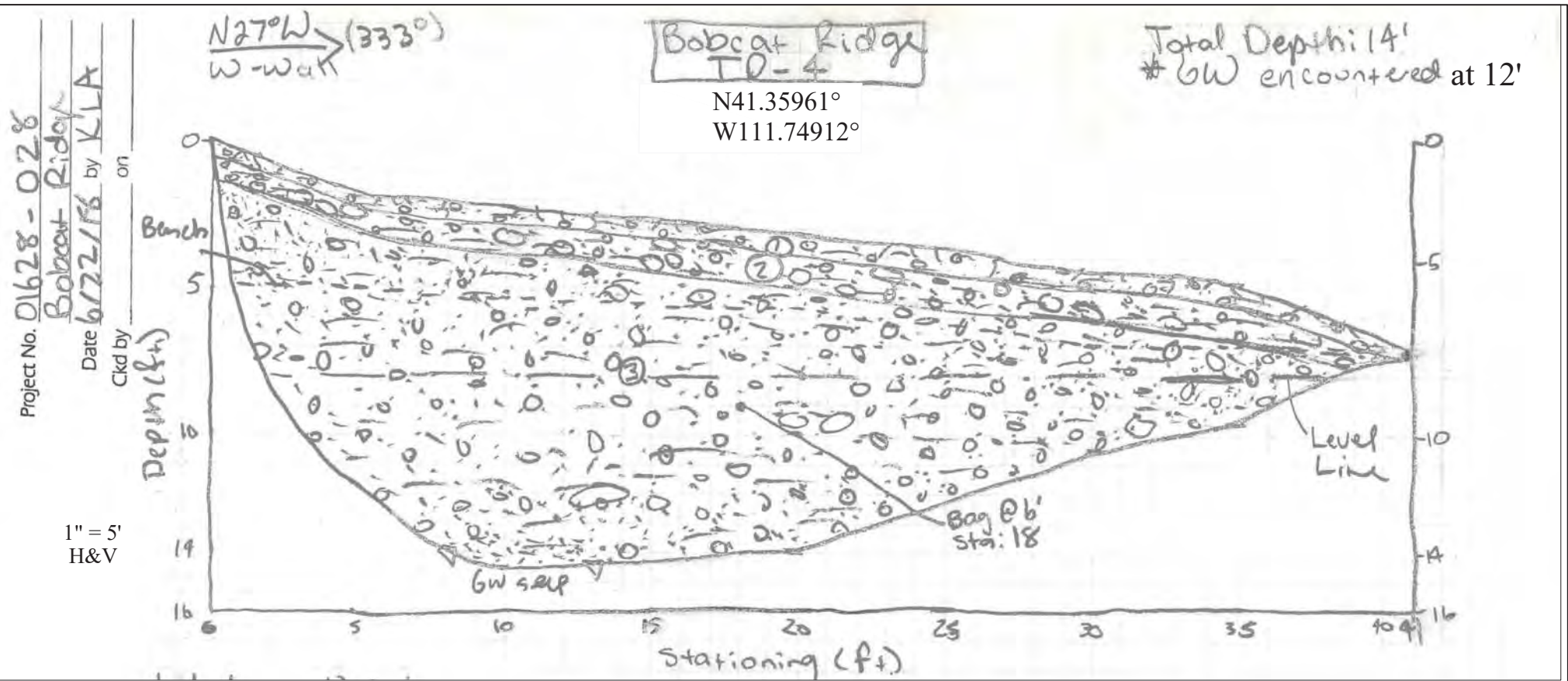
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Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Figure

A-5

TP-3 Log



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6" thick; grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular light brown (5YR 4/2) to medium gray (N5) quartzite up to 4" in diameter, though mode clast size is ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~1' thick; dark yellowish brown (10YR 4/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above up to 1.5' in diameter, though mode clast size is ~2-4"; topsoil matrix, abundant plant and tree roots; sharp, planar basal contact.

**3. Wasatch Formation:** >10' thick; moderate reddish brown (10R 4/2) to dark yellowish orange (10YR 6/2) clayey SAND with gravel (SC) gradational to sandy lean CLAY with gravel (CL), medium dense to dense, moist to wet, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~25-30% of the unit; clasts are predominantly subrounded to subangular quartzite as above, though minor light gray (N7) sandstone and medium dark gray (N4) chert; clasts are up to 1.5' in diameter, though the mode clast size is ~2-3"; occasional plant roots; basal 1.5-2' is sandier and has groundwater seepage; sand is fine- to medium-grained.

\*~1" of groundwater accumulation at bottom of test pit. Minor sloughing of pit walls in lower part of unit 3 during logging.



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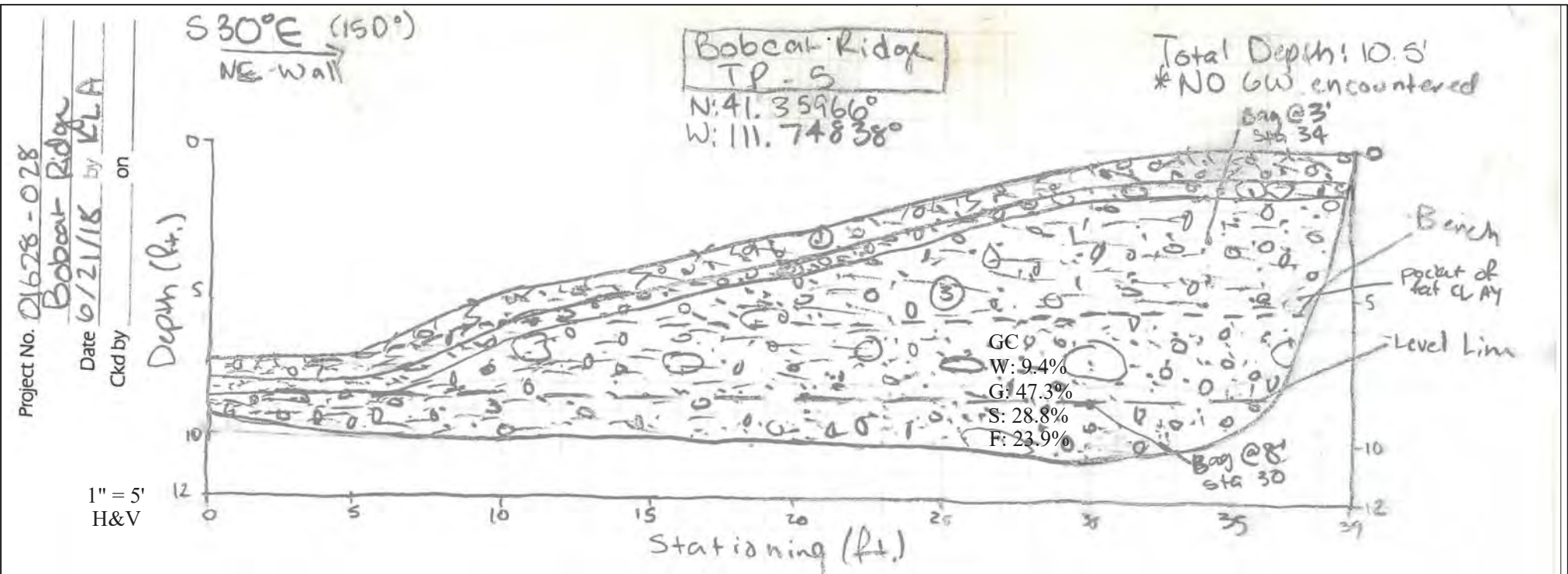
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

TP-4 Log

Figure

A-6



## LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; light brown (5YR 4/3) to moderate yellowish brown (10YR 4/3) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular light brown to medium dark gray (N4) to moderate orange pink (10R 7/4) quartzite up to ~2-3" in diameter, though mode clast size ~0.5"; abundant plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~6" thick; light brown (5YR 4/3) to moderate yellowish brown (10YR 4/3) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~2-3"; topsoil matrix; sharp, planar basal contact.

**3. Wasatch Formation:** >8.5' thick; moderate reddish orange (10R 6/3) to moderate yellowish brown (10YR 4/3) clayey GRAVEL with sand (GC) gradational to sandy lean CLAY with gravel (CL), medium dense, moist, moderate to low plasticity fines, massive; gravel and larger sized clasts comprise ~20-50% of the unit; clasts are subrounded to subangular moderate reddish orange to medium dark gray (N4) quartzite and sandstone up to 1.5' in diameter, though the mode clast size is ~2-4"; occasional plant roots; becomes sandier with depth; sand component is fine- to medium-grained; a fat clay lens is present at ~5' below existing grade on the southeast end of the test pit.



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Geotechnical and Geologic Hazards Assessment  
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 Summit Powder Mountain Resort  
 Weber County, Utah

Figure

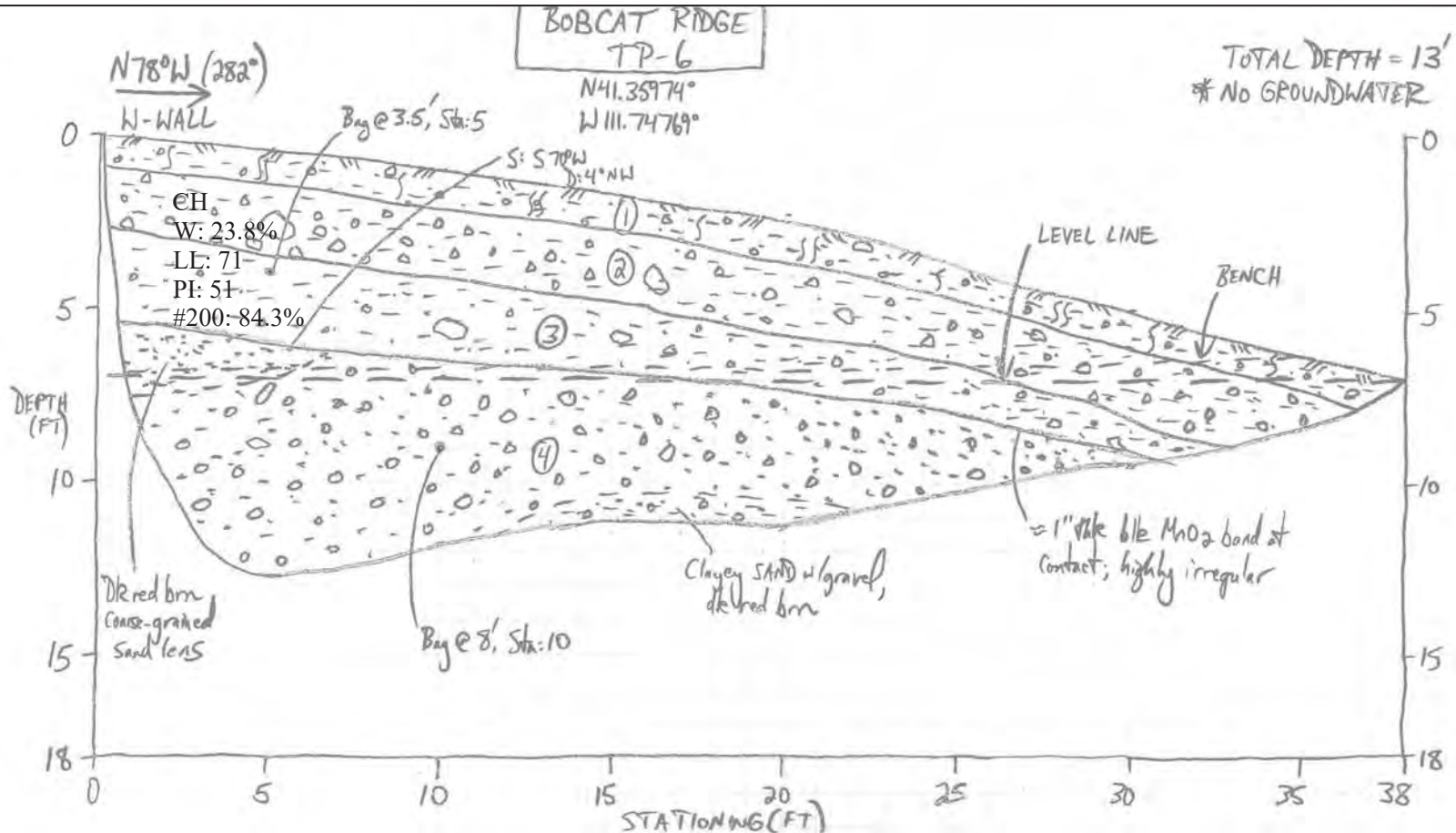
A-7

TP-5 Log

Project No. 01628-028

Date 6-26-18 by PED on  
Ckd by

1" = 5'  
H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~12-14" thick; dark yellowish brown (10YR 4/2) to grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular medium gray (N5) to pale yellowish orange (10YR 8/6) quartzite, up to 10" in diameter, though mode clast size is ~1-2"; common to abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~2-3' thick; dark yellowish brown (10YR 4/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above, with minor angular dark yellowish orange (10YR 8/6) micaceous sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~3-4"; topsoil matrix; common plant and tree roots; sharp, irregular basal contact.

**3. Shallow Landslide:** ~2-3' thick; mottled moderate reddish orange (10R 6/6), moderate reddish brown (10R 4/4) and moderate yellowish brown (10YR 5/4) sandy fat CLAY with gravel (CH), stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subangular quartzite and sandstone as above up to 1' in diameter, though mode clast size is ~1"; minor fat clay sheen, though no slickensides observed; common light gray (N7) to dark reddish brown (10R 3/3) clayey lenses; silty in part; possibly uppermost Wasatch Formation; occasional plant and tree roots; sharp, irregular basal contact.

**4. Wasatch Formation:** >7' poorly graded SAND with gravel (SP) gradational to clayey SAND with gravel (SC) at depth, medium dense to dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 7" in diameter, though the mode clast size is ~2-3"; sand component is medium- to coarse-grained; occasional plant and tree roots.



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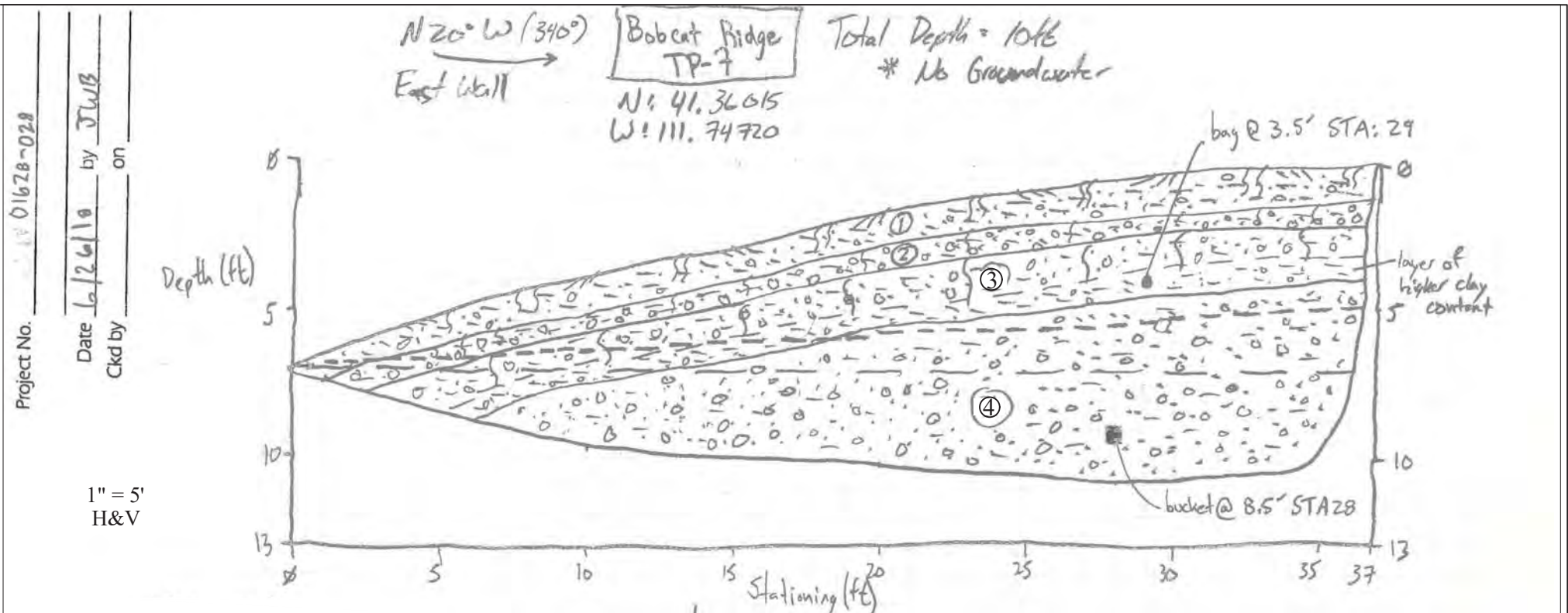
Project No: 01628-028

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Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Figure

A-8

TP-6 Log



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~12-18" thick; grayish brown (5Y 3/2) to moderate yellowish brown (10YR 3/2) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular medium gray (N5) to pale yellowish orange (10YR 8/6) quartzite up to ~6" in diameter, though mode clast size is ~1-2"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~2-3' thick; dark yellowish brown (10YR 4/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above, with minor angular dark yellowish orange (10YR 8/6) micaceous sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~3-4"; topsoil matrix; common plant and tree roots; sharp, irregular basal contact.

**3. Shallow Landslide:** ~2' thick; mottled light brownish gray (5YR 6/1) to moderate reddish orange (10R 6/2) to dark yellowish orange (10YR 8/6) sandy lean CLAY with gravel (CL) gradational to clayey SAND with gravel (SC), stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the subunit and decrease with depth; clasts are predominantly subrounded to subangular quartzite as above and minor dark yellowish orange (10YR 8/6) sandstone; clasts are up to 8" in diameter, though mode clast size is ~1-2"; common to occasional plant and tree roots; unit is sandy at top and gets progressively more clayey with depth; clay plasticity also increases with depth; gradational, irregular basal contact.

**4. Wasatch Formation:** >6' thick; moderate reddish brown (10R 4/4) clayey SAND with gravel (SC) gradational to clayey GRAVEL with sand (GC), dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~40-50% of the unit; clasts are subangular to subrounded quartzite and sandstone as above up to 2-3' in diameter, with a mode clast size of ~3"; few plant roots; occasional black organic or MnO2 staining.



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TP-7 Log

Figure

A-9

Project No. 01628-028

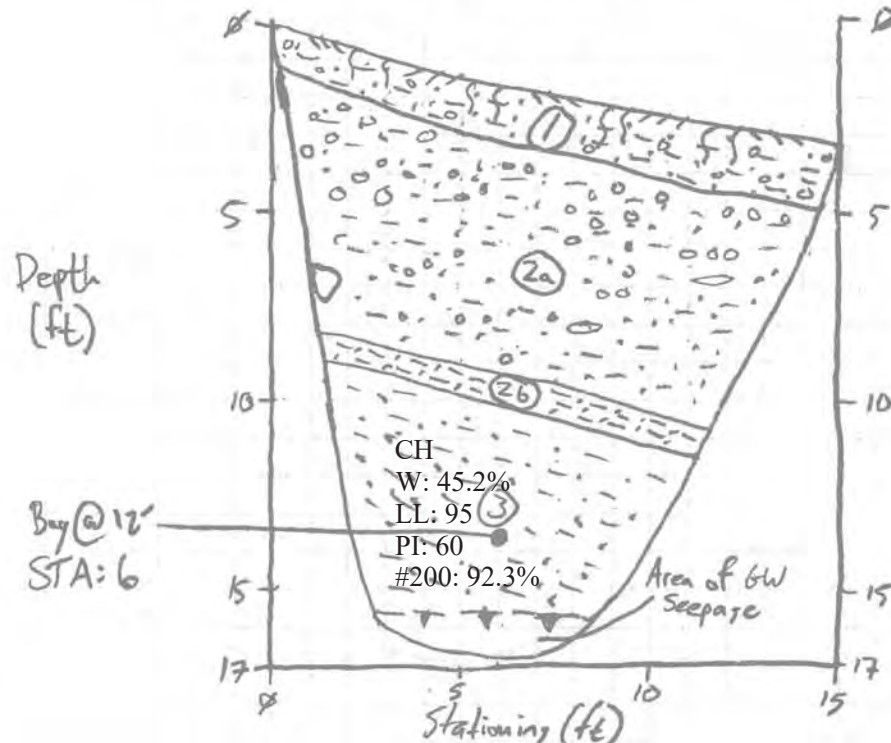
Date 6/21/19 by JWB  
Ckd by on

1" = 5'  
H&V

N 10° W (350°)  
NW Wall

Bobcat Ridge  
TP-8  
N: 41.35926  
W: 111.75034

Total Depth = 16'  
\*Groundwater ~ 1 ft deep at TP base  
Also seeping @ ~ 9 ft on SE Wall



## LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~1.5'-2' thick; grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, slightly moist to moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular medium light gray (N6) quartzite up to ~1.5' in diameter, though mode clast size is ~1"; common plant roots; sharp, irregular basal contact.

3. **Clay Seam:** >7' thick; medium light gray (N6) sandy fat CLAY, stiff, moist to wet, high plasticity, massive; appears like weathered Norwood Formation, as seen in other test pits; occasional fine-grained biotite and muscovite mica grains present; rare quartzite and dark yellowish orange (10YR 8) sandstone clasts.

2. **Wasatch Formation?:** ~6-7' thick; possible landslide deposits; 2 subunits.

a. ~6' thick; moderate reddish brown (10R 4/2) to dark reddish brown (10R 3/2) sandy fat CLAY with gravel (CH) gradational to clayey SAND with gravel (SC), stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the subunit; clasts are quartzite as above up to 3' in diameter, though mode clast size is ~3-4"; upper ~1' may include intermittent colluvium; possibly fewer clasts with depth; sharp, irregular basal contact.

b. ~1' thick; moderate reddish brown (10R 4/2) to dark reddish brown (10R 3/2) sandy fat CLAY (CH) gradational to clayey SAND (SC), stiff, moist, moderate to high plasticity, massive; rare quartzite clasts as above; sharp, planar basal contact.



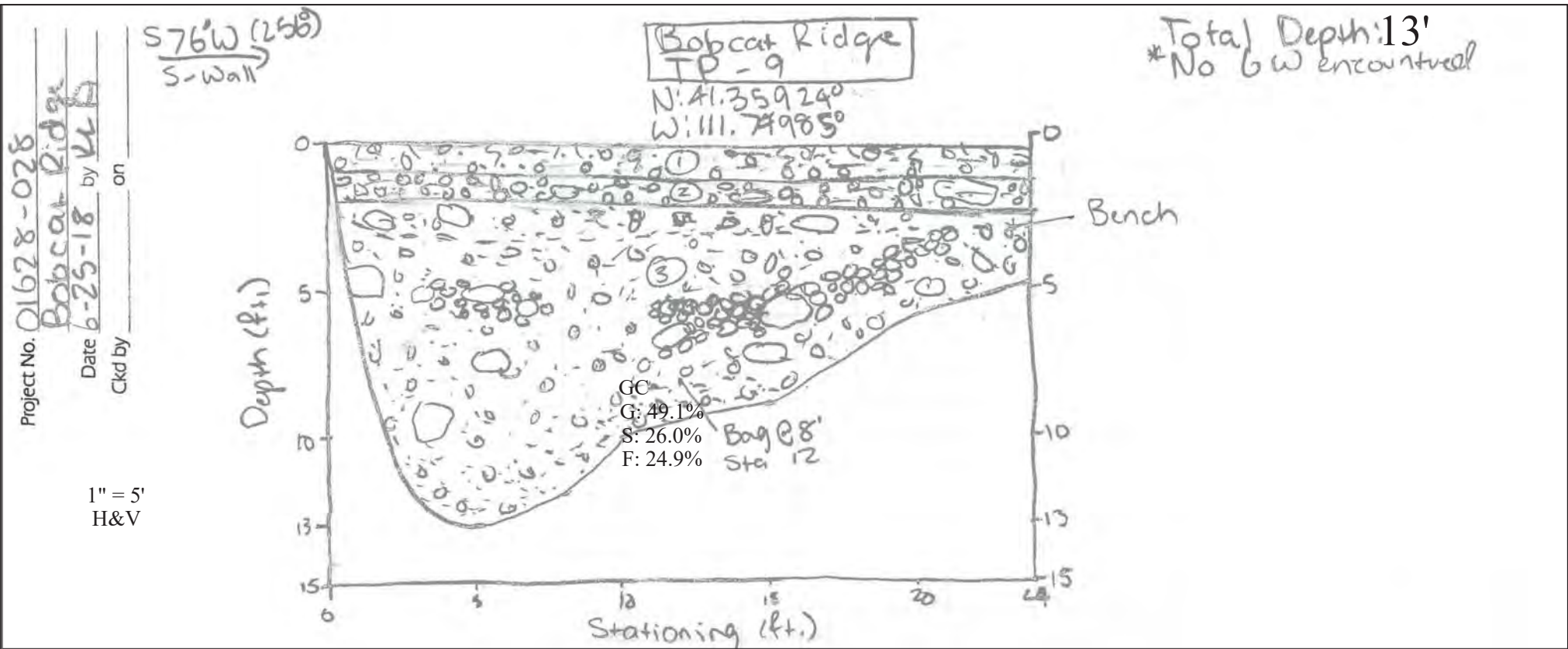
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Figure

A-10

TP-8 Log



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; light brown (5YR 4/3) sandy lean CLAY with gravel (CL), medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subangular to subrounded light brown (5YR 4/3) to medium gray (N5) quartzite up to ~6" in diameter, though mode clast size ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~1' thick; light brown (5YR 4/3) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~35% of the unit; clasts are subrounded to subangular quartzite as above up to 2' in diameter, though mode clast size is ~2-4"; abundant plant and tree roots; topsoil matrix; sharp, planar basal contact.

**3. Wasatch Formation:** >11' thick; moderate reddish brown (10R 4/6) clayey GRAVEL with sand (GC), medium dense to dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-50% of the unit; clasts are subrounded to subangular grayish orange pink (10R 5/6) to medium gray (N5) quartzite and moderate reddish orange (10R 6/6) sandstone up to 1.5' in diameter, though the mode clast size is ~2-3"; multiple gravel lenses indicative of an alluvial component; basal 1' is a silty SAND with gravel (SM); sand component is fine- to medium-grained.



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Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

Figure

A-11

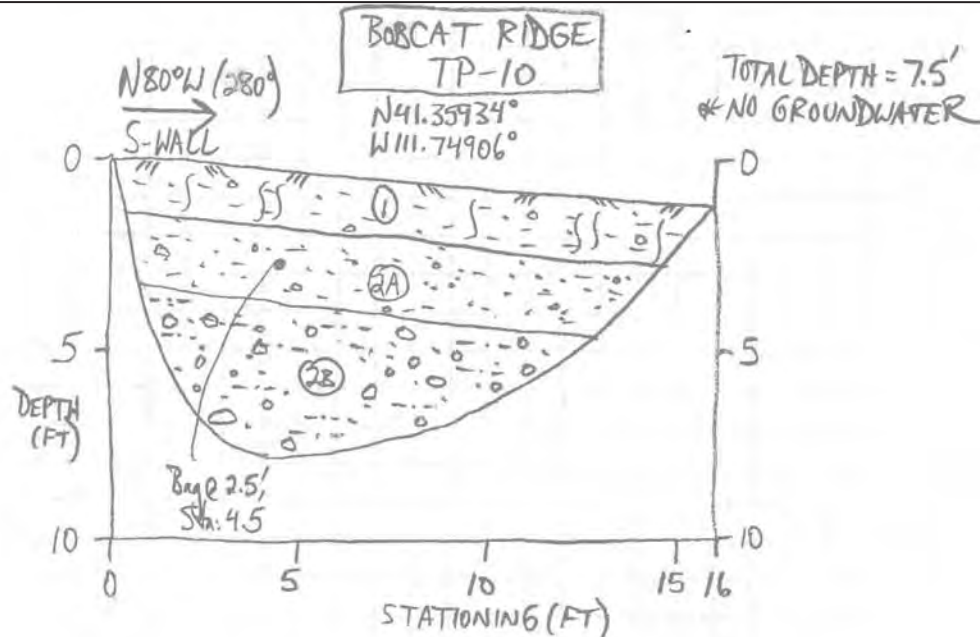
TP-9 Log



Project No. 01628-028

Date 6-21-18 by PED  
Ckd by on

1" = 5'  
H&V



## LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~1.5'-2' thick; grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, slightly moist to moist, low pl~1.5' thick; grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium light gray (N6) to pale yellowish orange (10YR 8) quartzite up to ~2" in diameter, though mode clast size is ~1"; abundant plant and tree roots; sharp, irregular basal contact. asticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular medium light gray (N6) quartzite up to ~1.5' in diameter, though mode clast size is ~1"; common plant roots; sharp, irregular basal contact.

2. **Wasatch Formation:** >6' thick; 2 subunits.

- ~2' thick; moderate yellowish brown (10Y 4/2) clayey SAND with gravel (SC), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~10-15% of the subunit; clasts are subrounded to subangular quartzite as above with few dark yellowish orange (10YR 8) highly oxidized sandstone clasts; clasts are up to 4" in diameter, though mode clast size is ~0.5"; occasional plant and tree roots; possible B-horizon; sand is fine- to medium-grained; sharp, planar basal contact.
- >4' thick; moderate reddish brown (10R 6/2) gravelly SILT (ML) gradational to clayey SAND with gravel (SC), dense, slightly moist to moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular quartzite as above up to ~10" in diameter, though mode clast size is ~3-4"; silt is gradational to very fine-grained sand; few tree roots.



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Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Figure

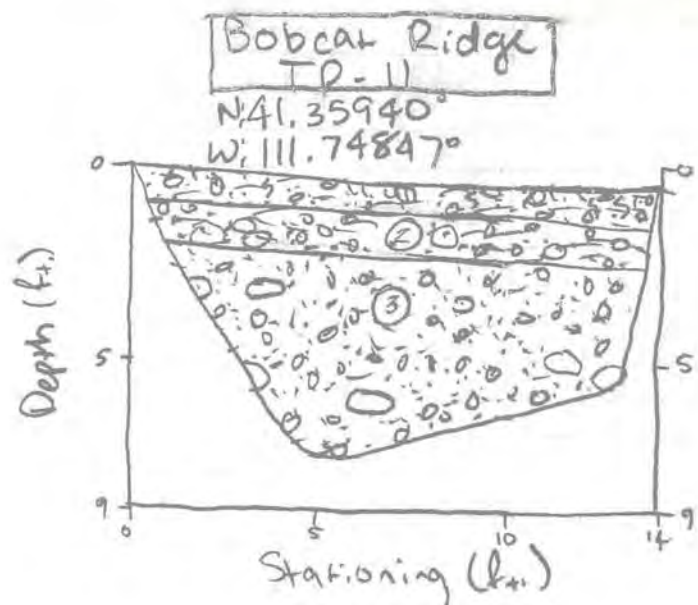
A-12

TP-10 Log

Project No. 01628-028  
 Bobcat Ridge  
 Date 6-21-18 by KLA  
 Ckd by \_\_\_\_\_ on \_\_\_\_\_

S53°W (233°)  
 S-Wall →

1" = 5'  
 H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; light brown (5YR 6/4) to moderate yellowish brown (10YR 5/4) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular light brown (5YR 6/4) to medium dark gray (N4) to moderate orange pink (10R 7/4) quartzite up to ~2-3" in diameter, though mode clast size ~0.5"; abundant plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~1' thick; light brown (5YR 6/4) to moderate yellowish brown (10YR 5/4) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~2-3"; topsoil matrix; sharp, planar basal contact.

**3. Wasatch Formation:** >5.5' thick; dark yellowish orange (10YR 6/6) to moderate reddish orange (10R 6/6) clayey GRAVEL with sand (GC), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~35-40% of the unit; clasts are subrounded to subangular pale yellowish orange (10YR 8/6) to medium gray (N5) quartzite and moderate reddish orange (10R 6/6) sandstone; clasts are up to 3' in diameter, though mode clast size is ~2-4"; occasional plant roots; traces of lean clay; sand is fine- to medium-grained.



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 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

TP-11 Log

**Figure**  
**A-13**

Project No. 01628-028

Date 6/26/10 by JWB  
Ckd by on

1" = 5'  
H&V

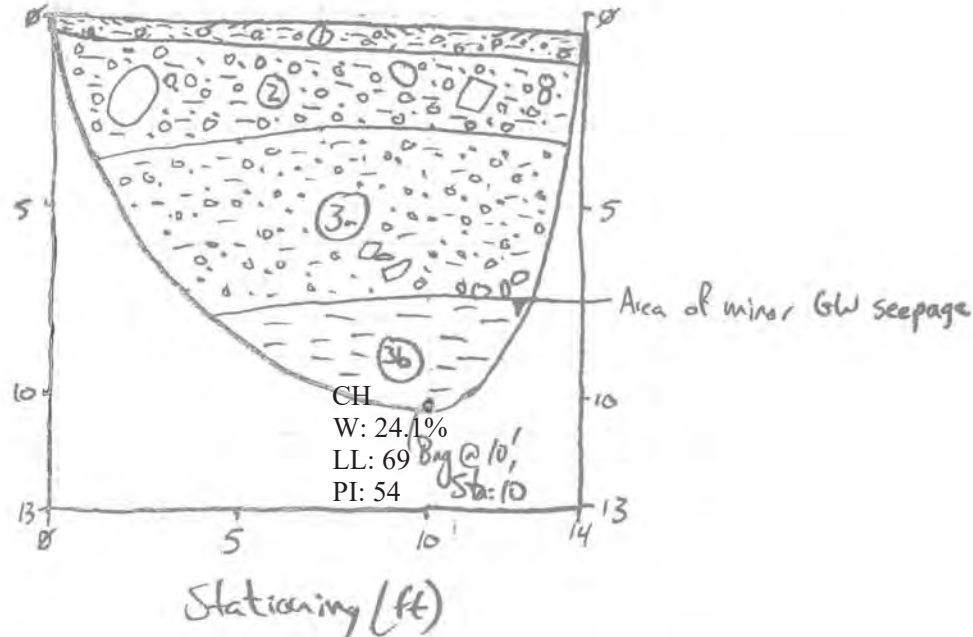
S 68°W (248°)  
East Wall

Bobcat Ridge  
TP-12  
N: 41,35952°  
W: 111,74768°

Total Depth = 10ft

\* Very minor Groundwater seepage at 3a-3b boundary (~7ft)

Depth (ft)



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6-8" thick; light brown (5YR 4/3) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are subrounded to subangular medium gray (N5) to moderate reddish brown (10R 4/3) quartzite up to ~6" in diameter, though mode clast size is ~1"; common plant and tree roots; sharp, irregular basal contact.

**2. Colluvium:** ~2-3' thick; light brown (5YR 4/3) to moderate yellowish brown (10YR 4/3) sandy lean CLAY with gravel (CL), medium stiff, slightly moist to moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit, clasts are subrounded quartzite as above, clasts are up to 4' in diameter, though model clast size is ~3"; occasional plant roots; topsoil matrix; sharp, irregular basal contact.

**3. Wasatch Formation:** >7' thick; 2 subunits.

a. ~4-5' thick; mottled moderate yellowish brown (10YR 4/3) to moderate reddish brown (10R 4/3) clayey SAND with gravel (SC), dense, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~30% of the subunit; clasts are subangular to subrounded quartzite as above up to 1' in diameter, though mode clast size is ~1-2"; few plant roots; sharp, wavy basal contact.

b. >3' thick; moderate reddish brown (10R 4/3) silty fat CLAY (CH), dense, moist to wet, high plasticity, massive; largely devoid of clasts; common muscovite mica flakes; minor fat clay sheen, though no slickensides observed.



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Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Figure

A-14

TP-12 Log

Project No. 01628-028

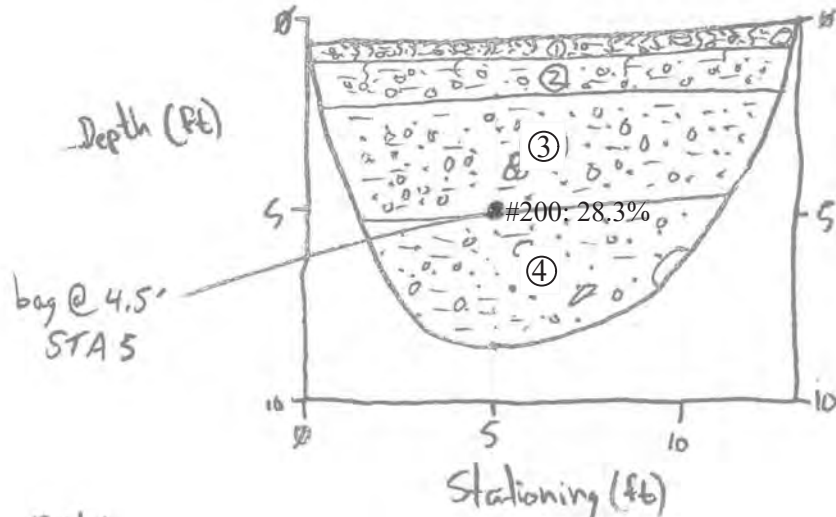
Date 6-26-18 by JWB on Ckd by on

1" = 5'  
H&V

N87° E (087°)  
North Wall

Bobcat Ridge  
TP-13  
N: 41.35973  
W: 111.74700

Total Depth = 8.5'  
\* No Groundwater



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~8-10" thick; light brown (5YR 4/4) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are subrounded to subangular medium gray (N5) to pale reddish brown (10R 5/4) quartzite up to ~19" in diameter, though mode clast size is ~1-3"; abundant plant and tree roots; sharp, irregular basal contact.

**2. Colluvium:** ~1' thick; moderate yellowish brown (10YR 5/4) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above up to 15" in diameter, though mode clast size is ~1" in a wide variety of clast sizes; occasional plant roots; topsoil matrix; gradational, irregular basal contact.

**3. Shallow Landslide:** ~3' thick; mottled moderate yellowish brown (10YR 5/4) to moderate reddish brown (10R 4/6) to grayish blue (5PB 5/2) clayey SAND with gravel (SC), dense, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above with minor medium gray (N5) dolomite and moderate yellowish brown (10YR 5/4) sandstone; clasts are up to 1' in diameter, though mode clast size is ~3-4"; gradational, irregular basal contact.

**4. Wasatch Formation:** >3.5' thick; moderate reddish brown (10R 4/6) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are quartzite, dolomite, and sandstone as above up to 1' in diameter, though mode clast size is ~3-4"; possibly increases in clay content with depth.



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Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
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Weber County, Utah

Figure

A-15

TP-13 Log

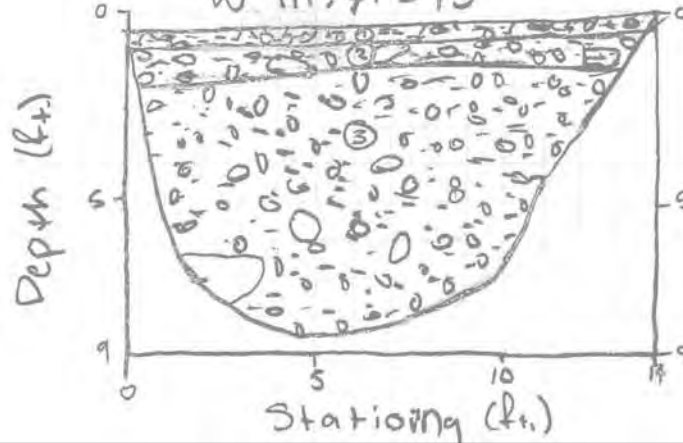
Project No. 01628-028  
 Bobcat Ridge  
 Date 6/21/18 by KLA  
 Ckd by \_\_\_\_\_ on \_\_\_\_\_

S39° E (141°)  
 E-Wall →

Bobcat Ridge  
 TP-15  
 N: 41.35978°  
 W: 111.74595°

Total Depth: 8.5'  
 \* NO GW encountered

1" = 5'  
 H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6" thick; light brown (5YR 4/3) to moderate yellowish brown (10YR 5/3) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular light brown (5YR 4/3) to medium gray (N5) to moderate reddish brown (10R 4/3) quartzite up to ~4" in diameter, though mode clast size ~0.5"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~1' thick; light brown (5YR 4/3) to moderate yellowish brown (10YR 5/3) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular quartzite as above up to 12" in diameter, though mode clast size is ~2-4"; topsoil matrix; abundant plant and tree roots; sharp, planar basal contact.

**3. Wasatch Formation:** >7' thick; moderate yellowish brown (10YR 5/3) to moderate reddish orange (10R 6/3) well-graded gravelly SAND (SW), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~35% of the unit; clasts are subrounded to subangular quartzite as above with minor moderate reddish orange sandstone; clasts are up to 2' in diameter, though mode clast size is ~2-4"; clasts appear to become larger in size with depth; occasional plant roots; trace lean clay; sand is fine- to medium-grained.



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Geotechnical and Geologic Hazards Assessment  
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 Summit Powder Mountain Resort  
 Weber County, Utah

TP-15 Log

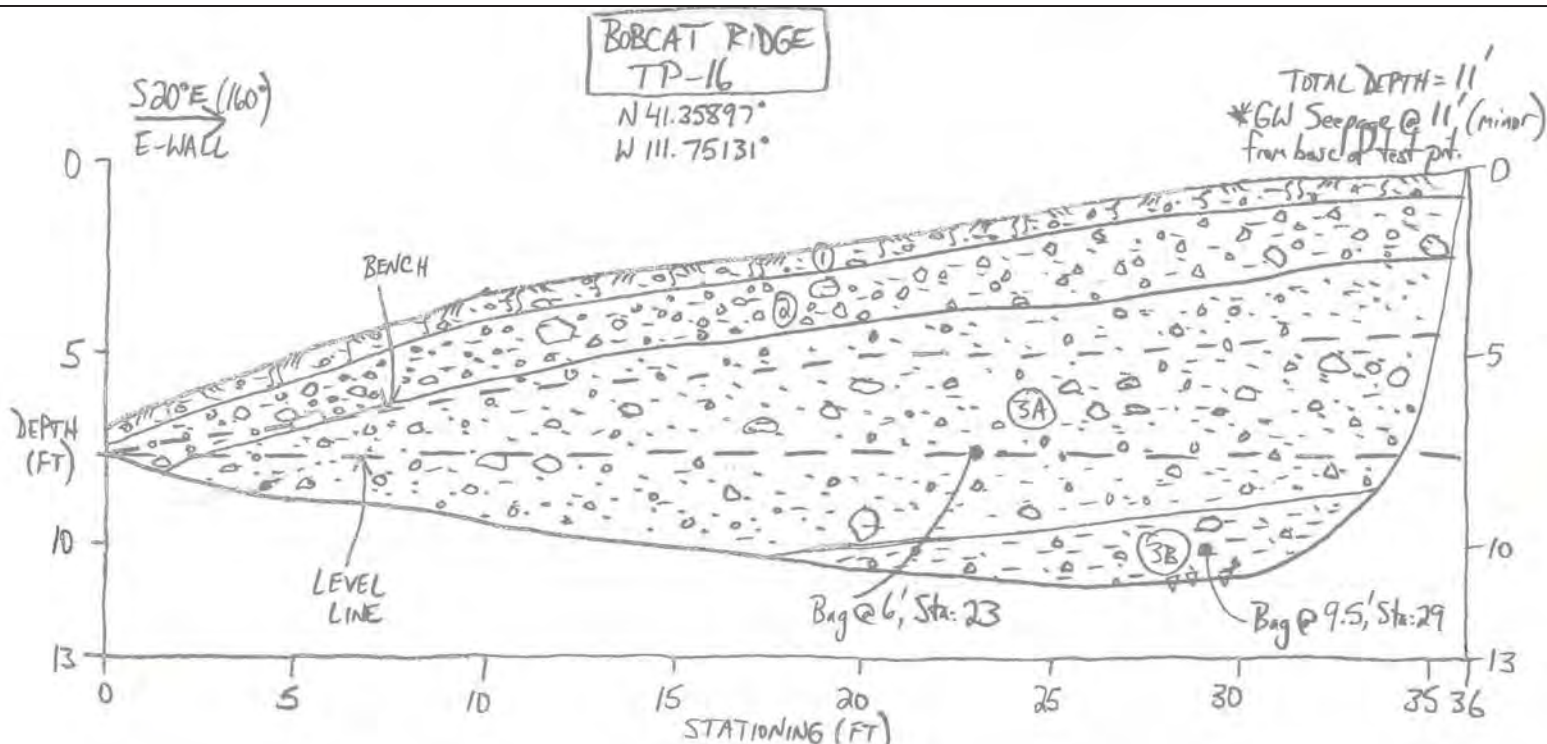
Figure

A-16

Project No. 01628-028

Date 6-22-18 by PED on Ckd by

1" = 5'  
H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6" thick; grayish brown (5Y 3/4) sandy lean CLAY with gravel (CL), loose, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular medium gray (N5) to pale yellowish orange (10YR 8/6) quartzite up to ~10" in diameter, though mode clast size is ~1-2"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~1-1.5' thick; dark yellowish brown (10YR 4/4) sandy lean CLAY with gravel (CL) gradational to clayey GRAVEL with sand (GC), medium stiff to loose, moist, low plasticity, massive; gravel and larger sized clasts comprise ~40% of the unit; clasts are subrounded to subangular quartzite as above up to 1.5' in diameter, though mode clast size is ~3-6"; common to abundant plant roots; topsoil matrix; possible B-horizon; becomes more clast-rich downslope to the north; sharp, irregular basal contact.

**3. Wasatch Formation:** >9' thick; 2 subunits.

- a. ~7' thick; moderate reddish brown (10R 4/4) clayey SAND with gravel (SC), medium dense to dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite up to 1' in diameter, though mode clast size is ~2-4"; occasional plant and tree roots; sand is fine- to medium-grained; sharp, planar basal contact.
- b. >2' thick; dark reddish brown (10R 3/3) sandy lean CLAY with gravel (CL), stiff, moist to wet, moderate plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular quartzite as above up to 8" in diameter, with a mode clast size of ~1-2"; likely represents a facies change to a more clay-rich lithology during Wasatch Formation deposition.



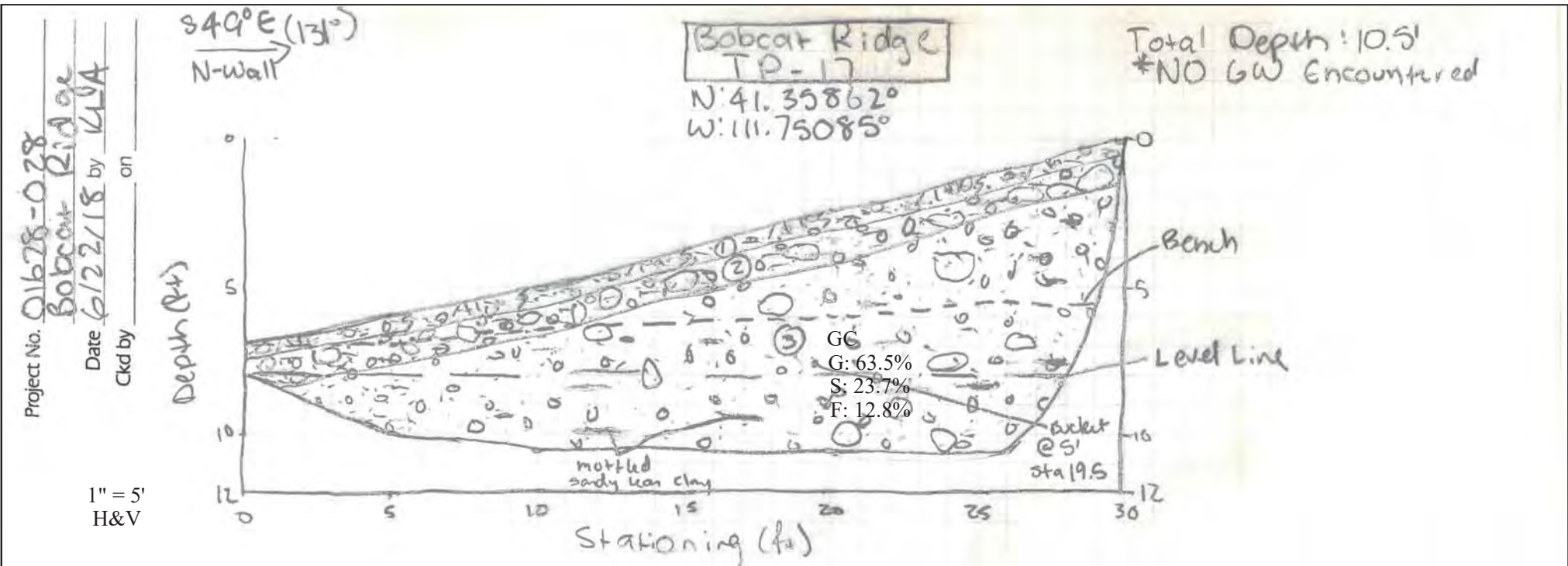
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Figure

A-17

TP-16 Log



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6" thick; light brown (5YR  $\frac{5}{4}$ ) to moderate yellowish brown (10YR  $\frac{5}{4}$ ) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular light brown to medium dark gray (N4) to moderate orange pink (10R  $\frac{7}{4}$ ) quartzite up to ~2-3" in diameter, though mode clast size ~0.5"; abundant plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~1' thick; light brown (5YR  $\frac{5}{4}$ ) to moderate yellowish brown (10YR  $\frac{5}{4}$ ) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~2-3"; topsoil matrix; sharp, planar basal contact.

**3. Wasatch Formation:** >8' thick; dark yellowish orange (10YR  $\frac{6}{8}$ ) to moderate reddish brown (10R  $\frac{4}{4}$ ) clayey GRAVEL with sand (GC) with areas of mottled moderate red (5R  $\frac{7}{4}$ ) sandy lean CLAY with gravel (CL), medium dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-65% of the unit; clasts are subrounded to subangular quartzite as above with minor moderate reddish orange (10R  $\frac{6}{8}$ ) sandstone; clasts are up to 2' in diameter, though the mode clast size is ~2-3"; sand is fine- to medium-grained.



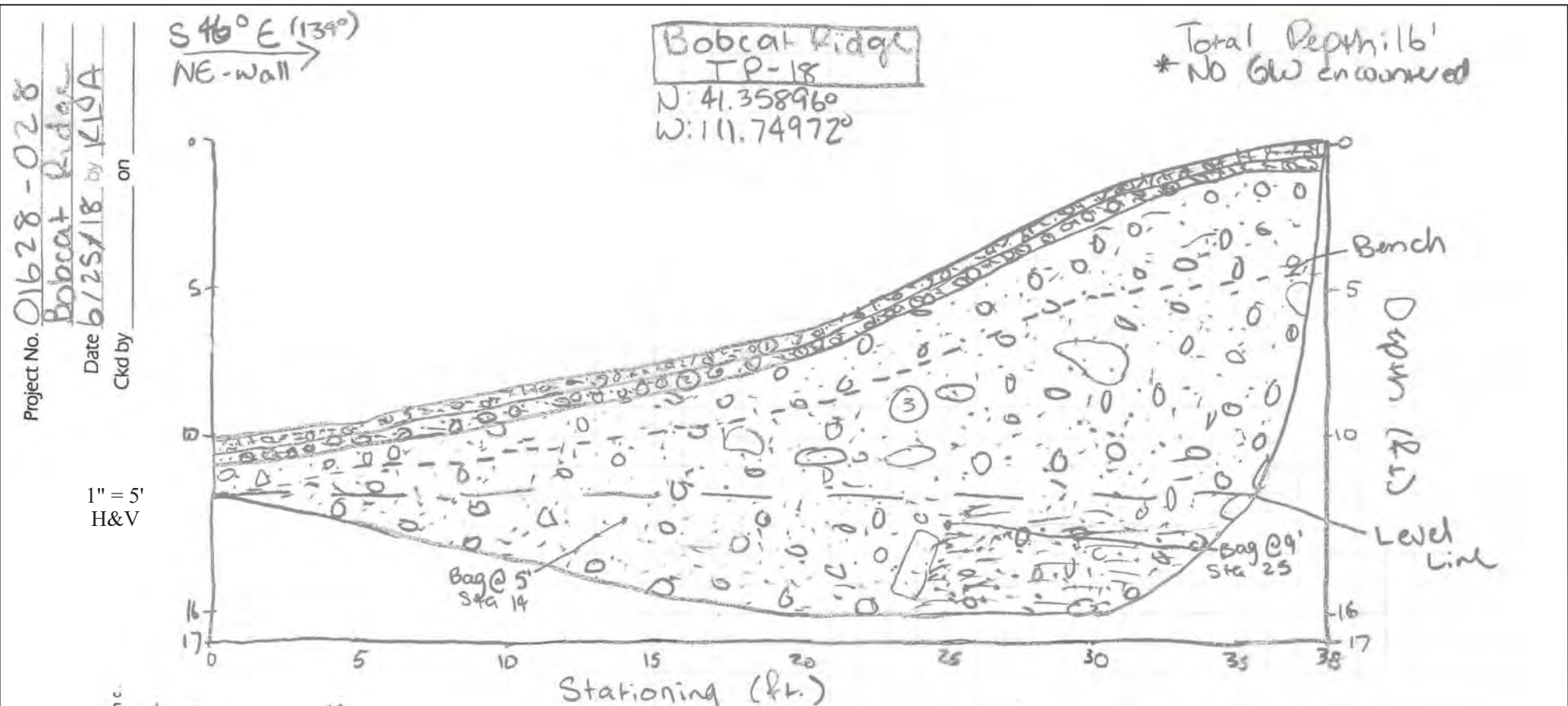
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

TP-17 Log

Figure

A-18



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6" thick; light brown (5YR 4/1) to dusky yellowish brown (10YR 4/2) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subangular to subrounded light brown to medium gray (N5) quartzite up to ~6" in diameter, though mode clast size ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~6" thick; light brown (5YR 4/1) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~35% of the unit; clasts are subrounded to subangular quartzite as above up to 2' in diameter, though mode clast size is ~2-4"; abundant plant and tree roots; topsoil matrix; sharp, planar basal contact.

**3. Wasatch Formation:** >12' thick; well-graded gravelly SAND (SW), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above with minor moderate reddish orange (10R 6/6) sandstone; clasts are up to 3' in diameter, though mode clast size is ~2-3"; sand is fine- to medium-grained; occasional tree roots; basal 3' between stations 24 and 38 exhibits a moderate reddish brown (10R 4/6) clayey SAND (SC).



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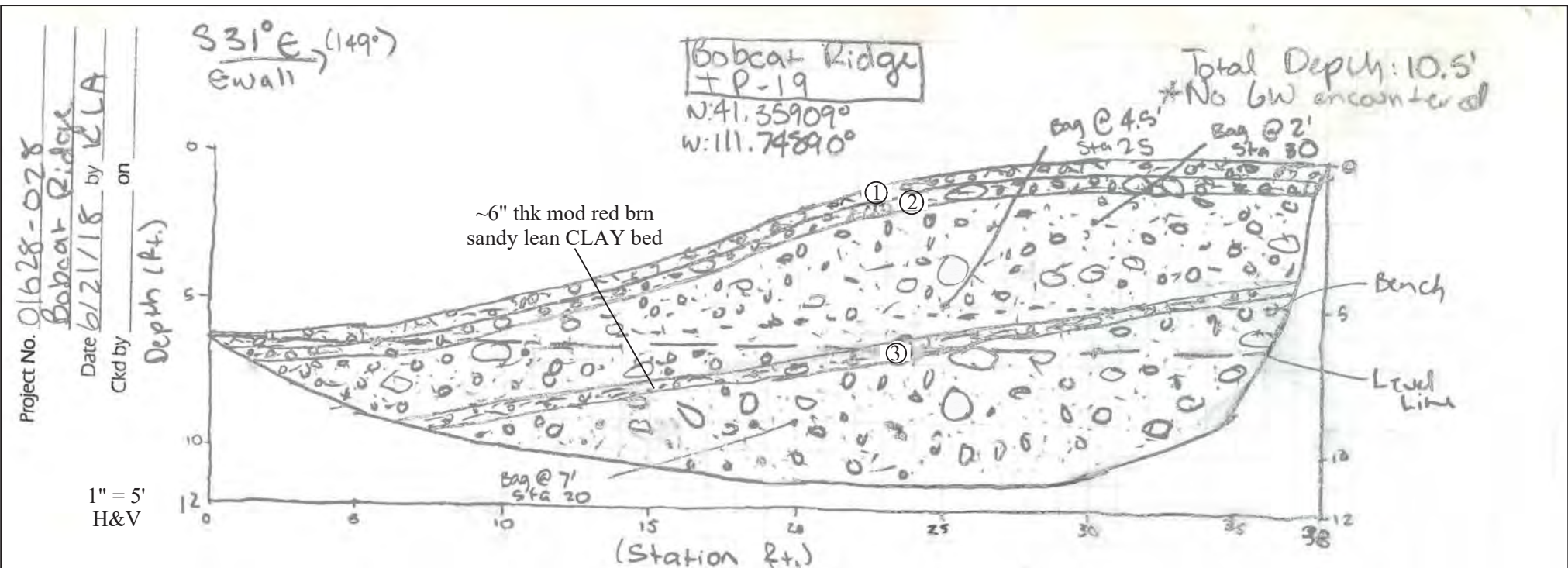
Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

Figure

A-19

TP-18 Log





### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6" thick; light brown (5YR 4/4) to moderate yellowish brown (10YR 4/4) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular light brown to medium dark gray (N4) to moderate orange pink (10R 7/4) quartzite up to ~2-3" in diameter, though mode clast size ~0.5"; abundant plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~6" thick; light brown (5YR 4/4) to moderate yellowish brown (10YR 4/4) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~2-3"; topsoil matrix; sharp, planar basal contact.

**3. Wasatch Formation:** >10' thick; dark yellowish orange (10YR 6/6) to moderate reddish orange (10R 6/6) well-graded gravelly SAND (SW), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular pale yellowish orange (10YR 6/6) to medium gray (N5) quartzite with minor moderate reddish orange (10R 6/6) sandstone; clasts are up to 2' in diameter, though mode clast size is ~2-4"; occasional plant roots; trace lean clay; sand is fine- to medium-grained.



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 Summit Powder Mountain Resort  
 Weber County, Utah

Figure

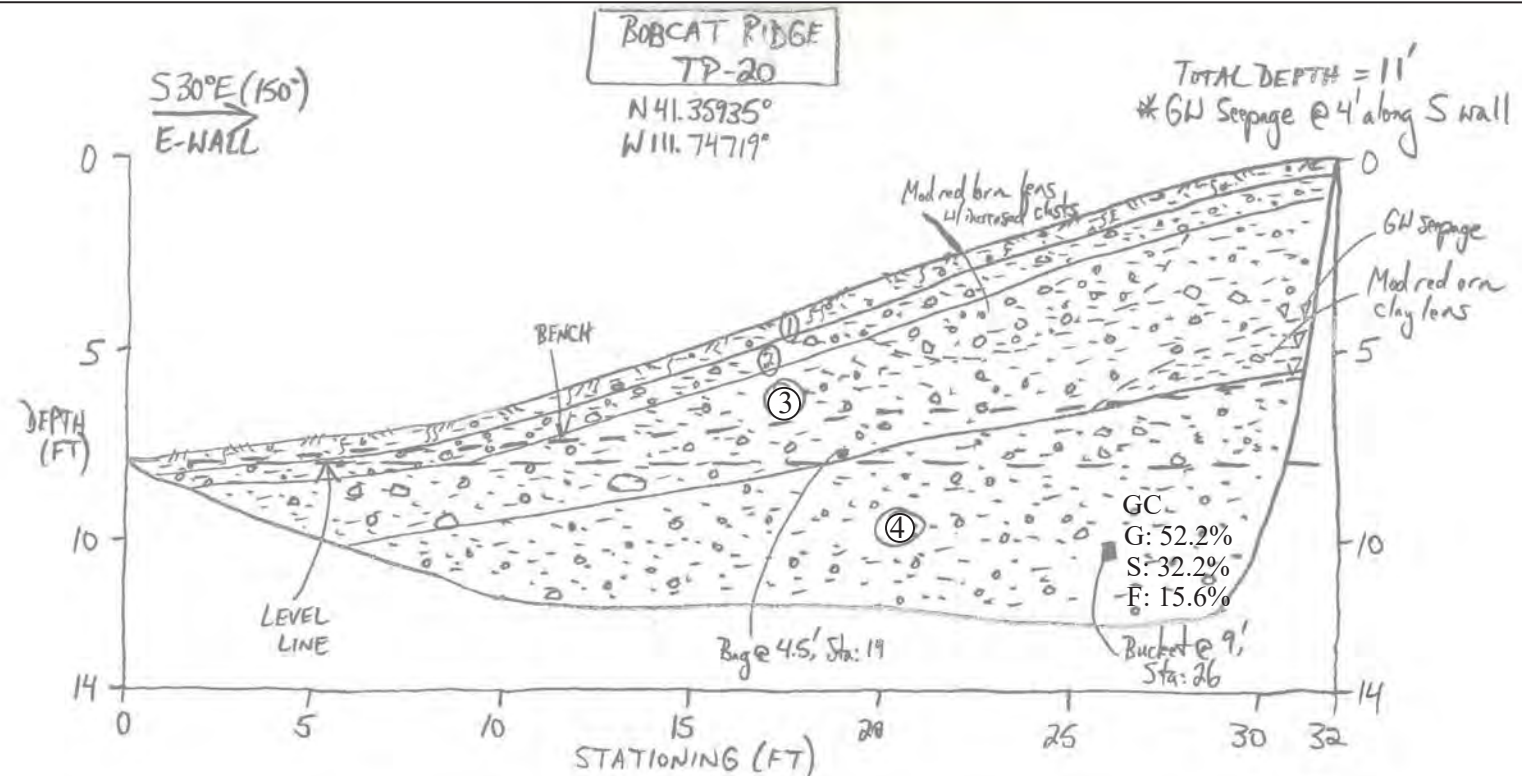
A-20

TP-19 Log

Project No. 01628-028

Date 6-26-18 by PED on  
Ckd by

1" = 5'  
H&V



### LITHOLOGIC UNIT DESCRIPTIONS

- 1. **A/B Soil Horizon:** ~8" thick; grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular medium gray (N5) to pale yellowish orange (10YR 8/6) quartzite up to ~1' in diameter, though mode clast size ~1"; abundant plant and tree roots; gradational, irregular basal contact.
- 2. **Colluvium:** ~8" thick; moderate yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above up to 10" in diameter, though mode clast size is ~2-3"; topsoil matrix; common plant and tree roots; sharp, irregular basal contact.
- 3. **Shallow Landslide:** ~2-4' thick; mottled light gray (N7) and moderate reddish brown (10R 4/6) clayey SAND with gravel (SC) gradational to sandy fat CLAY with gravel (CH), dense, moist to wet, moderate to high plasticity fines, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular quartzite as above up to 8" in diameter, though mode clast size is ~1-2"; sand component is fine- to medium-grained and increases in frequency with depth; unit is heterogeneous and includes multiple lenses of clay and sand; groundwater seepage from this unit; sharp, irregular basal contact.

- 4. **Wasatch Formation:** >6' thick; dark reddish brown (10R 3/4) clayey GRAVEL with gravel (GC), dense to medium dense, moist to wet, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-50% of the unit; clasts are subrounded to subangular quartzite as above with minor dark yellowish orange (10YR 6/6) sandstone; clasts are up to 6" in diameter, though mode clast size is ~2-3"; sand component is medium- to coarse-grained; mottled with dark yellowish orange oxidation and black MnO2 staining in places; appears similar to unit that appears as a fine-grained breccia in other test pits, except less dense.

\* Groundwater seepage also observed at a depth of 5' along west wall; continuous seepage induced sloughing of the south and west test pit walls during logging.

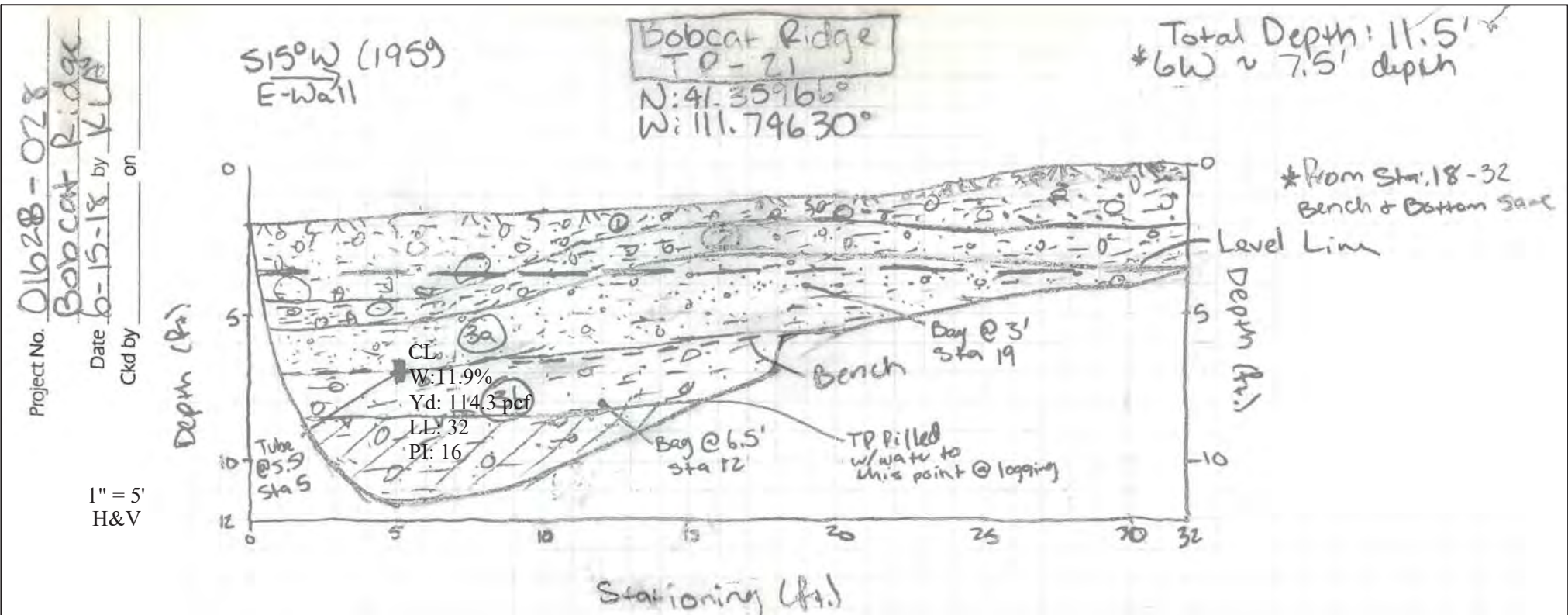


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Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

TP-20 Log

**Figure**  
**A-21**

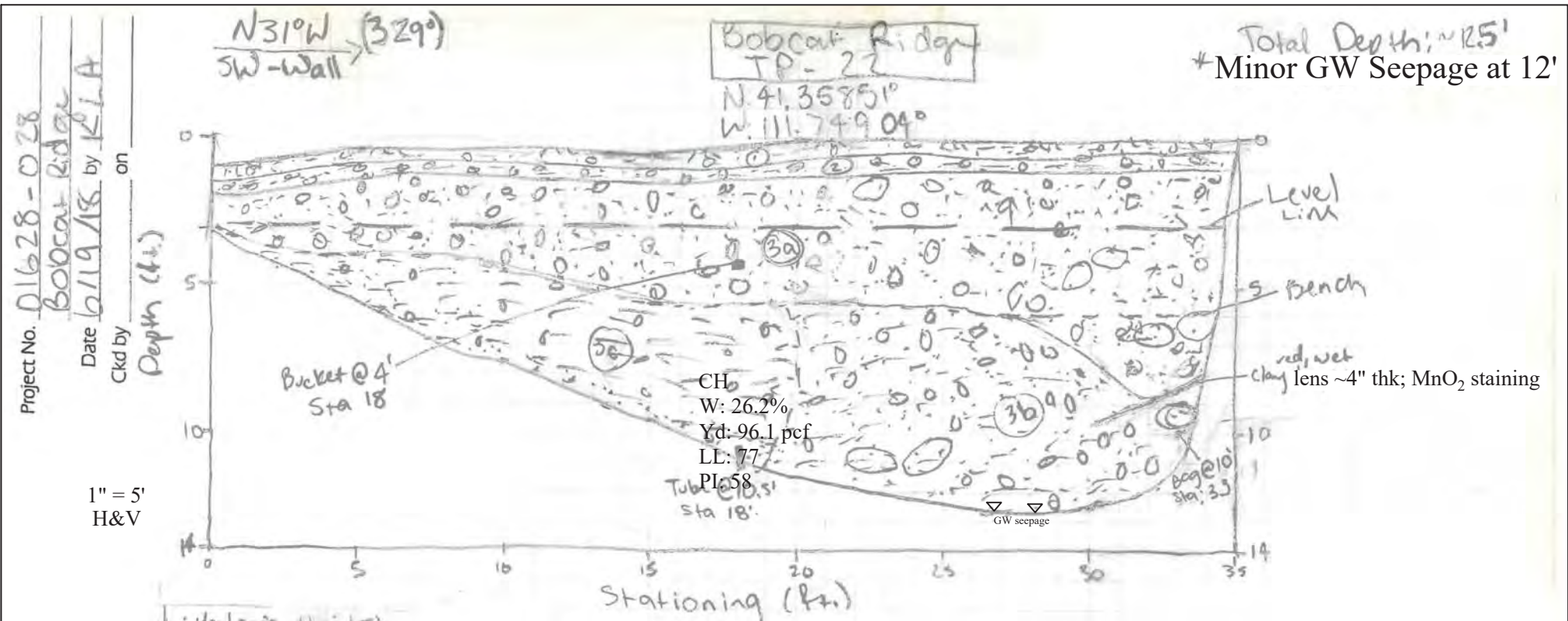


### LITHOLOGIC UNIT DESCRIPTIONS

- 1. **A/B Soil Horizon:** ~1'-2.5' thick; light brown (5YR 4) to moderate yellowish brown (10YR 4) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular dark gray (N3) to medium dark gray (N4) quartzite up to ~1' in diameter, though mode clast size ~1/2" to 1"; abundant plant and tree roots; sharp, wavy basal contact.
- 2. **Colluvium:** ~1' thick; light brown (5YR 4) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 9" in diameter, though mode clast size is ~1/2"-1"; possible small surficial slide deposit, though no shear observed; few plant roots; sharp, irregular basal contact.

- 3. **Wasatch Formation:** >6' thick, with two subunits:
  - a. ~1.5'-3' thick; moderate reddish orange (10R 4) to moderate reddish brown (10R 4) clayey SAND (SC), medium dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~5% of the unit; clasts are subrounded to subangular quartzite as above up to 4" in diameter, though mode clast size is ~1/2"; few plant roots.
  - b. >3' thick; moderate reddish brown to moderate red (5R 4) sandy lean CLAY with gravel (CL) gradational to clayey SAND with gravel (SC), stiff, moist to wet, moderate plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular quartzite as above up to 6" in diameter, though mode clast size is ~1/2"-1"; few plant roots.

\*At time of logging, the northern part of the test pit was filled with 3 feet of water.



### LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~8" thick; light brownish gray (5YR 4) to pale brown (5YR 5) sandy lean CLAY (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~5% of the unit; clasts are subrounded to subangular medium gray (N5) quartzite up to 4" in diameter, though mode clast size is ~1/2"; abundant plant and tree roots; gradational, irregular basal contact.

2. **Colluvium:** ~6" thick; dark yellowish brown (10YR 4) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular yellowish gray (5Y 7) to medium gray (N5) quartzite up to 1' in diameter, though mode clast size is ~2"; topsoil matrix; abundant plant and tree roots; sharp, planar basal contact.

\*~1" of water at bottom of west end of test pit during logging; 2" noted at base of test pit seeping from Unit 3b at a depth of 12' on 6/21/18.

3. **Wasatch Formation:** >11.5'+ thick, with three subunits:

- a. ~2.5'-7.5' thick; moderate yellowish brown (10YR 4) well-graded gravelly SAND (SW), medium dense to dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the subunit; clasts are subrounded to subangular quartzite as above and moderate reddish brown (10R 4) sandstone; clasts are up to 1' in diameter, though mode clast size is ~2-3"; occasional plant roots; sand is fine-grained to medium-grained.
- b. ~6.5' thick; moderate reddish brown (10R 4) to dark reddish brown (10R 5) clayey SAND with gravel (SC) gradational to sandy lean CLAY with gravel (CL), medium dense, moist to wet, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the subunit; clasts are subrounded to subangular quartzite and sandstone as above up to 1' in diameter, though mode clast size is ~2"-4"; sand is fine-grained to medium-grained; common muscovite flakes.
- c. ~5.5' thick; moderate reddish brown sandy fat CLAY with gravel (CH), stiff to very stiff, moist, high plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 2" in diameter, though mode clast size is <1/2"; few discontinuous slickensides observed; common muscovite flakes, especially on slickensided surfaces; occasional tree roots.



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Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

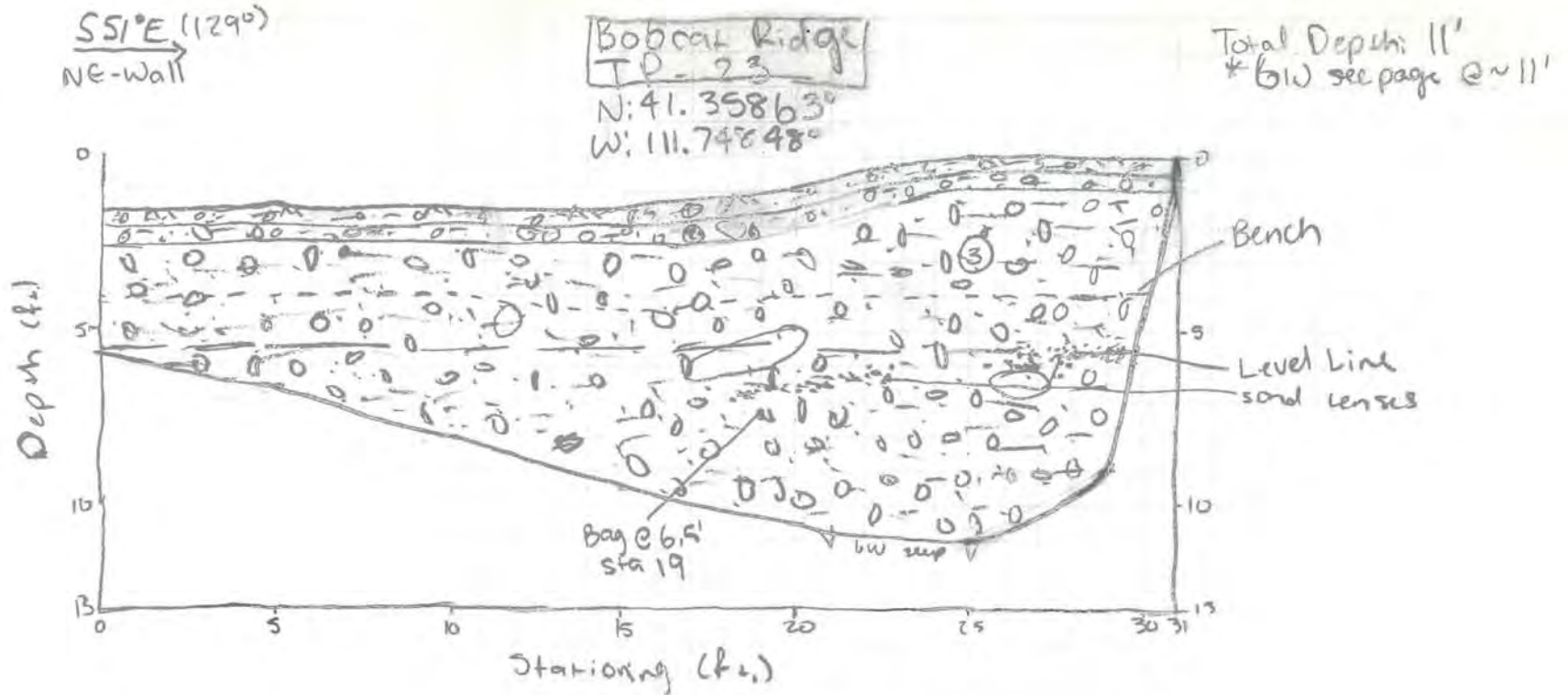
Figure

A-23

TP-22 Log

Project No. 01628-028  
 Bobcat Ridge  
 Date 6/19/18 by KLA  
 Ckd by \_\_\_\_\_ on \_\_\_\_\_

1" = 5'  
 H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6" thick; light brownish gray (5YR 4) to pale brown (5YR 5) sandy lean CLAY (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium gray (N5) quartzite up to 4" in diameter, though mode clast size is ~1/2"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~6" thick; dark yellowish brown (10YR 4) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular yellowish gray (5Y 3) to medium gray (N5) quartzite up to 1' in diameter, though mode clast size is ~2"; topsoil matrix; abundant plant and tree roots; sharp, planar basal contact.

**3. Wasatch Formation:** >10' thick; moderate reddish orange (10R 6) sandy lean CLAY with gravel (CL) gradational to clayey SAND with gravel (SC) with depth, medium stiff, moist to wet, moderate plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular pale yellowish orange (10YR 6) to light gray (N7) to medium gray (N5) quartzite and moderate reddish orange sandstone up to 3' in diameter, though mode clast size is ~2-4"; several lean clay and sand lenses with few clasts; occasional plant roots; basal ~2-3' is clayey sand with gravel, moist to wet, dense.

\*~3" of water at base of east side of test pit during logging.



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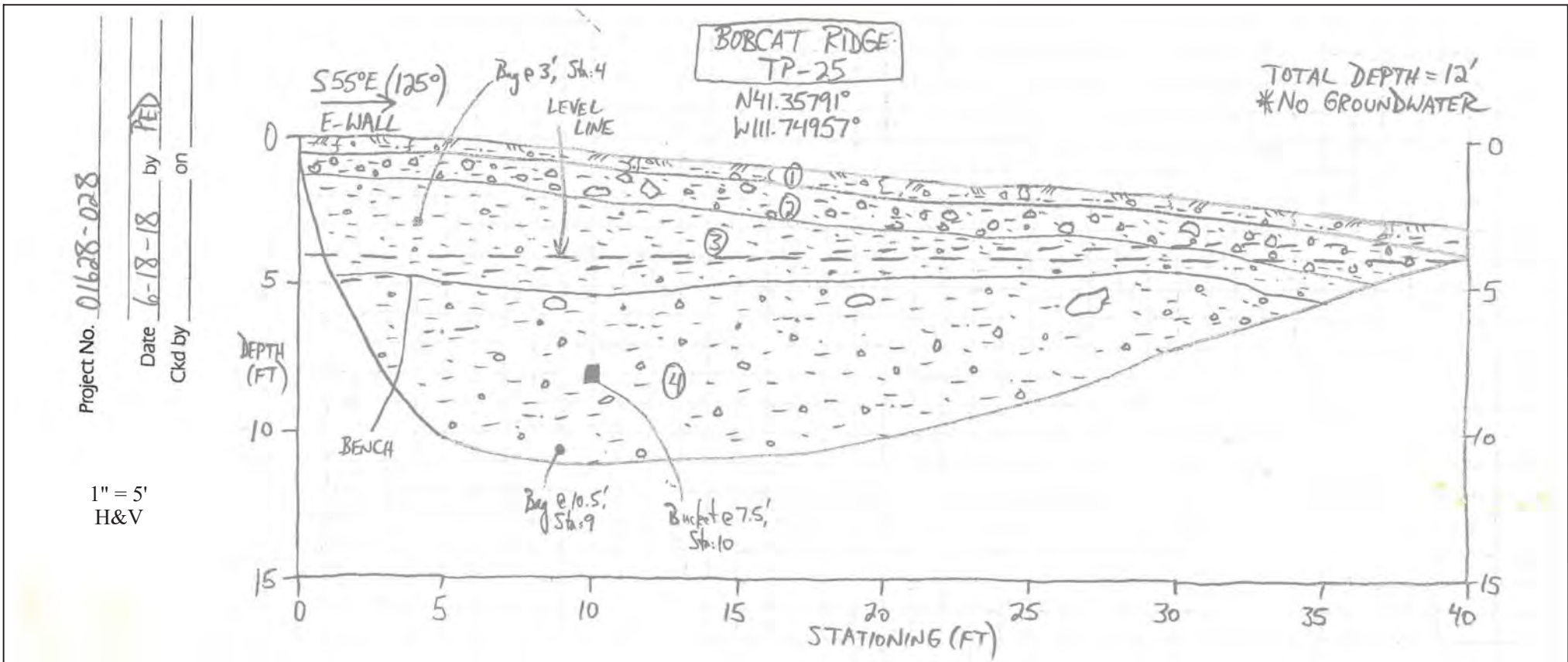
Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

Figure

A-24

TP-23 Log





### LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~6" thick; light brown (5YR 4) gravelly SILT (ML), medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are entirely subrounded to subangular medium light gray (N6) to pale yellowish orange (10YR 8) quartzite up to 14" in diameter, though mode clast size is ~1"; common plant roots; gradational, irregular basal contact.
2. **Colluvium:** ~1-1.5' thick; moderate yellowish brown (10YR 5) to dark yellowish brown (10YR 4) sandy lean CLAY with gravel (CL), medium stiff to loose, slightly moist to dry, low to moderate plasticity; gravel and larger sized clasts comprise ~30-35% of the unit; clasts entirely subrounded quartzite as above up to 1.5' in diameter, though mode clast size is ~3-5"; common plant roots; largely topsoil matrix, though grades with depth to increased moisture and fat clay content in matrix, some dark reddish brown (10R 3) coloration; sharp, irregular basal contact.

3. **Shallow Landslide?:** ~1-3' thick; mottled light gray (N7) and dark yellowish orange (10YR 8) sandy fat CLAY with gravel (CH), stiff, moist, moderate to high plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded quartzite as above up to 4" in diameter, though mode clast size is ~1"; common fat clay glossy sheen, though no slickensides observed; looks similar to shallow slide deposit in TP-24, except no basal cobbles; sharp, irregular basal contact.
4. **Wasatch Formation:** >6' thick; dark reddish brown (10R 3) sandy lean CLAY with gravel (CL) gradational to clayey SAND with gravel (SC), stiff, moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded quartzite as above up to 1.5' in diameter, though mode clast size is <1"; occasional 1 mm pinholes where clayey; becomes more clayey with depth; sand component is very fine-grained and gradational to silt.



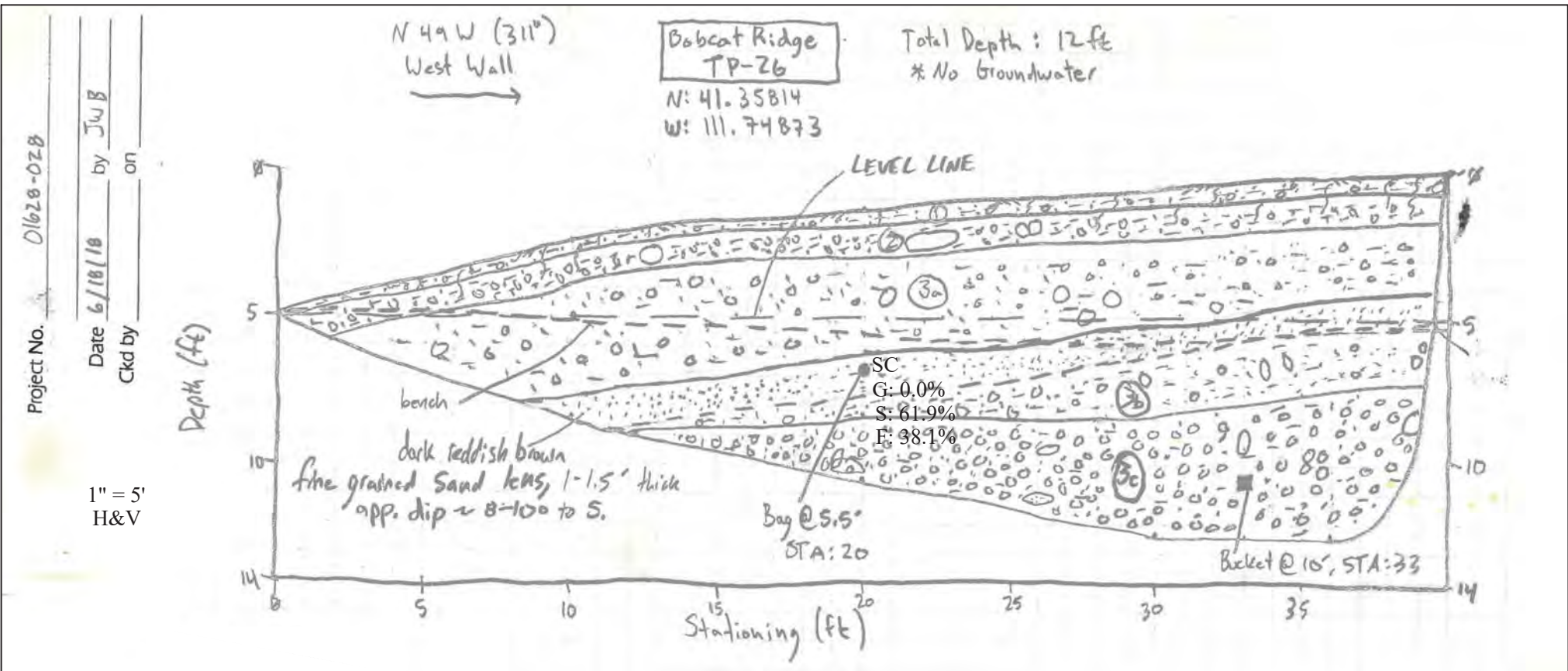
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

Figure

A-26

TP-25 Log



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~7" thick; light brown (5YR 8) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are subrounded to subangular medium gray (N5) quartzite and dark yellowish orange (10YR 6) sandstone; clasts are up to ~10" in diameter, though mode clast size ~1"; common plant roots; sharp, irregular basal contact.

**2. Colluvium:** ~1' thick; moderate yellowish brown (10YR 5) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~25-35% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 2' in diameter, though mode clast size is ~3-4"; common plant roots; sharp, irregular basal contact.

**3. Wasatch Formation:** >10.5' thick, with 3 subunits.

a. ~3-4' thick; mottled moderate reddish brown (10R 4) and dark yellowish orange (10YR 6) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30% of the subunit; clasts are subrounded to subangular quartzite and sandstone as above, with minor grayish brown (5Y 3) to medium dark gray (N4) dolomite; clasts are up to 1.5' in diameter, though mode clast size is ~3"; occasional plant roots; sharp, irregular basal contact.

b. ~1.5-3' thick; dark reddish brown (10R 3) clayey SAND with gravel (SC), dense, moist, medium plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the subunit and are concentrated at the base of the subunit, clasts are subrounded to subangular sandstone and dolomite as above, clasts are up to 10" in diameter, though mode clast size is ~2-4"; few plant roots; gradational, irregular basal contact.

c. >5' thick; dark reddish brown (10R 3) clayey GRAVEL with sand, dense to very dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~50-60% of the subunit; clasts are subangular to subrounded quartzite, sandstone and dolomite as above up to 10" in diameter, though mode clast size is <0.5"; significant portion of clasts are dolomite; highly weathered clasts in places; few plant roots.

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 Summit Powder Mountain Resort  
 Weber County, Utah

TP-26 Log

Figure  
 A-27

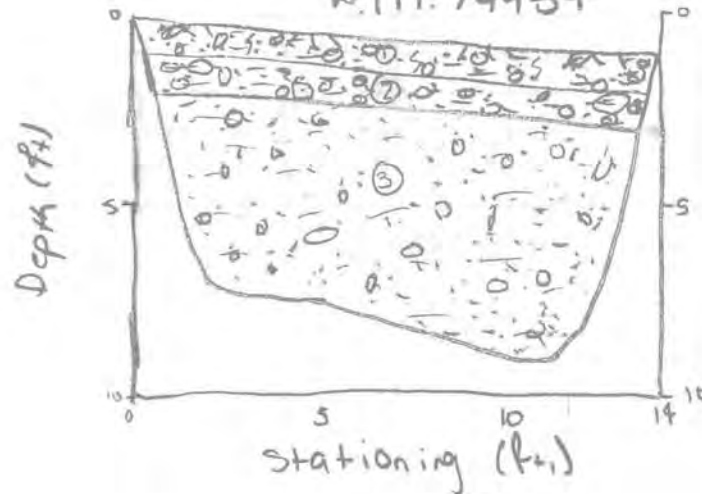


Project No. 01628-028  
 Bobcat Ridge  
 Date 6/18/18 by KLA  
 Ckd by [signature]

N32°W(328°)  
 SW-Wall

Bobcat Ridge  
 TP-27  
 N: 41.358380  
 W: 111.749540

Total Depth: 9'  
 \*No GW seepage



1" = 5'  
 H&V

### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; light brown (5YR 4) to yellowish gray (5Y 7) sandy lean CLAY with gravel (CL), loose, dry, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular pale yellowish brown (10YR 6) to medium gray (N5) quartzite up to ~3" in diameter, though mode clast size ~0.5"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~1' thick; light brown (5YR 4) to yellowish gray (5Y 7) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular quartzite as above up to ~1' in diameter, though mode clast size ~1-2"; topsoil matrix; abundant plant roots; sharp, irregular basal contact.

**3. Wasatch Formation:** >6.5' thick; moderate reddish orange (10R 6) to moderate reddish brown (10R 4) clayey SAND with gravel (SC), medium dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular moderate reddish orange to medium gray (N5) quartzite with minor moderate reddish orange to moderate yellow (5Y 7) sandstone; clasts are up to 2' in diameter, though mode clast size is ~2-3"; occasional plant roots; sand is fine- to medium-grained; some possible clay lenses.



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Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

TP-27 Log

Figure

A-28

Project No. 01628-028

Date 6/18/06 by JWB on Ckd by

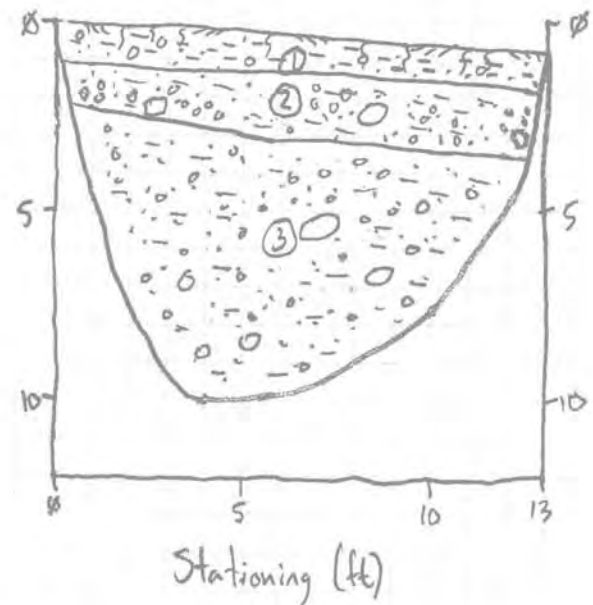
S 30° E (150°)  
East Wall

Bobcat Ridge  
TP-28  
N: 41.35808  
W: 111.94902

Total Depth: 10 ft  
\* No Groundwater

1" = 5'  
H&V

Depth (ft)



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~8-12" thick; light brown (5YR 4/3) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular light gray (N7) quartzite and dark yellowish orange (10YR 6/8) fine-grained sandstone up to ~3" in diameter, though mode clast size ~1"; common plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~1.5-2' thick; moderate yellowish brown (10YR 4/3) to dark yellowish brown (10YR 4/2) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 1' in diameter, though mode clast size is ~3-5"; common plant roots; topsoil matrix; sharp, irregular basal contact.

**3. Wasatch Formation:** >7' thick; dark reddish brown (10R 4/3) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 1.5' in diameter, though mode clast size is ~2-3"; few plant roots.



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Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

TP-28 Log

**Figure**  
**A-29**

Project No. 01628-028

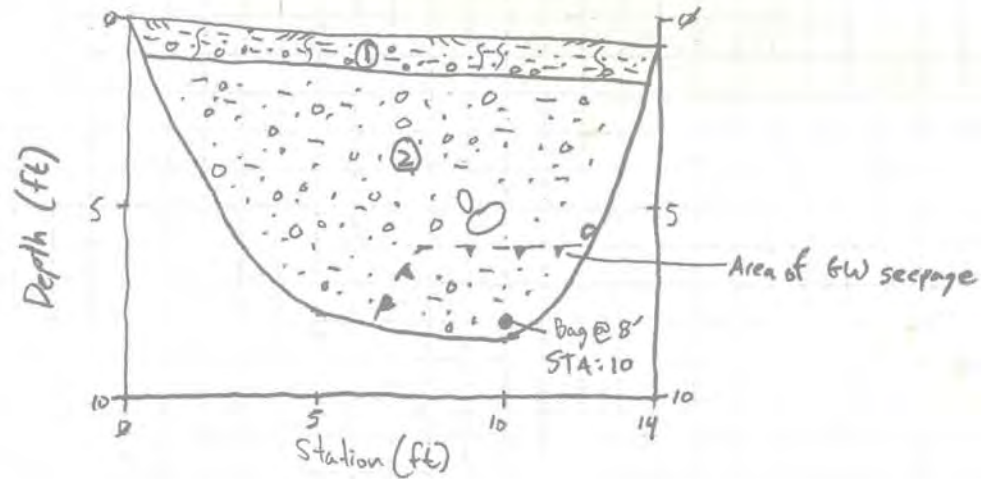
Date 6-18-18 by JWB  
Ckd by on

1" = 5'  
H&V

Due S (180°)  
→  
East Well,

Bobcat Ridge  
TP-29/  
N: 41.35725  
W: 111.74943

Total Depth: 8.5'  
\* Groundwater seepage @ 6.0'  
along W wall



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; dark yellowish brown (10YR 4/3) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular medium gray (N5) quartzite and moderate reddish orange (10R 6/6) finely bedded, fine-grained, highly oxidized sandstone; clasts are up to ~5" in diameter, though mode clast size ~1"; common plant roots; mulch layer at surface; gravel concentrated at base of unit, possibly representing a thin colluvial unit; sharp, irregular basal contact.

**2. Wasatch Formation:** >7' thick; mottled dark reddish brown (10R 4/3) and dark yellowish orange (10YR 6/6) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~25-35% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 1.5' in diameter, though mode clast size is ~2"; few plant roots.



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Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

TP-29 Log

Figure

A-30

Project No. 01628-028

Bobcat Ridge

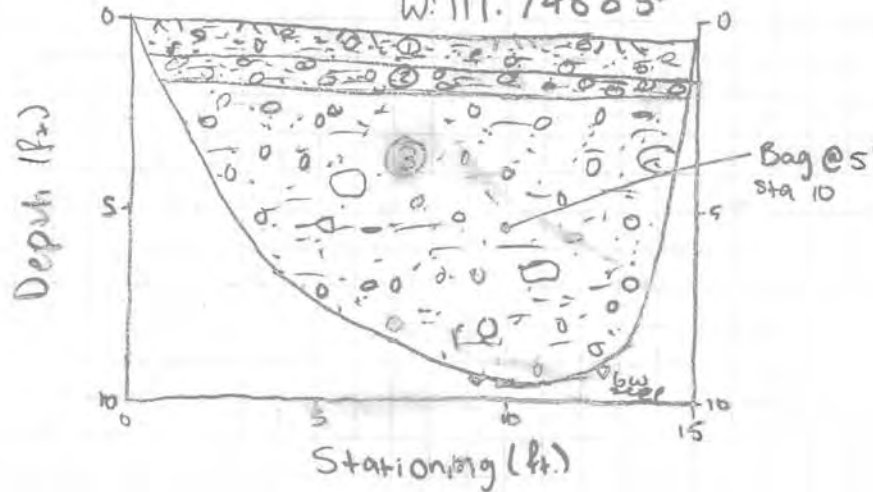
Date 6/18/18 by KLA

Ckd by \_\_\_\_\_ on \_\_\_\_\_

N40°E (40°)  
NW-Wall

Bobcat Ridge  
TP-30  
N: 41.35751°  
W: 111.74883°

Total Depth: 9.5'  
\* Minor GW @ bottom of  
TP ~ 1'



1" = 5'  
H&V

### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; light brown (5YR 4/4) to yellowish gray (5Y 7/2) sandy lean CLAY with gravel (CL), loose, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular pale yellowish brown (10YR 6/4) to medium gray (N5) quartzite up to ~3" in diameter, though mode clast size ~0.5"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~6" thick; ; light brown (5YR 4/4) to yellowish gray (5Y 7/2) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular quartzite as above up to ~1' in diameter, though mode clast size ~1-2"; topsoil matrix; abundant plant roots; sharp, irregular basal contact.

**3. Wasatch Formation:** >7.5' thick; moderate reddish orange (10R 6/4) to moderate reddish brown (10R 3/4) clayey SAND with gravel (SC), medium dense, moist to wet, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular moderate reddish orange to medium gray (N5) quartzite with minor moderate reddish orange to moderate yellow (5Y 7/2) sandstone; clasts are up to 2' in diameter, though mode clast size is ~2-3"; occasional plant roots; sand is fine- to medium-grained; sandstone clasts are banded with alternating yellow and red color, likely a product of groundwater flow.



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Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

TP-30 Log

Figure

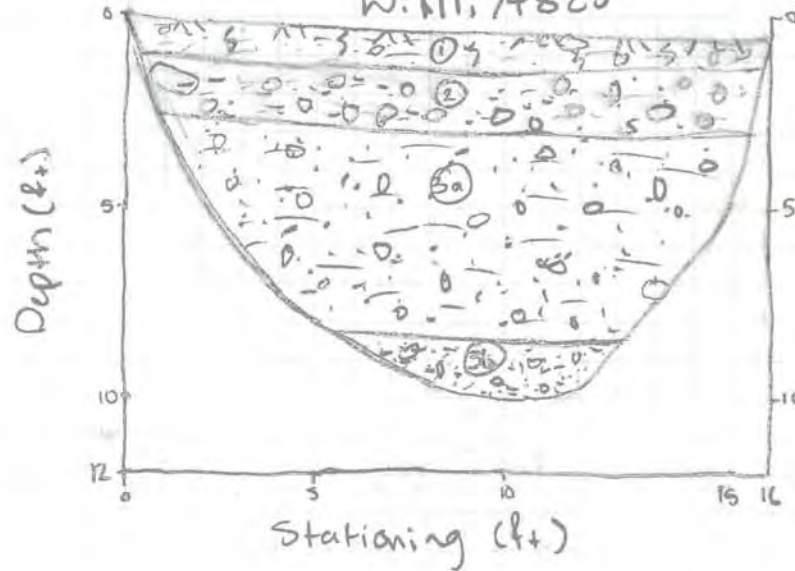
A-31

Project No. 01628-028  
 Bobcat Ridge  
 Date 6/18/18 by JLA  
 Ckd by \_\_\_\_\_ on \_\_\_\_\_

S48°W (2280)  
 6-wall

Bobcat Ridge  
 TP-31  
 N: 41.35783°  
 W: 111.74825°

Total Depth: 10.5'  
 \* No GW encountered



1" = 5'  
 H&V

## LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; light brown (5YR 4/3) to yellowish gray (5Y 7/2) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit, clasts are subrounded to subangular pale yellowish brown (10YR 8/2) to medium gray (N5) quartzite up to ~6" in diameter, though mode clast size ~0.5-1"; abundant plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~1.5' thick; light brown (5YR 4/3) to yellowish gray (5Y 7/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~3-4"; topsoil matrix; abundant plant roots; sharp, planar basal contact.

**3. Wasatch Formation:** >7' thick; 2 subunits

**a.** ~5.5' thick; moderate reddish orange (10R 6/3) to moderate reddish brown (10R 3/3) clayey SAND with gravel (SC), medium dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular moderate reddish orange to medium dark gray (N4) quartzite; clasts are up to 2' in diameter, though mode clast size is ~3-4"; sand is fine- to medium-grained.

**b.** >2.5' thick; moderate red (5R 4/3) silty SAND with gravel (SM), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular quartzite as above and moderate reddish orange (10R 6/6) sandstone; clasts are up to 4" in diameter, though mode clast size is ~0.5"; MnO2 traces; common muscovite mica flakes; sand is fine-grained; minor clay component.



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Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

Figure

A-32

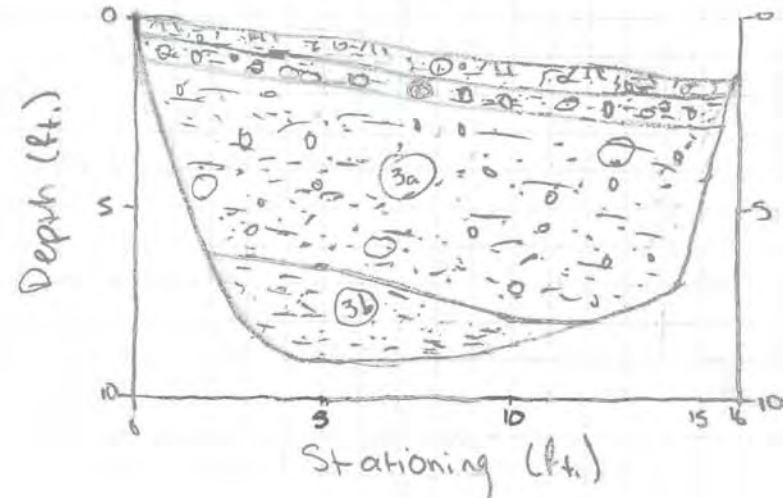
TP-31 Log

Project No. 01628-028  
 Bobcat Ridge  
 Date 6/18/18 by KLA  
 Ckd by \_\_\_\_\_ on \_\_\_\_\_

S15°W (195°)  
 E-Wall

Bobcat Ridge  
 TP-32  
 N: 41.35820°  
 W: 111.74776°

Total Depth: 9 ft  
 \* No GW encountered



1" = 5'  
 H&V

### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6" thick; light brown (5YR 4/4) to yellowish gray (5Y 7/2) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular pale yellowish brown (10YR 4/4) to medium gray (N5) quartzite up to ~1" in diameter, though mode clast size ~0.5"; abundant plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~6-12" thick; light brown (5YR 4/4) to yellowish gray (5Y 7/2) sandy lean CLAY with gravel (CL), loose to medium stiff, dry to moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to ~5" in diameter, though mode clast size ~1-2"; topsoil matrix; abundant plant roots; sharp, planar basal contact.

**3. Wasatch Formation:** >7' thick; 2 subunits.

- a. ~5' thick; moderate reddish orange (10R 6/6) to moderate reddish brown (10R 3/3) clayey SAND with gravel (SC), medium dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular moderate reddish orange (10R 6/6) to medium dark gray (N4) quartzite, clasts are up to 2' in diameter, though mode clast size is ~3-4"; sand is fine to medium grained.
- b. >2.5' thick; dark reddish brown (10R 3/3) sandy fat CLAY (CH) medium stiff, moist, moderate to high plasticity, massive; devoid of clasts; exhibits fat clay glossy sheen, but no slickensides observed.



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Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

TP-32 Log

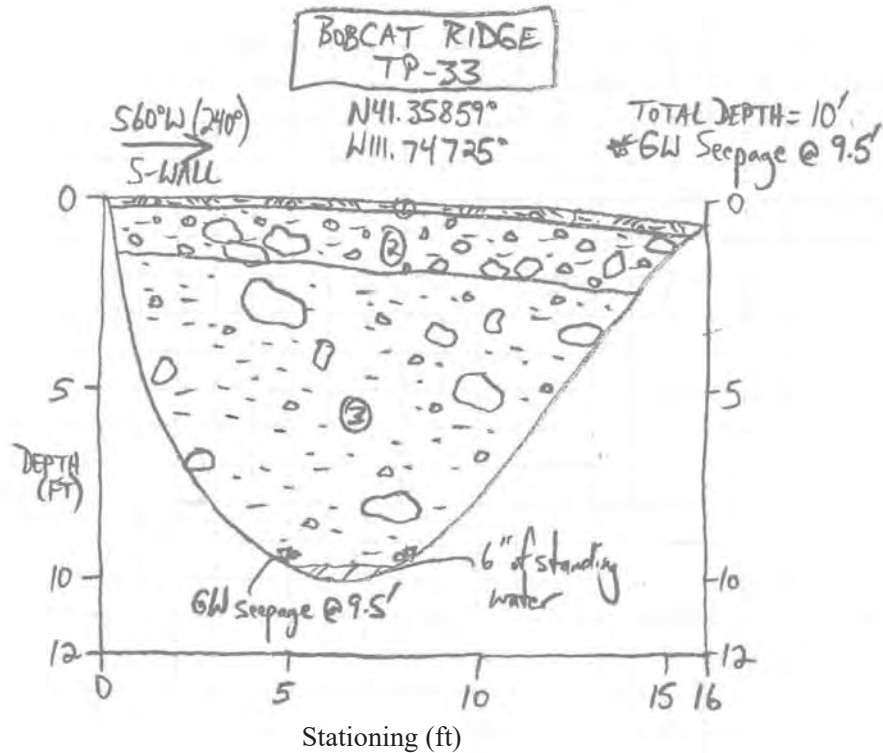
Figure

A-33

Project No. 01628-028

Date 6-14-18 by PED  
Ckd by on

1" = 5'  
H&V



## LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~2-3" thick; light brownish gray (5YR 6/4) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular medium gray (N5) to moderate reddish brown (10R 4/4) quartzite up to ~5" in diameter, though mode clast size ~1"; abundant plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~1.5' thick; light brown (5YR 6/4) clayey GRAVEL with sand (GC), medium dense, slightly moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~50-60% of the unit; clasts are subrounded to subangular medium light gray (N6) to pale yellowish orange (10YR 8/6) quartzite up to 15" in diameter, though mode clast size is ~4-6"; topsoil matrix; common plant roots; sharp, irregular basal contact.

**3. Wasatch Formation:** >8' thick; moderate reddish brown (10R 6/4) to dark reddish brown (10R 3/4) clayey SAND with gravel (SC), dense, moist to wet, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular quartzite as above up to 3' in diameter, though mode clast size is ~1-2" in a wide variety of clast sizes; sand is fine-grained; occasional highly weathered medium gray (N5) sandstone clasts; heterogeneous unit.

\*Groundwater seepage at 9.5' has accumulated in base of test pit to a depth of 6" at the time of logging.



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Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Figure

A-34

TP-33 Log

Project No. 01628-028

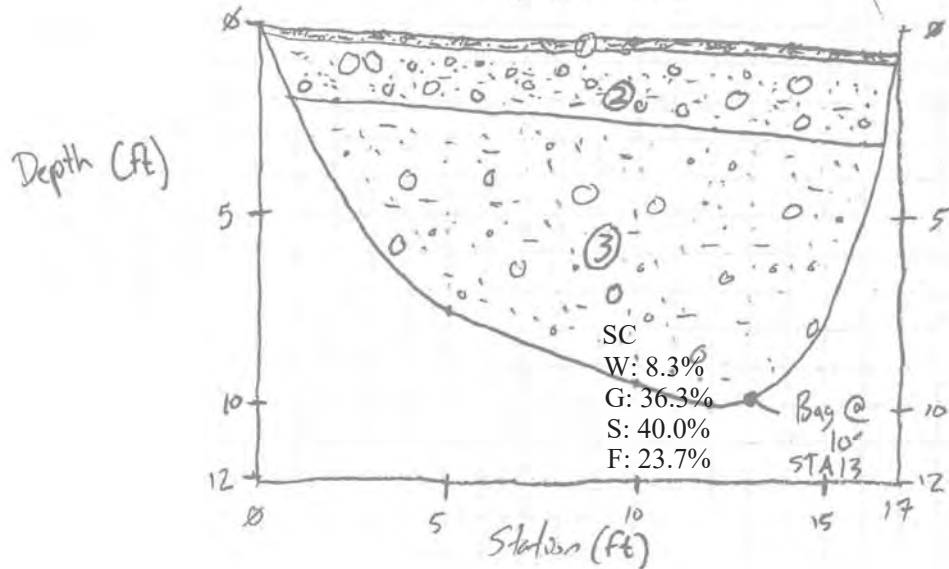
Date 6-14-18 by JWB  
Ckd by on

1" = 5'  
H&V

S 52 W (232)  
SE Wall

BOBCAT RIDGE  
TP-34  
N 41.33891  
W 111.74670

Total Depth = 10'  
\* No Groundwater



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~3-4" thick; light brownish gray (5YR 6) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular medium gray (N5) to moderate reddish brown (10R 6) quartzite up to ~5" in diameter, though mode clast size ~1"; abundant plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~1.5-2' thick; moderate yellowish brown (10YR 5) to dark yellowish brown (10YR 4) clayey GRAVEL with sand (GC), medium dense, slightly moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~40% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~4"; common plant roots; topsoil matrix; sharp, irregular basal contact.

**3. Wasatch Formation:** >8' thick; dark reddish brown (10R 3) clayey SAND with gravel (SC), dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above with minor dark yellowish orange (10YR 6) sandstone; clasts are up to 1' in diameter, though mode clast size is ~2-3"; sand is fine- to medium-grained.



Project No: 01628-028

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TP-34 Log

Figure

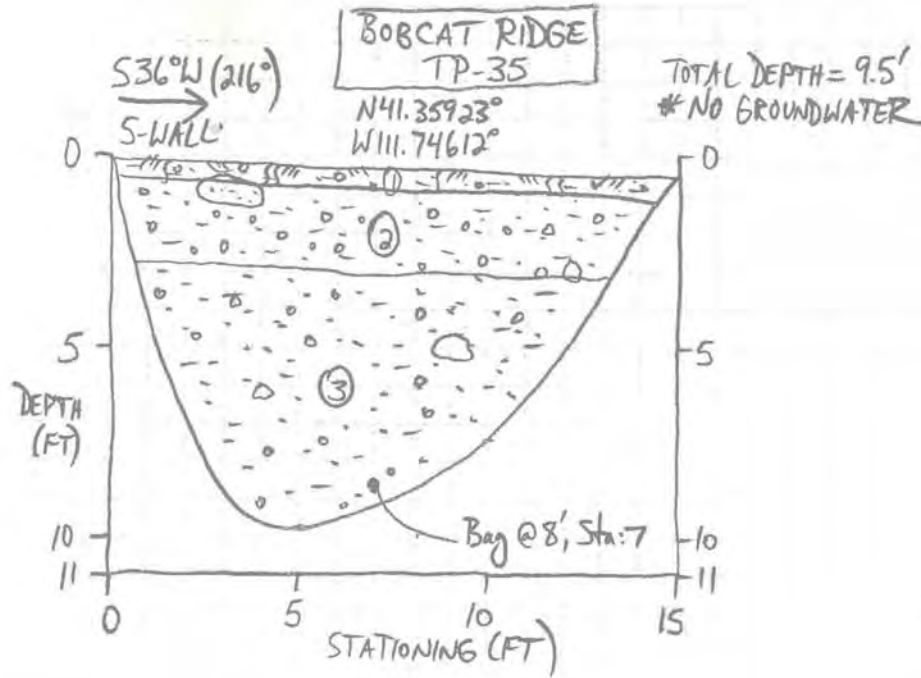
A-35



Project No. 01628-028

Date 6-14-18 by PED  
Ckd by on

1" = 5'  
H&V



## LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6" thick; light brown (5YR  $\frac{4}{2}$ ) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular medium gray (N5) to dark reddish brown (10R  $\frac{3}{4}$ ) quartzite up to ~1' in diameter, though mode clast size ~1"; common plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~2' thick; dark yellowish brown (10YR  $\frac{4}{2}$ ) sandy lean CLAY with gravel (CL), medium stiff, slightly moist to moist, low plasticity, massive; gravel and larger sized clasts comprise ~40% of the unit; clasts are subrounded to subangular medium gray (N5) to dark reddish brown (10R  $\frac{3}{4}$ ) quartzite up to 2.5' in diameter, though mode clast size is ~1-2"; occasional plant roots; topsoil matrix; similar to as seen in TP-36, except thicker unit and smaller clast sizes; sharp, largely planar basal contact.

**3. Wasatch Formation:** >6.5' thick; moderate reddish brown (10R  $\frac{4}{2}$ ) to dark reddish brown (10R  $\frac{3}{4}$ ) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~25-30% of the unit; clasts are subrounded to subangular quartzite as above; clasts are up to 8" in diameter, though mode clast size is ~1-2"; fine- to medium-grained sand, fining upwards; uppermost ~1' is clayier; few small plant roots.



Project No: 01628-028

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Summit Powder Mountain Resort  
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TP-35 Log

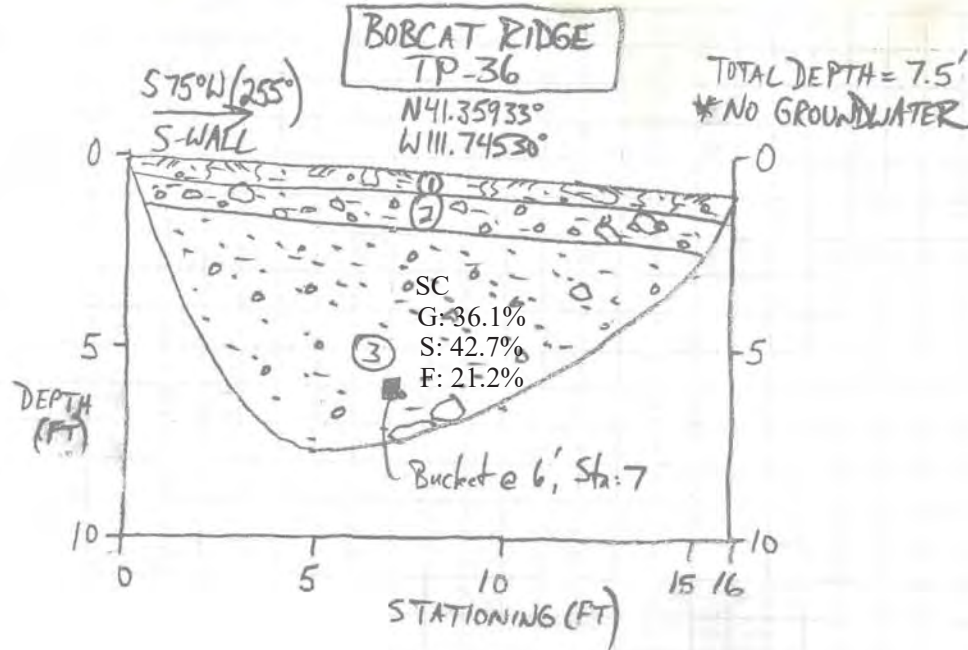
Figure

A-36

Project No. 01628-028

Date 6-14-18 by PED  
Ckd by on

1" = 5'  
H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~6" thick; light brown (5YR 4/3) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular medium gray (N5) to dark reddish brown (10R 3/4) quartzite up to 1' in diameter, though mode clast size ~1"; common plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~1' thick; light brown (5YR 4/3) to moderate reddish brown (10R 4/3) clayey GRAVEL with sand (GC) gradational to sandy lean CLAY with gravel (CL), medium dense to loose, slightly moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~40-50% of the unit; clasts are subrounded to subangular quartzite as above up to 13" in diameter, though mode clast size is ~3-4"; common plant roots; topsoil matrix; sharp, largely planar basal contact.

**3. Wasatch Formation:** >5.5' thick; moderate reddish brown (10R 4/3) to dark reddish brown (10R 3/4) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above up to 8" in diameter, though mode clast size is ~1-2"; fine- to medium-grained sand, fining upwards; uppermost ~1' is clay-rich; few small plant roots.



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Geotechnical and Geologic Hazards Assessment  
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Weber County, Utah

TP-36 Log

Figure

A-37

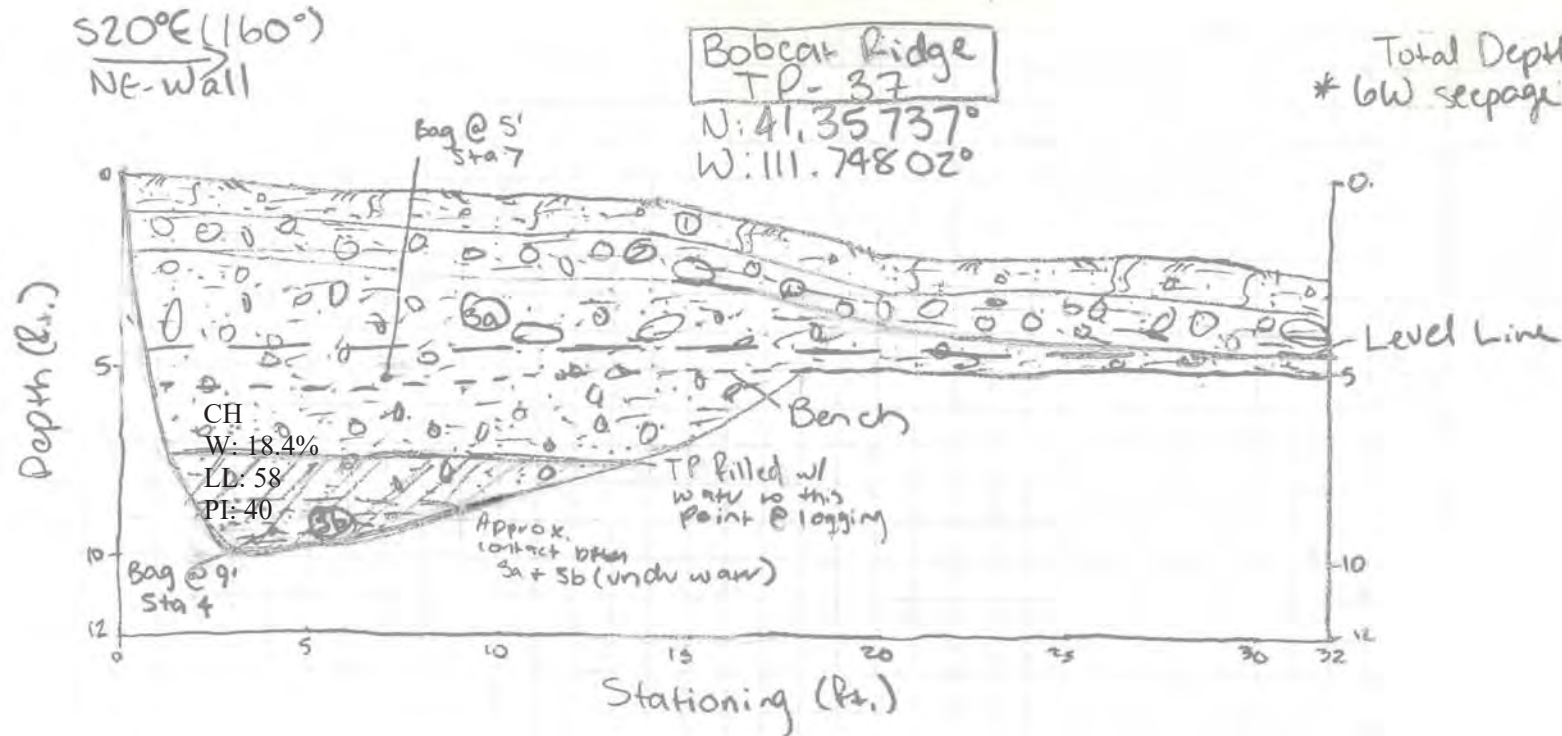
Project No. 01628-028

Bobcat Ridge

Date 6/18/18 by KLA

Ckd by \_\_\_\_\_ on \_\_\_\_\_

1" = 5'  
H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; light brown (5YR 4/4) to yellowish gray (5Y 7/2) sandy lean CLAY with gravel (CL), medium stiff, slightly moist to dry, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular pale yellowish brown (10YR 6/4) to medium gray (N5) quartzite up to ~2" in diameter, though mode clast size ~0.5"; abundant plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~1-1.5' thick; light brown (5YR 4/4) to yellowish gray (5Y 7/2) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~1-2"; abundant plant roots; topsoil matrix; sharp, planar basal contact.

**3. Wasatch Formation:** >8' thick; 2 subunits.

- a. ~6.5' thick; pale yellowish orange (10YR 8/6) to moderate reddish brown (10R 4/6) clayey SAND with gravel (SC), medium dense to dense, moist to wet, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30% of the subunit; clasts are subrounded to subangular quartzite as above with minor moderate reddish orange (10R 6/6) sandstone; clasts are up to 1' in diameter, though mode clast size is ~1-2"; sand is fine- to medium-grained; occasional plant roots; basal contact underwater at time of logging.
- b. >1-1.5' thick; moderate reddish brown (10R 4/6) sandy fat CLAY (CH), medium stiff, wet, moderate to high plasticity, massive; devoid of clasts; muscovite mica flakes common; MnO2 mottled throughout.

\*Groundwater seepage at 9-10', filling bottom of test pit 1-2' deep at time of logging.



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Figure

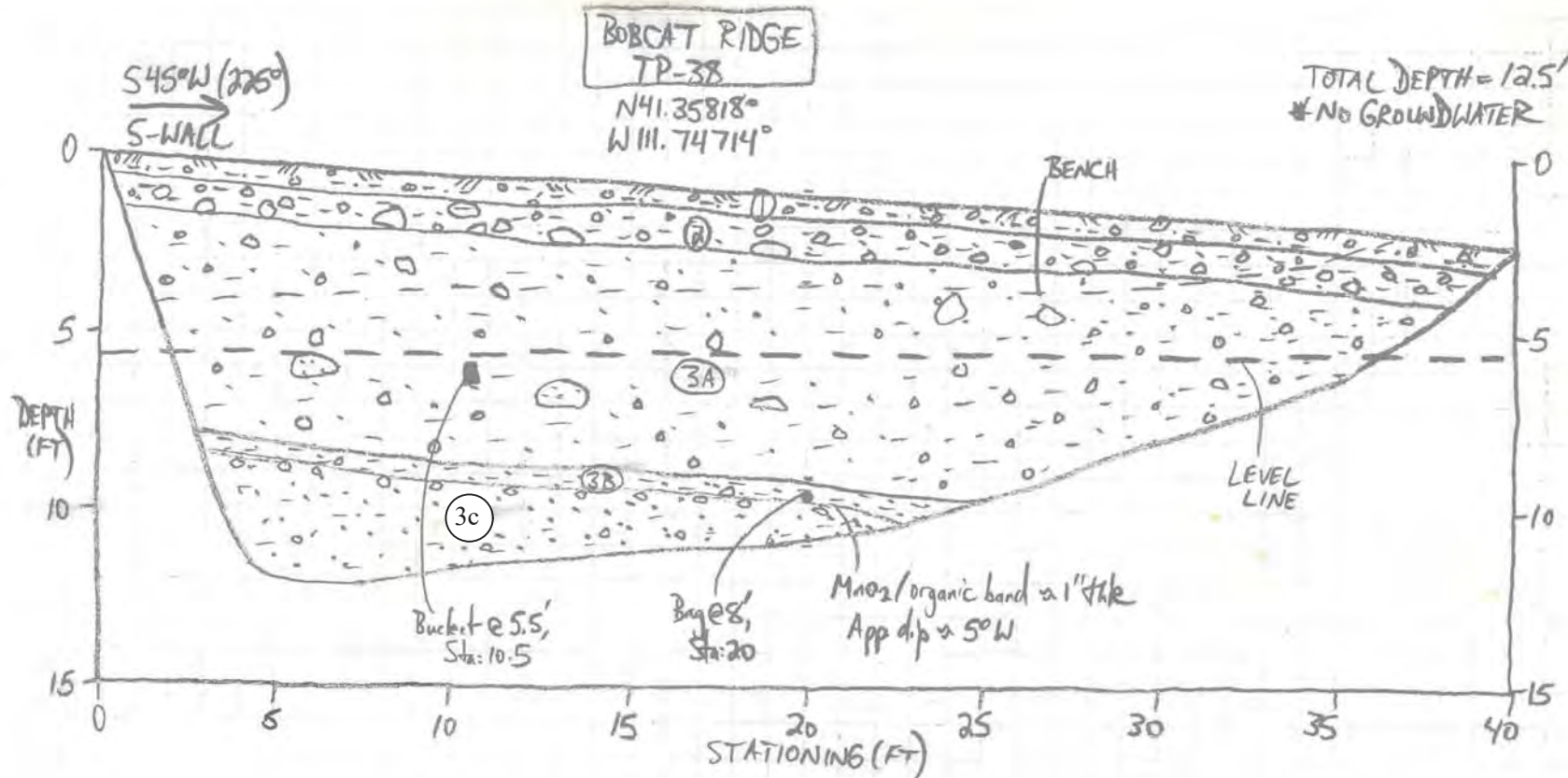
A-38

TP-37 Log

Project No. 01628-028

Date 6-15-18 by PED on  
Ckd by

1" = 5'  
H&V



### LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~6-8" thick; light brown (5YR 4/6) gravelly SILT (ML), medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~25-30% of the unit; clasts are subangular to subrounded medium gray (N5) to pale reddish brown (10R 4/6) quartzite up to ~6" in diameter, though mode clast size ~1"; common plant roots; gradational, irregular basal contact.

2. **Colluvium:** ~1' thick; light brown (5YR 4/6) to moderate yellowish brown (10YR 4/6) sandy lean CLAY with gravel (CL), medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~40% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~3-4"; common plant roots; topsoil matrix; sharp, irregular basal contact.

3. **Wasatch Formation:** >9' thick; 3 subunits.

- a. ~5' thick; mottled dark reddish brown (10R 4/6) and dark yellowish orange (10YR 4/6) clayey SAND with gravel (SC) gradational to sandy lean CLAY with gravel (CL), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-25% of the subunit; clasts are subrounded to subangular quartzite as above up to 1.5' in diameter, though mode clast size is ~1-2" in a wide variety of clast sizes; highly heterogenous unit with common clay lenses and highly weathered clasts; common glossy fat clay sheen but no slickensides observed; common 1 mm pinholes where clayey; possibly older landslide deposits.
- b. ~8" thick; dark reddish brown (10R 4/6) clayey SAND (SC) gradational to sandy lean CLAY (CL), stiff, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise <5% of the subunit; clasts are subrounded to subangular quartzite as above up to 2" in diameter; no slickensides observed; sand is fine-grained and micaceous; minor MnO2 staining; sharp, irregular basal contact.
- c. >3' thick; dark reddish brown (10R 4/6) with some dark yellowish orange (10YR 4/6) mottles; clayey SAND with gravel (SC), dense, moist, low to moderate plasticity fines, massive; gravel and larger sized clasts comprise ~10% of the subunit; clasts are subrounded to subangular quartzite as above up to 6" in diameter, though mode clast size is ~1"; occasional plant and tree roots; sand is fine- to medium-grained, though some coarse-grained; subunit has a fine-grained brecciated appearance as seen in other pits; some muscovite mica flakes; top of subunit denoted by presence of a MnO2 band and associated cobbles.



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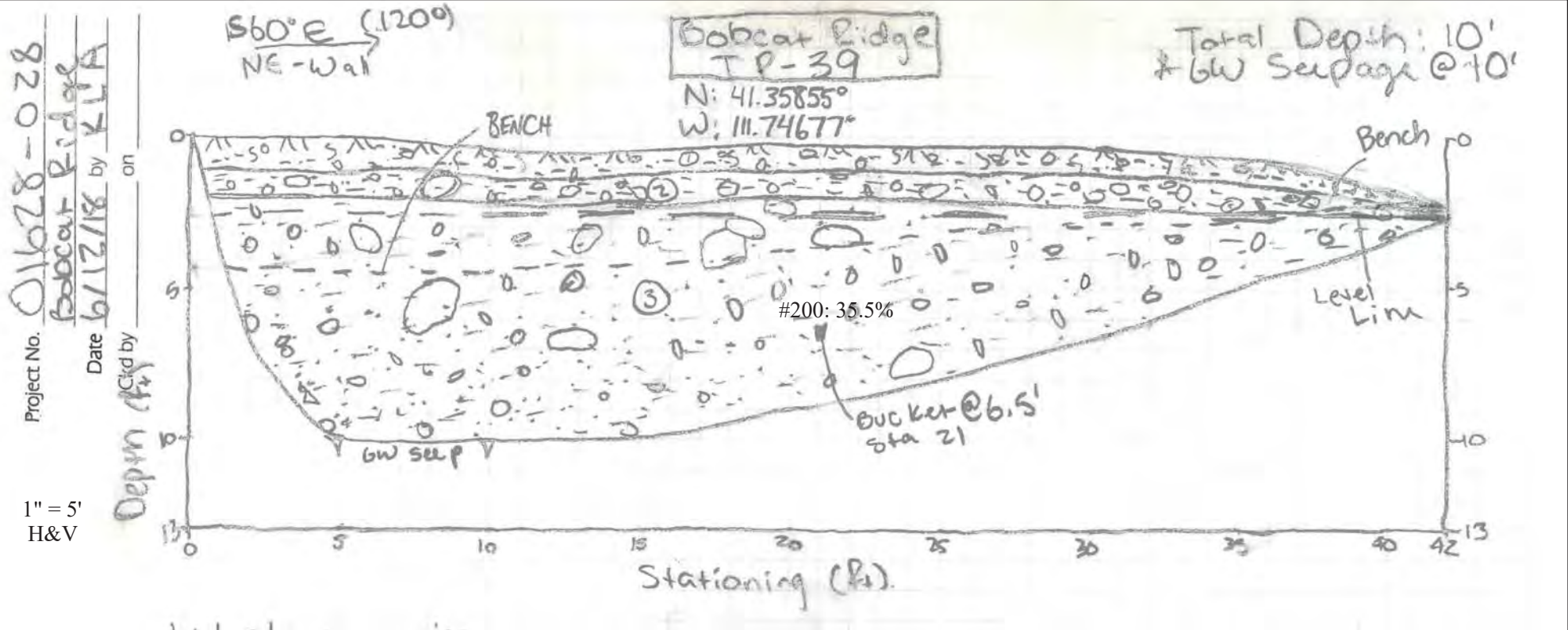
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Figure

A-39

TP-38 Log



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; pale brown (5YR 5/2) gravelly SILT (ML), medium stiff to loose, moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium gray (N5) to moderate reddish brown (10R 4/2) quartzite up to ~4" in diameter, though mode clast size is ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~1' thick; moderate yellowish brown (10YR 5/2) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above up to 14" in diameter, though mode clast size is ~2-4"; common plant and tree roots; topsoil matrix; sharp, irregular basal contact; possible B-Horizon.

**3. Wasatch Formation:** >8' thick; moderate reddish brown (10R 4/2) to dark reddish brown (10R 3/2) with mottled yellowish gray (5Y 7/2; from highly weathered sandstone clasts) clayey SAND with gravel (SC) gradational to sandy lean CLAY with gravel (CL), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular moderate reddish orange (10R 5/2) to light gray (N7) quartzite up to ~17" in diameter, though mode clast size is ~2-3"; occasional plant roots; minor muscovite grains; mottled yellowish gray areas are mostly fine-grained sand; no slickensides observed, though common fat clay glossy sheen where clayey; heterogenous unit, with pockets and lenses of sand and clay and clustered cobbles; possibly older landslide deposits; becomes sandier with depth.

\*At the time of logging, ~6" of water, seeping from 10', had accumulated in the northern end of the test pit.



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Figure

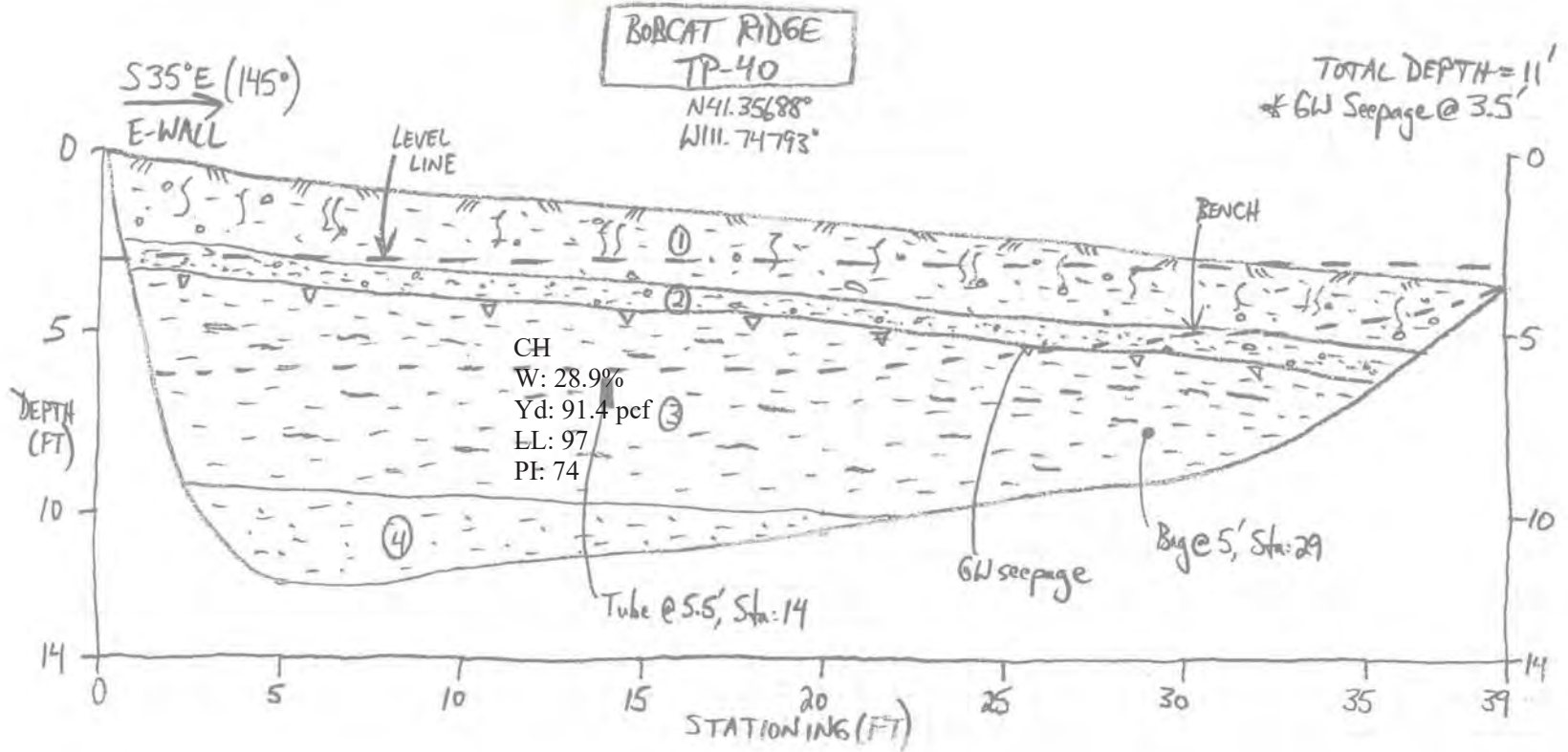
A-40

TP-39 Log

Project No. 01628-028

Date 6-8-18 by PED on Ckd by

1" = 5'  
H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~2' thick; dark yellowish brown (10YR  $\frac{4}{6}$ ) sandy lean CLAY with gravel (CL), loose to medium stiff, moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are entirely subrounded to subangular medium dark gray (N4) to pale yellowish orange (10YR  $\frac{8}{6}$ ) quartzite up to 16" in diameter, though mode clast size is ~1-2"; abundant plant and tree roots; sharp, irregular basal contact.

**2. Shallow Landslide:** ~6"-1' thick; moderate reddish brown (10R  $\frac{4}{6}$ ) to brownish gray (5YR  $\frac{4}{6}$ ) sandy fat CLAY with gravel (CH) gradational to clayey SAND with gravel (SC), medium stiff, wet, moderate plasticity, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are subrounded to subangular quartzite as above; common 1 mm pinholes; common plant roots; sharp, irregular basal contact.

**3. Shear Plane:** ~5-6' thick; light gray (N7) to mottled light gray and dark yellowish orange (10YR  $\frac{6}{6}$ ) fat CLAY (CH), medium dense to dense, wet, high plasticity, massive; devoid of clasts; heavily slickensided throughout with fat clay glossy sheen on every soil face, and a greasy feel; common 1 mm pinholes; occasional plant roots; sharp, irregular basal contact.

**4. Wasatch Formation:** > 3' thick; dark reddish brown (10R  $\frac{3}{6}$ ) sandy fat CLAY (CH), very stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~3-5% of the unit; clasts are subrounded to subangular dark yellowish orange (10YR  $\frac{6}{6}$ ) sandstone to medium gray (N5) quartzite, all <0.5" in diameter; common muscovite sand flakes; no slickensides observed.

\* Hole significantly sloughing while logging, mainly Unit 3. Groundwater seepage at a depth of 3.5' below existing grade along the length of the test pit, near the Unit 2/3 contact, but also appeared to be slowly emanating from Unit 3 as well. Pit base filled to a depth of 7" of water at the end of logging.



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Figure

A-41

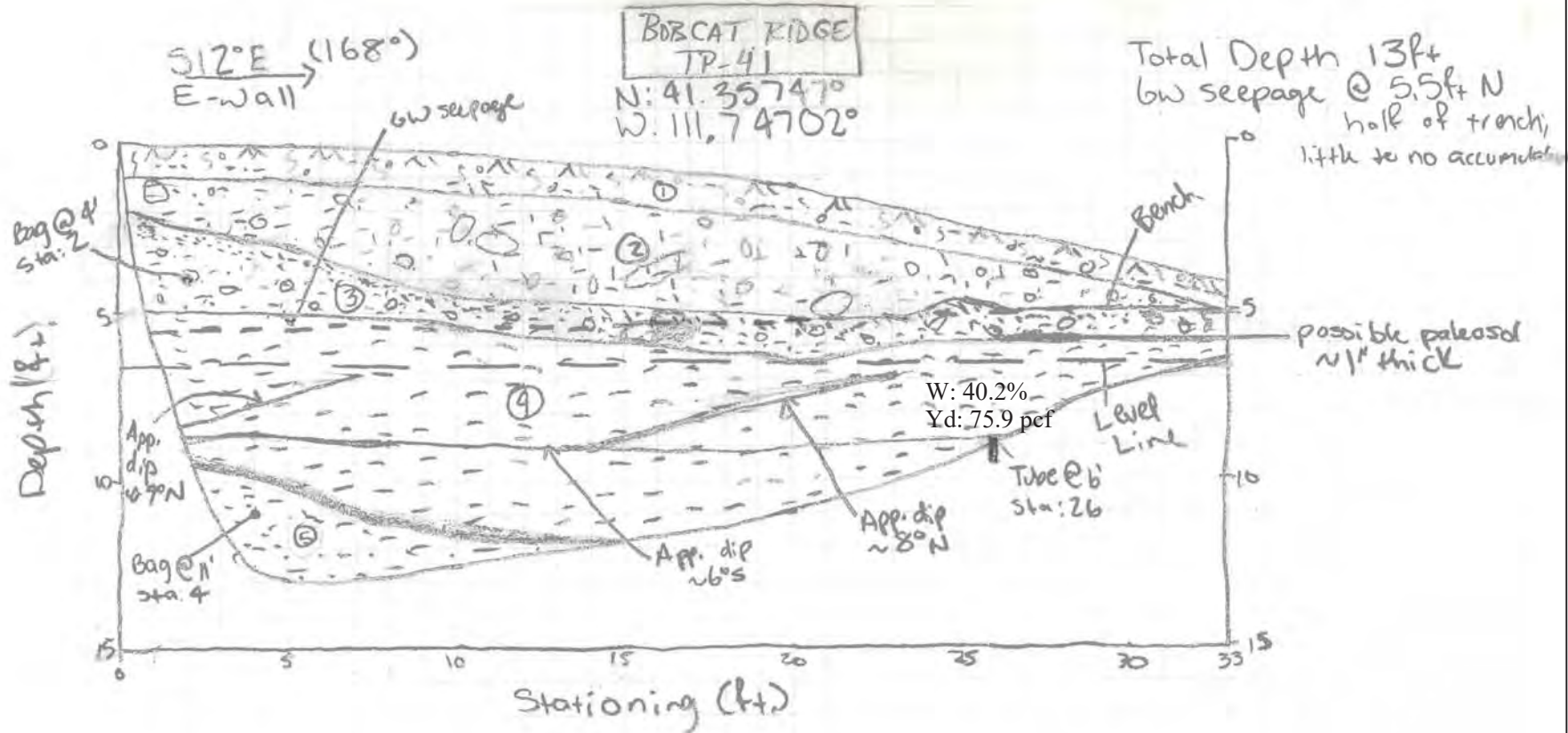
TP-40 Log

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Date 6-8-18 by KLA

Ckd by on

1" = 5'  
H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; pale brown (5YR 5) gravelly SILT (ML), medium stiff to loose, moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium gray (N5) to moderate orange pink (10R 7) quartzite up to ~3" in diameter, though mode clast size is ~1-2"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~2-3' thick; moderate yellowish brown (10YR 5) to dark yellowish brown (10YR 4) sandy lean CLAY with gravel (CL), medium stiff, moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~40% of the unit; clasts are subrounded to subangular quartzite as above and include moderate reddish orange (10R 6) sandstone; clasts are up to 20" in diameter, though mode clast size is ~2-5"; topsoil matrix; common plant and tree roots; sharp, planar basal contact.

**3. Shallow Landslide:** ~1-2.5' thick; dark yellowish orange (10YR 6) clayey SAND with gravel (SC) gradational to a light brownish gray (5YR 6) mottled with dark yellowish orange sandy lean CLAY with gravel (CL), medium dense, moist to wet, moderate to low plasticity fines, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular quartzite and sandstone as above up to 9" in diameter, though mode clast size is ~1-3"; sandier at top of unit; common plant and few tree roots; ~1' thick pocket of MnO<sub>2</sub> at station 16; gradational, irregular basal contact.

**4. Shear Plane:** ~5-6' thick; mottled light brownish gray (5YR 6) and dark yellowish orange (10YR 6) fat CLAY (CH), medium stiff to stiff, moist, high plasticity, massive; devoid of clasts; slickensides in places, with common fat clay glossy sheen and greasy feel; several continuous slide planes; common 1 mm pinholes; occasional plant roots; base is mottled with MnO<sub>2</sub>; gradational, planar basal contact.

**5. Wasatch Formation:** >2' thick; dark reddish brown (10R 3) sandy fat CLAY (CH), very stiff, moist, moderate plasticity, massive; devoid of clasts; common muscovite mica flakes; no slickensides observed; some mottled MnO<sub>2</sub> especially common in uppermost ~1' of unit.



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Figure

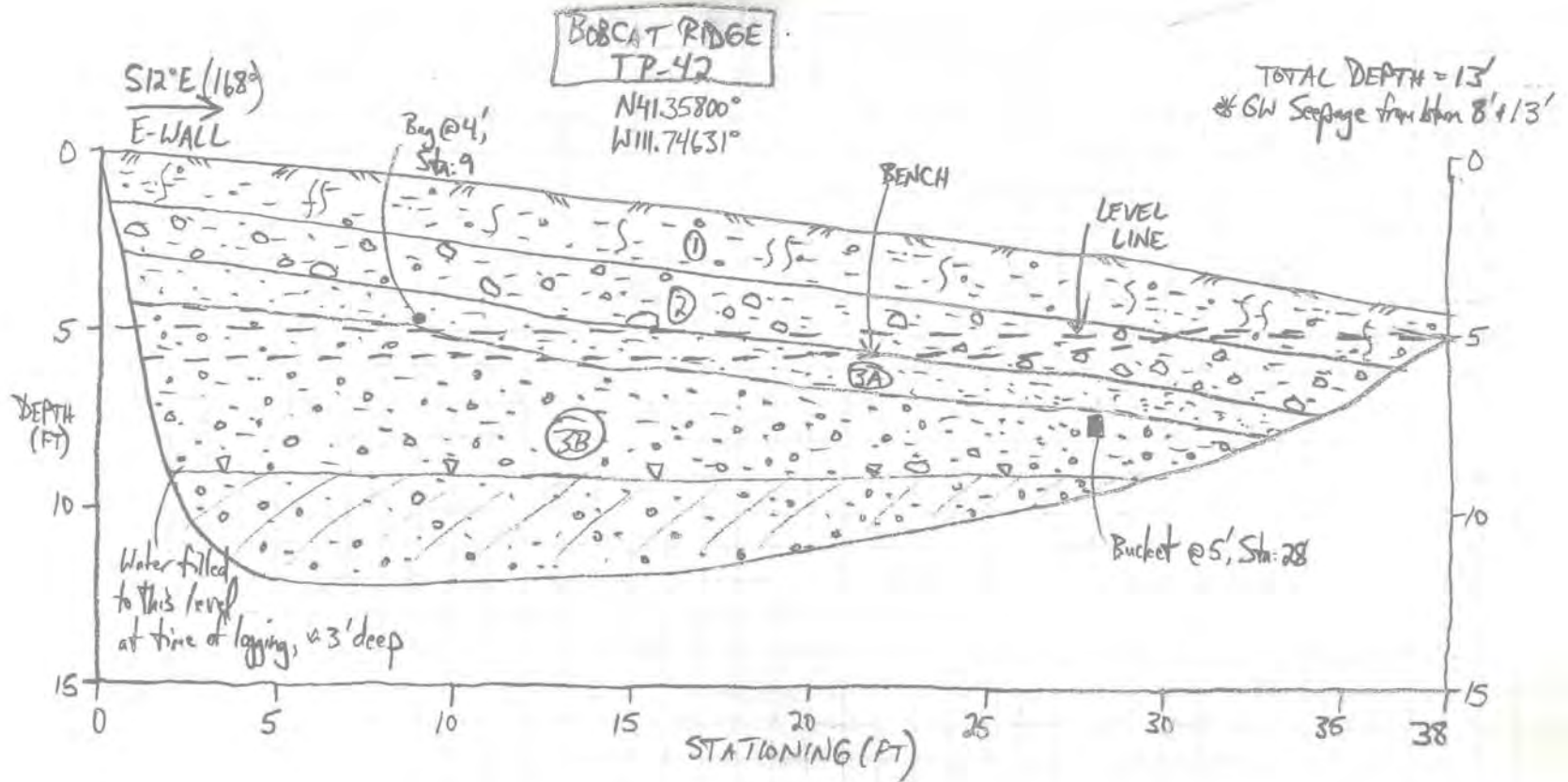
A-42

TP-41 Log

Project No. 01628-028

Date 6-8-18 by PEV on  
Ckd by

1" = 5'  
H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1.5' thick; dark yellowish brown (10YR 4/3) to pale brown (5YR 5/3) silty lean CLAY with gravel (CL), loose to medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular pale yellowish orange (10YR 8/6) to medium gray (N5) quartzite up to ~7" in diameter, though mode clast size is ~1"; increases in moisture with depth; abundant plant roots; gradational, planar basal contact.

**2. Colluvium:** ~1.5' thick; dark yellowish brown (10YR 4/3) sandy lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded quartzite as above up to 18" in diameter, though mode clast size is ~3-4"; abundant plant roots; topsoil matrix; possible B-Horizon; sharp, planar basal contact.

**3. Wasatch Formation:** >10' thick; 2 subunits.

- a. ~1-1.5' thick; moderate reddish brown (10R 4/6) clayey SAND (SC), medium dense, moist, low plasticity fines, massive; gravel and larger sized clasts are rare, likely comprise <3% of the unit; where present, clasts are subrounded quartzite as above up to ~2" in diameter; few small plant roots; gradational, irregular basal contact.
- b. >9' thick; dark reddish brown (10R 3/3) clayey SAND with gravel (SC), medium dense, moist to wet, low plasticity fines, weakly thinly bedded; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above up to 6" in diameter with a mode size of ~1-3"; few small plant roots; homogeneous unit; fine- to medium-grained sand.

\*Groundwater seepage filling pit 3' deep at time of logging.



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Figure

A-43

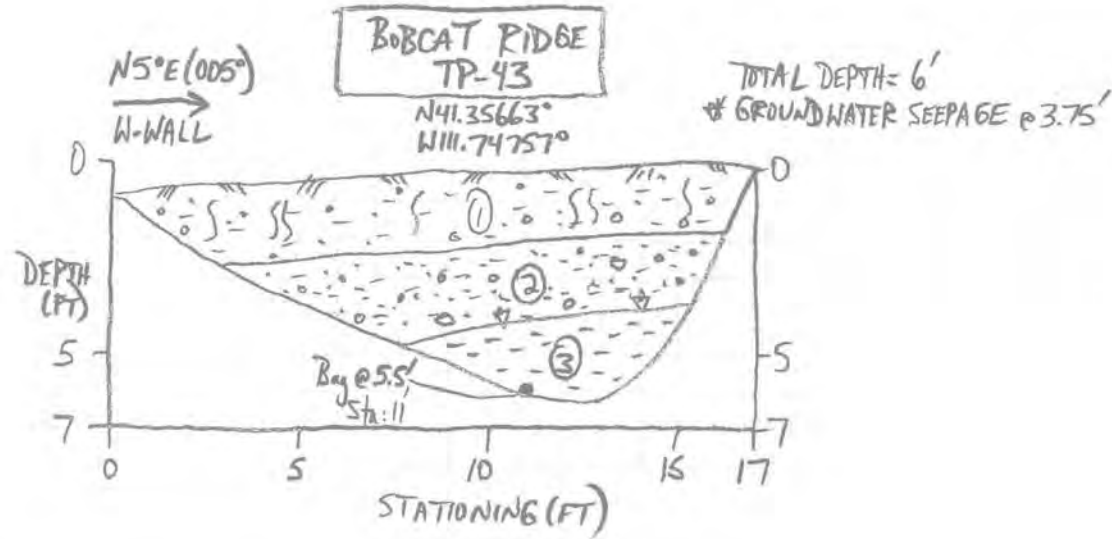
TP-42 Log



Project No. 01628-028

Date 6-7-18 by PED  
Ckd by on

1" = 5'  
H&V



## LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~2' thick; dark yellowish brown (10YR  $\frac{4}{2}$ ) sandy lean CLAY with gravel (CL), loose to medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular medium gray (N5) to dark yellowish orange (10R  $\frac{6}{6}$ ) quartzite up to ~18" in diameter, though mode clast size is ~1-2"; abundant plant roots, sharp, irregular basal contact.

**2. Shallow Landslide:** ~2' thick; mottled light brownish gray (5YR  $\frac{4}{4}$ ) and moderate reddish orange (10R  $\frac{6}{6}$ ) clayey SAND with gravel (SC), medium dense, wet, moderate to high plasticity fines, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular quartzite as above up to ~3" in diameter, though mode clast size is ~1"; few plant roots; soil character is similar to that of the Wasatch Formation but not in color and unit appears similar to shallow landslide deposit observed in TP-51; groundwater seepage from base of unit; sharp, planar basal contact.

**3. Shear Plane:** >2' thick; medium light gray (N6) to pale yellowish orange fat CLAY (CH), stiff, moist to wet, high plasticity, massive; devoid of clasts; appears similar in character to slide plane seen in TP-49 except no slickensides (likely due to wetness) and no underlying dark red clay; also appears similar in character to weathered Norwood Formation fat clays.



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Figure

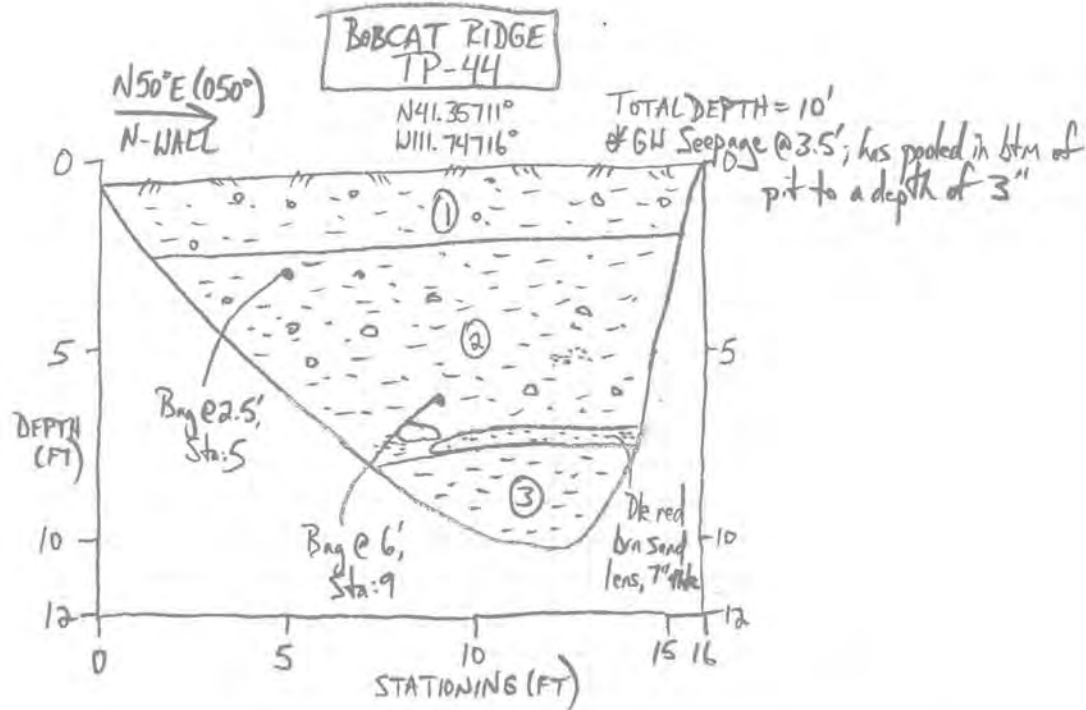
A-44

TP-43 Log

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Date 6-7-18 by PFD  
Ckd by

1" = 5'  
H&V



## LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~2' thick; dark yellowish brown (10YR 5/2) sandy lean CLAY with gravel (CL), loose to medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular medium gray (N5) to dark yellowish orange (10R 6/2) quartzite up to ~18" in diameter, though mode clast size is ~1-2"; abundant plant roots, sharp, irregular basal contact.

**2. Shallow Landslide:** ~5' thick; mottled light brownish gray (5YR 6/2) and moderate reddish orange (10R 6/2) sandy fat CLAY with gravel (CH), medium stiff, wet, moderate to high plasticity, massive; gravel and larger sized clasts comprise ~20% of the unit; clasts are subrounded to subangular quartzite as above up to 18" in diameter, though mode clast size is ~2-3"; few plant roots; has sandy lenses and pockets, some with MnO<sub>2</sub>; possibly weathered Wasatch Formation.

**3. Shear Plane:** >3' thick; mottled light brownish gray (5YR 6/2) and dark yellowish orange (10YR 6/2) fat CLAY (CH), stiff, moist to wet, high plasticity, massive; devoid of clasts; appears similar to unit as seen in TP-43, except no slickensides, but very greasy feel when wet.



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TP-44 Log

Figure

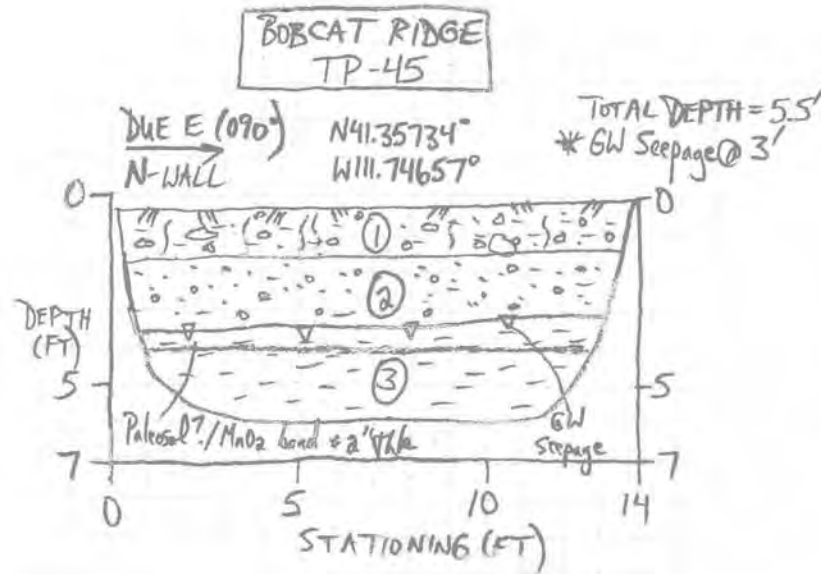
A-45

Project No. 01628-028

Date 6-8-18 by PED

Ckd by on

1" = 5'  
H&V



\* GW Seepage @ 3' across all of test pit, at sand/clay contact. Seepage has filled test pit base to a depth of 7' at time of logging.

\* Common sloughing of side walls

### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1.5' thick; dark yellowish brown (10YR 4/3) to grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), loose to medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular pale yellowish orange (10R 8/3) to medium gray (N5) quartzite up to ~2' in diameter, mode clast size is ~2"; may represent colluvial unit with topsoil matrix; abundant plant and tree roots; gradational, largely planar basal contact.

**2. Shallow Landslide:** ~1.5' thick; moderate yellowish brown (10YR 5/3) sandy fat CLAY with gravel (CH), medium stiff, moist to wet, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are subrounded quartzite as above up to 4" in diameter, though mode clast size is ~1-2"; occasional plant roots; possible B-horizon or colluvial unit; sharp, largely planar basal contact.

**3. Shear Plane:** >2.5' thick; mottled dark yellowish orange (10YR 6/3), light gray (N7) and light brownish gray (5YR 4/3) fat CLAY (CH), stiff, wet, high plasticity, massive; devoid of clasts; very similar to what was seen in TP-41.



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Figure

A-46

TP-45 Log

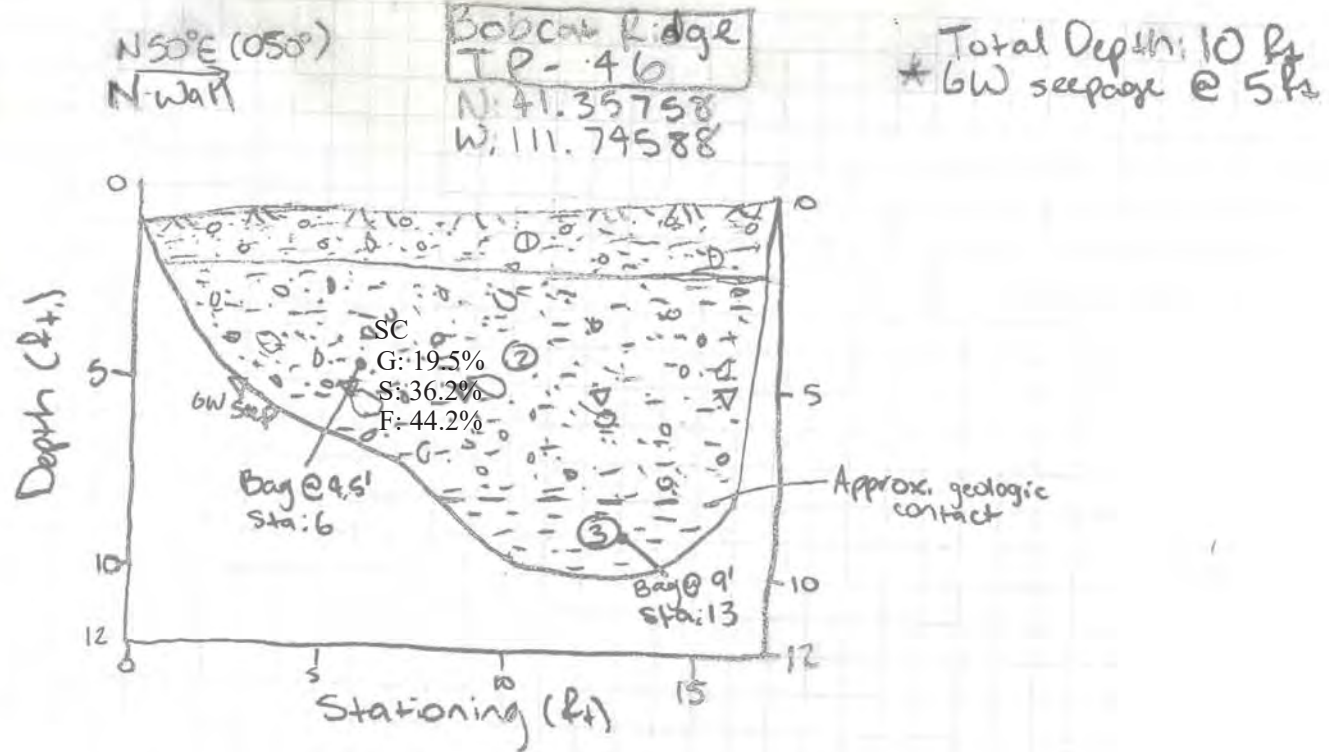
Project No. 01628-028

Bobcat Ridge

Date 6-8-18 by KLA

Ckd by on

1" = 5'  
H&V



## LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1.5-2' thick; pale brown (5YR  $\frac{5}{6}$ ) clayey SAND with gravel (SC), medium dense, moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium gray (N5) quartzite up to ~3" in diameter, mode clast size is ~1-2"; abundant plant roots; sharp, irregular basal contact.

**2. Shallow Landslide:** ~6' thick; light gray (N7) to pale yellowish orange (10YR  $\frac{5}{6}$ ) to moderate reddish orange (10R  $\frac{5}{6}$ ) clayey SAND with gravel (SC) gradational to sandy fat CLAY with gravel (CH), dense, moist to wet, moderate plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular medium gray (N5) to grayish pink (5R  $\frac{5}{6}$ ) quartzite up to ~6" in diameter, though mode clast size is ~1-3"; few plant roots; unknown character of basal contact.

**3. Wasatch Formation:** >2' thick; dark reddish brown (10R  $\frac{3}{4}$ ) sandy fat CLAY (CH), very stiff, moist, moderate plasticity, massive; devoid of clasts; common muscovite mica flakes; no slickensides observed; similar in character to basal unit of TP-52, with fine-grained brecciated appearance.



Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Figure

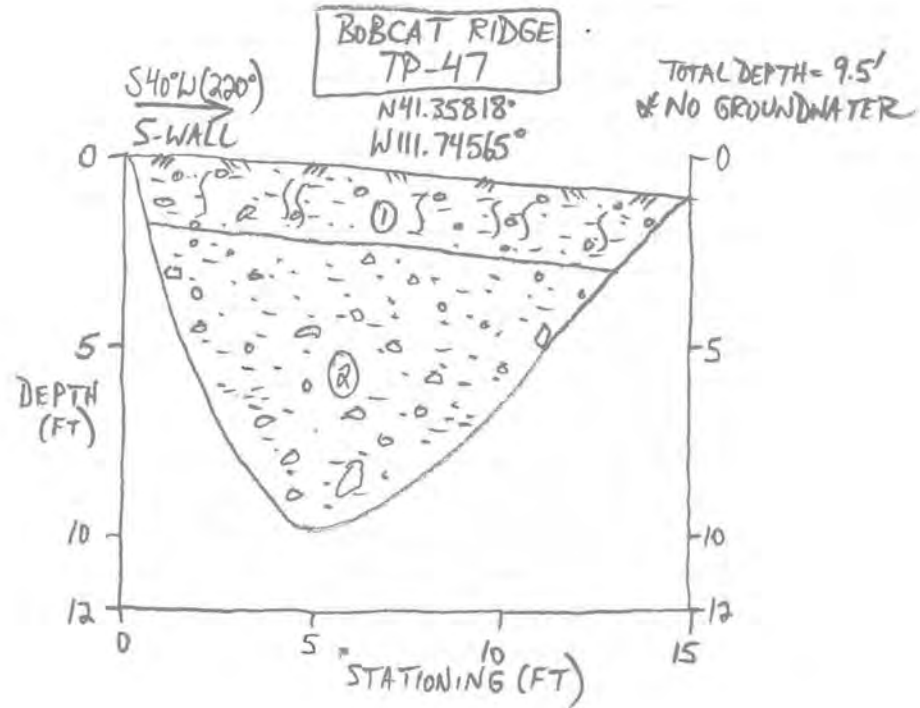
A-47

TP-46 Log

Project No. 01628-028

Date 6-8-18 by PED  
Ckd by on

1" = 5'  
H&V



## LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~2' thick; dark yellowish brown (10YR  $\frac{4}{3}$ ) sandy lean CLAY with gravel (CL), medium stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~25-30% of the unit; clasts are subrounded to subangular pale yellowish orange (10R  $\frac{8}{6}$ ) to medium gray (N5) quartzite up to ~8" in diameter, mode clast size is ~2-4"; abundant plant and tree roots; sharp, planar basal contact.

**2. Wasatch Formation:** >8' thick; dark reddish brown (10R  $\frac{3}{3}$ ) clayey SAND with gravel (SC), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above up to ~2' in diameter, though mode clast size is ~3-4"; occasional small plant roots; occasional pockets of dark red fat clay, though no slickensides observed; unit is fairly homogeneous and poorly sorted; sand is fine- to medium-grained.



Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

TP-47 Log

Figure

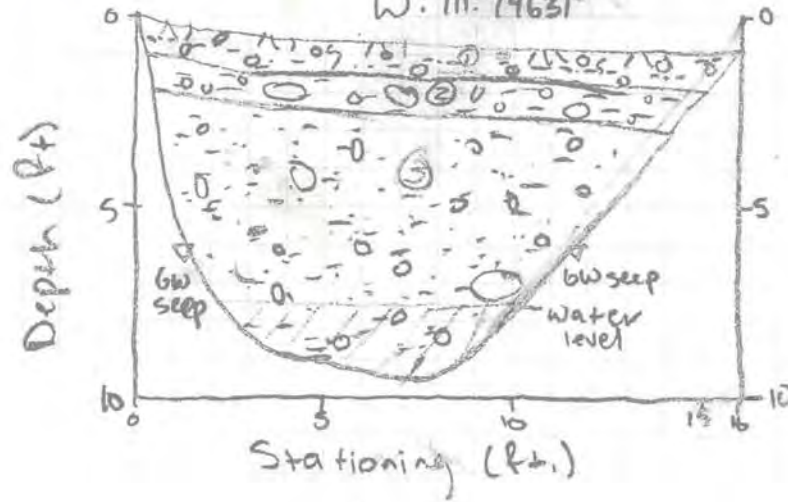
A-48

Project No. 01628-028  
 Bobcat Ridge  
 Date 6/12/18 by VLA  
 Ckd by \_\_\_\_\_ on \_\_\_\_\_

S 65° E (125°)  
 NE wall

Bobcat Ridge  
 TP-48  
 N: 41.35858°  
 W: 111.74631°

Total Depth: 10.5'  
 \*GW Seepage @ 6.5'



1" = 5'  
 H&V

### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; pale brown (5YR 5/2) gravelly SILT (ML), loose, dry, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium gray (N5) quartzite up to ~4" in diameter, though mode clast size ~0.5-1"; abundant plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~1' thick; moderate yellowish brown (10YR 5/4) sandy lean CLAY with gravel (CL), medium stiff to loose, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above up to 6" in diameter, though mode clast size is ~2-4"; common plant roots; sharp, planar basal contact.

**3. Wasatch Formation:** >7' thick; moderate reddish brown (10R 4/6) mottled with yellowish gray (5Y 7/2) clayey SAND with gravel (SC), dense, moist to wet, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular moderate reddish orange (10R 6/6) to light gray (N7) quartzite up to 2' in diameter, though mode clast size is ~2-3"; no slickensides observed; minor muscovite mica grains; largely homogeneous.

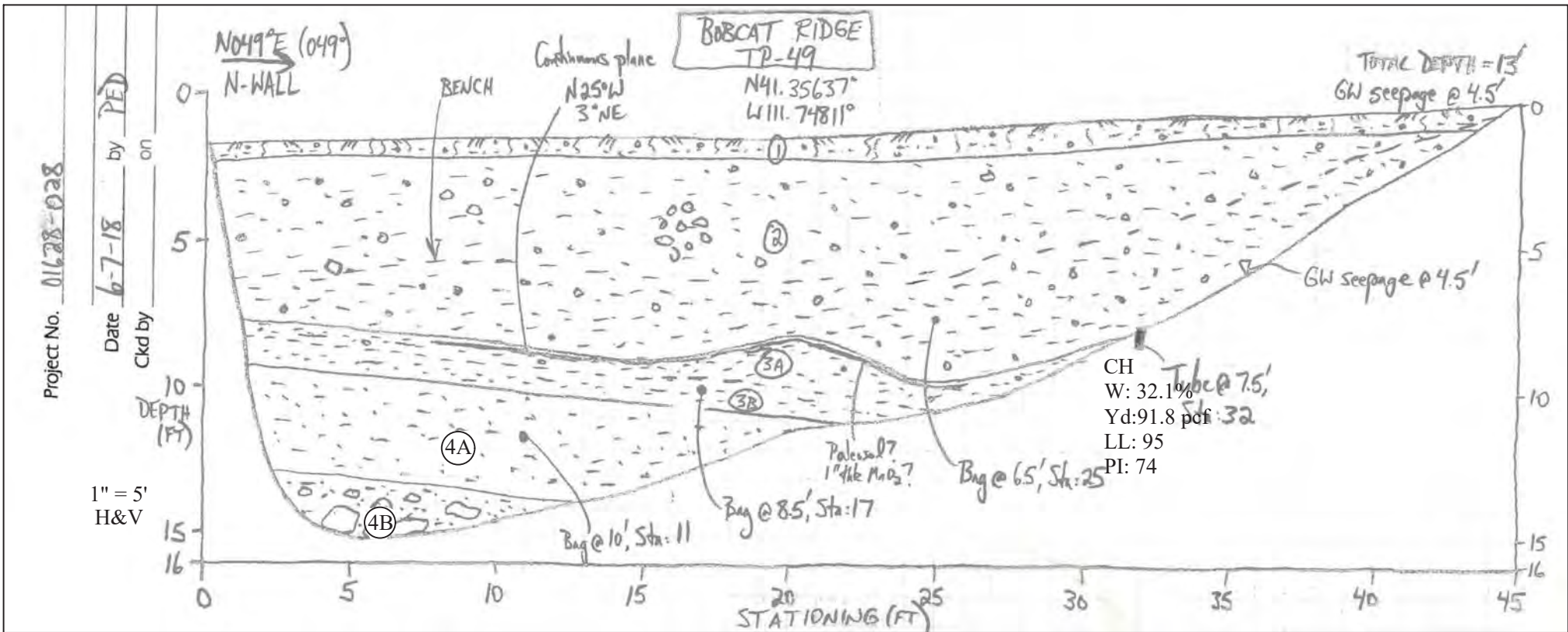


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Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

TP-48 Log

**Figure**  
**A-49**



### LITHOLOGIC UNIT DESCRIPTIONS

1. **A/B Soil Horizon:** ~6-12" thick; light brown (5YR 4) sandy SILT with gravel (ML), medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~15-20% of the unit; clasts are subrounded to subangular medium light gray (N6) to dark gray (N3) quartzite up to ~9" in diameter, though mode clast size ~0.5"; common plant roots; gradational, irregular basal contact.
2. **Shallow Landslide:** ~7" thick; mottled moderate reddish brown (10R 4) and moderate reddish orange (10R 6) sandy lean CLAY with gravel (CL), medium stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~20-30% of the unit; clasts are subrounded to subangular quartzite as above up to 11" in diameter, though mode clast size is ~2"; highly heterogenous unit with organic and MnO<sub>2</sub> smears; occasional small plant roots; becomes more clay-rich with depth; sharp, curvilinear basal contact.
3. **Shear Plane:** ~2' thick; 2 subunits.
  - a. ~6-8" thick; pale yellowish orange (10YR 8/6) fat CLAY with gravel (CH), medium stiff, moist, high plasticity, massive; gravel and larger sized clasts comprise ~5% of the unit; clasts are subrounded to subangular quartzite as above up to 3" in diameter; heavily slickensided with continuous plane observed ~2" below the top of the subunit; sharp, planar basal contact.

3. **Shear Plane (continued)**
  - b. ~14-16" thick; dark reddish brown (10R 3/4) fat CLAY (CH), stiff, moist, moderate to high plasticity, massive; common slickensides, but short and discontinuous; slickensides decrease with depth; gradational, planar basal contact.
4. **Wasatch Formation:** >6' thick; 2 subunits.
  - a. ~4' thick; dark reddish brown (10R 3/4) sandy lean CLAY (CL), very stiff, moist, moderate plasticity, massive; largely devoid of clasts; common light-colored quartzite sand grains give the unit a fine-grained brecciated appearance; glossy sheen in places, but no slickensides observed; appears like a weathered in-place, clay-rich lens of the Wasatch Formation; sharp, irregular basal contact.
  - b. >2' thick; dark reddish brown (10R 3/4) clayey SAND with gravel (SC), medium dense, moist, moderate to high plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular quartzite as above and minor dark yellowish orange (10YR 6/6) fine-grained sandstone; clasts are up to 18" in diameter, though mode size of ~1-2" in a wide range of clast sizes; heterogeneous, possibly alluvial subunit.



Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

Figure  
 A-50

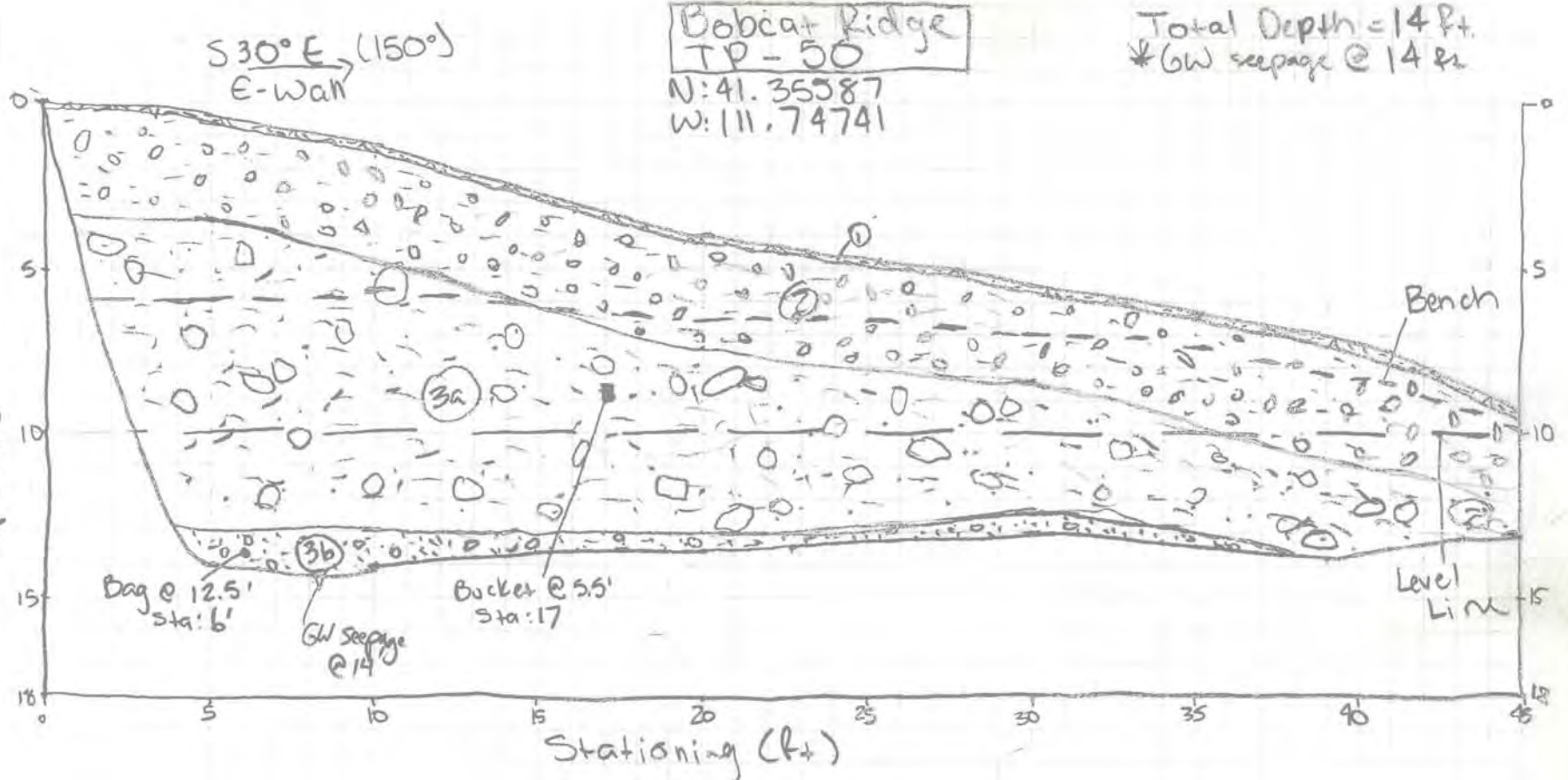
Project No. 01628-028

Date 6-7-18 by KLA on

Depth (ft.) Skd by

1" = 5'  
H&V

INC.



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~2" thick; light brown (5YR 5) gravelly SILT (ML), medium stiff to loose, dry, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are subrounded to subangular moderate reddish orange (10R 5) to medium gray (N5) quartzite up to ~18" in diameter at the surface, though mode clast size ~3-5"; abundant plant roots; gradational, irregular basal contact.

**2. Colluvium:** ~2-3' thick; dark yellowish brown (10YR 4) lean CLAY with gravel (CL) gradational to clayey GRAVEL (GC), medium stiff, moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~40-60% of the unit; clasts are subrounded to subangular quartzite as above up to 1' in diameter, though mode clast size is ~3-5"; common plant roots; gradational, irregular basal contact.

**3. Wasatch Formation:** >10' thick; 2 subunits.

a. ~4-5' thick; pale reddish brown (10R 5) to moderate reddish orange (10R 5) to dark yellowish brown (10YR 4) clayey SAND with gravel (SC) gradational to sandy lean CLAY (CL), dense to very dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~30-40% of the subunit; clasts are subrounded to subangular quartzite as above with minor pale yellowish orange (10YR 5) to moderate reddish orange (10R 5) sandstone; clasts are up to 2' in diameter, though mode clast size is ~6".

b. >1' thick; pale reddish brown (10R 5) to moderate reddish orange (10R 5) well-graded SAND with gravel (SW), dense, moist, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~20-30% of the subunit; clasts are quartzite and sandstone as above up to 6" in diameter, though mode clast size ~1-3"; sand is very fine to fine-grained.



Project No: 01628-028

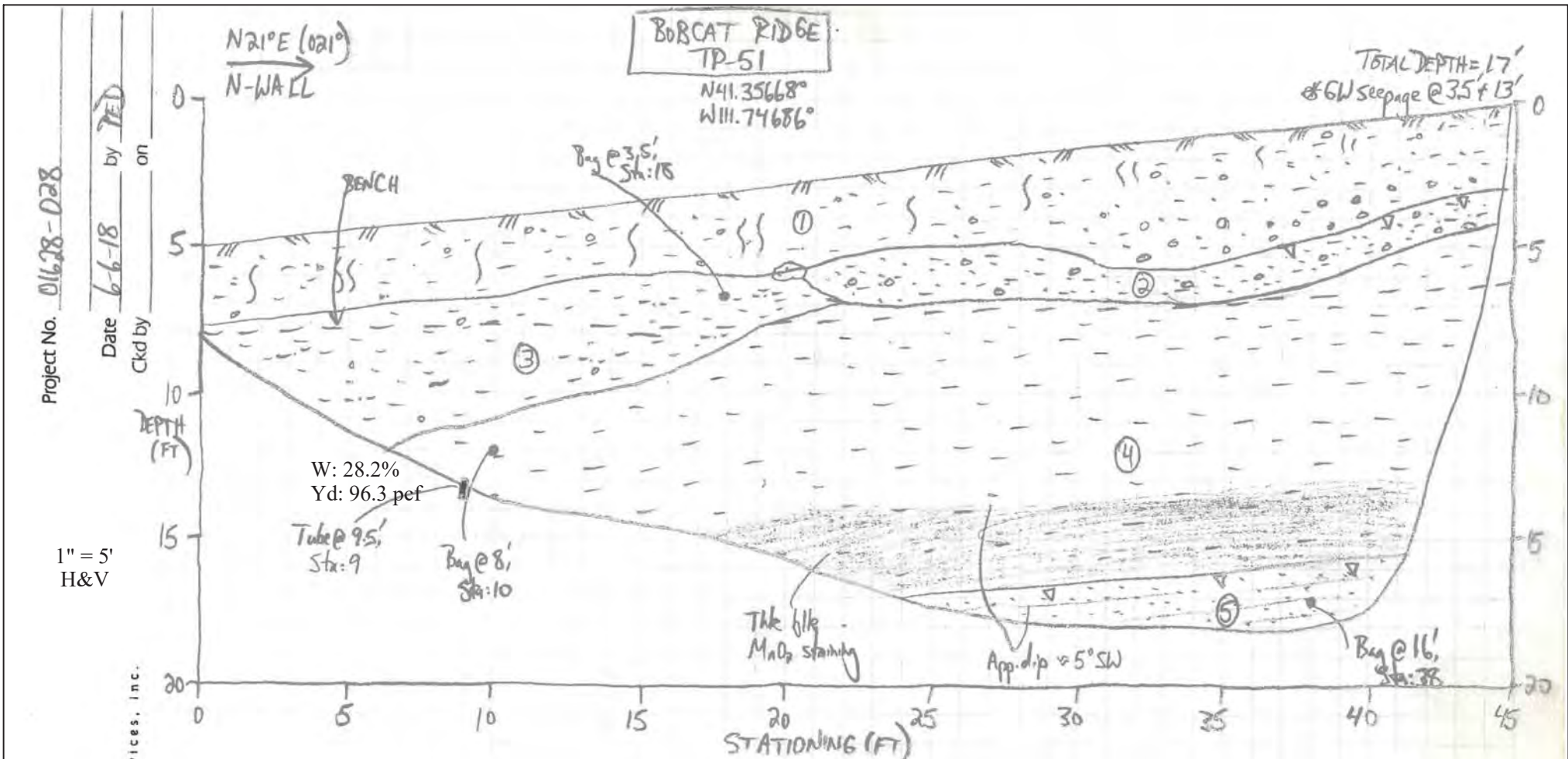
Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Figure

A-51

TP-50 Log





### LITHOLOGIC UNIT DESCRIPTIONS

- 1. **A/B Soil Horizon:** ~2-3.5' thick; grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~5-10% of the unit; clasts are subrounded to subangular medium light gray (N6) to pale yellowish orange (10YR 8/6) quartzite up to ~13" in diameter, though mode clast size ~1"; abundant plant and tree roots; sharp, highly irregular basal contact.
- 2. **Shallow Landslide 1:** ~2' thick; medium light gray (N6) to light brownish gray (5YR 4/4) clayey SAND with gravel (SC), medium dense to loose, wet and seeping groundwater, moderate plasticity fines, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular quartzite as above up to 6" in diameter, though mode clast size is ~1-2"; occasional small plant roots; thin organic-rich layer formed on basal contact.
- 3. **Shallow Landslide 2:** ~5' thick; dark yellowish orange (10YR 6/6) silty fat CLAY with gravel (CH), stiff, moist, high plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular quartzite as above up to 4" in diameter, though mode clast size of ~2"; occasional small discontinuous slickensides and poorly-defined slide plane along basal contact; highly heterogenous unit; gradational, irregular basal contact.

- 4. **Shear Plane:** ~9' thick; moderate red (5R 4/4) to moderate reddish brown (10R 6/6) to black (N1) fat CLAY with gravel (CH), very stiff, moist, moderate to high plasticity, possibly thickly bedded; gravel and larger sized clasts comprise ~3% of unit; clasts are quartzite as above up to 3" in diameter; not as fat as unit 3 but similar except for fewer slickensides; abundant black MnO2 smear in matrix and along fractures throughout unit; basal ~3' of unit is covered black in MnO2 staining; sharp, planar basal contact.

- 5. **Wasatch Formation:** >3' thick; moderate red (5R 5/4) clayey SAND (SC), medium dense, wet and seeping groundwater, low to moderate plasticity fines, finely bedded; sand is fine- to medium-grained; occasional MnO2 along bedding planes; devoid of clasts.

\* Test pit walls constantly sloughing in during the course of logging, causing significant wall failures.



Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

Figure

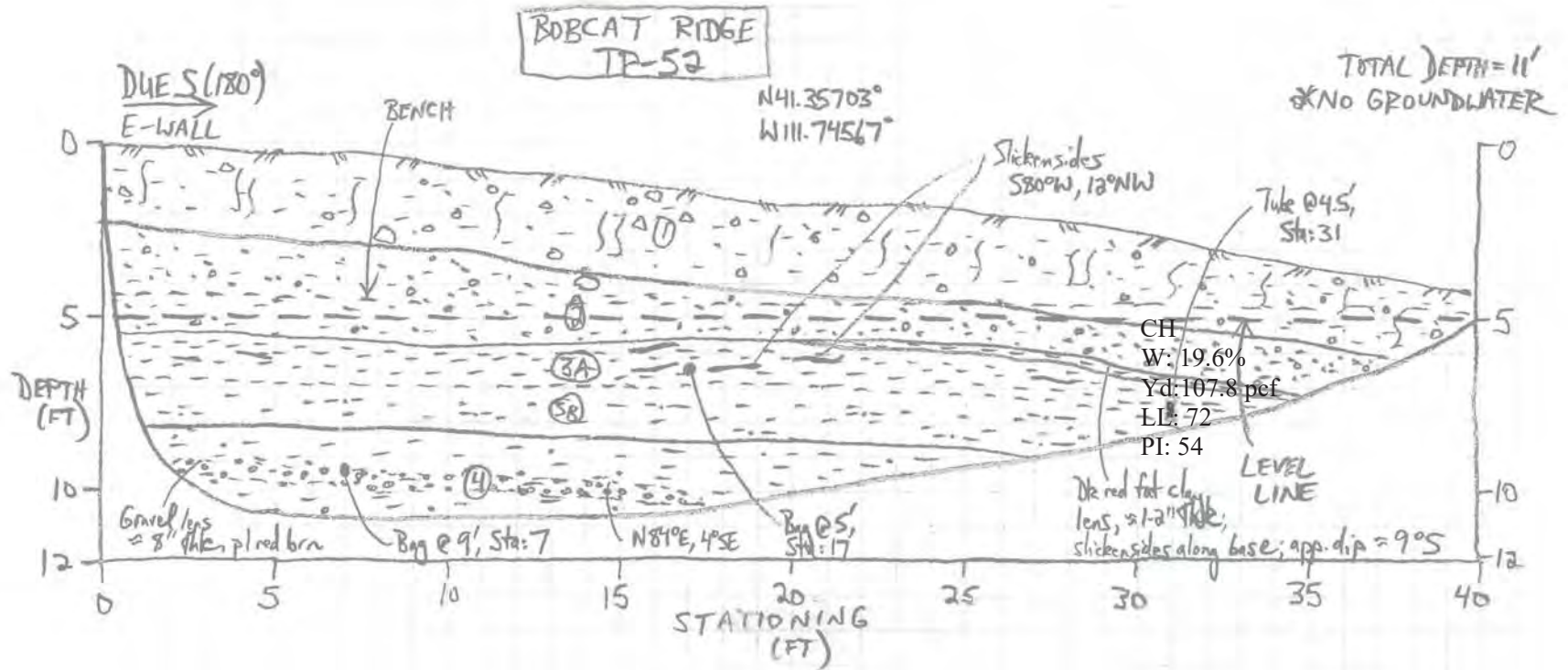
A-52

TP-51 Log

Project No. 01628-028

Date 6-6-18 by FED on  
Ckd by

1" = 5'  
H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~2.5' thick; grayish brown (5Y 3/2) sandy lean CLAY with gravel (CL), medium stiff, moist to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are subrounded to subangular medium gray (N5) to dark yellowish orange (10YR 8/6) quartzite up to 7" in diameter, though mode clast size ~2-3"; abundant plant and tree roots; sharp, irregular basal contact.

**2. Shallow Landslide:** ~2-3' thick; moderate reddish brown (10R 4/6) to dark reddish brown (10R 3/4) sandy lean CLAY with gravel (CL) gradational to clayey SAND with gravel (SC), stiff, moist, moderate plasticity, massive; gravel and larger sized clasts comprise ~10% of the unit; clasts are subrounded to subangular quartzite as above up to 6" in diameter, though mode clast size is ~1-2"; occasional small plant roots; sharp, irregular basal contact exhibited by a thin dark red fat clay in the southern end of test pit.

\* Excavator noted hard digging at bottom of test pit.

**3. Shear Plane:** >2.5' thick; 2 subunits.

- a. ~1-1.5' thick; grayish red (10R 4/2) to medium light gray (N6) fat CLAY (CH), stiff, moist, high plasticity, massive; devoid of clasts; common slickensides, though discontinuous; slickensides appear to be developed along old bedding planes, and these appear to dip mainly upslope to the north; few 1 mm pinholes; common blocky texture in places; gradational, irregular basal contact.
- b. ~1-1.5' thick; mottled moderate reddish brown (10R 4/6) and medium light gray (N6) silty fat CLAY (CH), very stiff, slightly moist, moderate plasticity, massive; devoid of clasts; blocky texture; occasional 1 mm pinholes; no slickensides observed; sharp, irregular basal contact.

**4. Wasatch Formation:** >3' thick; dark reddish brown (10R 3/4) to pale reddish brown (10R 5/4) fat CLAY (CH), very stiff, moist, moderate to high plasticity, thickly bedded; gravel and larger sized clasts comprise ~30-40% within gravel lenses, otherwise ~5% of the unit; clasts are subangular to subrounded dark yellowish orange (10YR 8/6) to pale yellowish orange (10YR 8/6) to black (N1) quartzite, sandstone and dolomite; clasts are all <0.5" in diameter; unit gives a finely brecciated appearance; no slickensides observed.



Project No: 01628-028

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Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

Figure

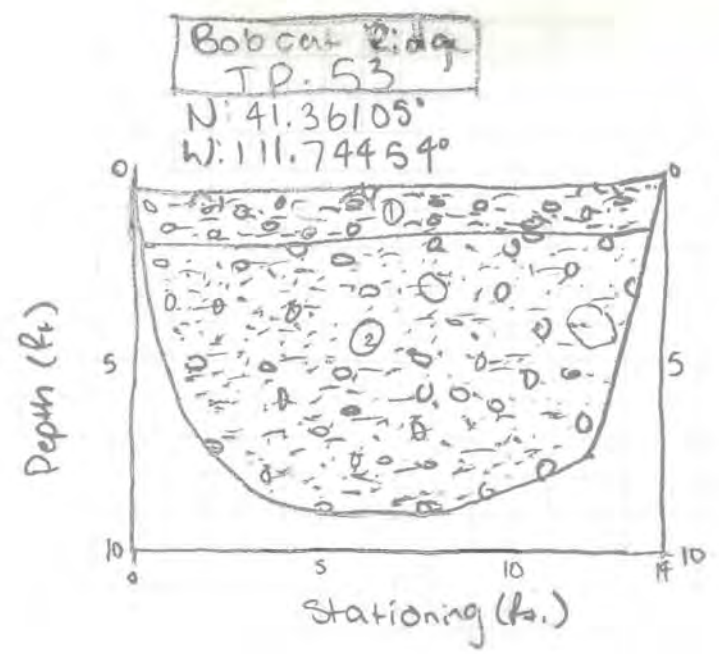
A-53

TP-52 Log

Project No. 01628-028  
 Bobcat Ridge  
 Date 6/19/18 by VLA  
 Ckd by \_\_\_\_\_ on \_\_\_\_\_

S 26° E (154°)  
 NE-Wall

1" = 5'  
 H&V



### LITHOLOGIC UNIT DESCRIPTIONS

**1. Undocumented Fill:** ~1.5' thick; light brown (5YR 6/3) silty lean CLAY with gravel (CL), medium stiff to stiff, dry to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to angular moderate reddish orange (10R 6/3) to medium gray (N5) to dark gray (N3) quartzite, sandstone, and dolomite; clasts are up to 2' in diameter at the surface and have a mode size of ~1"; abundant tree roots and wood fragments; sharp, planar basal contact.

**2. Wasatch Formation:** >7.5' thick; moderate reddish orange (10R 6/3) to dark yellowish brown (10YR 4/3) clayey SAND with gravel (SC) gradational to sandy lean CLAY with gravel (CL), medium dense to dense, moist to wet, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular moderate reddish orange (10R 6/3) to very pale orange (10YR 8/3) to grayish purple (5P 4/3) quartzite with minor moderate reddish orange (10R 6/3) sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~1-3"; occasional tree and plant roots; traces of lean clay.



Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

TP-53 Log

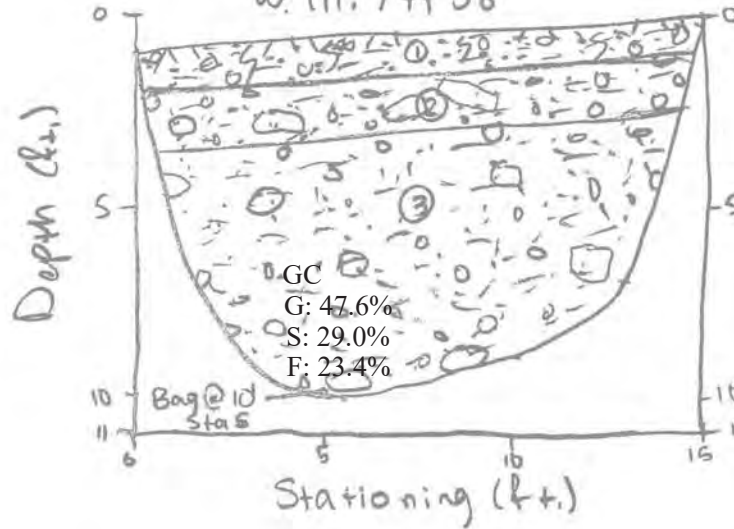
**Figure**  
  
**A-54**

Project No. 01628-028  
 Bobcat Ridge  
 Date 6/19/18 by KLA  
 Ckd by \_\_\_\_\_ on \_\_\_\_\_

S22°E (158°)  
 E-wall

Bobcat Ridge  
 TP-53B  
 N: 41.36161°  
 W: 111.74458°

Total Depth: 10'  
 \* NO GW



1" = 5'  
 H&V

### LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; light brown (5YR 4/4) sandy lean CLAY with gravel (CL), loose to medium stiff, dry, low plasticity, massive; gravel and larger sized clasts comprise ~10-20% of the unit; clasts are subrounded to subangular light brown (5YR 4/4) to medium gray (N5) quartzite up to ~4" in diameter, though mode clast size ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~1.5' thick; light brown (5YR 4/4) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist to moist, low plasticity, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above up to 2" in diameter, though mode clast size is ~1-2"; topsoil matrix; abundant plant roots; sharp, planar basal contact.

**3. Wasatch Formation:** >7' thick; moderate reddish orange (10R 6/6) to dark yellowish brown (10YR 4/4) clayey SAND with gravel (SC), dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular moderate reddish orange (10R 6/6) to very pale orange (10YR 8/8) to grayish purple (5P 4/4) quartzite with minor moderate reddish orange (10R 6/6) sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~1-3"; occasional tree and plant roots; traces of lean clay.



Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

TP-53B Log

Figure

A-55

Project No. 01628-028

Bobcat Ridge

Date 6/19/18 by CLA

Ckd by \_\_\_\_\_ on \_\_\_\_\_

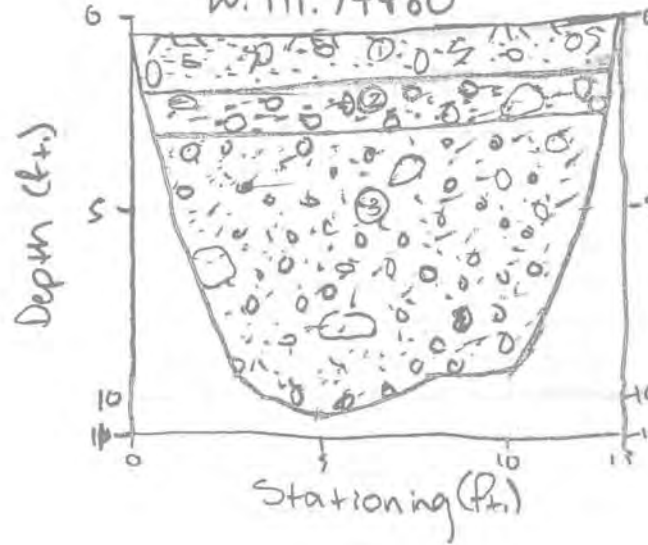
1" = 5'  
H&V

S35°E (145°)  
NE-wah

Bobcat Ridge  
TP-54

N: 41.36044°  
W: 111.74480°

Total Depth: 10.5'  
\*NO GW encountered



## LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1.5' thick; light brown (5YR 6/4) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular light brown (5YR 6/4) to medium gray (N5) quartzite up to 4" in diameter, though mode clast size ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~1' thick; light brown (5YR 6/4) sandy lean CLAY with gravel (CL), loose to medium stiff, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above up to 2" in diameter, though mode clast size is ~1-2"; topsoil matrix; abundant plant roots; sharp, planar basal contact.

**3. Wasatch Formation:** >7' thick; moderate reddish orange (10R 6/8) dark yellowish brown (10YR 4/8) gravelly SAND (SW), medium dense to dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular moderate reddish orange (10R 6/8) to very pale orange (10YR 8/8) to grayish purple (5P 4/8) quartzite with minor moderate reddish orange (10R 6/8) sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~1-3"; occasional tree and plant roots; traces of lean clay.



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Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

TP-54 Log

Figure

A-56

Project No. 01628-028

Bobcat Ridge

Date 6/19/18 by KLA

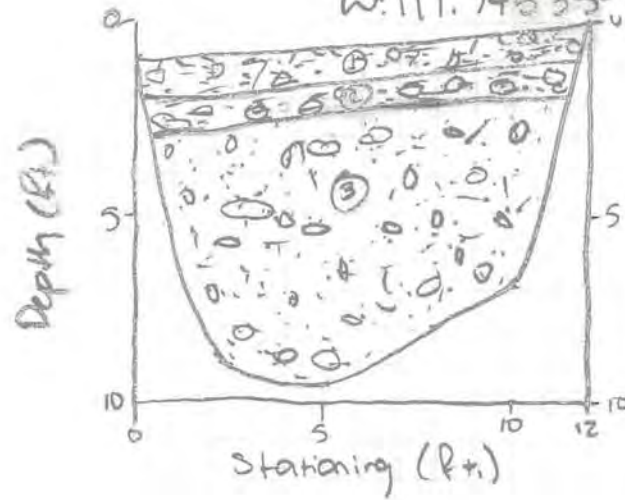
Ckd by \_\_\_\_\_ on \_\_\_\_\_

S29°E (151°)  
E wall

Bobcat Ridge  
TP-55

N: 41.35989°  
W: 111.74635°

Total Depth: 9.5'  
\* No GW seepage



1" = 5'  
H&V

## LITHOLOGIC UNIT DESCRIPTIONS

**1. A/B Soil Horizon:** ~1' thick; light brown (5YR 4/4) sandy lean CLAY with gravel (CL), loose to medium stiff, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~20-25% of the unit; clasts are subrounded to subangular light brown (5YR 4/4) to medium gray (N5) quartzite up to 4" in diameter, though mode clast size ~0.5-1"; abundant plant and tree roots; gradational, irregular basal contact.

**2. Colluvium:** ~1' thick; light brown (5YR 4/4) sandy lean CLAY with gravel (CL), loose to medium stiff, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30% of the unit; clasts are subrounded to subangular quartzite as above up to 2" in diameter, though mode clast size is ~1-2"; topsoil matrix; abundant plant roots; sharp, planar basal contact.

**3. Wasatch Formation:** >7' thick; moderate reddish orange (10R 6/6) to dark yellowish brown (10YR 4/4) gravelly SAND (SW), medium dense to dense, moist, low plasticity fines, massive; gravel and larger sized clasts comprise ~30-35% of the unit; clasts are subrounded to subangular moderate reddish orange (10R 6/6) to very pale orange (10YR 8/6) to grayish purple (5P 4/4) quartzite with minor moderate reddish orange (10R 6/6) sandstone; clasts are up to 1.5' in diameter, though mode clast size is ~1-3"; occasional tree and plant roots; traces of lean clay.



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Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

**Figure**

**A-57**

**TP-55 Log**

UNIFIED SOIL CLASSIFICATION SYSTEM

| MAJOR DIVISIONS  |   | USCS SYMBOL   | TYPICAL DESCRIPTIONS  |   |
|--|---|---|---|---|
| COARSE GRAINED SOILS<br><br>(More than half of material is larger than the #200 sieve)             | GRAVELS<br><br>(More than half of coarse fraction is larger than the #4 sieve)        | CLEAN GRAVELS WITH LITTLE OR NO FINES   | GW<br>WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES   |   |
|  |   | GRAVELS WITH OVER 12% FINES   | GP<br>POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES |   |
|  |   | SANDS<br><br>(More than half of coarse fraction is smaller than the #4 sieve) | CLEAN SANDS WITH LITTLE OR NO FINES                                       | GM<br>SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES  |
|  |   |   | SANDS WITH OVER 12% FINES   | GC<br>CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES |
|  | FINE GRAINED SOILS<br><br>(More than half of material is smaller than the #200 sieve) | SILTS AND CLAYS<br><br>(Liquid limit less than 50)                            | WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES           | SW  |
|  |   |   | POORLY-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES         | SP  |
|  |   |   | SILTY SANDS, SAND-GRAVEL-SILT MIXTURES                                    | SM  |
|  |   | SILTS AND CLAYS<br><br>(Liquid limit greater than 50)                         | CLAYEY SANDS SAND-GRAVEL-CLAY MIXTURES                                    | SC  |
| INORGANIC SILTS & VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, CLAYEY SILTS WITH SLIGHT PLASTICITY |   |   | ML  |   |
| INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS  |   |   | CL  |   |
| HIGHLY ORGANIC SOILS   | ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY                                 | OL  |   |   |
|  | INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT                          | MH  |   |   |
|  | INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS   | CH  |   |   |
|  | ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY                            | OH  |   |   |
|  | PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS                                   | PT  |   |   |

LOG KEY SYMBOLS

|  |                                      |  |   |
|--|--------------------------------------|--|---|
|  | BORING SAMPLE LOCATION               |  | TEST-PIT SAMPLE LOCATION                    |
|  | WATER LEVEL (level after completion) |  | WATER LEVEL (level where first encountered) |

CEMENTATION

| DESCRIPTION | DESCRIPTION  |
|-------------|--|
| WEAKLY      | CRUMBLES OR BREAKS WITH HANDLING OR SLIGHT FINGER PRESSURE |
| MODERATELY  | CRUMBLES OR BREAKS WITH CONSIDERABLE FINGER PRESSURE       |
| STRONGLY    | WILL NOT CRUMBLE OR BREAK WITH FINGER PRESSURE             |

OTHER TESTS KEY

| TEST | DESCRIPTION                   | TEST | DESCRIPTION       |
|------|-------------------------------|------|-------------------|
| C    | CONSOLIDATION                 | SA   | SIEVE ANALYSIS    |
| AL   | ATTERBERG LIMITS              | DS   | DIRECT SHEAR      |
| UC   | UNCONFINED COMPRESSION        | T    | TRIAXIAL          |
| S    | SOLUBILITY                    | R    | RESISTIVITY       |
| O    | ORGANIC CONTENT               | RV   | R-VALUE           |
| CBR  | CALIFORNIA BEARING RATIO      | SU   | SOLUBLE SULFATES  |
| COMP | MOISTURE/DENSITY RELATIONS-IP | PM   | PERMEABILITY      |
| CI   | CALIFORNIA IMPACT             | -200 | % FINER THAN #200 |
| COL  | COLLAPSE POTENTIAL            | Gs   | SPECIFIC GRAVITY  |
| SS   | SHRINK SWELL                  | SL   | SWELL LOAD        |

MODIFIERS

| DESCRIPTION | %      |
|-------------|--------|
| TRACE       | <5     |
| SOME        | 5 - 12 |
| WITH        | >12    |

GENERAL NOTES

- Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual.
- No warranty is provided as to the continuity of soil conditions between individual sample locations.
- Logs represent general soil conditions observed at the point of exploration on the date indicated.
- In general, Unified Soil Classification designations presented on the logs were evaluated by visual methods only. Therefore, actual designations (based on laboratory tests) may vary.

MOISTURE CONTENT

| DESCRIPTION | FIELD TEST   |
|-------------|--|
| DRY         | ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH       |
| MOIST       | DAMP BUT NO VISIBLE WATER                          |
| WET         | VISIBLE FREE WATER, USUALLY SOIL BELOW WATER TABLE |

STRATIFICATION

| DESCRIPTION | THICKNESS   | DESCRIPTION | THICKNESS                           |
|-------------|-------------|-------------|-------------------------------------|
| SEAM        | 1/16 - 1/2" | OCCASIONAL  | ONE OR LESS PER FOOT OF THICKNESS   |
| LAYER       | 1/2 - 12"   | FREQUENT    | MORE THAN ONE PER FOOT OF THICKNESS |

APPARENT / RELATIVE DENSITY - COARSE-GRAINED SOIL

| APPARENT DENSITY | SPT (blows/ft) | MODIFIED CA. SAMPLER (blows/ft) | CALIFORNIA SAMPLER (blows/ft) | RELATIVE DENSITY (%) | FIELD TEST  |
|------------------|----------------|---------------------------------|-------------------------------|----------------------|---|
| VERY LOOSE       | <4             | <4                              | <5                            | 0 - 15               | EASILY PENETRATED WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND                      |
| LOOSE            | 4 - 10         | 5 - 12                          | 5 - 15                        | 15 - 35              | DIFFICULT TO PENETRATE WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND                 |
| MEDIUM DENSE     | 10 - 30        | 12 - 35                         | 15 - 40                       | 35 - 65              | EASILY PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER      |
| DENSE            | 30 - 50        | 35 - 60                         | 40 - 70                       | 65 - 85              | DIFFICULT TO PENETRATE A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER |
| VERY DENSE       | >50            | >60                             | >70                           | 85 - 100             | PENETRATED ONLY A FEW INCHES WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER  |

CONSISTENCY - FINE-GRAINED SOIL

| CONSISTENCY  | SPT (blows/ft) | TORVANE                        |   | FIELD TEST   |
|--------------|----------------|--------------------------------|---|--|
|              |                | UNTRAINED SHEAR STRENGTH (tsf) | POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH (tsf) |  |
| VERY SOFT    | <2             | <0.125                         | <0.25   | EASILY PENETRATED SEVERAL INCHES BY THUMB. EXUDES BETWEEN THUMB AND FINGERS WHEN SQUEEZED BY HAND. |
| SOFT         | 2 - 4          | 0.125 - 0.25                   | 0.25 - 0.5  | EASILY PENETRATED ONE INCH BY THUMB. MOLDED BY LIGHT FINGER PRESSURE.                              |
| MEDIUM STIFF | 4 - 8          | 0.25 - 0.5                     | 0.5 - 1.0   | PENETRATED OVER 1/2 INCH BY THUMB WITH MODERATE EFFORT. MOLDED BY STRONG FINGER PRESSURE.          |
| STIFF        | 8 - 15         | 0.5 - 1.0                      | 1.0 - 2.0   | INDENTED ABOUT 1/2 INCH BY THUMB BUT PENETRATED ONLY WITH GREAT EFFORT.                            |
| VERY STIFF   | 15 - 30        | 1.0 - 2.0                      | 2.0 - 4.0   | READILY INDENTED BY THUMB/NAIL.  |
| HARD         | >30            | >2.0                           | >4.0  | INDENTED WITH DIFFICULTY BY THUMB/NAIL.  |

KEY TO SOIL SYMBOLS AND TERMINOLOGY

Project No. 01628-028  
 Engr. DAG  
 Drafted By DAG  
 Date July 2018



Figure A-58

### Weathering

| Rock Classification Should Include: |   |
|-------------------------------------|---|
| 1.                                  | Rock name (or classification)   |
| 2.                                  | Color   |
| 3.                                  | Weathering  |
| 4.                                  | Fracturing  |
| 5.                                  | Competency  |
| 6.                                  | Additional comments indicating rock characteristics which might affect engineering properties |

| Weathering           | Field Test   |
|----------------------|--|
| Fresh                | No visible sign of decomposition or discoloration. Rings under hammer impact.  |
| Slightly Weathered   | Slight discoloration inwards from open fractures, otherwise similar to Fresh.  |
| Moderately Weathered | Discoloration throughout. Weaker minerals such as feldspar are decomposed. Strength somewhat less than fresh rock but cores cannot be broken by hand or scraped with a knife. Texture preserved. |
| Highly Weathered     | Most minerals somewhat decomposed. Specimens can be broken by hand with effort or shaved with a knife. Core stones present in rock mass. Texture becoming indistinct but fabric preserved.       |
| Completely Weathered | Minerals decomposed to soil but fabric and structure preserved. Specimens easily crumble or penetrated.  |

### Fracturing

| Spacing  | Description  |
|----------|--------------|
| >6 ft    | Very Widely  |
| 2-6 ft   | Widely       |
| 8-24 in  | Moderately   |
| 2 ½-8 in | Closely      |
| ¾-2 ½ in | Very Closely |

### Bedding of Sedimentary Rocks

| Splitting Property | Thickness  | Stratification    |
|--------------------|------------|-------------------|
| Massive            | >4.0 ft    | Very thick bedded |
| Blocky             | 2.0-4.0 ft | Thick-bedded      |
| Slabby             | 2 ½-24 in  | Thin-bedded       |
| Flaggy             | ½-2 ½ in   | Very thin-bedded  |
| Shaly or platy     | ¼ - ½ in   | Laminated         |
| Papery             | < ¼ in     | Thinly laminated  |

### RQD

| RQD (%) | Rock Quality |
|---------|--------------|
| 90-100  | Excellent    |
| 75-90   | Good         |
| 50-75   | Fair         |
| 25-50   | Poor         |
| 0-25    | Very Poor    |

### Competency

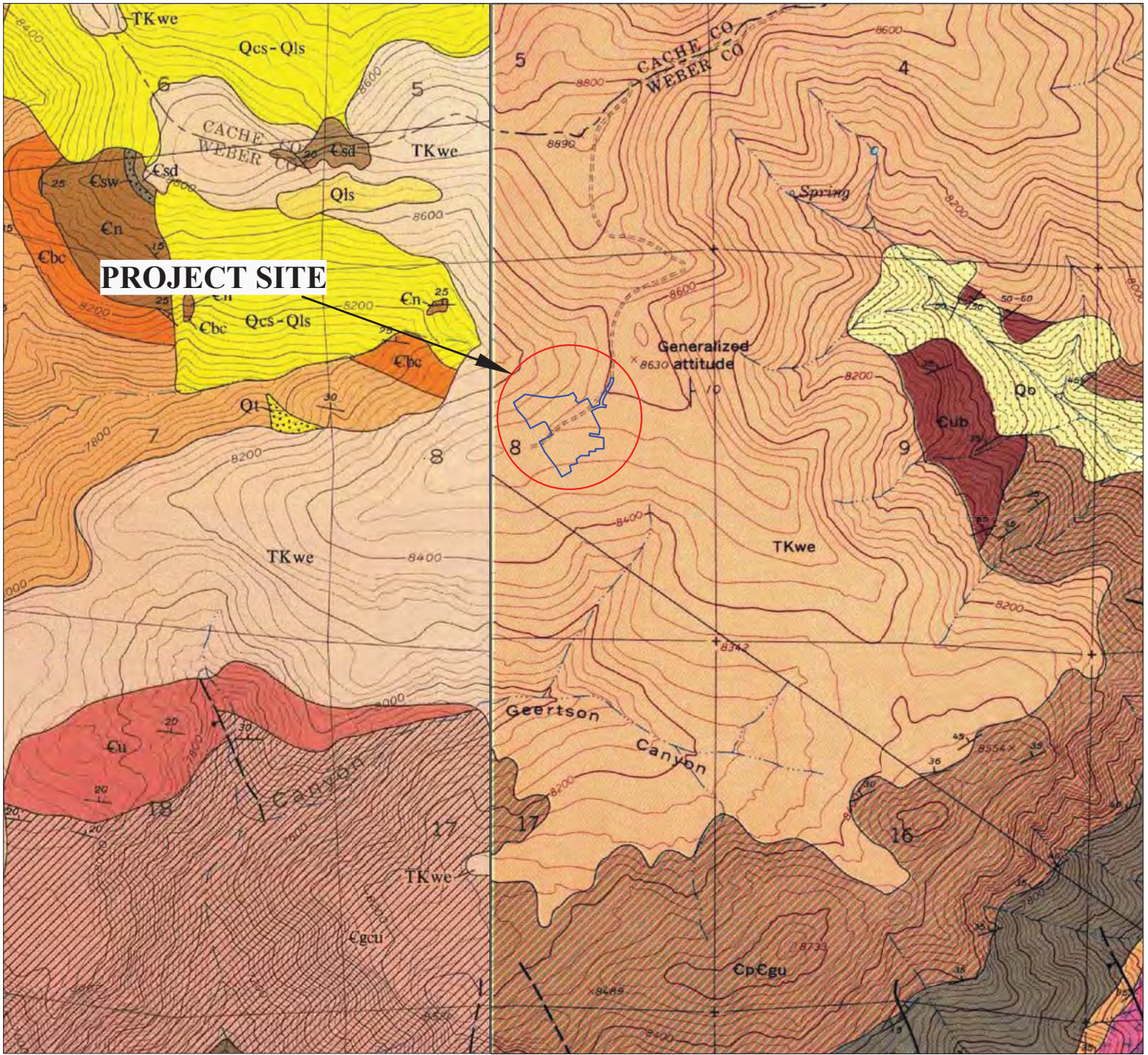
| Class | Strength          | Field Test   | Approximate Range of Unconfined Compressive Strength (tsf) |
|-------|-------------------|--|--|
| I     | Extremely Strong  | Many blows with geologic hammer required to break intact specimen.   | >2000  |
| II    | Very Strong       | Hand-held specimen breaks with pick end of hammer under more than one blow.  | 2000-1000  |
| III   | Strong            | Cannot be scraped or peeled with knife, hand-held specimen can be broken with single moderate blow with pick end of hammer                         | 1000-500   |
| IV    | Moderately Strong | Can just be scraped or peeled with knife. Indentations 1-3 mm show in specimen with moderate blow with pick end of hammer.                         | 500-250  |
| V     | Weak              | Material crumbles under moderate blow with pick end of hammer and can be peeled with a knife, but is hard to hand-trim for triaxial test specimen. | 250-10   |
| VI    | Friable           | Material crumbles in hand.   | N/A  |

## KEY TO PHYSICAL ROCK PROPERTIES

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 Date July 2018



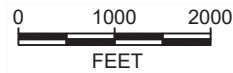




**Base Maps:**

-USGS *Huntsville Quadrangle*, 1:24,000 scale, map GQ-1503, Sorensen and Crittenden (1979)

-USGS *Brown's Hole Quadrangle*, 1:24,000 scale, map GQ-968, Crittenden (1979)



1" = 2000'



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Geotechnical and Geologic Hazards Assessment  
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**Regional Geology Map 1**

**Figure  
 A-60a**

# LEGEND

- Qcs** COLLUVIUM AND SLOPEWASH (Holocene) – Bouldery, colluvium and slopewash chiefly along eastern margin of Ogden Valley; in part, lag from Tertiary units; thickness 0-30 m
- Qls** LANDSLIDE DEPOSITS (Holocene) – thickness 0-6 m
- Qt** TALUS DEPOSITS (Holocene) – thickness 0-6 m
- TKwe** WASATCH AND EVANSTON(?) FORMATIONS, UNDIVIDED (Eocene, Paleocene, and Upper Cretaceous?) – Unconsolidated pale-reddish-brown pebble, cobble, and boulder conglomerate; forms boulder-covered slopes. Clasts are mainly Precambrian quartzite and are tan, gray, or purple; matrix is mainly poorly consolidated sand and silt; thickness 0-150 m
- En** NOUNAN DOLOMITE (Upper and Middle Cambrian) – Thin- to thick-bedded, finely crystalline, medium-gray, light- to medium-gray-weathering, cliff-forming dolomite; white twiggy structures common throughout unit; thickness 150-230 m
- Ebc** CALLS FORT SHALE MEMBER OF BLOOMINGTON FORMATION (Middle Cambrian) – Olive-drab to light-brown shale and light- to dark-blue-gray limestone with intercalated orange to rusty-brown silty limestone; intraformational conglomerate common throughout unit; thickness 23-90 m
- Elu** CAMBRIAN LIMESTONES, UNDIVIDED (Middle Cambrian) – Includes limestone and Hodges Shale Members of Bloomington Formation, and Blacksmith and Ute Limestones



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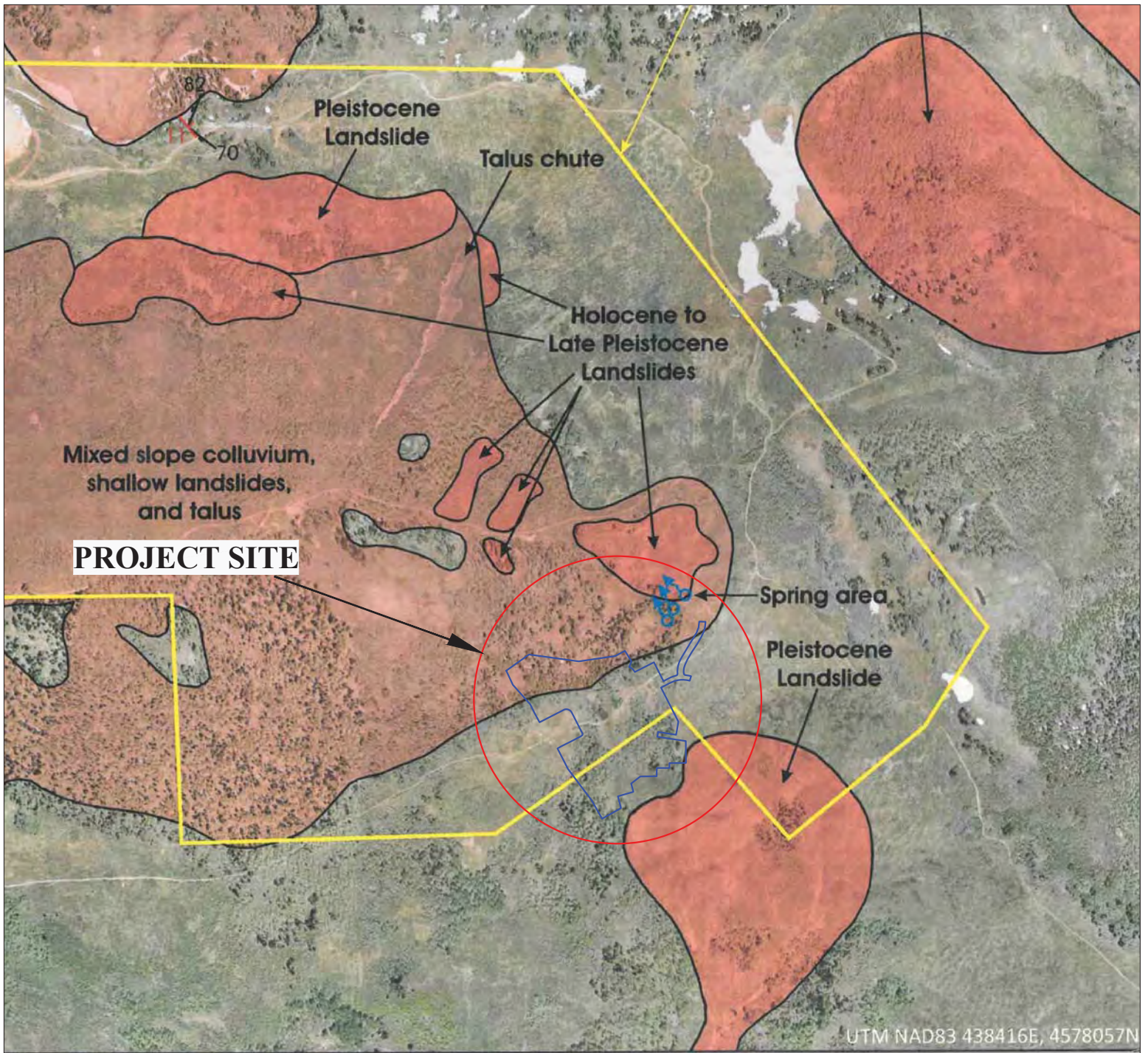
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Regional Geology Map 1

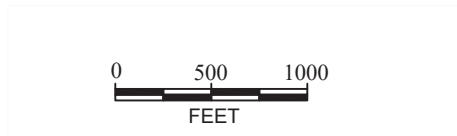
**Figure**

**A-60b**



**Base Map:**

-Western Geologic (2012)  
Geologic Hazards Reconnaissance Report,  
Figure 3



1" = 1000'



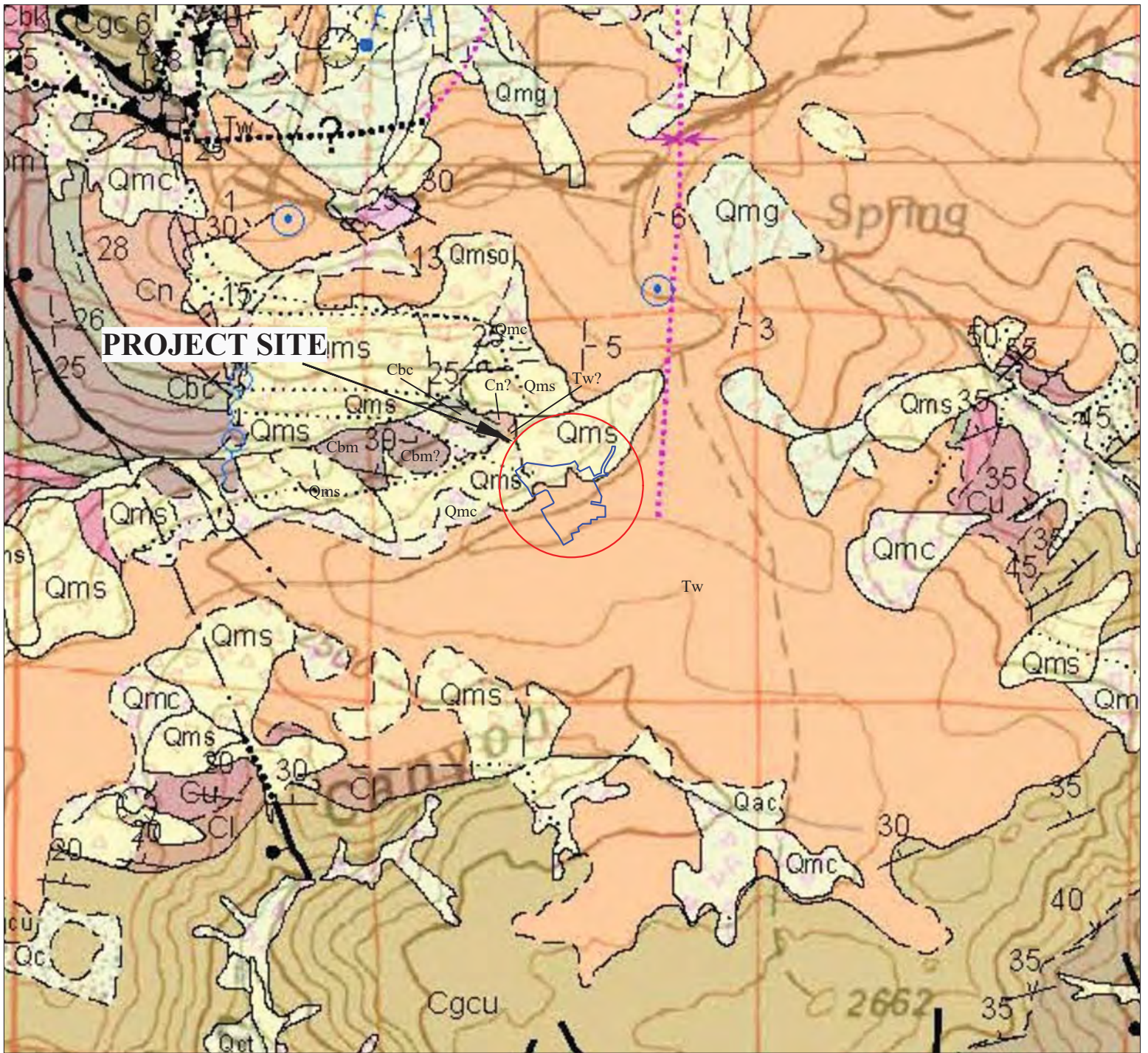
Project No: 01628-028

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**Regional Geology Map 2**

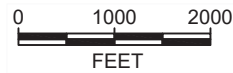
**Figure**

**A-61**

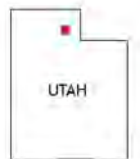


**Base Map:**

-UGS Ogden 30'x60' Geologic Quadrangle,  
 1:62,500 scale, map OFR-635DM, Coogan and  
 King (2016).



1" = 2000'



QUADRANGLE LOCATION



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Regional Geology Map 3

Figure

A-62a

# LEGEND

Qms, Qms?, Qmsy, Qmsy?, Qmso, Qmso?

**Landslide deposits (Holocene and upper and middle? Pleistocene)** – Poorly sorted clay- to boulder-sized material; includes slides, slumps, and locally flows and floods; generally characterized by hummocky topography, main and internal scarps, and chaotic bedding in displaced blocks; composition depends on local sources; morphology becomes more subdued with time and amount of water in material during emplacement; Qms may be in contact with Qms when landslides are different/distinct; thickness highly variable, up to about 20 to 30 feet (6-9 m) for small slides, and 80 to 100 feet (25-30 m) thick for larger landslides. Qmsy and Qmso queried where relative age uncertain; Qms queried where classification uncertain. Numerous landslides are too small to show at map scale and more detailed maps shown in the index to geologic mapping should be examined.

Qms without a suffix is mapped where the age is uncertain (though likely Holocene and/or late Pleistocene), where portions of slide complexes have different ages but cannot be shown separately at map scale, or where boundaries between slides of different ages are not distinct. Estimated time of emplacement is indicated by relative-age letter suffixes with: Qmsy mapped where landslides deflect streams or failures are in Lake Bonneville deposits, and scarps are variably vegetated; Qmso typically mapped where deposits are “perched” above present drainages, rumpled morphology typical of mass movements has been diminished, and/or younger surficial deposits cover or cut Qmso. Lower perched Qmso deposits are at Qao heights above drainages (95 ka and older) and the higher perched deposits may correlate with high level alluvium (QTa\_) (likely older than 780 ka) (see table 1). Suffixes y and o indicate probable Holocene and Pleistocene ages, respectively, with all Qmso likely emplaced before Lake Bonneville transgression. These older deposits are as unstable as other slides, and are easily reactivated with the addition of water, be it irrigation or septic tank drain fields.

Qmc **Landslide and colluvial deposits, undivided (Holocene and Pleistocene)** – Poorly sorted to unsorted clay- to boulder-sized material; mapped where landslide deposits are difficult to distinguish from colluvium (slopewash and soil creep) and where mapping separate, small, intermingled areas of landslide and colluvial deposits is not possible at map scale; locally includes talus and debris flow and flood deposits; typically mapped where landslides are thin (“shallow”); also mapped where the blocky or rumpled morphology that is characteristic of landslides has been diminished (“smoothed”) by slopewash and soil creep; composition depends on local sources; 6 to 40 feet (2-12 m) thick. These deposits are as unstable as other landslide units (Qms, Qmsy, Qmso).



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Regional Geology Map 3

Figure

A-62b

# LEGEND

Tw, Tw?

**Wasatch Formation (Eocene and upper Paleocene)** – Typically red to brownish-red sandstone, siltstone, mudstone, and conglomerate with minor gray limestone and marlstone locally (see Tw1); lighter shades of red, yellow, tan, and light gray present locally and more common in uppermost part, complicating mapping of contacts with overlying similarly colored Norwood and Fowkes Formations; clasts typically rounded Neoproterozoic and Paleozoic sedimentary rocks, mainly Neoproterozoic and Cambrian quartzite; basal conglomerate more gray and less likely to be red, and containing more locally derived angular clasts of limestone, dolomite and sandstone, typically from Paleozoic strata, for example in northern Causey Dam quadrangle; sinkholes indicate karstification of limestone beds; thicknesses on Willard thrust sheet likely up to about 400 to 600 feet (120-180 m) in Sharp Mountain, Dairy Ridge, and Horse Ridge quadrangles (Coogan, 2006a-b), about 1300 feet (400 m) in Monte Cristo Peak quadrangle, about 1100 feet (335 m) in northeast Browns Hole quadrangle, about 2200 feet (670 m) in southwest Causey Dam quadrangle, about 2600 feet (800 m) at Herd Mountain in Bybee Knoll quadrangle, and about 1300 feet (400 m) in northwest Lost Creek Dam quadrangle, estimated by elevation differences between pre-Wasatch rocks exposed in drainages and the crests of gently dipping Wasatch Formation on adjacent ridges (King); thickness varies locally due to considerable relief on basal erosional surface, for example along Right Fork South Fork Ogden River, and along leading edge of Willard thrust; much thicker, about 5000 to 6000 feet (1500-1800 m), south of Willard thrust sheet near Morgan. Wasatch Formation is queried (Tw?) where poor exposures may actually be surficial deposits. The Wasatch Formation is prone to slope failures. Other information on the Wasatch Formation is in Tw descriptions under the heading “Sub-Willard Thrust - Ogden Canyon Area” since Tw strata are extensive near Morgan Valley and cover the Willard thrust, Ogden Canyon, and Durst Mountain areas.

Along the South Fork Ogden River, Wasatch strata are mostly pebble, cobble, and boulder conglomerate with a matrix of smaller gravel, sand, and silt in the Browns Hole quadrangle, and coarse-grained sandstone to granule conglomerate as well as siltstone and mudstone to the east in the Causey Dam quadrangle; note thinning to east away from source area. The Wasatch weathers to boulder-covered dip(?) slopes north of the South Fork Ogden River, for example in Evergreen Park. Along the South Fork, the Wasatch Formation is separated from the underlying Hams Fork Member of the Evanston Formation by an angular unconformity of a few degrees, with the Hams Fork containing less siltstone and mudstone than the Wasatch and having a lighter color.

The Herd Mountain surface is developed on the Wasatch Formation at elevations of 7600 to 8600 feet (2300-2620 m) in the Bybee Knoll quadrangle and in remnants in the Huntsville, Browns Hole, and Sharp Mountain quadrangles. The origin of this boulder-strewn surface is debated (see Eardley, 1944; Hafen, 1961; Mullens, 1971). Eardley’s (1944) Herd Mountain surface is flat lying or gently east dipping, about the same as the underlying Wasatch Formation, and is strewn with quartzite boulders to pebbles that King thinks are residual and colluvial deposits of uncertain age that were derived from the Wasatch Formation. The other characteristic of this surface is the presence of pimple mounds and, given the elevations of greater than about 7500 feet (2300 m), possible periglacial patterned ground. Photogrammetric dips on the Wasatch Formation under the surface are nearly flat ( $<3^{\circ}$ ) and an apparent angular unconformity is present in the Wasatch since dips on older Wasatch strata are greater than 3 degrees. King mapped this unconformity as a marker bed, but Coogan does not agree that this is an unconformity.



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Regional Geology Map 3

Figure

A-62c

# LEGEND

Cn, Cn? **Nounan Formation (Upper Cambrian)** – Medium-gray to dark-gray, very thick to thick-bedded, light to medium gray and tan-weathering, typically cliff forming, variably sandy and silty dolomite and lesser limestone, with crude laminae to partings and mottling of sandstone and siltstone that weather tan or reddish; little sandstone and siltstone in more resistant lower part; about 600 to 1150 feet (180-350 m) thick.

The Nounan Formation thickness range in our map area is based on numerous studies. It is about 800 feet (245 m) thick in the Huntsville quadrangle, using Coogan's mapping of about 300 feet (90 m) each of the Blacksmith and Langston Formations; about 900- and 999-foot (275 and 300 m) thicknesses reported at the South Fork Little Bear River in the James Peak quadrangle (Ezell, 1953; Gardiner, 1974; respectively) and 1145 feet (350 m) thick at Sharp Mountain (Hafen, 1961). To the east the Nounan thins southward from 1025 feet (312.5 m) thick in the Curtis Ridge quadrangle (Hansen, 1964) to 800 feet (245 m) thick in Sugar Pine Canyon (Creek) in the Dairy Ridge quadrangle (Gardiner, 1974; Coogan, 2006a) to 675 feet (205 m) thick in the Horse Ridge quadrangle (Coogan, 2006b). The Nounan is about 630 feet (190 m) thick in the Causey Dam quadrangle (Mullens, 1969), possibly the "average" of the 571 feet (174 m) and 696 feet (210 m) measured by Rigo (1968, aided by Mullens) and Gardiner (1974), respectively, on Baldy Ridge in the quadrangle, with Gardiner's (1974) thickness more closely matching Mullens' (1969) mapped thickness. So the Nounan thins to the south and east over the Tooele arch (see Hintze, 1959).

Williams (1948) reported that the Nounan was Late Cambrian in age, using unpublished fossil collections (in part from Maxey, 1941). In the Wellsville Mountains north of our map, Oviatt (1986) reported the upper Nounan was Dresbachian (Late Cambrian) in age based on *Dunderbergia*(?) and *Crepicephalus* zone trilobite fauna.

Cbc, Cbc?

**Calls Fort Shale Member (Middle Cambrian)** – Brown-weathering, slope-forming, olive-gray to tan-gray, thin bedded, shale and micaceous argillite with minor, thin-bedded, dark-gray, silty limestone; *Bolaspidella* sp. trilobite fossils reported by Rigo (1968, USGS No. 5965-CO) in the Causey Dam quadrangle; 75 to 125 feet (23-40 m) thick on the leading edge of the Willard thrust sheet (Coogan, 2006a-b; see Rigo, 1968, aided by Mullens), 100 to 120 feet (30-35 m) thick in Causey Dam quadrangle (King this report), and about 400 feet (120 m) thick in Huntsville quadrangle (King this report).

Cbm, Cbm?

**Middle limestone member (Middle Cambrian)** – Dark to medium-gray, thick- to thin-bedded, argillaceous limestone with tan-, yellow-, and red-weathering, wavy, silty layers and partings; contains subordinate olive-gray and tan-gray, thin-bedded, shale and micaceous argillite; typically forms "rib" or cliff between less resistant shale members; on leading edge of Willard thrust sheet, thickens southward from 425 feet (130 m) along Sugar Pine Creek, Dairy Ridge quadrangle, to 850 feet (260 m) along Sawmill Canyon, Horse Ridge quadrangle (Coogan, 2006a-b), and 548 feet (167 m) thick at Baldy Ridge section (Rigo, 1968, aided by Mullens) in Causey Dam or Horse Ridge quadrangle, but may be faulted, since about 400 feet (120 m) thick on flanks of Baldy and Knighton Ridges (King this report); 680 feet (200 m) thick in Huntsville quadrangle (Coogan, this report).



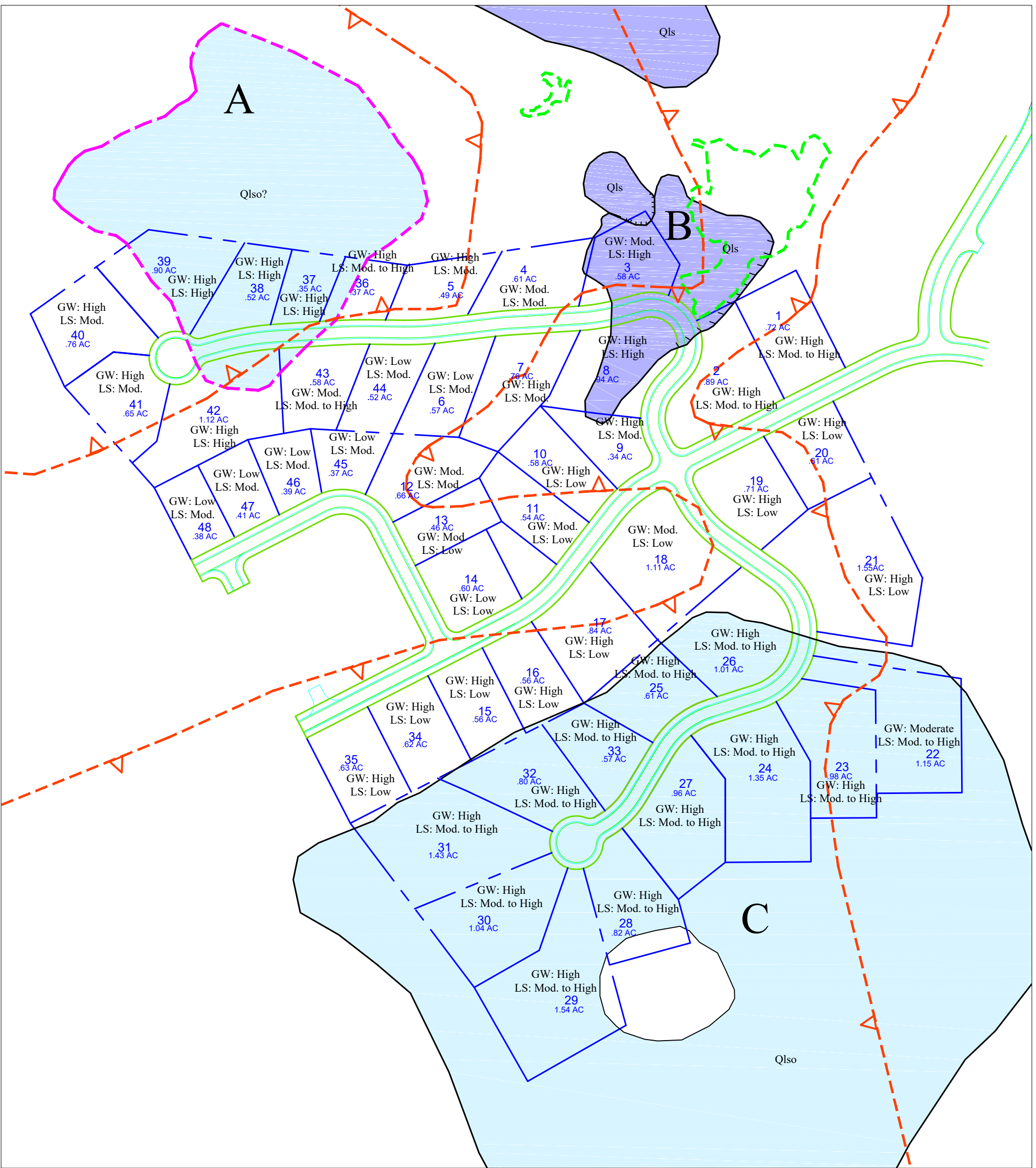
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Regional Geology Map 3

Figure

A-62d



**Basemap:**

-Bobcat Ridge Preliminary Plat, provided by Talisman Civil Consultants, dated 8-13-2018

\*All Geologic Contacts Approximate

**LEGEND**

- Qls Landslide Deposit (Holocene-aged)
- Qlso Older landslide deposit (Pleistocene-aged)

Delineated Wetland Area

Project Boundary

Deeper clay seam area; possible older landslide

Landslide Scarp

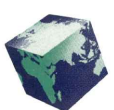
Area of Shallow Groundwater (<10' below existing grade) Triangle points in direction of groundwater

GW: Shallow Groundwater Hazard  
LS: Landslide Hazard

A= Landslide A

B= Landslide B

C= Landslide C



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**Geologic Hazard Classification Map**

**Figure**

**A-63**



# **APPENDIX B**

# Water Content and Unit Weight of Soil

(In General Accordance with ASTM D7263 Method B and D2216)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: Powder Mountain, Weber Co., UT

Date: 7/6/2018

By: BRR/JP

| Sample Info.                                     | Boring No.                       | TP-2        | TP-5       | TP-6        | TP-8        | TP-12       | TP-24       | TP-34      | TP-37       |
|--|----------------------------------|-------------|------------|-------------|-------------|-------------|-------------|------------|-------------|
|  | Station                          | 7           | 30         | 5           | 6           | 10          | 6.5         | 13         | 4           |
|  | Depth                            | 12.0'       | 8.0'       | 3.5'        | 12.0'       | 10.0'       | 3.0'        | 10.0'      | 9.0'        |
|  | Split                            | No          | Yes        | No          | No          | No          | No          | Yes        | No          |
|  | Split sieve                      |             | 3/8"       |             |             |             |             | 3/8"       |             |
| Total sample (g)                                 |                                  |             | 4007.14    |             |             |             |             | 4125.79    |             |
| Moist coarse fraction (g)                        |                                  |             | 1633.40    |             |             |             |             | 1070.99    |             |
| Moist split fraction (g)                         |                                  |             | 2373.74    |             |             |             |             | 3054.80    |             |
|  | Sample height, H (in)            |             |            |             |             |             |             |            |             |
|  | Sample diameter, D (in)          |             |            |             |             |             |             |            |             |
|  | Mass rings + wet soil (g)        |             |            |             |             |             |             |            |             |
|  | Mass rings/tare (g)              |             |            |             |             |             |             |            |             |
|  | Moist unit wt., $\gamma_m$ (pcf) |             |            |             |             |             |             |            |             |
| Coarse Fraction                                  | Wet soil + tare (g)              |             | 2456.50    |             |             |             |             | 1806.74    |             |
|  | Dry soil + tare (g)              |             | 2388.17    |             |             |             |             | 1790.75    |             |
|  | Tare (g)                         |             | 882.10     |             |             |             |             | 171.27     |             |
|  | Water content (%)                |             | 4.5        |             |             |             |             | 1.0        |             |
| Split Fraction                                   | Wet soil + tare (g)              | 457.31      | 468.03     | 375.85      | 362.12      | 541.14      | 674.08      | 407.42     | 548.46      |
|  | Dry soil + tare (g)              | 347.13      | 432.66     | 328.07      | 296.91      | 459.62      | 562.49      | 383.89     | 486.81      |
|  | Tare (g)                         | 127.01      | 160.24     | 127.49      | 152.69      | 121.87      | 127.69      | 171.27     | 151.56      |
|  | Water content (%)                | 50.1        | 13.0       | 23.8        | 45.2        | 24.1        | 25.7        | 11.1       | 18.4        |
| <b>Water Content, w (%)</b>                      |                                  | <b>50.1</b> | <b>9.4</b> | <b>23.8</b> | <b>45.2</b> | <b>24.1</b> | <b>25.7</b> | <b>8.3</b> | <b>18.4</b> |
| <b>Dry Unit Wt., <math>\gamma_d</math> (pcf)</b> |                                  |             |            |             |             |             |             |            |             |

Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

# Water Content and Unit Weight of Soil

(In General Accordance with ASTM D7263 Method B and D2216)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/9/2018**

**By: BSS**

|  |                                     |             |             |  |  |  |  |  |
|--|-------------------------------------|-------------|-------------|--|--|--|--|--|
| Sample Info.                                     | Boring No.                          | TP-41       | TP-51       |  |  |  |  |  |
|  | Station:                            | 26          | 9           |  |  |  |  |  |
|  | Depth:                              | 6.0'        | 9.5'        |  |  |  |  |  |
| Unit Weight Info.                                | Sample height, H (in)               | 4.881       | 4.655       |  |  |  |  |  |
|  | Sample diameter, D (in)             | 2.411       | 2.401       |  |  |  |  |  |
|  | Sample volume, V (ft <sup>3</sup> ) | 0.0129      | 0.0122      |  |  |  |  |  |
|  | Mass rings + wet soil (g)           | 868.74      | 924.96      |  |  |  |  |  |
|  | Mass rings/tare (g)                 | 246.42      | 242.28      |  |  |  |  |  |
|  | Moist soil, Ws (g)                  | 622.32      | 682.68      |  |  |  |  |  |
|  | Moist unit wt., $\gamma_m$ (pcf)    | 106.39      | 123.40      |  |  |  |  |  |
| Water Content                                    | Wet soil + tare (g)                 | 749.68      | 808.67      |  |  |  |  |  |
|  | Dry soil + tare (g)                 | 571.42      | 658.80      |  |  |  |  |  |
|  | Tare (g)                            | 127.89      | 126.48      |  |  |  |  |  |
| <b>Water Content, w (%)</b>                      |                                     | <b>40.2</b> | <b>28.2</b> |  |  |  |  |  |
| <b>Dry Unit Wt., <math>\gamma_d</math> (pcf)</b> |                                     | <b>75.9</b> | <b>96.3</b> |  |  |  |  |  |

Comments:

Sample was disturbed, and contained air voids.

Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/3/2018**

By: **BRR**

Grooving tool type: **Plastic**

Liquid limit device: **Mechanical**

Rolling method: **Hand**

**Boring No.: TP-1**

**Station: 16**

**Depth: 4.0'**

Description: **Reddish brown fat clay**

Preparation method: **Wet**

Liquid limit test method: **Multipoint**

Screened over No.40: **Yes**

Larger particles removed: **Wet sieved**

Approximate maximum grain size: **No.10**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **Not requested**

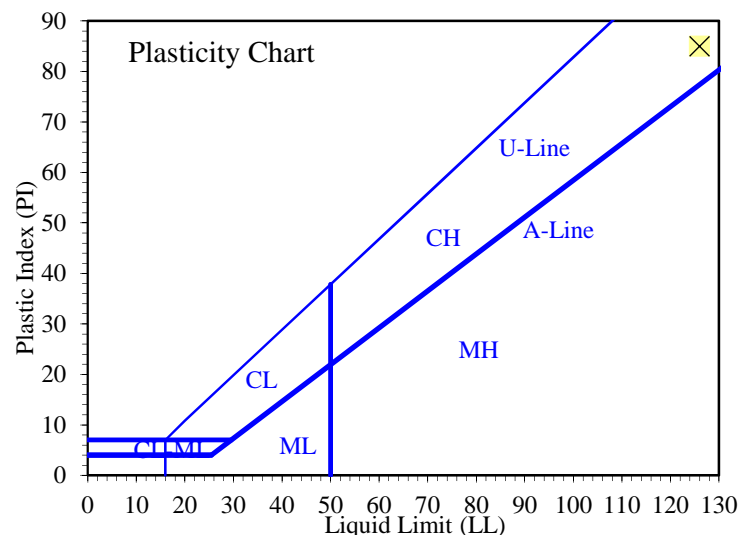
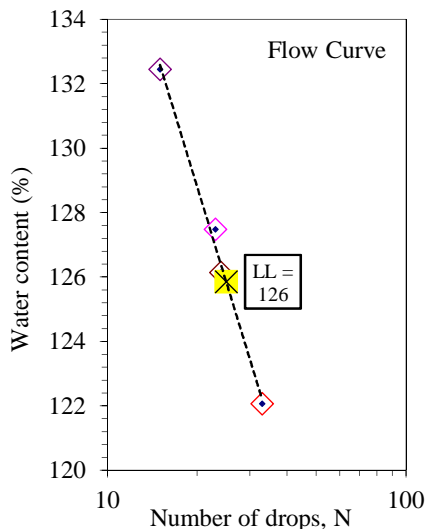
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 12.57 | 13.70 |  |  |  |  |
| Dry Soil + Tare (g)  | 10.77 | 11.76 |  |  |  |  |
| Water Loss (g)       | 1.80  | 1.94  |  |  |  |  |
| Tare (g)             | 6.42  | 7.08  |  |  |  |  |
| Dry Soil (g)         | 4.35  | 4.68  |  |  |  |  |
| Water Content, w (%) | 41.38 | 41.45 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1      | 2      | 3      | 4      |  |  |
|----------------------|--------|--------|--------|--------|--|--|
| Number of Drops, N   | 33     | 23     | 15     | 24     |  |  |
| Wet Soil + Tare (g)  | 13.42  | 13.55  | 14.07  | 13.52  |  |  |
| Dry Soil + Tare (g)  | 10.10  | 10.07  | 10.11  | 9.90   |  |  |
| Water Loss (g)       | 3.32   | 3.48   | 3.96   | 3.62   |  |  |
| Tare (g)             | 7.38   | 7.34   | 7.12   | 7.03   |  |  |
| Dry Soil (g)         | 2.72   | 2.73   | 2.99   | 2.87   |  |  |
| Water Content, w (%) | 122.06 | 127.47 | 132.44 | 126.13 |  |  |
| One-Point LL (%)     |        | 126    |        | 126    |  |  |

|                                 |            |
|---------------------------------|------------|
| <b>Liquid Limit, LL (%)</b>     | <b>126</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>41</b>  |
| <b>Plasticity Index, PI (%)</b> | <b>85</b>  |



Entered by: \_\_\_\_\_  
Reviewed: \_\_\_\_\_

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/10/2018**

By: **BRR**

Grooving tool type: **Plastic**

Liquid limit device: **Mechanical**

Rolling method: **Hand**

**Boring No.: TP-2**

**Station: 7**

**Depth: 12.0'**

Description: **Light brown fat clay**

Preparation method: **Air Dry**

Liquid limit test method: **Multipoint**

Screened over No.40: **Yes**

Larger particles removed: **Dry sieved**

Approximate maximum grain size: **No.4**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **50.1**

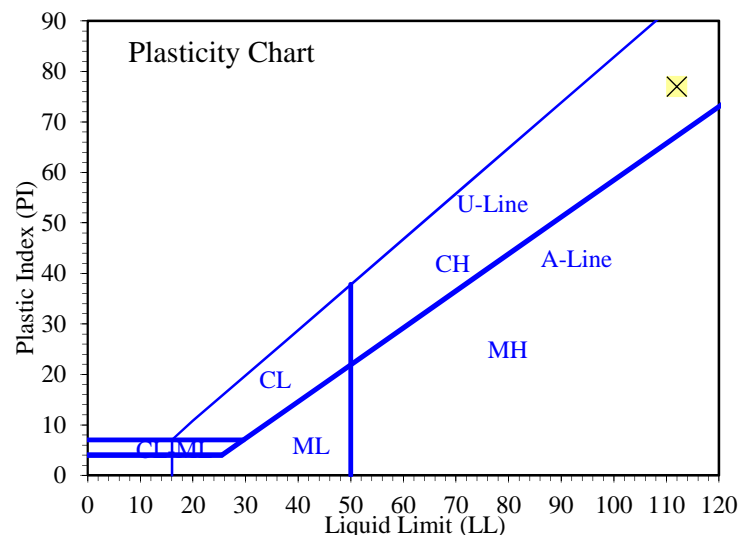
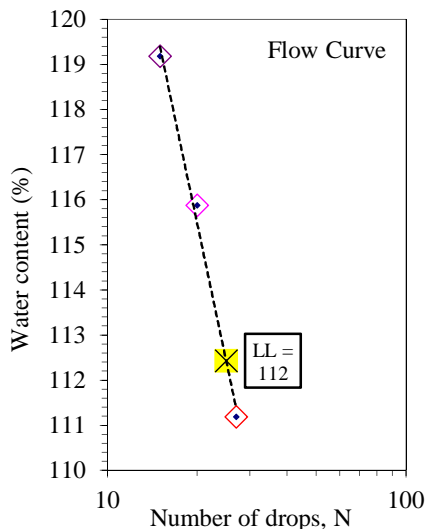
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 13.65 | 14.08 |  |  |  |  |
| Dry Soil + Tare (g)  | 11.97 | 12.27 |  |  |  |  |
| Water Loss (g)       | 1.68  | 1.81  |  |  |  |  |
| Tare (g)             | 7.09  | 7.08  |  |  |  |  |
| Dry Soil (g)         | 4.88  | 5.19  |  |  |  |  |
| Water Content, w (%) | 34.43 | 34.87 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1      | 2      | 3      |  |  |  |
|----------------------|--------|--------|--------|--|--|--|
| Number of Drops, N   | 27     | 20     | 15     |  |  |  |
| Wet Soil + Tare (g)  | 14.03  | 13.92  | 13.48  |  |  |  |
| Dry Soil + Tare (g)  | 10.35  | 10.27  | 10.00  |  |  |  |
| Water Loss (g)       | 3.68   | 3.65   | 3.48   |  |  |  |
| Tare (g)             | 7.04   | 7.12   | 7.08   |  |  |  |
| Dry Soil (g)         | 3.31   | 3.15   | 2.92   |  |  |  |
| Water Content, w (%) | 111.18 | 115.87 | 119.18 |  |  |  |
| One-Point LL (%)     | 112    | 113    |        |  |  |  |

|                                 |            |
|---------------------------------|------------|
| <b>Liquid Limit, LL (%)</b>     | <b>112</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>35</b>  |
| <b>Plasticity Index, PI (%)</b> | <b>77</b>  |



Entered by: \_\_\_\_\_  
Reviewed: \_\_\_\_\_

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/10/2018**

By: **DKS/BRR**

Grooving tool type: **Plastic**

Liquid limit device: **Mechanical**

Rolling method: **Hand**

**Boring No.: TP-3**

**Station: 26**

**Depth: 9.5'**

Description: **Reddish brown fat clay**

Preparation method: **Wet**

Liquid limit test method: **Multipoint**

Screened over No.40: **No**

Larger particles removed: **Mixed on glass plate**

Approximate maximum grain size: **No.40**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **Not requested**

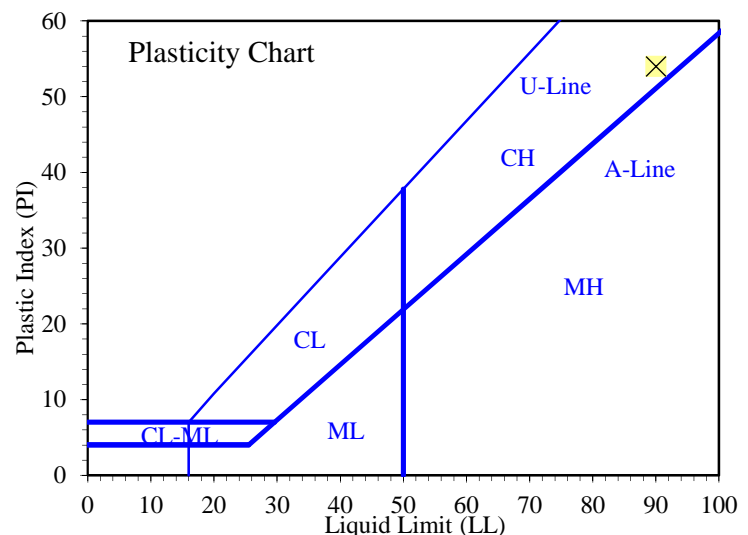
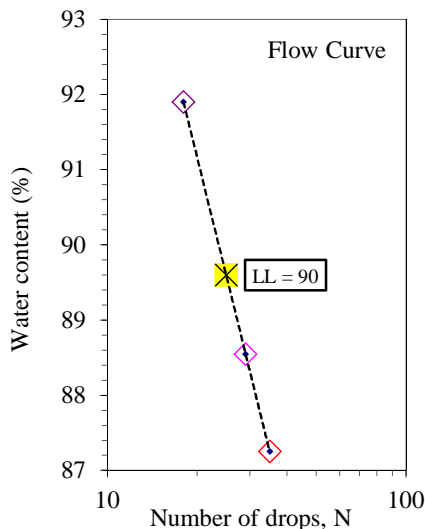
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 14.02 | 13.42 |  |  |  |  |
| Dry Soil + Tare (g)  | 12.17 | 11.74 |  |  |  |  |
| Water Loss (g)       | 1.85  | 1.68  |  |  |  |  |
| Tare (g)             | 7.01  | 7.07  |  |  |  |  |
| Dry Soil (g)         | 5.16  | 4.67  |  |  |  |  |
| Water Content, w (%) | 35.85 | 35.97 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1     | 2     | 3     |  |  |  |
|----------------------|-------|-------|-------|--|--|--|
| Number of Drops, N   | 35    | 29    | 18    |  |  |  |
| Wet Soil + Tare (g)  | 16.77 | 14.35 | 14.64 |  |  |  |
| Dry Soil + Tare (g)  | 12.39 | 10.95 | 11.01 |  |  |  |
| Water Loss (g)       | 4.38  | 3.40  | 3.63  |  |  |  |
| Tare (g)             | 7.37  | 7.11  | 7.06  |  |  |  |
| Dry Soil (g)         | 5.02  | 3.84  | 3.95  |  |  |  |
| Water Content, w (%) | 87.25 | 88.54 | 91.90 |  |  |  |
| One-Point LL (%)     |       | 90    |       |  |  |  |

|                                 |           |
|---------------------------------|-----------|
| <b>Liquid Limit, LL (%)</b>     | <b>90</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>36</b> |
| <b>Plasticity Index, PI (%)</b> | <b>54</b> |



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/5/2018**

By: **BRR**

Grooving tool type: **Plastic**

Liquid limit device: **Mechanical**

Rolling method: **Hand**

**Boring No.: TP-6**

**Station: 5**

**Depth: 3.5'**

Description: **Reddish brown fat clay**

Preparation method: **Air Dry**

Liquid limit test method: **Multipoint**

Screened over No.40: **Yes**

Larger particles removed: **Dry sieved**

Approximate maximum grain size: **3/4"**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **23.8**

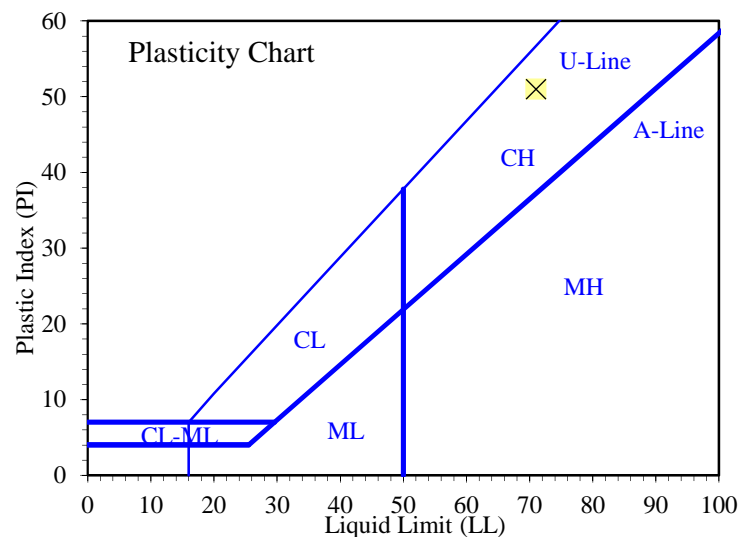
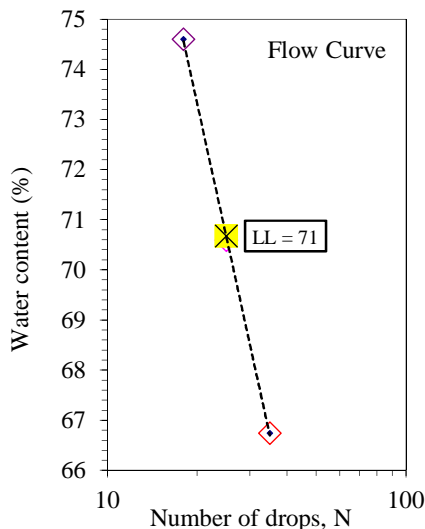
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 13.60 | 13.52 |  |  |  |  |
| Dry Soil + Tare (g)  | 12.51 | 12.46 |  |  |  |  |
| Water Loss (g)       | 1.09  | 1.06  |  |  |  |  |
| Tare (g)             | 7.04  | 7.08  |  |  |  |  |
| Dry Soil (g)         | 5.47  | 5.38  |  |  |  |  |
| Water Content, w (%) | 19.93 | 19.70 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1     | 2     | 3     |  |  |  |
|----------------------|-------|-------|-------|--|--|--|
| Number of Drops, N   | 35    | 25    | 18    |  |  |  |
| Wet Soil + Tare (g)  | 14.78 | 14.01 | 13.62 |  |  |  |
| Dry Soil + Tare (g)  | 11.71 | 11.25 | 10.83 |  |  |  |
| Water Loss (g)       | 3.07  | 2.76  | 2.79  |  |  |  |
| Tare (g)             | 7.11  | 7.34  | 7.09  |  |  |  |
| Dry Soil (g)         | 4.60  | 3.91  | 3.74  |  |  |  |
| Water Content, w (%) | 66.74 | 70.59 | 74.60 |  |  |  |
| One-Point LL (%)     |       | 71    |       |  |  |  |

|                                 |           |
|---------------------------------|-----------|
| <b>Liquid Limit, LL (%)</b>     | <b>71</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>20</b> |
| <b>Plasticity Index, PI (%)</b> | <b>51</b> |



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/6/2018**

By: **DKS**

Grooving tool type: **Plastic**

Liquid limit device: **Mechanical**

Rolling method: **Hand**

**Boring No.: TP-8**

**Station: 6**

**Depth: 12.0'**

Description: **Light brown fat clay**

Preparation method: **Air Dry**

Liquid limit test method: **Multipoint**

Screened over No.40: **Yes**

Larger particles removed: **Dry sieved**

Approximate maximum grain size: **3/8"**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **45.2**

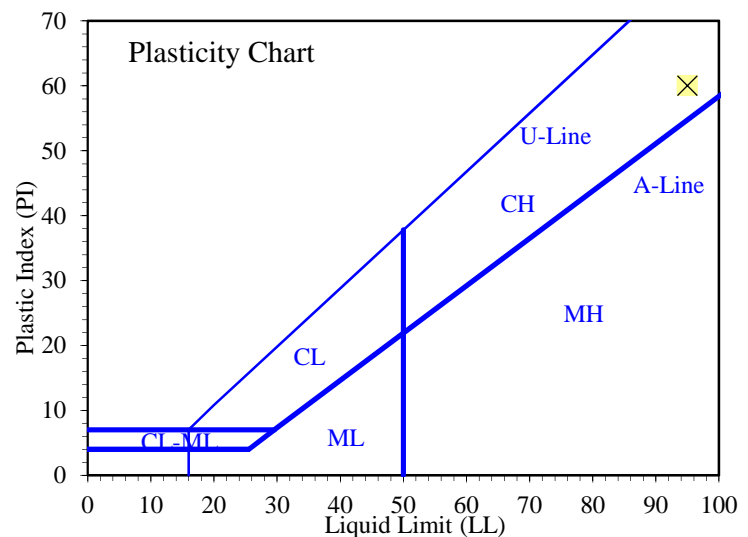
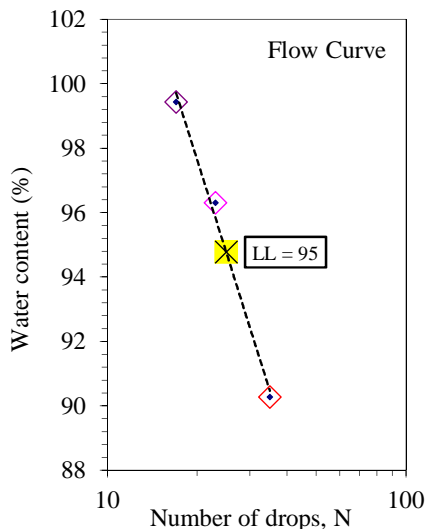
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 14.36 | 15.35 |  |  |  |  |
| Dry Soil + Tare (g)  | 12.47 | 13.21 |  |  |  |  |
| Water Loss (g)       | 1.89  | 2.14  |  |  |  |  |
| Tare (g)             | 7.09  | 7.07  |  |  |  |  |
| Dry Soil (g)         | 5.38  | 6.14  |  |  |  |  |
| Water Content, w (%) | 35.13 | 34.85 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1     | 2     | 3     |  |  |  |
|----------------------|-------|-------|-------|--|--|--|
| Number of Drops, N   | 35    | 23    | 17    |  |  |  |
| Wet Soil + Tare (g)  | 17.61 | 18.45 | 17.61 |  |  |  |
| Dry Soil + Tare (g)  | 12.60 | 12.99 | 12.33 |  |  |  |
| Water Loss (g)       | 5.01  | 5.46  | 5.28  |  |  |  |
| Tare (g)             | 7.05  | 7.32  | 7.02  |  |  |  |
| Dry Soil (g)         | 5.55  | 5.67  | 5.31  |  |  |  |
| Water Content, w (%) | 90.27 | 96.30 | 99.44 |  |  |  |
| One-Point LL (%)     |       | 95    |       |  |  |  |

|                                 |           |
|---------------------------------|-----------|
| <b>Liquid Limit, LL (%)</b>     | <b>95</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>35</b> |
| <b>Plasticity Index, PI (%)</b> | <b>60</b> |



Entered by: \_\_\_\_\_  
Reviewed: \_\_\_\_\_



**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/6/2018**

By: **DKS**

Grooving tool type: **Plastic**

Liquid limit device: **Mechanical**

Rolling method: **Hand**

**Boring No.: TP-12**

**Station: 10**

**Depth: 10.0'**

Description: **Reddish brown fat clay**

Preparation method: **Air Dry**

Liquid limit test method: **Multipoint**

Screened over No.40: **Yes**

Larger particles removed: **Dry sieved**

Approximate maximum grain size: **No.4**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **24.1**

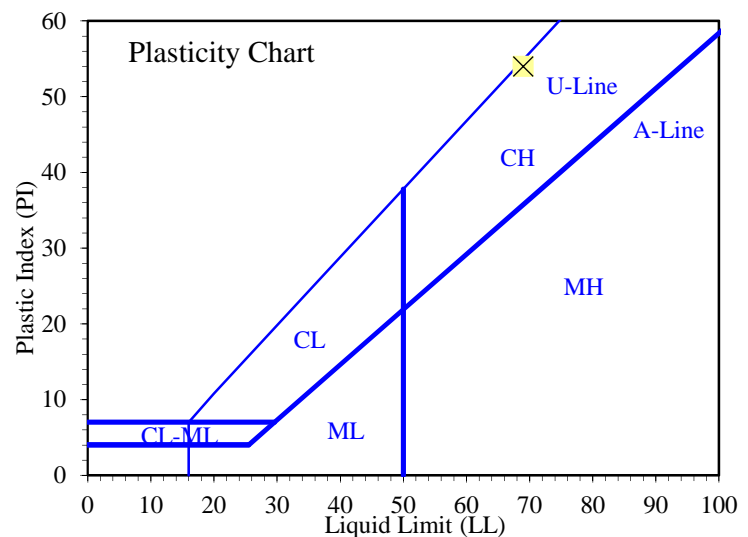
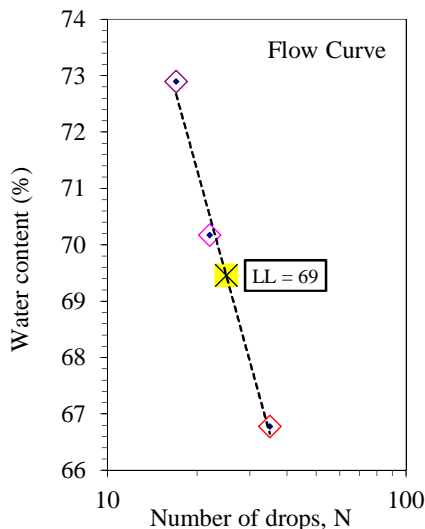
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 15.45 | 15.23 |  |  |  |  |
| Dry Soil + Tare (g)  | 14.26 | 14.14 |  |  |  |  |
| Water Loss (g)       | 1.19  | 1.09  |  |  |  |  |
| Tare (g)             | 6.48  | 7.07  |  |  |  |  |
| Dry Soil (g)         | 7.78  | 7.07  |  |  |  |  |
| Water Content, w (%) | 15.30 | 15.42 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1     | 2     | 3     |  |  |  |
|----------------------|-------|-------|-------|--|--|--|
| Number of Drops, N   | 35    | 22    | 17    |  |  |  |
| Wet Soil + Tare (g)  | 17.59 | 20.42 | 16.79 |  |  |  |
| Dry Soil + Tare (g)  | 13.41 | 15.01 | 12.81 |  |  |  |
| Water Loss (g)       | 4.18  | 5.41  | 3.98  |  |  |  |
| Tare (g)             | 7.15  | 7.30  | 7.35  |  |  |  |
| Dry Soil (g)         | 6.26  | 7.71  | 5.46  |  |  |  |
| Water Content, w (%) | 66.77 | 70.17 | 72.89 |  |  |  |
| One-Point LL (%)     |       | 69    |       |  |  |  |

|                                 |           |
|---------------------------------|-----------|
| <b>Liquid Limit, LL (%)</b>     | <b>69</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>15</b> |
| <b>Plasticity Index, PI (%)</b> | <b>54</b> |



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/11/2018**

By: **BRR**

Grooving tool type: **Plastic**

Liquid limit device: **Mechanical**

Rolling method: **Hand**

**Boring No.: TP-21**

**Station: 5**

**Depth: 5.5'**

Description: **Reddish brown lean clay**

Preparation method: **Wet**

Liquid limit test method: **Multipoint**

Screened over No.40: **Yes**

Larger particles removed: **Wet sieved**

Approximate maximum grain size: **No.10**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **Not requested**

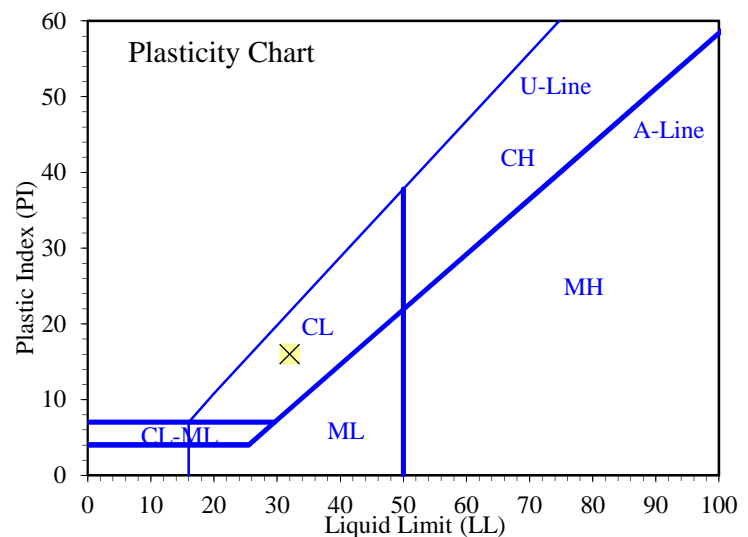
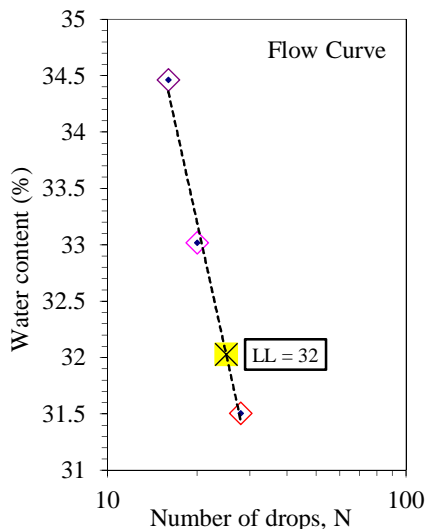
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 15.02 | 14.50 |  |  |  |  |
| Dry Soil + Tare (g)  | 13.90 | 13.46 |  |  |  |  |
| Water Loss (g)       | 1.12  | 1.04  |  |  |  |  |
| Tare (g)             | 7.05  | 7.07  |  |  |  |  |
| Dry Soil (g)         | 6.85  | 6.39  |  |  |  |  |
| Water Content, w (%) | 16.35 | 16.28 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1     | 2     | 3     |  |  |  |
|----------------------|-------|-------|-------|--|--|--|
| Number of Drops, N   | 28    | 20    | 16    |  |  |  |
| Wet Soil + Tare (g)  | 14.46 | 15.51 | 13.79 |  |  |  |
| Dry Soil + Tare (g)  | 12.68 | 13.43 | 12.06 |  |  |  |
| Water Loss (g)       | 1.78  | 2.08  | 1.73  |  |  |  |
| Tare (g)             | 7.03  | 7.13  | 7.04  |  |  |  |
| Dry Soil (g)         | 5.65  | 6.30  | 5.02  |  |  |  |
| Water Content, w (%) | 31.50 | 33.02 | 34.46 |  |  |  |
| One-Point LL (%)     | 32    | 32    |       |  |  |  |

|                                 |           |
|---------------------------------|-----------|
| <b>Liquid Limit, LL (%)</b>     | <b>32</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>16</b> |
| <b>Plasticity Index, PI (%)</b> | <b>16</b> |



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**  
**No: 01628-028**

**Boring No.: TP-22**

**Station: 18**

Location: **Powder Mountain, Weber Co., UT**

**Depth: 10.5'**

Date: **7/11/2018**

Description: **Reddish brown fat clay**

By: **BRR**

Grooving tool type: **Plastic**

Preparation method: **Wet**

Liquid limit device: **Mechanical**

Liquid limit test method: **Multipoint**

Rolling method: **Hand**

Screened over No.40: **Yes**

Larger particles removed: **Wet sieved**

Approximate maximum grain size: **3/8"**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **Not requested**

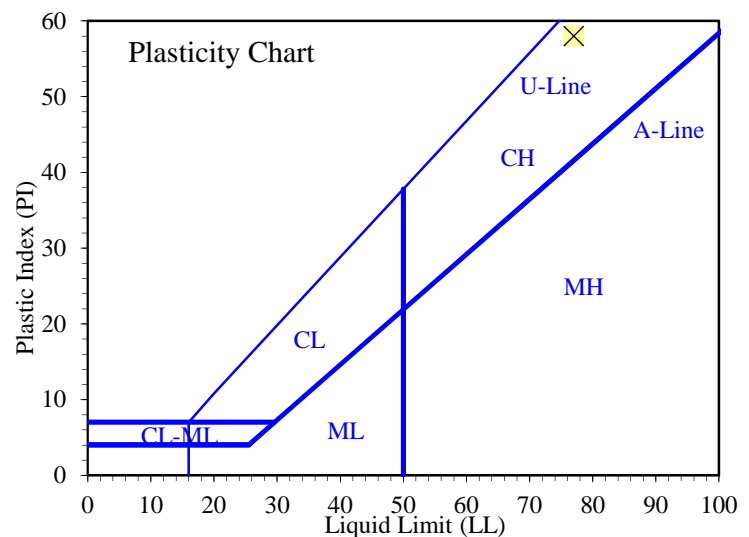
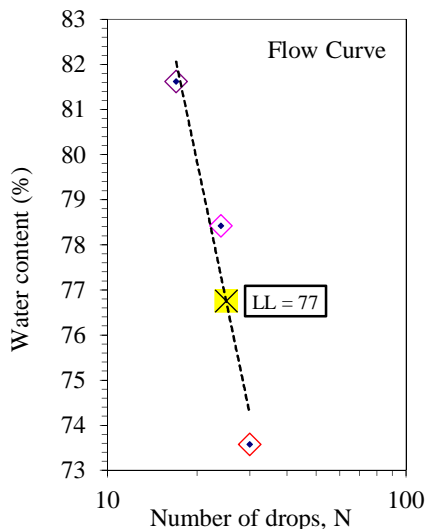
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 13.34 | 13.96 |  |  |  |  |
| Dry Soil + Tare (g)  | 12.23 | 12.75 |  |  |  |  |
| Water Loss (g)       | 1.11  | 1.21  |  |  |  |  |
| Tare (g)             | 6.44  | 6.43  |  |  |  |  |
| Dry Soil (g)         | 5.79  | 6.32  |  |  |  |  |
| Water Content, w (%) | 19.17 | 19.15 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1     | 2     | 3     |  |  |  |
|----------------------|-------|-------|-------|--|--|--|
| Number of Drops, N   | 30    | 24    | 17    |  |  |  |
| Wet Soil + Tare (g)  | 13.43 | 13.86 | 13.17 |  |  |  |
| Dry Soil + Tare (g)  | 10.73 | 10.88 | 10.55 |  |  |  |
| Water Loss (g)       | 2.70  | 2.98  | 2.62  |  |  |  |
| Tare (g)             | 7.06  | 7.08  | 7.34  |  |  |  |
| Dry Soil (g)         | 3.67  | 3.80  | 3.21  |  |  |  |
| Water Content, w (%) | 73.57 | 78.42 | 81.62 |  |  |  |
| One-Point LL (%)     | 75    | 78    |       |  |  |  |

|                                 |           |
|---------------------------------|-----------|
| <b>Liquid Limit, LL (%)</b>     | <b>77</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>19</b> |
| <b>Plasticity Index, PI (%)</b> | <b>58</b> |



Entered by: \_\_\_\_\_  
Reviewed: \_\_\_\_\_

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/10/2018**

By: **BRR**

Grooving tool type: **Plastic**

Liquid limit device: **Mechanical**

Rolling method: **Hand**

**Boring No.: TP-24**

**Station: 6.5**

**Depth: 3.0'**

Description: **Reddish brown fat clay**

Preparation method: **Wet**

Liquid limit test method: **Multipoint**

Screened over No.40: **Yes**

Larger particles removed: **Wet sieved**

Approximate maximum grain size: **1-1/2"**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **25.7**

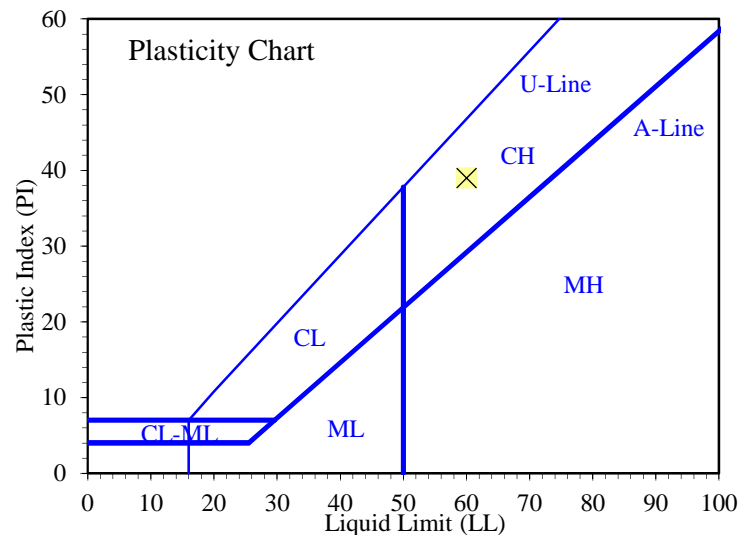
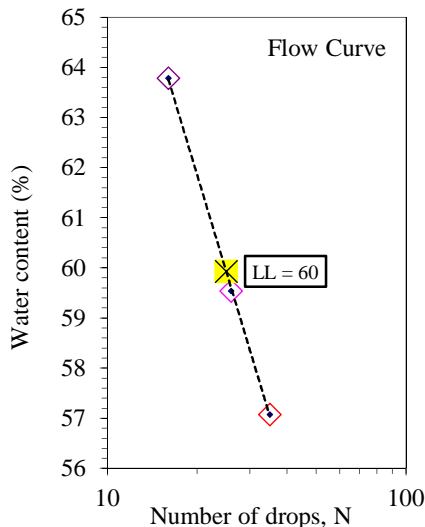
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 13.32 | 13.29 |  |  |  |  |
| Dry Soil + Tare (g)  | 12.21 | 12.21 |  |  |  |  |
| Water Loss (g)       | 1.11  | 1.08  |  |  |  |  |
| Tare (g)             | 7.10  | 7.13  |  |  |  |  |
| Dry Soil (g)         | 5.11  | 5.08  |  |  |  |  |
| Water Content, w (%) | 21.72 | 21.26 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1     | 2     | 3     |  |  |  |
|----------------------|-------|-------|-------|--|--|--|
| Number of Drops, N   | 35    | 26    | 16    |  |  |  |
| Wet Soil + Tare (g)  | 13.29 | 13.66 | 14.34 |  |  |  |
| Dry Soil + Tare (g)  | 11.03 | 11.35 | 11.54 |  |  |  |
| Water Loss (g)       | 2.26  | 2.31  | 2.80  |  |  |  |
| Tare (g)             | 7.07  | 7.47  | 7.15  |  |  |  |
| Dry Soil (g)         | 3.96  | 3.88  | 4.39  |  |  |  |
| Water Content, w (%) | 57.07 | 59.54 | 63.78 |  |  |  |
| One-Point LL (%)     |       | 60    |       |  |  |  |

|                                 |           |
|---------------------------------|-----------|
| <b>Liquid Limit, LL (%)</b>     | <b>60</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>21</b> |
| <b>Plasticity Index, PI (%)</b> | <b>39</b> |



Entered by: \_\_\_\_\_  
Reviewed: \_\_\_\_\_

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/5/2018**

By: **BRR**

Grooving tool type: **Plastic**

Liquid limit device: **Mechanical**

Rolling method: **Hand**

**Boring No.: TP-37**

**Station: 4**

**Depth: 9.0'**

Description: **Reddish brown fat clay**

Preparation method: **Wet**

Liquid limit test method: **Multipoint**

Screened over No.40: **Yes**

Larger particles removed: **Wet sieved**

Approximate maximum grain size: **No.4**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **18.4**

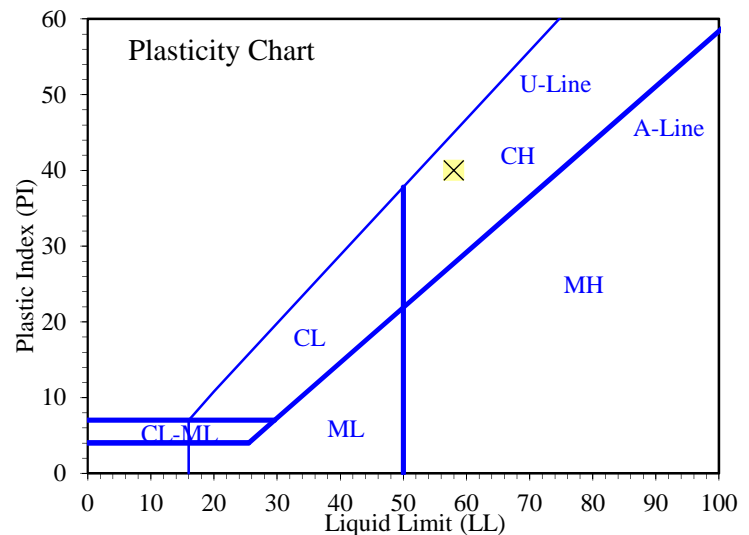
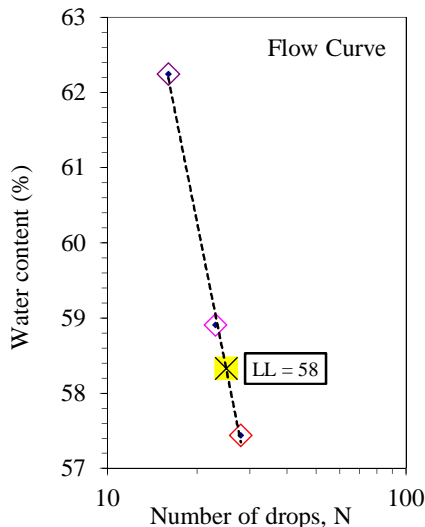
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 13.50 | 14.51 |  |  |  |  |
| Dry Soil + Tare (g)  | 12.53 | 13.39 |  |  |  |  |
| Water Loss (g)       | 0.97  | 1.12  |  |  |  |  |
| Tare (g)             | 7.14  | 7.08  |  |  |  |  |
| Dry Soil (g)         | 5.39  | 6.31  |  |  |  |  |
| Water Content, w (%) | 18.00 | 17.75 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1     | 2     | 3     |  |  |  |
|----------------------|-------|-------|-------|--|--|--|
| Number of Drops, N   | 28    | 23    | 16    |  |  |  |
| Wet Soil + Tare (g)  | 15.46 | 13.76 | 14.19 |  |  |  |
| Dry Soil + Tare (g)  | 12.37 | 11.28 | 11.47 |  |  |  |
| Water Loss (g)       | 3.09  | 2.48  | 2.72  |  |  |  |
| Tare (g)             | 6.99  | 7.07  | 7.10  |  |  |  |
| Dry Soil (g)         | 5.38  | 4.21  | 4.37  |  |  |  |
| Water Content, w (%) | 57.43 | 58.91 | 62.24 |  |  |  |
| One-Point LL (%)     | 58    | 58    |       |  |  |  |

|                                 |           |
|---------------------------------|-----------|
| <b>Liquid Limit, LL (%)</b>     | <b>58</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>18</b> |
| <b>Plasticity Index, PI (%)</b> | <b>40</b> |



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/12/2018**

By: **BRR**

Grooving tool type: **Plastic**

Liquid limit device: **Mechanical**

Rolling method: **Hand**

**Boring No.: TP-40**

**Station: 14**

**Depth: 5.5'**

Description: **Reddish brown fat clay**

Preparation method: **Air Dry**

Liquid limit test method: **Multipoint**

Screened over No.40: **Yes**

Larger particles removed: **Dry sieved**

Approximate maximum grain size: **No.40**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **Not requested**

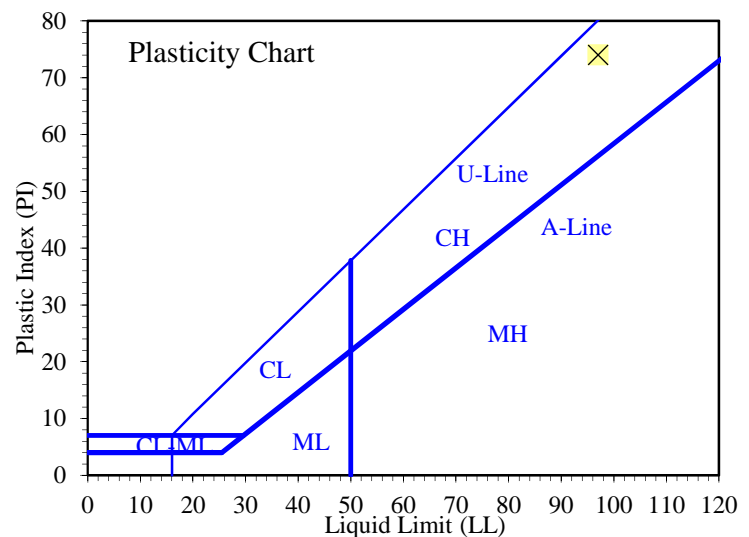
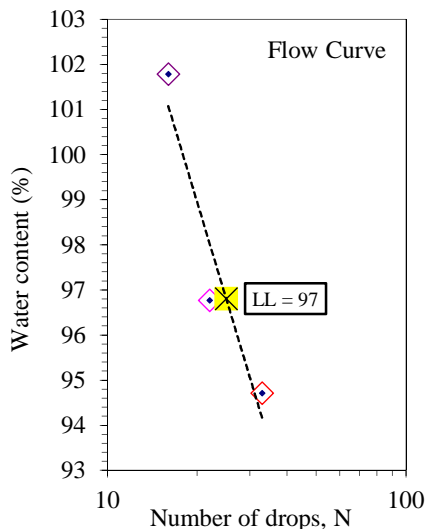
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 14.00 | 14.11 |  |  |  |  |
| Dry Soil + Tare (g)  | 12.71 | 12.81 |  |  |  |  |
| Water Loss (g)       | 1.29  | 1.30  |  |  |  |  |
| Tare (g)             | 7.05  | 7.06  |  |  |  |  |
| Dry Soil (g)         | 5.66  | 5.75  |  |  |  |  |
| Water Content, w (%) | 22.79 | 22.61 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1     | 2     | 3      |  |  |  |
|----------------------|-------|-------|--------|--|--|--|
| Number of Drops, N   | 33    | 22    | 16     |  |  |  |
| Wet Soil + Tare (g)  | 13.58 | 12.51 | 12.77  |  |  |  |
| Dry Soil + Tare (g)  | 10.54 | 9.82  | 9.91   |  |  |  |
| Water Loss (g)       | 3.04  | 2.69  | 2.86   |  |  |  |
| Tare (g)             | 7.33  | 7.04  | 7.10   |  |  |  |
| Dry Soil (g)         | 3.21  | 2.78  | 2.81   |  |  |  |
| Water Content, w (%) | 94.70 | 96.76 | 101.78 |  |  |  |
| One-Point LL (%)     |       | 95    |        |  |  |  |

|                                 |           |
|---------------------------------|-----------|
| <b>Liquid Limit, LL (%)</b>     | <b>97</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>23</b> |
| <b>Plasticity Index, PI (%)</b> | <b>74</b> |



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/12/2018**

By: **BRR**

Grooving tool type: **Plastic**

Liquid limit device: **Mechanical**

Rolling method: **Hand**

**Boring No.: TP-49**

**Station: 32**

**Depth: 7.5'**

Description: **Reddish brown fat clay**

Preparation method: **Wet**

Liquid limit test method: **Multipoint**

Screened over No.40: **Yes**

Larger particles removed: **Wet sieved**

Approximate maximum grain size: **No.4**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **Not requested**

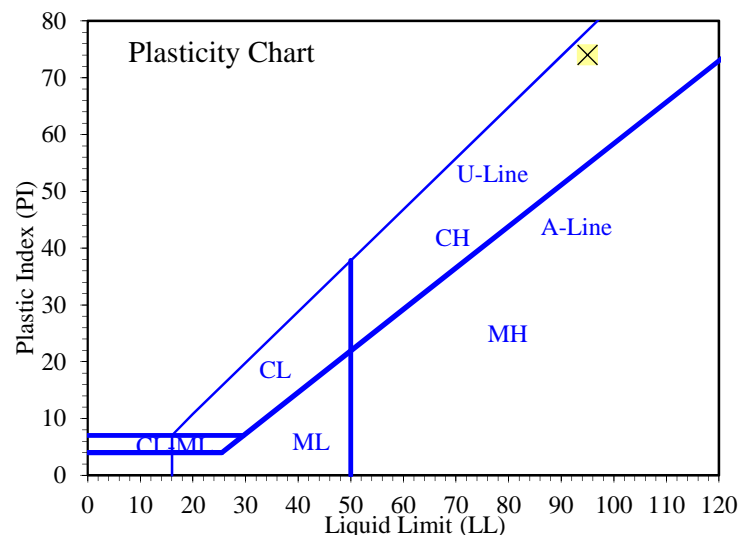
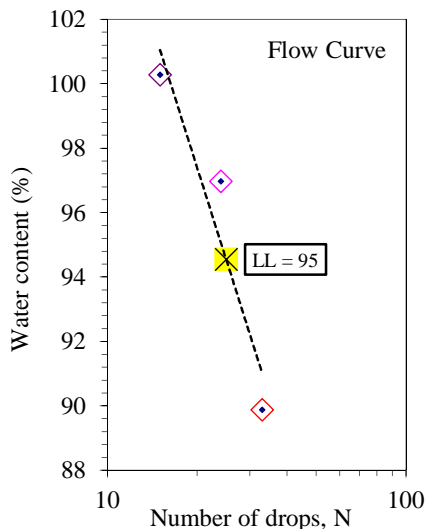
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 13.33 | 14.42 |  |  |  |  |
| Dry Soil + Tare (g)  | 12.16 | 13.16 |  |  |  |  |
| Water Loss (g)       | 1.17  | 1.26  |  |  |  |  |
| Tare (g)             | 6.43  | 7.12  |  |  |  |  |
| Dry Soil (g)         | 5.73  | 6.04  |  |  |  |  |
| Water Content, w (%) | 20.42 | 20.86 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1     | 2     | 3      |  |  |  |
|----------------------|-------|-------|--------|--|--|--|
| Number of Drops, N   | 33    | 24    | 15     |  |  |  |
| Wet Soil + Tare (g)  | 12.94 | 13.55 | 14.47  |  |  |  |
| Dry Soil + Tare (g)  | 10.19 | 10.35 | 10.77  |  |  |  |
| Water Loss (g)       | 2.75  | 3.20  | 3.70   |  |  |  |
| Tare (g)             | 7.13  | 7.05  | 7.08   |  |  |  |
| Dry Soil (g)         | 3.06  | 3.30  | 3.69   |  |  |  |
| Water Content, w (%) | 89.87 | 96.97 | 100.27 |  |  |  |
| One-Point LL (%)     |       | 96    |        |  |  |  |

|                                 |           |
|---------------------------------|-----------|
| <b>Liquid Limit, LL (%)</b>     | <b>95</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>21</b> |
| <b>Plasticity Index, PI (%)</b> | <b>74</b> |



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Liquid Limit, Plastic Limit, and Plasticity Index of Soils**

(ASTM D4318)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/11/2018**

By: **BRR**

Grooving tool type: **Plastic**

Liquid limit device: **Mechanical**

Rolling method: **Hand**

**Boring No.: TP-52**

**Station: 31**

**Depth: 4.5'**

Description: **Reddish brown fat clay**

Preparation method: **Wet**

Liquid limit test method: **Multipoint**

Screened over No.40: **Yes**

Larger particles removed: **Wet sieved**

Approximate maximum grain size: **No.10**

Estimated percent retained on No.40: **Not requested**

As-received water content (%): **Not requested**

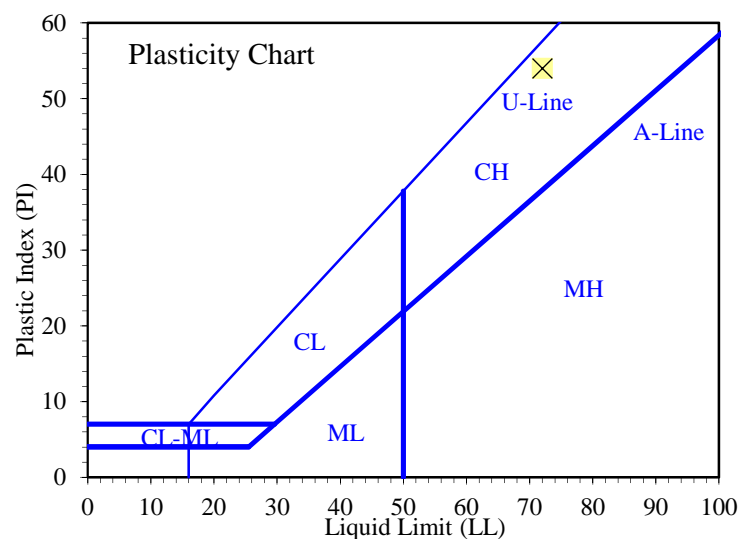
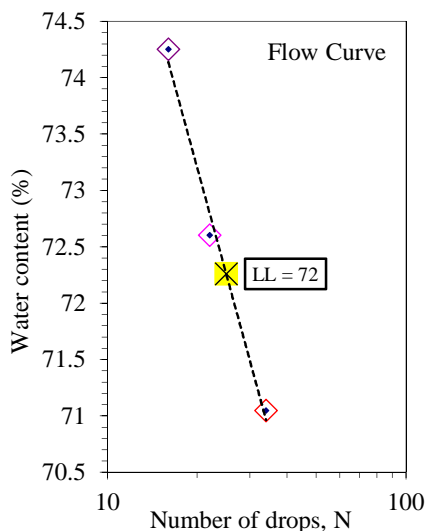
**Plastic Limit**

| Determination No     | 1     | 2     |  |  |  |  |
|----------------------|-------|-------|--|--|--|--|
| Wet Soil + Tare (g)  | 14.37 | 13.94 |  |  |  |  |
| Dry Soil + Tare (g)  | 13.27 | 12.90 |  |  |  |  |
| Water Loss (g)       | 1.10  | 1.04  |  |  |  |  |
| Tare (g)             | 7.08  | 7.05  |  |  |  |  |
| Dry Soil (g)         | 6.19  | 5.85  |  |  |  |  |
| Water Content, w (%) | 17.77 | 17.78 |  |  |  |  |

**Liquid Limit**

| Determination No     | 1     | 2     | 3     |  |  |  |
|----------------------|-------|-------|-------|--|--|--|
| Number of Drops, N   | 34    | 22    | 16    |  |  |  |
| Wet Soil + Tare (g)  | 14.41 | 13.38 | 14.09 |  |  |  |
| Dry Soil + Tare (g)  | 11.49 | 10.73 | 11.12 |  |  |  |
| Water Loss (g)       | 2.92  | 2.65  | 2.97  |  |  |  |
| Tare (g)             | 7.38  | 7.08  | 7.12  |  |  |  |
| Dry Soil (g)         | 4.11  | 3.65  | 4.00  |  |  |  |
| Water Content, w (%) | 71.05 | 72.60 | 74.25 |  |  |  |
| One-Point LL (%)     |       | 71    |       |  |  |  |

|                                 |           |
|---------------------------------|-----------|
| <b>Liquid Limit, LL (%)</b>     | <b>72</b> |
| <b>Plastic Limit, PL (%)</b>    | <b>18</b> |
| <b>Plasticity Index, PI (%)</b> | <b>54</b> |



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_



# Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/11/2018**

**By: DKS/BSS**

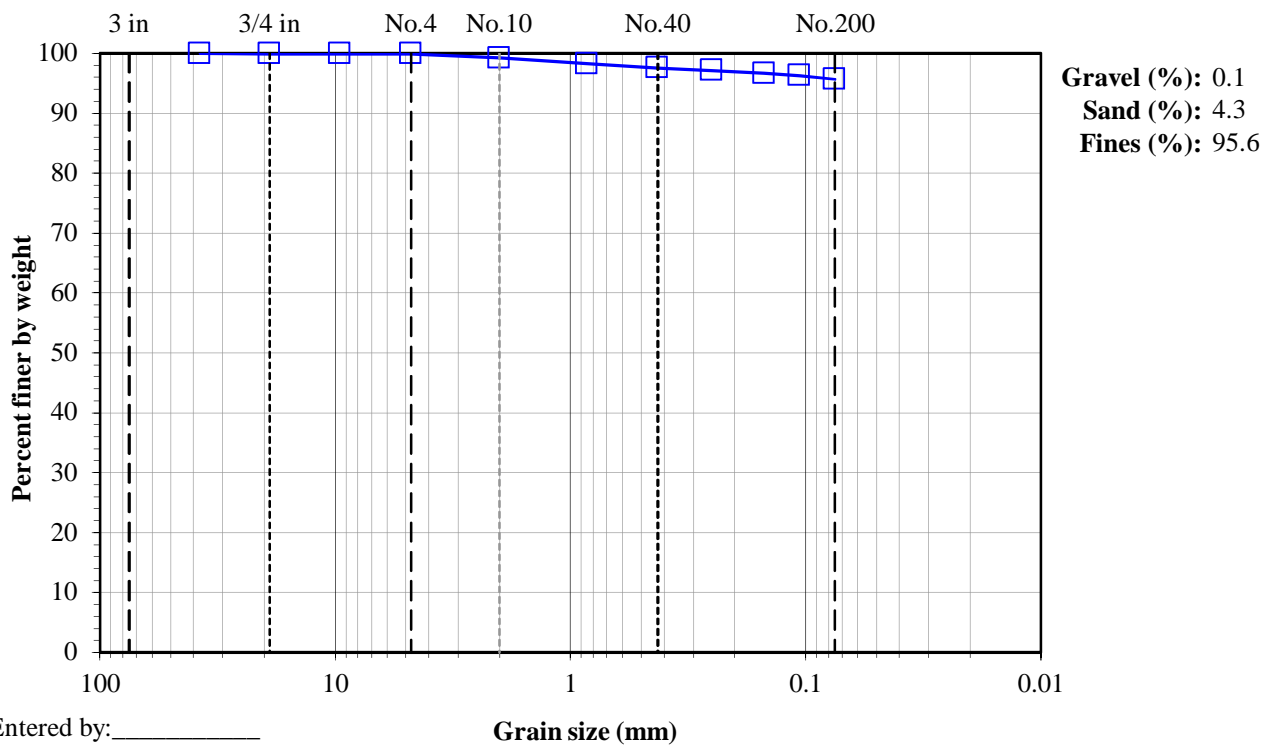
**Boring No.: TP-1**

**Station: 22**

**Depth: 10.0'**

**Description: Light brown clay**

| Split: <b>Yes</b><br>Split sieve: <b>3/8"</b>                                      |                     | Moist      Dry<br>Total sample wt. (g): <b>21043.2</b> <b>18752.19</b> |               | <u>Water content data</u> C.F.(+3/8") S.F.(-3/8")<br>Moist soil + tare (g): <b>3320.36</b> <b>402.89</b><br>Dry soil + tare (g): <b>2991.11</b> <b>372.05</b><br>Tare (g): <b>310.48</b> <b>119.62</b><br>Water content (%): <b>12.3</b> <b>12.2</b> |  |
|--|---------------------|--|---------------|--|--|
| +3/8" Coarse fraction (g): <b>15.29</b><br>-3/8" Split fraction (g): <b>283.27</b> |                     | 13.62<br>252.43  |               |  |  |
| Split fraction: <b>0.999</b>   |                     |  |               |  |  |
| Sieve  | Accum. Wt. Ret. (g) | Grain Size (mm)  | Percent Finer |  |  |
| 8"   | -                   | 200  | -             |  |  |
| 6"   | -                   | 150  | -             |  |  |
| 4"   | -                   | 100  | -             |  |  |
| 3"   | -                   | 75   | -             |  |  |
| 1.5"   | -                   | 37.5   | 100.0         |  |  |
| 3/4"   | 11.01               | 19   | 99.9          |  |  |
| 3/8"   | 13.62               | 9.5  | 99.9          | ←Split   |  |
| No.4   | 0.00                | 4.75   | 99.9          |  |  |
| No.10  | 1.82                | 2  | 99.2          |  |  |
| No.20  | 4.17                | 0.85   | 98.3          |  |  |
| No.40  | 5.89                | 0.425  | 97.6          |  |  |
| No.60  | 7.01                | 0.25   | 97.2          |  |  |
| No.100   | 8.26                | 0.15   | 96.7          |  |  |
| No.140   | 9.19                | 0.106  | 96.3          |  |  |
| No.200   | 10.85               | 0.075  | 95.6          |  |  |



Entered by: \_\_\_\_\_  
 Reviewed: \_\_\_\_\_

**Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis**

(ASTM D6913)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/11/2018**

**By: DKS/BSS**

**Boring No.: TP-3**

**Station: 27**

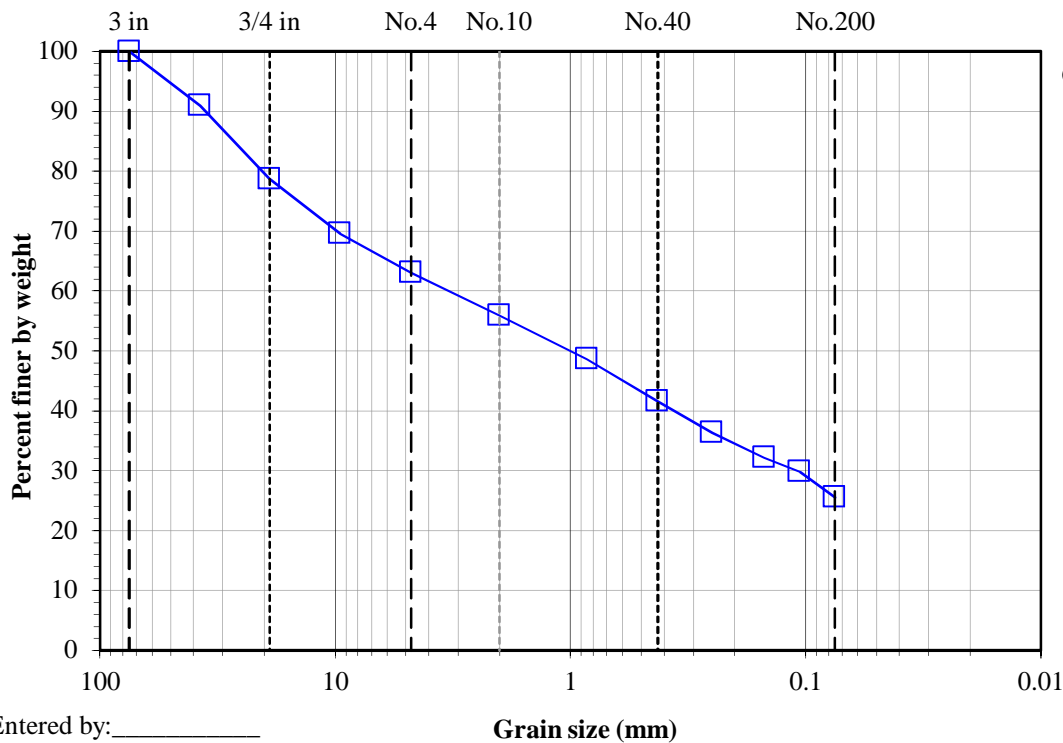
**Depth: 6.5'**

**Description: Reddish brown clayey sand with gravel**

|                                   |   |                             |
|-----------------------------------|---|-----------------------------|
| Split: Yes                        | <u>Water content data</u> C.F.(+3/8") S.F.(-3/8") |                             |
| Split sieve: 3/8"                 | Moist soil + tare (g): 9906.1                     | 433.02                      |
| Moist                             | Dry soil + tare (g): 9511.0                       | 403.23                      |
| Dry                               | Tare (g): 1627.5                                  | 123.19                      |
| Total sample wt. (g): 26496.2     | 24325.00  | Water content (%): 5.0 10.6 |
| +3/8" Coarse fraction (g): 7772.9 | 7401.90   |                             |
| -3/8" Split fraction (g): 309.83  | 280.04  |                             |
| Split fraction: 0.696             |   |                             |

| Sieve  | Accum. Wt. Ret. (g) | Grain Size (mm) | Percent Finer |
|--------|---------------------|-----------------|---------------|
| 8"     | -                   | 200             | -             |
| 6"     | -                   | 150             | -             |
| 4"     | -                   | 100             | -             |
| 3"     | -                   | 75              | 100.0         |
| 1.5"   | 2198.0              | 37.5            | 91.0          |
| 3/4"   | 5178.5              | 19              | 78.7          |
| 3/8"   | 7401.9              | 9.5             | 69.6          |
| No.4   | 26.27               | 4.75            | 63.0          |
| No.10  | 55.08               | 2               | 55.9          |
| No.20  | 84.35               | 0.85            | 48.6          |
| No.40  | 112.67              | 0.425           | 41.6          |
| No.60  | 133.66              | 0.25            | 36.4          |
| No.100 | 150.39              | 0.15            | 32.2          |
| No.140 | 159.88              | 0.106           | 29.9          |
| No.200 | 177.20              | 0.075           | 25.5          |

←Split



**Gravel (%): 37.0**  
**Sand (%): 37.5**  
**Fines (%): 25.5**

Entered by: \_\_\_\_\_  
Reviewed: \_\_\_\_\_

# Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/11/2018**

**By: JP**

**Boring No.: TP-5**

**Station: 30**

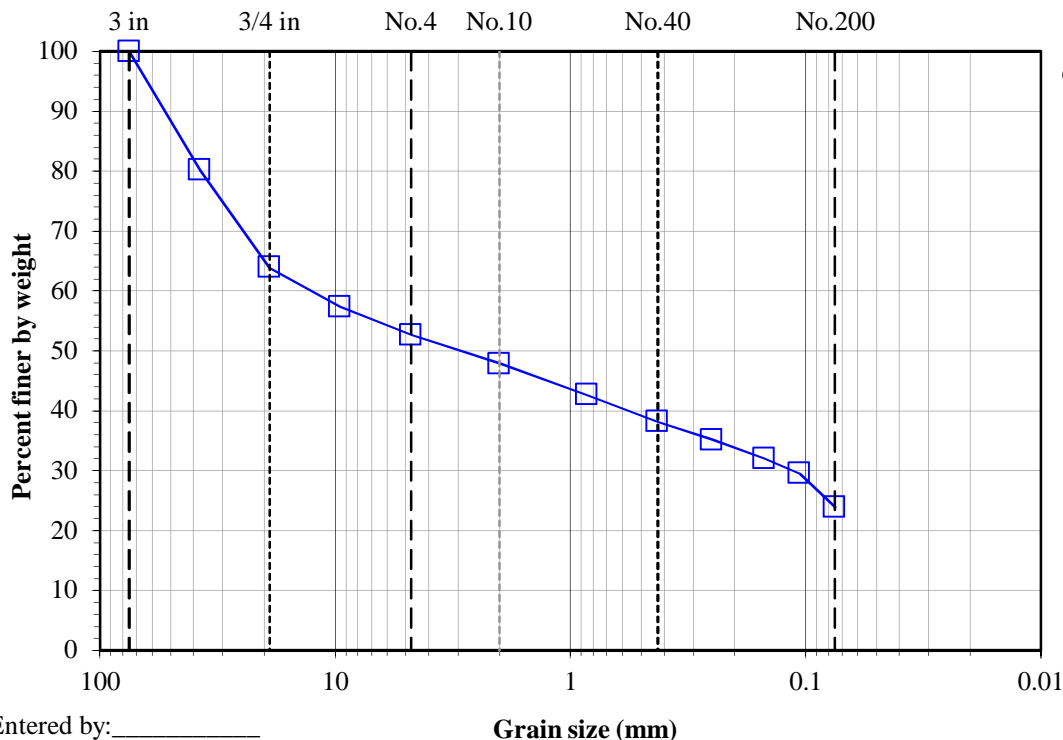
**Depth: 8.0'**

**Description: Brown clayey gravel with sand**

|   |   |                              |
|---|---|------------------------------|
| Split: <b>Yes</b><br>Split sieve: <b>3/8"</b><br>Moist            Dry<br>Total sample wt. (g): <b>4007.14</b> <b>3663.47</b><br>+3/8" Coarse fraction (g): <b>1633.40</b> <b>1562.51</b><br>-3/8" Split fraction (g): <b>307.79</b> <b>272.42</b><br><br>Split fraction: <b>0.573</b> | <u>Water content data</u> C.F.(+3/8") S.F.(-3/8") |                              |
|   | Moist soil + tare (g):                            | <b>2456.50</b> <b>468.03</b> |
|   | Dry soil + tare (g):                              | <b>2388.17</b> <b>432.66</b> |
|   | Tare (g):   | <b>882.10</b> <b>160.24</b>  |
|   | Water content (%):                                | <b>4.5</b> <b>13.0</b>       |

| Sieve  | Accum. Wt. Ret. (g) | Grain Size (mm) | Percent Finer |
|--------|---------------------|-----------------|---------------|
| 8"     | -                   | 200             | -             |
| 6"     | -                   | 150             | -             |
| 4"     | -                   | 100             | -             |
| 3"     | -                   | 75              | 100.0         |
| 1.5"   | <b>726.92</b>       | 37.5            | 80.2          |
| 3/4"   | <b>1322.88</b>      | 19              | 63.9          |
| 3/8"   | <b>1562.51</b>      | 9.5             | 57.3          |
| No.4   | <b>22.24</b>        | 4.75            | 52.7          |
| No.10  | <b>45.10</b>        | 2               | 47.9          |
| No.20  | <b>69.84</b>        | 0.85            | 42.6          |
| No.40  | <b>91.08</b>        | 0.425           | 38.2          |
| No.60  | <b>105.62</b>       | 0.25            | 35.1          |
| No.100 | <b>120.36</b>       | 0.15            | 32.0          |
| No.140 | <b>132.19</b>       | 0.106           | 29.5          |
| No.200 | <b>158.96</b>       | 0.075           | 23.9          |

←Split



**Gravel (%): 47.3**  
**Sand (%): 28.8**  
**Fines (%): 23.9**

Entered by: \_\_\_\_\_  
 Reviewed: \_\_\_\_\_

**Grain size (mm)**

# Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/11/2018**

**By: EH/JP**

**Boring No.: TP-9**

**Station: 12**

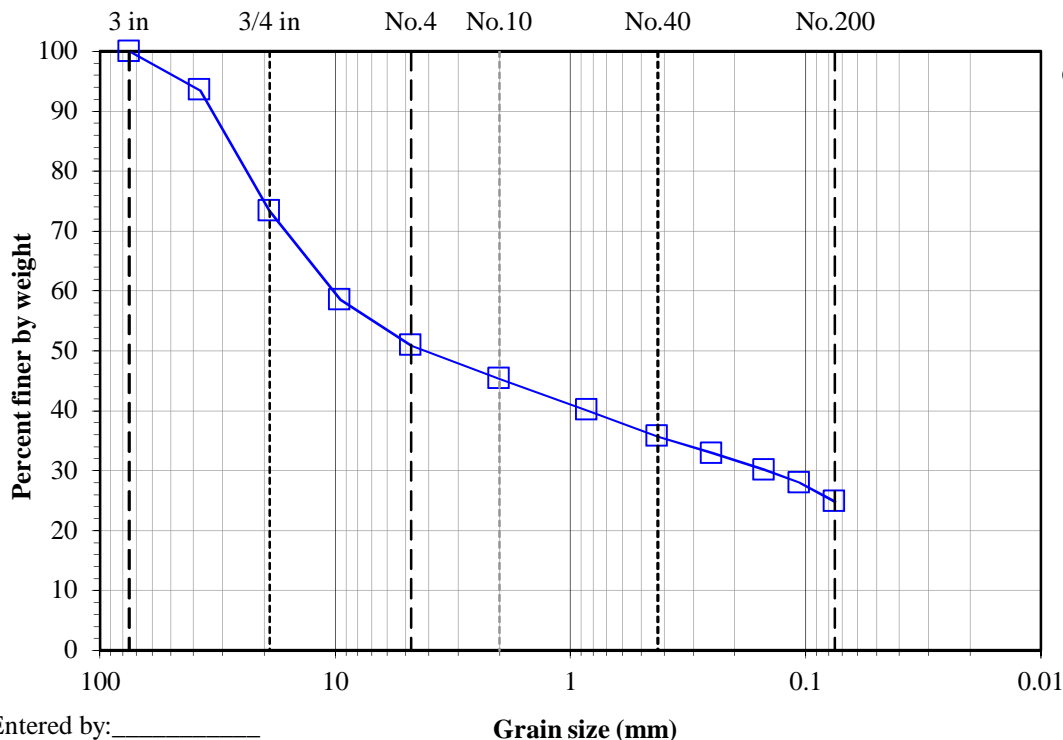
**Depth: 8.0'**

**Description: Reddish brown clayey gravel with sand**

|  |                                     |                                       |               |
|--|-------------------------------------|---------------------------------------|---------------|
| Split: <b>Yes</b><br>Split sieve: <b>#4</b><br>Moist<br>Total sample wt. (g): <b>3345.81</b><br>+#4 Coarse fraction (g): <b>1576.79</b><br>-#4 Split fraction (g): <b>221.41</b><br>Split fraction: <b>0.509</b> | Dry<br>3087.15<br>1516.44<br>196.59 | <b>Water content data</b>             |               |
|  |                                     | C.F.(+#4)                             | S.F.(−#4)     |
|  |                                     | Moist soil + tare (g): <b>1800.26</b> | <b>345.11</b> |
|  |                                     | Dry soil + tare (g): <b>1739.91</b>   | <b>320.29</b> |
|  |                                     | Tare (g): <b>223.47</b>               | <b>123.70</b> |
|  |                                     | Water content (%): <b>4.0</b>         | <b>12.6</b>   |

| Sieve  | Accum. Wt. Ret. (g) | Grain Size (mm) | Percent Finer |
|--------|---------------------|-----------------|---------------|
| 8"     | -                   | 200             | -             |
| 6"     | -                   | 150             | -             |
| 4"     | -                   | 100             | -             |
| 3"     | -                   | 75              | 100.0         |
| 1.5"   | 201.06              | 37.5            | 93.5          |
| 3/4"   | 821.43              | 19              | 73.4          |
| 3/8"   | 1280.65             | 9.5             | 58.5          |
| No.4   | 1516.44             | 4.75            | 50.9          |
| No.10  | 21.41               | 2               | 45.3          |
| No.20  | 41.74               | 0.85            | 40.1          |
| No.40  | 58.64               | 0.425           | 35.7          |
| No.60  | 69.55               | 0.25            | 32.9          |
| No.100 | 80.26               | 0.15            | 30.1          |
| No.140 | 88.56               | 0.106           | 28.0          |
| No.200 | 100.50              | 0.075           | 24.9          |

←Split



Entered by: \_\_\_\_\_  
Reviewed: \_\_\_\_\_

# Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/11/2018**

**By: DKS/BSS**

**Boring No.: TP-17**

**Station: 19.5**

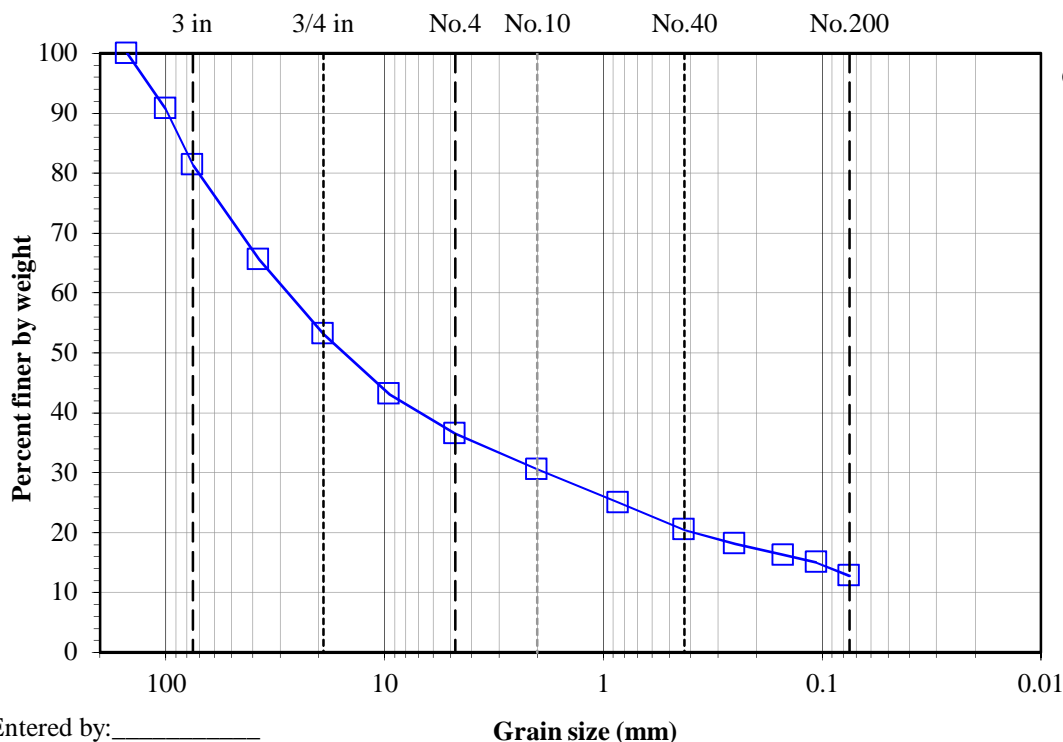
**Depth: 5.0'**

**Description: Reddish brown clayey gravel with sand**

|   |   |                             |
|---|---|-----------------------------|
| Split: <b>Yes</b><br>Split sieve: <b>3/8"</b><br>Moist            Dry<br>Total sample wt. (g): <b>29867.3</b> <b>28605.59</b><br>+3/8" Coarse fraction (g): <b>16499.6</b> <b>16285.86</b><br>-3/8" Split fraction (g): <b>507.17</b> <b>467.41</b><br>Split fraction: <b>0.431</b> | <u>Water content data</u> C.F.(+3/8") S.F.(-3/8") |                             |
|   | Moist soil + tare (g):                            | <b>5786.0</b> <b>700.76</b> |
|   | Dry soil + tare (g):                              | <b>5718.0</b> <b>661.00</b> |
|   | Tare (g):   | <b>536.7</b> <b>193.59</b>  |
|   | Water content (%):                                | <b>1.3</b> <b>8.5</b>       |

| Sieve  | Accum. Wt. Ret. (g) | Grain Size (mm) | Percent Finer |
|--------|---------------------|-----------------|---------------|
| 8"     | -                   | 200             | -             |
| 6"     | -                   | 150             | 100.0         |
| 4"     | 2648.9              | 100             | 90.7          |
| 3"     | 5348.1              | 75              | 81.3          |
| 1.5"   | 9847.1              | 37.5            | 65.6          |
| 3/4"   | 13406.2             | 19              | 53.1          |
| 3/8"   | 16285.9             | 9.5             | 43.1          |
| No.4   | 71.26               | 4.75            | 36.5          |
| No.10  | 135.91              | 2               | 30.5          |
| No.20  | 196.50              | 0.85            | 25.0          |
| No.40  | 245.62              | 0.425           | 20.4          |
| No.60  | 270.94              | 0.25            | 18.1          |
| No.100 | 291.25              | 0.15            | 16.2          |
| No.140 | 305.06              | 0.106           | 15.0          |
| No.200 | 328.60              | 0.075           | 12.8          |

←Split



**Gravel (%): 63.5**  
**Sand (%): 23.7**  
**Fines (%): 12.8**

Entered by: \_\_\_\_\_  
 Reviewed: \_\_\_\_\_

**Grain size (mm)**

# Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/11/2018**

**By: DKS/JP**

**Boring No.: TP-20**

**Station: 26**

**Depth: 9.0'**

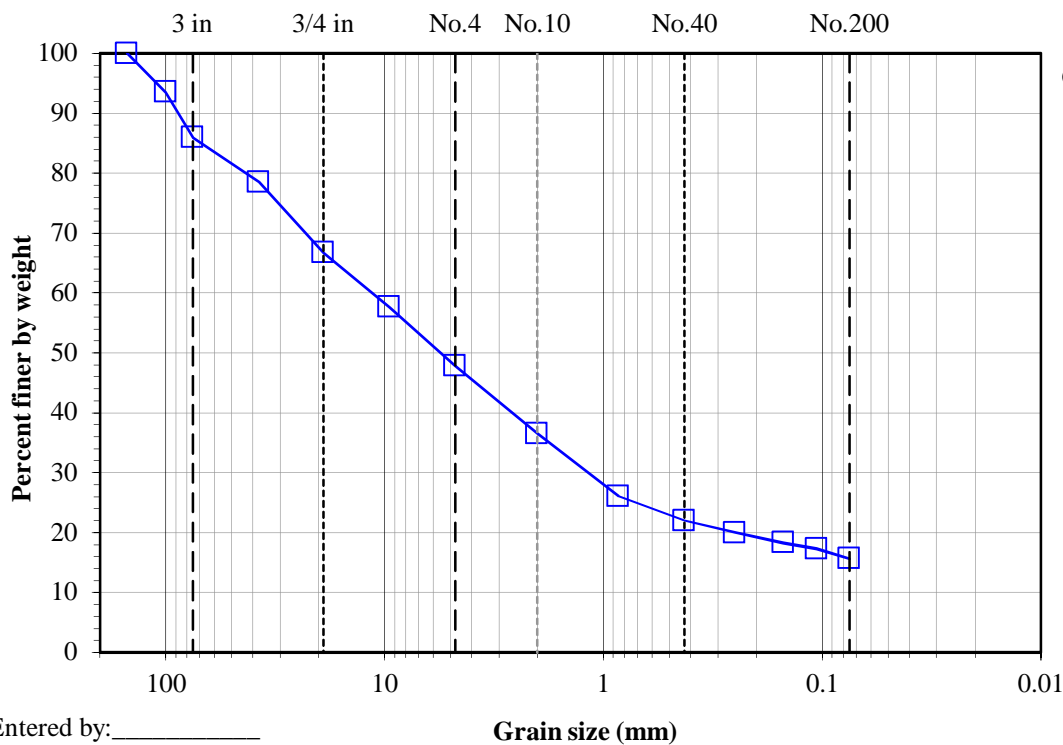
**Description: Reddish brown clayey gravel with sand**

|   |  |                 |  |     |  |
|---|--|-----------------|--|-----|--|
| Split: <b>Yes</b>                         |  | Moist           |  | Dry |  |
| Split sieve: <b>3/8"</b>                  |  |                 |  |     |  |
| Total sample wt. (g): <b>29065.99</b>     |  | <b>26751.34</b> |  |     |  |
| +3/8" Coarse fraction (g): <b>11853.2</b> |  | <b>11342.34</b> |  |     |  |
| -3/8" Split fraction (g): <b>341.91</b>   |  | <b>306.08</b>   |  |     |  |
| Split fraction: <b>0.576</b>              |  |                 |  |     |  |

|                           |                |               |
|---------------------------|----------------|---------------|
| <u>Water content data</u> |                |               |
| C.F.(+3/8")               | S.F.(-3/8")    |               |
| Moist soil + tare (g):    | <b>13882.9</b> | <b>564.14</b> |
| Dry soil + tare (g):      | <b>13344.8</b> | <b>528.31</b> |
| Tare (g):                 | <b>1397.5</b>  | <b>222.23</b> |
| Water content (%):        | <b>4.5</b>     | <b>11.7</b>   |

| Sieve  | Accum. Wt. Ret. (g) | Grain Size (mm) | Percent Finer |
|--------|---------------------|-----------------|---------------|
| 8"     | -                   | 200             | -             |
| 6"     | -                   | 150             | 100.0         |
| 4"     | 1729.8              | 100             | 93.5          |
| 3"     | 3761.7              | 75              | 85.9          |
| 1.5"   | 5754.0              | 37.5            | 78.5          |
| 3/4"   | 8907.3              | 19              | 66.7          |
| 3/8"   | 11342.3             | 9.5             | 57.6          |
| No.4   | 52.01               | 4.75            | 47.8          |
| No.10  | 112.08              | 2               | 36.5          |
| No.20  | 167.63              | 0.85            | 26.1          |
| No.40  | 189.15              | 0.425           | 22.0          |
| No.60  | 199.95              | 0.25            | 20.0          |
| No.100 | 208.87              | 0.15            | 18.3          |
| No.140 | 214.35              | 0.106           | 17.3          |
| No.200 | 223.02              | 0.075           | 15.6          |

←Split



**Gravel (%): 52.2**  
**Sand (%): 32.2**  
**Fines (%): 15.6**

Entered by: \_\_\_\_\_  
Reviewed: \_\_\_\_\_

**Grain size (mm)**

**Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis**

(ASTM D6913)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/11/2018**

**By: JP**

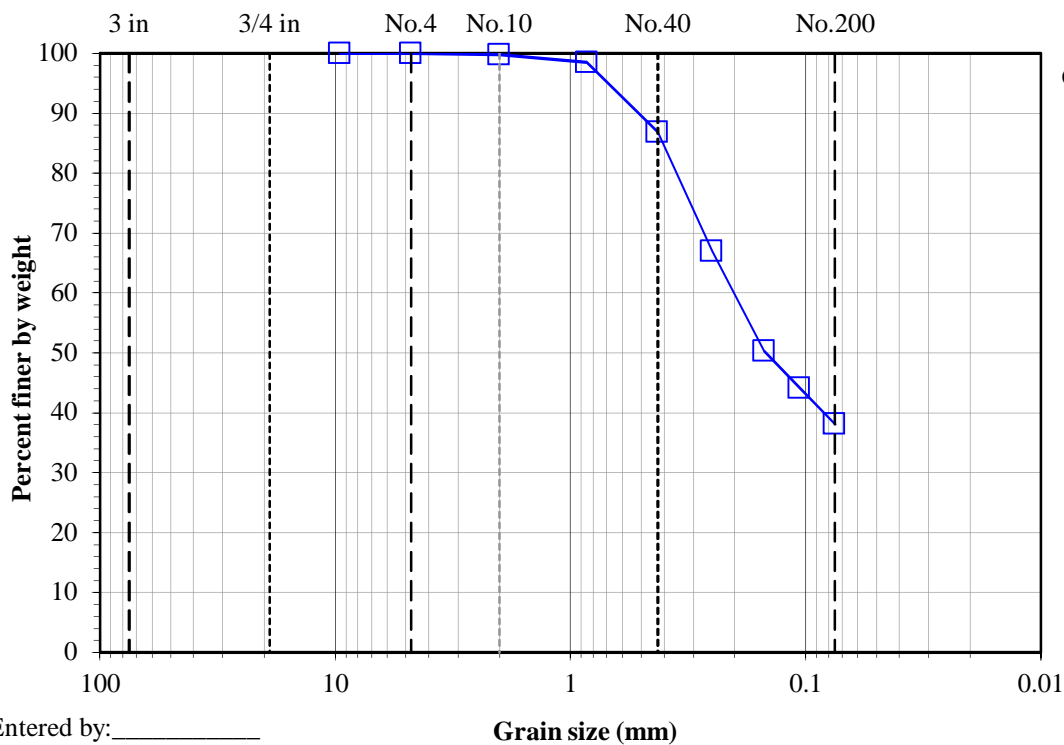
**Boring No.: TP-26**

**Station: 20**

**Depth: 5.5'**

**Description: Reddish brown clayey sand**

| Split: <b>No</b>                    |                     |                 |               | <u>Water content data</u> |          |
|-------------------------------------|---------------------|-----------------|---------------|---------------------------|----------|
| Moist                               |                     | Dry             |               | Moist soil + tare (g):    | - 583.85 |
| Total sample wt. (g): <b>418.47</b> |                     | 366.04          |               | Dry soil + tare (g):      | - 531.42 |
|                                     |                     |                 |               | Tare (g):                 | - 165.38 |
|                                     |                     |                 |               | Water content (%):        | 0.0 14.3 |
| Split fraction: <b>1.000</b>        |                     |                 |               |                           |          |
| Sieve                               | Accum. Wt. Ret. (g) | Grain Size (mm) | Percent Finer |                           |          |
| 8"                                  | -                   | 200             | -             |                           |          |
| 6"                                  | -                   | 150             | -             |                           |          |
| 4"                                  | -                   | 100             | -             |                           |          |
| 3"                                  | -                   | 75              | -             |                           |          |
| 1.5"                                | -                   | 37.5            | -             |                           |          |
| 3/4"                                | -                   | 19              | -             |                           |          |
| 3/8"                                | -                   | 9.5             | 100.0         |                           |          |
| No.4                                | 0.02                | 4.75            | 100.0         |                           |          |
| No.10                               | 0.84                | 2               | 99.8          |                           |          |
| No.20                               | 5.52                | 0.85            | 98.5          |                           |          |
| No.40                               | 48.22               | 0.425           | 86.8          |                           |          |
| No.60                               | 120.91              | 0.25            | 67.0          |                           |          |
| No.100                              | 182.00              | 0.15            | 50.3          |                           |          |
| No.140                              | 204.57              | 0.106           | 44.1          |                           |          |
| No.200                              | 226.62              | 0.075           | 38.1          |                           |          |



**Gravel (%): 0.0**  
**Sand (%): 61.9**  
**Fines (%): 38.1**

Entered by: \_\_\_\_\_  
Reviewed: \_\_\_\_\_

# Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/11/2018**

**By: JP**

**Boring No.: TP-34**

**Station: 13**

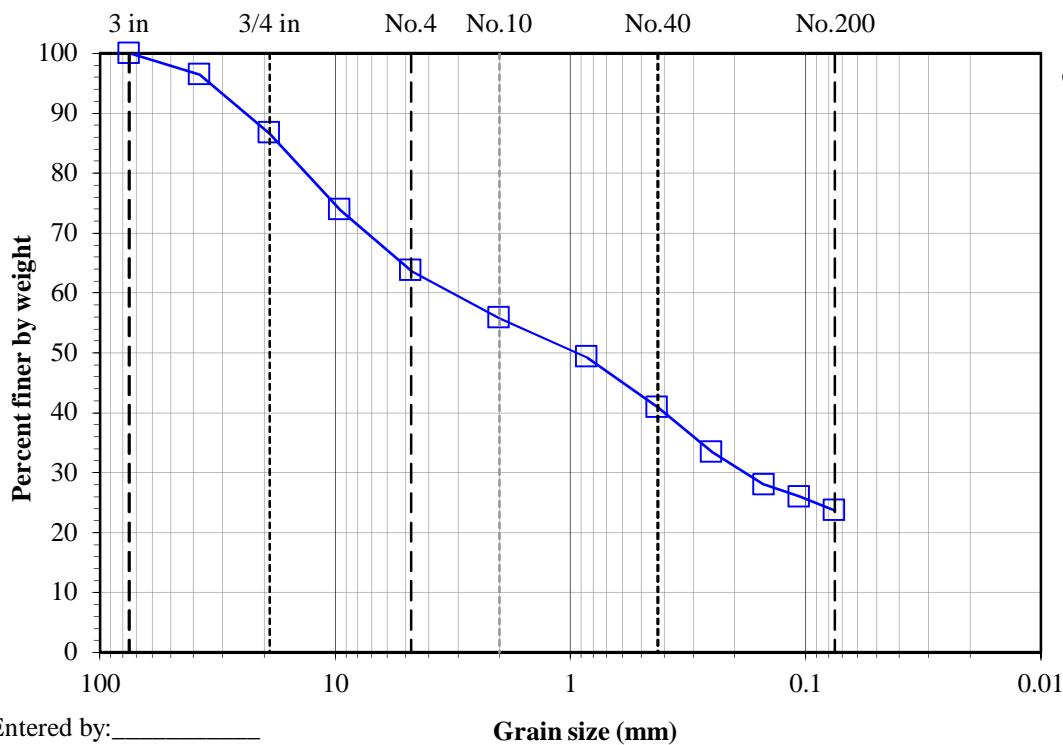
**Depth: 10.0'**

**Description: Reddish brown clayey sand with gravel**

|   |                           |                |                    |                    |
|---|---------------------------|----------------|--------------------|--------------------|
| Split: <b>Yes</b><br>Split sieve: <b>3/8"</b><br>Moist            Dry<br>Total sample wt. (g): <b>4125.79</b> 3800.12<br>+3/8" Coarse fraction (g): <b>1008.38</b> 993.32<br>-3/8" Split fraction (g): <b>236.15</b> 212.62<br><br>Split fraction: <b>0.739</b> | <b>Water content data</b> |                | <b>C.F.(+3/8")</b> | <b>S.F.(-3/8")</b> |
|   | Moist soil + tare (g):    | <b>1806.74</b> | <b>407.42</b>      |                    |
|   | Dry soil + tare (g):      | <b>1790.75</b> | <b>383.89</b>      |                    |
|   | Tare (g):                 | <b>735.75</b>  | <b>171.27</b>      |                    |
|   | Water content (%):        | <b>1.5</b>     | <b>11.1</b>        |                    |

| Sieve  | Accum. Wt. Ret. (g) | Grain Size (mm) | Percent Finer |
|--------|---------------------|-----------------|---------------|
| 8"     | -                   | 200             | -             |
| 6"     | -                   | 150             | -             |
| 4"     | -                   | 100             | -             |
| 3"     | -                   | 75              | 100.0         |
| 1.5"   | 137.37              | 37.5            | 96.4          |
| 3/4"   | 506.12              | 19              | 86.7          |
| 3/8"   | 993.32              | 9.5             | 73.9          |
| No.4   | 29.29               | 4.75            | 63.7          |
| No.10  | 52.03               | 2               | 55.8          |
| No.20  | 70.73               | 0.85            | 49.3          |
| No.40  | 94.91               | 0.425           | 40.9          |
| No.60  | 116.40              | 0.25            | 33.4          |
| No.100 | 132.09              | 0.15            | 28.0          |
| No.140 | 137.93              | 0.106           | 25.9          |
| No.200 | 144.40              | 0.075           | 23.7          |

←Split



**Gravel (%): 36.3**  
**Sand (%): 40.0**  
**Fines (%): 23.7**

Entered by: \_\_\_\_\_  
 Reviewed: \_\_\_\_\_

**Grain size (mm)**



# Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/12/2018**

**By: JP/BSS**

**Boring No.: TP-36**

**Station: 7**

**Depth: 6.0'**

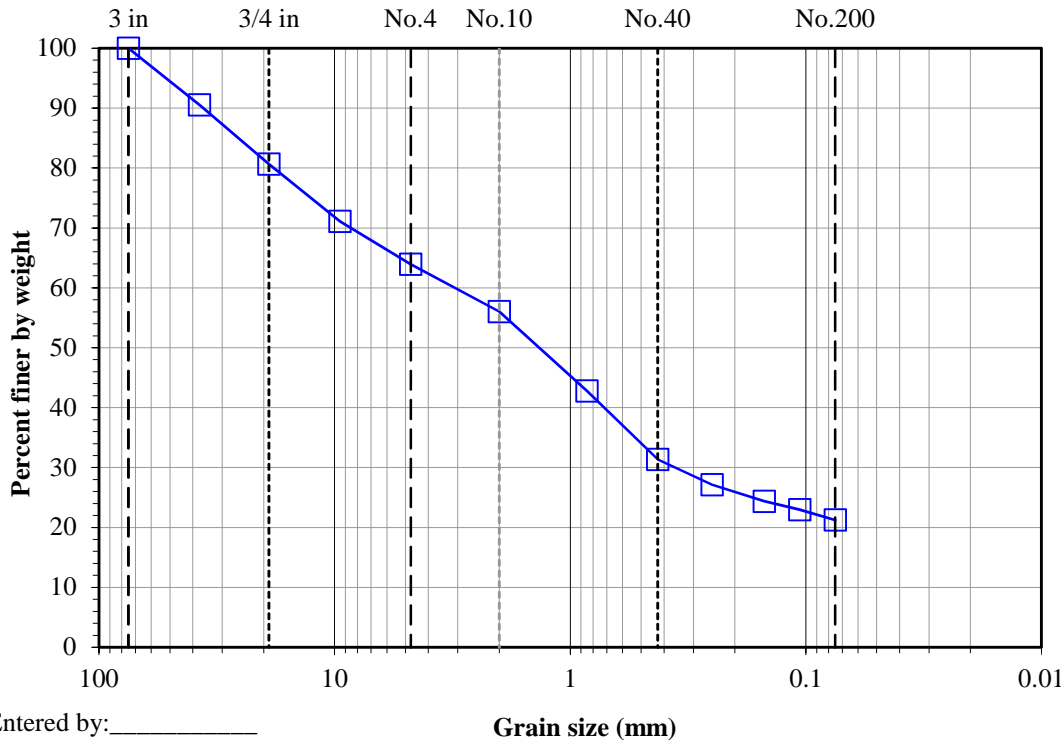
**Description: Reddish brown clayey sand with gravel**

| Sieve  | Accum. Wt. Ret. (g) | Grain Size (mm) | Percent Finer |
|--------|---------------------|-----------------|---------------|
| 8"     | -                   | 200             | -             |
| 6"     | -                   | 150             | -             |
| 4"     | -                   | 100             | -             |
| 3"     | -                   | 75              | 100.0         |
| 1.5"   | 1945.7              | 37.5            | 90.5          |
| 3/4"   | 3983.0              | 19              | 80.7          |
| 3/8"   | 5953.3              | 9.5             | 71.1          |
| No.4   | 30.07               | 4.75            | 63.9          |
| No.10  | 63.12               | 2               | 56.1          |
| No.20  | 118.75              | 0.85            | 42.8          |
| No.40  | 166.79              | 0.425           | 31.4          |
| No.60  | 184.66              | 0.25            | 27.1          |
| No.100 | 196.31              | 0.15            | 24.3          |
| No.140 | 202.03              | 0.106           | 23.0          |
| No.200 | 209.37              | 0.075           | 21.2          |

| Water content data     |             |             |
|------------------------|-------------|-------------|
|                        | C.F.(+3/8") | S.F.(-3/8") |
| Moist soil + tare (g): | 3078.02     | 427.03      |
| Dry soil + tare (g):   | 3018.56     | 409.21      |
| Tare (g):              | 741.46      | 123.33      |
| Water content (%):     | 2.6         | 6.2         |

Split: **Yes**  
 Split sieve: **3/8"**  
 Moist Total sample wt. (g): **21656.2**  
 Dry Total sample wt. (g): **20588.48**  
 +3/8" Coarse fraction (g): **6108.8**  
 -3/8" Split fraction (g): **317.17**  
 Split fraction: **0.711**

←Split



Entered by: \_\_\_\_\_  
 Reviewed: \_\_\_\_\_

# Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

**Project: Bobcat Ridge**

**Boring No.: TP-46**

**No: 01628-028**

**Station: 6**

**Location: Powder Mountain, Weber Co., UT**

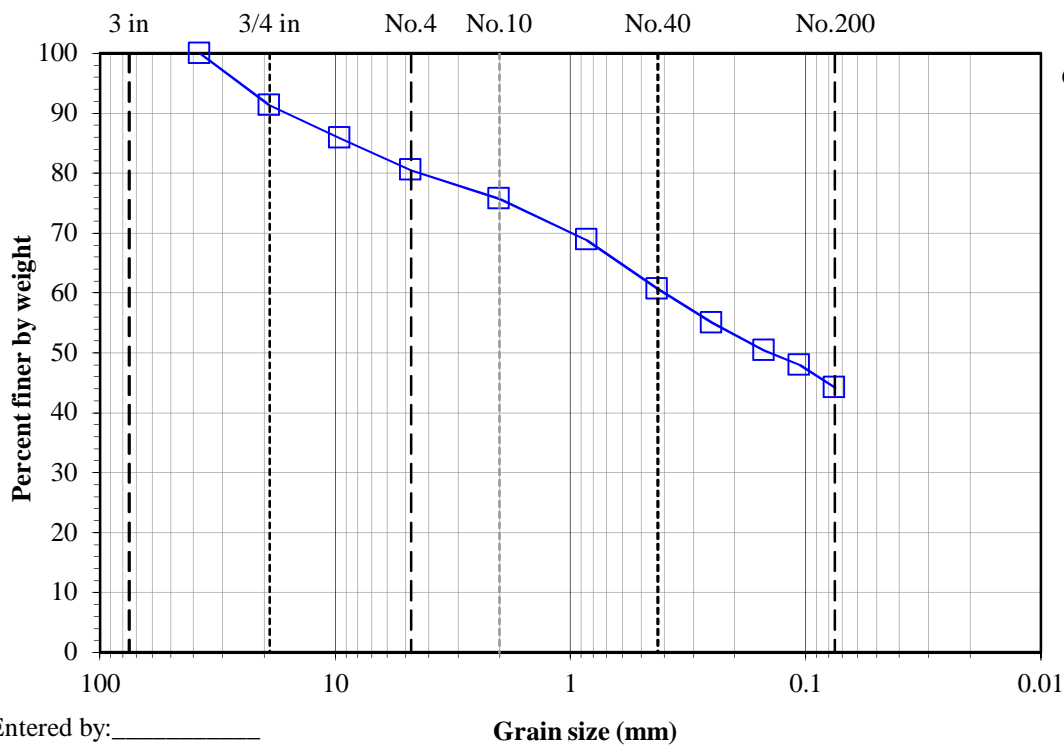
**Depth: 4.5'**

**Date: 7/11/2018**

**Description: Reddish brown clayey sand with gravel**

**By: BSS/JP**

| Split: <b>Yes</b><br>Split sieve: <b>3/8"</b>                                       |                     | Moist      Dry<br>Total sample wt. (g): <b>3948.41</b> <b>3469.56</b>   |               | <u>Water content data</u> C.F.(+3/8") S.F.(-3/8")<br>Moist soil + tare (g): <b>834.67</b> <b>451.21</b><br>Dry soil + tare (g): <b>820.60</b> <b>407.47</b><br>Tare (g): <b>288.36</b> <b>127.92</b><br>Water content (%): <b>2.6</b> <b>15.6</b> |  |
|---|---------------------|---|---------------|---|--|
| +3/8" Coarse fraction (g): <b>505.32</b><br>-3/8" Split fraction (g): <b>323.29</b> |                     | +3/8" Coarse fraction (g): <b>505.32</b> <b>492.31</b><br>-3/8" Split fraction (g): <b>323.29</b> <b>279.55</b> |               |   |  |
| Split fraction: <b>0.858</b>  |                     |   |               |   |  |
| Sieve   | Accum. Wt. Ret. (g) | Grain Size (mm)   | Percent Finer |   |  |
| 8"  | -                   | 200   | -             |   |  |
| 6"  | -                   | 150   | -             |   |  |
| 4"  | -                   | 100   | -             |   |  |
| 3"  | -                   | 75  | -             |   |  |
| 1.5"  | -                   | 37.5  | 100.0         |   |  |
| 3/4"  | <b>301.04</b>       | 19  | 91.3          |   |  |
| 3/8"  | <b>492.31</b>       | 9.5   | 85.8          | ←Split  |  |
| No.4  | <b>17.42</b>        | 4.75  | 80.5          |   |  |
| No.10   | <b>32.99</b>        | 2   | 75.7          |   |  |
| No.20   | <b>55.26</b>        | 0.85  | 68.8          |   |  |
| No.40   | <b>81.86</b>        | 0.425   | 60.7          |   |  |
| No.60   | <b>100.45</b>       | 0.25  | 55.0          |   |  |
| No.100  | <b>115.34</b>       | 0.15  | 50.4          |   |  |
| No.140  | <b>123.33</b>       | 0.106   | 48.0          |   |  |
| No.200  | <b>135.51</b>       | 0.075   | 44.2          |   |  |



**Gravel (%): 19.5**  
**Sand (%): 36.2**  
**Fines (%): 44.2**

Entered by: \_\_\_\_\_  
 Reviewed: \_\_\_\_\_

**Grain size (mm)**

**Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis**

(ASTM D6913)

**Project: Bobcat Ridge**

**Boring No.: TP-53B**

**No: 01628-028**

**Station: 5**

**Location: Powder Mountain, Weber Co., UT**

**Depth: 10.0'**

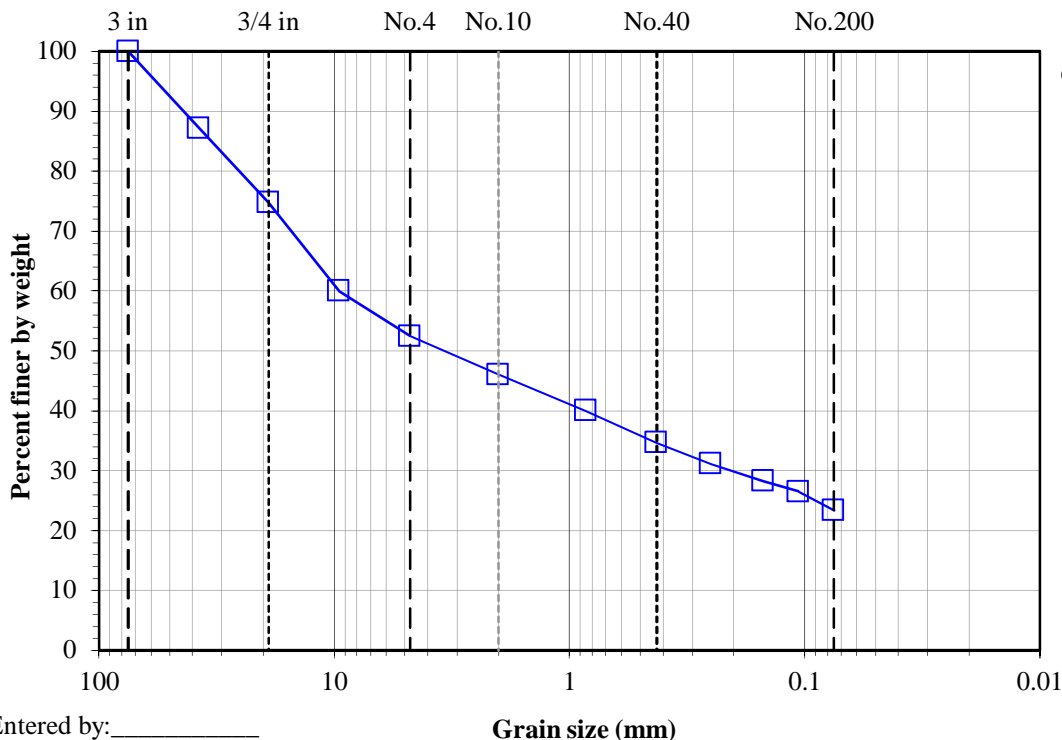
**Date: 7/11/2018**

**Description: Reddish brown clayey gravel with sand**

**By: BSS/JP**

|   |   |                              |
|---|---|------------------------------|
| Split: <b>Yes</b><br>Split sieve: <b>3/8"</b><br>Moist            Dry<br>Total sample wt. (g): <b>3414.3</b> <b>3267.89</b><br>+3/8" Coarse fraction (g): <b>1321.2</b> <b>1307.57</b><br>-3/8" Split fraction (g): <b>512.48</b> <b>479.97</b><br><br>Split fraction: <b>0.600</b> | <b>Water content data C.F.(+3/8") S.F.(-3/8")</b> |                              |
|   | Moist soil + tare (g):                            | <b>1536.56</b> <b>654.21</b> |
|   | Dry soil + tare (g):                              | <b>1522.93</b> <b>621.70</b> |
|   | Tare (g):   | <b>215.34</b> <b>141.73</b>  |
|   | Water content (%):                                | <b>1.0</b> <b>6.8</b>        |

| Sieve  | Accum. Wt. Ret. (g) | Grain Size (mm) | Percent Finer |
|--------|---------------------|-----------------|---------------|
| 8"     | -                   | 200             | -             |
| 6"     | -                   | 150             | -             |
| 4"     | -                   | 100             | -             |
| 3"     | -                   | 75              | 100.0         |
| 1.5"   | 419.0               | 37.5            | 87.2          |
| 3/4"   | 825.5               | 19              | 74.7          |
| 3/8"   | 1307.6              | 9.5             | 60.0 ← Split  |
| No.4   | 60.48               | 4.75            | 52.4          |
| No.10  | 111.71              | 2               | 46.0          |
| No.20  | 160.12              | 0.85            | 40.0          |
| No.40  | 202.97              | 0.425           | 34.6          |
| No.60  | 231.14              | 0.25            | 31.1          |
| No.100 | 253.89              | 0.15            | 28.3          |
| No.140 | 267.98              | 0.106           | 26.5          |
| No.200 | 292.82              | 0.075           | 23.4          |



**Gravel (%): 47.6**  
**Sand (%): 29.0**  
**Fines (%): 23.4**

Entered by: \_\_\_\_\_  
 Reviewed: \_\_\_\_\_

**Grain size (mm)**

**Amount of Material in Soil Finer than the No. 200 (75µm) Sieve**

(ASTM D1140)

**Project: Bobcat Ridge**  
**No: 01628-028**  
 Location: Powder Mountain, Weber Co., UT  
 Date: 7/10/2018  
 By: BRR/EH/BSS

|  |                       |             |             |             |             |             |             |  |  |
|--|-----------------------|-------------|-------------|-------------|-------------|-------------|-------------|--|--|
| Sample Info.                             | Boring No.            | TP-1        | TP-3        | TP-6        | TP-8        | TP-13       | TP-39       |  |  |
|  | Station               | 16          | 26          | 5           | 6           | 5           | 21          |  |  |
|  | Depth                 | 4.0'        | 9.5'        | 3.5'        | 12.0'       | 4.5'        | 6.5'        |  |  |
|  | Split                 | No          | No          | No          | No          | Yes         | Yes         |  |  |
|  | Split Sieve*          |             |             |             |             | 3/8"        | 3/8"        |  |  |
|  | Method                | B           | B           | B           | B           | B           | B           |  |  |
| Specimen soak time (min)                 |                       | 490         | 430         | 260         | 270         | 430         | 280         |  |  |
| Moist total sample wt. (g)               |                       | 186.88      | 154.45      | 248.36      | 209.43      | 3811.2      | 21189.6     |  |  |
| Moist coarse fraction (g)                |                       |             |             |             |             | 1067.6      | 5546.4      |  |  |
| Moist split fraction + tare (g)          |                       |             |             |             |             | 567.48      | 595.03      |  |  |
| Split fraction tare (g)                  |                       |             |             |             |             | 208.41      | 213.89      |  |  |
| Dry split fraction (g)                   |                       |             |             |             |             | 350.97      | 341.92      |  |  |
| Dry retained No. 200 + tare (g)          |                       | 137.99      | 146.80      | 159.02      | 163.83      | 420.56      | 387.12      |  |  |
| Wash tare (g)                            |                       | 127.90      | 128.58      | 127.49      | 152.69      | 208.41      | 213.89      |  |  |
| No. 200 Dry wt. retained (g)             |                       | 10.09       | 18.22       | 31.53       | 11.14       | 212.15      | 173.23      |  |  |
| Split sieve* Dry wt. retained (g)        |                       |             |             |             |             | 1060.17     | 5455.31     |  |  |
| Dry total sample wt. (g)                 |                       | 121.96      | 103.12      | 200.58      | 144.22      | 3741.85     | 19488.80    |  |  |
| Coarse Fraction                          | Moist soil + tare (g) |             |             |             |             | 1235.24     | 4110.12     |  |  |
|  | Dry soil + tare (g)   |             |             |             |             | 1227.78     | 4047.72     |  |  |
|  | Tare (g)              |             |             |             |             | 167.61      | 310.46      |  |  |
|  | Water content (%)     |             |             |             |             | 0.70        | 1.67        |  |  |
| Split Fraction                           | Moist soil + tare (g) | 314.78      | 283.03      | 375.85      | 362.12      | 567.48      | 595.03      |  |  |
|  | Dry soil + tare (g)   | 249.86      | 231.70      | 328.07      | 296.91      | 559.38      | 555.81      |  |  |
|  | Tare (g)              | 127.90      | 128.58      | 127.49      | 152.69      | 208.41      | 213.89      |  |  |
|  | Water content (%)     | 53.23       | 49.78       | 23.82       | 45.22       | 2.31        | 11.47       |  |  |
| <b>Percent passing split sieve* (%)</b>  |                       |             |             |             |             | <b>71.7</b> | <b>72.0</b> |  |  |
| <b>Percent passing No. 200 sieve (%)</b> |                       | <b>91.7</b> | <b>82.3</b> | <b>84.3</b> | <b>92.3</b> | <b>28.3</b> | <b>35.5</b> |  |  |

Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

# Unconfined Compressive Strength of Cohesive Soils

(ASTM D2166)



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**Project:** Bobcat Ridge

**No:** 01628-028

**Location:** Powder Mountain, Weber Co., UT

**Date:** 7/11/2018

**By:** EH

**Boring No.:** TP-22

**Station:** 18

**Depth:** 10.5'

**Sample Description:** Reddish brown fat clay

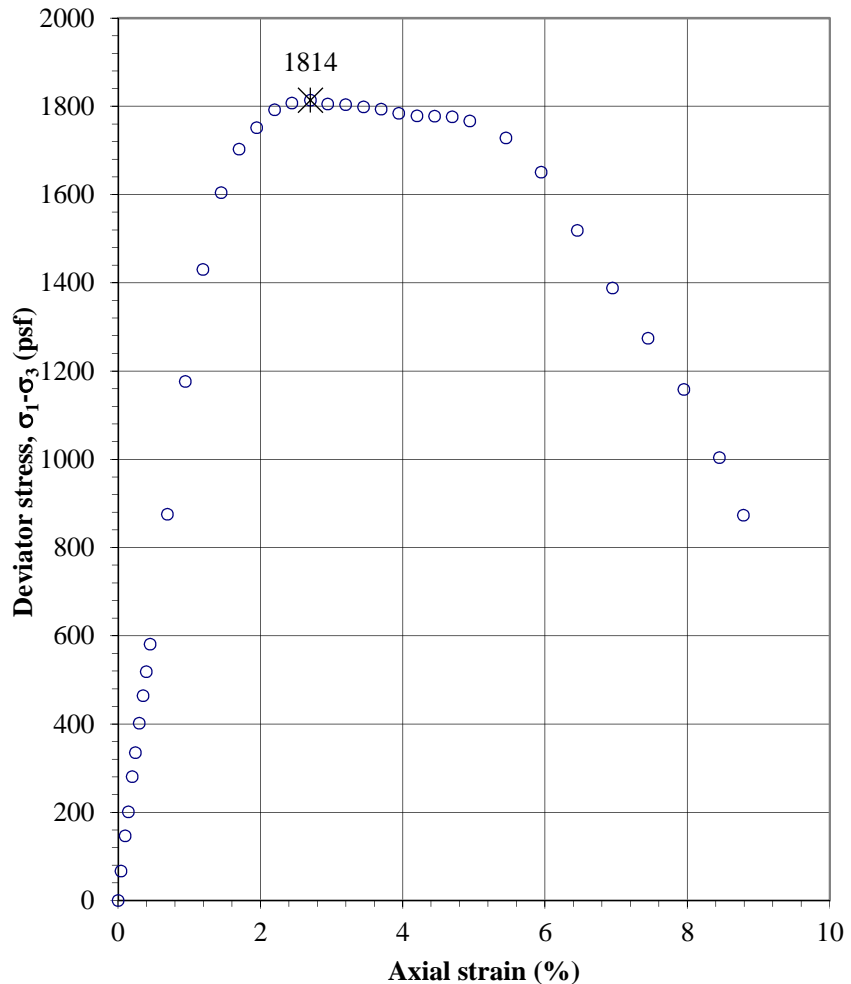
**Sample type:** Undisturbed

|                                     |             |         |
|-------------------------------------|-------------|---------|
| Specific gravity, Gs                | 2.70        | Assumed |
| Sample height, H (in.)              | 5.444       |         |
| Sample diameter, D (in.)            | 2.414       |         |
| Sample volume, V (ft <sup>3</sup> ) | 0.0144      |         |
| Wt. rings + wet soil (g)            | 793.30      |         |
| Wt. rings/tare (g)                  | 0.00        |         |
| Moist soil, Ws (g)                  | 793.30      |         |
| Moist unit wt., $\gamma_m$ (pcf)    | 121.3       |         |
| Dry unit wt., $\gamma_d$ (pcf)      | <b>96.1</b> |         |
| Saturation (%)                      | 93.5        |         |
| Void ratio, e                       | 0.76        |         |



|  |             |
|--|-------------|
| Wet soil + tare (g)  | 694.50      |
| Dry soil + tare (g)  | 576.07      |
| Tare (g)   | 124.45      |
| Water content, w (%)   | <b>26.2</b> |
| Strain rate (%/min)  | 2.0         |
| Strain at failure, $\epsilon_f$ (%)                                | 2.70        |
| Deviator stress at failure, $(\sigma_1 - \sigma_3)_f$ (psf)        | 1814        |
| Shear stress at failure, $q_f = (\sigma_1 - \sigma_3)_f / 2$ (psf) | 907         |

| Axial Strain (%) | $\sigma_d$ ( $\sigma_1 - \sigma_3$ ) (psf) | Q ( $1/2 \sigma_d$ ) (psf) |
|------------------|--|----------------------------|
| 0.00             | 0.0  | 0.0                        |
| 0.04             | 67.2                                       | 33.6                       |
| 0.10             | 146.8                                      | 73.4                       |
| 0.14             | 201.2                                      | 100.6                      |
| 0.20             | 280.7                                      | 140.4                      |
| 0.24             | 335.0                                      | 167.5                      |
| 0.30             | 401.8                                      | 200.9                      |
| 0.35             | 464.3                                      | 232.2                      |
| 0.40             | 518.4                                      | 259.2                      |
| 0.45             | 580.8                                      | 290.4                      |
| 0.69             | 875.3                                      | 437.7                      |
| 0.95             | 1176.6                                     | 588.3                      |
| 1.19             | 1430.6                                     | 715.3                      |
| 1.45             | 1604.5                                     | 802.3                      |
| 1.70             | 1703.2                                     | 851.6                      |
| 1.95             | 1751.9                                     | 876.0                      |
| 2.20             | 1792.1                                     | 896.1                      |
| 2.45             | 1807.5                                     | 903.8                      |
| 2.70             | 1814.3                                     | 907.2                      |
| 2.95             | 1805.1                                     | 902.6                      |
| 3.20             | 1803.9                                     | 902.0                      |
| 3.45             | 1798.6                                     | 899.3                      |
| 3.70             | 1793.4                                     | 896.7                      |
| 3.94             | 1784.1                                     | 892.1                      |
| 4.20             | 1778.7                                     | 889.4                      |
| 4.45             | 1777.6                                     | 888.8                      |
| 4.70             | 1776.4                                     | 888.2                      |
| 4.94             | 1767.1                                     | 883.6                      |
| 5.45             | 1728.6                                     | 864.3                      |
| 5.94             | 1651.1                                     | 825.6                      |
| 6.45             | 1519.0                                     | 759.5                      |
| 6.95             | 1388.4                                     | 694.2                      |
| 7.45             | 1274.6                                     | 637.3                      |
| 7.95             | 1158.0                                     | 579.0                      |
| 8.45             | 1004.1                                     | 502.1                      |
| 8.79             | 873.0                                      | 436.5                      |



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Unconfined Compressive Strength of Cohesive Soils**

(ASTM D2166)



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**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/11/2018**

**By: EH**

**Boring No.: TP-40**

**Station: 14**

**Depth: 5.5'**

**Sample Description: Reddish brown clay**

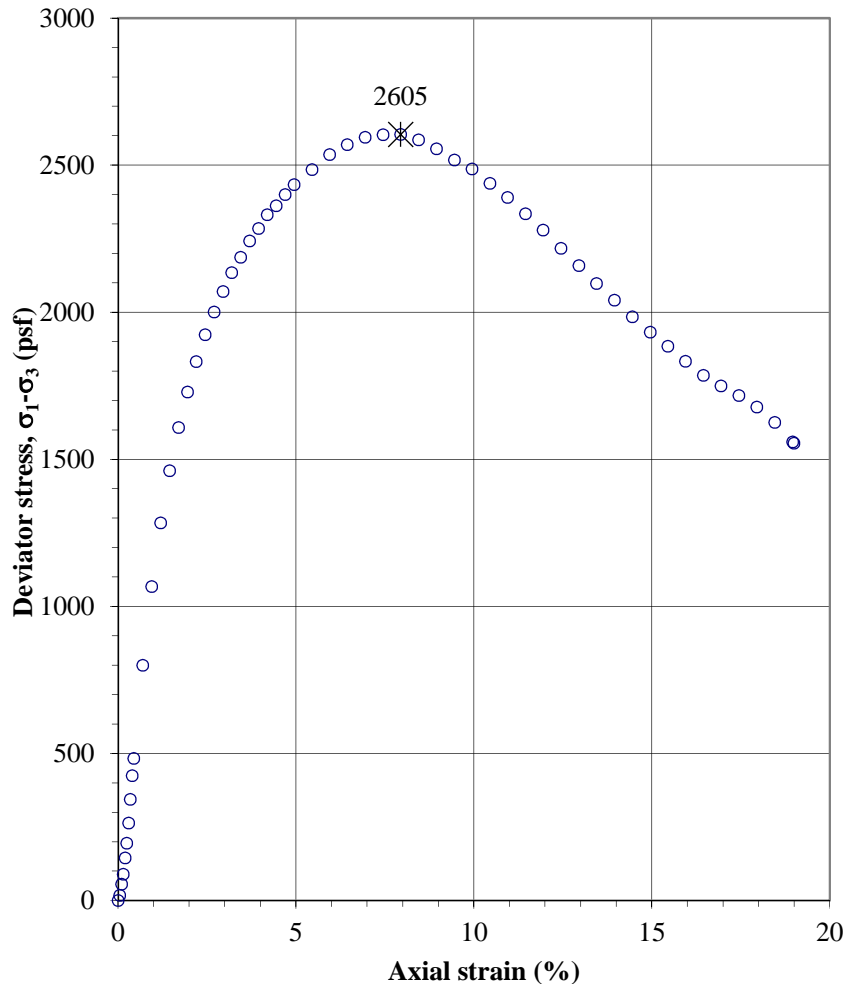
**Sample type: Undisturbed**

|                                      |             |         |
|--------------------------------------|-------------|---------|
| Specific gravity, G <sub>s</sub>     | 2.70        | Assumed |
| Sample height, H (in.)               | 4.573       |         |
| Sample diameter, D (in.)             | 2.397       |         |
| Sample volume, V (ft <sup>3</sup> )  | 0.0119      |         |
| Wt. rings + wet soil (g)             | 638.06      |         |
| Wt. rings/tare (g)                   | 0.00        |         |
| Moist soil, W <sub>s</sub> (g)       | 638.06      |         |
| Moist unit wt., γ <sub>m</sub> (pcf) | 117.8       |         |
| Dry unit wt., γ <sub>d</sub> (pcf)   | <b>91.4</b> |         |
| Saturation (%)                       | 92.0        |         |
| Void ratio, e                        | 0.85        |         |



|   |             |
|---|-------------|
| Wet soil + tare (g)   | 526.88      |
| Dry soil + tare (g)   | 437.61      |
| Tare (g)  | 128.40      |
| Water content, w (%)  | <b>28.9</b> |
| Strain rate (%/min)   | 2.0         |
| Strain at failure, ε <sub>f</sub> (%)   | 7.94        |
| Deviator stress at failure, (σ <sub>1</sub> -σ <sub>3</sub> ) <sub>f</sub> (psf)                  | 2605        |
| Shear stress at failure, q <sub>f</sub> = (σ <sub>1</sub> -σ <sub>3</sub> ) <sub>f</sub> /2 (psf) | 1302        |

| Axial Strain (%) | σ <sub>d</sub> (psf)           | Q (psf)            |
|------------------|--------------------------------|--------------------|
|                  | σ <sub>1</sub> -σ <sub>3</sub> | 1/2 σ <sub>d</sub> |
| 0.00             | 0.0                            | 0.0                |
| 0.05             | 17.0                           | 8.5                |
| 0.10             | 55.3                           | 27.6               |
| 0.15             | 89.2                           | 44.6               |
| 0.20             | 144.5                          | 72.2               |
| 0.25             | 195.4                          | 97.7               |
| 0.30             | 263.3                          | 131.6              |
| 0.35             | 343.8                          | 171.9              |
| 0.40             | 424.3                          | 212.1              |
| 0.44             | 483.5                          | 241.7              |
| 0.70             | 799.6                          | 399.8              |
| 0.95             | 1067.6                         | 533.8              |
| 1.20             | 1283.8                         | 641.9              |
| 1.45             | 1460.9                         | 730.4              |
| 1.70             | 1607.8                         | 803.9              |
| 1.95             | 1728.8                         | 864.4              |
| 2.20             | 1832.6                         | 916.3              |
| 2.45             | 1923.2                         | 961.6              |
| 2.70             | 2001.0                         | 1000.5             |
| 2.95             | 2070.0                         | 1035.0             |
| 3.20             | 2134.6                         | 1067.3             |
| 3.45             | 2186.4                         | 1093.2             |
| 3.70             | 2242.0                         | 1121.0             |
| 3.95             | 2285.0                         | 1142.5             |
| 4.20             | 2331.9                         | 1165.9             |
| 4.44             | 2362.2                         | 1181.1             |
| 4.70             | 2400.3                         | 1200.1             |
| 4.95             | 2434.2                         | 1217.1             |
| 5.45             | 2485.3                         | 1242.6             |
| 5.95             | 2535.7                         | 1267.8             |
| 6.44             | 2569.4                         | 1284.7             |
| 6.95             | 2594.6                         | 1297.3             |
| 7.45             | 2603.7                         | 1301.8             |
| 7.94             | 2604.8                         | 1302.4             |
| 8.45             | 2585.8                         | 1292.9             |
| 8.95             | 2555.4                         | 1277.7             |
| 9.45             | 2517.5                         | 1258.7             |
| 9.95             | 2487.6                         | 1243.8             |
| 10.45            | 2438.7                         | 1219.3             |
| 10.95            | 2390.3                         | 1195.1             |
| 11.45            | 2334.6                         | 1167.3             |
| 11.95            | 2279.4                         | 1139.7             |
| 12.45            | 2217.1                         | 1108.5             |
| 12.95            | 2159.1                         | 1079.5             |
| 13.45            | 2098.0                         | 1049.0             |
| 13.95            | 2041.1                         | 1020.5             |
| 14.45            | 1984.7                         | 992.3              |
| 14.95            | 1932.4                         | 966.2              |
| 15.45            | 1884.3                         | 942.1              |
| 15.95            | 1833.0                         | 916.5              |
| 16.45            | 1785.7                         | 892.8              |
| 16.95            | 1749.5                         | 874.7              |
| 17.45            | 1717.1                         | 858.5              |
| 17.95            | 1677.8                         | 838.9              |
| 18.45            | 1625.1                         | 812.5              |
| 18.95            | 1559.0                         | 779.5              |
| 18.99            | 1554.7                         | 777.3              |



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Unconfined Compressive Strength of Cohesive Soils**

(ASTM D2166)



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**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/11/2018**

**By: EH**

**Boring No.: TP-52**

**Station: 31**

**Depth: 4.5'**

**Sample Description: Reddish brown fat clay**

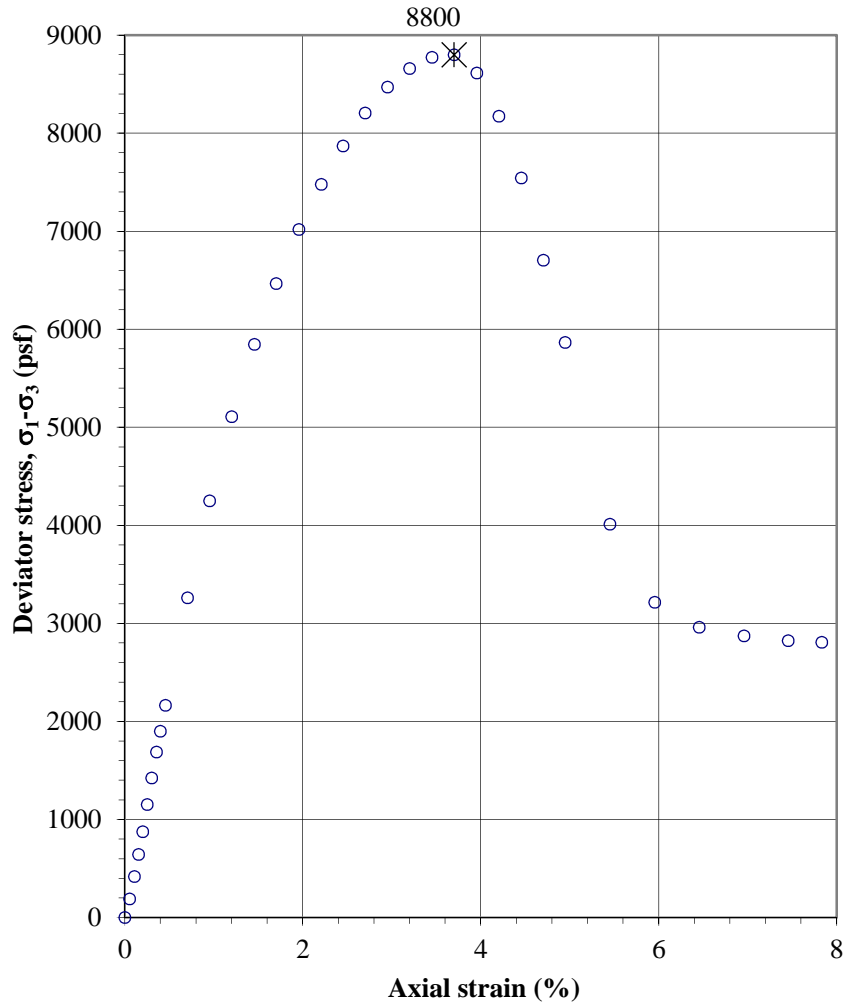
**Sample type: Undisturbed**

|                                     |              |         |
|-------------------------------------|--------------|---------|
| Specific gravity, Gs                | 2.70         | Assumed |
| Sample height, H (in.)              | 5.816        |         |
| Sample diameter, D (in.)            | 2.380        |         |
| Sample volume, V (ft <sup>3</sup> ) | 0.0150       |         |
| Wt. rings + wet soil (g)            | 876.40       |         |
| Wt. rings/tare (g)                  | 0.00         |         |
| Moist soil, Ws (g)                  | 876.40       |         |
| Moist unit wt., $\gamma_m$ (pcf)    | 129.0        |         |
| Dry unit wt., $\gamma_d$ (pcf)      | <b>107.8</b> |         |
| Saturation (%)                      | 93.8         |         |
| Void ratio, e                       | 0.57         |         |



|  |             |
|--|-------------|
| Wet soil + tare (g)  | 598.28      |
| Dry soil + tare (g)  | 520.85      |
| Tare (g)   | 126.66      |
| Water content, w (%)   | <b>19.6</b> |
| Strain rate (%/min)  | 2.0         |
| Strain at failure, $\epsilon_f$ (%)                                | 3.70        |
| Deviator stress at failure, $(\sigma_1 - \sigma_3)_f$ (psf)        | 8800        |
| Shear stress at failure, $q_f = (\sigma_1 - \sigma_3)_f / 2$ (psf) | 4400        |

| Axial Strain (%) | $\sigma_d$ ( $\sigma_1 - \sigma_3$ ) (psf) | Q ( $1/2 \sigma_d$ ) (psf) |
|------------------|--|----------------------------|
| 0.00             | 0.0  | 0.0                        |
| 0.05             | 190.0                                      | 95.0                       |
| 0.11             | 418.7                                      | 209.4                      |
| 0.15             | 643.0                                      | 321.5                      |
| 0.20             | 875.6                                      | 437.8                      |
| 0.25             | 1151.1                                     | 575.5                      |
| 0.30             | 1422.1                                     | 711.0                      |
| 0.36             | 1688.4                                     | 844.2                      |
| 0.40             | 1898.6                                     | 949.3                      |
| 0.45             | 2164.3                                     | 1082.1                     |
| 0.70             | 3261.9                                     | 1630.9                     |
| 0.95             | 4251.0                                     | 2125.5                     |
| 1.20             | 5106.9                                     | 2553.4                     |
| 1.45             | 5847.4                                     | 2923.7                     |
| 1.70             | 6465.5                                     | 3232.7                     |
| 1.95             | 7016.0                                     | 3508.0                     |
| 2.21             | 7479.1                                     | 3739.5                     |
| 2.45             | 7868.8                                     | 3934.4                     |
| 2.70             | 8205.3                                     | 4102.6                     |
| 2.95             | 8468.5                                     | 4234.2                     |
| 3.20             | 8659.4                                     | 4329.7                     |
| 3.45             | 8773.8                                     | 4386.9                     |
| 3.70             | 8800.1                                     | 4400.0                     |
| 3.96             | 8613.5                                     | 4306.7                     |
| 4.20             | 8171.8                                     | 4085.9                     |
| 4.46             | 7541.5                                     | 3770.7                     |
| 4.71             | 6704.4                                     | 3352.2                     |
| 4.95             | 5863.8                                     | 2931.9                     |
| 5.45             | 4010.4                                     | 2005.2                     |
| 5.96             | 3213.8                                     | 1606.9                     |
| 6.45             | 2959.9                                     | 1479.9                     |
| 6.96             | 2873.2                                     | 1436.6                     |
| 7.46             | 2823.6                                     | 1411.8                     |
| 7.83             | 2806.5                                     | 1403.2                     |



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils**

(ASTM D2850)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/11/2018**

**By: EH**

**Boring No.: TP-49**

**Station: 32**

**Depth: 7.5'**

**Sample Description: Reddish brown clay**

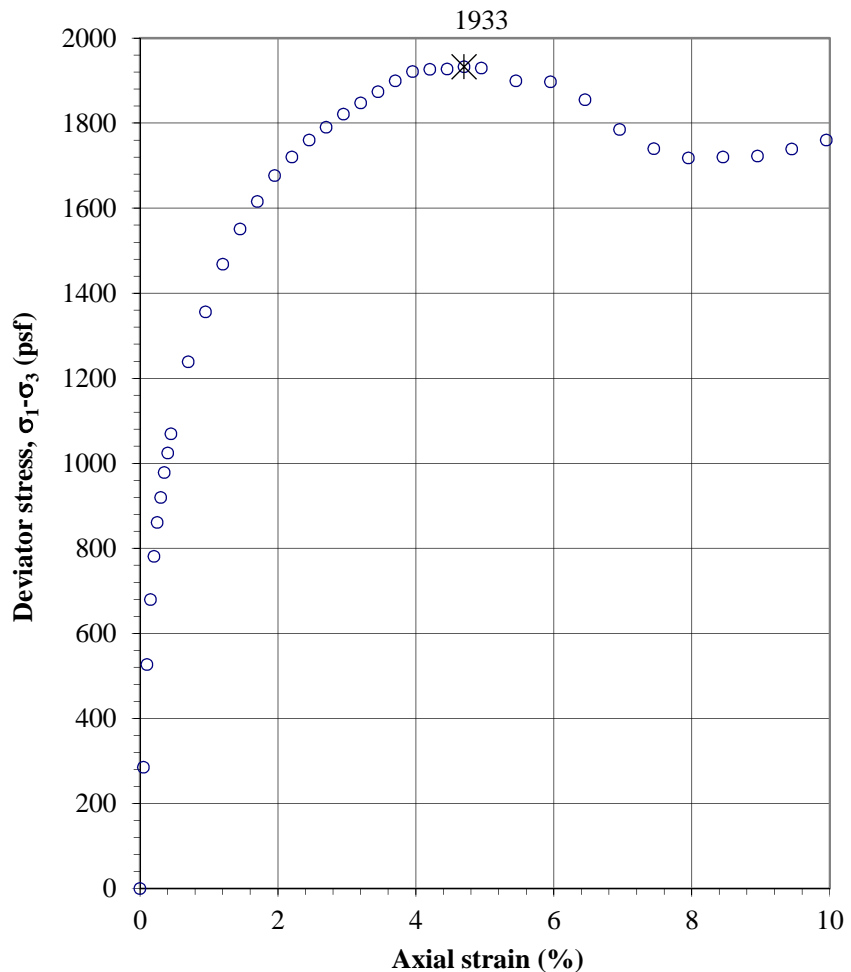
**Sample type: Undisturbed**

|                                      |             |         |
|--------------------------------------|-------------|---------|
| Specific gravity, G <sub>s</sub>     | 2.85        | Assumed |
| Sample height, H (in.)               | 5.257       |         |
| Sample diameter, D (in.)             | 2.398       |         |
| Sample volume, V (ft <sup>3</sup> )  | 0.0137      |         |
| Wt. rings + wet soil (g)             | 755.82      |         |
| Wt. rings/tare (g)                   | 0.00        |         |
| Moist soil, W <sub>s</sub> (g)       | 755.82      |         |
| Moist unit wt., γ <sub>m</sub> (pcf) | 121.3       |         |
| Dry unit wt., γ <sub>d</sub> (pcf)   | <b>91.8</b> |         |
| Saturation (%)                       | 97.2        |         |
| Void ratio, e                        | 0.94        |         |



|   |             |
|---|-------------|
| Wet soil + tare (g)   | 232.34      |
| Dry soil + tare (g)   | 205.55      |
| Tare (g)  | 122.18      |
| Water content, w (%)  | <b>32.1</b> |
| Confining stress, σ <sub>3</sub> (psf)  | 600         |
| Shear rate (in/min)   | 0.0158      |
| Strain at failure, ε <sub>f</sub> (%)   | 4.70        |
| Deviator stress at failure, (σ <sub>1</sub> -σ <sub>3</sub> ) <sub>f</sub> (psf)                  | 1933        |
| Shear stress at failure, q <sub>f</sub> = (σ <sub>1</sub> -σ <sub>3</sub> ) <sub>f</sub> /2 (psf) | 966         |

| Axial Strain (%) | σ <sub>d</sub> (psf)                 | Q (psf)                  |
|------------------|--------------------------------------|--------------------------|
|                  | σ <sub>1</sub> -σ <sub>3</sub> (psf) | 1/2 σ <sub>d</sub> (psf) |
| 0.00             | 0.0                                  | 0.0                      |
| 0.05             | 285.0                                | 142.5                    |
| 0.10             | 527.1                                | 263.5                    |
| 0.15             | 679.6                                | 339.8                    |
| 0.20             | 781.0                                | 390.5                    |
| 0.25             | 861.0                                | 430.5                    |
| 0.30             | 919.6                                | 459.8                    |
| 0.35             | 978.2                                | 489.1                    |
| 0.40             | 1024.0                               | 512.0                    |
| 0.45             | 1069.8                               | 534.9                    |
| 0.70             | 1238.6                               | 619.3                    |
| 0.95             | 1355.9                               | 677.9                    |
| 1.20             | 1468.4                               | 734.2                    |
| 1.45             | 1550.9                               | 775.4                    |
| 1.70             | 1616.2                               | 808.1                    |
| 1.95             | 1676.9                               | 838.4                    |
| 2.20             | 1720.7                               | 860.3                    |
| 2.45             | 1760.0                               | 880.0                    |
| 2.70             | 1790.8                               | 895.4                    |
| 2.95             | 1821.4                               | 910.7                    |
| 3.20             | 1847.7                               | 923.8                    |
| 3.45             | 1873.8                               | 936.9                    |
| 3.70             | 1899.8                               | 949.9                    |
| 3.95             | 1921.4                               | 960.7                    |
| 4.20             | 1926.7                               | 963.3                    |
| 4.45             | 1927.7                               | 963.8                    |
| 4.70             | 1932.8                               | 966.4                    |
| 4.95             | 1929.7                               | 964.8                    |
| 5.45             | 1899.3                               | 949.6                    |
| 5.95             | 1897.2                               | 948.6                    |
| 6.45             | 1855.0                               | 927.5                    |
| 6.95             | 1785.4                               | 892.7                    |
| 7.45             | 1740.0                               | 870.0                    |
| 7.95             | 1718.5                               | 859.2                    |
| 8.45             | 1720.6                               | 860.3                    |
| 8.95             | 1722.4                               | 861.2                    |
| 9.45             | 1739.5                               | 869.7                    |
| 9.95             | 1760.1                               | 880.0                    |
| 10.45            | 1753.6                               | 876.8                    |



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_



# Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/9/2018**

**By: EH**

Test type: **Inundated**

Lateral displacement (in.): **0.3**

Shear rate (in./min): **0.0003**

Specific gravity, Gs: **2.70 Assumed**

**Boring No.: TP-3**

**Station: 26**

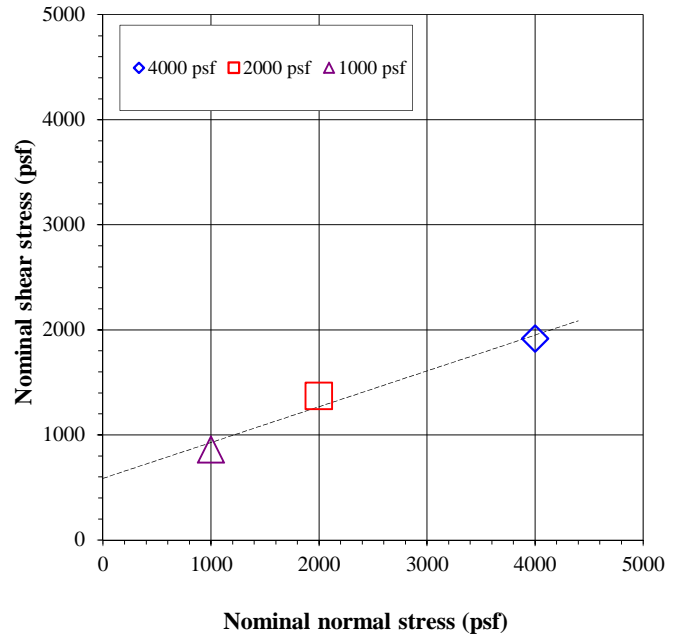
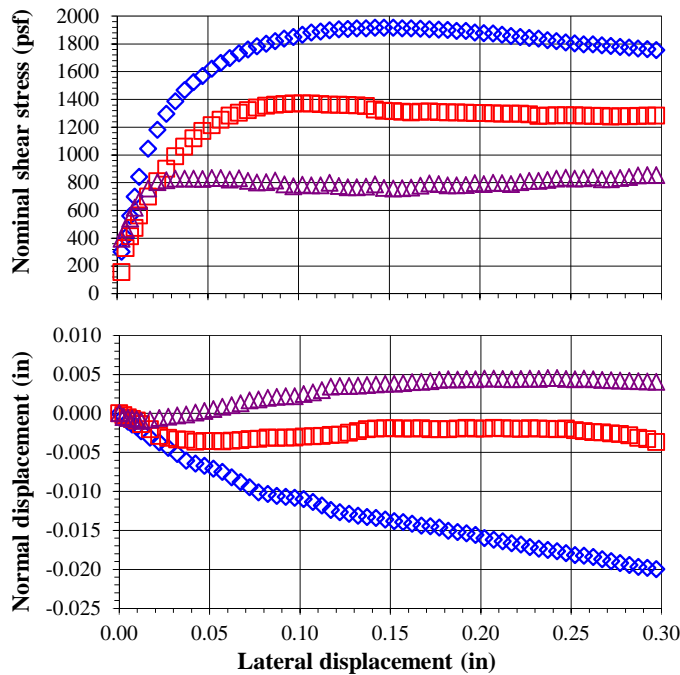
**Depth: 9.5'**

Sample Description: **Reddish brown and grey elastic silt**

Sample type: **Undisturbed-trimmed from thin-wall**

|                                   | Sample 1 |                       | Sample 2 |           | Sample 3  |           |
|-----------------------------------|----------|-----------------------|----------|-----------|-----------|-----------|
| Nominal normal stress (psf)       | 4000     |                       | 2000     |           | 1000      |           |
| Peak shear stress (psf)           | 1916     |                       | 1370     |           | 860       |           |
| Lateral displacement at peak (in) | 0.142    |                       | 0.097    |           | 0.302     |           |
| Load Duration (min)               | 277      |                       | 278      |           | 289       |           |
|                                   | Initial  | Pre-shear             | Initial  | Pre-shear | Initial   | Pre-shear |
| Sample height (in)                | 0.998    | 0.960                 | 1.002    | 0.965     | 0.995     | 0.980     |
| Sample diameter (in)              | 2.427    | 2.427                 | 2.413    | 2.413     | 2.419     | 2.419     |
| Wt. rings + wet soil (g)          | 169.07   | 168.22                | 172.06   | 170.66    | 168.25    | 168.88    |
| Wt. rings (g)                     | 41.98    | 41.98                 | 44.83    | 44.83     | 42.05     | 42.05     |
| Wet soil + tare (g)               | 283.03   |                       | 283.03   |           | 283.03    |           |
| Dry soil + tare (g)               | 231.70   |                       | 231.70   |           | 231.70    |           |
| Tare (g)                          | 128.58   |                       | 128.58   |           | 128.58    |           |
| Water content (%)                 | 49.8     | 48.8                  | 49.8     | 48.1      | 49.8      | 50.5      |
| Dry unit weight (pcf)             | 70.0     | 72.7                  | 70.6     | 73.3      | 70.2      | 71.3      |
| Void ratio, e, for assumed Gs     | 1.41     | 1.32                  | 1.39     | 1.30      | 1.40      | 1.36      |
| Saturation (%)*                   | 95.5     | 100.0                 | 96.9     | 100.0     | 95.9      | 100.0     |
| $\phi'$ (deg)                     | 19       | Average of 3 samples  |          | Initial   | Pre-shear |           |
| c' (psf)                          | 587      | Water content (%)     |          | 49.8      | 49.1      |           |
|                                   |          | Dry unit weight (pcf) |          | 70.3      | 72.4      |           |

\*Pre-shear saturation set to 100% for phase calculations



Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Direct Shear Test for Soils Under Drained Conditions**

(ASTM D3080)

**Project: Bobcat Ridge**

**Boring No.: TP-3**

**No: 01628-028**

**Station: 26**

**Location: Powder Mountain, Weber Co., UT**

**Depth: 9.5'**

| Nominal normal stress = 4000 psf |                            |                           | Nominal normal stress = 2000 psf |                            |                           | Nominal normal stress = 1000 psf |                            |                           |
|----------------------------------|----------------------------|---------------------------|----------------------------------|----------------------------|---------------------------|----------------------------------|----------------------------|---------------------------|
| Lateral Displacement (in.)       | Nominal Shear Stress (psf) | Normal Displacement (in.) | Lateral Displacement (in.)       | Nominal Shear Stress (psf) | Normal Displacement (in.) | Lateral Displacement (in.)       | Nominal Shear Stress (psf) | Normal Displacement (in.) |
| 0.000                            | -10                        | 0.000                     | 0.000                            | -2                         | 0.000                     | 0.000                            | -1                         | 0.000                     |
| 0.002                            | 302                        | 0.000                     | 0.002                            | 155                        | 0.000                     | 0.002                            | 396                        | 0.000                     |
| 0.005                            | 407                        | -0.001                    | 0.005                            | 327                        | -0.001                    | 0.005                            | 465                        | -0.001                    |
| 0.007                            | 560                        | -0.001                    | 0.007                            | 412                        | -0.001                    | 0.007                            | 539                        | -0.001                    |
| 0.010                            | 698                        | -0.002                    | 0.010                            | 473                        | -0.001                    | 0.010                            | 620                        | -0.001                    |
| 0.012                            | 842                        | -0.002                    | 0.012                            | 564                        | -0.001                    | 0.012                            | 667                        | -0.001                    |
| 0.017                            | 1046                       | -0.003                    | 0.017                            | 700                        | -0.002                    | 0.017                            | 757                        | -0.001                    |
| 0.022                            | 1182                       | -0.004                    | 0.022                            | 809                        | -0.003                    | 0.022                            | 803                        | -0.001                    |
| 0.027                            | 1297                       | -0.004                    | 0.027                            | 901                        | -0.003                    | 0.027                            | 816                        | 0.000                     |
| 0.032                            | 1386                       | -0.005                    | 0.032                            | 991                        | -0.003                    | 0.032                            | 829                        | 0.000                     |
| 0.037                            | 1468                       | -0.006                    | 0.037                            | 1060                       | -0.003                    | 0.037                            | 829                        | 0.000                     |
| 0.042                            | 1525                       | -0.006                    | 0.042                            | 1118                       | -0.004                    | 0.042                            | 828                        | 0.000                     |
| 0.047                            | 1568                       | -0.007                    | 0.047                            | 1171                       | -0.004                    | 0.047                            | 827                        | 0.000                     |
| 0.052                            | 1622                       | -0.007                    | 0.052                            | 1213                       | -0.004                    | 0.052                            | 832                        | 0.001                     |
| 0.057                            | 1663                       | -0.007                    | 0.057                            | 1252                       | -0.004                    | 0.057                            | 832                        | 0.001                     |
| 0.062                            | 1698                       | -0.008                    | 0.062                            | 1282                       | -0.004                    | 0.062                            | 822                        | 0.001                     |
| 0.067                            | 1732                       | -0.009                    | 0.067                            | 1303                       | -0.003                    | 0.067                            | 831                        | 0.001                     |
| 0.072                            | 1760                       | -0.009                    | 0.072                            | 1321                       | -0.003                    | 0.072                            | 811                        | 0.002                     |
| 0.077                            | 1783                       | -0.010                    | 0.077                            | 1340                       | -0.003                    | 0.077                            | 800                        | 0.002                     |
| 0.082                            | 1801                       | -0.010                    | 0.082                            | 1354                       | -0.003                    | 0.082                            | 803                        | 0.002                     |
| 0.087                            | 1821                       | -0.011                    | 0.087                            | 1362                       | -0.003                    | 0.087                            | 814                        | 0.002                     |
| 0.092                            | 1839                       | -0.011                    | 0.092                            | 1366                       | -0.003                    | 0.092                            | 788                        | 0.002                     |
| 0.097                            | 1849                       | -0.011                    | 0.097                            | 1370                       | -0.003                    | 0.097                            | 773                        | 0.002                     |
| 0.102                            | 1867                       | -0.011                    | 0.102                            | 1370                       | -0.003                    | 0.102                            | 785                        | 0.002                     |
| 0.107                            | 1883                       | -0.011                    | 0.107                            | 1370                       | -0.003                    | 0.107                            | 779                        | 0.003                     |
| 0.112                            | 1890                       | -0.012                    | 0.112                            | 1366                       | -0.003                    | 0.112                            | 781                        | 0.003                     |
| 0.117                            | 1898                       | -0.012                    | 0.117                            | 1362                       | -0.003                    | 0.117                            | 798                        | 0.003                     |
| 0.122                            | 1906                       | -0.013                    | 0.122                            | 1361                       | -0.003                    | 0.122                            | 774                        | 0.004                     |
| 0.127                            | 1908                       | -0.013                    | 0.127                            | 1359                       | -0.002                    | 0.127                            | 765                        | 0.004                     |
| 0.132                            | 1913                       | -0.013                    | 0.132                            | 1356                       | -0.002                    | 0.132                            | 767                        | 0.004                     |
| 0.137                            | 1913                       | -0.013                    | 0.137                            | 1352                       | -0.002                    | 0.137                            | 770                        | 0.004                     |
| 0.142                            | 1916                       | -0.013                    | 0.142                            | 1326                       | -0.002                    | 0.142                            | 786                        | 0.004                     |
| 0.147                            | 1916                       | -0.014                    | 0.147                            | 1317                       | -0.002                    | 0.147                            | 763                        | 0.004                     |
| 0.152                            | 1916                       | -0.014                    | 0.152                            | 1315                       | -0.002                    | 0.152                            | 756                        | 0.004                     |
| 0.157                            | 1913                       | -0.014                    | 0.157                            | 1311                       | -0.002                    | 0.157                            | 760                        | 0.004                     |
| 0.162                            | 1913                       | -0.014                    | 0.162                            | 1306                       | -0.002                    | 0.162                            | 764                        | 0.004                     |
| 0.167                            | 1911                       | -0.014                    | 0.167                            | 1311                       | -0.002                    | 0.167                            | 779                        | 0.004                     |
| 0.172                            | 1906                       | -0.014                    | 0.172                            | 1312                       | -0.002                    | 0.172                            | 794                        | 0.004                     |
| 0.177                            | 1903                       | -0.015                    | 0.177                            | 1309                       | -0.002                    | 0.177                            | 789                        | 0.004                     |
| 0.182                            | 1901                       | -0.015                    | 0.182                            | 1306                       | -0.002                    | 0.182                            | 780                        | 0.004                     |
| 0.187                            | 1893                       | -0.015                    | 0.187                            | 1305                       | -0.002                    | 0.187                            | 781                        | 0.004                     |
| 0.192                            | 1893                       | -0.015                    | 0.192                            | 1303                       | -0.002                    | 0.192                            | 782                        | 0.004                     |
| 0.197                            | 1883                       | -0.016                    | 0.197                            | 1302                       | -0.002                    | 0.197                            | 796                        | 0.004                     |
| 0.202                            | 1878                       | -0.016                    | 0.202                            | 1301                       | -0.002                    | 0.202                            | 790                        | 0.004                     |
| 0.207                            | 1875                       | -0.016                    | 0.207                            | 1299                       | -0.002                    | 0.207                            | 799                        | 0.004                     |
| 0.212                            | 1867                       | -0.016                    | 0.212                            | 1296                       | -0.002                    | 0.212                            | 795                        | 0.004                     |
| 0.217                            | 1857                       | -0.017                    | 0.217                            | 1296                       | -0.002                    | 0.217                            | 790                        | 0.004                     |
| 0.222                            | 1849                       | -0.017                    | 0.222                            | 1296                       | -0.002                    | 0.222                            | 802                        | 0.004                     |
| 0.227                            | 1842                       | -0.017                    | 0.227                            | 1293                       | -0.002                    | 0.227                            | 812                        | 0.004                     |
| 0.232                            | 1839                       | -0.017                    | 0.232                            | 1280                       | -0.002                    | 0.232                            | 811                        | 0.004                     |
| 0.237                            | 1826                       | -0.018                    | 0.237                            | 1283                       | -0.002                    | 0.237                            | 820                        | 0.005                     |
| 0.242                            | 1819                       | -0.018                    | 0.242                            | 1286                       | -0.002                    | 0.242                            | 830                        | 0.005                     |
| 0.247                            | 1811                       | -0.018                    | 0.247                            | 1286                       | -0.002                    | 0.247                            | 836                        | 0.004                     |
| 0.252                            | 1803                       | -0.018                    | 0.252                            | 1285                       | -0.002                    | 0.252                            | 829                        | 0.004                     |
| 0.257                            | 1798                       | -0.018                    | 0.257                            | 1282                       | -0.002                    | 0.257                            | 831                        | 0.004                     |
| 0.262                            | 1796                       | -0.018                    | 0.262                            | 1280                       | -0.002                    | 0.262                            | 837                        | 0.004                     |
| 0.267                            | 1791                       | -0.019                    | 0.267                            | 1281                       | -0.002                    | 0.267                            | 825                        | 0.004                     |
| 0.272                            | 1785                       | -0.019                    | 0.272                            | 1276                       | -0.003                    | 0.272                            | 823                        | 0.004                     |
| 0.277                            | 1778                       | -0.019                    | 0.277                            | 1279                       | -0.003                    | 0.277                            | 833                        | 0.004                     |
| 0.282                            | 1775                       | -0.019                    | 0.282                            | 1278                       | -0.003                    | 0.282                            | 841                        | 0.004                     |
| 0.287                            | 1768                       | -0.020                    | 0.287                            | 1280                       | -0.003                    | 0.287                            | 851                        | 0.004                     |
| 0.292                            | 1762                       | -0.020                    | 0.292                            | 1282                       | -0.003                    | 0.292                            | 855                        | 0.004                     |
| 0.297                            | 1755                       | -0.020                    | 0.297                            | 1283                       | -0.004                    | 0.297                            | 855                        | 0.004                     |
| 0.301                            | 1755                       | -0.020                    | 0.301                            | 1285                       | -0.004                    | 0.302                            | 860                        | 0.004                     |

**Direct Shear Test for Soils Under Drained Conditions**

(ASTM D3080)

**Project: Bobcat Ridge**

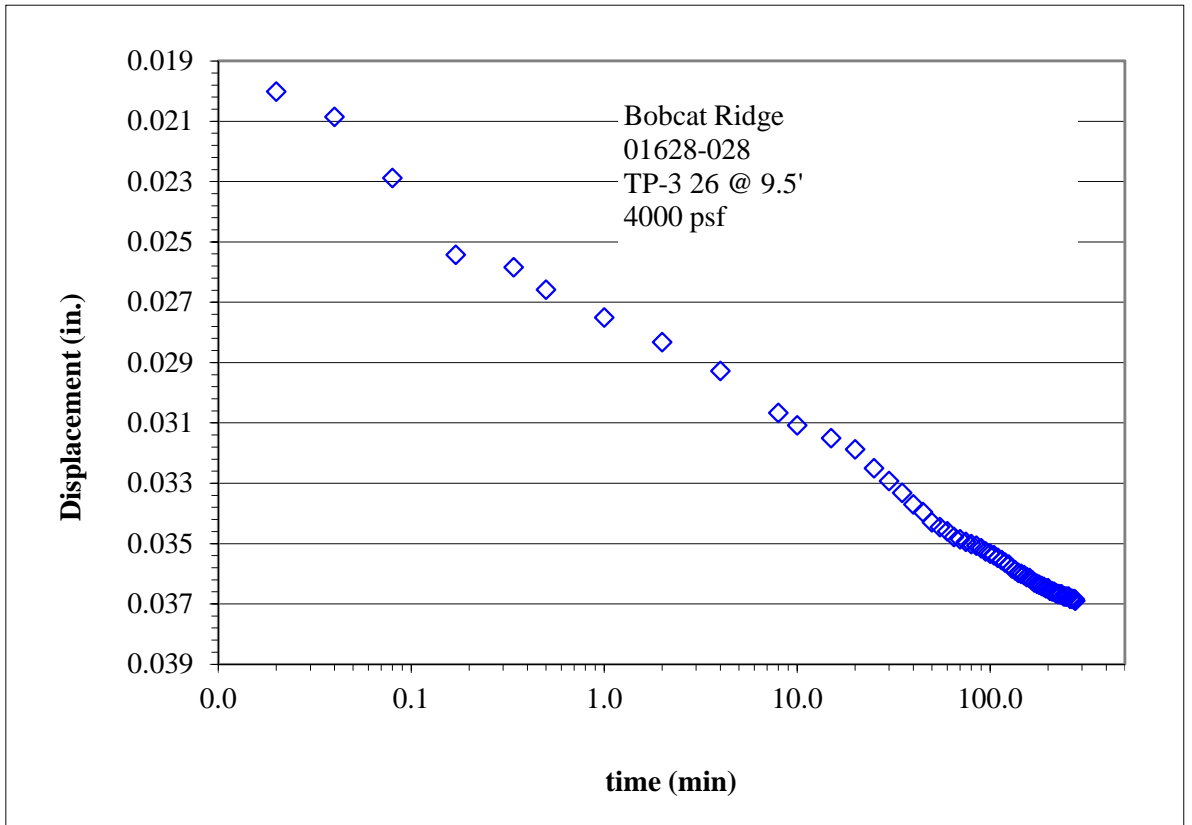
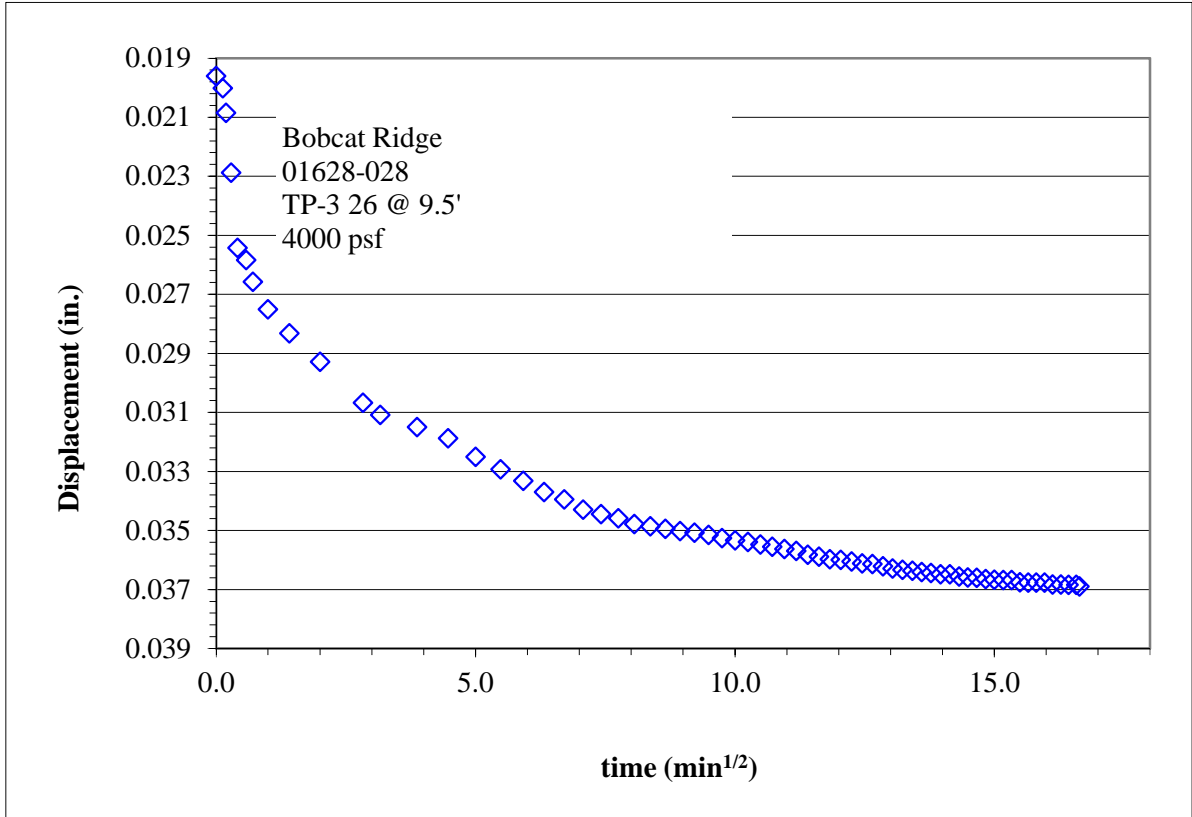
**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Boring No.: TP-3**

**Station: 26**

**Depth: 9.5'**



# Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

**Project: Bobcat Ridge**

**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**

Date: **7/11/2018**

By: **EH**

**Boring No.: TP-9**

**Station: 12**

**Depth: 8.0'**

Sample Description: **Reddish brown clayey sand**

Sample type: **Arbitrary remold**

Test type: **Inundated**

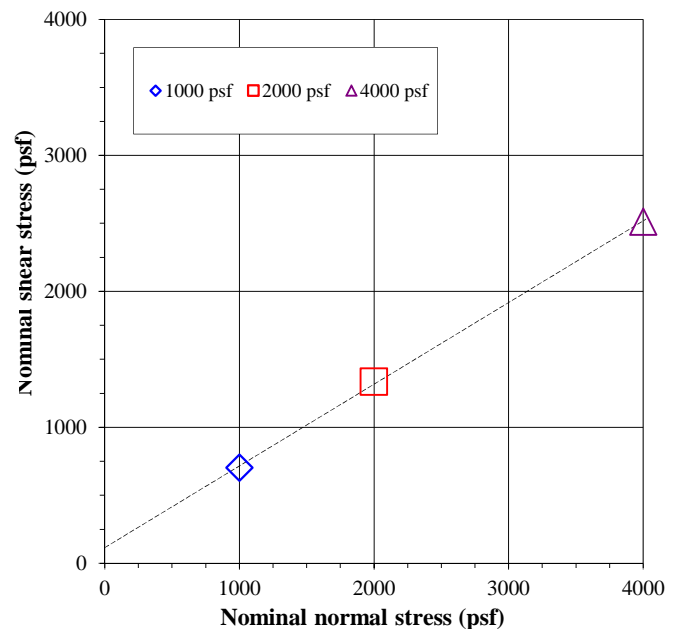
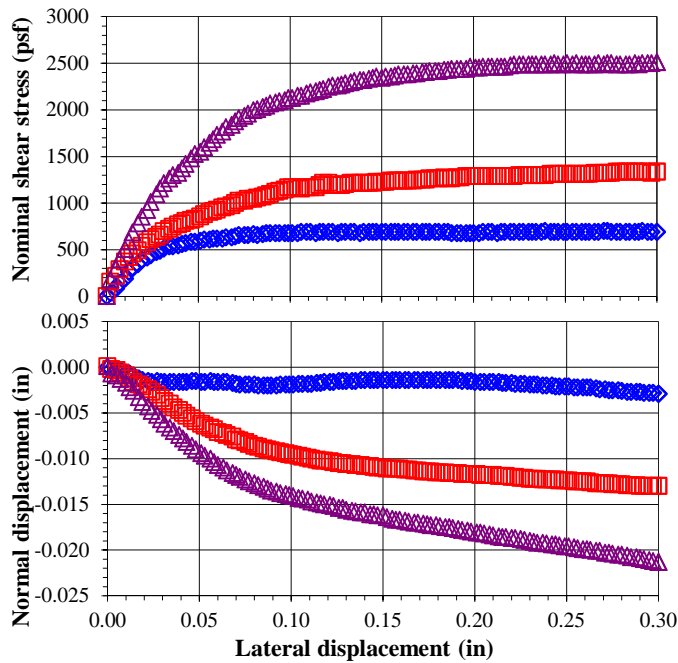
Lateral displacement (in.): **0.3**

Shear rate (in./min): **0.0010**

Specific gravity, Gs: **2.70 Assumed**

|                                   | Sample 1                    |                       | Sample 2 |           | Sample 3  |           |
|-----------------------------------|-----------------------------|-----------------------|----------|-----------|-----------|-----------|
|                                   | Nominal normal stress (psf) | 1000                  |          | 2000      |           | 4000      |
| Peak shear stress (psf)           | 703                         |                       | 1336     |           | 2512      |           |
| Lateral displacement at peak (in) | 0.239                       |                       | 0.278    |           | 0.300     |           |
| Load Duration (min)               | 360                         |                       | 4245     |           | 4500      |           |
|                                   | Initial                     | Pre-shear             | Initial  | Pre-shear | Initial   | Pre-shear |
| Sample height (in)                | 0.996                       | 0.984                 | 0.999    | 0.979     | 0.997     | 0.976     |
| Sample diameter (in)              | 2.424                       | 2.424                 | 2.412    | 2.412     | 2.414     | 2.414     |
| Wt. rings + wet soil (g)          | 198.03                      | 203.99                | 199.96   | 205.23    | 199.50    | 204.63    |
| Wt. rings (g)                     | 42.72                       | 42.72                 | 45.63    | 45.63     | 45.11     | 45.11     |
| Wet soil + tare (g)               | 345.11                      |                       | 345.11   |           | 345.11    |           |
| Dry soil + tare (g)               | 320.29                      |                       | 320.29   |           | 320.29    |           |
| Tare (g)                          | 123.70                      |                       | 123.70   |           | 123.70    |           |
| Water content (%)                 | 12.6                        | 16.9                  | 12.6     | 16.5      | 12.6      | 16.4      |
| Dry unit weight (pcf)             | 114.3                       | 115.6                 | 114.4    | 116.6     | 114.4     | 116.8     |
| Void ratio, e, for assumed Gs     | 0.47                        | 0.46                  | 0.47     | 0.44      | 0.47      | 0.44      |
| Saturation (%)*                   | 71.8                        | 100.0                 | 71.9     | 100.0     | 72.1      | 100.0     |
| $\phi'$ (deg)                     | 31                          | Average of 3 samples  |          | Initial   | Pre-shear |           |
| c' (psf)                          | 115                         | Water content (%)     |          | 12.6      | 16.6      |           |
|                                   |                             | Dry unit weight (pcf) |          | 114.4     | 116.4     |           |

\*Pre-shear saturation set to 100% for phase calculations



Comments:

Sample screened on No. 4 sieve and remolded to estimated 90% of maximum dry density at in-situ moisture content.

Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

**Direct Shear Test for Soils Under Drained Conditions**

(ASTM D3080)

**Project: Bobcat Ridge**

**Boring No.: TP-9**

**No: 01628-028**

**Station: 12**

**Location: Powder Mountain, Weber Co., UT**

**Depth: 8.0'**

| Nominal normal stress = 1000 psf |                            |                           | Nominal normal stress = 2000 psf |                            |                           | Nominal normal stress = 4000 psf |                            |                           |
|----------------------------------|----------------------------|---------------------------|----------------------------------|----------------------------|---------------------------|----------------------------------|----------------------------|---------------------------|
| Lateral Displacement (in.)       | Nominal Shear Stress (psf) | Normal Displacement (in.) | Lateral Displacement (in.)       | Nominal Shear Stress (psf) | Normal Displacement (in.) | Lateral Displacement (in.)       | Nominal Shear Stress (psf) | Normal Displacement (in.) |
| 0.000                            | 0                          | 0.000                     | 0.000                            | 0                          | 0.000                     | 0.000                            | 0                          | 0.000                     |
| 0.002                            | 36                         | 0.000                     | 0.002                            | 157                        | 0.000                     | 0.002                            | 180                        | -0.001                    |
| 0.005                            | 83                         | 0.000                     | 0.005                            | 217                        | 0.000                     | 0.005                            | 300                        | -0.001                    |
| 0.007                            | 143                        | 0.000                     | 0.007                            | 289                        | -0.001                    | 0.007                            | 397                        | -0.001                    |
| 0.010                            | 191                        | -0.001                    | 0.010                            | 373                        | -0.001                    | 0.010                            | 505                        | -0.002                    |
| 0.012                            | 262                        | -0.001                    | 0.012                            | 421                        | -0.001                    | 0.012                            | 589                        | -0.002                    |
| 0.014                            | 310                        | -0.001                    | 0.014                            | 457                        | -0.002                    | 0.014                            | 685                        | -0.003                    |
| 0.017                            | 346                        | -0.001                    | 0.017                            | 494                        | -0.002                    | 0.017                            | 781                        | -0.003                    |
| 0.019                            | 393                        | -0.001                    | 0.019                            | 542                        | -0.002                    | 0.019                            | 853                        | -0.004                    |
| 0.022                            | 417                        | -0.002                    | 0.022                            | 578                        | -0.002                    | 0.022                            | 925                        | -0.004                    |
| 0.024                            | 441                        | -0.002                    | 0.024                            | 614                        | -0.003                    | 0.024                            | 1010                       | -0.005                    |
| 0.027                            | 477                        | -0.002                    | 0.027                            | 638                        | -0.003                    | 0.027                            | 1094                       | -0.005                    |
| 0.029                            | 489                        | -0.002                    | 0.029                            | 662                        | -0.003                    | 0.029                            | 1154                       | -0.006                    |
| 0.031                            | 513                        | -0.002                    | 0.031                            | 698                        | -0.004                    | 0.031                            | 1214                       | -0.006                    |
| 0.034                            | 536                        | -0.002                    | 0.034                            | 722                        | -0.004                    | 0.034                            | 1262                       | -0.007                    |
| 0.036                            | 536                        | -0.002                    | 0.036                            | 746                        | -0.004                    | 0.036                            | 1298                       | -0.007                    |
| 0.039                            | 548                        | -0.002                    | 0.039                            | 771                        | -0.005                    | 0.039                            | 1322                       | -0.007                    |
| 0.041                            | 560                        | -0.002                    | 0.041                            | 783                        | -0.005                    | 0.041                            | 1370                       | -0.008                    |
| 0.043                            | 572                        | -0.002                    | 0.043                            | 807                        | -0.005                    | 0.043                            | 1418                       | -0.008                    |
| 0.046                            | 584                        | -0.002                    | 0.046                            | 819                        | -0.006                    | 0.046                            | 1478                       | -0.009                    |
| 0.048                            | 584                        | -0.002                    | 0.048                            | 831                        | -0.006                    | 0.048                            | 1526                       | -0.009                    |
| 0.051                            | 596                        | -0.002                    | 0.051                            | 855                        | -0.006                    | 0.051                            | 1550                       | -0.009                    |
| 0.053                            | 608                        | -0.002                    | 0.053                            | 879                        | -0.006                    | 0.053                            | 1599                       | -0.010                    |
| 0.056                            | 608                        | -0.002                    | 0.056                            | 903                        | -0.007                    | 0.056                            | 1647                       | -0.010                    |
| 0.058                            | 620                        | -0.002                    | 0.058                            | 915                        | -0.007                    | 0.058                            | 1683                       | -0.010                    |
| 0.060                            | 620                        | -0.002                    | 0.060                            | 927                        | -0.007                    | 0.060                            | 1731                       | -0.011                    |
| 0.063                            | 620                        | -0.002                    | 0.063                            | 951                        | -0.007                    | 0.063                            | 1767                       | -0.011                    |
| 0.065                            | 632                        | -0.002                    | 0.065                            | 963                        | -0.007                    | 0.065                            | 1815                       | -0.011                    |
| 0.068                            | 632                        | -0.002                    | 0.068                            | 975                        | -0.008                    | 0.068                            | 1839                       | -0.012                    |
| 0.070                            | 644                        | -0.002                    | 0.070                            | 999                        | -0.008                    | 0.070                            | 1875                       | -0.012                    |
| 0.072                            | 656                        | -0.002                    | 0.072                            | 1023                       | -0.008                    | 0.072                            | 1911                       | -0.012                    |
| 0.075                            | 656                        | -0.002                    | 0.075                            | 1023                       | -0.008                    | 0.075                            | 1935                       | -0.012                    |
| 0.077                            | 656                        | -0.002                    | 0.077                            | 1047                       | -0.008                    | 0.077                            | 1959                       | -0.013                    |
| 0.080                            | 668                        | -0.002                    | 0.080                            | 1047                       | -0.009                    | 0.080                            | 1995                       | -0.013                    |
| 0.082                            | 656                        | -0.002                    | 0.082                            | 1059                       | -0.009                    | 0.082                            | 2007                       | -0.013                    |
| 0.085                            | 668                        | -0.002                    | 0.085                            | 1071                       | -0.009                    | 0.085                            | 2031                       | -0.013                    |
| 0.087                            | 679                        | -0.002                    | 0.087                            | 1084                       | -0.009                    | 0.087                            | 2043                       | -0.013                    |
| 0.089                            | 679                        | -0.002                    | 0.089                            | 1096                       | -0.009                    | 0.089                            | 2067                       | -0.014                    |
| 0.092                            | 679                        | -0.002                    | 0.092                            | 1120                       | -0.009                    | 0.092                            | 2079                       | -0.014                    |
| 0.094                            | 679                        | -0.002                    | 0.094                            | 1132                       | -0.009                    | 0.094                            | 2091                       | -0.014                    |
| 0.097                            | 679                        | -0.002                    | 0.097                            | 1144                       | -0.009                    | 0.097                            | 2103                       | -0.014                    |
| 0.099                            | 679                        | -0.002                    | 0.099                            | 1168                       | -0.010                    | 0.099                            | 2127                       | -0.014                    |
| 0.101                            | 679                        | -0.002                    | 0.101                            | 1168                       | -0.010                    | 0.101                            | 2127                       | -0.014                    |
| 0.104                            | 679                        | -0.002                    | 0.104                            | 1168                       | -0.010                    | 0.104                            | 2151                       | -0.014                    |
| 0.106                            | 691                        | -0.002                    | 0.106                            | 1156                       | -0.010                    | 0.106                            | 2151                       | -0.014                    |
| 0.109                            | 691                        | -0.002                    | 0.109                            | 1168                       | -0.010                    | 0.109                            | 2175                       | -0.015                    |
| 0.111                            | 691                        | -0.002                    | 0.111                            | 1168                       | -0.010                    | 0.111                            | 2187                       | -0.015                    |
| 0.114                            | 679                        | -0.002                    | 0.114                            | 1168                       | -0.010                    | 0.114                            | 2200                       | -0.015                    |
| 0.116                            | 691                        | -0.002                    | 0.116                            | 1192                       | -0.010                    | 0.116                            | 2212                       | -0.015                    |
| 0.118                            | 691                        | -0.002                    | 0.118                            | 1216                       | -0.010                    | 0.118                            | 2224                       | -0.015                    |
| 0.121                            | 691                        | -0.002                    | 0.121                            | 1216                       | -0.010                    | 0.121                            | 2248                       | -0.015                    |
| 0.123                            | 691                        | -0.002                    | 0.123                            | 1192                       | -0.010                    | 0.123                            | 2260                       | -0.015                    |
| 0.126                            | 679                        | -0.002                    | 0.126                            | 1192                       | -0.011                    | 0.126                            | 2260                       | -0.015                    |
| 0.128                            | 691                        | -0.002                    | 0.128                            | 1192                       | -0.011                    | 0.128                            | 2272                       | -0.015                    |
| 0.130                            | 691                        | -0.002                    | 0.130                            | 1204                       | -0.011                    | 0.130                            | 2284                       | -0.016                    |
| 0.133                            | 691                        | -0.002                    | 0.133                            | 1216                       | -0.011                    | 0.133                            | 2296                       | -0.016                    |
| 0.135                            | 691                        | -0.002                    | 0.135                            | 1216                       | -0.011                    | 0.135                            | 2308                       | -0.016                    |
| 0.138                            | 679                        | -0.001                    | 0.138                            | 1216                       | -0.011                    | 0.138                            | 2320                       | -0.016                    |
| 0.140                            | 691                        | -0.001                    | 0.140                            | 1216                       | -0.011                    | 0.140                            | 2320                       | -0.016                    |
| 0.143                            | 691                        | -0.001                    | 0.143                            | 1216                       | -0.011                    | 0.143                            | 2332                       | -0.016                    |
| 0.145                            | 691                        | -0.001                    | 0.145                            | 1216                       | -0.011                    | 0.145                            | 2344                       | -0.016                    |
| 0.147                            | 691                        | -0.001                    | 0.147                            | 1228                       | -0.011                    | 0.147                            | 2356                       | -0.016                    |
| 0.150                            | 691                        | -0.001                    | 0.150                            | 1228                       | -0.011                    | 0.150                            | 2344                       | -0.016                    |
| 0.152                            | 691                        | -0.001                    | 0.152                            | 1228                       | -0.011                    | 0.152                            | 2356                       | -0.016                    |
| 0.155                            | 691                        | -0.001                    | 0.155                            | 1240                       | -0.011                    | 0.155                            | 2356                       | -0.017                    |

# Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: **Bobcat Ridge**

Boring No.: **TP-9**

No: **01628-028**

Station: **12**

Location: **Powder Mountain, Weber Co., UT**

Depth: **8.0'**

| Nominal normal stress = 1000 psf |                            |                           | Nominal normal stress = 2000 psf |                            |                           | Nominal normal stress = 4000 psf |                            |                           |
|----------------------------------|----------------------------|---------------------------|----------------------------------|----------------------------|---------------------------|----------------------------------|----------------------------|---------------------------|
| Lateral Displacement (in.)       | Nominal Shear Stress (psf) | Normal Displacement (in.) | Lateral Displacement (in.)       | Nominal Shear Stress (psf) | Normal Displacement (in.) | Lateral Displacement (in.)       | Nominal Shear Stress (psf) | Normal Displacement (in.) |
| 0.157                            | 691                        | -0.001                    | 0.157                            | 1240                       | -0.011                    | 0.157                            | 2368                       | -0.017                    |
| 0.159                            | 691                        | -0.001                    | 0.159                            | 1240                       | -0.011                    | 0.159                            | 2380                       | -0.017                    |
| 0.162                            | 691                        | -0.001                    | 0.162                            | 1240                       | -0.011                    | 0.162                            | 2380                       | -0.017                    |
| 0.164                            | 691                        | -0.001                    | 0.164                            | 1240                       | -0.011                    | 0.164                            | 2380                       | -0.017                    |
| 0.167                            | 691                        | -0.001                    | 0.167                            | 1240                       | -0.011                    | 0.167                            | 2392                       | -0.017                    |
| 0.169                            | 691                        | -0.001                    | 0.169                            | 1252                       | -0.011                    | 0.169                            | 2392                       | -0.017                    |
| 0.172                            | 691                        | -0.001                    | 0.172                            | 1252                       | -0.011                    | 0.172                            | 2404                       | -0.017                    |
| 0.174                            | 691                        | -0.001                    | 0.174                            | 1252                       | -0.011                    | 0.174                            | 2404                       | -0.017                    |
| 0.176                            | 691                        | -0.001                    | 0.176                            | 1264                       | -0.011                    | 0.176                            | 2416                       | -0.017                    |
| 0.179                            | 691                        | -0.001                    | 0.179                            | 1264                       | -0.012                    | 0.179                            | 2416                       | -0.017                    |
| 0.181                            | 691                        | -0.001                    | 0.181                            | 1264                       | -0.012                    | 0.181                            | 2416                       | -0.017                    |
| 0.184                            | 691                        | -0.001                    | 0.184                            | 1276                       | -0.012                    | 0.184                            | 2428                       | -0.018                    |
| 0.186                            | 691                        | -0.001                    | 0.186                            | 1264                       | -0.012                    | 0.186                            | 2428                       | -0.018                    |
| 0.188                            | 679                        | -0.001                    | 0.188                            | 1264                       | -0.012                    | 0.188                            | 2440                       | -0.018                    |
| 0.191                            | 679                        | -0.001                    | 0.191                            | 1276                       | -0.012                    | 0.191                            | 2440                       | -0.018                    |
| 0.193                            | 679                        | -0.002                    | 0.193                            | 1276                       | -0.012                    | 0.193                            | 2440                       | -0.018                    |
| 0.196                            | 679                        | -0.002                    | 0.196                            | 1288                       | -0.012                    | 0.196                            | 2440                       | -0.018                    |
| 0.198                            | 679                        | -0.002                    | 0.198                            | 1288                       | -0.012                    | 0.198                            | 2464                       | -0.018                    |
| 0.200                            | 679                        | -0.002                    | 0.201                            | 1288                       | -0.012                    | 0.201                            | 2452                       | -0.018                    |
| 0.203                            | 679                        | -0.002                    | 0.203                            | 1288                       | -0.012                    | 0.203                            | 2452                       | -0.018                    |
| 0.205                            | 691                        | -0.002                    | 0.205                            | 1288                       | -0.012                    | 0.205                            | 2464                       | -0.018                    |
| 0.208                            | 691                        | -0.002                    | 0.208                            | 1288                       | -0.012                    | 0.208                            | 2464                       | -0.018                    |
| 0.210                            | 691                        | -0.002                    | 0.210                            | 1288                       | -0.012                    | 0.210                            | 2464                       | -0.018                    |
| 0.213                            | 679                        | -0.002                    | 0.213                            | 1288                       | -0.012                    | 0.213                            | 2464                       | -0.019                    |
| 0.215                            | 691                        | -0.002                    | 0.215                            | 1288                       | -0.012                    | 0.215                            | 2464                       | -0.019                    |
| 0.217                            | 691                        | -0.002                    | 0.217                            | 1288                       | -0.012                    | 0.217                            | 2464                       | -0.019                    |
| 0.220                            | 691                        | -0.002                    | 0.220                            | 1288                       | -0.012                    | 0.220                            | 2476                       | -0.019                    |
| 0.222                            | 691                        | -0.002                    | 0.222                            | 1288                       | -0.012                    | 0.222                            | 2488                       | -0.019                    |
| 0.225                            | 691                        | -0.002                    | 0.225                            | 1300                       | -0.012                    | 0.225                            | 2488                       | -0.019                    |
| 0.227                            | 691                        | -0.002                    | 0.227                            | 1300                       | -0.012                    | 0.227                            | 2488                       | -0.019                    |
| 0.230                            | 691                        | -0.002                    | 0.230                            | 1300                       | -0.012                    | 0.230                            | 2488                       | -0.019                    |
| 0.232                            | 691                        | -0.002                    | 0.232                            | 1300                       | -0.012                    | 0.232                            | 2488                       | -0.019                    |
| 0.234                            | 691                        | -0.002                    | 0.234                            | 1300                       | -0.012                    | 0.234                            | 2488                       | -0.019                    |
| 0.237                            | 691                        | -0.002                    | 0.237                            | 1300                       | -0.012                    | 0.237                            | 2488                       | -0.019                    |
| 0.239                            | 703                        | -0.002                    | 0.239                            | 1300                       | -0.012                    | 0.239                            | 2488                       | -0.019                    |
| 0.242                            | 691                        | -0.002                    | 0.242                            | 1312                       | -0.012                    | 0.242                            | 2488                       | -0.019                    |
| 0.244                            | 691                        | -0.002                    | 0.244                            | 1312                       | -0.012                    | 0.244                            | 2500                       | -0.019                    |
| 0.246                            | 691                        | -0.002                    | 0.246                            | 1312                       | -0.012                    | 0.246                            | 2488                       | -0.020                    |
| 0.249                            | 691                        | -0.002                    | 0.249                            | 1312                       | -0.012                    | 0.249                            | 2488                       | -0.020                    |
| 0.251                            | 691                        | -0.002                    | 0.251                            | 1312                       | -0.012                    | 0.251                            | 2500                       | -0.020                    |
| 0.254                            | 691                        | -0.002                    | 0.254                            | 1312                       | -0.013                    | 0.254                            | 2488                       | -0.020                    |
| 0.256                            | 691                        | -0.002                    | 0.256                            | 1312                       | -0.013                    | 0.256                            | 2500                       | -0.020                    |
| 0.259                            | 691                        | -0.002                    | 0.259                            | 1312                       | -0.013                    | 0.259                            | 2488                       | -0.020                    |
| 0.261                            | 691                        | -0.002                    | 0.261                            | 1312                       | -0.013                    | 0.261                            | 2488                       | -0.020                    |
| 0.263                            | 691                        | -0.002                    | 0.263                            | 1312                       | -0.013                    | 0.263                            | 2488                       | -0.020                    |
| 0.266                            | 691                        | -0.002                    | 0.266                            | 1324                       | -0.013                    | 0.266                            | 2488                       | -0.020                    |
| 0.268                            | 691                        | -0.002                    | 0.268                            | 1324                       | -0.013                    | 0.268                            | 2500                       | -0.020                    |
| 0.271                            | 703                        | -0.002                    | 0.271                            | 1324                       | -0.013                    | 0.271                            | 2488                       | -0.020                    |
| 0.273                            | 703                        | -0.003                    | 0.273                            | 1324                       | -0.013                    | 0.273                            | 2500                       | -0.020                    |
| 0.275                            | 691                        | -0.003                    | 0.275                            | 1324                       | -0.013                    | 0.275                            | 2500                       | -0.020                    |
| 0.278                            | 691                        | -0.003                    | 0.278                            | 1336                       | -0.013                    | 0.278                            | 2488                       | -0.021                    |
| 0.280                            | 691                        | -0.003                    | 0.280                            | 1336                       | -0.013                    | 0.280                            | 2488                       | -0.021                    |
| 0.283                            | 691                        | -0.003                    | 0.283                            | 1336                       | -0.013                    | 0.283                            | 2488                       | -0.021                    |
| 0.285                            | 691                        | -0.003                    | 0.285                            | 1336                       | -0.013                    | 0.285                            | 2488                       | -0.021                    |
| 0.288                            | 691                        | -0.003                    | 0.288                            | 1336                       | -0.013                    | 0.288                            | 2500                       | -0.021                    |
| 0.290                            | 691                        | -0.003                    | 0.290                            | 1336                       | -0.013                    | 0.290                            | 2488                       | -0.021                    |
| 0.292                            | 703                        | -0.003                    | 0.292                            | 1336                       | -0.013                    | 0.292                            | 2500                       | -0.021                    |
| 0.295                            | 691                        | -0.003                    | 0.295                            | 1336                       | -0.013                    | 0.295                            | 2500                       | -0.021                    |
| 0.297                            | 691                        | -0.003                    | 0.297                            | 1324                       | -0.013                    | 0.297                            | 2500                       | -0.021                    |
| 0.300                            | 691                        | -0.003                    | 0.300                            | 1336                       | -0.013                    | 0.300                            | 2512                       | -0.021                    |
| 0.300                            | 691                        | -0.003                    | 0.300                            | 1336                       | -0.013                    | 0.300                            | 2512                       | -0.021                    |

**Direct Shear Test for Soils Under Drained Conditions**

(ASTM D3080)

**Project: Bobcat Ridge**

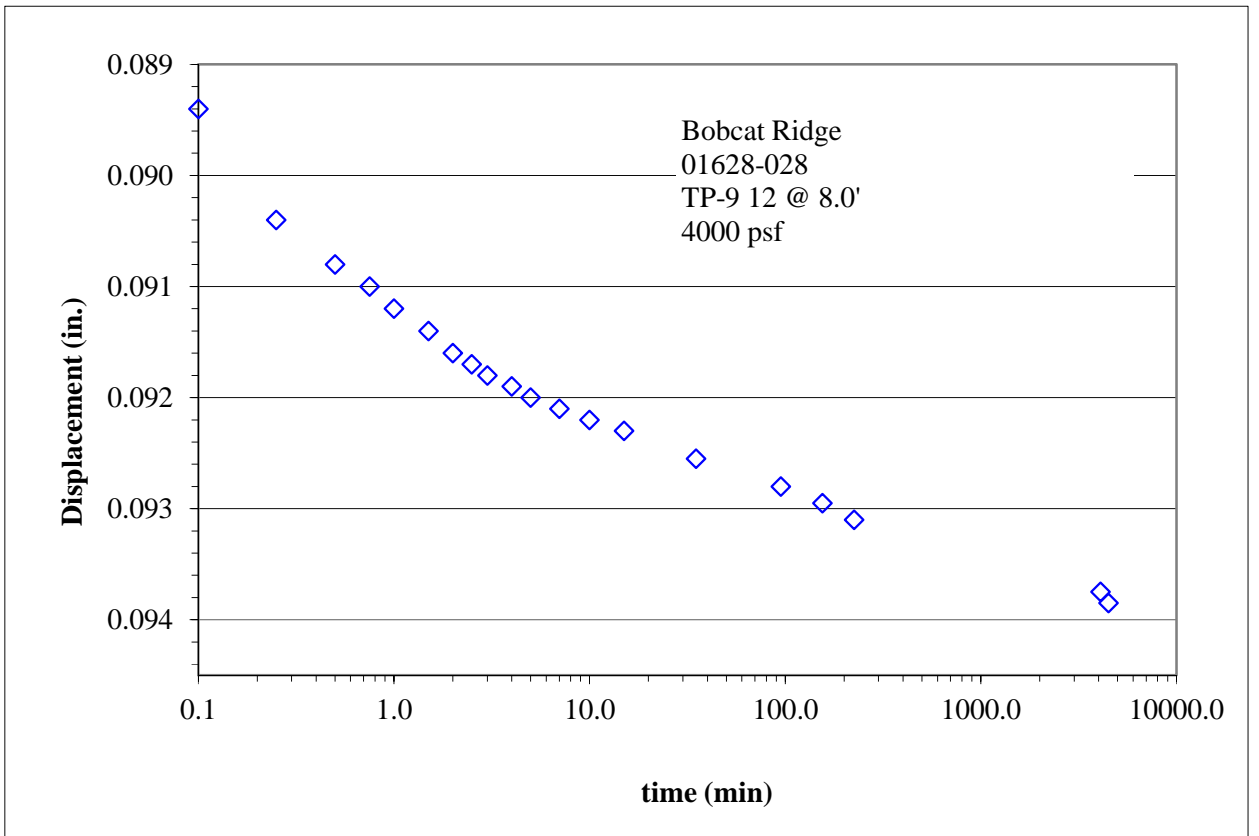
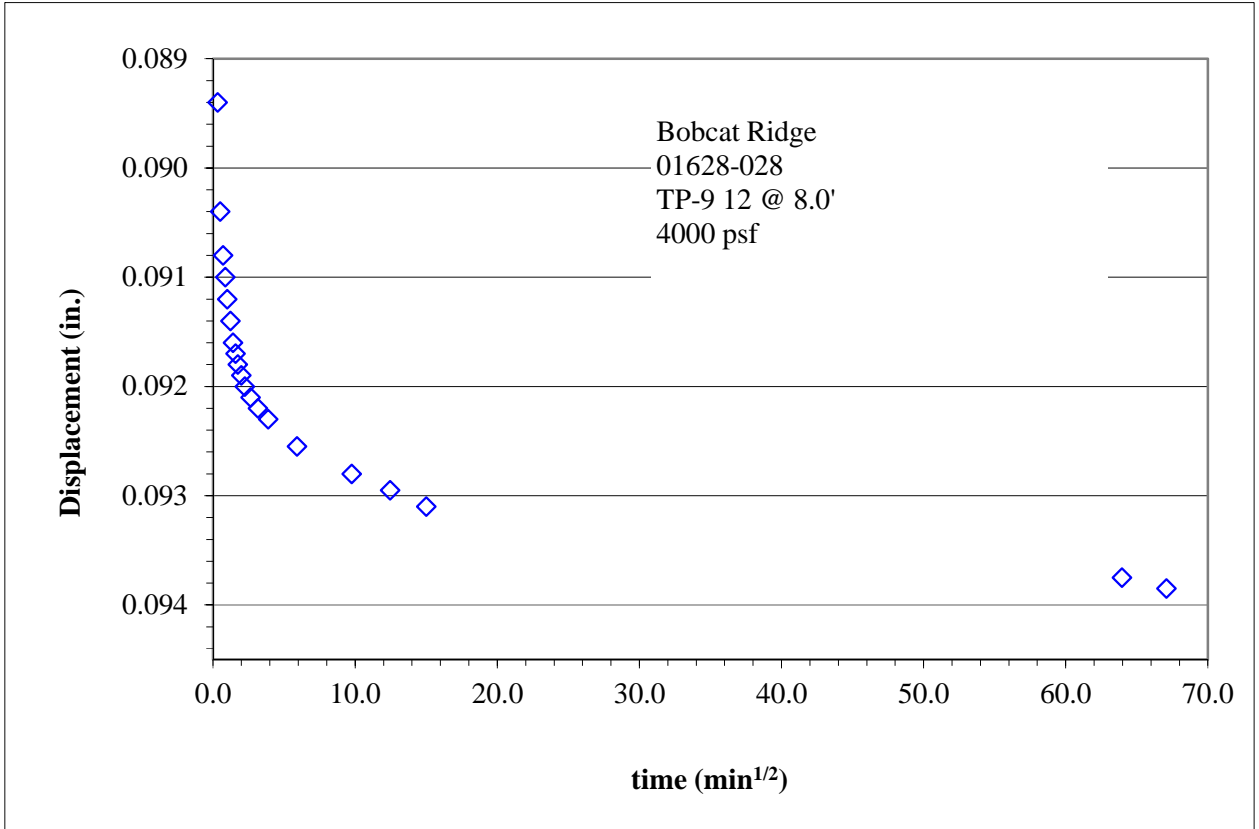
**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Boring No.: TP-9**

**Station: 12**

**Depth: 8.0'**



# Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/9/2018**

**By: EH**

Test type: **Inundated**

Lateral displacement (in.): **0.3**

Shear rate (in./min): **0.0009**

Specific gravity, Gs: **2.70 Assumed**

**Boring No.: TP-21**

**Station: 5**

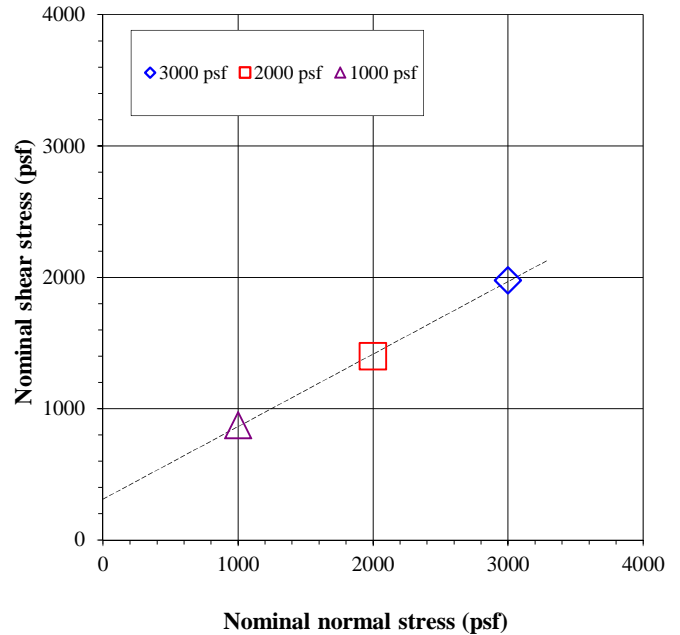
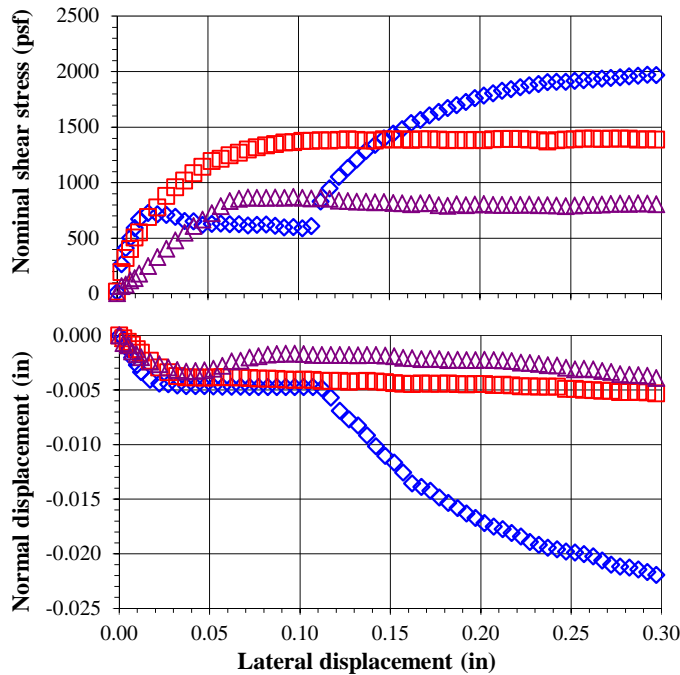
**Depth: 5.5'**

Sample Description: **Reddish brown sandy clay**

Sample type: **Undisturbed-trimmed from thin-wall**

|                                   | Sample 1 |                       | Sample 2 |           | Sample 3  |           |
|-----------------------------------|----------|-----------------------|----------|-----------|-----------|-----------|
| Nominal normal stress (psf)       | 3000     |                       | 2000     |           | 1000      |           |
| Peak shear stress (psf)           | 1977     |                       | 1397     |           | 872       |           |
| Lateral displacement at peak (in) | 0.300    |                       | 0.262    |           | 0.097     |           |
| Load Duration (min)               | 184      |                       | 200      |           | 215       |           |
|                                   | Initial  | Pre-shear             | Initial  | Pre-shear | Initial   | Pre-shear |
| Sample height (in)                | 0.996    | 0.998                 | 0.997    | 0.958     | 0.999     | 0.965     |
| Sample diameter (in)              | 2.424    | 2.424                 | 2.414    | 2.414     | 2.412     | 2.412     |
| Wt. rings + wet soil (g)          | 194.62   | 203.61                | 200.08   | 204.16    | 199.56    | 204.44    |
| Wt. rings (g)                     | 42.72    | 42.72                 | 45.11    | 45.11     | 45.63     | 45.63     |
| Wet soil + tare (g)               | 314.59   |                       | 314.59   |           | 314.59    |           |
| Dry soil + tare (g)               | 294.24   |                       | 294.24   |           | 294.24    |           |
| Tare (g)                          | 123.63   |                       | 123.63   |           | 123.63    |           |
| Water content (%)                 | 11.9     | 18.6                  | 11.9     | 14.9      | 11.9      | 15.5      |
| Dry unit weight (pcf)             | 112.5    | 112.2                 | 115.6    | 120.2     | 114.8     | 118.8     |
| Void ratio, e, for assumed Gs     | 0.50     | 0.50                  | 0.46     | 0.40      | 0.47      | 0.42      |
| Saturation (%)*                   | 64.6     | 100.0                 | 70.3     | 100.0     | 68.7      | 100.0     |
| $\phi'$ (deg)                     | 29       | Average of 3 samples  |          | Initial   | Pre-shear |           |
| c' (psf)                          | 311      | Water content (%)     |          | 11.9      | 16.3      |           |
|                                   |          | Dry unit weight (pcf) |          | 114.3     | 117.1     |           |

\*Pre-shear saturation set to 100% for phase calculations



Comments:

Specimens contain gravel that may have influenced the behavior of specimen S1.

Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_



**Direct Shear Test for Soils Under Drained Conditions**

(ASTM D3080)

**Project: Bobcat Ridge**

**Boring No.: TP-21**

**No: 01628-028**

**Station: 5**

**Location: Powder Mountain, Weber Co., UT**

**Depth: 5.5'**

| Nominal normal stress = 3000 psf |                            |                           | Nominal normal stress = 2000 psf |                            |                           | Nominal normal stress = 1000 psf |                            |                           |
|----------------------------------|----------------------------|---------------------------|----------------------------------|----------------------------|---------------------------|----------------------------------|----------------------------|---------------------------|
| Lateral Displacement (in.)       | Nominal Shear Stress (psf) | Normal Displacement (in.) | Lateral Displacement (in.)       | Nominal Shear Stress (psf) | Normal Displacement (in.) | Lateral Displacement (in.)       | Nominal Shear Stress (psf) | Normal Displacement (in.) |
| 0.000                            | 15                         | 0.000                     | 0.000                            | 19                         | 0.000                     | 0.000                            | 4                          | 0.000                     |
| 0.002                            | 267                        | 0.000                     | 0.002                            | 195                        | 0.000                     | 0.002                            | 68                         | -0.001                    |
| 0.005                            | 410                        | -0.001                    | 0.005                            | 320                        | -0.001                    | 0.005                            | 81                         | -0.001                    |
| 0.007                            | 503                        | -0.002                    | 0.007                            | 402                        | -0.001                    | 0.007                            | 118                        | -0.001                    |
| 0.010                            | 592                        | -0.003                    | 0.010                            | 505                        | -0.001                    | 0.010                            | 139                        | -0.002                    |
| 0.012                            | 672                        | -0.003                    | 0.012                            | 551                        | -0.002                    | 0.012                            | 180                        | -0.002                    |
| 0.017                            | 728                        | -0.004                    | 0.017                            | 689                        | -0.002                    | 0.017                            | 249                        | -0.002                    |
| 0.022                            | 715                        | -0.004                    | 0.022                            | 777                        | -0.003                    | 0.022                            | 328                        | -0.003                    |
| 0.027                            | 710                        | -0.004                    | 0.027                            | 880                        | -0.003                    | 0.027                            | 405                        | -0.003                    |
| 0.032                            | 692                        | -0.005                    | 0.032                            | 957                        | -0.004                    | 0.032                            | 479                        | -0.003                    |
| 0.037                            | 654                        | -0.005                    | 0.037                            | 1018                       | -0.004                    | 0.037                            | 548                        | -0.003                    |
| 0.042                            | 651                        | -0.005                    | 0.042                            | 1085                       | -0.004                    | 0.042                            | 610                        | -0.003                    |
| 0.047                            | 621                        | -0.005                    | 0.047                            | 1142                       | -0.004                    | 0.047                            | 666                        | -0.003                    |
| 0.052                            | 628                        | -0.005                    | 0.052                            | 1194                       | -0.004                    | 0.052                            | 725                        | -0.003                    |
| 0.057                            | 631                        | -0.005                    | 0.057                            | 1215                       | -0.004                    | 0.057                            | 787                        | -0.003                    |
| 0.062                            | 626                        | -0.005                    | 0.062                            | 1245                       | -0.004                    | 0.062                            | 834                        | -0.002                    |
| 0.067                            | 626                        | -0.005                    | 0.067                            | 1269                       | -0.004                    | 0.067                            | 853                        | -0.002                    |
| 0.072                            | 615                        | -0.005                    | 0.072                            | 1297                       | -0.004                    | 0.072                            | 866                        | -0.002                    |
| 0.077                            | 621                        | -0.005                    | 0.077                            | 1317                       | -0.004                    | 0.077                            | 861                        | -0.002                    |
| 0.082                            | 623                        | -0.005                    | 0.082                            | 1336                       | -0.004                    | 0.082                            | 861                        | -0.002                    |
| 0.087                            | 613                        | -0.005                    | 0.087                            | 1346                       | -0.004                    | 0.087                            | 866                        | -0.002                    |
| 0.092                            | 598                        | -0.005                    | 0.092                            | 1360                       | -0.004                    | 0.092                            | 864                        | -0.002                    |
| 0.097                            | 600                        | -0.005                    | 0.097                            | 1365                       | -0.004                    | 0.097                            | 872                        | -0.002                    |
| 0.102                            | 590                        | -0.005                    | 0.102                            | 1375                       | -0.004                    | 0.102                            | 861                        | -0.002                    |
| 0.107                            | 610                        | -0.005                    | 0.107                            | 1377                       | -0.004                    | 0.107                            | 857                        | -0.002                    |
| 0.112                            | 831                        | -0.005                    | 0.112                            | 1381                       | -0.004                    | 0.112                            | 862                        | -0.002                    |
| 0.117                            | 949                        | -0.006                    | 0.117                            | 1379                       | -0.004                    | 0.117                            | 853                        | -0.002                    |
| 0.122                            | 1054                       | -0.007                    | 0.122                            | 1384                       | -0.004                    | 0.122                            | 835                        | -0.002                    |
| 0.127                            | 1133                       | -0.008                    | 0.127                            | 1389                       | -0.004                    | 0.127                            | 833                        | -0.002                    |
| 0.132                            | 1208                       | -0.008                    | 0.132                            | 1385                       | -0.004                    | 0.132                            | 829                        | -0.002                    |
| 0.137                            | 1287                       | -0.009                    | 0.137                            | 1380                       | -0.004                    | 0.137                            | 827                        | -0.002                    |
| 0.142                            | 1341                       | -0.010                    | 0.142                            | 1379                       | -0.004                    | 0.142                            | 824                        | -0.002                    |
| 0.147                            | 1398                       | -0.011                    | 0.147                            | 1389                       | -0.004                    | 0.147                            | 825                        | -0.002                    |
| 0.152                            | 1441                       | -0.012                    | 0.152                            | 1387                       | -0.004                    | 0.152                            | 816                        | -0.002                    |
| 0.157                            | 1482                       | -0.013                    | 0.157                            | 1390                       | -0.004                    | 0.157                            | 813                        | -0.002                    |
| 0.162                            | 1536                       | -0.014                    | 0.162                            | 1385                       | -0.004                    | 0.162                            | 806                        | -0.002                    |
| 0.167                            | 1567                       | -0.014                    | 0.167                            | 1390                       | -0.004                    | 0.167                            | 813                        | -0.002                    |
| 0.172                            | 1605                       | -0.014                    | 0.172                            | 1389                       | -0.004                    | 0.172                            | 816                        | -0.002                    |
| 0.177                            | 1639                       | -0.015                    | 0.177                            | 1386                       | -0.004                    | 0.177                            | 797                        | -0.002                    |
| 0.182                            | 1674                       | -0.015                    | 0.182                            | 1382                       | -0.004                    | 0.182                            | 790                        | -0.002                    |
| 0.187                            | 1698                       | -0.016                    | 0.187                            | 1385                       | -0.004                    | 0.187                            | 804                        | -0.002                    |
| 0.192                            | 1726                       | -0.016                    | 0.192                            | 1382                       | -0.004                    | 0.192                            | 797                        | -0.002                    |
| 0.197                            | 1762                       | -0.017                    | 0.197                            | 1385                       | -0.004                    | 0.197                            | 801                        | -0.002                    |
| 0.202                            | 1785                       | -0.017                    | 0.202                            | 1382                       | -0.004                    | 0.202                            | 808                        | -0.002                    |
| 0.207                            | 1805                       | -0.018                    | 0.207                            | 1391                       | -0.005                    | 0.207                            | 799                        | -0.002                    |
| 0.212                            | 1828                       | -0.018                    | 0.212                            | 1393                       | -0.005                    | 0.212                            | 799                        | -0.002                    |
| 0.217                            | 1844                       | -0.018                    | 0.217                            | 1393                       | -0.005                    | 0.217                            | 798                        | -0.002                    |
| 0.222                            | 1859                       | -0.018                    | 0.222                            | 1393                       | -0.005                    | 0.222                            | 798                        | -0.002                    |
| 0.227                            | 1877                       | -0.019                    | 0.227                            | 1386                       | -0.005                    | 0.227                            | 803                        | -0.003                    |
| 0.232                            | 1890                       | -0.019                    | 0.232                            | 1382                       | -0.005                    | 0.232                            | 796                        | -0.003                    |
| 0.237                            | 1905                       | -0.019                    | 0.237                            | 1371                       | -0.005                    | 0.237                            | 797                        | -0.003                    |
| 0.242                            | 1908                       | -0.020                    | 0.242                            | 1381                       | -0.005                    | 0.242                            | 792                        | -0.003                    |
| 0.247                            | 1910                       | -0.020                    | 0.247                            | 1386                       | -0.005                    | 0.247                            | 788                        | -0.003                    |
| 0.252                            | 1918                       | -0.020                    | 0.252                            | 1391                       | -0.005                    | 0.252                            | 794                        | -0.003                    |
| 0.257                            | 1923                       | -0.020                    | 0.257                            | 1395                       | -0.005                    | 0.257                            | 799                        | -0.003                    |
| 0.262                            | 1928                       | -0.020                    | 0.262                            | 1397                       | -0.005                    | 0.262                            | 799                        | -0.003                    |
| 0.267                            | 1939                       | -0.021                    | 0.267                            | 1393                       | -0.005                    | 0.267                            | 803                        | -0.003                    |
| 0.272                            | 1944                       | -0.021                    | 0.272                            | 1397                       | -0.005                    | 0.272                            | 809                        | -0.003                    |
| 0.277                            | 1949                       | -0.021                    | 0.277                            | 1397                       | -0.005                    | 0.277                            | 811                        | -0.004                    |
| 0.282                            | 1959                       | -0.021                    | 0.282                            | 1395                       | -0.005                    | 0.282                            | 808                        | -0.004                    |
| 0.287                            | 1964                       | -0.021                    | 0.287                            | 1386                       | -0.005                    | 0.287                            | 814                        | -0.004                    |
| 0.292                            | 1972                       | -0.022                    | 0.292                            | 1390                       | -0.005                    | 0.292                            | 812                        | -0.004                    |
| 0.297                            | 1969                       | -0.022                    | 0.297                            | 1388                       | -0.005                    | 0.297                            | 804                        | -0.004                    |
| 0.300                            | 1977                       | -0.022                    | 0.300                            | 1389                       | -0.005                    | 0.301                            | 803                        | -0.004                    |

**Direct Shear Test for Soils Under Drained Conditions**

(ASTM D3080)

**Project: Bobcat Ridge**

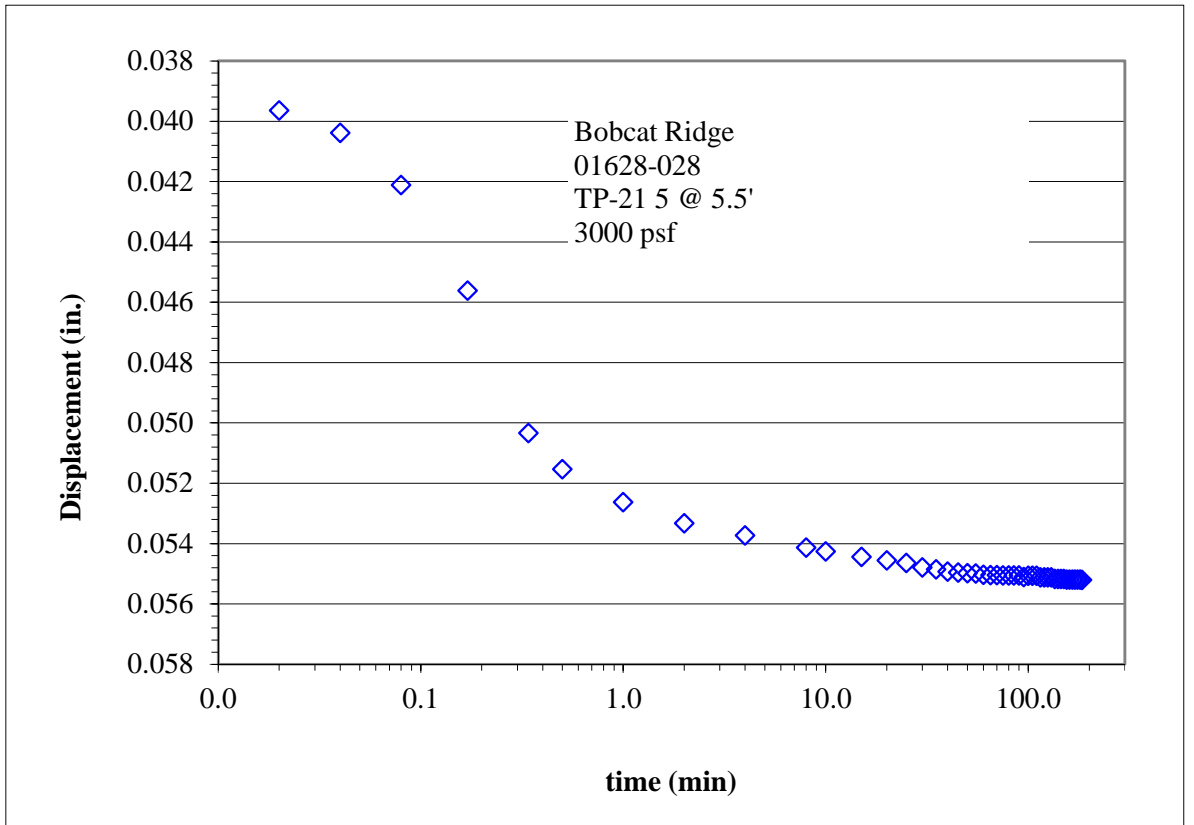
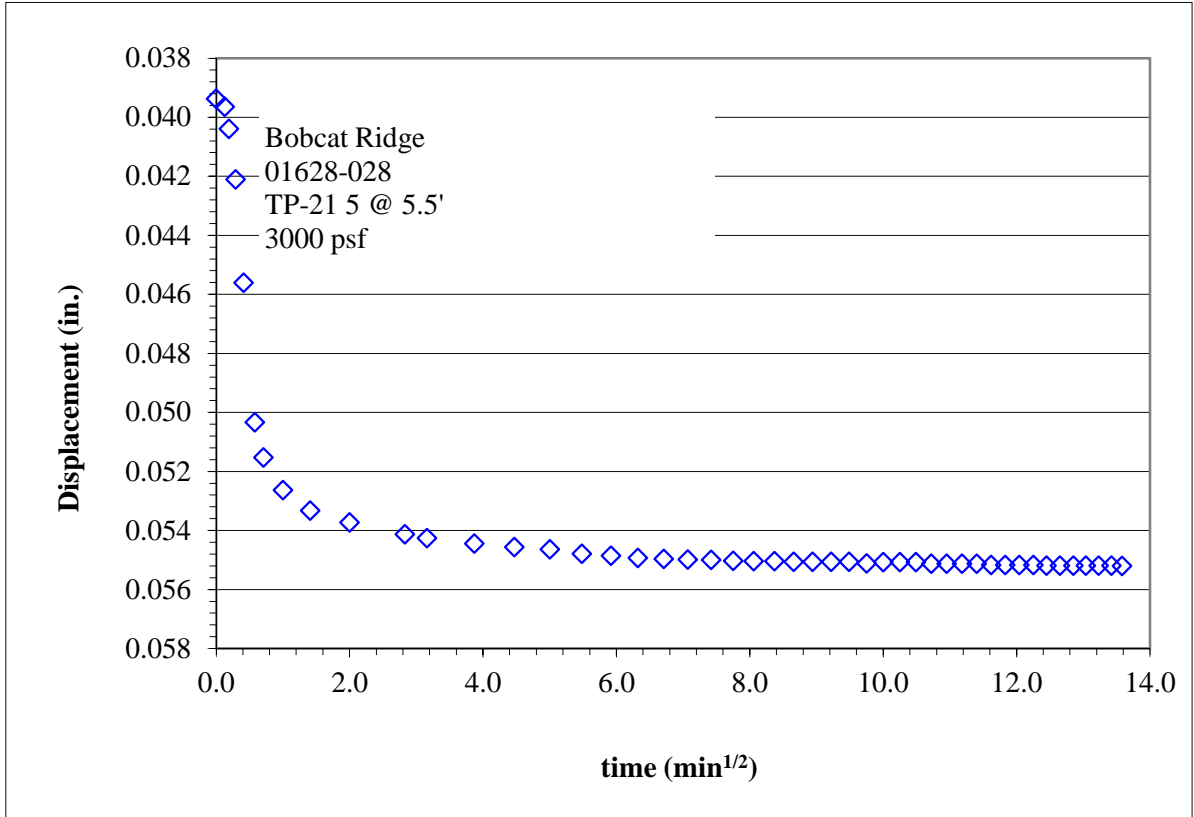
**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Boring No.: TP-21**

**Station: 5**

**Depth: 5.5'**



**Torsional Ring Shear Test to Determine Drained Residual Shear Strength of Cohesive Soils** (ASTM 6467)

**Project: Bobcat Ridge**  
**No: 01628-028**

Location: **Powder Mountain, Weber Co., UT**  
Date: **7/20/2018**  
By: **NB**

**Boring No.: TP-1**  
**Station: 16**  
**Depth: 4.0'**

Sample Description: **Reddish brown fat clay**  
Engineering Classification: **CH**

Sample preparation: **Screened over No.40 / remolded near liquid limit**

Test type: **Residual**

Ring friction remarks: **Modified upper platen**

Ring shear device: **Bromhead type, WF 25850 #1**

Sample presheared: **Yes**

Failure surface location: **Near top**

|   |    |      |      |
|---|----|------|------|
| inner/outter/avg. dia. (mm)             | 70 | 100  | 85   |
| inner/outter/avg. radii (mm)            | 35 | 50   | 42.5 |
| Thickness (mm)/area (cm <sup>2</sup> ): | 5  | 40.1 |      |

|                                  |     |                      |     |
|----------------------------------|-----|----------------------|-----|
| LL (%):                          | 126 | CF <sup>a</sup> (%): | N/A |
| PL (%):                          | 41  | Gs assum.:           | 2.8 |
| % Finer No. 200 (tested sample): |     | 94.3                 |     |

LL, PL = liquid and plastic limits, respectively

<sup>a</sup>CF = % < 0.002 mm and passing No. 10

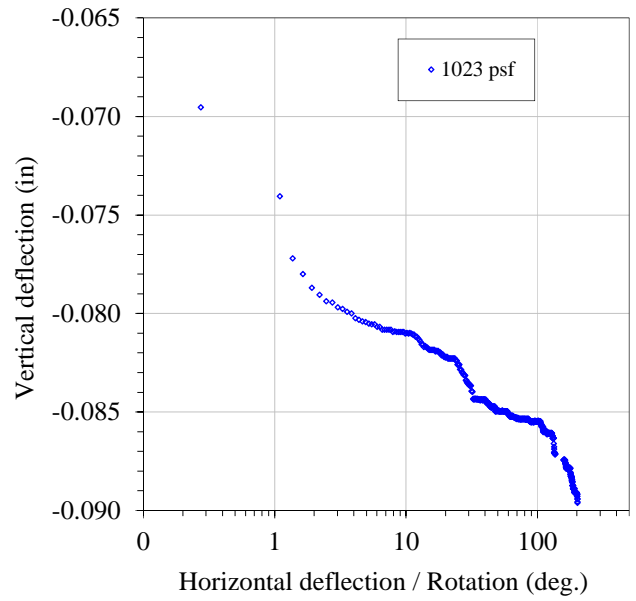
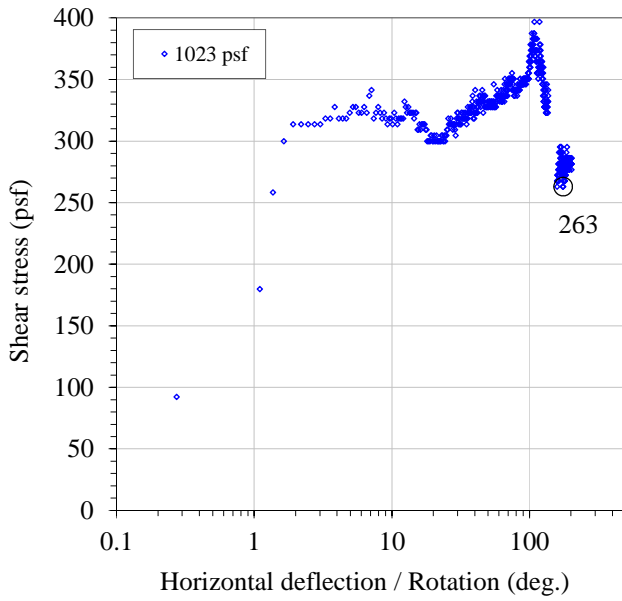
|             | τ stress  | σ stress | Horz. def | Vert. def |
|-------------|-----------|----------|-----------|-----------|
| Units:      | (psf)     | (psf)    | (deg.)    | (in)      |
| Conversion: | 20885.434 | 2048.2   | 1         | 3.94E-05  |

| Sample 1                         |         |       |
|----------------------------------|---------|-------|
|                                  | Initial | Final |
| Sample thickness (mm)            | 5.00    | 2.73  |
| Wt. container + wet soil (g)     | 622.38  |       |
| Wt. container (g)                | 593.32  |       |
| Wet soil + tare (g)              | 16.11   | 25.68 |
| Dry soil + tare (g)              | 11.10   | 20.11 |
| Tare (g)                         | 7.06    | 12.72 |
| Water content (%)                | 124.0   | 75.4  |
| Dry density (g/cm <sup>3</sup> ) | 0.65    | 1.19  |
| Saturation (%)                   | 104.5   | 155.3 |

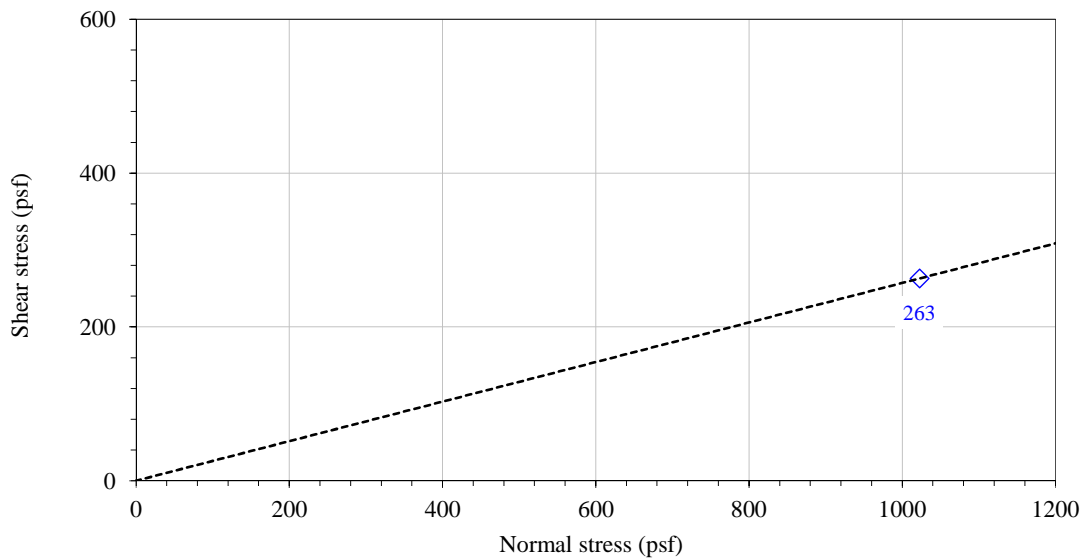
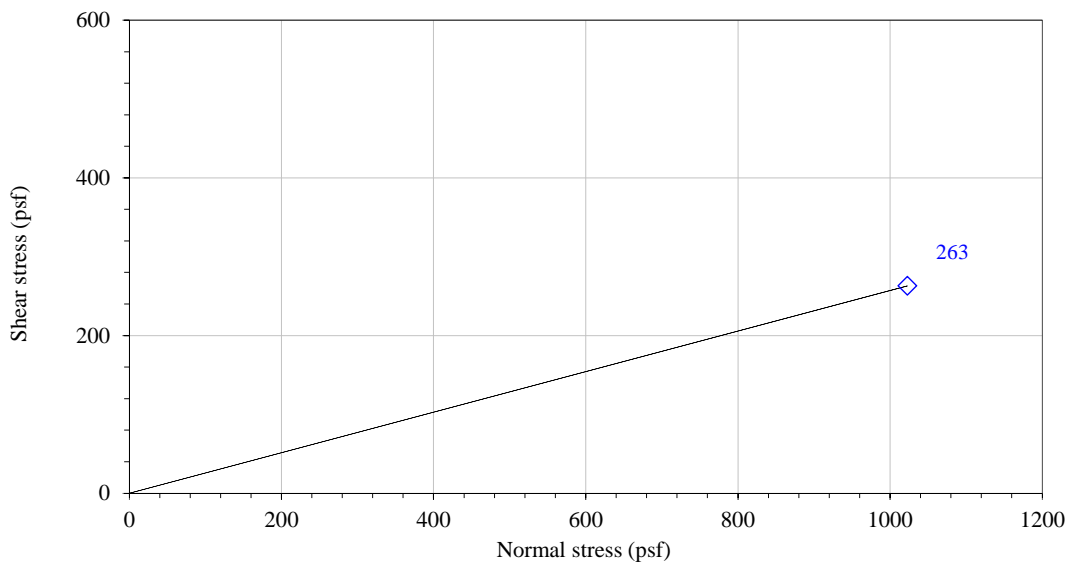
| Sample 1  |           |
|---|-----------|
| Normal load on lever arm (kg)                     | 2         |
| Conversion factor (kg/cm <sup>2</sup> ) to (psf): | 2048.1614 |
| Residual deformation (deg.)                       | 175.7     |
| Normal stress (psf)                               | 1023      |
| Residual shear stress (psf)                       | 263       |
| Peak shear stress (psf)                           | 411       |
| Secant residual friction angle (deg)              | 14.4      |
| Secant peak friction angle (deg)                  | 21.9      |

Entered by: \_\_\_\_\_  
Reviewed: \_\_\_\_\_

**Torsional Ring Shear Test to Determine Drained Residual Shear Strength of Cohesive Soils** (ASTM 6467)



$Horizontal\ deflection\ (in) = Degrees\ rotation * 0.0292$



**Minimum Laboratory Soil Resistivity, pH of Soil for Use in Corrosion Testing, and**



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**Ions in Water by Chemically Suppressed Ion Chromatography** (AASHTO T 288, T 289, ASTM D4327, and C1580)

**Project: Bobcat Ridge**

**No: 01628-028**

**Location: Powder Mountain, Weber Co., UT**

**Date: 7/9/2018**

**By: JP**

|                    |                                   |                                |                        |                          |                    |                                |                        |                          |                    |
|--------------------|-----------------------------------|--------------------------------|------------------------|--------------------------|--------------------|--------------------------------|------------------------|--------------------------|--------------------|
| Sample info.       | Boring No.                        | TP-25                          |                        |                          |                    |                                |                        |                          |                    |
|                    | Station                           | 4                              |                        |                          |                    |                                |                        |                          |                    |
|                    | Depth                             | 3.0'                           |                        |                          |                    |                                |                        |                          |                    |
| Water content data | Wet soil + tare (g)               | 72.31                          |                        |                          |                    |                                |                        |                          |                    |
|                    | Dry soil + tare (g)               | 67.90                          |                        |                          |                    |                                |                        |                          |                    |
|                    | Tare (g)                          | 37.23                          |                        |                          |                    |                                |                        |                          |                    |
|                    | Water content (%)                 | 14.4                           |                        |                          |                    |                                |                        |                          |                    |
| Chem. data         | pH                                | 4.21                           |                        |                          |                    |                                |                        |                          |                    |
|                    | Soluble chloride* (ppm)           | 18.9                           |                        |                          |                    |                                |                        |                          |                    |
|                    | Soluble sulfate** (ppm)           | <5.80                          |                        |                          |                    |                                |                        |                          |                    |
| Resistivity data   | Pin method                        | 2                              |                        |                          |                    |                                |                        |                          |                    |
|                    | Soil box                          | Miller Small                   |                        |                          |                    |                                |                        |                          |                    |
|                    |                                   | Approximate Soil condition (%) | Resistance Reading (Ω) | Soil Box Multiplier (cm) | Resistivity (Ω-cm) | Approximate Soil condition (%) | Resistance Reading (Ω) | Soil Box Multiplier (cm) | Resistivity (Ω-cm) |
|                    |                                   | As Is                          | 5708                   | 0.67                     | 3824               |                                |                        |                          |                    |
|                    |                                   | +3                             | 2670                   | 0.67                     | 1789               |                                |                        |                          |                    |
|                    |                                   | +6                             | 1750                   | 0.67                     | 1173               |                                |                        |                          |                    |
|                    |                                   | +9                             | 1460                   | 0.67                     | 978                |                                |                        |                          |                    |
|                    |                                   | +12                            | 1496                   | 0.67                     | 1002               |                                |                        |                          |                    |
|                    |                                   |                                |                        |                          |                    |                                |                        |                          |                    |
|                    |                                   |                                |                        |                          |                    |                                |                        |                          |                    |
|                    | <b>Minimum resistivity (Ω-cm)</b> | <b>978</b>                     |                        |                          |                    |                                |                        |                          |                    |

\* Performed by AWAL using EPA 300.0

\*\* Performed by AWAL using ASTM C1580

Entered by: \_\_\_\_\_

Reviewed: \_\_\_\_\_

# **APPENDIX C**


**Design Maps Detailed Report**

2012/2015 International Building Code (41.3578°N, 111.7496°W)

Site Class C – “Very Dense Soil and Soft Rock”, Risk Category I/II/III

**Section 1613.3.1 — Mapped acceleration parameters**

Note: Ground motion values provided below are for the direction of maximum horizontal spectral response acceleration. They have been converted from corresponding geometric mean ground motions computed by the USGS by applying factors of 1.1 (to obtain  $S_S$ ) and 1.3 (to obtain  $S_1$ ). Maps in the 2012/2015 International Building Code are provided for Site Class B. Adjustments for other Site Classes are made, as needed, in Section 1613.3.3.

From [Figure 1613.3.1\(1\)](#) <sup>[1]</sup> $S_S = 0.814 \text{ g}$ From [Figure 1613.3.1\(2\)](#) <sup>[2]</sup> $S_1 = 0.270 \text{ g}$ **Section 1613.3.2 — Site class definitions**

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class C, based on the site soil properties in accordance with Section 1613.

2010 ASCE-7 Standard – Table 20.3-1  
SITE CLASS DEFINITIONS

| Site Class  | $\bar{v}_s$         | $\bar{N}$ or $\bar{N}_{ch}$ | $\bar{s}_u$        |
|---|---------------------|-----------------------------|--------------------|
| A. Hard Rock  | >5,000 ft/s         | N/A                         | N/A                |
| B. Rock   | 2,500 to 5,000 ft/s | N/A                         | N/A                |
| C. Very dense soil and soft rock  | 1,200 to 2,500 ft/s | >50                         | >2,000 psf         |
| D. Stiff Soil   | 600 to 1,200 ft/s   | 15 to 50                    | 1,000 to 2,000 psf |
| E. Soft clay soil   | <600 ft/s           | <15                         | <1,000 psf         |
| Any profile with more than 10 ft of soil having the characteristics:  |                     |                             |                    |
| <ul style="list-style-type: none"> <li>• Plasticity index <math>PI &gt; 20</math>,</li> <li>• Moisture content <math>w \geq 40\%</math>, and</li> <li>• Undrained shear strength <math>\bar{s}_u &lt; 500 \text{ psf}</math></li> </ul> |                     |                             |                    |
| F. Soils requiring site response analysis in accordance with Section 21.1   | See Section 20.3.1  |                             |                    |

For SI: 1ft/s = 0.3048 m/s 1lb/ft<sup>2</sup> = 0.0479 kN/m<sup>2</sup>

### Section 1613.3.3 — Site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters

TABLE 1613.3.3(1)  
VALUES OF SITE COEFFICIENT  $F_a$

| Site Class | Mapped Spectral Response Acceleration at Short Period |              |              |              |                 |
|------------|---|--------------|--------------|--------------|-----------------|
|            | $S_s \leq 0.25$                                       | $S_s = 0.50$ | $S_s = 0.75$ | $S_s = 1.00$ | $S_s \geq 1.25$ |
| A          | 0.8   | 0.8          | 0.8          | 0.8          | 0.8             |
| B          | 1.0   | 1.0          | 1.0          | 1.0          | 1.0             |
| C          | 1.2   | 1.2          | 1.1          | 1.0          | 1.0             |
| D          | 1.6   | 1.4          | 1.2          | 1.1          | 1.0             |
| E          | 2.5   | 1.7          | 1.2          | 0.9          | 0.9             |
| F          | See Section 11.4.7 of ASCE 7                          |              |              |              |                 |

Note: Use straight-line interpolation for intermediate values of  $S_s$

**For Site Class = C and  $S_s = 0.814$  g,  $F_a = 1.075$**

TABLE 1613.3.3(2)  
VALUES OF SITE COEFFICIENT  $F_v$

| Site Class | Mapped Spectral Response Acceleration at 1-s Period |              |              |              |                 |
|------------|---|--------------|--------------|--------------|-----------------|
|            | $S_1 \leq 0.10$                                     | $S_1 = 0.20$ | $S_1 = 0.30$ | $S_1 = 0.40$ | $S_1 \geq 0.50$ |
| A          | 0.8   | 0.8          | 0.8          | 0.8          | 0.8             |
| B          | 1.0   | 1.0          | 1.0          | 1.0          | 1.0             |
| C          | 1.7   | 1.6          | 1.5          | 1.4          | 1.3             |
| D          | 2.4   | 2.0          | 1.8          | 1.6          | 1.5             |
| E          | 3.5   | 3.2          | 2.8          | 2.4          | 2.4             |
| F          | See Section 11.4.7 of ASCE 7                        |              |              |              |                 |

Note: Use straight-line interpolation for intermediate values of  $S_1$

**For Site Class = C and  $S_1 = 0.270$  g,  $F_v = 1.530$**



**Equation (16-37):**

$$S_{MS} = F_a S_s = 1.075 \times 0.814 = 0.874 \text{ g}$$

---

**Equation (16-38):**

$$S_{M1} = F_v S_1 = 1.530 \times 0.270 = 0.413 \text{ g}$$

---

Section 1613.3.4 — Design spectral response acceleration parameters

**Equation (16-39):**

$$S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} \times 0.874 = 0.583 \text{ g}$$

---

**Equation (16-40):**

$$S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3} \times 0.413 = 0.275 \text{ g}$$

---

## Section 1613.3.5 — Determination of seismic design category

TABLE 1613.3.5(1)

SEISMIC DESIGN CATEGORY BASED ON SHORT-PERIOD (0.2 second) RESPONSE ACCELERATION

| VALUE OF $S_{DS}$            | RISK CATEGORY |     |    |
|------------------------------|---------------|-----|----|
|                              | I or II       | III | IV |
| $S_{DS} < 0.167g$            | A             | A   | A  |
| $0.167g \leq S_{DS} < 0.33g$ | B             | B   | C  |
| $0.33g \leq S_{DS} < 0.50g$  | C             | C   | D  |
| $0.50g \leq S_{DS}$          | D             | D   | D  |

For Risk Category = I and  $S_{DS} = 0.583 g$ , Seismic Design Category = D

TABLE 1613.3.5(2)

SEISMIC DESIGN CATEGORY BASED ON 1-SECOND PERIOD RESPONSE ACCELERATION

| VALUE OF $S_{D1}$             | RISK CATEGORY |     |    |
|-------------------------------|---------------|-----|----|
|                               | I or II       | III | IV |
| $S_{D1} < 0.067g$             | A             | A   | A  |
| $0.067g \leq S_{D1} < 0.133g$ | B             | B   | C  |
| $0.133g \leq S_{D1} < 0.20g$  | C             | C   | D  |
| $0.20g \leq S_{D1}$           | D             | D   | D  |

For Risk Category = I and  $S_{D1} = 0.275 g$ , Seismic Design Category = D

Note: When  $S_1$  is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category  $\equiv$  "the more severe design category in accordance with Table 1613.3.5(1) or 1613.3.5(2)" = D

---

Note: See Section 1613.3.5.1 for alternative approaches to calculating Seismic Design Category.

## References

1. *Figure 1613.3.1(1)*: [https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1\(1\).pdf](https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(1).pdf)
2. *Figure 1613.3.1(2)*: [https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1\(2\).pdf](https://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(2).pdf)

# USGS Design Maps Summary Report

## User-Specified Input

**Report Title** Bobcat  
Fri July 20, 2018 20:16:05 UTC

**Building Code Reference Document** 2012/2015 International Building Code  
(which utilizes USGS hazard data available in 2008)

**Site Coordinates** 41.3578°N, 111.7496°W

**Site Soil Classification** Site Class C – “Very Dense Soil and Soft Rock”

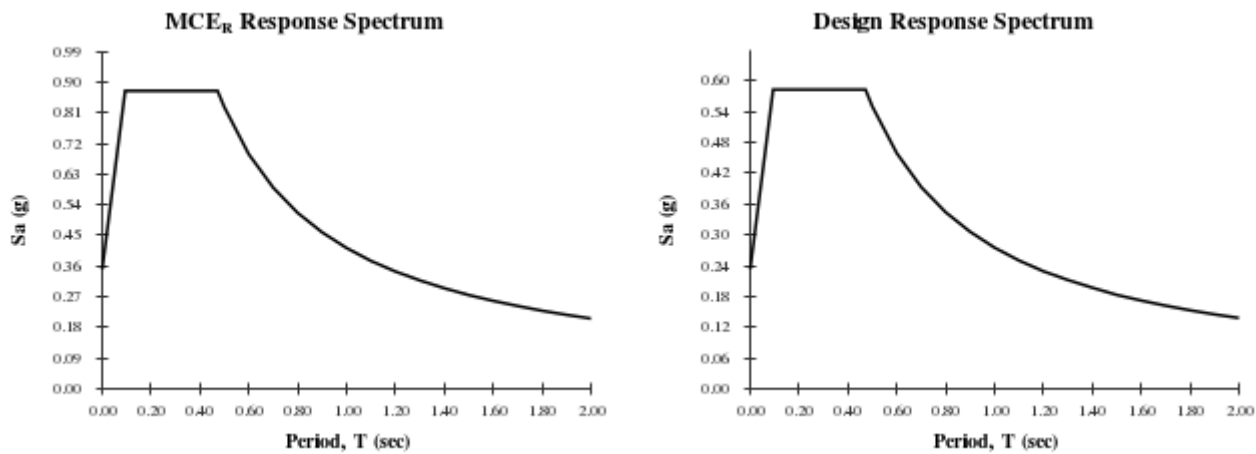
**Risk Category** I/II/III



## USGS-Provided Output

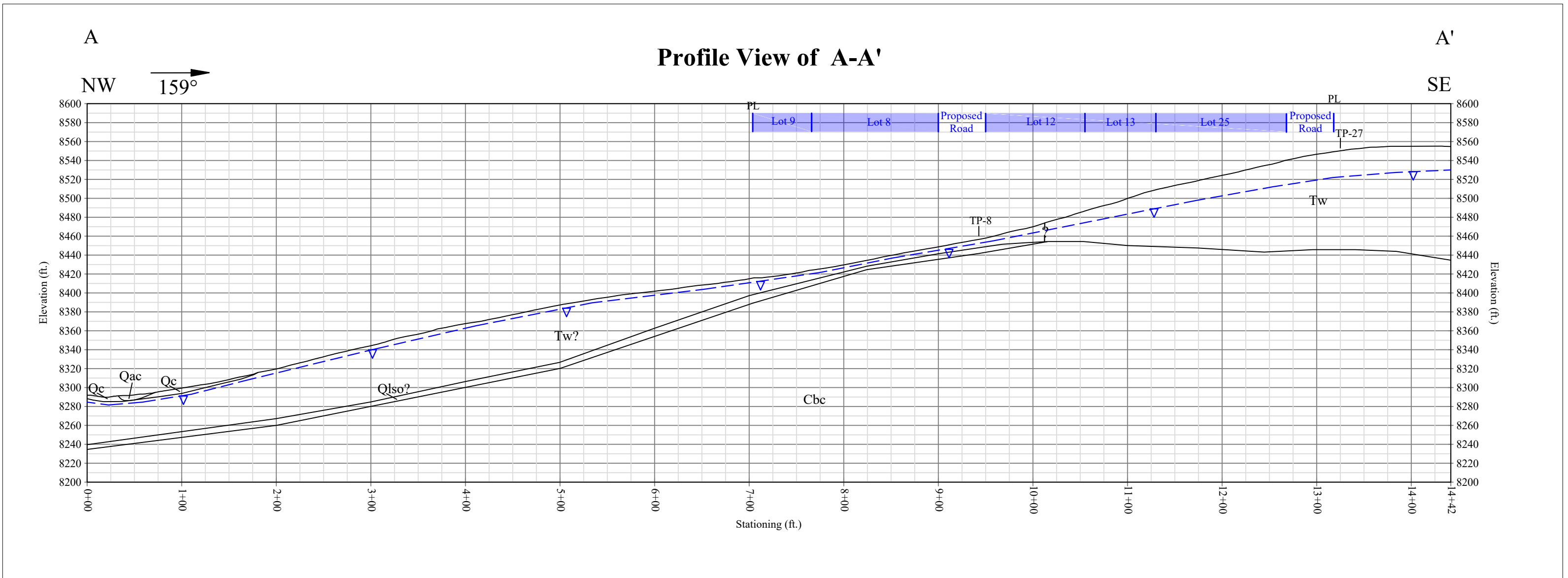
|                         |                            |                            |
|-------------------------|----------------------------|----------------------------|
| $S_S = 0.814 \text{ g}$ | $S_{MS} = 0.874 \text{ g}$ | $S_{DS} = 0.583 \text{ g}$ |
| $S_1 = 0.270 \text{ g}$ | $S_{M1} = 0.413 \text{ g}$ | $S_{D1} = 0.275 \text{ g}$ |

For information on how the  $S_S$  and  $S_1$  values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the “2009 NEHRP” building code reference document.



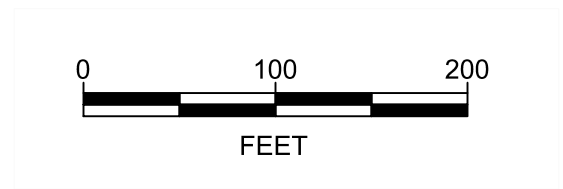
Although this information is a product of the U.S. Geological Survey, we provide no warranty, expressed or implied, as to the accuracy of the data contained therein. This tool is not a substitute for technical subject-matter knowledge.

# **APPENDIX D**



#### LEGEND

- |  |  |   |
|--|--|---|
| <p><span style="border: 1px solid black; padding: 2px;">Qac</span> Alluvial and Colluvial Deposits</p> <p><span style="border: 1px solid black; padding: 2px;">Qc</span> Colluvium</p> | <p><span style="border: 1px solid black; padding: 2px;">Qlso?</span> Deeper Clay Seam; possible older landslide slide plane</p> <p><span style="border: 1px solid black; padding: 2px;">Tw</span> Wasatch Formation; queried where possible older landslide deposits</p> | <p><span style="border: 1px solid black; padding: 2px;">Cbc</span> Calls Fort Shale Member of Bloomington Formation</p> |
| <p>*All Geologic Contacts Approximate</p> <p><span style="color: blue; font-weight: bold;">- - - ▽ - - -</span> Groundwater (perched)</p>  |  |   |



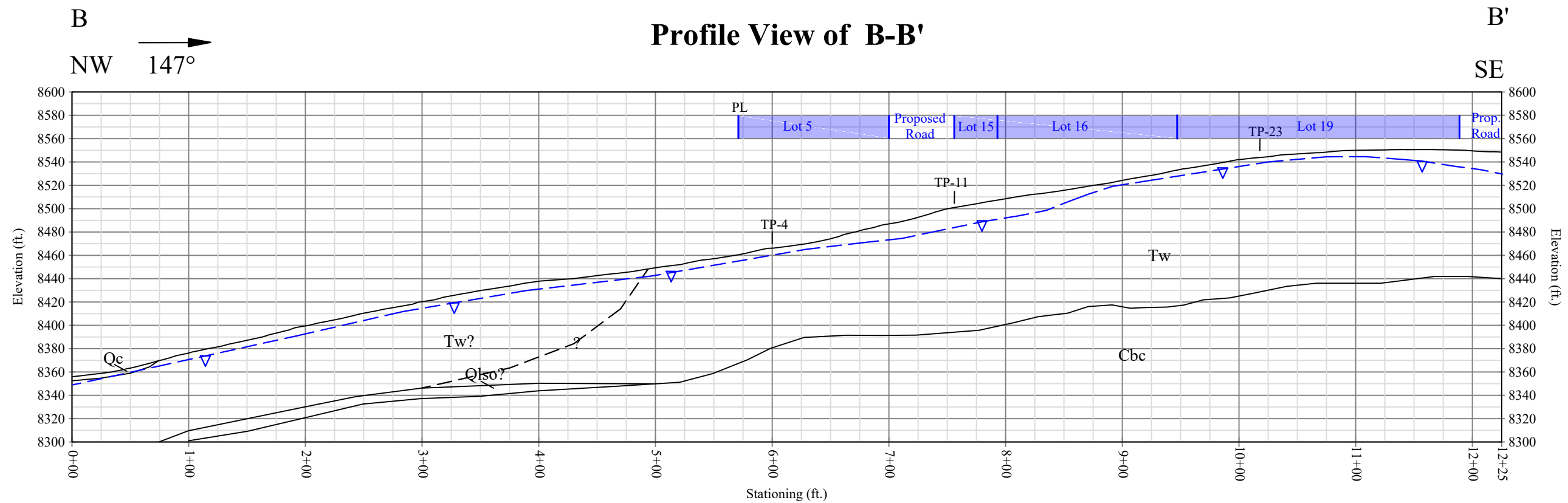
**IGES**<sup>®</sup>

Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

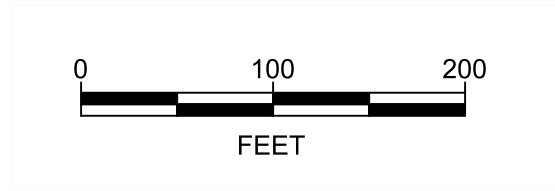
Cross Section A-A'

Figure  
D-1



**LEGEND**

- Qac Alluvial and Colluvial Deposits
  - Qc Colluvium
  - Qlso? Deeper Clay Seam; possible older landslide deposit
  - Tw Wasatch Formation; queried where possible older landslide deposits
  - Cbc Calls Fort Shale Member of Bloomington Formation
  - - - ▽ Groundwater (perched)
- \*All Geologic Contacts Approximate



1" = 100'

**IGES**<sup>®</sup>

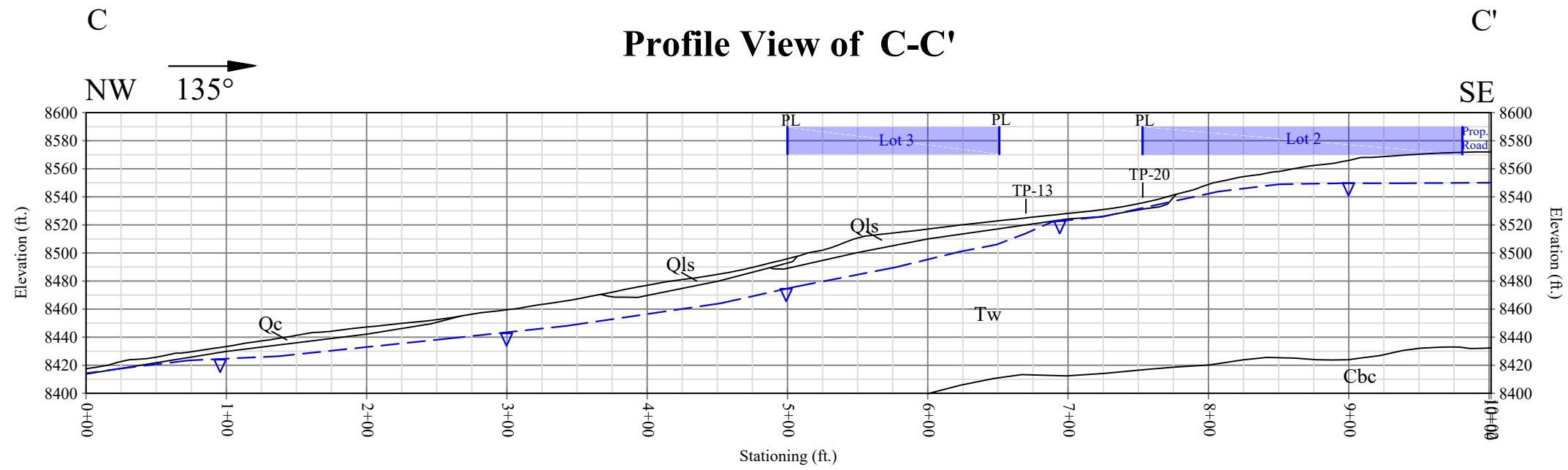
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

**Cross Section B-B'**

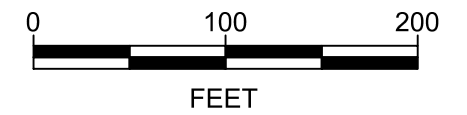
**Figure**

**D-2**



**LEGEND**

- |   |   |
|---|---|
| <span style="border: 1px solid black; padding: 2px;">Qac</span> Alluvial and Colluvial Deposits | <span style="border: 1px solid black; padding: 2px;">Qs</span> Landslide Deposits (Holocene-aged)                                 |
| <span style="border: 1px solid black; padding: 2px;">Qc</span> Colluvium                        | <span style="border: 1px solid black; padding: 2px;">Tw</span> Wasatch Formation; queried where possible older landslide deposits |
|   | <span style="border: 1px solid black; padding: 2px;">Cbc</span> Calle Fort Shale Member of Bloomington Formation                  |
| *All Geologic Contacts Approximate  |   |
|   | Groundwater (perched)   |



1" = 100'



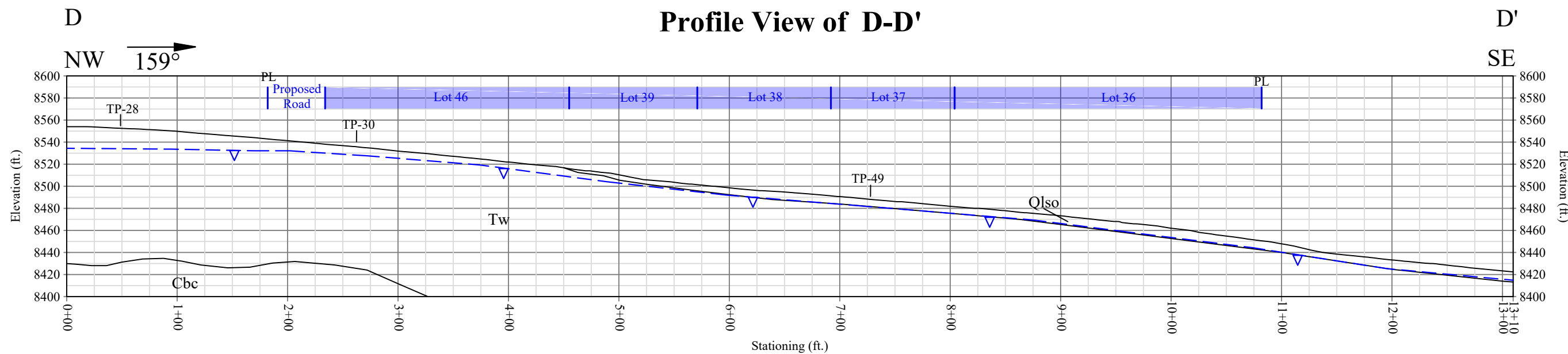
Project No: 01628-028

Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

**Cross Section C-C'**

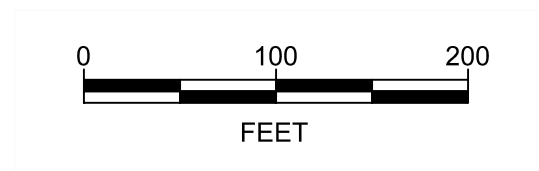
**Figure**

**D-3**

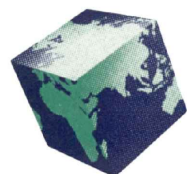


#### LEGEND

- |  |  |   |
|--|--|---|
| <b>Qac</b> Alluvial and Colluvial Deposits | <b>Qlso</b> Older Landslide Deposits (Pleistocene-aged)                      |   |
| <b>Qc</b> Colluvium                        | <b>Tw</b> Wasatch Formation; queried where possible older landslide deposits | <b>Cbc</b> Calls Fort Shale Member of Bloomington Formation |
| *All Geologic Contacts Approximate         |  | Groundwater (perched)                                       |



1" = 100'



# IGES<sup>®</sup>

Project No: 01628-028

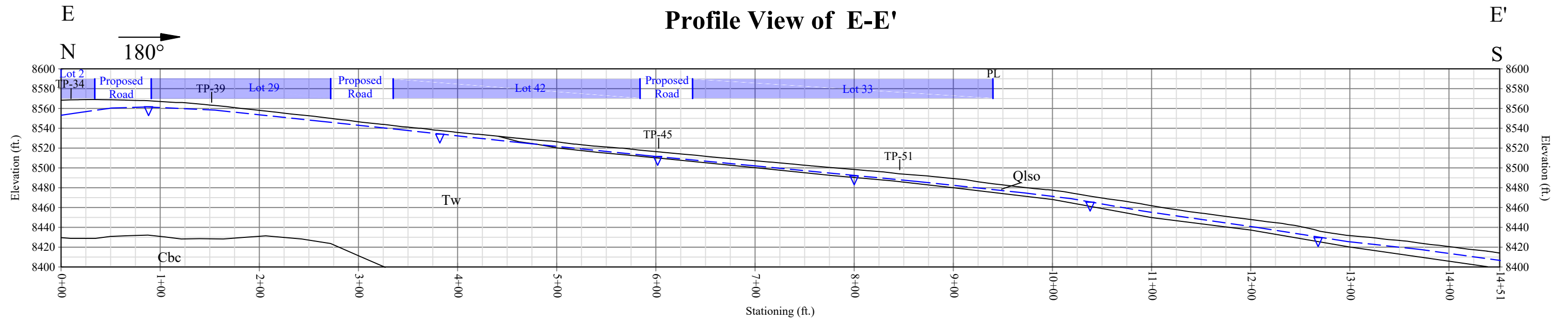
Geotechnical and Geologic Hazards Assessment  
Bobcat Ridge Subdivision  
Summit Powder Mountain Resort  
Weber County, Utah

**Cross Section D-D'**

**Figure**

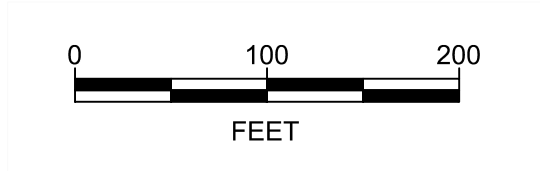
**D-4**





#### LEGEND

- |   |   |  |
|---|---|--|
| <span style="border: 1px solid black; padding: 2px;">Qac</span> Alluvial and Colluvial Deposits | <span style="border: 1px solid black; padding: 2px;">Qlso</span> Older Landslide Deposits (Pleistocene-aged)                      |  |
| <span style="border: 1px solid black; padding: 2px;">Qc</span> Colluvium                        | <span style="border: 1px solid black; padding: 2px;">Tw</span> Wasatch Formation; queried where possible older landslide deposits | <span style="border: 1px solid black; padding: 2px;">Cbc</span> Calls Fort Shale Member of Bloomington Formation |
| *All Geologic Contacts Approximate  |   | <span style="color: blue; font-size: 1.2em;">- - - ▽ - - -</span> Groundwater (perched)                          |



1" = 100'

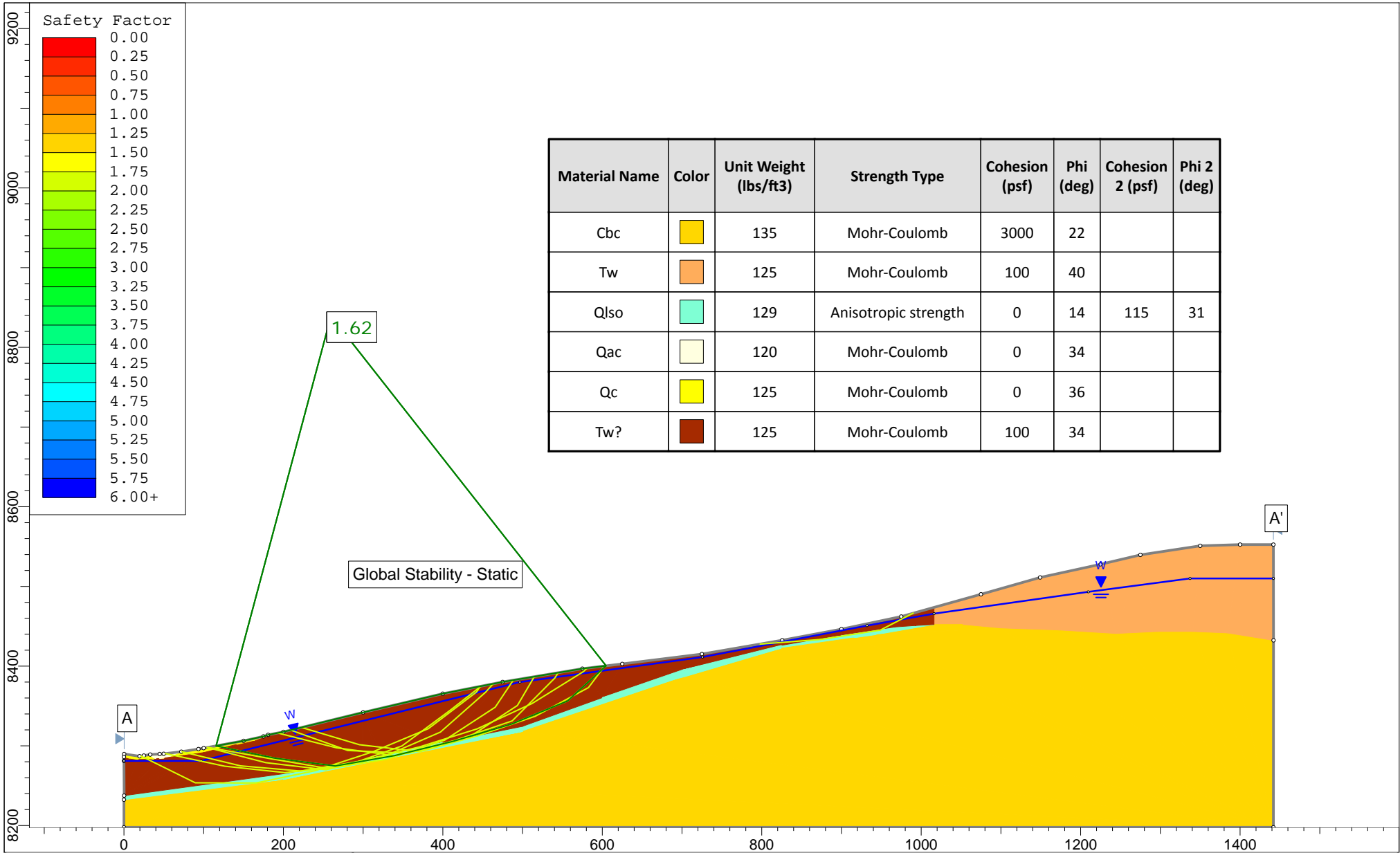
**IGES**<sup>®</sup>

Project No: 01628-028

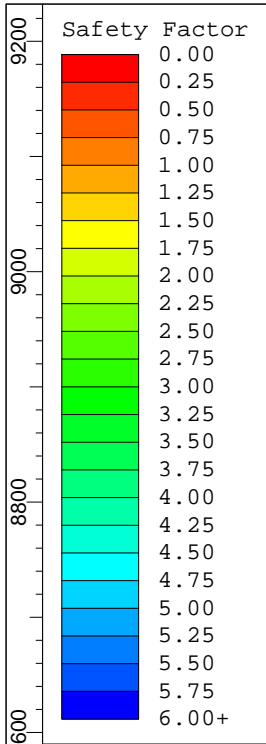
Geotechnical and Geologic Hazards Assessment  
 Bobcat Ridge Subdivision  
 Summit Powder Mountain Resort  
 Weber County, Utah

Cross Section E-E'

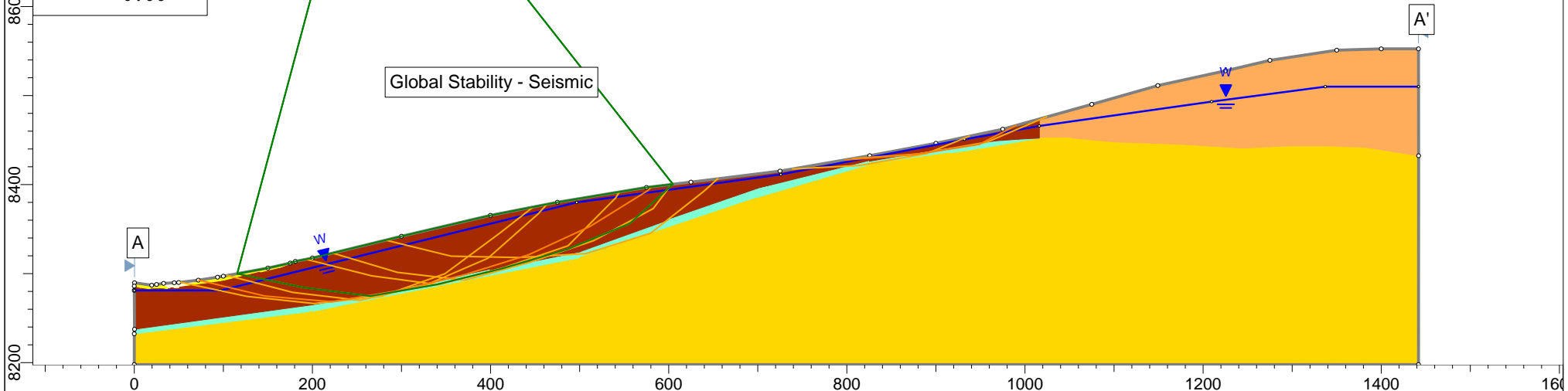
Figure  
D-5



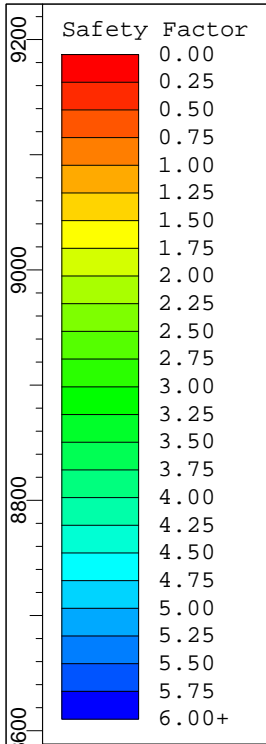
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|--|----------------------|-----------|-------|----------------|-----------|----------|
|  | Project              |           |       | Bobcat Ridge   |           |          |
|  | Analysis Description |           |       | A-A' 01628-028 |           |          |
|  | Drawn By             | EBF       | Scale | 1:2000         | Company   | IGES Inc |
|  | Date                 | 7/20/2018 |       | File Name      | A-A'.slim |          |



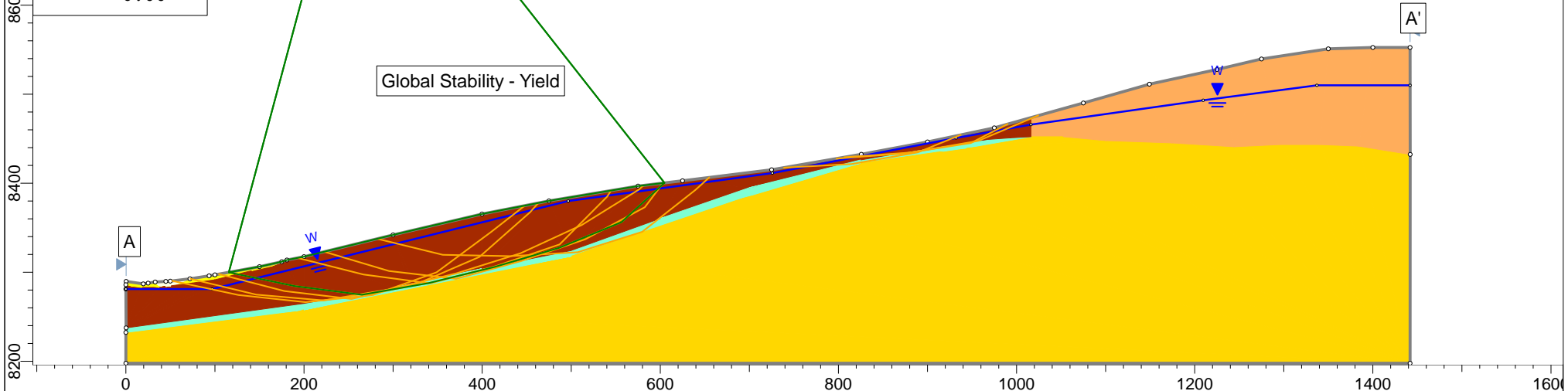
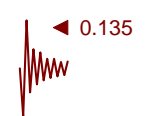
| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type        | Cohesion (psf) | Phi (deg) | Cohesion 2 (psf) | Phi 2 (deg) |
|---------------|-------|-----------------------|----------------------|----------------|-----------|------------------|-------------|
| Cbc           |       | 135                   | Mohr-Coulomb         | 3000           | 22        |                  |             |
| Tw            |       | 125                   | Mohr-Coulomb         | 100            | 40        |                  |             |
| Qlso          |       | 129                   | Anisotropic strength | 0              | 14        | 115              | 31          |
| Qac           |       | 120                   | Mohr-Coulomb         | 0              | 34        |                  |             |
| Qc            |       | 125                   | Mohr-Coulomb         | 0              | 36        |                  |             |
| Tw?           |       | 125                   | Mohr-Coulomb         | 100            | 34        |                  |             |



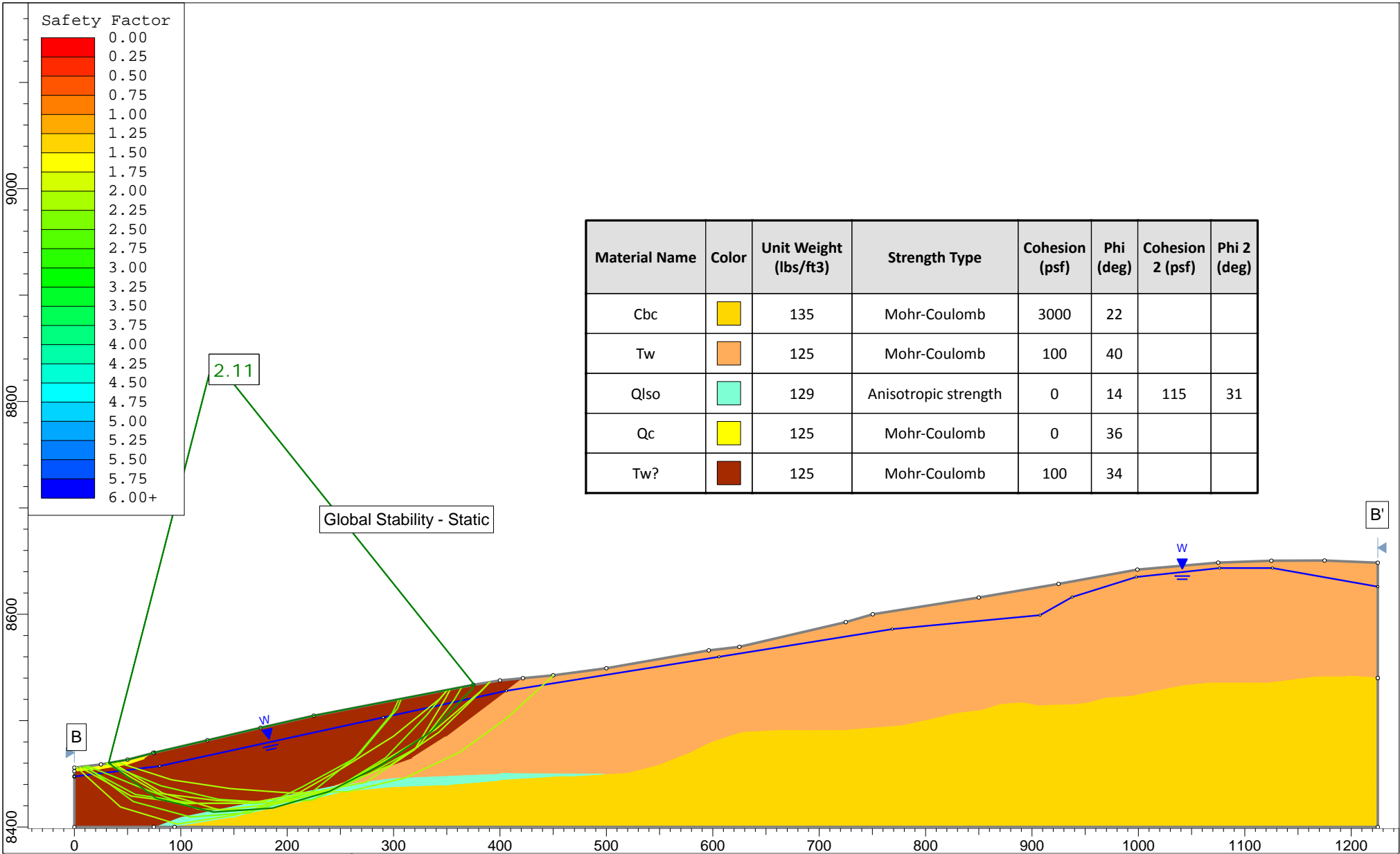
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|-------------------------------------|----------------------|-----------|-----------|----------------|---------|
|                                     | Project              |           |           | Bobcat Ridge   |         |
|                                     | Analysis Description |           |           | A-A' 01628-028 |         |
|                                     | Drawn By             | EBF       | Scale     | 1:2000         | Company |
|                                     | Date                 | 7/20/2018 | File Name | A-A'.slim      |         |
| <small>SLIDEINTERPRET 8.008</small> |                      |           |           |                |         |



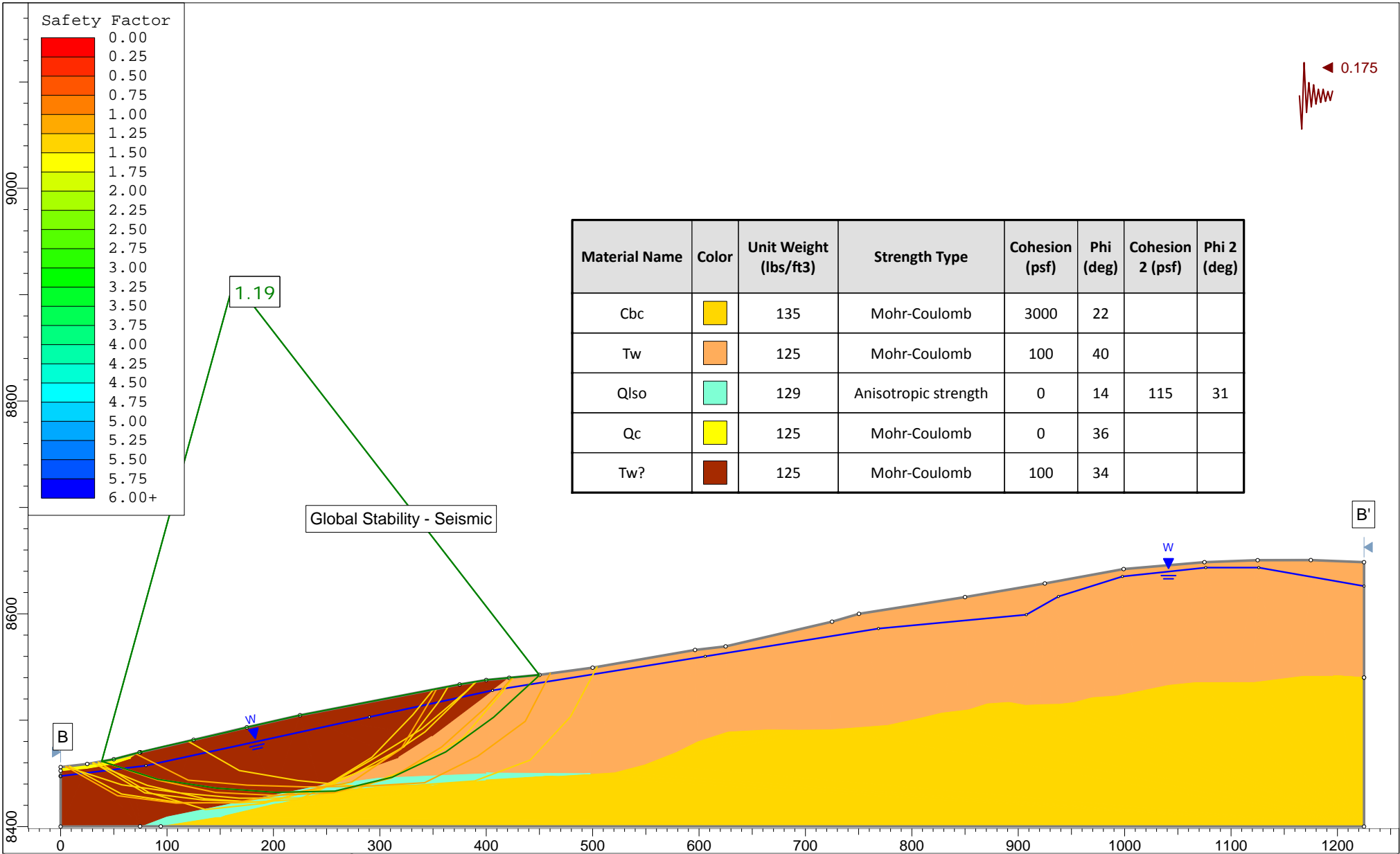
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|---------------|-------|-----------------------|----------------------|----------------|-----------|------------------|-------------|
| Cbc           |       | 135                   | Mohr-Coulomb         | 3000           | 22        |                  |             |
| Tw            |       | 125                   | Mohr-Coulomb         | 100            | 40        |                  |             |
| Q so          |       | 129                   | Anisotropic strength | 0              | 14        | 115              | 31          |
| Qac           |       | 120                   | Mohr-Coulomb         | 0              | 34        |                  |             |
| Qc            |       | 125                   | Mohr-Coulomb         | 0              | 36        |                  |             |
| Tw?           |       | 125                   | Mohr-Coulomb         | 100            | 34        |                  |             |



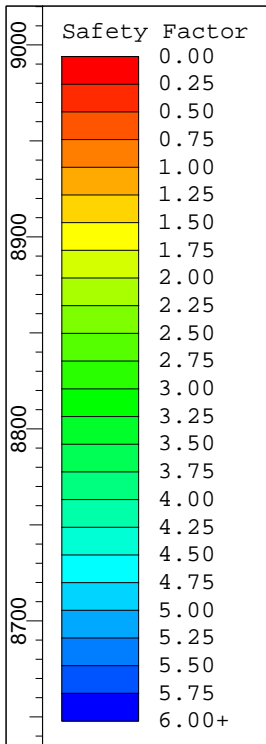
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|--|----------------------|-----------|-----------|----------------|---------|----------|
|  | Project              |           |           | Bobcat Ridge   |         |          |
|  | Analysis Description |           |           | A-A' 01628-028 |         |          |
|  | Drawn By             | EBF       | Scale     | 1:2000         | Company | IGES Inc |
|  | Date                 | 7/20/2018 | File Name | A-A'.slim      |         |          |



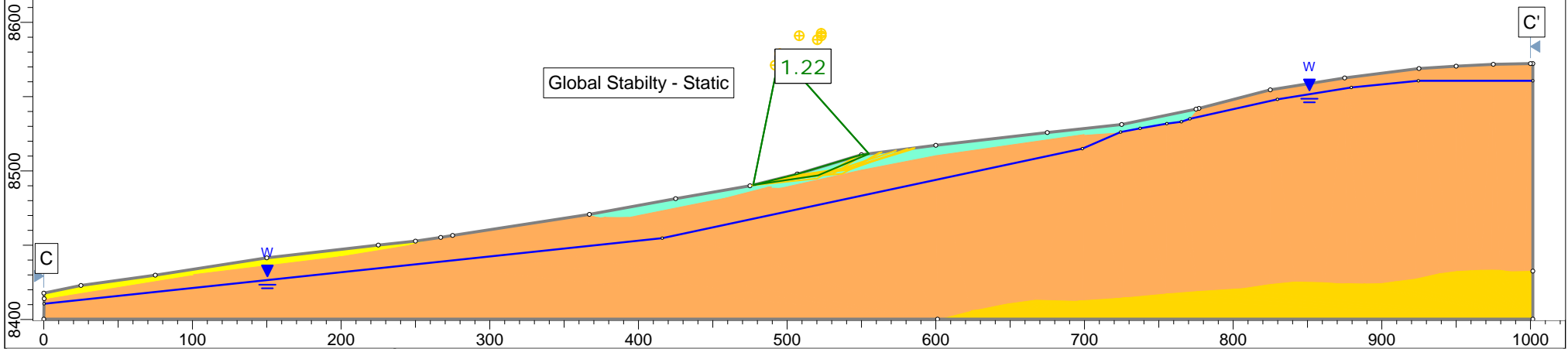
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|--|----------------------|-----------|-------|----------------|-----------|----------|
|  | Project              |           |       | Bobcat Ridge   |           |          |
|  | Analysis Description |           |       | B-B' 01628-028 |           |          |
|  | Drawn By             | EBF       | Scale | 1:1500         | Company   | IGES Inc |
|  | Date                 | 7/20/2018 |       | File Name      | B-B'.slim |          |



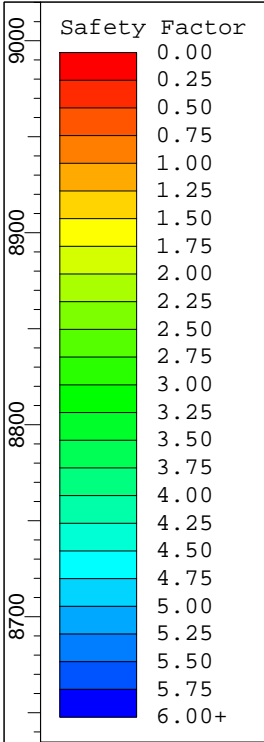
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|--|----------------------|-----------|-------|----------------|-----------|----------|
|  | Project              |           |       | Bobcat Ridge   |           |          |
|  | Analysis Description |           |       | B-B' 01628-028 |           |          |
|  | Drawn By             | EBF       | Scale | 1:1500         | Company   | IGES Inc |
|  | Date                 | 7/20/2018 |       | File Name      | B-B'.slim |          |



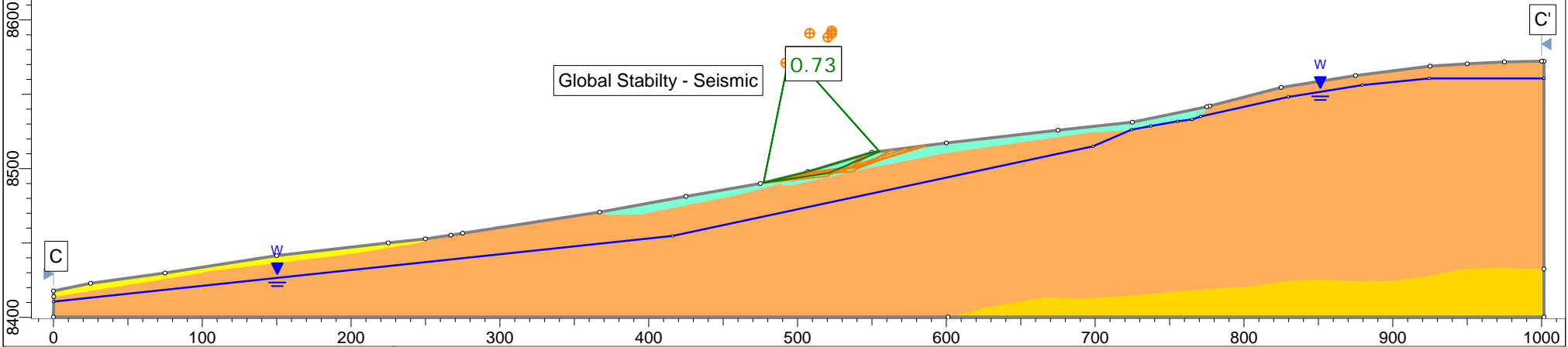
| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type        | Cohesion (psf) | Phi (deg) | Cohesion 2 (psf) | Phi 2 (deg) |
|---------------|-------|-----------------------|----------------------|----------------|-----------|------------------|-------------|
| Cbc           |       | 135                   | Mohr-Coulomb         | 3000           | 22        |                  |             |
| Tw            |       | 125                   | Mohr-Coulomb         | 100            | 40        |                  |             |
| Qls           |       | 129                   | Anisotropic strength | 0              | 14        | 115              | 31          |
| Qc            |       | 125                   | Mohr-Coulomb         | 0              | 36        |                  |             |



|  |                      |           |       |                |           |          |
|--|----------------------|-----------|-------|----------------|-----------|----------|
|  | Project              |           |       | Bobcat Ridge   |           |          |
|  | Analysis Description |           |       | C-C' 01628-028 |           |          |
|  | Drawn By             | EBF       | Scale | 1:1200         | Company   | IGES Inc |
|  | Date                 | 7/20/2018 |       | File Name      | C-C'.slim |          |

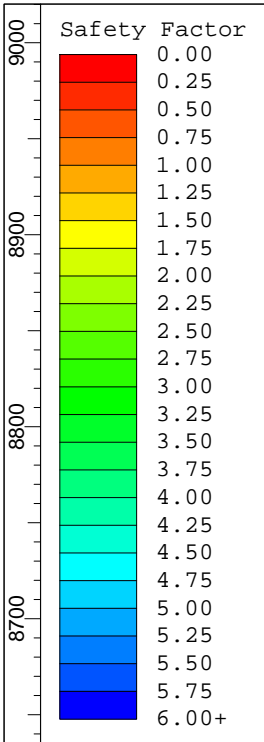


| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type        | Cohesion (psf) | Phi (deg) | Cohesion 2 (psf) | Phi 2 (deg) |
|---------------|-------|-----------------------|----------------------|----------------|-----------|------------------|-------------|
| Cbc           |       | 135                   | Mohr-Coulomb         | 3000           | 22        |                  |             |
| Tw            |       | 125                   | Mohr-Coulomb         | 100            | 40        |                  |             |
| Qls           |       | 129                   | Anisotropic strength | 0              | 14        | 115              | 31          |
| Qc            |       | 125                   | Mohr-Coulomb         | 0              | 36        |                  |             |

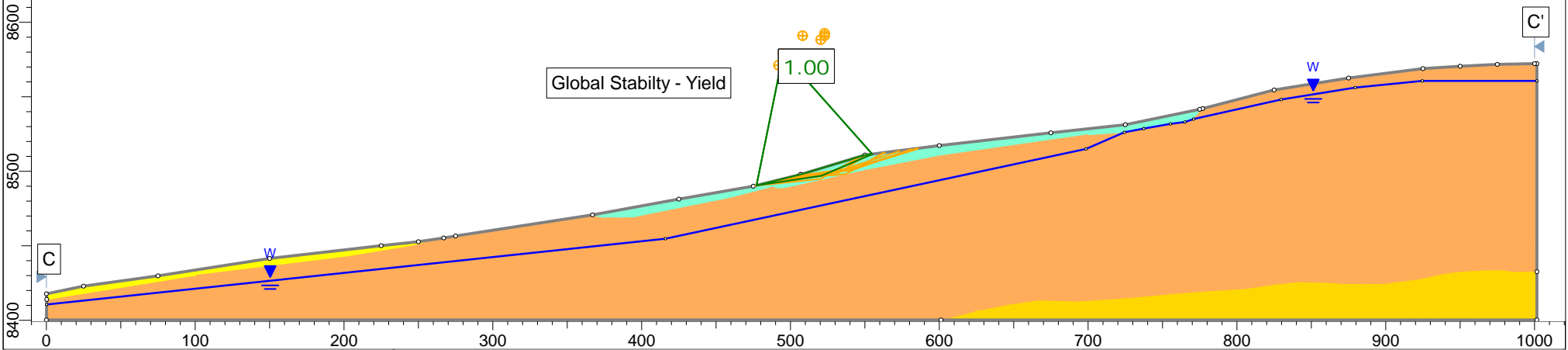
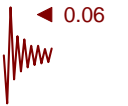


|  |                      |           |       |                |           |          |
|--|----------------------|-----------|-------|----------------|-----------|----------|
|  | Project              |           |       | Bobcat Ridge   |           |          |
|  | Analysis Description |           |       | C-C' 01628-028 |           |          |
|  | Drawn By             | EBF       | Scale | 1:1200         | Company   | IGES Inc |
|  | Date                 | 7/20/2018 |       | File Name      | C-C'.slim |          |

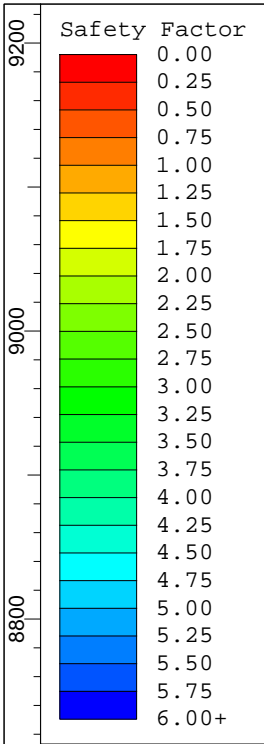




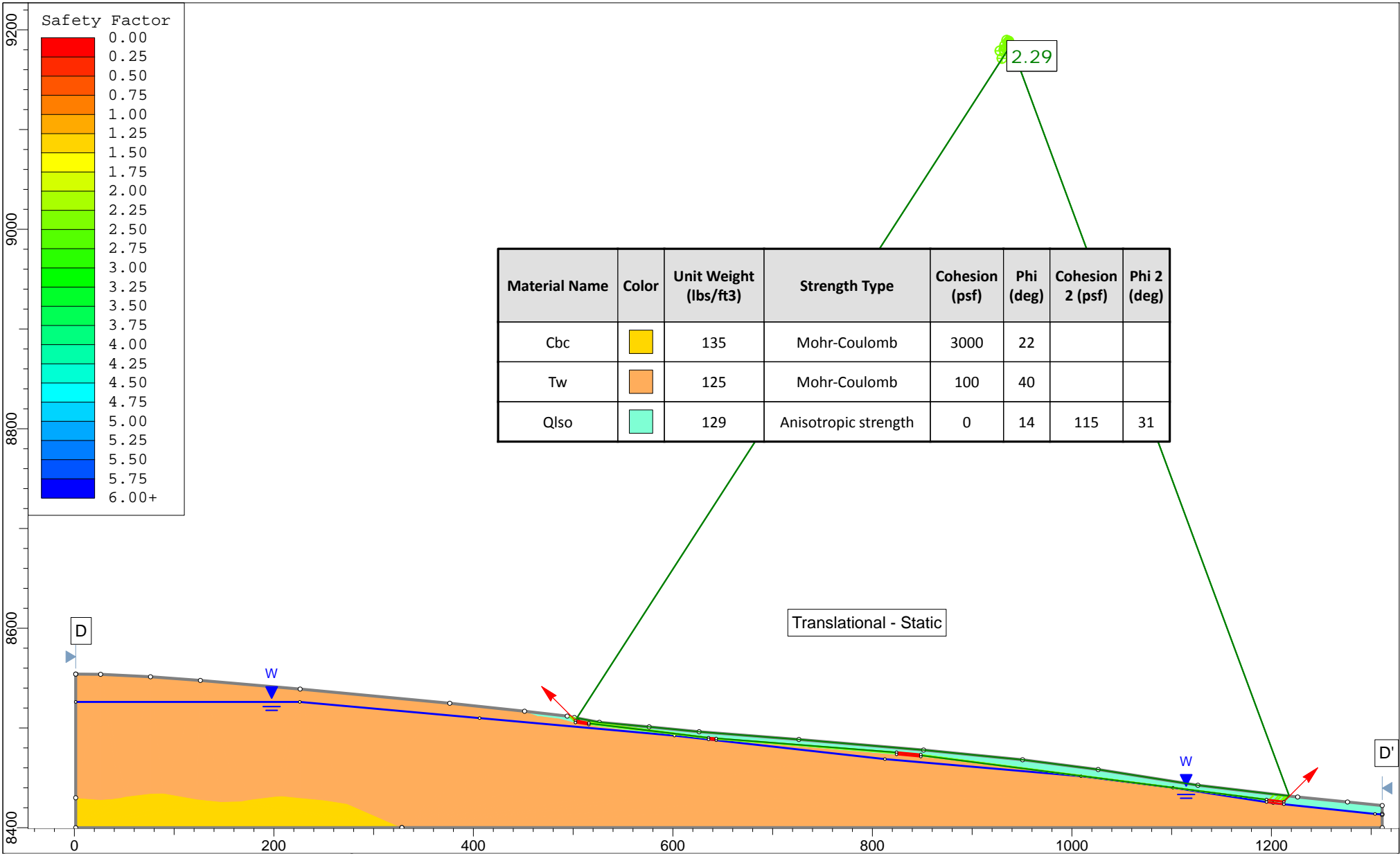
| Material Name | Color | Unit Weight (lbs/ft <sup>3</sup> ) | Strength Type        | Cohesion (psf) | Phi (deg) | Cohesion 2 (psf) | Phi 2 (deg) |
|---------------|-------|------------------------------------|----------------------|----------------|-----------|------------------|-------------|
| Cbc           |       | 135                                | Mohr-Coulomb         | 3000           | 22        |                  |             |
| Tw            |       | 125                                | Mohr-Coulomb         | 100            | 40        |                  |             |
| Qls           |       | 129                                | Anisotropic strength | 0              | 14        | 115              | 31          |
| Qc            |       | 125                                | Mohr-Coulomb         | 0              | 36        |                  |             |



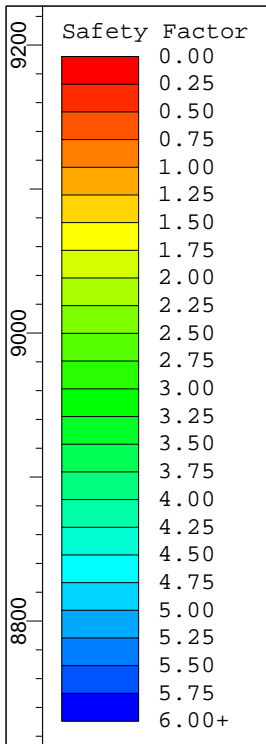
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|--|----------------------|-----------|-------|----------------|-----------|----------|
|  | Project              |           |       | Bobcat Ridge   |           |          |
|  | Analysis Description |           |       | C-C' 01628-028 |           |          |
|  | Drawn By             | EBF       | Scale | 1:1200         | Company   | IGES Inc |
|  | Date                 | 7/20/2018 |       | File Name      | C-C'.slim |          |



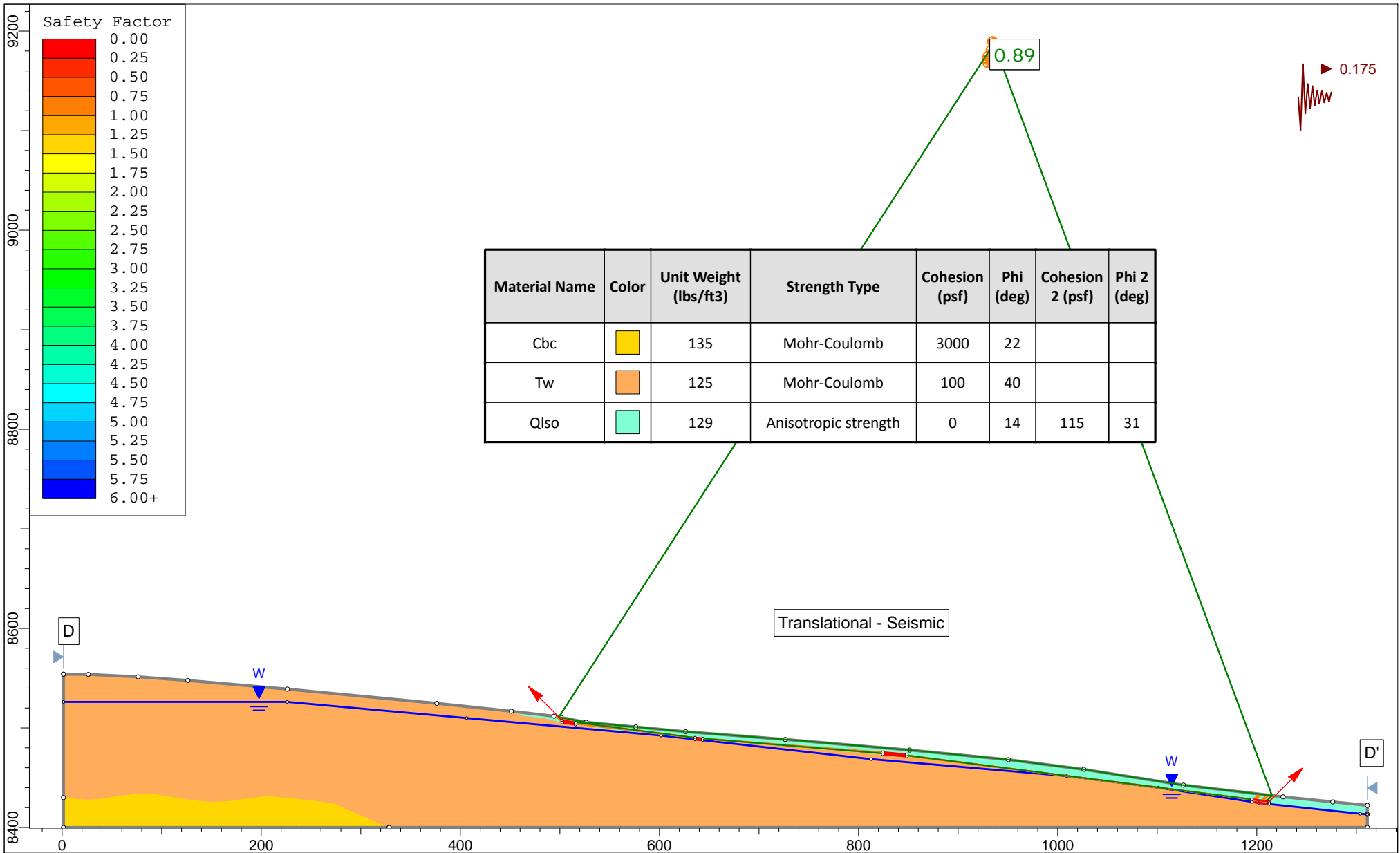
| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type        | Cohesion (psf) | Phi (deg) | Cohesion 2 (psf) | Phi 2 (deg) |
|---------------|-------|-----------------------|----------------------|----------------|-----------|------------------|-------------|
| Cbc           |       | 135                   | Mohr-Coulomb         | 3000           | 22        |                  |             |
| Tw            |       | 125                   | Mohr-Coulomb         | 100            | 40        |                  |             |
| Qlso          |       | 129                   | Anisotropic strength | 0              | 14        | 115              | 31          |



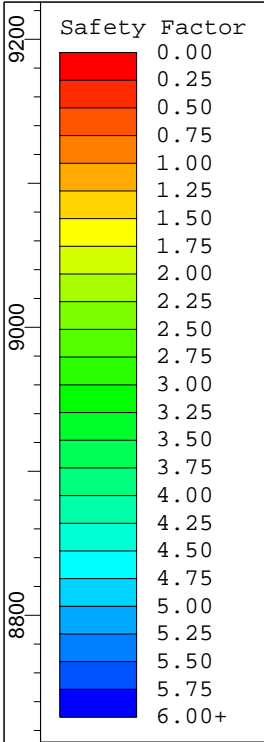
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|--|----------------------|-----------|-------|----------------|-----------|----------|
|  | Project              |           |       | Bobcat Ridge   |           |          |
|  | Analysis Description |           |       | D-D' 01628-028 |           |          |
|  | Drawn By             | EBF       | Scale | 1:1600         | Company   | IGES Inc |
|  | Date                 | 7/20/2018 |       | File Name      | D-D'.slim |          |



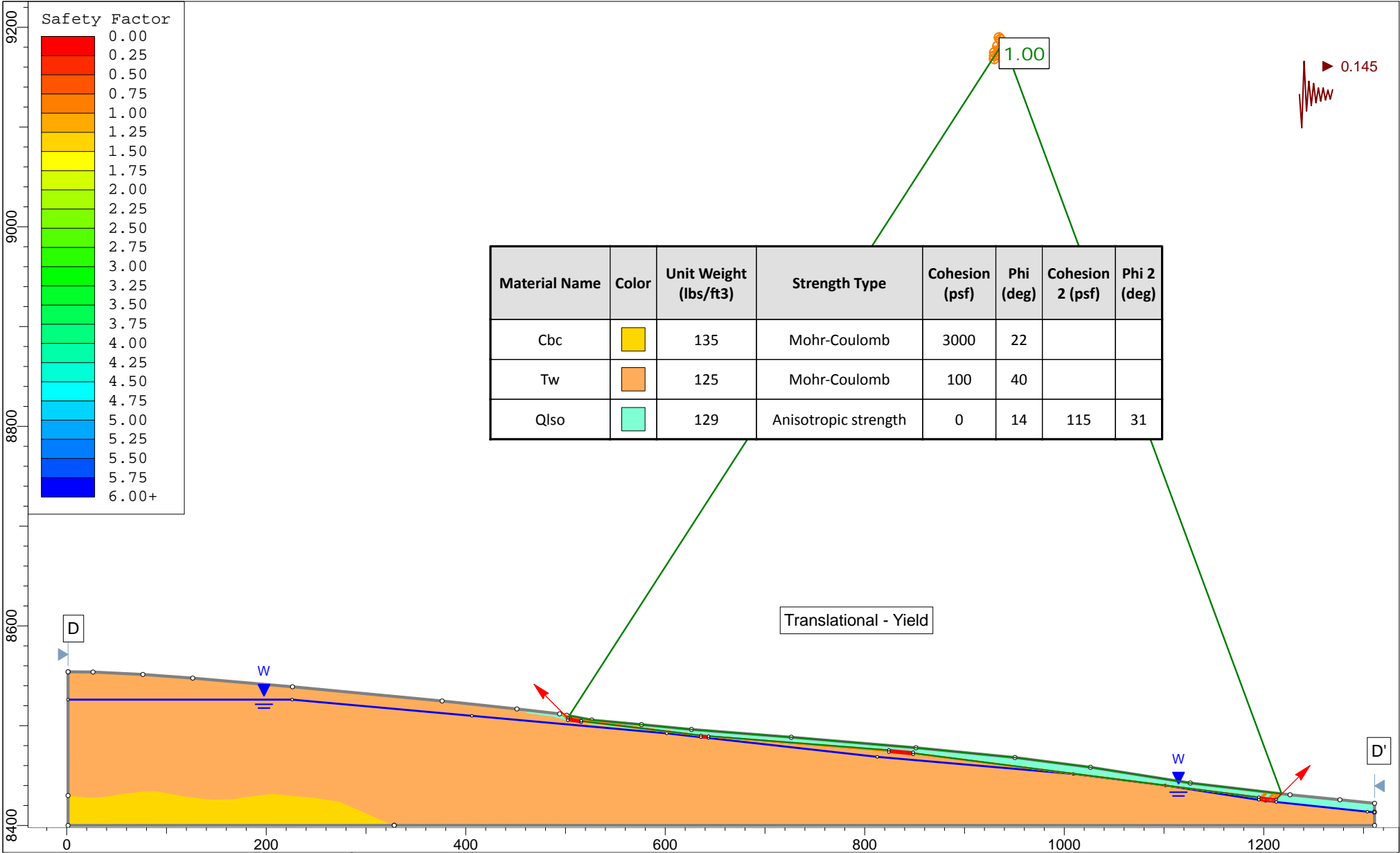
| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type        | Cohesion (psf) | Phi (deg) | Cohesion 2 (psf) | Phi 2 (deg) |
|---------------|-------|-----------------------|----------------------|----------------|-----------|------------------|-------------|
| Cbc           |       | 135                   | Mohr-Coulomb         | 3000           | 22        |                  |             |
| Tw            |       | 125                   | Mohr-Coulomb         | 100            | 40        |                  |             |
| QIso          |       | 129                   | Anisotropic strength | 0              | 14        | 115              | 31          |



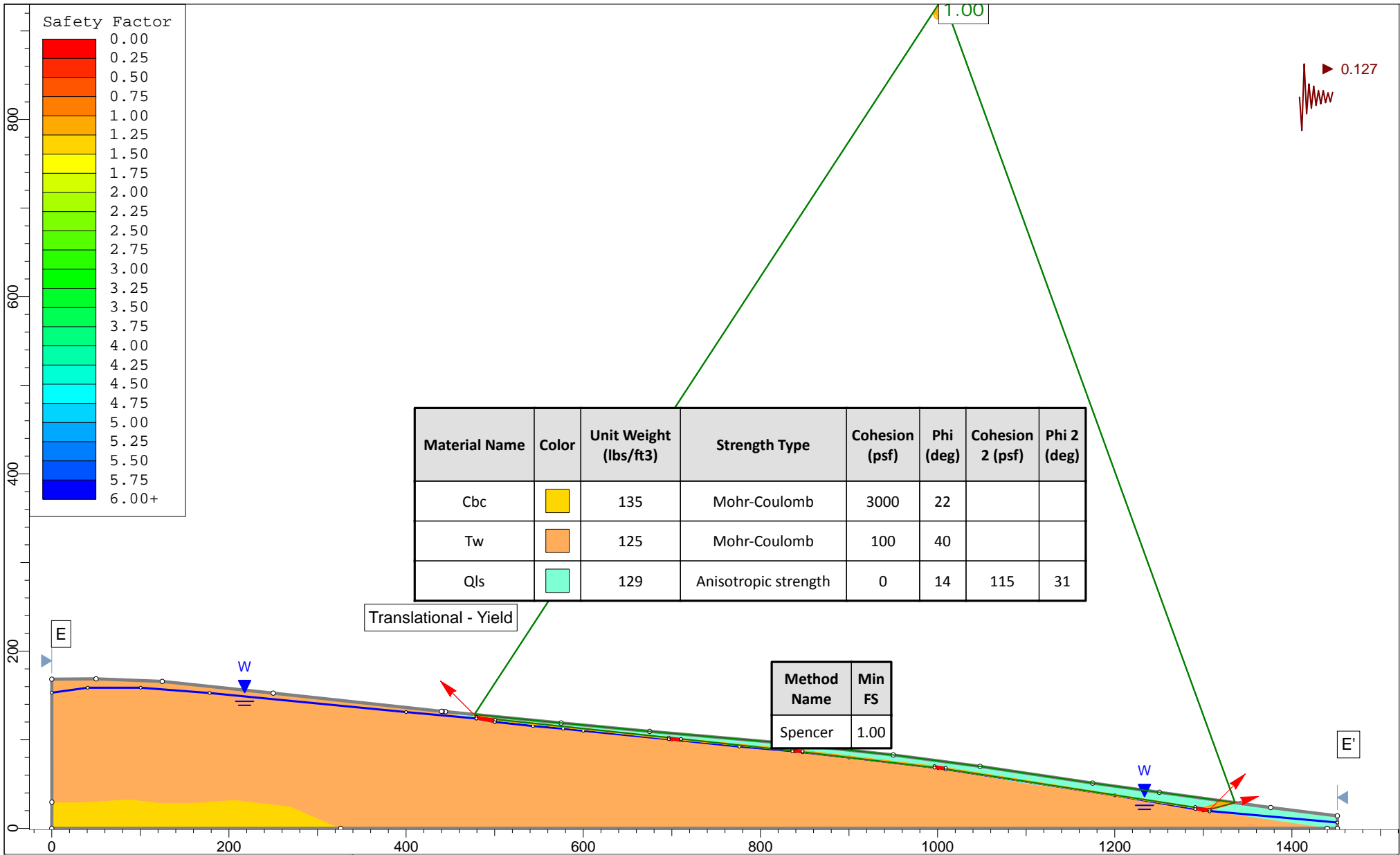
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|--|----------------------|-----------|-------|----------------|-----------|----------|
|  | Project              |           |       | Bobcat Ridge   |           |          |
|  | Analysis Description |           |       | D-D' 01628-028 |           |          |
|  | Drawn By             | EBF       | Scale | 1:1600         | Company   | IGES Inc |
|  | Date                 | 7/20/2018 |       | File Name      | D-D'.slim |          |



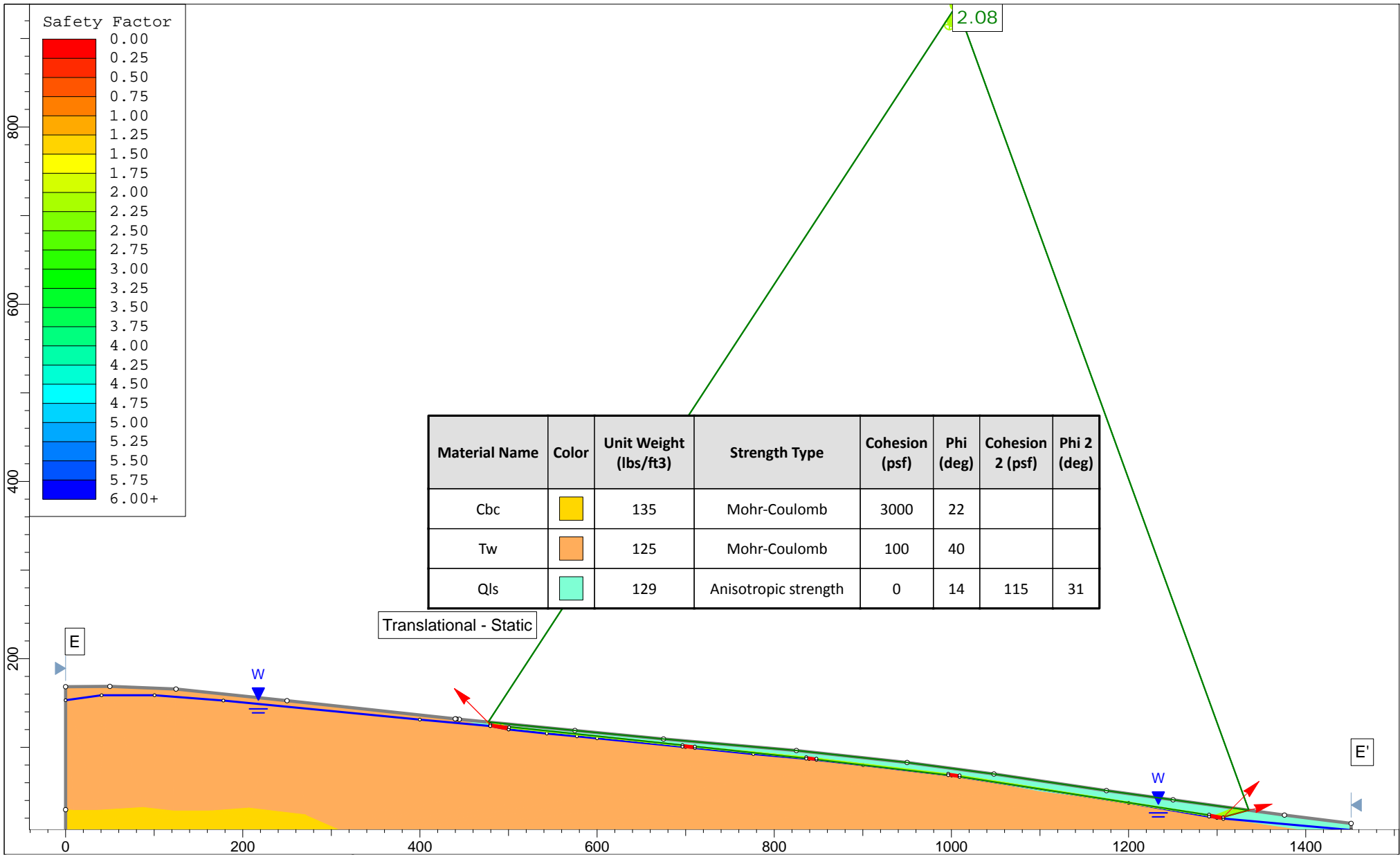
| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type        | Cohesion (psf) | Phi (deg) | Cohesion 2 (psf) | Phi 2 (deg) |
|---------------|-------|-----------------------|----------------------|----------------|-----------|------------------|-------------|
| Cbc           |       | 135                   | Mohr-Coulomb         | 3000           | 22        |                  |             |
| Tw            |       | 125                   | Mohr-Coulomb         | 100            | 40        |                  |             |
| Qlso          |       | 129                   | Anisotropic strength | 0              | 14        | 115              | 31          |




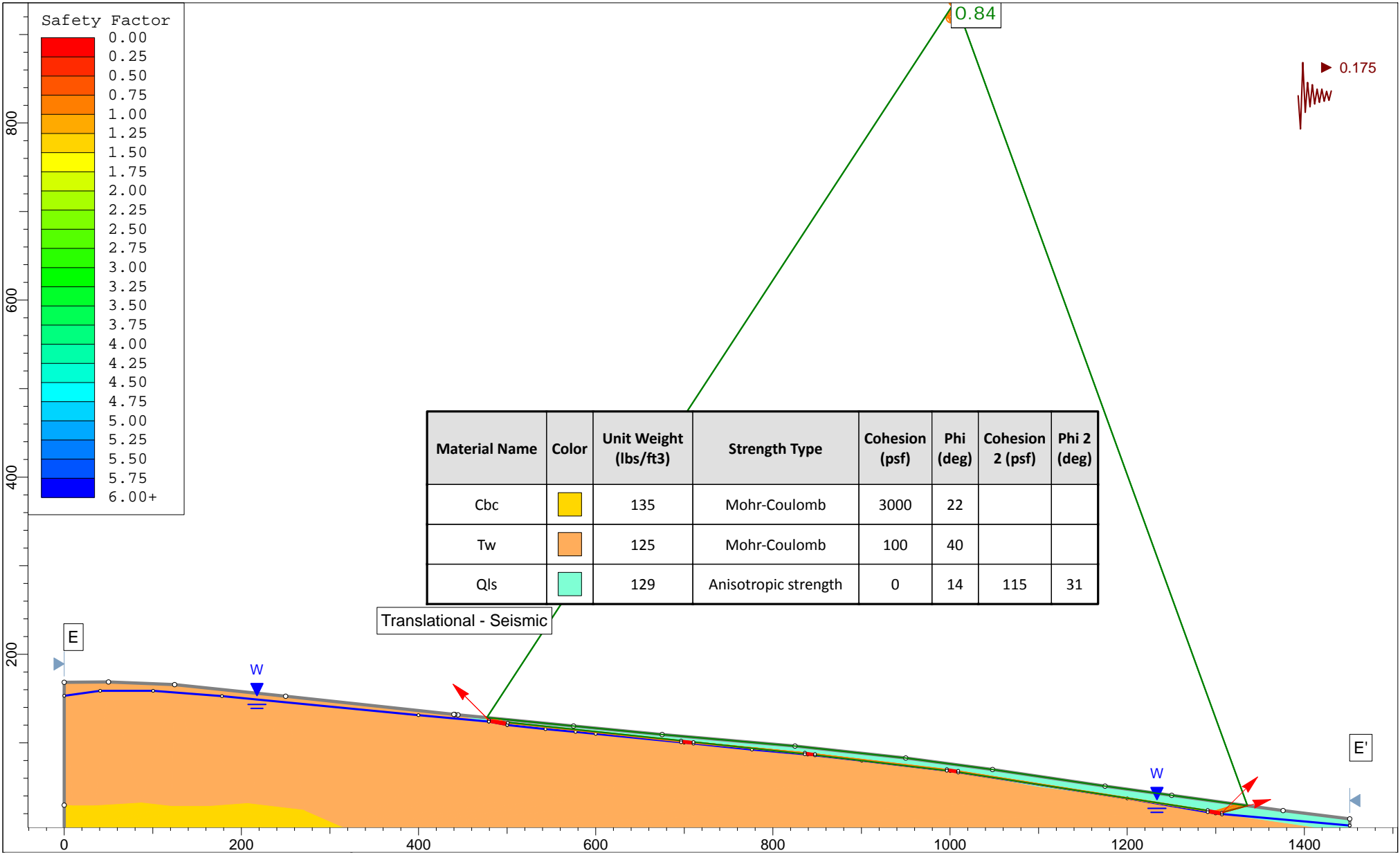
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|--|----------------------|-----------|-------|----------------|-----------|----------|
|  | Project              |           |       | Bobcat Ridge   |           |          |
|  | Analysis Description |           |       | D-D' 01628-028 |           |          |
|  | Drawn By             | EBF       | Scale | 1:1600         | Company   | IGES Inc |
|  | Date                 | 7/20/2018 |       | File Name      | D-D'.slim |          |






|  |                                      |                      |                   |
|--|--------------------------------------|----------------------|-------------------|
|  | Project: Bobcat Ridge                |                      |                   |
|  | Analysis Description: E-E' 01628-028 |                      |                   |
|  | Drawn By: EBF                        | Scale: 1:1800        | Company: IGES Inc |
|  | Date: 7/20/2018                      | File Name: E-E'.slim |                   |




|  |                      |           |       |                |           |          |
|--|----------------------|-----------|-------|----------------|-----------|----------|
|  | Project              |           |       | Bobcat Ridge   |           |          |
|  | Analysis Description |           |       | E-E' 01628-028 |           |          |
|  | Drawn By             | EBF       | Scale | 1:1800         | Company   | IGES Inc |
|  | Date                 | 7/20/2018 |       | File Name      | E-E'.slim |          |



| Material Name | Color   | Unit Weight (lbs/ft3) | Strength Type        | Cohesion (psf) | Phi (deg) | Cohesion 2 (psf) | Phi 2 (deg) |
|---------------|---|-----------------------|----------------------|----------------|-----------|------------------|-------------|
| Cbc           |  | 135                   | Mohr-Coulomb         | 3000           | 22        |                  |             |
| Tw            |  | 125                   | Mohr-Coulomb         | 100            | 40        |                  |             |
| Qls           |  | 129                   | Anisotropic strength | 0              | 14        | 115              | 31          |

Translational - Seismic

|  |                      |           |       |                |           |          |
|--|----------------------|-----------|-------|----------------|-----------|----------|
|  | Project              |           |       | Bobcat Ridge   |           |          |
|  | Analysis Description |           |       | E-E' 01628-028 |           |          |
|  | Drawn By             | EBF       | Scale | 1:1800         | Company   | IGES Inc |
|  | Date                 | 7/20/2018 |       | File Name      | E-E'.slim |          |

SECTION A-A'

**Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements**

by Jonathan D. Bray and Thaleia Travasarou

*Journal of Geotechnical and Geoenvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007*

**SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET**

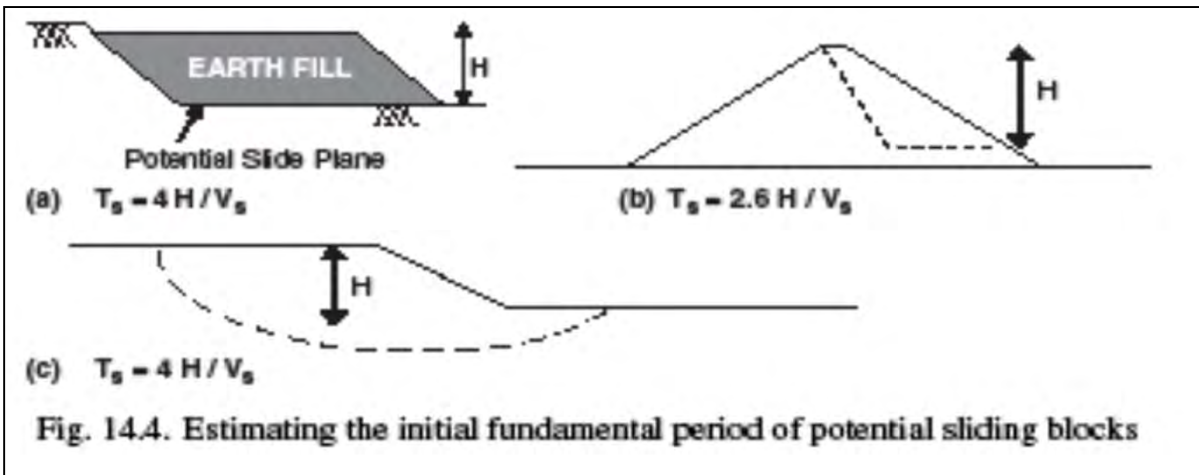
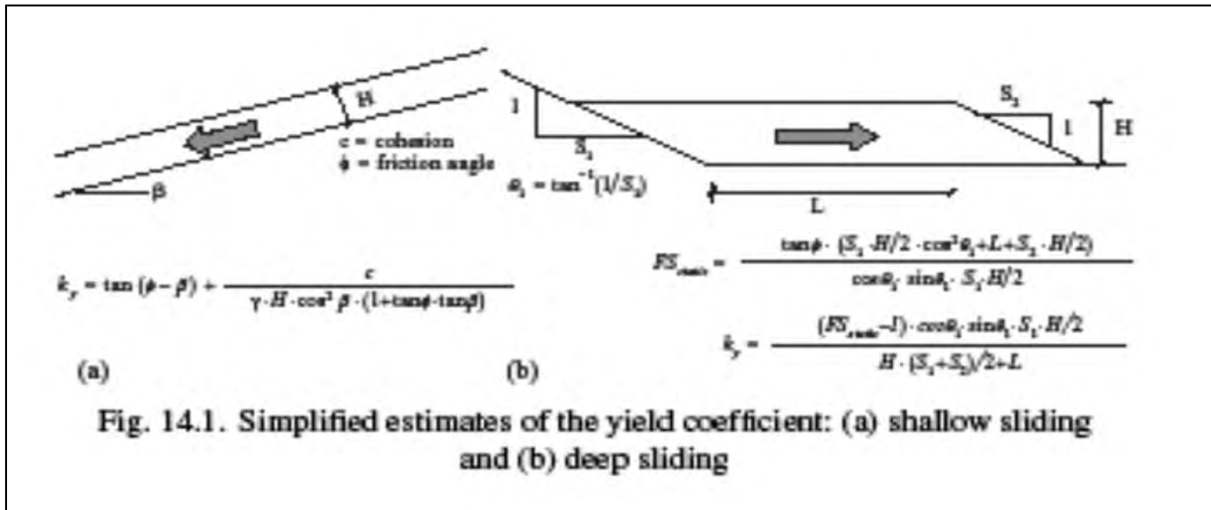
| <b>Input Parameters</b>                   |              |                                |
|---|--------------|--------------------------------|
| Yield Coefficient (ky)                    | 0.135        | Based on pseudostatic analysis |
| Initial Fundamental Period (Ts)           | 0.43 seconds | 1D: Ts=4H/Vs 2D: Ts=2.6H/Vs    |
| Degraded Period (1.5Ts)                   | 0.64 seconds |                                |
| Moment Magnitude (Mw)                     | 7.0          |                                |
| Spectral Acceleration ( Sa(1.5Ts) )       | 0.25 g       |                                |
| <b>Additional Input Parameters</b>        |              |                                |
| Probability of Exceedance #1 (P1)         | 84 %         |                                |
| Probability of Exceedance #2 (P2)         | 50 %         |                                |
| Probability of Exceedance #3 (P3)         | 16 %         |                                |
| Displacement Threshold (d_threshold)      | 5 cm         |                                |
| <b>Intermediate Calculated Parameters</b> |              |                                |
| Non-Zero Seismic Displacement Est (D)     | 2.14 cm      | eq. (5) or (6)                 |
| Standard Deviation of Non-Zero Seismic D  | 0.66         |                                |
| <b>Results</b>                            |              |                                |
| Probability of Negligible Displ. (P(D=0)) | 0.41         | eq. (3)                        |
| D1  | <1 cm        | calc. using eq. (7)            |
| D2  | 1.1 cm       | calc. using eq. (7)            |
| D3  | 3.2 cm       | calc. using eq. (7)            |
| P(D>d_threshold)                          | 0.06         | eq. (7)                        |

**Notes**

1. Values highlighted in blue are input parameters, and results are presented in the table with the yellow heading.
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.  
(e.g., the probability of exceeding displacement D1 is P1)
4. The 16%, 50%, and 84% percentile displacement values at selected ky values are shown to the right.
5. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
6. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
7. Rigid slope is assumed for Ts < 0.05 s
8. When a value for D is not calculated, D is < 1cm
9. ky may be estimated using the simplified equations shown below.
10. Examples of how Ts is estimated are shown below.
11. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)



SECTION A-A'

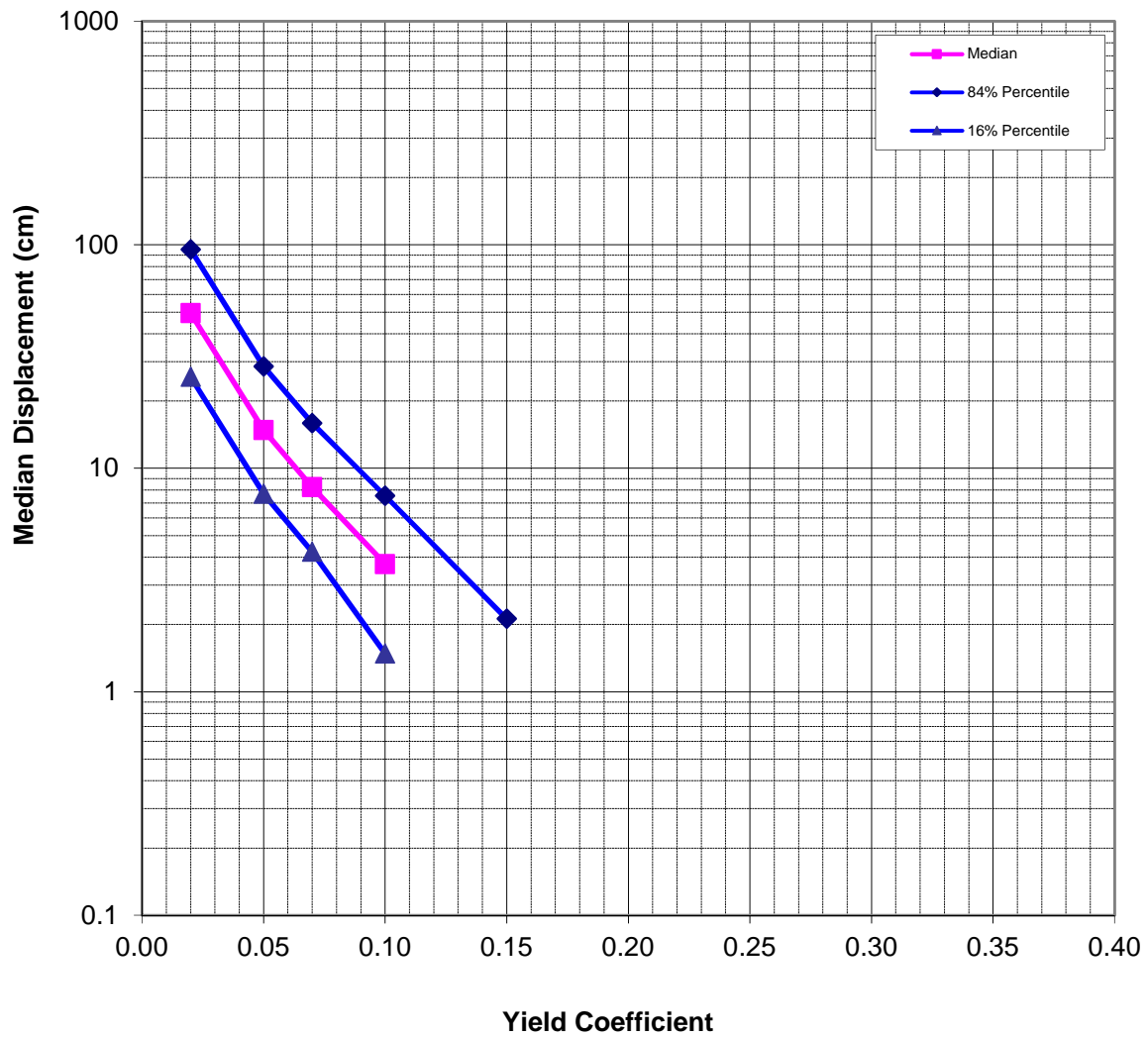


Figures from Bray, J.D. (2007) "Chapter 14: Simplified Seismic Slope Displacement Procedures," Earthquake Geotechnical Engineering, 4th Inter. Conf. on Earthquake Geotechnical Engineering - Invited Lectures, in Geotechnical, Geological, and Earthquake Engineering Series, Vol. 6, Pitilakis, Kyriazis D., Ed., Springer, Vol. 6, pp. 327-353.

SECTION A-A'

Dependence on  $k_y$

| $k_y$ | P(D="0") | D (cm) | Dmedian (cm) | D-84% (cm) | D-16% (cm) |
|-------|----------|--------|--------------|------------|------------|
| 0.020 | 0.00     | 49.5   | 49.5         | 95.3       | 25.7       |
| 0.05  | 0.00     | 14.8   | 14.8         | 28.6       | 7.7        |
| 0.07  | 0.01     | 8.3    | 8.2          | 15.9       | 4.2        |
| 0.1   | 0.11     | 4.1    | 3.7          | 7.5        | 1.5        |
| 0.15  | 0.56     | 1.7    | <1           | 2.1        | <1         |
| 0.2   | 0.87     | 0.8    | <1           | <1         | <1         |
| 0.3   | 0.99     | 0.3    | <1           | <1         | <1         |
| 0.4   | 1.00     | 0.1    | <1           | <1         | <1         |



SECTION C-C'

**Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements**

by Jonathan D. Bray and Thaleia Travasarou

*Journal of Geotechnical and Geoenvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007*

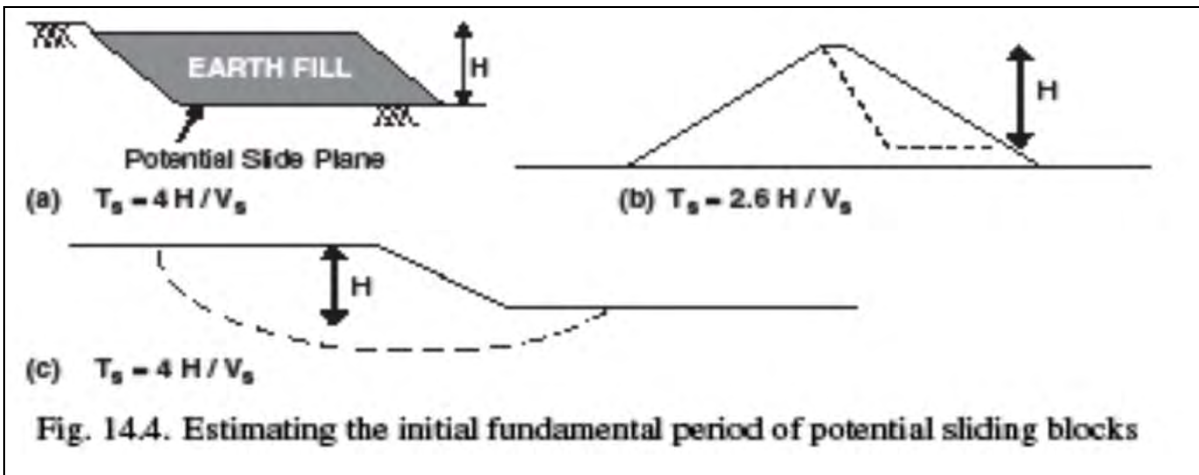
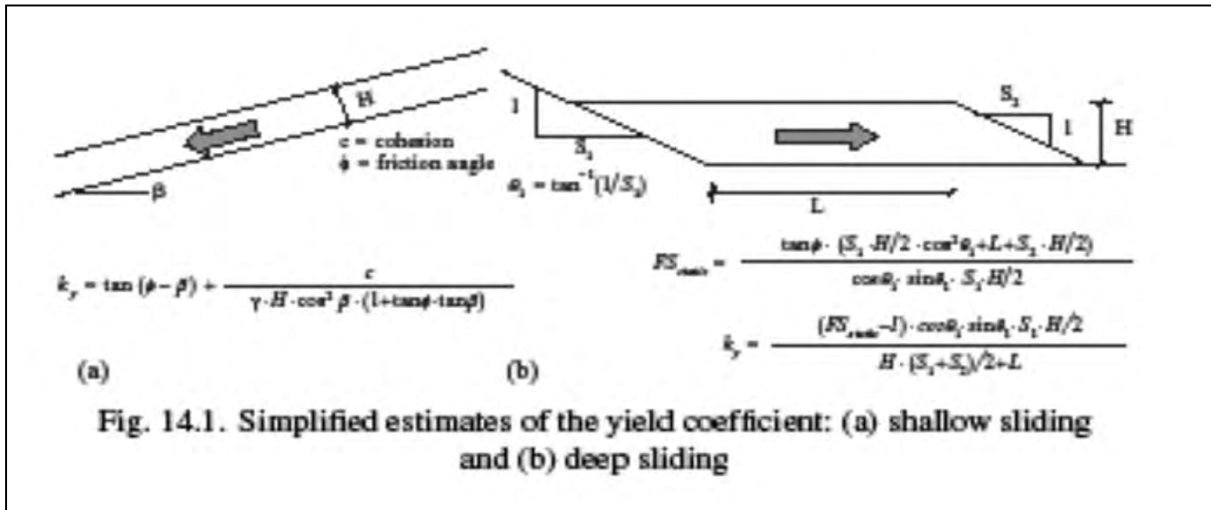
**SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET**

| <b>Input Parameters</b>                   |              |                                |
|---|--------------|--------------------------------|
| Yield Coefficient (ky)                    | 0.06         | Based on pseudostatic analysis |
| Initial Fundamental Period (Ts)           | 0.07 seconds | 1D: Ts=4H/Vs 2D: Ts=2.6H/Vs    |
| Degraded Period (1.5Ts)                   | 0.10 seconds |                                |
| Moment Magnitude (Mw)                     | 7.0          |                                |
| Spectral Acceleration ( Sa(1.5Ts) )       | 0.25 g       |                                |
| <b>Additional Input Parameters</b>        |              |                                |
| Probability of Exceedance #1 (P1)         | 84 %         |                                |
| Probability of Exceedance #2 (P2)         | 50 %         |                                |
| Probability of Exceedance #3 (P3)         | 16 %         |                                |
| Displacement Threshold (d_threshold)      | 5 cm         |                                |
| <b>Intermediate Calculated Parameters</b> |              |                                |
| Non-Zero Seismic Displacement Est (D)     | 6.36 cm      | eq. (5) or (6)                 |
| Standard Deviation of Non-Zero Seismic D  | 0.66         |                                |
| <b>Results</b>                            |              |                                |
| Probability of Negligible Displ. (P(D=0)) | 0.01         | eq. (3)                        |
| D1  | 3.3 cm       | calc. using eq. (7)            |
| D2  | 6.3 cm       | calc. using eq. (7)            |
| D3  | 12.2 cm      | calc. using eq. (7)            |
| P(D>d_threshold)                          | 0.64         | eq. (7)                        |

**Notes**

1. Values highlighted in blue are input parameters, and results are presented in the table with the yellow heading.
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.  
(e.g., the probability of exceeding displacement D1 is P1)
4. The 16%, 50%, and 84% percentile displacement values at selected ky values are shown to the right.
5. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
6. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
7. Rigid slope is assumed for Ts < 0.05 s
8. When a value for D is not calculated, D is < 1cm
9. ky may be estimated using the simplified equations shown below.
10. Examples of how Ts is estimated are shown below.
11. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

SECTION C-C'

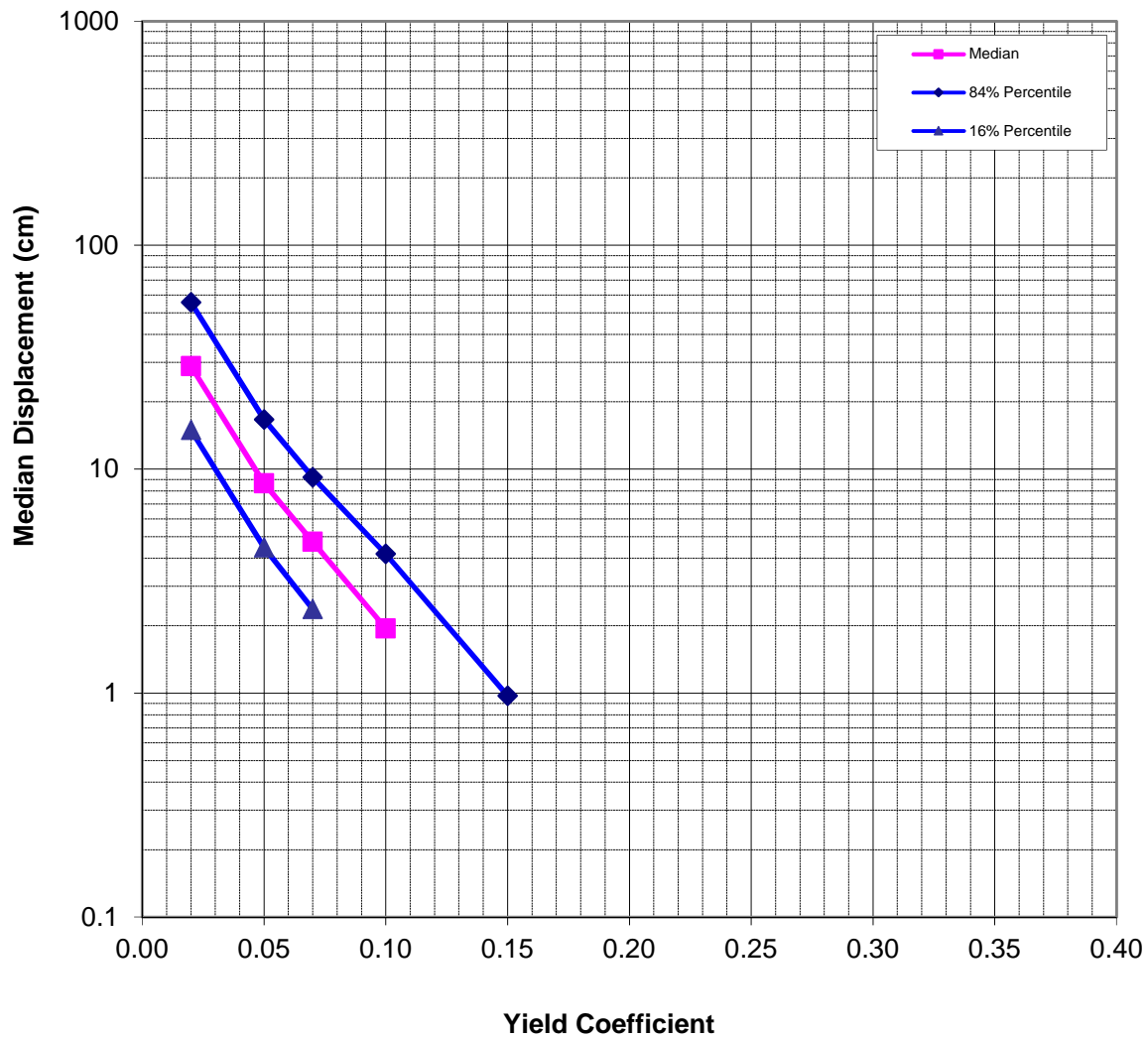


Figures from Bray, J.D. (2007) "Chapter 14: Simplified Seismic Slope Displacement Procedures," Earthquake Geotechnical Engineering, 4th Inter. Conf. on Earthquake Geotechnical Engineering - Invited Lectures, in Geotechnical, Geological, and Earthquake Engineering Series, Vol. 6, Pitilakis, Kyriazis D., Ed., Springer, Vol. 6, pp. 327-353.

SECTION C-C'

Dependence on  $k_y$

| $k_y$ | $P(D="0")$ | D (cm) | Dmedian (cm) | D-84% (cm) | D-16% (cm) |
|-------|------------|--------|--------------|------------|------------|
| 0.020 | 0.00       | 28.8   | 28.8         | 55.6       | 15.0       |
| 0.05  | 0.00       | 8.6    | 8.6          | 16.7       | 4.5        |
| 0.07  | 0.02       | 4.8    | 4.7          | 9.2        | 2.4        |
| 0.1   | 0.20       | 2.4    | 1.9          | 4.2        | <1         |
| 0.15  | 0.68       | 1.0    | <1           | 1.0        | <1         |
| 0.2   | 0.92       | 0.5    | <1           | <1         | <1         |
| 0.3   | 1.00       | 0.2    | <1           | <1         | <1         |
| 0.4   | 1.00       | 0.1    | <1           | <1         | <1         |



SECTION D-D'

**Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements**

by Jonathan D. Bray and Thaleia Travasarou

*Journal of Geotechnical and Geoenvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007*

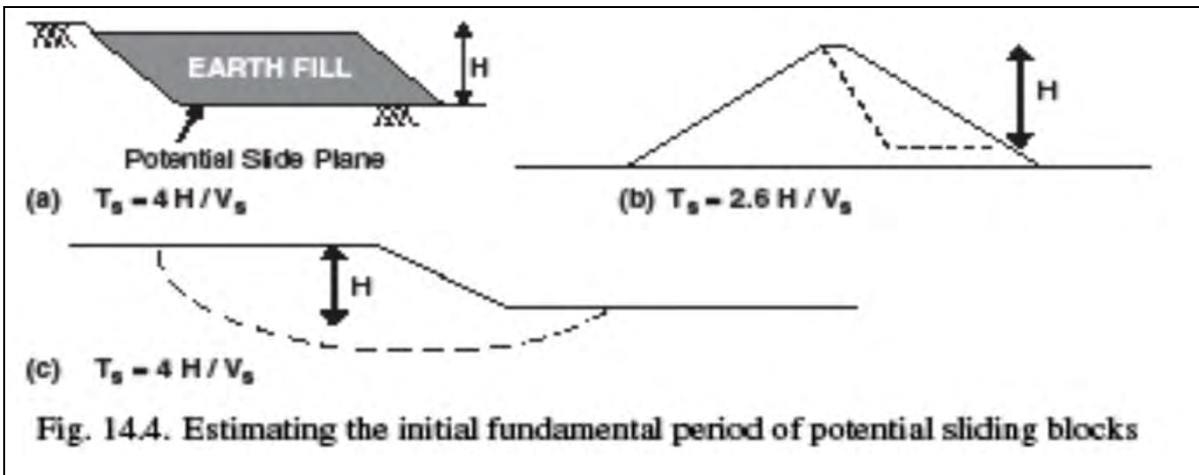
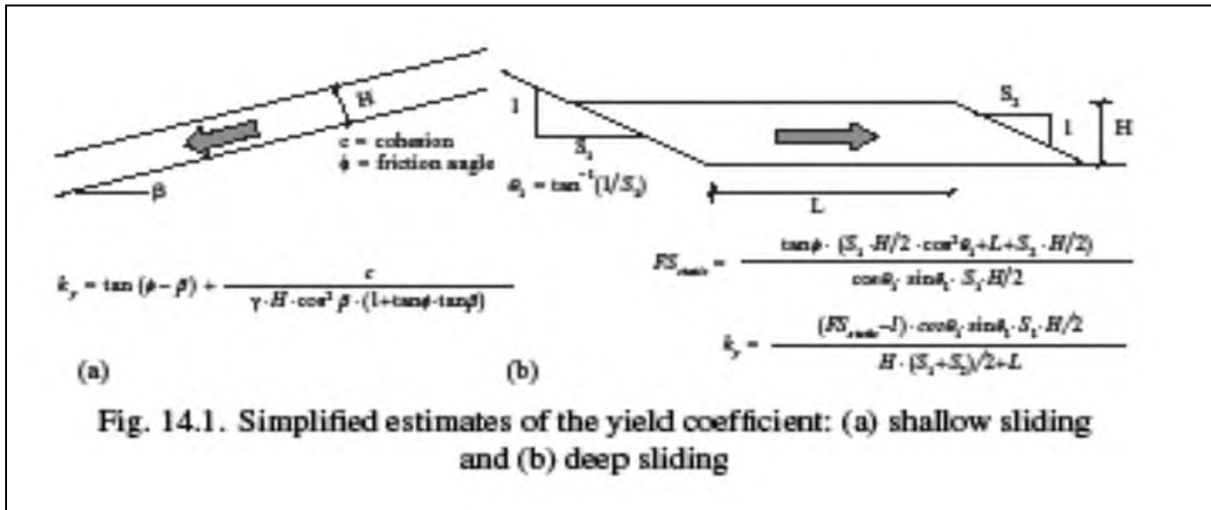
**SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET**

| <b>Input Parameters</b>                   |              |                                |
|---|--------------|--------------------------------|
| Yield Coefficient (ky)                    | 0.145        | Based on pseudostatic analysis |
| Initial Fundamental Period (Ts)           | 0.05 seconds | 1D: Ts=4H/Vs 2D: Ts=2.6H/Vs    |
| Degraded Period (1.5Ts)                   | 0.07 seconds |                                |
| Moment Magnitude (Mw)                     | 7.0          |                                |
| Spectral Acceleration ( Sa(1.5Ts) )       | 0.25 g       |                                |
| <b>Additional Input Parameters</b>        |              |                                |
| Probability of Exceedance #1 (P1)         | 84 %         |                                |
| Probability of Exceedance #2 (P2)         | 50 %         |                                |
| Probability of Exceedance #3 (P3)         | 16 %         |                                |
| Displacement Threshold (d_threshold)      | 5 cm         |                                |
| <b>Intermediate Calculated Parameters</b> |              |                                |
| Non-Zero Seismic Displacement Est (D)     | 2.47 cm      | eq. (5) or (6)                 |
| Standard Deviation of Non-Zero Seismic D  | 0.66         |                                |
| <b>Results</b>                            |              |                                |
| Probability of Negligible Displ. (P(D=0)) | 0.65         | eq. (3)                        |
| D1  | <1 cm        | calc. using eq. (7)            |
| D2  | <1 cm        | calc. using eq. (7)            |
| D3  | 2.7 cm       | calc. using eq. (7)            |
| P(D>d_threshold)                          | 0.05         | eq. (7)                        |

**Notes**

1. Values highlighted in blue are input parameters, and results are presented in the table with the yellow heading.
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.  
(e.g., the probability of exceeding displacement D1 is P1)
4. The 16%, 50%, and 84% percentile displacement values at selected ky values are shown to the right.
5. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
6. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
7. Rigid slope is assumed for Ts < 0.05 s
8. When a value for D is not calculated, D is < 1cm
9. ky may be estimated using the simplified equations shown below.
10. Examples of how Ts is estimated are shown below.
11. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

SECTION D-D'

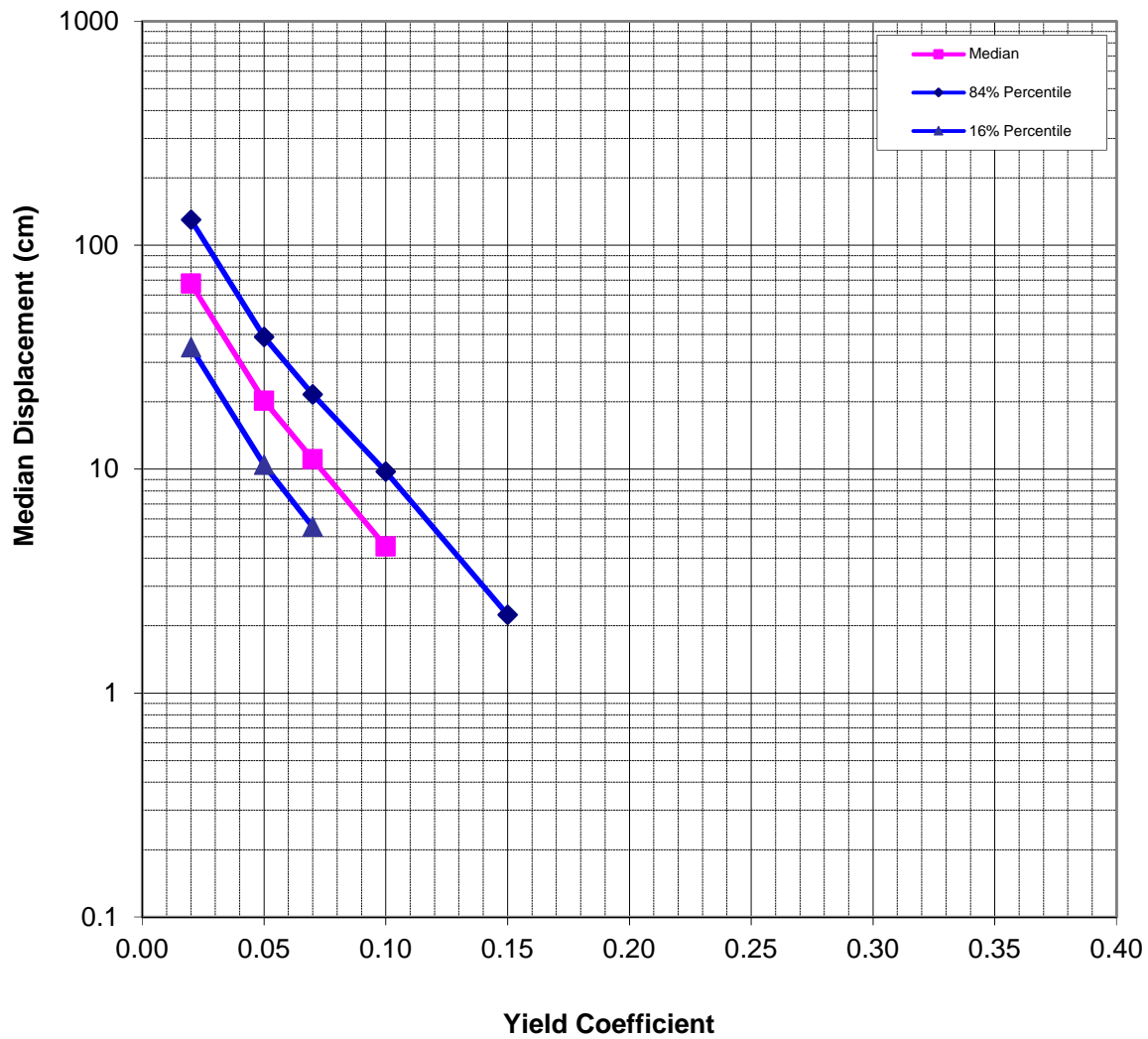


Figures from Bray, J.D. (2007) "Chapter 14: Simplified Seismic Slope Displacement Procedures," Earthquake Geotechnical Engineering, 4th Inter. Conf. on Earthquake Geotechnical Engineering - Invited Lectures, in Geotechnical, Geological, and Earthquake Engineering Series, Vol. 6, Pitilakis, Kyriazis D., Ed., Springer, Vol. 6, pp. 327-353.

SECTION D-D'

Dependence on  $k_y$

| $k_y$ | P(D="0") | D (cm) | Dmedian (cm) | D-84% (cm) | D-16% (cm) |
|-------|----------|--------|--------------|------------|------------|
| 0.020 | 0.00     | 67.4   | 67.4         | 130.0      | 35.0       |
| 0.05  | 0.00     | 20.2   | 20.2         | 39.0       | 10.5       |
| 0.07  | 0.02     | 11.3   | 11.1         | 21.5       | 5.5        |
| 0.1   | 0.20     | 5.6    | 4.5          | 9.7        | <1         |
| 0.15  | 0.69     | 2.3    | <1           | 2.2        | <1         |
| 0.2   | 0.92     | 1.1    | <1           | <1         | <1         |
| 0.3   | 1.00     | 0.4    | <1           | <1         | <1         |
| 0.4   | 1.00     | 0.2    | <1           | <1         | <1         |





SECTION E-E'

**Simplified Procedure for Estimating Earthquake Induced Deviatoric Slope Displacements**

by Jonathan D. Bray and Thaleia Travasarou

*Journal of Geotechnical and Geoenvironmental Engineering, ASCE, V. 133(4), pp. 381-392, April 2007*

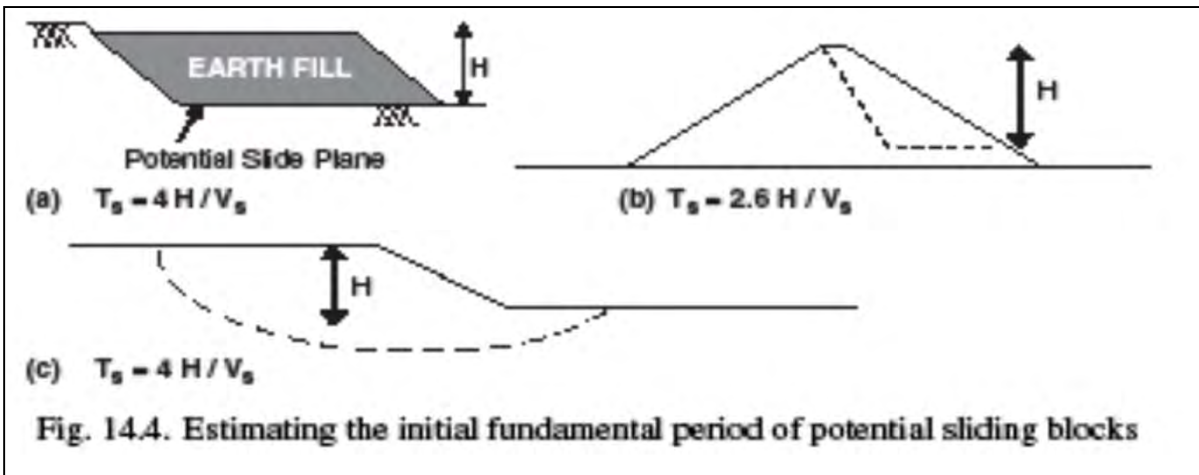
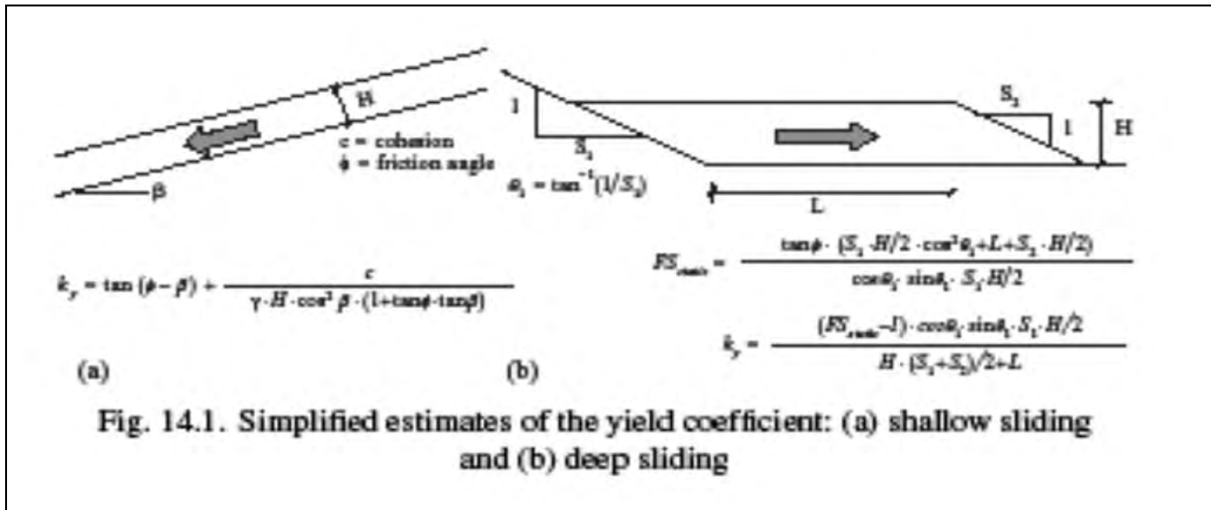
**SEE NOTES BELOW FOR GUIDANCE IN THE USE OF SPREADSHEET**

| <b>Input Parameters</b>                   |              |                                |
|---|--------------|--------------------------------|
| Yield Coefficient (ky)                    | 0.127        | Based on pseudostatic analysis |
| Initial Fundamental Period (Ts)           | 0.05 seconds | 1D: Ts=4H/Vs 2D: Ts=2.6H/Vs    |
| Degraded Period (1.5Ts)                   | 0.07 seconds |                                |
| Moment Magnitude (Mw)                     | 7.0          |                                |
| Spectral Acceleration ( Sa(1.5Ts) )       | 0.25 g       |                                |
| <b>Additional Input Parameters</b>        |              |                                |
| Probability of Exceedance #1 (P1)         | 84 %         |                                |
| Probability of Exceedance #2 (P2)         | 50 %         |                                |
| Probability of Exceedance #3 (P3)         | 16 %         |                                |
| Displacement Threshold (d_threshold)      | 5 cm         |                                |
| <b>Intermediate Calculated Parameters</b> |              |                                |
| Non-Zero Seismic Displacement Est (D)     | 3.35 cm      | eq. (5) or (6)                 |
| Standard Deviation of Non-Zero Seismic D  | 0.66         |                                |
| <b>Results</b>                            |              |                                |
| Probability of Negligible Displ. (P(D=0)) | 0.48         | eq. (3)                        |
| D1  | <1 cm        | calc. using eq. (7)            |
| D2  | 1.0 cm       | calc. using eq. (7)            |
| D3  | 4.7 cm       | calc. using eq. (7)            |
| P(D>d_threshold)                          | 0.14         | eq. (7)                        |

**Notes**

1. Values highlighted in blue are input parameters, and results are presented in the table with the yellow heading.
2. Probability of Exceedance is the desired probability of exceeding a particular displacement value.
3. Displacements D1, D2, and D3 correspond to P1, P2, and P3, respectively.  
(e.g., the probability of exceeding displacement D1 is P1)
4. The 16%, 50%, and 84% percentile displacement values at selected ky values are shown to the right.
5. Calculated seismic displacements are due to deviatoric deformation only (add in volumetrically induced movement).
6. ky may range between 0.01 and 0.5, Ts between 0 and 2 s, Sa between 0.002 and 2.7 g, M between 4.5 and 9
7. Rigid slope is assumed for Ts < 0.05 s
8. When a value for D is not calculated, D is < 1cm
9. ky may be estimated using the simplified equations shown below.
10. Examples of how Ts is estimated are shown below.
11. Vs = weighted avg. shear wave velocity for the sliding mass, e.g., for 2 layers, Vs = [(h1)(Vs1) + (h2)(Vs2)]/(h1 + h2)

SECTION E-E'

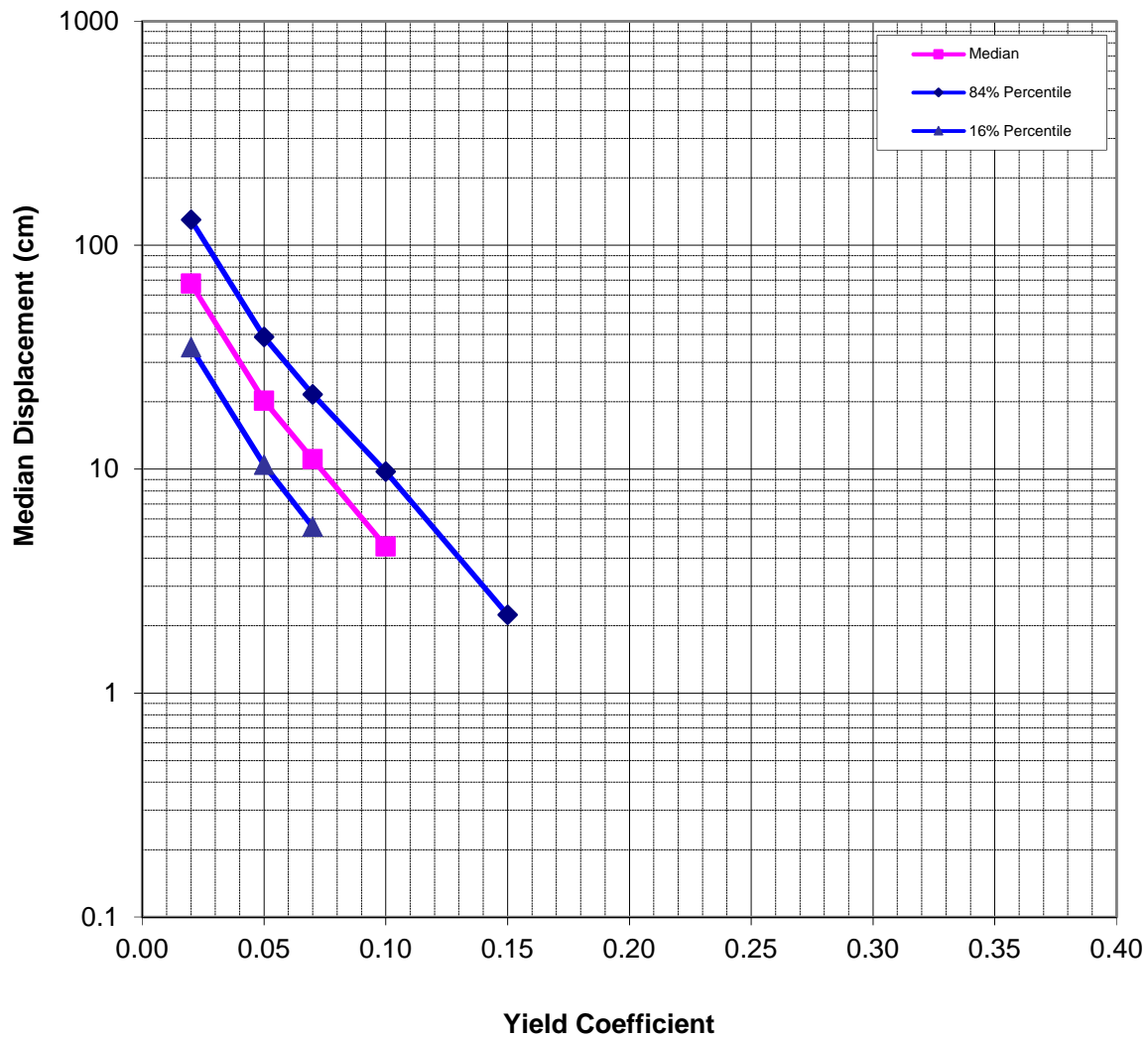


Figures from Bray, J.D. (2007) "Chapter 14: Simplified Seismic Slope Displacement Procedures," Earthquake Geotechnical Engineering, 4th Inter. Conf. on Earthquake Geotechnical Engineering - Invited Lectures, in Geotechnical, Geological, and Earthquake Engineering Series, Vol. 6, Pitilakis, Kyriazis D., Ed., Springer, Vol. 6, pp. 327-353.

SECTION E-E'

Dependence on  $k_y$

| $k_y$ | $P(D="0")$ | D (cm) | Dmedian (cm) | D-84% (cm) | D-16% (cm) |
|-------|------------|--------|--------------|------------|------------|
| 0.020 | 0.00       | 67.4   | 67.4         | 130.0      | 35.0       |
| 0.05  | 0.00       | 20.2   | 20.2         | 39.0       | 10.5       |
| 0.07  | 0.02       | 11.3   | 11.1         | 21.5       | 5.5        |
| 0.1   | 0.20       | 5.6    | 4.5          | 9.7        | <1         |
| 0.15  | 0.69       | 2.3    | <1           | 2.2        | <1         |
| 0.2   | 0.92       | 1.1    | <1           | <1         | <1         |
| 0.3   | 1.00       | 0.4    | <1           | <1         | <1         |
| 0.4   | 1.00       | 0.2    | <1           | <1         | <1         |



# **APPENDIX E**

## Bobcat Ridge Table of Lots

| Lot No. | Est. Depth to Groundwater (ft) | *Estimated Min. OX (ft) | Recommendations  |
|---------|--------------------------------|-------------------------|--|
| Lot 1   | 8-9                            | n/a                     | <u>Southern half of lot</u> – no special requirements<br><u>Northern half of lot</u> – development currently not recommended due to shallow groundwater and proximity to landslide scarp to the north; may be developable pending additional subsurface investigation and analysis and the development of an appropriate hazard mitigation plan, but would likely be an on-grade structure (no basement) unless groundwater remediation is also performed. |
| Lot 2   | >10 (south)<br>4-10 (north)    | n/a                     | <u>Southern half of lot</u> – no special requirements<br><u>Northern half of lot</u> – development currently not recommended due to shallow groundwater and proximity to landslide scarp to the north; may be developable pending additional subsurface investigation and analysis and the development of an appropriate hazard mitigation plan, but would likely be an on-grade structure (no basement) unless groundwater remediation is also performed. |
| Lot 3   | >13                            | 6-8                     | Over-excavate (OX) below landslide deposits across entire building footprint.  |
| Lot 4   | >10.5                          | n/a                     | Over-excavate below landslide deposits across entire building footprint (if present); otherwise no special requirements.   |
| Lot 5   | 12                             | n/a                     | No special requirements – basement depth may be limited due to shallow groundwater (identified at approximately 12 feet below existing grade) unless groundwater remediation is performed.   |
| Lot 6   | >10.5                          | n/a                     | No special requirements.   |
| Lot 7   | 10-15                          | n/a                     | No special requirements. Basement depth may be limited on the eastern half of the lot due to shallow groundwater unless groundwater remediation is performed.  |
| Lot 8   | 4                              | 5-6                     | Over-excavate below landslide deposits across entire building footprint. Probable shallow groundwater; on-grade structure recommended (no basement) unless groundwater remediation is also performed; possible temporary dewatering could be needed during construction.   |
| Lot 9   | 6-7                            | n/a                     | Over-excavate below landslide deposits across entire building footprint. Probable shallow groundwater; on-grade structure recommended (no basement) unless groundwater remediation is performed.   |
| Lot 10  | 6-7                            | n/a                     | Probable shallow groundwater; on-grade structure recommended (no basement) unless groundwater remediation is performed.  |
| Lot 11  | 11                             | n/a                     | Possible shallow groundwater in northwest ~1/3 of lot that may limit basement depth in this area unless groundwater remediation is performed, otherwise no special requirements.   |
| Lot 12  | 12                             | n/a                     | No special requirements – basement depth may be limited due to shallow groundwater (identified at approximately 12 feet below existing grade) unless groundwater remediation is performed.   |
| Lot 13  | >12                            | n/a                     | Possible shallow groundwater at northeast corner of lot that may limit basement depth in this area unless groundwater remediation is performed, otherwise no special requirements.   |

| Lot No. | Est. Depth to Groundwater (ft)          | *Estimated Min. OX (ft) | Recommendations   |
|---------|---|-------------------------|---|
| Lot 14  | >12                                     | n/a                     | No special requirements.  |
| Lot 15  | 9                                       | n/a                     | No special requirements – basement depth may be limited due to shallow groundwater (identified at approximately 9 feet below existing grade) unless groundwater remediation is performed.   |
| Lot 16  | 9                                       | n/a                     | No special requirements – basement depth may be limited due to shallow groundwater (identified at approximately 9 feet below existing grade) unless groundwater remediation is performed.   |
| Lot 17  | 10 (southern half of lot)               | n/a                     | No special requirements – possible shallow groundwater on the southern half of the property, which may limit the depth of basement on the southern half unless groundwater remediation is performed.  |
| Lot 18  | >12.5                                   | n/a                     | No special requirements – possible shallow groundwater near/along southeast property boundary.  |
| Lot 19  | 10                                      | n/a                     | No special requirements – basement depth may be limited due to shallow groundwater (identified at approximately 10 feet below existing grade) unless groundwater remediation is performed.  |
| Lot 20  | 6.5 (west)                              | n/a                     | Shallow groundwater on western 1/3 <sup>rd</sup> of lot; on-grade structure recommended unless structure is placed outside of western 1/3 <sup>rd</sup> of lot or groundwater remediation is performed.   |
| Lot 21  | 8 (western half)<br>>9.5 (eastern half) | n/a                     | <u>Western half of lot</u> – on-grade structure (no basement) recommended due to shallow groundwater unless groundwater remediation is performed.<br><u>Eastern half of lot</u> - basement depth may be limited due to shallow groundwater unless groundwater remediation is performed. |
| Lot 22  | >11                                     | 9                       | Over-excavate below landslide deposits across entire building footprint.  |
| Lot 23  | 6-9                                     | 12                      | Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement) unless groundwater remediation is performed.   |
| Lot 24  | 3-4                                     | 16                      | Over-excavate below landslide deposits across entire building footprint. Significant temporary dewatering needed during over-excavation. On-grade structure recommended (no basement) unless groundwater remediation is performed.  |
| Lot 25  | 5-6                                     | 11-13                   | Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement) unless groundwater remediation is performed.   |
| Lot 26  | 5-6                                     | 9-11                    | Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement) unless groundwater remediation is performed.   |
| Lot 27  | 3-4                                     | 16                      | Over-excavate below landslide deposits across entire building footprint. Significant temporary dewatering needed during over-excavation. On-grade structure recommended (no basement) unless groundwater remediation is performed.  |
| Lot 28  | 4-5                                     | 12                      | Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement) unless groundwater remediation is performed.   |

| Lot No. | Est. Depth to Groundwater (ft) | *Estimated Min. OX (ft) | Recommendations   |
|---------|--------------------------------|-------------------------|---|
| Lot 29  | 5-12                           | 12-16                   | Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement) unless groundwater remediation is performed.   |
| Lot 30  | 5                              | 10-12                   | Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement) unless groundwater remediation is performed.   |
| Lot 31  | 4-6                            | 10-12                   | Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement) unless groundwater remediation is performed.   |
| Lot 32  | 3-4                            | 9-11                    | Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement) unless groundwater remediation is performed.   |
| Lot 33  | 3-4                            | 9-11                    | Over-excavate below landslide deposits across entire building footprint. Probable temporary dewatering needed during over-excavation. On-grade structure recommended (no basement) unless groundwater remediation is performed.   |
| Lot 34  | 6                              | n/a                     | On-grade structure recommended (no basement) due to shallow groundwater unless groundwater remediation is performed.  |
| Lot 35  | 6                              | n/a                     | On-grade structure recommended (no basement) due to shallow groundwater unless groundwater remediation is performed.  |
| Lot 36  | 9-10                           | n/a                     | <u>East half of lot</u> - No special requirements – basement depth may be limited due to shallow groundwater (identified at approximately 9 to 10 feet below existing grade) unless groundwater remediation is performed.<br><u>West half of lot</u> - development currently not recommended pending additional subsurface investigation and analysis and the development of an appropriate hazard mitigation plan, or significant remedial earthwork to mitigate the landslide hazard for this area. |
| Lot 37  | 7                              | n/a                     | Development currently not recommended pending additional subsurface investigation and/or analysis - significant remedial earthwork to mitigate the landslide hazard for this area should be anticipated.  |
| Lot 38  | 8-10                           | n/a                     | Development currently not recommended pending additional subsurface investigation and/or analysis - significant remedial earthwork to mitigate the landslide hazard for this area should be anticipated.  |
| Lot 39  | 5                              | n/a                     | Development currently not recommended pending additional subsurface investigation and/or analysis - significant remedial earthwork to mitigate the landslide hazard for this area should be anticipated.  |
| Lot 40  | ~6-10                          | n/a                     | Probable shallow groundwater; on-grade structure recommended (no basement) unless lot-specific data indicates favorable groundwater depth within the building footprint or groundwater remediation is performed.  |
| Lot 41  | 11                             | n/a                     | No special requirements – basement depth may be limited due to shallow groundwater (identified at approximately 11 feet below existing grade) unless groundwater remediation is performed.  |

| Lot No. | Est. Depth to Groundwater (ft) | *Estimated Min. OX (ft) | Recommendations  |
|---------|--------------------------------|-------------------------|--|
| Lot 42  | ~10                            | n/a                     | The northern 1/5 <sup>th</sup> of this lot is within landslide deposit (Qlso?); recommend a minimum structural set-back of 30 feet from the limits of the landslide. Basement depth may be limited due to shallow groundwater (estimated at approximately 10 feet below existing grade) unless groundwater remediation is performed. |
| Lot 43  | >16                            | n/a                     | The northwestern corner of this lot is within landslide deposit (Qlso?); recommend a minimum structural set-back of 20 feet from the limits of the landslide.  |
| Lot 44  | >16                            | n/a                     | No special requirements.   |
| Lot 45  | >16                            | n/a                     | No special requirements.   |
| Lot 46  | >16                            | n/a                     | No special requirements.   |
| Lot 47  | >10.5                          | n/a                     | No special requirements.   |
| Lot 48  | >10.5                          | n/a                     | No special requirements.   |

\*Estimated minimum over-excavation below existing grade. Values are estimated based on current subsurface data – the actual depth of over-excavation may be more, or less, depending on the specific geologic conditions within the building footprint.