Intermountain GeoEnvironmental Services, Inc.
12429 South 300 East, Suite 100, Draper, Utah 84120
Phone (801) 748-4044 ~ F: (801) 748-4045
www.igesinc.com

GEOTECHNICAL AND GEOLOGIC HAZARD INVESTIGATION
The Overlook – Phase I
Summit Powder Mountain Resort
Weber County, Utah

IGES Project No. 01628-021

January 30, 2017

Prepared for:

Summit Mountain Holding Group

Intermountain GeoEnvironmental Services, Inc.
12429 South 300 East, Suite 100, Draper, Utah 84120 ~ T: (801) 748-4044 ~ F: (801) 748-4045

Prepared for:

Summit Mountain Holding Group
3632 North Wolf Creek Drive
Eden, Utah 84310
Attn: Mr. Rick Everson

Geotechnical and Geologic Hazard Investigation
The Overlook – Phase I
Summit Powder Mountain Resort
Weber County, Utah

IGES Project No. 01628-021

Prepared by:

PROFESSIONAL ENGINEER
No. 6370734
DAVID A. GLASS
01-30-17
ELECTRONIC SEAL
STATE OF UTAH

David A. Glass, P.E.
Senior Geotechnical Engineer

LICENSED PROFESSIONAL GEOLOGIST
9325094-2250
PETER ELI DOUMIT
01-30-17
ELECTRONIC SEAL
STATE OF UTAH

Peter E. Doumit, P.G., C.P.G.
Senior Geologist

IGES, Inc.
12429 South 300 East, Suite 100
Draper, Utah 84120
(801) 748-4044

January 30, 2017

TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 PURPOSE AND SCOPE OF WORK 1
1.2 PROJECT DESCRIPTION 1

2.0 METHODS OF STUDY 2

2.1 LITERATURE REVIEW 2
2.1.1 Geotechnical *2*
2.1.2 Geological *2*
2.2 FIELD INVESTIGATION 3
2.3 LABORATORY TESTING 3

3.0 GEOLOGIC CONDITIONS 4

3.1 GENERAL GEOLOGIC SETTING 4
3.2 SURFICIAL GEOLOGY 4
3.3 HYDROLOGY 5
3.4 GEOLOGIC HAZARDS FROM LITERATURE 5
3.4.1 Landslides *6*
3.4.2 Faults *6*
3.4.3 Debris Flows *6*
3.4.4 Liquefaction *6*
3.5 REVIEW OF AERIAL IMAGERY 6
3.6 SEISMICITY 7
3.7 GEOLOGIC HAZARD ASSESSMENT 8
3.7.1 Landslides/Mass Movement/Slope Stability *9*
3.7.2 Rockfall *10*
3.7.3 Surface-Fault Rupture and Earthquake-Related Hazards *10*
3.7.4 Liquefaction *10*
3.7.5 Debris-Flows and Flooding Hazards *10*
3.7.6 Shallow Groundwater *10*

4.0 GENERALIZED SITE CONDITIONS 12

4.1 SITE RECONNAISSANCE 12
4.2 SUBSURFACE CONDITIONS 13
4.2.1 Earth Materials *13*
4.2.2 Groundwater *14*
4.2.3 Strength of Earth Materials *14*

5.0 CONCLUSIONS AND RECOMMENDATIONS 15

5.1 GENERAL CONCLUSIONS 15

5.2 GEOLOGIC CONCLUSIONS AND RECOMMENDATIONS 15
5.3 EARTHWORK 16
5.3.1 General Site Preparation and Grading *16*
5.3.2 Excavations *16*
5.3.3 Excavation Stability *16*
5.3.4 Structural Fill and Compaction *17*
5.3.5 Oversize Material *18*
5.3.6 Utility Trench Backfill *18*
5.4 FOUNDATION RECOMMENDATIONS 18
5.5 SETTLEMENT 19
5.5.1 Static Settlement *19*
5.5.2 Dynamic Settlement *19*
5.6 EARTH PRESSURES AND LATERAL RESISTANCE 19
5.7 CONCRETE SLAB-ON-GRADE CONSTRUCTION 20
5.8 MOISTURE PROTECTION AND SURFACE DRAINAGE 21
5.9 SOIL CORROSION POTENTIAL 21
5.10 CONSTRUCTION CONSIDERATIONS 21
5.10.1 Over-Size Material *21*
5.10.2 Excavation Difficulty *21*

6.0 CLOSURE 23

6.1 LIMITATIONS 23
6.2 ADDITIONAL SERVICES 23

7.0 REFERENCES 24

APPENDICES

Appendix A	Figure A-1	Site Vicinity Map
	Figures A-2 to A-6	Test Pit Logs
	Figure A-7	Key to Soil Symbols and Terminology
	Figure A-8	Regional Geology Map 1
	Figure A-9	Regional Geology Map 2
	Figure A-10	Regional Geology Map 3
	Plate A-1	Geotechnical & Geologic Map

Appendix B Laboratory Test Results

Appendix C Design Response Spectra (*Design Maps* Output)

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 Overlook – Phase I* development, part of the currently on-going expansion at the Powder Mountain Ski Resort in Weber County. 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, 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 October 20, 2016. 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 the Optimized Site Plan prepared by Studio MA, dated 12-13-2015, plus 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 several 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 Summit Powder Mountain project area is accessed by Powder Ridge Road. *The Overlook* development will be located northeast of and adjacent to the Phase 1C area of Summit Powder Mountain (see *Site Vicinity Map*, Figure A-1 in Appendix A).

We understand that the greater *The Overlook* project will include several assorted types of vacation homes, cabins and similar type residential structures, and associated infrastructure including roadways and utilities over an approximately 25-acre site – over 100 residential units are planned. The site is on a natural ridge, with sloping sides draining to the southeast and northeast at gradients ranging from about 2.5H:1V to 5H:1V. The project will include about 2,000 LF of new paved access road and one or possibly two skier bridges. Construction of the roadway is expected to require several relatively shallow cuts and fills, and possibly the construction of rockeries of modest height. The focus of this geotechnical and geologic hazard study is Phase I of *The Overlook* project; Phase I will include 15 individual units, plus supporting infrastructure (Phase I is shown on the *Geotechnical and Geology Map*, Plate A-1 in Appendix A).

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 (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.

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 Overlook* 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 (2014) 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.

2.2 FIELD INVESTIGATION

Subsurface soils were investigated by excavating five test pits at representative locations across the site. The approximate location of the test pits are illustrated on the *Geotechnical and Geology Map* (Plate A-1 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-2 through A-6 in Appendix A. A key to USCS symbols and terminology is included as Figure A-7.

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:

- Grain-Size Distribution (ASTM D6913)
- Fines Content (ASTM D1140)
- In situ Moisture Content (ASTM D2216)
- Direct Shear (ASTM D3080)
- Corrosion Suite (soluble sulfate, soluble chlorite, pH, and resistivity).

Results of the laboratory testing are discussed in this report and presented in Appendix B. Some test results, including moisture content and grain size distribution, have been incorporated into the test pit logs (Figures A-2 through A-6).

3.0 GEOLOGIC CONDITIONS

3.1 GENERAL GEOLOGIC SETTING

The Overlook property is situated in the western portion of the northern Wasatch Mountains, approximately 4 miles northeast 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, 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 subject property is located approximately 10.3 miles to the northeast of the Weber Segment of the Wasatch Fault, which is the closest documented Holocene-aged (active) fault to the property and trends north-south along the Wasatch Front (USGS and UGS, 2006).

3.2 SURFICIAL GEOLOGY

According to 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 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-8). Coogan and King (2001) produced a regional-scale geologic map that covered the property; this map shows the property to be entirely underlain by the Wasatch Formation. Western Geologic (2012) identified a number of landslide deposits contained within the Powder Mountain Resort expansion area, though none of these were shown underlying the *The Overlook* area (Figure A-9). Deposits mapped as "mixed slope colluvium, shallow landslides, and talus" are found southwest of the property. Northeast of the property is a large mapped Pleistocene landslide lobe. Finally, Coogan and King (2016) updated their 2001 map, which shows the property to be situated entirely upon Wasatch Formation bedrock (unit Tw), though the property is just northeast of the northeasternmost reach of a lobe of landslide deposits (unit Qms) (Figure A-10). 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 straddles a north-south trending concealed syncline[1].

3.3 HYDROLOGY

The USGS topographic maps for the Huntsville and Brown's Hole Quadrangles (2014) show that *The Overlook* project area is situated partially on a ridge top and partially on a slope, with the topographic gradient down to the southwest towards Lefty's Canyon (see Figure A-1). No active or ephemeral stream drainages are found on the property, though several small, dry gullies were observed during the site reconnaissance. No springs are known to occur on the property, though it is possible that springs may occur on various parts of the property during peak runoff.

Baseline groundwater depths for the subject property are currently unknown, but are anticipated to fluctuate both seasonally and annually. Groundwater was not encountered in the five test pits excavated in this investigation.

3.4 GEOLOGIC HAZARDS FROM LITERATURE

Based upon the available geologic literature, regional-scale geologic hazard maps that cover *The Overlook* 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.

[1] Syncline: A fold of which the core contains the stratigraphically younger rocks; it is generally concave upward. (AGI, 2005)

3.4.1 Landslides

Two regional-scale landslide hazard maps have been produced that cover the project area. Colton (1991) does not show the property to be underlain by or adjacent to landslide deposits, though landslides are mapped near the northeastern and southeastern margins of the property. Consistent with Colton (1991), Elliott and Harty (2010) shows deposits mapped as "Landslide undifferentiated from talus and/or colluvial deposits" near the northeastern and southeastern margins of the property. Most recently and more site-specific, Western Geologic (2012) used the Elliott and Harty (2010) map as a base map, which shows Pleistocene landslide deposits northeast of the property, though the landslide deposits shown to the southeast of the property on Colton (1991) and Elliott and Harty (2010) are not present (see Figure A-9).

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 10.3 miles southwest of the western margin of the property (USGS and UGS, 2006).

3.4.3 Debris Flows

Christensen and Shaw (2008b) do 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 Overlook* property. This included a review of photos collected from the years 1947, 1953, 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, fault scarps, landslide headscarps, or landslide deposits were observed in the aerial photography on the subject property.

Google Earth imagery of the property from between the years of 1993 and 2016 was also reviewed. The property was observed to contain some surficial gravel, cobbles, and boulders, and be devoid of drainages. Immediately west of the property is an area where multiple north-south trending gullies and an abundance of surficial gravel, cobbles, and boulders are found. Most of the project area was found to be covered in various forms of vegetation, predominantly low-lying shrubs and bushes; no bedrock exposures were observed on the property. Much of the north-central part of the property is densely covered in aspen and some pine trees, and dense tree patches are also found along the southern margin of the property.

No landslide or other geological hazard features were noted on the subject property in the imagery, though a few suspicious features potentially related to landsliding were observed adjacent to the property. Approximately 250 feet northwest of the northwestern corner of *The Overlook* property was observed a scar in the hillside that appeared to be a small landslide headscarp. Similarly, approximately 150 feet northeast of the northeastern margin of the property, a break in slope coinciding with a larger bowl-shaped area extending to the northeast and exhibiting conspicuously less vegetation than the surrounding hillslope and irregular, possibly hummocky topography was observed. Additionally, approximately 40 feet south of the south-central margin of the property, a break in slope possibly representing a small landslide headscarp was observed, which coincided with a small area of limited vegetation and irregular topography. Each of these suspicious areas were later assessed first-hand during the site reconnaissance.

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 (0.2 sec)	Long Period (1.0 sec)
MCE Spectral Response Acceleration (g)	$S_S = 0.810$	$S_1 = 0.268$
MCE Spectral Response Acceleration Site Class C (g)	$S_{MS} = S_sF_a = 0.871$	$S_{M1} = S_1F_v = 0.411$
Design Spectral Response Acceleration (g)	$S_{DS} = S_{MS}{*}^2/_3 = 0.581$	$S_{D1} = S_{M1}{*}^2/_3 = 0.274$

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 1.076 and the long-period (F_v) site coefficient is 1.531. 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 $0.4{*}S_{MS}$.

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 affect 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 Overlook-Phase I* property.

3.7.1 Landslides/Mass Movement/Slope Stability

The property is situated on Wasatch Formation bedrock, according to the most recent geologic map covering the property (Coogan and King, 2016). Additionally, landslide deposits or headscarps were not observed in the aerial imagery evaluation on or upslope of the property, and no geomorphic expression of landslide deposits or headscarps were observed on or upslope of the property during the site reconnaissance. No shear planes, slickensides, or other evidence of landsliding was observed in any of the test pits excavated on *The Overlook-Phase I* property, and refusal in hard Wasatch Formation bedrock was encountered in all five test pits within 8 feet below existing grade. The average slope across the property is found to be approximately 4:1 (horizontal:vertical), which does not require site-specific slope stability analyses. Though evidence of soil creep was observed in the aspen trees found on the property, the subsurface data indicate that this is restricted to the topsoil. Given this data, the risk associated with landslide and slope stability hazards on the property is considered to be low.

It should be noted, however, that evidence of potential landsliding was found near the property. The property is near several deposits mapped as landslide or colluvial deposits to the north, southwest, and southeast of the property (Western Geologic (2012), Elliott and Harty (2010)). The potential landslide areas adjacent to the property that were observed in the aerial imagery were assessed in the site reconnaissance to be likely representative of landslide deposits. However, these areas are not on the property and are downslope of the property, and are therefore not considered to be imminently capable of adversely impacting *The Overlook-Phase I* property. A dark reddish brown fat clay seam displaying slickensides was observed in the road cut along the southern margin of the property. This seam was also observed in TP-3 excavated for the *West Village Sliver* property to the southwest, but was not observed in any of the five test pits excavated in this investigation, nor in the two test pits excavated for the *Main Street West* property to the south; it is therefore considered a highly localized unit (IGES, 2016b, 2016c).

3.7.2 Rockfall

The northern part of the property is at the top of the ridge, and though the remaining portion of the property is 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 Wasatch Fault Zone, located approximately 10.3 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 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 and near the top of a ridge with a consistent slope downhill to the south-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 not encountered in any of the five test pits excavated as part of this investigation. The test pits were excavated in mid-November, and the groundwater level was likely to be on its way down towards its seasonal low. No springs were observed on the property, and no plants indicative of shallow groundwater conditions were observed on the property. It should be noted, however, that groundwater seeps were observed in test pits excavated in the nearby *Copper Crest West* and *Main Street West* properties just prior to *The Overlook-Phase I* test pits being excavated (IGES, 2016a, 2016b). Additionally, seeps are known to emanate from the road cut along Powder Ridge Road during the spring.

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 low to moderate. Spring thaw and runoff are likely to significantly contribute to elevated groundwater conditions. However, shallow groundwater issues can be mitigated through appropriate grading measures and/or the avoidance of the construction of basement levels, or constructing basements with foundation drains.

4.0 GENERALIZED SITE CONDITIONS

4.1 SITE RECONNAISSANCE

Mr. Peter E. Doumit, P.G., C.P.G., of IGES conducted reconnaissance of the entire *The Overlook* site and the immediate adjacent properties on November 7 and 8, 2016. 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. Plate A-1 is a site-specific geologic map of *The Overlook – Phase I* property and adjacent areas.

At the time of the site reconnaissance, *The Overlook* property was observed to consistently slope downhill to the south-southwest, with little irregular topography. Patchy low-lying vegetation, including shrubs and bushes and some grasses, were most common across the property, though a highly dense patch of aspen trees was present in the north-central part of the property. The aspens displayed evidence of low to moderate shallow soil creep to the northeast. Along the southeastern margin of the property, additional dense patches of aspens and pine trees were observed to exhibit moderate to strong shallow soil creep to the south.

Variously-sized boulders and cobbles were found scattered across the property, as part of a surficial geologic unit considered to be either weathered Wasatch Formation or colluvial deposits derived from weathered Wasatch Formation. These were typically subrounded, and were found to be as large as 4.5 feet in diameter. The rock clasts[2] were found to be comprised entirely of banded to massive purple to gray to red quartzite.

No drainages, gullies, springs, seeps, or running water were observed on the property at the time of the site visit. Aside from shallow soil creep, no evidence of landsliding or other geologic hazards was observed on the property.

Specifically, *The Overlook-Phase I* property exhibited a consistent slope that got steeper further to the south, and no hummocky topography was observed. With the exception of a few scattered aspen trees, most of the property was covered by bushes and shrubs. Quartzite boulders up to 2 feet in diameter were present at the surface, though most clasts encountered were up to several inches in diameter.

Immediately west of *The Overlook-Phase I* property, a series of small gullies as much as 2 feet deep and 2 feet wide were observed to have carved through the underlying Wasatch Formation

[2] 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)

bedrock, causing a mix of alluvial and colluvial deposits to be exposed at the surface and much sparser vegetation than seen on the property (see Plate A-1).

The three potential landslide areas adjacent to *The Overlook* property that were observed in the aerial imagery were visited and assessed as landslide features. The small scar to the northwest of the property appeared to be the possible headscarp for a young, shallow landslide deposit that did not travel far downslope to the east (see Unit Qlsy? on Plate A-1). The small associated landslide lobe exhibited the most irregular, hummocky topography seen during the site reconnaissance.

The larger possible landslide deposit to the northeast of the property was observed to be less apparent as a landslide. The slope was found to be steep, but largely consistent, and most of the slope did not exhibit irregular topography. Some hummocky topography was observed approximately 1/3 of the way downslope into the adjacent drainage, but this was not common.

The small possible landslide deposit south of the property was observed to exhibit slightly hummocky topography, and a break in slope associated with an area absent of trees may possibly represent a small headscarp for the deposits. If an actual landslide deposit, it also appears shallow and does not appear to have moved very far downslope to the south.

4.2 SUBSURFACE CONDITIONS

On November 10 and 11, 2016, five exploration test pits were excavated at representative locations across *The Overlook-Phase I* property (Plate A-1). The test pits were excavated to depths ranging between 5 and 8 feet below existing grade with the aid of a Caterpillar 313F tracked excavator – in each test pit, the excavator met with refusal on hard stratum. Detailed logs for the test pits are displayed in Figure A-2 through Figure A-6. Four distinct geologic units were encountered in the subsurface, with two of these units being found in all of the test pits. 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 between approximately one foot and 3 feet thick in all five test pits. The unit was a grayish brown to dark brown, loose, moist, sandy lean CLAY with gravel (CL), with gravel and larger-sized quartzite clasts comprising between approximately 10 and 20% of the unit. In most of the test pits, the basal 6 inches to 1 foot of the unit contained a higher proportion of clasts (~25-35%) and cobbles that may represent a thin loose colluvium unit. The topsoil was largely found to be forming upon the underlying weathered Wasatch Formation unit.

Loose Colluvium: This unit was only encountered in TP-5, though it may have been present in TP-2, TP-3, and TP-4 as a much thinner unit. In TP-5, the unit was approximately 2 to 2.5 feet thick. The unit consisted of a grayish brown, medium-stiff to stiff, moist, gravelly lean CLAY

(CL). Gravel and larger-sized subrounded to subangular quartzite clasts comprised approximately 30-40% of the unit, with individual clasts up to 8 inches in diameter, though the mode clast size was approximately 4 to 6 inches in diameter. The matrix of the unit appeared to be topsoil.

Highly Weathered Wasatch Formation: This unit was observed in TP-2, TP-3, and TP-4, and was found to be between 2 and 4.5 feet thick. The unit consisted of moderate reddish brown to brownish gray, medium-dense to dense, moist, clayey SAND with gravel (SC). Gravel and larger-sized subrounded to subangular quartzite clasts comprised between approximately 20% and 60% of the unit, with individual clasts up to 1 foot in diameter. The unit was found to increase in red color and density with depth, grading into the less weathered underlying Wasatch Formation unit.

Wasatch Formation: This unit was found in all five test pits, being more than 3.5 feet thick and extending to the maximum depth of exploration in all five test pits. The unit consisted of weakly consolidated conglomerate bedrock that had been largely disaggregated into a heterogeneous pale reddish brown to moderate reddish brown, very dense to dense, moist to dry mixture of clay, sand, and gravel that collectively classifies as clayey GRAVEL with sand (GC). Gravel and larger-sized subrounded quartzite clasts comprised between approximately 30 and 55% of the unit, with individual clasts up to 9 inches in diameter, with a mode clast size of less than 1 inch.

4.2.2 Groundwater

Groundwater was not encountered in any of the test pits excavated for this project; however, it should be noted that the deepest test pit was 8 feet below existing grade. Therefore, it is possible that groundwater could be encountered locally in excavations that exceed a depth of 8 feet below existing grade. However, we understand that the proposed residential structures will be constructed on-grade (no basement). As such, groundwater is not expected to impact the proposed development.

4.2.3 Strength of Earth Materials

A direct shear test was completed under consolidated drained conditions on a remolded sample obtained from the Wasatch Formation deposits observed in TP-2 obtained from a depth of approximately 3½ feet. The test results indicate a friction angle of 29 degrees and cohesion of 180 psf (ultimate values).

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 GENERAL CONCLUSIONS

Based on the results of the field observations, literature review, and previously completed geotechnical investigation (IGES, 2012a), **the subsurface conditions are considered suitable for the proposed development, provided that the recommendations presented in this report are incorporated into the design and construction of the project.**

Supporting data upon which the following conclusions and 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 Overlook-Phase I* project area:

- ***The Overlook-Phase I* project area does not appear to have major geological hazards that would adversely affect the development as currently proposed.**

- 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.

- Shallow groundwater conditions were not observed in any of the five test pits, though groundwater seepage has been observed in test pits on adjacent properties; therefore, shallow groundwater hazards are considered to be low to moderate for the property.

- Landslide, 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:

- Because landslide deposits are noted near the property, an IGES geologist or geotechnical engineer should observe the foundation excavations to confirm the absence of landslide deposits.

- Because the landslide deposits adjacent to the property are downslope of the property, there is the possibility that an associated landslide slide plane can propagate upslope over time. Given this situation, we recommend that the road forming the southern border of the property and the southernmost portion of *The Overlook-Phase I* property be assessed annually (in the summer) for potential encroachment by the headscarp or other evidence indicative of possible movement. This should allow sufficient time for mitigation practices to be implemented, if needed.

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 one 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 hard 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). 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. Trench walls may need to be laid back at a steeper grade pending evaluation of soil conditions by the geotechnical engineer; steeper excavations may be particularly feasible where hard, cemented Wasatch Formation (conglomerate bedrock) is exposed. 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.

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.

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 (up to 2 feet), 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 may be water-densified in-place (jetting). Alternatively, pipe bedding and shading may consist of clean ¾-inch gravel, which generally does not require densification. Native earth materials can be used as backfill over the pipe bedding zone. 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 single-family cabin-type structures be founded either *entirely* on competent Wasatch Formation <u>or</u> *entirely* on a minimum of 2 feet of structural fill extending to competent Wasatch Formation. Native/fill transition zones are not allowed. Considering the structures will most likely be on-grade structures (no basements), we anticipate the structural foundations will be placed at least 3.5 feet below final adjacent grade for frost protection. The soil unit at this depth will most likely consist of 'Wasatch Formation', which is dense, cemented conglomerate bedrock that disaggregates to soils classifying as clayey gravel.

Shallow spread or continuous wall footings constructed entirely on structural fill, or entirely on competent, uniform native earth materials (Wasatch Formation conglomerate) 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 values presented above are for dead load plus live load conditions. The allowable bearing capacity may be increased by one-third for short-term loading (wind and seismic). 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 or seepage, which may be present at various times during the year, particularly spring run-off.

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, 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 0.50 for sandy/gravelly native soils or structural fill should be used.

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.

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)	0.33	35	0.53	56
At-rest (Ko)	0.50	55	0.80	85
Passive (Kp)	3.0	320	—	—

Clayey soils drain poorly and may swell upon wetting, thereby greatly increasing lateral pressures acting on earth retaining structures; therefore, 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 ½.

5.7 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’’ W4.0×W4.0 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 **325 psi/inch** may be used 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**.**

5.8 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 structures should be implemented.

We recommend roof runoff devices be installed to direct all runoff a minimum of 10 feet away from foundations. If a basement level is planned, the builder should be responsible for compacting the exterior backfill soils around the foundation. Additionally, the ground surface within 10 feet of the structures should be constructed so as to slope a minimum of **five** percent away from the structure. Pavement sections should be constructed to divert surface water off the pavement into storm drains, curb/gutter, or another suitable location.

Where basements are planned, IGES recommends a perimeter foundation drain be constructed in accordance with the International Residential Code (IRC).

5.9 SOIL CORROSION POTENTIAL

To evaluate the corrosion potential of concrete in contact with onsite native soil, a representative soil sample was tested in our soils laboratory for soluble sulfate content. Laboratory test results indicate that the sample tested had a sulfate content of 49 ppm. Based on this result, the onsite native soils are expected to exhibit a low potential for sulfate attack to concrete. Conventional Type I/II 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 representative soil sample was tested in our soils laboratory for soil resistivity (AASHTO T288), chloride content, and pH. The tests indicated that the onsite soil tested has minimum soil resistivity of 18,197 OHM-cm, a chloride content of 5.2 ppm, and a pH value of 6.1. Based on these results, the onsite native soil is considered *mildly corrosive* to ferrous metal.

5.10 CONSTRUCTION CONSIDERATIONS

5.10.1 Over-Size Material

Large boulders (up to 24 inches in diameter) were observed on the surface and within the test pits; as such, excavation of the basement may generate an abundance of over-size material that may require special handling, processing, or disposal.

5.10.2 Excavation Difficulty

In all five test pits, the excavator met with early refusal on hard stratum (bedrock consisting of Wasatch Formation, or conglomerate). The excavations were completed with a Caterpillar 313F tracked excavator. For equipment of this size or smaller, excavation for some foundations may be challenging, and excavations for basements or utilities may be very difficult. The Contractor should consider this information when determining the appropriate earth-moving equipment for this site.

6.0 CLOSURE

6.1 LIMITATIONS

The recommendations presented in this report are based on limited field exploration, review of existing hazard studies and other geotechnical data, and our understanding of the proposed construction. The subsurface data used in the preparation of this report were obtained from the explorations made for this investigation. It is possible that variations in the soil and groundwater conditions could exist between and beyond the points explored. The nature and extent of variations may not be evident until construction occurs. If any conditions are encountered at this site that are different from those described in this report, we should be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the scope of the proposed construction changes from that described in this report, IGES should also be notified.

This report was prepared in accordance with the generally accepted standard of practice at the time the report was written. No warranty, expressed or implied, is made.

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.

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.

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

AMEC, 2001. Report Engineering Geologic Reconnaissance/Geotechnical Study Powder Mountain Resort.

American Geologic Institute (AGI), 2005, Glossary of Geology, Fifth Edition, revised, Neuendorf, K.K.E., Mehl, Jr. J.P., and Jackson, J.A., editors: American Geological Institute, Alexandria, Virginia, 783 p.

Anderson, L.R., Keaton, J.R., and Bay, J.A., 1994, Liquefaction Potential Map for the Northern Wasatch Front, Utah, Complete Technical Report: Utah Geological Survey Contract Report 94-6, 169 p.

Christenson, G.E., and Shaw, L.M., 2008a, Surface Fault Rupture Special Study Areas, Wasatch Front and Nearby Areas, Utah: Utah Geological Survey Supplement Map to Utah Geological Survey Circular 106, 1 Plate, Scale 1:200,000.

Christenson, G.E., and Shaw, L.M., 2008b, Debris-Flow/Alluvial Fan Special Study Areas, Wasatch Front and Nearby Areas, Utah: Utah Geological Survey Supplement Map to Utah Geological Survey Circular 106, 1 Plate, Scale 1:200,000.

Christenson, G.E., and Shaw, L.M., 2008c, Liquefaction Special Study Areas, Wasatch Front and Nearby Areas, Utah: Utah Geological Survey Supplement Map to Utah Geological Survey Circular 106, 1 Plate, Scale 1:200,000.

Colton, R.B., 1991, Landslide Deposits in the Ogden 30' x 60' Quadrangle, Utah and Wyoming: U.S. Geological Survey Open-File Report 91-297, 1 Plate, 8 p., Scale 1:100,000.

Coogan, J.C., and King, J.K., 2001, Progress Report Geologic Map of the Ogden 30' x 60' Quadrangle, Utah and Wyoming – Year 3 of 3: Utah Geological Survey Open-File Report 380, 1 Plate, 33 p., Scale 1:100,000.

Coogan, J.C., and King, J.K., 2016, Interim Geologic Map of the Ogden 30' x 60' Quadrangle, Box Elder, Cache, Davis, Morgan, Rich, and Summit Counties, Utah, and Uinta County, Wyoming: Utah Geological Survey Open-File Report 653DM, 1 Plate, 151 p., Scale 1:100,000.

Crittenden, Jr., M.D., 1972, Geologic Map of the Browns Hole Quadrangle, Utah: U.S. Geological Survey Geologic Quadrangle Map GQ-968, 1 Plate, Scale 1:24,000.

Elliott, A.H., and Harty, K.M., 2010, Landslide Maps of Utah, Ogden 30' X 60'Quadrangle: Utah Geological Survey Map 246DM, Plate 6 of 46, Scale 1:100,000.

Federal Emergency Management Agency [FEMA], 1997, *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures*, FEMA 302, Washington, D.C.

REFERENCES (Cont.)

Frankel, A., Mueller, C., Barnard, T., Perkins, D., Leyendecker, E.V., Dickman, N., Hanson, S., and Hopper, M., 1996, *National Seismic-hazard Maps: Documentation*, U.S. Geological Survey Open-File Report 96-532, June.

Hintze, L.F., 1988, Geologic History of Utah: Brigham Young University Geology Studies Special Publication 7, Provo, Utah, 202 p.

IGES, Inc., 2012a, Preliminary Geotechnical Investigation, Powder Mountain Resort, Weber County, Utah, Project No. 01628-001, dated July 26, 2012.

IGES, Inc., 2012b, Design Geotechnical Investigation, Powder Mountain Resort, Weber County, Utah, Project No. 01628-003, dated November 9, 2012.

IGES, Inc., 2016a, Geotechnical and Geologic Hazard Investigation, Copper Crest West, Summit Powder Mountain Resort, Weber County, Utah, Project No. 01628-022, dated January 16, 2016.

IGES, Inc., 2016b, Geotechnical and Geologic Hazard Investigation, Main Street West, Summit Powder Mountain Resort, Weber County, Utah, Project No. 01628-023, dated January 18, 2016.

IGES, Inc., 2016c, Geotechnical and Geologic Hazard Investigation, West Village Sliver, Summit Powder Mountain Resort, Weber County, Utah, Project No. 01628-020, dated January 20, 2016.

International Building Code [IBC], 2015, International Code Council, Inc.

Lund, W.R., 1990, editor, Engineering geology of the Salt Lake City metropolitan area, Utah: Utah Geological Survey Bulletin 126, 66 p.

Milligan, M.R., 2000, How was Utah's topography formed? Utah Geological Survey, Survey Notes, v. 32, no.1, pp. 10-11.

Sorensen, M.L., and Crittenden, Jr., M.D., 1979, Geologic Map of the Huntsville Quadrangle, Weber and Cache Counties, Utah: U.S. Geological Survey Geologic Quadrangle Map GQ-1503, 1 Plate, Scale 1:24,000.

Stokes, W.L., 1987, Geology of Utah: Utah Museum of Natural History and Utah Geological and Mineral Survey Department of Natural Resources, Salt Lake City, UT, Utah Museum of Natural History Occasional Paper 6, 280 p.

U.S. Geological Survey, 2012/15, U.S. *Seismic "Design Maps" Web Application*, site: https://geohazards.usgs.gov/secure/designmaps/us/application.php, site accessed on July 20, 2012.

REFERENCES (Cont.)

U.S. Geological Survey, 2014, Topographic Map of the Huntsville Quadrangle, Huntsville, Utah: Scale 1:24,000.

U.S. Geological Survey, 2014, Topographic Map of the Brown's Hole Quadrangle, Brown's Hole, Utah: Scale 1:24,000.

U.S. Geological Survey and Utah Geological Survey, 2006, Quaternary fault and fold database for the United States, accessed 7-1-16, from USGS website: http://earthquakes.usgs.gov/regional/qfaults

Utah Geological Survey, 2016, Utah Geological Survey Aerial Imagery Collection https://geodata.geology.utah.gov/imagery/

Weber County, 2015, Natural Hazards Overlay Districts, Chapter 27 of Title 104 of the Weber County Code of Ordinances, adopted on December 22, 2015.

Western Geologic, 2012, Report: Geologic Hazards Reconnaissance, Proposed Area 1 Mixed-Use Development, Powder Mountain Resort, Weber County, Utah, dated August 28, 2012.

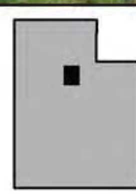
AERIAL PHOTOGRAPHS

Data Set	Date	Flight	Photographs	Scale
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 MAP:
USGS Huntsville, Browns Hole, James Peak and Sharp Mountain
7.5-Minute Quadrangle Topographic Maps (2011)



MAP LOCATION

0 1000' 2000'

SCALE 1:24,000

IGES®

Project No. 01628-021

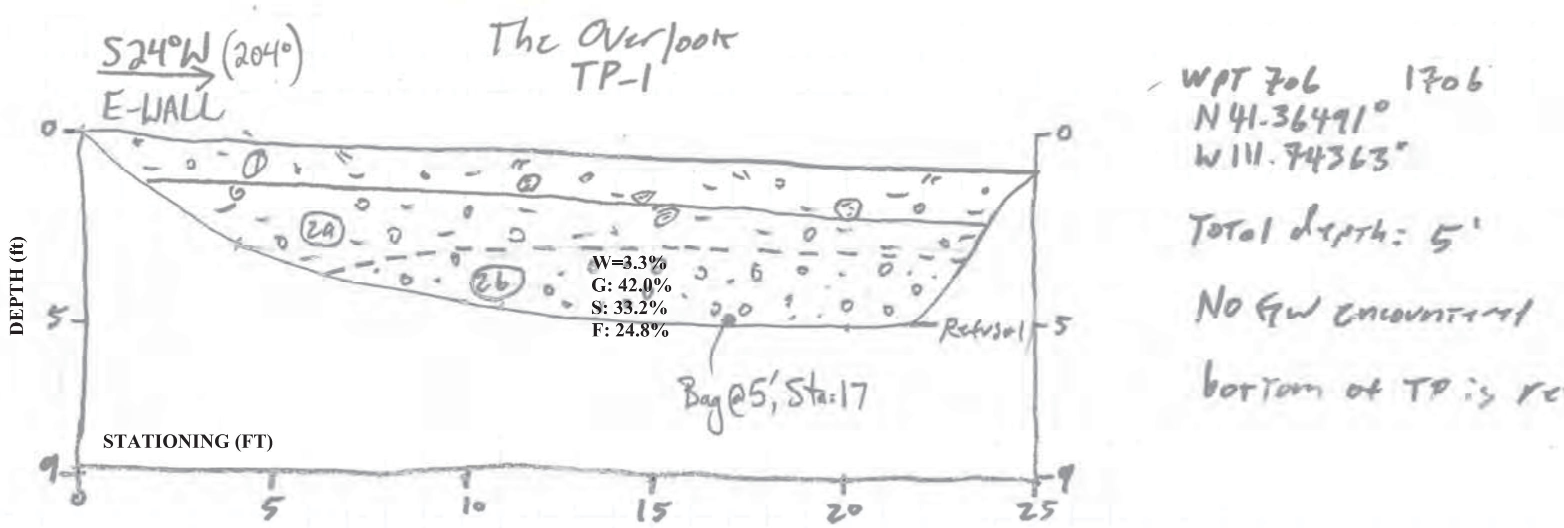
Geotechnical & Geologic Hazard Investigation
The Overlook - Phase I
Summit Powder Mountain Resort
Weber County, Utah

SITE VICINITY MAP

Figure

A-1

Project No. 01628-020
Date 11/10/16 by ET
Ckd by ____ on ____



LITHOLOGIC UNIT DESCRIPTIONS:

1) **A/B Soil Horizon:** ~1' thick; dark yellowish brown (10YR 4/2) sandy lean CLAY with gravel (CL), loose, moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~15-20% of unit; clasts entirely subangular quartzite up to 10" in diameter, though mode size 1-2"; abundant plant and tree roots; gradational, irregular basal contact.

2) **Wasatch Formation:** At least ~4' thick; contains 2 subunits:
2a: Highly Weathered Wasatch Formation: ~1-2' thick; dark reddish brown (10R ¾) to grayish brown (5Y 3/2) sandy fat CLAY with gravel (CH), medium-stiff, moist, moderate to high plasticity, massive; gravel and larger sized clasts comprise ~20% of subunit; clasts include ~70% subangular to subrounded quartzite and ~30% subangular to subrounded sandstone up to 7" in diameter, though mode size ~1-2"; occasional plant and tree roots; sharp, irregular basal contact.

2b: Competent Bedrock: At least ~2' thick; conglomerate bedrock disaggregated to moderate reddish brown (10R 4/6) to dark reddish brown (10R ¾) to pale reddish brown (10R 5/4) clayey GRAVEL with sand (GC) gradational to clayey SAND with gravel (SC), very dense, slightly moist, low plasticity fines, massive; gravel and larger sized clasts comprise 42% of subunit; clasts entirely subangular quartzite up to 5" in diameter, though mode size ~1"; subunit produced trackhoe refusal.

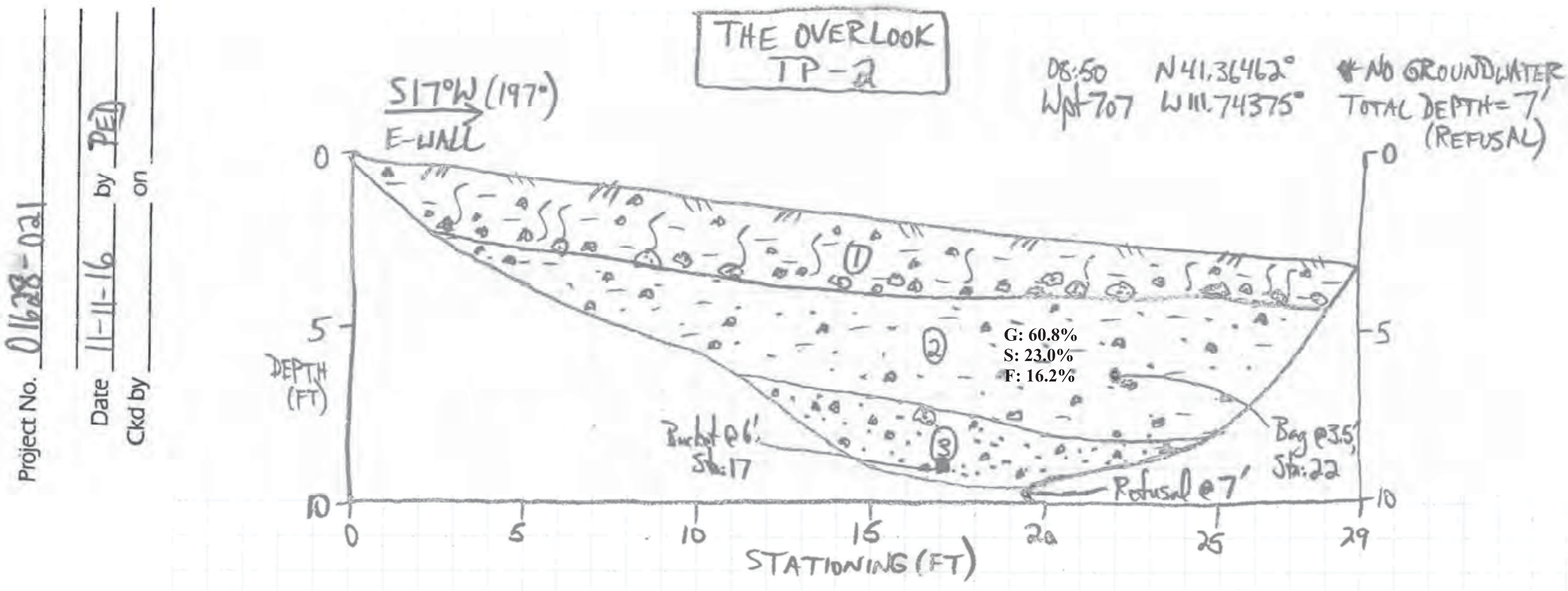
SCALE: 1"=5' H&V

IGES®
Project No. 01628-021

Geotechnical & Geologic Hazard Investigation
The Overlook - Phase I
Summit Powder Mountain Resort
Weber County, Utah

TEST PIT LOG TP-1

Figure
A-2



LITHOLOGIC UNIT DESCRIPTIONS:

1) **A/B Soil Horizon:** ~1.5-2' thick; grayish brown (5Y 3/2) to dark yellowish brown (10YR 4/2) lean CLAY with gravel (CL), loose to medium-stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~15-20% of unit; clasts entirely medium gray (N5) subrounded to subangular quartzite up to 7" in diameter, though mode size ~2-4"; basal ~6" is highly cobbly and may represent a thin, loose colluvium unit with topsoil matrix; abundant plant and tree roots; sharp, planar basal contact.

2) **Weathered Wasatch Formation:** ~3-4' thick; brownish gray (5YR 4/1) to moderate reddish brown (10R 4/6) clayey GRAVEL with sand (GC), medium-dense, moist, low plasticity, massive; gravel and larger sized clasts comprise ~61% of unit; clasts entirely subrounded to subangular medium gray (N5) to pale yellowish orange (10YR 8/6) quartzite up to 6" in diameter, though mode size ~2-4"; common plant and tree roots; becomes redder and more competent with depth; sharp, irregular basal contact.

3) **Wasatch Formation:** At least ~2' thick; competent conglomerate bedrock, partially disaggregated to light gray (N7) to pale reddish brown (10R 5/4) gravelly SAND (SW) gradational to sandy GRAVEL (GW), very dense to dense, slightly moist to dry, massive to weakly bedded; gravel and larger sized clasts comprise ~40-50% of unit; clasts entirely quartzite as above up to 5" in diameter, though mode size <1"; well-cemented, and close to original conglomerate bedrock; unit caused trackhoe refusal.

SCALE: 1"=5' H&V

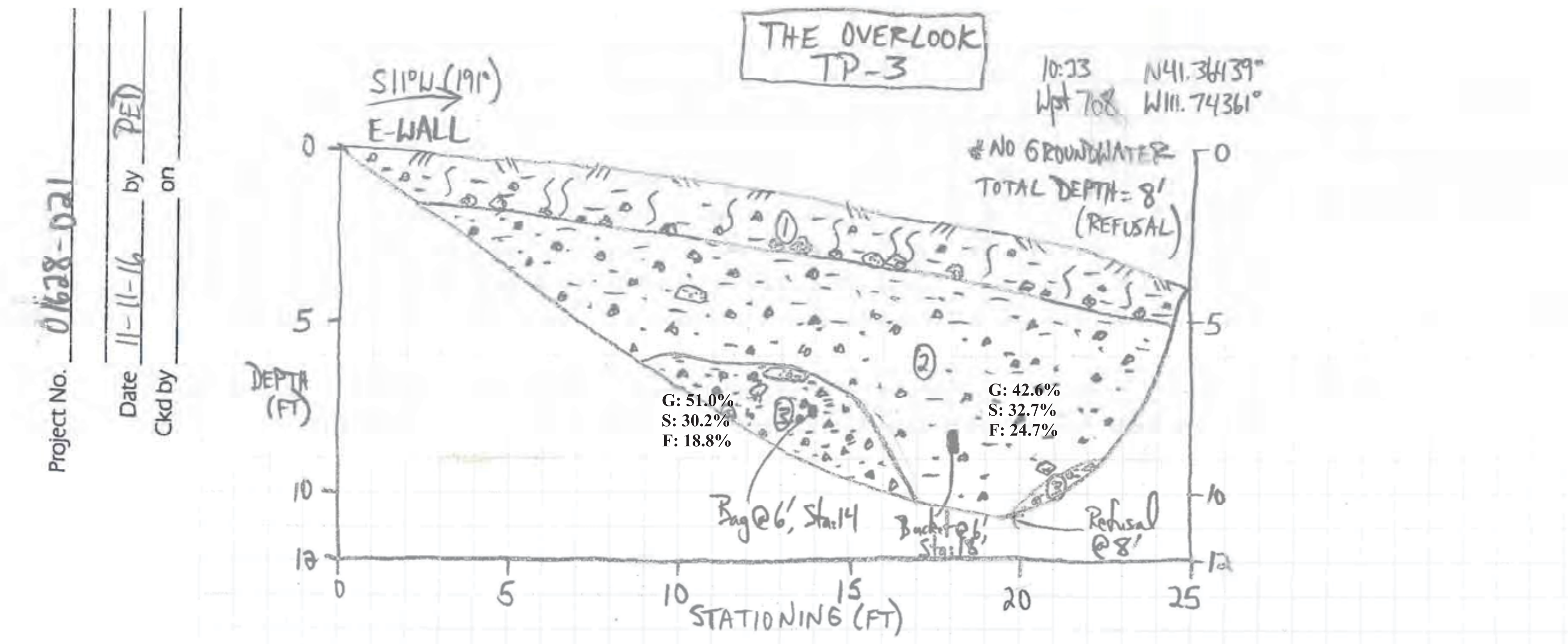
IGES®

Project No. 01628-021

Geotechnical & Geologic Hazard Investigation
The Overlook - Phase I
Summit Powder Mountain Resort
Weber County, Utah

TEST PIT LOG TP-2

Figure A-3



LITHOLOGIC UNIT DESCRIPTIONS:

1) **<u>A/B Soil Horizon</u>:** ~1.5-2' thick; grayish brown (5Y 3/2) to dark yellowish brown (10YR 4/2) lean CLAY with gravel (CL), loose to medium-stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~15-20% of unit; clasts entirely medium gray (N5) subrounded to subangular quartzite up to 10" in diameter, though mode size ~2-4"; basal ~6" is highly cobbly and may represent a thin, loose colluvium unit with topsoil matrix; cobbles within thin colluvial horizon comprise ~30-35% of basal 6"; abundant plant and tree roots; sharp, largely planar basal contact.

2) **<u>Weathered Wasatch Formation</u>:** ~2.5-4.5' thick; moderate reddish brown (10R 4/6) to brownish gray (5YR 4/1) to dark reddish brown (10R ¾) clayey GRAVEL with sand (GC), medium-dense to dense, moist, low plasticity, massive; gravel and larger sized clasts comprise ~43% of unit; clasts entirely subrounded to subangular medium gray (N5) to purple quartzite up to 1' in diameter, though mode size ~2-3"; sand is medium-grained; becomes denser and coarser with depth; uppermost ~1' is brownish gray, and unit increases in red color with depth which may reflect transition from partially weathered to largely unaltered bedrock; occasional to common plant roots; sharp, wavy basal contact may simply reflect moisture content, as irregular shape is not seen on west wall of test pit but simply a planar contact.

3) **<u>Wasatch Formation</u>:** At least ~2.5' thick; competent conglomerate bedrock, partially disaggregated to pale reddish brown (10R 5/4) to moderate reddish brown (10R 4/6) to light gray (N7) clayey GRAVEL with sand (GC), very dense, slightly moist to dry, low plasticity, massive; gravel and larger sized clasts comprise 51% of unit; clasts entirely quartzite as above up to 9" in diameter, though mode size <1"; well-cemented, and close to original conglomerate bedrock; sand is fine-grained; gradational between matrix-supported and clast-supported; unit caused trackhoe refusal.

SCALE: 1"=5' H&V

IGES®

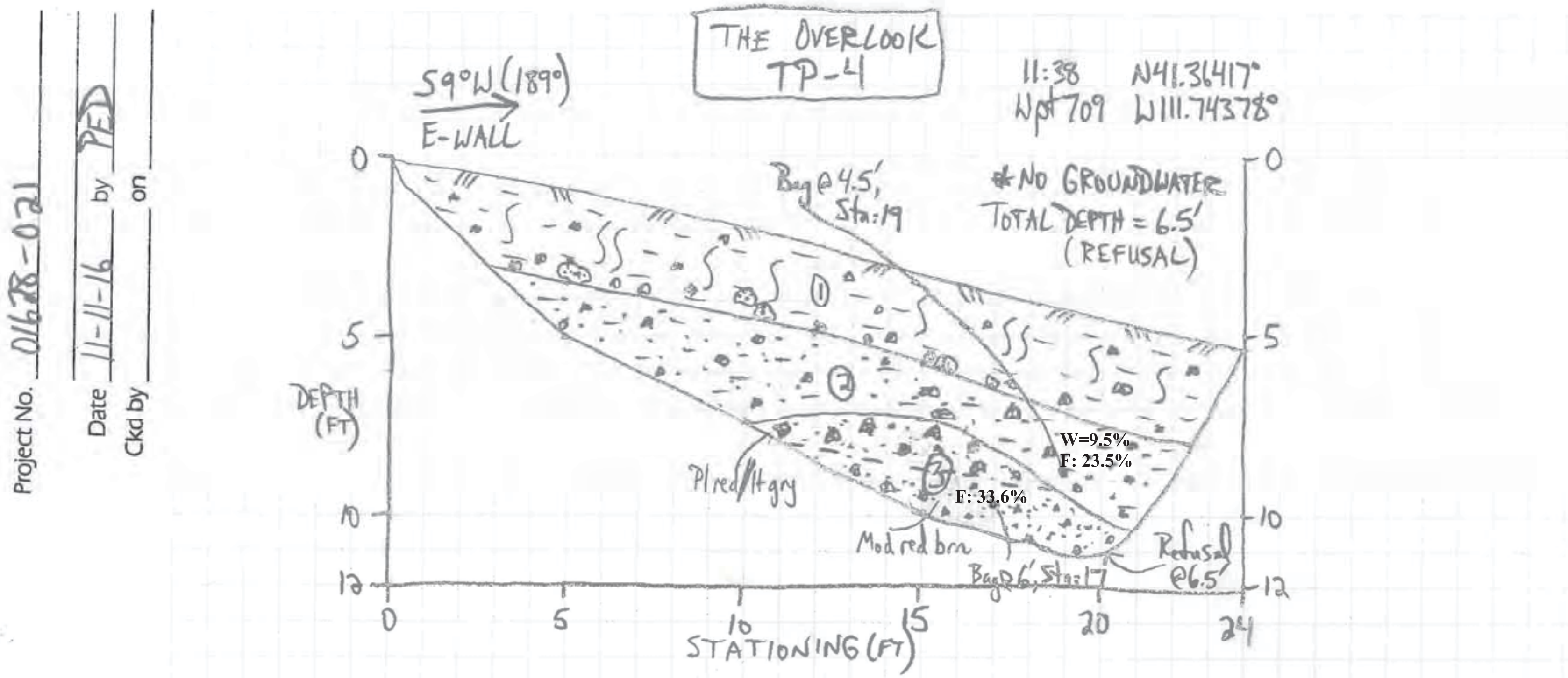
Project No. 01628-021

Geotechnical & Geologic Hazard Investigation
The Overlook - Phase I
Summit Powder Mountain Resort
Weber County, Utah

TEST PIT LOG TP-3

Figure

A-4



LITHOLOGIC UNIT DESCRIPTIONS:

1) **A/B Soil Horizon:** ~2.5-3' thick; grayish brown (5Y 3/2) to dark yellowish brown (10YR 4/2) lean CLAY with gravel (CL), loose to medium-stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of unit; clasts entirely medium gray (N5) to pale yellowish orange (10YR 8/6) subrounded to subangular quartzite up to 10" in diameter, though mode size ~2-4"; basal ~6"-1' is a possible thin, loose colluvium unit with topsoil matrix; cobbles within thin colluvial horizon comprise ~25% of basal 6"-1' of unit; abundant plant and tree roots; gradational, planar basal contact.

2) **Weathered Wasatch Formation:** ~2' thick; moderate reddish brown (10R 4/6) to brownish gray (5YR 4/1) clayey GRAVEL with sand (GC), medium-dense to dense, moist, low plasticity, massive; gravel and larger sized clasts comprise ~40% of unit; clasts entirely quartzite as above up to 5" in diameter, though mode size <1"; becomes denser and coarser with depth; grades with depth to largely unaltered Wasatch Formation; common plant and tree roots; sharp, irregular basal contact.

3) **Wasatch Formation:** At least ~3' thick; competent conglomerate bedrock, partially disaggregated to pale reddish brown (10R 5/4) to moderate reddish brown (10R 4/6) to light gray (N7) clayey GRAVEL with sand (GC), very dense, slightly moist to dry, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of unit; clasts entirely quartzite as above up to 7" in diameter, though mode size <1"; occasional pinholes (1 mm diameter); generally well-cemented, and close to original conglomerate bedrock; some clasts appear imbricated downslope and unit may have faint bedding downslope; occasional plant roots; unit caused trackhoe refusal.

SCALE: 1"=5' H&V

IGES®

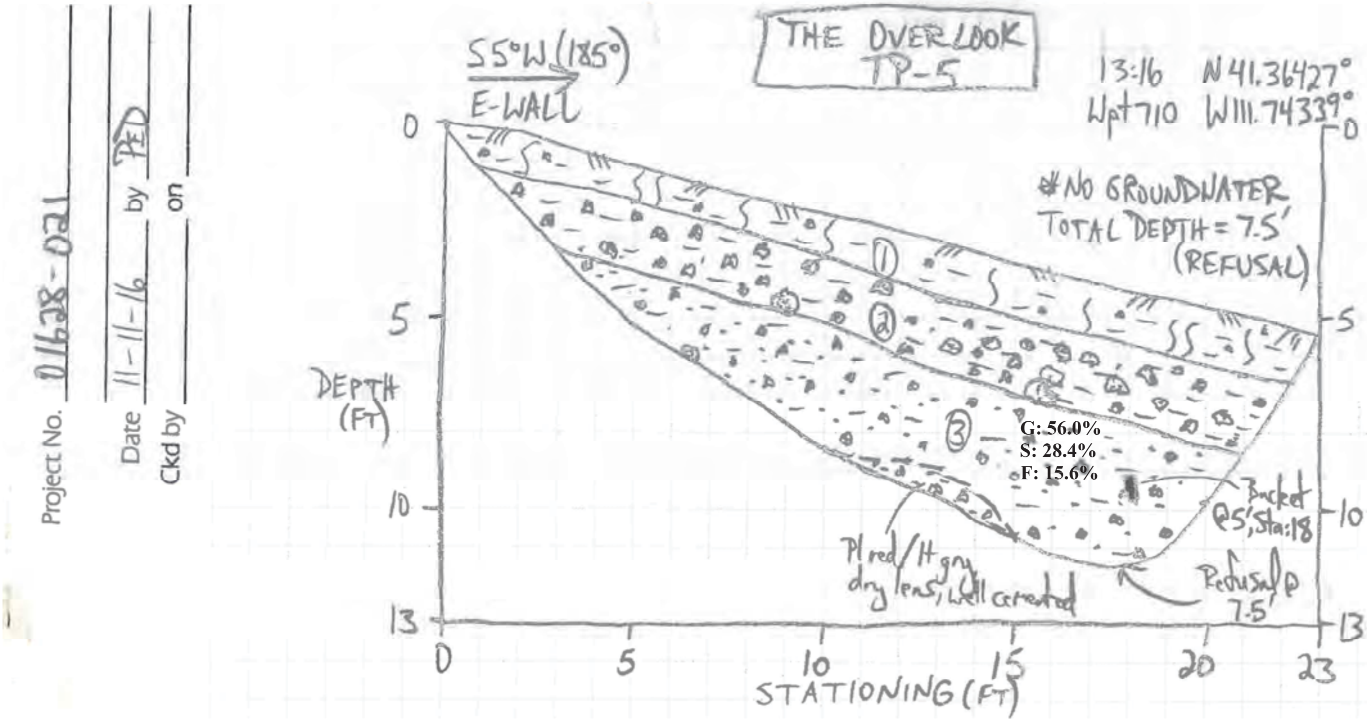
Project No. 01628-021

Geotechnical & Geologic Hazard Investigation
The Overlook - Phase I
Summit Powder Mountain Resort
Weber County, Utah

TEST PIT LOG TP-4

Figure

A-5



LITHOLOGIC UNIT DESCRIPTIONS:

1) **A/B Soil Horizon:** ~1-1.5' thick; grayish brown (5Y 3/2) lean CLAY with gravel (CL), loose to medium-stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of unit; clasts entirely medium gray (N5) to pale yellowish orange (10YR 8/6) subrounded to subangular quartzite up to 4" in diameter, though mode size ~1"; abundant plant and tree roots; largely gradational, planar basal contact.

2) **Loose Colluvium:** ~2-2.5' thick; grayish brown (5Y 3/2) gravelly lean CLAY with sand (CL), medium-stiff to loose, moist, low plasticity, massive; gravel and larger sized clasts comprise ~30-40% of unit; clasts entirely quartzite as above up to 8" in diameter, though mode size ~4-6"; topsoil matrix; abundant plant and tree roots; sharp, irregular basal contact.

3) **Wasatch Formation:** At least ~3.5' thick; competent conglomerate bedrock, partially disaggregated to moderate reddish brown (10R 4/6) to dark reddish brown (10R ¾) clayey GRAVEL with sand (GC), very dense to dense, moist to slightly moist, low plasticity, massive; gravel and larger sized clasts comprise 56% of unit; clasts entirely quartzite as above up to 6" in diameter, though mode size ~2-4"; loamy; largely well-cemented, very hard, and close to original conglomerate bedrock; sand is fine-grained to medium-grained; occasional plant roots; unit caused trackhoe refusal.

SCALE: 1"=5' H&V

IGES®

Project No. 01628-021

Geotechnical & Geologic Hazard Investigation
The Overlook - Phase I
Summit Powder Mountain Resort
Weber County, Utah

TEST PIT LOG TP-5

Figure

A-6

UNIFIED SOIL CLASSIFICATION SYSTEM

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

LOG KEY SYMBOLS

BORING SAMPLE LOCATION

TEST-PIT SAMPLE LOCATION

WATER LEVEL (level after completion)

WATER LEVEL (level where first encountered)

CEMENTATION

DESCRIPTION	DESCRIPTION
WEAKELY	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

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 RELATIONSHIP	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

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
SEAM	1/16 - 1/2"
LAYER	1/2 - 12"

DESCRIPTION	THICKNESS
OCCASIONAL	ONE OR LESS PER FOOT OF THICKNESS
FREQUENT	MORE THAN ONE PER FOOT OF THICKNESS

GENERAL NOTES

1. Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual.
2. No warranty is provided as to the continuity of soil conditions between individual sample locations.
3. Logs represent general soil conditions observed at the point of exploration on the date indicated.
4. 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.

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 PENETRATED 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 UNTRAINED SHEAR STRENGTH (tsf)	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH (tsf)	FIELD TEST
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 THUMBNAIL.
HARD	>30	>2.0	>4.0	INDENTED WITH DIFFICULTY BY THUMBNAIL.

IGES®

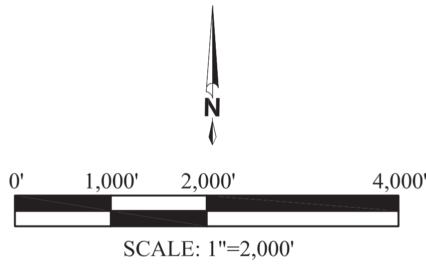
Key to Soil Symbols and Terminology

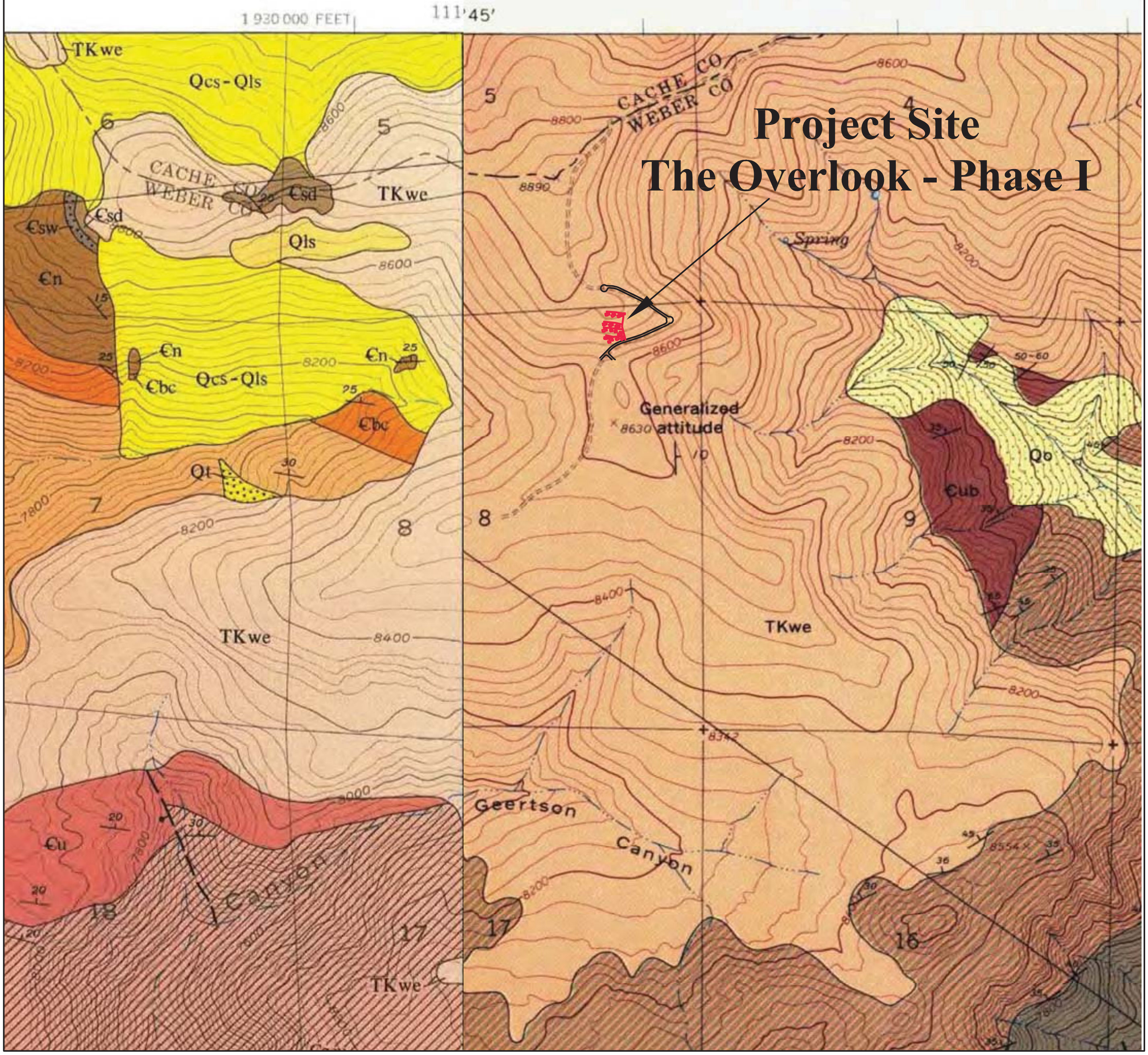
Figure A-7

BASE MAPS

-USGS Huntsville 7.5-Minute Geologic Quadrangle Map (GQ-1503), Sorensen and Crittenden, Jr. (1979)

-USGS Brown's Hole 7.5-Minute Geologic Quadrangle Map (GQ-968), Crittenden, Jr. (1972)





IGES®

Project No. 01628-021

Geotechnical & Geologic Hazard Investigation
The Overlook - Phase I
Summit Powder Mountain Resort
Weber County, Utah

REGIONAL GEOLOGY MAP 1

Figure

A-8a

MAP LEGEND

Qal — ALLUVIAL DEPOSITS, UNDIFFERENTIATED (Holocene) – Unconsolidated gravel, sand, and silt deposits in presently active stream channels and floodplains; thickness 0-6 m

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

Qf — ALLUVIAL FAN DEPOSITS (Holocene) – Alluvial fan deposits; postdate, at least in part, time of highest stand of former Lake Bonneville; 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

ST. CHARLES LIMESTONE (Upper Cambrian) – Includes:

Ꞓsd — Dolomite member – Thin- to thick-bedded, finely to medium crystalline, light- to medium-gray, white- to light-gray-weathering, cliff-forming dolomite; linguloid brachiopods common in basal 15 m; thickness 150-245 m

Ꞓsw — Worm Creek Quartzite Member – Thin-bedded, fine- to medium-grained, medium- to dark-gray, tan- to brown-weathering calcareous quartzitic sandstone; detrital grains well-sorted and well-rounded; thickness 6 m

Ꞓn — 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

Ꞓbc — 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

Ꞓlu — CAMBRIAN LIMESTONES, UNDIVIDED (Middle Cambrian) – Includes limestone and Hodges Shale Members of Bloomington Formation, and Blacksmith and Ute Limestones

Ꞓb — BLACKSMITH LIMESTONE (Middle Cambrian)) – Medium- to thin-bedded, light-gray to dark-blue-gray limestone; thin-bedded, flaggy-weathering, gray to tan silty limestone and interbedded siltstone; light- to dark-gray dolomite, with some reddish siliceous partings; thickness 400? m

MAP LEGEND

€u — **UTE LIMESTONE** (Middle Cambrian) — Medium- to thin-bedded, finely crystalline, light- to dark-gray silty limestone with irregular wavy partings, mottled and streaked surfaces, worm tracks, and twiggy structures common throughout unit; oolites and *Girvanella* in many beds; olive-drab fissile shale interbedded throughout unit. Includes thin-bedded, gray-weathering, pale-tan to brown dolomite exposed at base of unit, 18-24 m at head of Geertsen Canyon and 0-3 m elsewhere; thickness 245? m

€gcu — **GEERTSEN CANYON QUARTZITE** (Lower Cambrian) — Includes:
Upper member — Pale-buff to white or flesh-pink quartzite, locally streaked with pale red or purple. Coarse-grained; small pebbles occur throughout unit and increase in abundance downward. Base marked by zone 30-60 m thick of cobble conglomerate in beds 30 cm to 2 m thick; clasts, 5-10 cm in diameter, are mainly reddish vein quartz or quartzite, sparse gray quartzite, or red jasper; thickness 730-820 m

€gcl — Lower member — Pale-buff to white and tan quartzite with irregular streaks and lenses of cobble conglomerate decreasing in abundance downward. Lower 90-120 m strongly arkosic, streaked greenish or pinkish. Feldspar clasts increase in size to 0.6-1.3 cm in lower part of unit; thickness 490-520 m

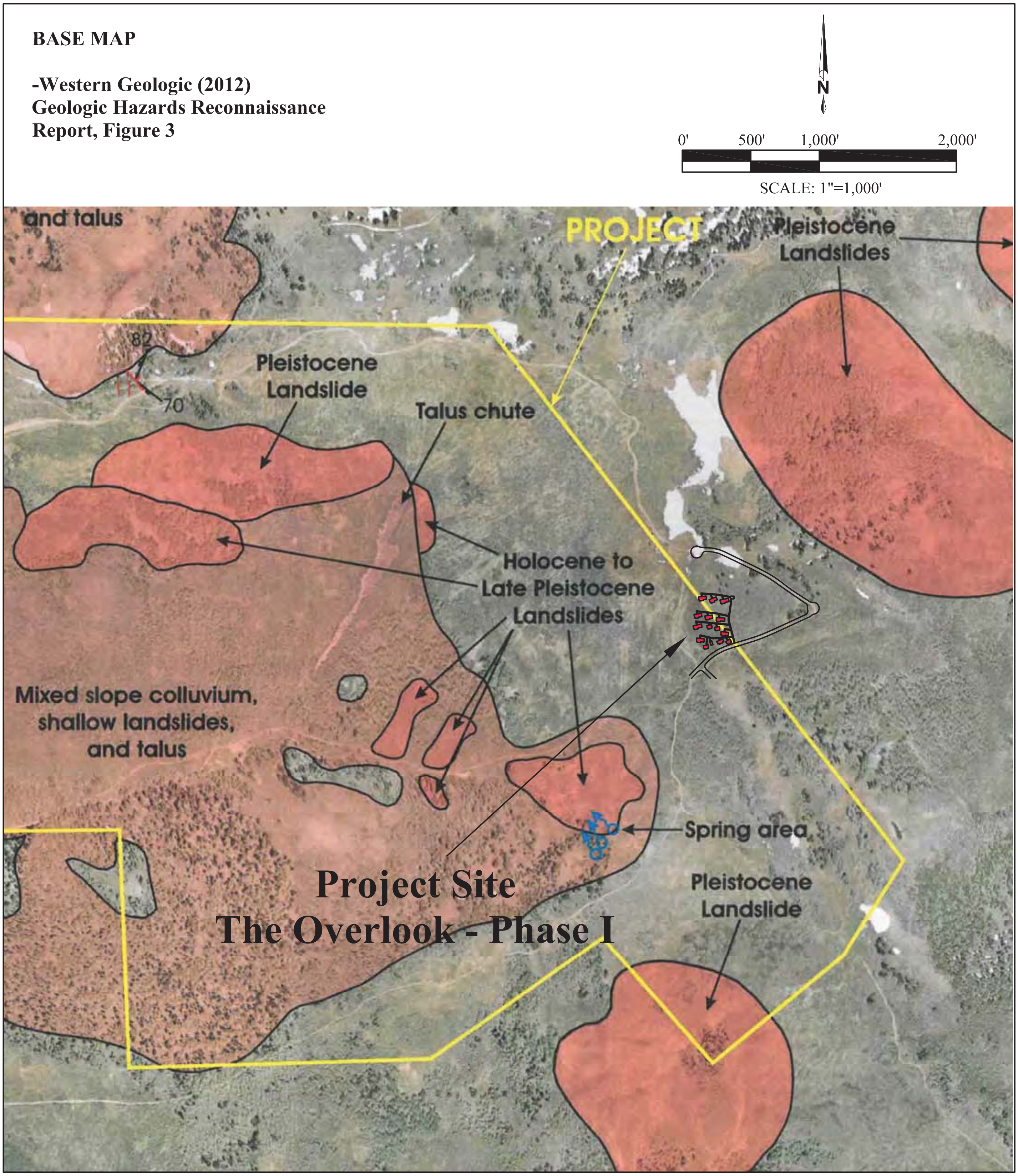
Recently active normal fault — Dashed where inferred. Ticks on downthrown side

Pre-Tertiary normal fault — Dotted where concealed Bar and ball on downthrown side

Thrust fault — Dashed where inferred Sawteeth on upper plate

BASE MAP

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



IGES®

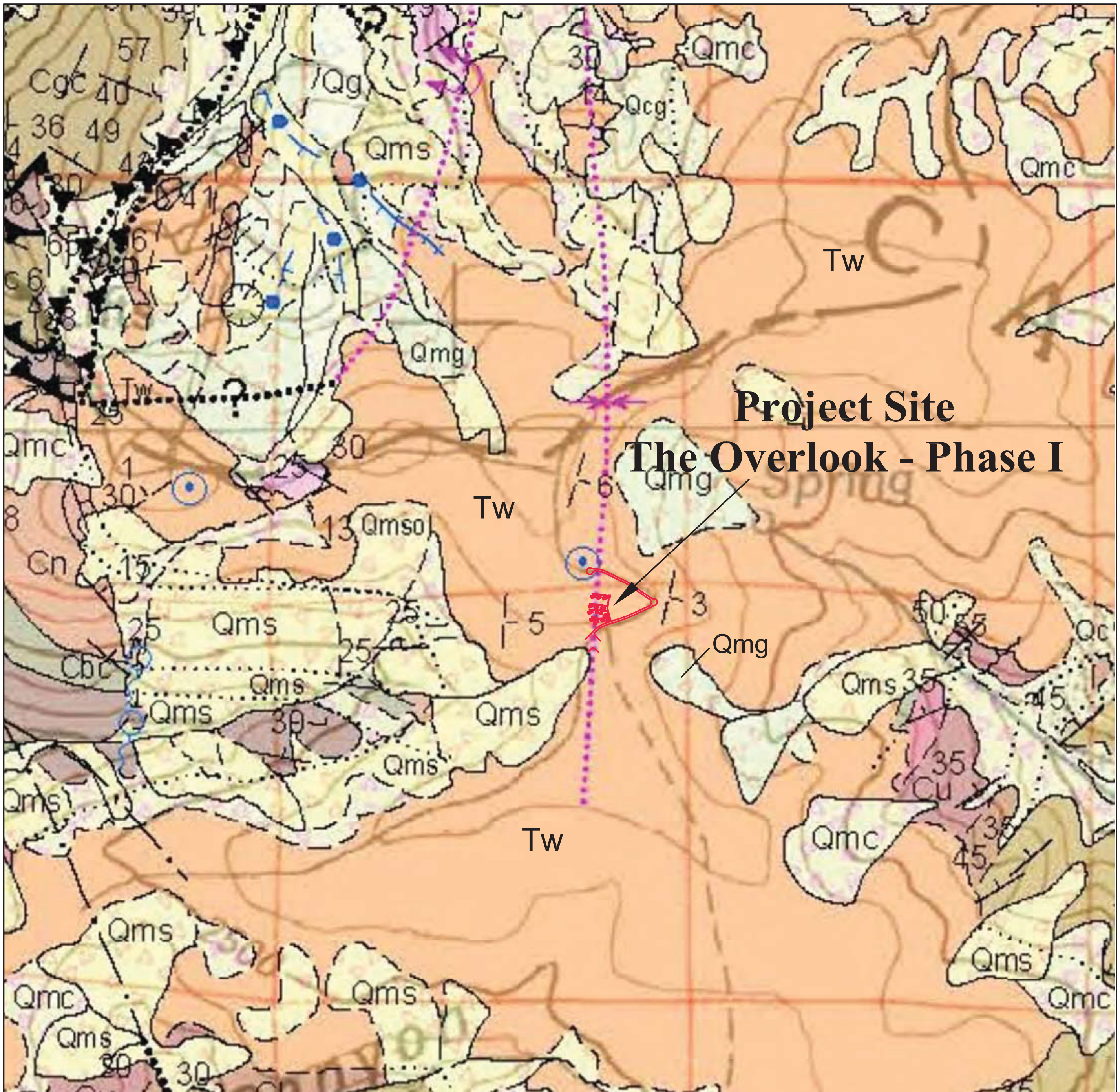
Project No. 01628-021

Geotechnical & Geologic Hazard Investigation
The Overlook - Phase I
Summit Powder Mountain Resort
Weber County, Utah

REGIONAL GEOLOGY MAP 2

Figure

A-9



BASE MAP

-Coogan and King (2016)
UGS Ogden 30'x60' Geologic
Quadrangle Map, OFR-635DM
Plate 1

N

0' 1,000' 2,000' 4,000'

SCALE: 1"=2,000'

IGES®

Project No. 01628-021

Geotechnical & Geologic Hazard Investigation
The Overlook - Phase I
Summit Powder Mountain Resort
Weber County, Utah

REGIONAL GEOLOGY MAP 3

Figure

A-10a

MAP LEGEND

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).

Human disturbances

Qh, Qh? **Human disturbances (Historical)** - Mapped disturbances obscure original deposits or rocks by cover or removal; only larger disturbances that pre-date the 1984 aerial photographs used to map the Ogden 30 x 60-minute quadrangle are shown; includes engineered fill, particularly along Interstate Highways 80 and 84, the Union Pacific Railroad, and larger dams, as well as aggregate operations, gravel pits, sewage-treatment facilities, cement plant quarries and operations, brick plant and clay pit, Defense Depot Ogden (Browning U.S. Army Reserve Center), gas and oil field operations (for example drill pads) including gas plants, and low dams along several creeks, including a breached dam on Yellow Creek.

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

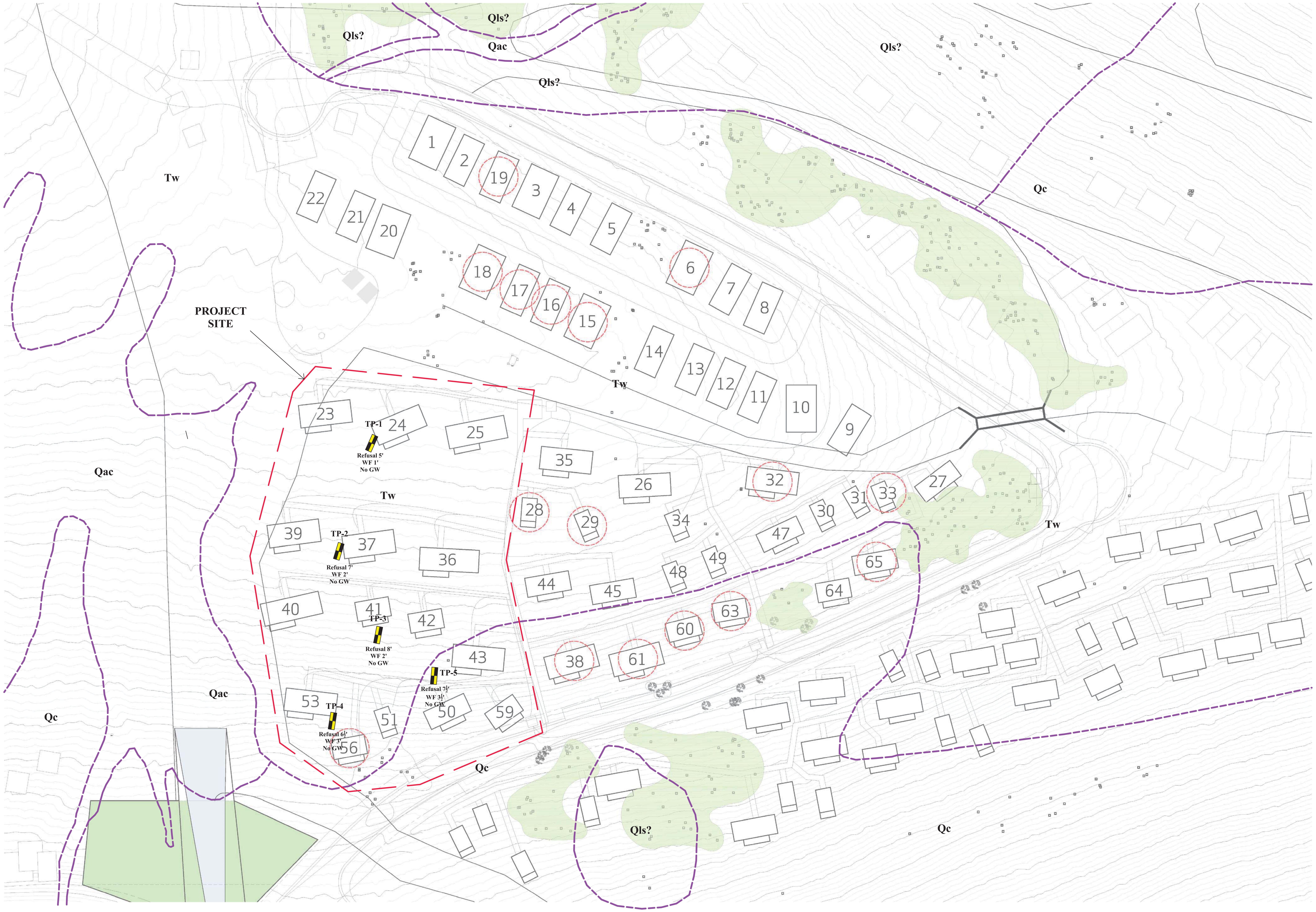
Landslide deposits (Holocene and upper and middle? Pleistocene) – Poorly sorted clay- to boulder-sized material; includes slides, slumps, and locally flows and floods; generally characterized by hummocky topography, main and internal scarps, and chaotic bedding in displaced blocks; composition depends 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.

Qmg, Qmg?

Mass-movement and glacial deposits, undivided (Holocene and Pleistocene) – Unsorted and unstratified clay, silt, sand, and gravel; mapped where glacial deposits lack typical moraine morphology, and appear to have failed or moved down slope; also mapped in upper Strawberry Bowl (Snow Basin quadrangle) where glacial deposits have lost their distinct morphology and the contacts between them and colluvium and talus in the cirques cannot be mapped; likely less than 30 feet (9 m) thick, but may be thicker in Mantua, James Peak, North Ogden, Huntsville, and Peterson quadrangles.

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 Twl); 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



LEGEND

TP-5 (Refusal 7½', WF 3½', No GW)	Approximate test pit location with total depth (or depth to refusal), depth to Wasatch Formation (WF), and depth to groundwater (GW)
Qc	Colluvium, derived from Wasatch Formation
Qac	Alluvium & Colluvium, slopewash in and adjacent to gullies
Qls?/Qlsy?	Possible landslide deposit (Qlsy denotes younger deposit)
Tw	Wasatch Formation (conglomerate bedrock)
	Geologic contact (contact between different units), all contacts approximate

0 25' 50'
SCALE 1'=50'

Basemap: 50-scale Site Plan by Studio MA, dated 12-13-2015

IGES®
Project No. 01628-021

Geotechnical & Geologic Hazard Investigation
The Overlook - Phase I
Summit Powder Mountain Resort
Weber County, Utah

GEOTECHNICAL AND GEOLOGIC MAP

PLATE
A-1

APPENDIX B

Water Content and Unit Weight of Soil

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

Project: **Summit-The Overlook**
No: **01628-021**
Location: Powder Mountain, UT
Date: 12/20/2016
By: NB/BSS

Sample Info.	Boring No.	TP-1	TP-4						
	Sample								
	Depth	5.0'	4.5'						
	Split	Yes	Yes						
	Split sieve	3/8"	3/8"						
	Total sample (g)	4297.06	4474.74						
	Moist coarse fraction (g)	1534.66	1423.14						
	Moist split fraction (g)	2762.40	3051.60						
	Sample height, H (in)								
	Sample diameter, D (in)								
	Mass rings + wet soil (g)								
	Mass rings/tare (g)								
	Moist unit wt., γ_m (pcf)								
Coarse Fraction	Wet soil + tare (g)	2246.20	1733.54						
	Dry soil + tare (g)	2229.71	1699.53						
	Tare (g)	711.55	310.40						
	Water content (%)	1.1	2.4						
Split Fraction	Wet soil + tare (g)	737.91	956.70						
	Dry soil + tare (g)	711.71	893.13						
	Tare (g)	128.88	409.81						
	Water content (%)	4.5	13.2						
	Water Content, w (%)	**3.3**	**9.5**						
	Dry Unit Wt., γ_d (pcf)								

Entered by:___________

Reviewed:___________

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

(ASTM D6913)

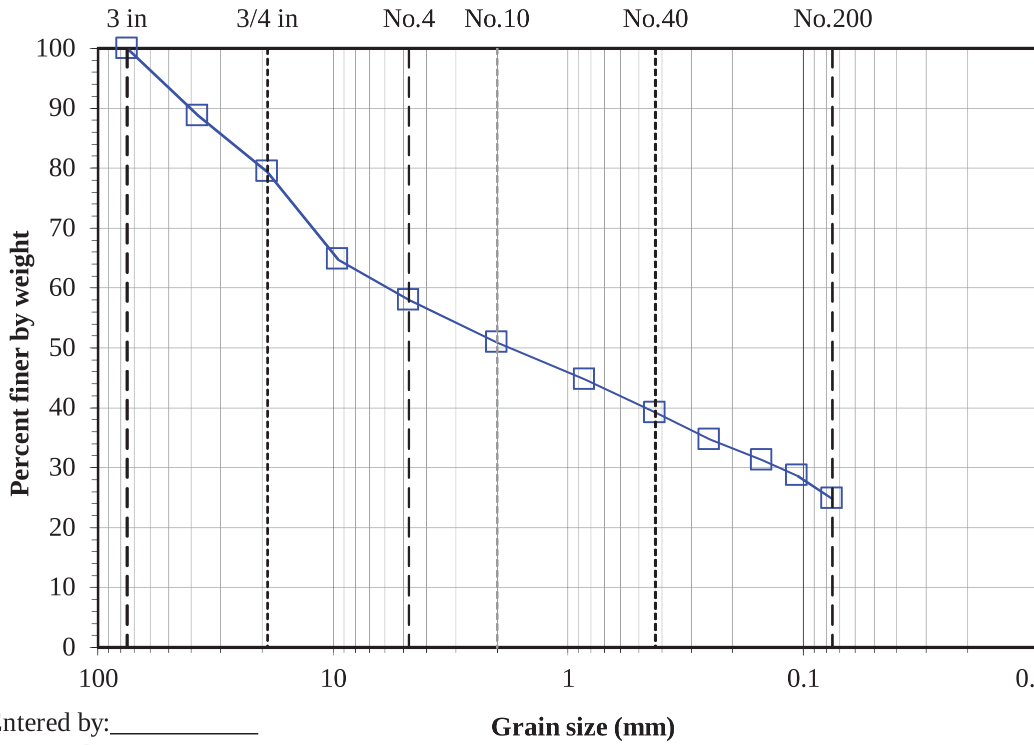
Project: Summit - The Overlook
No: 01628-021
Location: Powder Mountain, UT
Date: 12/20/2016
By: NB

Boring No.: TP-1
Sample:
Depth: 5.0'
Description: Reddish brown clayey gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	4297.06	4160.02
+3/8" Coarse fraction (g):	1481.93	1466.00
-3/8" Split fraction (g):	609.03	582.83
Split fraction:	0.648	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	2246.21	737.91
Dry soil + tare (g):	2229.71	711.71
Tare (g):	711.55	128.88
Water content (%):	1.1	4.5

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	467.60	37.5	88.8	
3/4"	856.80	19	79.4	
3/8"	1466.00	9.5	64.8	←Split
No.4	60.97	4.75	58.0	
No.10	124.69	2	50.9	
No.20	180.40	0.85	44.7	
No.40	230.37	0.425	39.2	
No.60	270.40	0.25	34.7	
No.100	301.56	0.15	31.3	
No.140	324.82	0.106	28.7	
No.200	359.63	0.075	24.8	



Gravel (%): 42.0
Sand (%): 33.2
Fines (%): 24.8

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

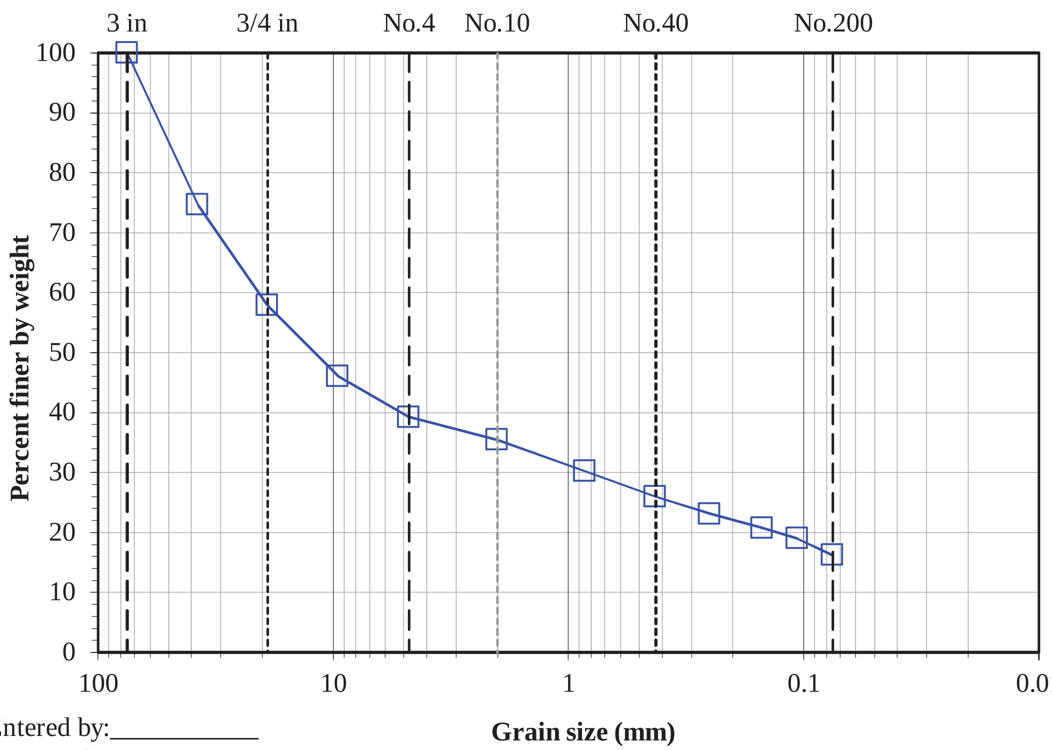
Project: Summit - The Overlook
No: 01628-021
Location: Powder Mountain, UT
Date: 12/21/2016
By: BSS

Boring No.: TP-2
Sample:
Depth: 3.5'
Description: Red clayey gravel with sand

Split:	Yes	
Split sieve:	#4	
	Moist	Dry
Total sample wt. (g):	5406.58	5088.86
+#4 Coarse fraction (g):	3181.58	3094.53
-#4 Split fraction (g):	360.27	322.92
Split fraction:	0.392	

Water content data	C.F.(+#4)	S.F.(-#4)
Moist soil + tare (g):	3492.10	768.21
Dry soil + tare (g):	3405.05	730.86
Tare (g):	310.52	407.94
Water content (%):	2.8	11.6

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	1291.28	37.5	74.6	
3/4"	2142.82	19	57.9	
3/8"	2748.00	9.5	46.0	
No.4	3094.53	4.75	39.2	←Split
No.10	31.43	2	35.4	
No.20	73.81	0.85	30.2	
No.40	109.13	0.425	25.9	
No.60	133.07	0.25	23.0	
No.100	152.15	0.15	20.7	
No.140	167.02	0.106	18.9	
No.200	189.74	0.075	16.2	



Gravel (%): 60.8
Sand (%): 23.0
Fines (%): 16.2

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01628_Powder_Mountain\021_The_Overlook\[GSDv2.xlsx]2

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

(ASTM D6913)

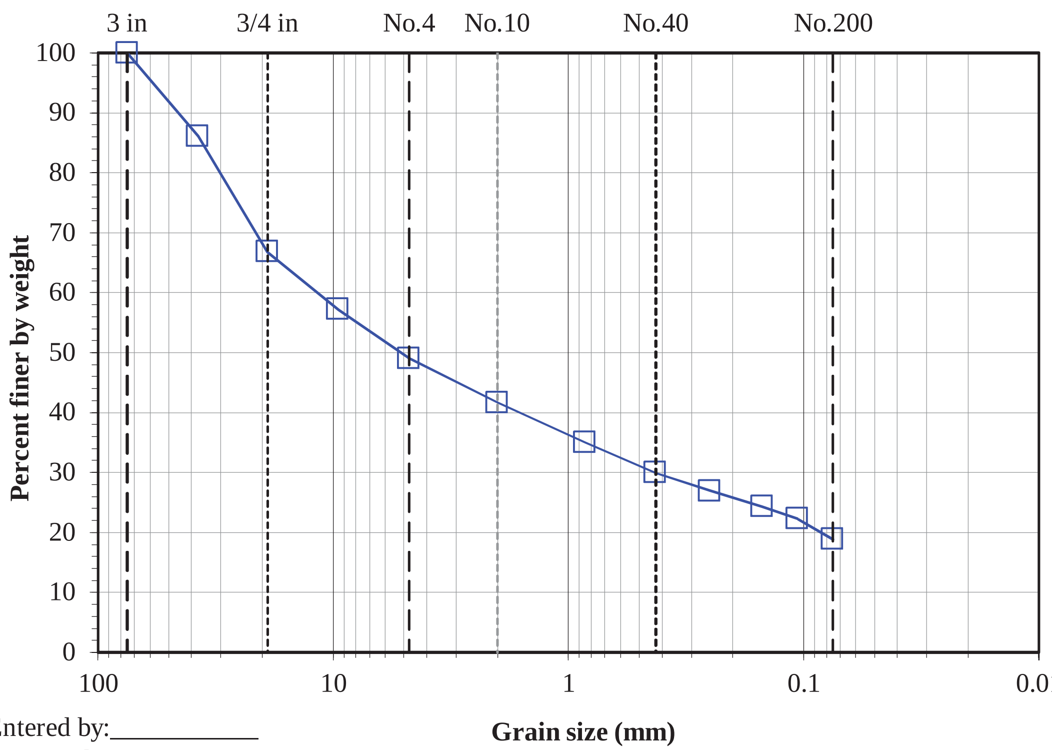
Project: Summit - The Overlook
No: 01628-021
Location: Powder Mountain, UT
Date: 12/21/2016
By: BSS

Boring No.: TP-3
Sample: Sta. 14
Depth: 6.0'
Description: Reddish brown clayey gravel with sand

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	5210.58	5068.15
+3/4" Coarse fraction (g):	1693.68	1682.47
-3/4" Split fraction (g):	657.99	633.44
Split fraction:	0.668	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	2004.70	968.63
Dry soil + tare (g):	1993.49	944.08
Tare (g):	311.02	310.64
Water content (%):	0.7	3.9

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	704.73	37.5	86.1	
3/4"	1682.47	19	66.8	←Split
3/8"	91.44	9.5	57.2	
No.4	168.58	4.75	49.0	
No.10	238.71	2	41.6	
No.20	301.62	0.85	35.0	
No.40	349.38	0.425	30.0	
No.60	378.54	0.25	26.9	
No.100	403.31	0.15	24.3	
No.140	422.72	0.106	22.2	
No.200	454.90	0.075	18.8	



Gravel (%): 51.0
Sand (%): 30.2
Fines (%): 18.8

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01628_Powder_Mountain\021_The_Overlook\[GSDv2.xlsx]3

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

(ASTM D6913)

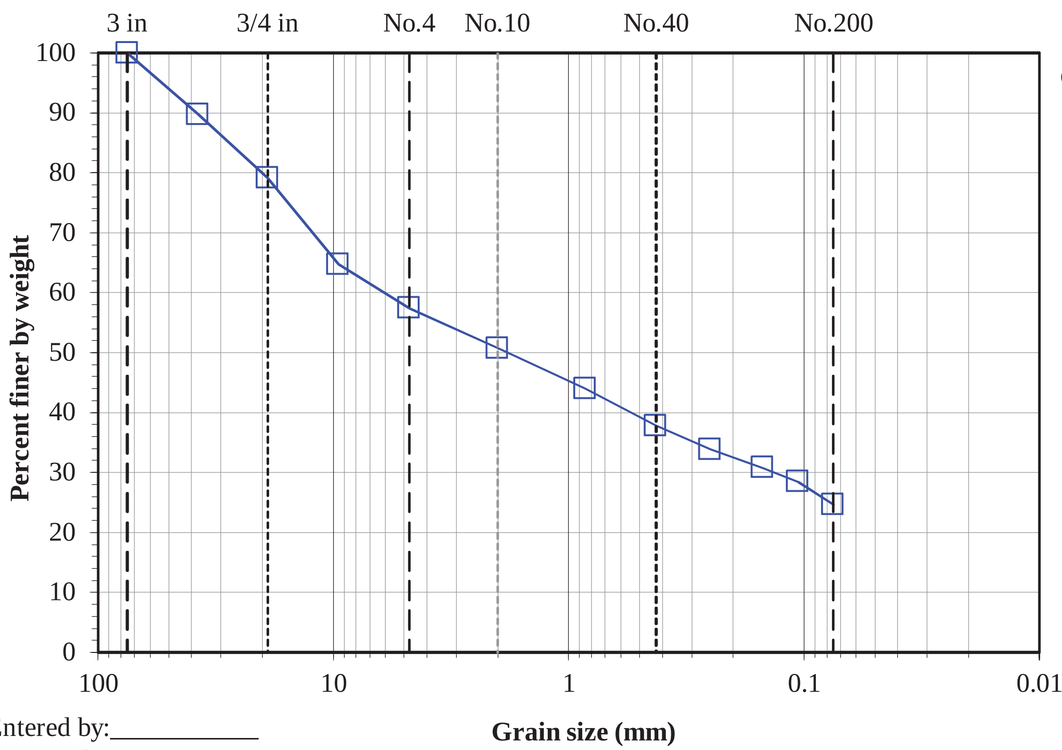
Project: Summit - The Overlook
No: 01628-021
Location: Powder Mountain, UT
Date: 12/21/2016
By: BSS

Boring No.: TP-3
Sample: Sta. 18
Depth: 6.0'
Description: Reddish brown clayey gravel with sand

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	24876.20	23078.04
+3/4" Coarse fraction (g):	4956.20	4815.11
-3/4" Split fraction (g):	754.57	691.80
Split fraction:	0.791	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	2798.82	1165.00
Dry soil + tare (g):	2728.05	1102.23
Tare (g):	312.83	410.43
Water content (%):	2.9	9.1

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	2377.57	37.5	89.7	
3/4"	4815.11	19	79.1	←Split
3/8"	126.17	9.5	64.7	
No.4	189.90	4.75	57.4	
No.10	248.60	2	50.7	
No.20	307.38	0.85	44.0	
No.40	361.31	0.425	37.8	
No.60	396.12	0.25	33.8	
No.100	422.75	0.15	30.8	
No.140	443.25	0.106	28.4	
No.200	476.10	0.075	24.7	



Gravel (%): 42.6
Sand (%): 32.7
Fines (%): 24.7

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01628_Powder_Mountain\021_The_Overlook\[GSDv2.xlsx]4

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

(ASTM D6913)

IGES

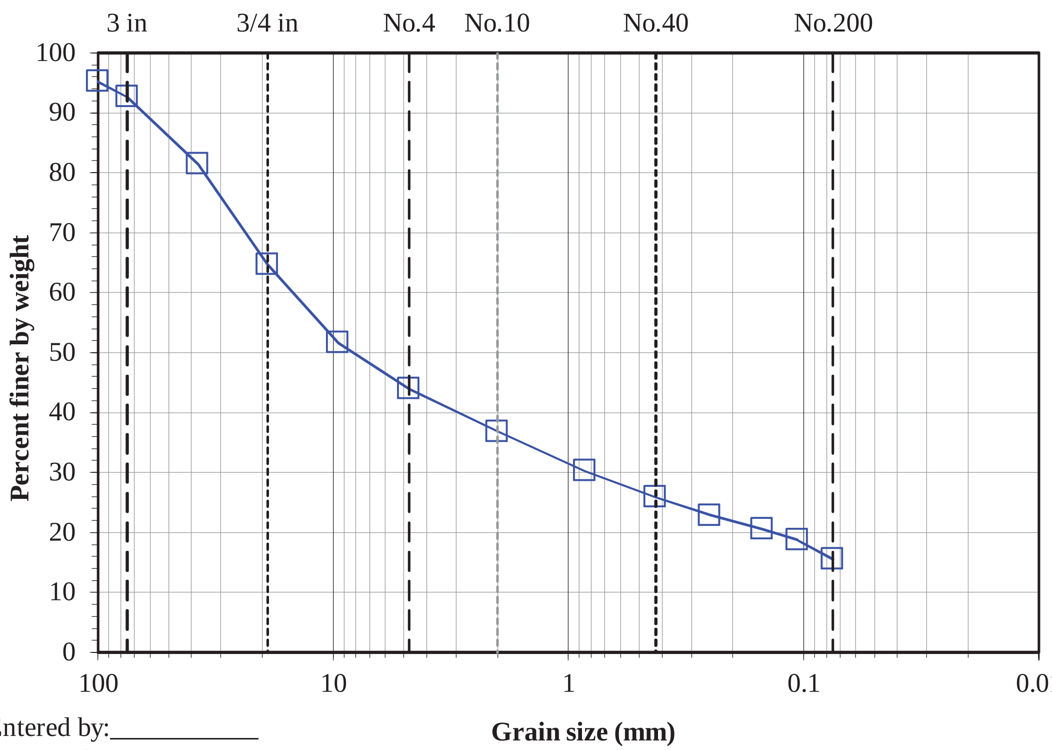
Project: Summit - The Overlook
No: 01628-021
Location: Powder Mountain, UT
Date: 12/22/2016
By: BSS

Boring No.: TP-5
Sample:
Depth: 5.0'
Description: Brown clayey gravel with sand

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	25928.60	25020.57
+3/4" Coarse fraction (g):	8996.00	8833.21
-3/4" Split fraction (g):	631.87	604.06
Split fraction:	0.647	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	3487.46	960.15
Dry soil + tare (g):	3431.75	932.34
Tare (g):	408.88	328.28
Water content (%):	1.8	4.6

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	100.0	
4"	1190.75	100	95.2	
3"	1841.07	75	92.6	
1.5"	4642.54	37.5	81.4	
3/4"	8833.21	19	64.7	←Split
3/8"	122.24	9.5	51.6	
No.4	193.66	4.75	44.0	
No.10	260.03	2	36.8	
No.20	321.75	0.85	30.2	
No.40	362.45	0.425	25.9	
No.60	390.74	0.25	22.8	
No.100	412.52	0.15	20.5	
No.140	429.30	0.106	18.7	
No.200	458.83	0.075	15.6	



Gravel (%): 56.0
Sand (%): 28.4
Fines (%): 15.6

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01628_Powder_Mountain\021_The_Overlook\[GSDv2.xlsx]5

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

(ASTM D1140)

Project: Summit - The Overlook
No: 01628-021
Location: Powder Mountain, UT
Date: 12/21/2016
By: BSS

	Boring No.	TP-4	TP-4						
Sample Info.	Sample								
	Depth	4.5'	6.0'						
	Split	Yes	Yes						
	Split Sieve*	3/8"	3/8"						
	Method	B	B						
	Specimen soak time (min)	390	370						
	Moist total sample wt. (g)	4474.74	4649.66						
	Moist coarse fraction (g)	1423.14	921.36						
	Moist split fraction + tare (g)	956.70	1053.17						
	Split fraction tare (g)	409.81	316.57						
	Dry split fraction (g)	483.32	701.10						
	Dry retained No. 200 + tare (g)	721.36	721.36						
	Wash tare (g)	409.81	316.57						
	No. 200 Dry wt. retained (g)	311.55	404.79						
	Split sieve* Dry wt. retained (g)	1389.13	913.61						
	Dry total sample wt. (g)	4086.01	4462.23						
Coarse Fraction	Moist soil + tare (g)	1733.54	1230.82						
	Dry soil + tare (g)	1699.53	1223.07						
	Tare (g)	310.40	309.46						
	Water content (%)	2.45	0.85						
Split Fraction	Moist soil + tare (g)	956.70	1053.17						
	Dry soil + tare (g)	893.13	1017.67						
	Tare (g)	409.81	316.57						
	Water content (%)	13.15	5.06						
	Percent passing split sieve* (%)	**66.0**	**79.5**						
	Percent passing No. 200 sieve (%)	**23.5**	**33.6**						

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01628_Powder_Mountain\021_The_Overlook\[FINESv3.xlsx]1

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: Summit - The Overlook
No: 01628-021
Location: Powder Mountain, UT
Date: 12/27/2016
By: JDF

Boring No.: TP-2
Sample:
Depth: 3.5'
Sample Description: Brown clayey sand
Sample type: Arbitrary remold

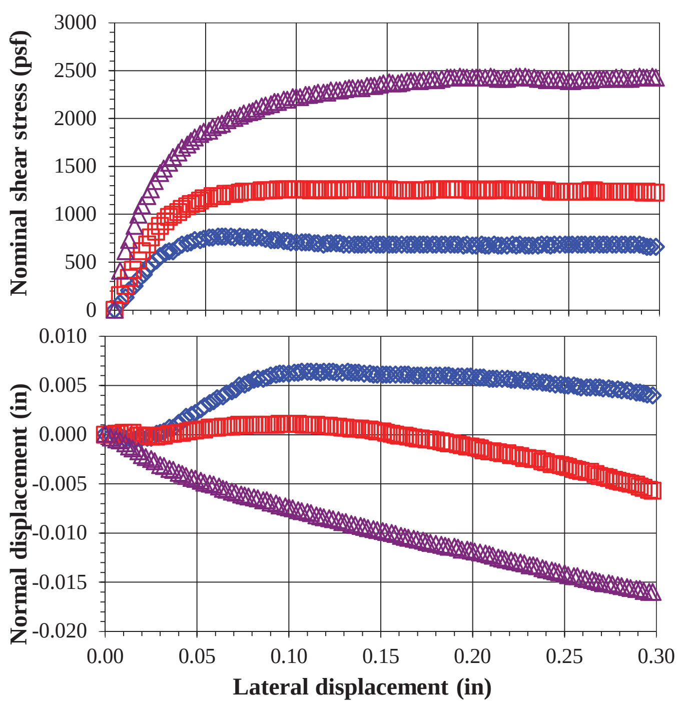
Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0172
Specific gravity, Gs: 2.65 Assumed

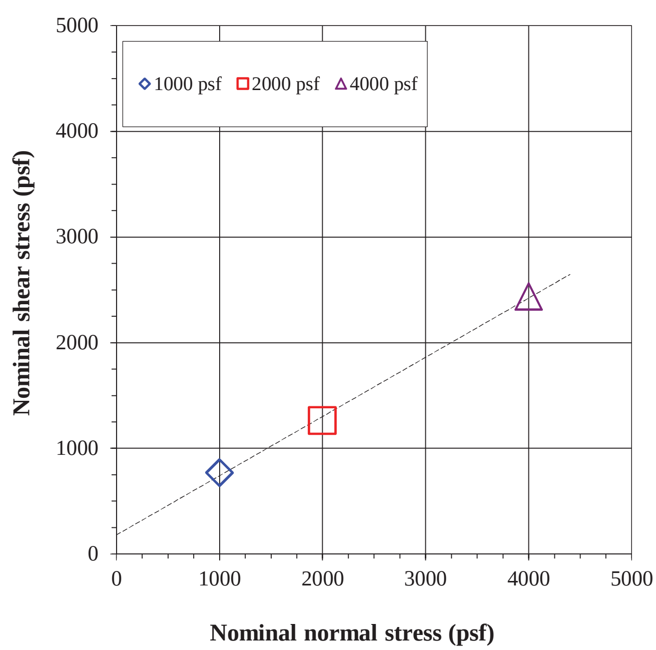
	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	1000		2000		4000	
Peak shear stress (psf)	768		1260		2436	
Lateral displacement at peak (in)	0.057		0.090		0.190	
Load Duration (min)	183		213		82	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	1.0000	0.9230	1.0000	0.9867	1.0000	0.9835
Sample diameter (in)	2.416	2.416	2.416	2.416	2.416	2.416
Wt. rings + wet soil (g)	197.71	198.40	197.19	202.66	199.25	204.48
Wt. rings (g)	43.12	43.12	42.60	42.60	44.66	44.66
Wet soil + tare (g)	365.67		365.67		365.67	
Dry soil + tare (g)	339.75		339.75		339.75	
Tare (g)	123.74		123.74		123.74	
Water content (%)	12.0	12.5	12.0	16.0	12.0	15.8
Dry unit weight (pcf)	114.7	124.2	114.7	116.2	114.7	116.6
Void ratio, e, for assumed Gs	0.44	0.33	0.44	0.42	0.44	0.42
Saturation (%)*	71.9	100.0	71.9	100.0	71.9	100.0

ϕ' (deg)	29
c' (psf)	180

Average of 3 samples	Initial	Pre-shear
Water content (%)	12.0	14.8
Dry unit weight (pcf)	114.7	119.0

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





Entered by:___________
Reviewed:___________

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: Summit - The Overlook
No: 01628-021
Location: Powder Mountain, UT
Boring No.: TP-2
Sample:
Depth: 3.5'

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
0.003	72	0.000	0.003	156	0.000	0.003	408	0.000
0.006	132	0.000	0.006	252	0.000	0.006	612	-0.001
0.008	204	0.000	0.008	336	0.000	0.008	732	-0.001
0.011	252	0.000	0.010	420	0.000	0.011	876	-0.001
0.013	324	0.000	0.013	516	0.000	0.013	996	-0.001
0.016	372	-0.001	0.015	612	0.000	0.015	1092	-0.001
0.018	432	0.000	0.018	684	0.000	0.018	1188	-0.002
0.020	480	0.000	0.020	756	0.000	0.020	1260	-0.002
0.023	516	0.000	0.023	816	0.000	0.022	1344	-0.002
0.025	564	0.000	0.025	876	0.000	0.025	1428	-0.003
0.028	600	0.000	0.028	924	0.000	0.027	1476	-0.003
0.030	612	0.000	0.030	972	0.000	0.030	1536	-0.003
0.032	612	0.000	0.032	996	0.000	0.032	1596	-0.003
0.035	660	0.001	0.035	1020	0.000	0.035	1644	-0.004
0.037	684	0.001	0.037	1056	0.000	0.037	1692	-0.004
0.040	696	0.001	0.040	1080	0.000	0.040	1728	-0.004
0.042	708	0.001	0.042	1104	0.000	0.042	1764	-0.004
0.044	732	0.002	0.045	1116	0.000	0.044	1800	-0.004
0.047	732	0.002	0.047	1140	0.000	0.047	1836	-0.004
0.049	744	0.002	0.049	1164	0.000	0.049	1860	-0.005
0.052	756	0.003	0.052	1164	0.001	0.052	1872	-0.005
0.054	756	0.003	0.054	1188	0.001	0.054	1908	-0.005
0.057	768	0.003	0.057	1188	0.001	0.057	1932	-0.005
0.059	768	0.003	0.059	1188	0.001	0.059	1944	-0.005
0.061	768	0.004	0.061	1212	0.001	0.062	1980	-0.005
0.064	768	0.004	0.064	1212	0.001	0.064	2004	-0.006
0.066	756	0.004	0.066	1212	0.001	0.066	2004	-0.006
0.069	768	0.004	0.069	1224	0.001	0.069	2028	-0.006
0.071	756	0.005	0.071	1236	0.001	0.071	2052	-0.006
0.073	756	0.005	0.073	1236	0.001	0.074	2064	-0.006
0.076	756	0.005	0.076	1236	0.001	0.076	2076	-0.006
0.078	756	0.005	0.078	1236	0.001	0.078	2100	-0.006
0.081	756	0.006	0.081	1248	0.001	0.081	2124	-0.006
0.083	744	0.006	0.083	1248	0.001	0.083	2136	-0.007
0.086	732	0.006	0.085	1248	0.001	0.086	2148	-0.007
0.088	732	0.006	0.088	1248	0.001	0.088	2172	-0.007
0.090	732	0.006	0.090	1260	0.001	0.090	2172	-0.007
0.093	720	0.006	0.093	1260	0.001	0.093	2196	-0.007
0.095	720	0.006	0.095	1260	0.001	0.095	2196	-0.007
0.097	708	0.006	0.098	1260	0.001	0.098	2220	-0.007
0.100	708	0.006	0.100	1260	0.001	0.100	2220	-0.007
0.103	708	0.006	0.102	1260	0.001	0.102	2220	-0.008
0.105	708	0.006	0.105	1260	0.001	0.105	2244	-0.008
0.107	708	0.006	0.108	1248	0.001	0.107	2244	-0.008
0.110	696	0.006	0.110	1260	0.001	0.110	2256	-0.008
0.112	696	0.006	0.112	1260	0.001	0.112	2268	-0.008
0.115	684	0.006	0.115	1248	0.001	0.115	2268	-0.008
0.117	696	0.006	0.117	1260	0.001	0.117	2268	-0.008
0.119	696	0.006	0.120	1260	0.001	0.119	2292	-0.008
0.122	696	0.006	0.122	1260	0.001	0.122	2292	-0.009
0.124	696	0.006	0.124	1248	0.001	0.124	2292	-0.009
0.126	684	0.006	0.127	1260	0.001	0.127	2304	-0.009
0.129	684	0.006	0.129	1260	0.001	0.129	2316	-0.009
0.132	684	0.006	0.131	1260	0.001	0.131	2316	-0.009
0.134	684	0.006	0.134	1260	0.001	0.134	2316	-0.009
0.136	684	0.006	0.136	1260	0.001	0.136	2316	-0.009
0.138	684	0.006	0.139	1260	0.001	0.139	2340	-0.009
0.141	684	0.006	0.141	1260	0.001	0.141	2340	-0.009
0.144	684	0.006	0.144	1260	0.001	0.143	2340	-0.010
0.146	684	0.006	0.146	1260	0.000	0.146	2352	-0.010
0.148	684	0.006	0.148	1260	0.000	0.148	2364	-0.010
0.151	684	0.006	0.151	1260	0.000	0.151	2376	-0.010
0.153	684	0.006	0.153	1248	0.000	0.153	2364	-0.010
0.155	684	0.006	0.156	1248	0.000	0.156	2364	-0.010

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

IGES

Project: Summit - The Overlook
No: 01628-021
Location: Powder Mountain, UT

Boring No.: TP-2
Sample:
Depth: 3.5'

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.)
0.158	684	0.006	0.158	1248	0.000	0.158	2376	-0.010
0.161	684	0.006	0.160	1248	0.000	0.161	2388	-0.010
0.163	684	0.006	0.163	1248	0.000	0.163	2388	-0.010
0.165	684	0.006	0.165	1248	0.000	0.165	2388	-0.011
0.168	684	0.006	0.168	1248	0.000	0.168	2388	-0.011
0.170	684	0.006	0.170	1248	0.000	0.170	2400	-0.011
0.172	684	0.006	0.172	1248	0.000	0.173	2400	-0.011
0.175	684	0.006	0.175	1260	-0.001	0.175	2412	-0.011
0.177	684	0.006	0.177	1260	-0.001	0.177	2400	-0.011
0.180	684	0.006	0.180	1260	-0.001	0.180	2412	-0.011
0.182	684	0.006	0.183	1260	-0.001	0.183	2424	-0.011
0.185	684	0.006	0.185	1260	-0.001	0.185	2424	-0.011
0.187	684	0.006	0.187	1260	-0.001	0.187	2424	-0.011
0.189	684	0.006	0.189	1260	-0.001	0.190	2436	-0.011
0.192	672	0.006	0.192	1260	-0.001	0.192	2424	-0.012
0.194	684	0.006	0.194	1260	-0.001	0.194	2424	-0.012
0.197	672	0.006	0.197	1248	-0.001	0.197	2424	-0.012
0.199	672	0.006	0.199	1248	-0.001	0.199	2424	-0.012
0.202	684	0.006	0.202	1260	-0.001	0.201	2424	-0.012
0.204	672	0.006	0.204	1248	-0.001	0.204	2424	-0.012
0.206	672	0.006	0.206	1248	-0.002	0.207	2436	-0.012
0.209	684	0.006	0.209	1248	-0.002	0.209	2424	-0.012
0.211	672	0.006	0.211	1260	-0.002	0.211	2412	-0.012
0.213	672	0.006	0.214	1260	-0.002	0.214	2412	-0.013
0.216	672	0.006	0.216	1260	-0.002	0.216	2412	-0.013
0.219	684	0.006	0.219	1248	-0.002	0.218	2424	-0.013
0.221	672	0.006	0.221	1248	-0.002	0.221	2436	-0.013
0.223	684	0.006	0.223	1248	-0.002	0.223	2436	-0.013
0.226	672	0.006	0.226	1260	-0.002	0.226	2436	-0.013
0.228	672	0.006	0.228	1248	-0.002	0.228	2424	-0.013
0.230	672	0.006	0.230	1248	-0.002	0.231	2424	-0.013
0.233	672	0.005	0.233	1248	-0.003	0.233	2412	-0.013
0.235	684	0.005	0.235	1248	-0.003	0.235	2412	-0.013
0.238	684	0.005	0.238	1248	-0.003	0.238	2400	-0.014
0.240	672	0.005	0.240	1236	-0.003	0.240	2412	-0.014
0.242	684	0.005	0.243	1236	-0.003	0.243	2412	-0.014
0.245	684	0.005	0.245	1236	-0.003	0.245	2400	-0.014
0.248	684	0.005	0.248	1236	-0.003	0.247	2400	-0.014
0.250	684	0.005	0.250	1236	-0.003	0.250	2388	-0.014
0.252	684	0.005	0.252	1236	-0.003	0.252	2388	-0.014
0.255	684	0.005	0.255	1236	-0.004	0.255	2400	-0.014
0.257	684	0.005	0.257	1236	-0.004	0.257	2412	-0.014
0.259	684	0.005	0.259	1236	-0.004	0.260	2400	-0.015
0.262	684	0.005	0.262	1248	-0.004	0.262	2400	-0.015
0.264	684	0.005	0.264	1248	-0.004	0.265	2412	-0.015
0.267	684	0.005	0.267	1236	-0.004	0.267	2412	-0.015
0.269	684	0.005	0.269	1236	-0.004	0.269	2412	-0.015
0.271	684	0.005	0.272	1236	-0.004	0.271	2412	-0.015
0.274	684	0.005	0.274	1236	-0.004	0.274	2412	-0.015
0.276	684	0.005	0.277	1236	-0.005	0.276	2424	-0.015
0.279	684	0.005	0.279	1236	-0.005	0.279	2424	-0.015
0.281	684	0.005	0.281	1236	-0.005	0.281	2412	-0.015
0.284	684	0.005	0.284	1236	-0.005	0.284	2412	-0.016
0.286	684	0.004	0.286	1236	-0.005	0.286	2424	-0.016
0.289	684	0.004	0.289	1236	-0.005	0.289	2436	-0.016
0.291	672	0.004	0.291	1224	-0.005	0.291	2424	-0.016
0.293	660	0.004	0.293	1236	-0.005	0.293	2424	-0.016
0.295	660	0.004	0.296	1224	-0.006	0.296	2436	-0.016
0.298	660	0.004	0.298	1224	-0.006	0.298	2424	-0.016
0.301	660	0.004	0.301	1224	-0.006	0.301	2244	-0.017
0.301	660	0.004	0.301	1224	-0.006	0.302	2316	-0.017

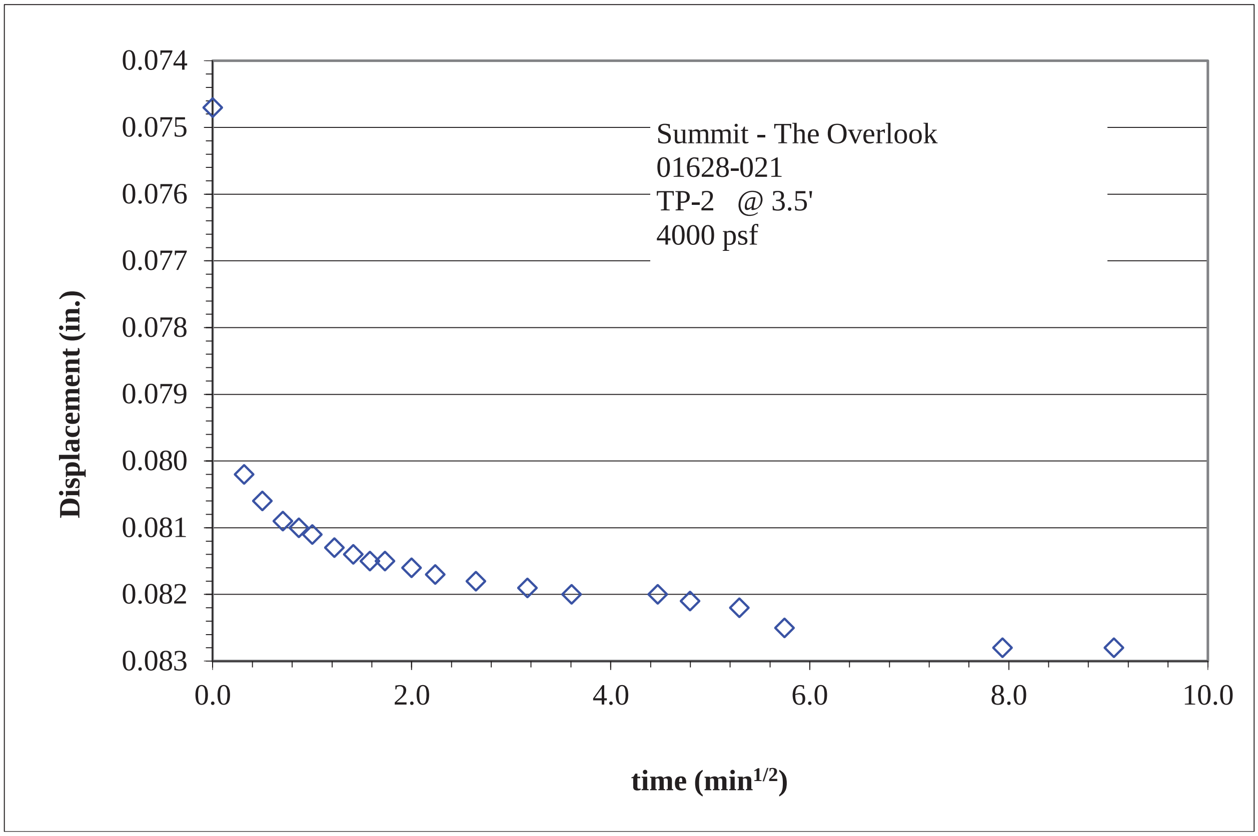
Direct Shear Test for Soils Under Drained Conditions

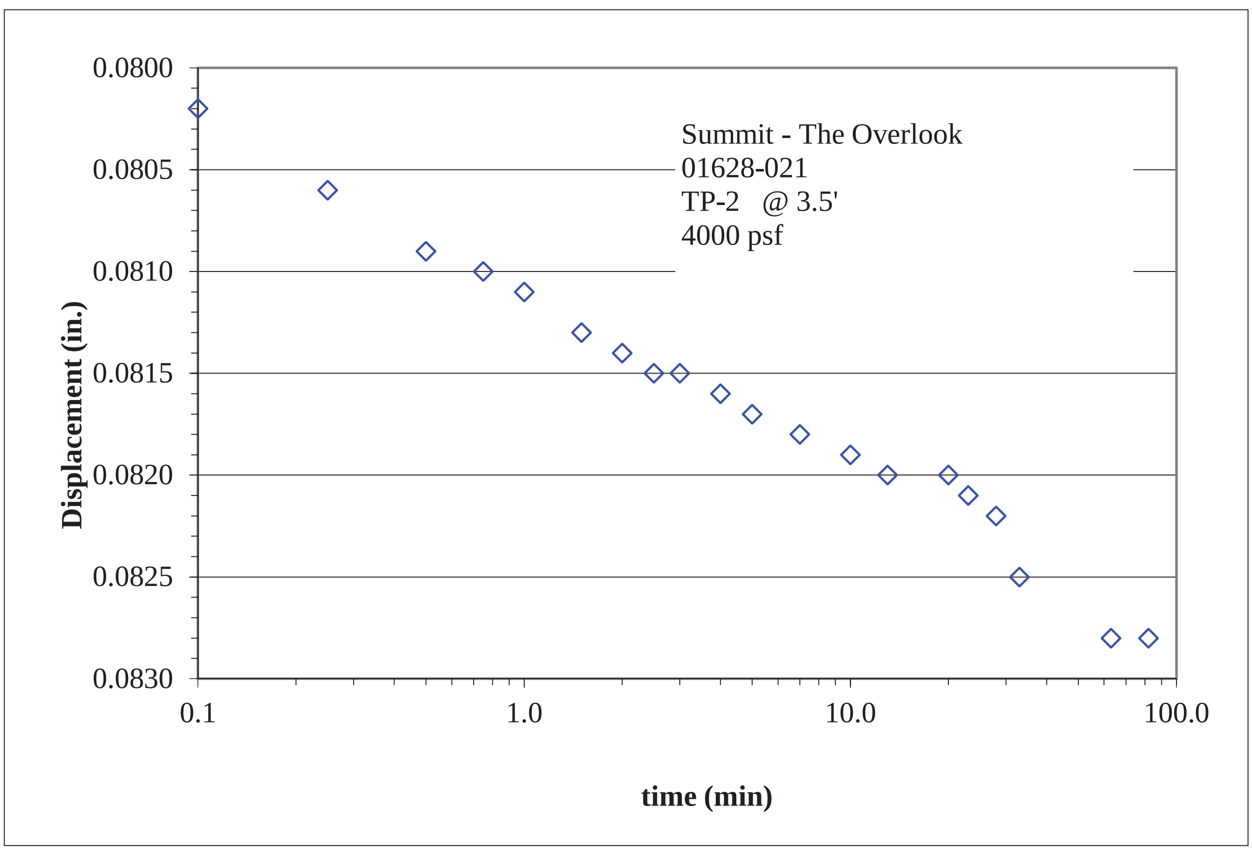
(ASTM D3080)

IGES

Project: Summit - The Overlook
No: 01628-021
Location: Powder Mountain, UT

Boring No.: TP-2
Sample:
Depth: 3.5'





Minimum Laboratory Soil Resistivity, pH of Soil for Use in Corrosion Testing, and Ions in Water by Chemically Suppressed Ion Chromatography *(AASHTO T 288, T 289, ASTM D4327, and C1580)*

IGES

Project: Summit - The Overlook
No: 01628-021
Location: Powder Mountain, UT
Date: 12/22/2016
By: DKS

Section	Field	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)
Sample info.	Boring No.	TP-1							
	Sample								
	Depth	5.0'							
Water content data	Wet soil + tare (g)	117.03							
	Dry soil + tare (g)	109.48							
	Tare (g)	37.28							
	Water content (%)	10.5							
Chem. data	pH	6.13							
	Soluble chloride* (ppm)	<5.21							
	Soluble sulfate** (ppm)	49.3							
Resistivity data	Pin method	2							
	Soil box	Miller Small							
		As Is	66960	0.67	44863				
		+3	37110	0.67	24864				
		+6	27160	0.67	18197				
		+9	27370	0.67	18338				
	Minimum resistivity (Ω-cm)	**18197**							

* Performed by AWAL using EPA 300.0

** Performed by AWAL using ASTM C1580

Entered by:___________
Reviewed:___________

APPENDIX C

USGS Design Maps Detailed Report

2012/2015 International Building Code (41.3645°N, 111.7436°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) [1] $S_S = 0.810$ g

From Figure 1613.3.1(2) [2] $S_1 = 0.268$ 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: • Plasticity index *PI* > 20, • Moisture content *w* ≥ 40%, and • Undrained shear strength $\bar{s}_u$ < 500 psf		
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/ft² = 0.0479 kN/m²

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				
	$S_S \le 0.25$	$S_S = 0.50$	$S_S = 0.75$	$S_S = 1.00$	$S_S \ge 1.25$
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 = 0.810 g, F_a = 1.076

TABLE 1613.3.3(2)
VALUES OF SITE COEFFICIENT F_v

Site Class	Mapped Spectral Response Acceleration at 1–s Period				
	$S_1 \le 0.10$	$S_1 = 0.20$	$S_1 = 0.30$	$S_1 = 0.40$	$S_1 \ge 0.50$
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 = 0.268 g, F_v = 1.532

Equation (16-37): $S_{MS} = F_a S_S = 1.076 \times 0.810 = 0.871$ g

Equation (16-38): $S_{M1} = F_v S_1 = 1.532 \times 0.268 = 0.411$ g

Section 1613.3.4 — Design spectral response acceleration parameters

Equation (16-39): $S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} \times 0.871 = 0.581$ g

Equation (16-40): $S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3} \times 0.411 = 0.274$ 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
$0.167g \le S_{DS} < 0.33g$	B	B	C
$0.33g \le S_{DS} < 0.50g$	C	C	D
$0.50g \le S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 0.581 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
$0.067g \le S_{D1} < 0.133g$	B	B	C
$0.133g \le S_{D1} < 0.20g$	C	C	D
$0.20g \le S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.274 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 ≡ "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)*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(1).pdf
2. *Figure 1613.3.1(2)*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(2).pdf

USGS Design Maps Summary Report

User–Specified Input

Report Title The Overlook
Fri January 27, 2017 18:56:30 UTC

Building Code Reference Document 2012/2015 International Building Code
(which utilizes USGS hazard data available in 2008)

Site Coordinates 41.3645°N, 111.7436°W

Site Soil Classification Site Class C – "Very Dense Soil and Soft Rock"

Risk Category I/II/III

USGS–Provided Output

S_S =	0.810 g	S_{MS} =	0.871 g	S_{DS} =	0.581 g
S_1 =	0.268 g	S_{M1} =	0.411 g	S_{D1} =	0.274 g

For information on how the SS and S1 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.