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GEOTECHNICAL AND GEOLOGIC HAZARD INVESTIGATION
Lot 86R of Summit Eden Phase 1C
8549 E. Spring Park
Summit Powder Mountain Resort
Weber County, Utah

IGES Project No. 03091-001

July 1, 2019

Prepared for:

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1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical and geologic hazards investigation conducted for Lot 86R of Summit Eden Phase 1C, 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, site reconnaissance, subsurface exploration, engineering analyses, and preparation of this report.

Our services were performed in accordance with our proposal dated May 6, 2019, and your signed authorization. The recommendations presented in this report are subject to the limitations presented in the "Limitations" section of this report (Section 6.1).

1.2 PROJECT DESCRIPTION

Our understanding of the project is based primarily on our previous involvement with the Summit Powder Mountain Resort project, which included two geotechnical investigations for the greater 200-acre Powder Mountain Resort expansion project (IGES, 2012a and 2012b), as well as a number of lot-specific and site-specific geotechnical and geologic hazard investigations in various locations across the greater Powder Mountain Resort expansion area. The project site is located within the Summit Powder Mountain Resort, illustrated on the *Site Vicinity Map*, Figure A-1 in Appendix A.

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. Lot 86R is located within Phase 1C of the Powder Mountain expansion project (Summit Eden), on the south side of Spring Park – the street address is 8549 E. Spring Park. The 0.113-acre residential lot has an approximate buildable area (building envelope) of 3,285 square feet. The proposed improvements will include a single-family home, presumably a high-end vacation home, with associated improvements such as utilities and hardscape. Construction plans were not available for our review; however, based on the architectural drawings provided by Scandinavian, the new home will be a three-level structure, the lowest level consisting of a partial walk-out basement, founded on conventional spread footings.

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 project-wide work included twenty-two test pits and one soil boring excavated at various locations across the 200-acre development. IGES has performed geotechnical and geologic hazard investigations for nearby projects, including for Lot 84R (IGES, 2017a) and the D7R (Building 4 Lodge) parcel (IGES, 2017b), which straddles the Lot 86R property. As a part of this current study, the logs from relevant nearby test pits and other data from our previous 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 Lot 86R area. The Western Geologic (2012) study modified some of the potential landslide hazard boundaries that had previously been mapped at a regional scale (1:100,000) by Coogan and King (2001) and Elliott and Harty (2010). The corresponding United States Geological Survey (USGS) topographic maps for the Huntsville and Brown's Hole Quadrangles (2017) provide physiographic and hydrologic data for the project area. Regional-scale geologic hazard maps pertaining to landslides (Elliott and Harty, 2010; Colton, 1991), faults (Christenson and Shaw, 2008a; USGS and Utah Geological Survey (UGS), 2006), debris-flows (Christenson and Shaw, 2008b), and liquefaction (Christenson and Shaw, 2008c; Anderson et al., 1994) that cover the project area were also reviewed. The Quaternary Fault and Fold Database (USGS and UGS, 2006), was reviewed to identify the location of proximal faults that have had associated Quaternary-aged displacement.

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

2.2 FIELD INVESTIGATION

Subsurface soils were investigated by excavating a single test pit within the property boundary. The approximate location of the test pit is illustrated on the *Geotechnical & Geology Map* (Figure A-2 in Appendix A). The soil types were visually logged at the time of our field work in general accordance with the *Unified Soil Classification System* (USCS). Soil classifications and descriptions are included on the test pit log, presented as Figure A-3 in Appendix A. A key to USCS symbols and terminology is included as Figure A-4, and a key to physical rock properties is included as Figure A-5.

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)
- Direct Shear (ASTM D3080)
- Corrosion Suite (resistivity, pH, soluble sulfate, soluble chloride)

Results of the laboratory testing are discussed in this report and presented in Appendix B.

3.0 GEOLOGIC CONDITIONS

3.1 GENERAL GEOLOGIC SETTING

The Lot 86R 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 almost 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 Lot 86R property is located approximately 10.25 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 FROM LITERATURE

According to Sorensen and Crittenden, Jr. (1979), the property is entirely underlain by the undivided Tertiary/Cretaceous Wasatch and Evanston Formations (map unit TKwe), described as "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." 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-6). Coogan and King (2001) produced a regional-scale geologic map that covered the property; this map shows the property to be near the contact between undifferentiated mass-movement deposits to the west and the Wasatch Formation to the east. Western Geologic (2012) identified a number of landslide deposits contained within the Powder Mountain Resort expansion area (*Regional Geology Map 2*, Figure A-7). In this map, the property is not located within mapped landslide deposits, though deposits mapped as "mixed slope colluvium, shallow landslides, and talus," and a large Holocene to Late Pleistocene landslide deposit have been mapped within 500 feet of west of the property. Finally, Coogan and King (2016) updated their 2001 map, which shows the property to be entirely located within the northeastern end of a large lobe of landslide deposits (map unit Qms), but near the contact with the Wasatch Formation (map unit Tw; see *Regional Geology Map 3*, Figure A-8). A nearby bedding attitude shows the Wasatch Formation to be striking nearly due north and dipping at 5 degrees to the east.

Previous geotechnical and geologic hazard investigations have been performed by IGES for the nearby Lot 84R (IGES, 2017a) and D7R Parcel (IGES, 2017b), which effectively straddle the Lot 86R property. The test pit excavated for Lot 84R found a 2-foot thick loose cobbly alluvium unit underlying a 4-foot thick topsoil, with poorly consolidated Wasatch Formation consisting of clayey gravel with sand underlying the alluvium and extending to the maximum depth of exploration (11 feet below existing grade). A test pit (TP-2) excavated for the D7R parcel was located just outside of the southeastern margin of the Lot 86R property. In this test pit, 1.5 to 2 feet of topsoil was observed to overlie a 3 to 4-foot thick sandy lean clay with gravel colluvium unit, which in turn was found to overlie at least 5 feet of poorly consolidated Wasatch Formation consisting of clayey sand with gravel, which extended to the maximum depth of exploration (11 feet below existing grade).

3.3 HYDROLOGY

The USGS topographic maps for the Huntsville and Brown's Hole Quadrangles (2017) show that the Lot 86R project area is situated on a gentle slope, with the local topographic gradient down to the southwest towards a larger west-trending ephemeral drainage locally known as Lefty's Canyon (see Figure A-1). No active or ephemeral stream drainages are found on or adjacent to the property, and 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. A known spring is present approximately 750 feet southwest of the property (see Figure A-1), and groundwater seepage is known to occur at the base of the slope at the Lot 75R road cut in the spring (IGES, 2017c).

Baseline groundwater depths for the Lot 86R property are currently unknown, but are anticipated to fluctuate both seasonally and annually. Groundwater was not encountered in the test pit excavated in this investigation.

3.4 GEOLOGIC HAZARDS FROM LITERATURE

Based upon the available geologic literature, regional-scale geologic hazard maps that cover the Lot 86R project area have been produced for landslide, fault, debris-flow, and liquefaction hazards. The following is a summary of the data presented in these regional geologic hazard maps.

3.4.1 Landslides

Two regional-scale landslide hazard maps have been produced that cover the project area. Colton (1991) does not show the property to be underlain by or adjacent to landslide deposits, though south-trending landslide deposits are mapped further west of the property. Elliott and Harty (2010) similarly does not show the property to be located within mapped landslide deposits, though deposits mapped as "Landslide undifferentiated from talus and/or colluvial deposits" are mapped southwest of the property. On a site-specific basis, Western Geologic (2012) used the Elliott and Harty (2010) map as a base map, showing undivided mass-movement deposits within approximately 250 feet west of the property (see Figure A-7). As noted above, most recently Coogan and King (2016) on a regional scale show the property to be situated within a lobe of landslide deposits (see Figure A-8).

3.4.2 Faults

Neither Christenson 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 10.25 miles southwest of the western margin of the property (USGS and UGS, 2006).

3.4.3 Debris Flows

Christenson 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 Christenson 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 (UGS, 2019) and analyzed stereoscopically for the presence of adverse geologic conditions across the property. This included a review of photos collected from the years 1946, 1952, and 1963. A table displaying the details of the aerial photographs reviewed can be found in the *References* section at the end of this report.

No geologic lineaments, fault scarps, landslide headscarps, or landslide deposits were observed on the subject property in the aerial photography.

Google Earth imagery of the property from between the years of 1993 and 2018 was also reviewed. No landslide or other geological hazard features were noted in the imagery. Preceding more recent disturbance, the property was observed to be densely covered in aspen trees, and no drainages were observed to be passing through the property. No notable changes to the property, either human or natural, were observed in the aerial imagery until Spring Park Road was cut in between September of 2011 and October of 2014. During this time, approximately two-thirds of the northern portion of the property was disturbed as part of the excavation and covered in fill.

UGS 2015-2017 0.5-meter LiDAR data that covers the project area was reviewed. This imagery showed the human disturbance across the property in the form of Spring Park Road and a northwest trending two-track road that passed along the base of the fill slope through the northern part of the property. No landslide deposits or other adverse geologic conditions were observed on the property.

3.6 SEISMICITY

Following the criteria outlined in the 2018 International Building Code (IBC, 2018), 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 *ASCE-7 Hazard Tool*; 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. These maps have been incorporated into the *International Building Code* (IBC) (International Code Council, 2018).

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 (30 meters, V_{S30}); site classifications are identified in Table 3.6a.

Table 3.6a
Site Class Categories

Site Class	Earth Materials	Shear Wave Velocity Range (Vs_{30}) m/s
A	Hard Rock	>1,500
B	Rock	760-1,500
C	Very Dense Soil/Soft Rock	360-760
D	Stiff Soil	180-360
E	Soft Soil	<180
F	Special Soils Requiring Site-Specific Evaluation (e.g. liquefiable)	n/a

Based on our field exploration and our understanding of the geology in this area, the site is underlain by Tertiary-age conglomeratic bedrock of the Wasatch Formation, and would reasonably be expected to classify as Site Class C or possibly B. IGES has reviewed shear wave velocity measurements performed for the greater Summit Powder Mountain project (PSI, 2012); this data was obtained in similar geologic conditions just west of the project site. The shear wave velocity data indicates that the B/C boundary is located between 25 and 50 feet below existing grade across much of the Powder Mountain area, with a maximum recorded shear wave velocity of 3,000 fps below this interface. Based on this information and considering that the proposed home could conceivably be underlain by as much as 10 feet of surficial soils overlying bedrock, the site is appropriately categorized as Site Class C (measured). Based on the assumed Site Class C site coefficients, the short- and long-period *Design Spectral Response Accelerations* are presented in Table 3.6b. For geotechnical practice, the geo-mean peak ground acceleration (PGA_M) is presented in Table 3.6c. A summary of the ASCE-7-16 data output is presented in Appendix C.

Table 3.6b
Spectral Accelerations for MCE, Risk-Targeted Values (Structural)

Mapped B/C Boundary S_a (g)		Site Coefficient (Site Class C)		Design Sa (g)		
Ss	S_1	F_a	F_v	PGA	S_{DS}	S_{D1}
0.802	0.277	1.2	1.5		0.642	0.277

1) T_L=8
2) Cv=1.051
3) Seismic Design Category D for Risk Categories I, II, and III

Table 3.6c
Spectral Accelerations for MCE, Geo-Mean Values (Geotechnical)

Mapped B/C Boundary PGA (g)	Site Coefficient F_{PGA} (Site Class C)	PGA_M (g)
0.349	1.2	0.419

3.7 GEOLOGIC HAZARDS ASSESSMENT

Geologic hazards 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 Lot 86R property.

3.7.1 Landslides/Mass-Movement

According to the most recent geologic maps produced that cover the property, the lot is either entirely situated on mapped landslide deposits (Coogan and King, 2016) or near them (Western Geologic, 2012; Elliott and Harty, 2010). However, landslide deposits or geomorphic features indicative of landsliding were not observed on the property in the aerial imagery, during the site reconnaissance, or in the subsurface. Given the geologic data alone, the risk associated with landslides and mass-movement is considered to be low to moderate, due to the proximity to mapped landslide deposits.

Slope stability modeling as part of our assessment indicates that the critical slope for the project, which is the 1.8H:1V road embankment fill associated with Spring Park, is stable under current conditions for both static and seismic cases. The slope stability modeling confirms the landslide hazard risk classification for the property as being low to moderate.

3.7.2 Rockfall

Though 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 10.25 miles to the southwest 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 the Wasatch Formation, a poorly consolidated sedimentary rock unit (conglomerate). Rock units such as these are not considered susceptible to liquefaction; as such, the potential for liquefaction occurring at the site is considered low.

3.7.5 Debris-Flows and Flooding Hazards

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

3.7.6 Shallow Groundwater

Groundwater was not encountered in the test pit excavated as part of this investigation. The test pit was excavated in early June, and the groundwater level was likely to be at or near its annual high. No springs were observed on the property, and no plants indicative of shallow groundwater conditions were observed on the property. However, a spring has been identified downslope approximately 750 feet southwest of the property (see Figure A-1), and shallow groundwater seepage has been observed in excavations on nearby properties (IGES, 2017c).

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 (localized perched 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 site and the immediate adjacent properties on June 7, 2019. The site reconnaissance was conducted with the intent to assess the general geologic conditions present across the property, with specific interest in those areas identified in the geologic literature and aerial imagery reviews as potential geologic hazard areas. Additionally, the site reconnaissance provided the opportunity to geologically map the surficial geology of the area. Figure A-2 is a site-specific geologic map of the Lot 86R property and adjacent areas.

At the time of the site reconnaissance, the property was observed to be gently sloping downhill to the southwest. A small cluster of aspen trees were observed in the south-central portion of the lot, while the northern half consisted of a steep fill slope extending north to Spring Park Road. A two-track road was present at the base of the fill slope. Small patches of snow were also still present in the middle of the aspen cluster.

Variously-sized boulders and cobbles were found scattered across the surface of the property. These were typically subrounded, and were found to be as large as 2 feet in diameter. The rock clasts[1] were found to be comprised entirely of massive, coarsely crystalline quartzite, which was medium gray to purple in color when unweathered, but commonly weathered to pale yellowish orange or dark yellowish orange. The clasts were interpreted to be part of a surficial colluvial geologic unit derived from weathered Wasatch Formation.

No springs, seeps, or running water were observed on the property at the time of the site visit. Aside from the fill slope and two-track road on the northern part of the property, the ground appeared to be largely in its native state. No adverse geologic conditions were observed on the property at this time.

4.2 SUBSURFACE CONDITIONS

On June 7, 2019, one exploration test pit was excavated in the southwestern portion of the lot (see Figure A-2). The test pit was excavated to a depth of 13 feet below existing grade with the aid of a Doosan DX 340 LC-HD tracked excavator. Upon completion of logging, the test pit was backfilled without engineered compaction controls. A detailed log for the test pit is displayed in Figure A-3. Two distinct geologic units were encountered in the subsurface. The soil and moisture conditions encountered during our investigation are discussed in the following paragraphs.

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[1] 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)

4.2.1 Earth Materials

<u>A/B Soil Horizon</u>: This topsoil unit was found to be between approximately 1½ and 2 feet thick. The unit was a grayish brown, medium stiff, moist, lean CLAY with gravel (CL), with gravel and larger-sized quartzite clasts comprising between approximately 10 and 15% of the unit. The topsoil contained abundant plant and tree roots and was found to be forming upon the underlying Wasatch Formation unit.

<u>Wasatch Formation</u>: This unit was at least 11 feet thick and extended to the maximum depth of exploration within the test pit. The unit consisted of weakly consolidated conglomerate bedrock that had been largely disaggregated into two subunits. The upper subunit was up to 7 feet thick, and consisted of a dark yellowish brown to moderate reddish orange, medium stiff to stiff, moist, massive, sandy lean CLAY with gravel (CL). For this subunit, subrounded to subangular quartzite clasts comprised between approximately 30 and 40% of the unit, with clasts up to 14 inches in diameter but most commonly between 3 and 4 inches in diameter. Pinhole voids up to 1 mm in diameter were commonly observed within this subunit.

The lower subunit was at least 5 feet thick, and consisted of a moderate reddish orange, medium-dense to dense, moist, weakly thinly bedded mixture of clay, sand, and gravel that collectively classifies as clayey GRAVEL with sand (GC). Gravel and larger-sized subrounded to subangular quartzite clasts comprised between approximately 50 and 60% of the unit, with individual clasts up to 14 inches in diameter, with a mode clast size of 3 to 4 inches. The sand component of this unit was fine- to medium-grained, and the unit contained common pinhole voids where clayey.

4.2.2 Groundwater

Groundwater was not encountered in the test pit excavated for this project to a depth of 13 feet below existing grade.

4.3 SLOPE STABILITY

4.3.1 Global Stability

The natural grade of the lot consists of a relatively modest slope on the order of 7H:1V; the critical slope on the lot is the fill slope that is a part of the roadway embankment (see Section D-1 in Appendix D). This fill slope is approximately 26 feet tall and is at an approximate 1.8H:1V gradient. The specific impact of this slope to the proposed improvements is unknown, since construction plans are not yet available; however, we would expect the new home will have a walk-out basement hence at least one and possibly two subterranean levels would reasonably be expected to be built into this fill slope.

The stability of the existing fill slope has been assessed in accordance with methodologies set forth in Blake et al. (2002) and AASHTO LRFD for Bridge Design Specifications with respect to a representative cross-section, illustrated on Figure D-1 in Appendix D (the section is identified in plan-view on Figure A-2). The stability of the slope was modeled using SLIDE, a computer application incorporating (among others) Spencer's Method of analysis. Calculations for stability were developed by searching for the minimum factor of safety for a rotational-type failure occurring through the road embankment. Analysis was performed for both static and seismic (pseudo-static) cases.

Groundwater, e.g. a piezometric groundwater surface, was not encountered during our subsurface investigation; accordingly, groundwater was not modeled in our limit-equilibrium analysis.

Spring Park is located at the top of the slope; accordingly, a traffic surcharge of 250 psf has been modeled for static conditions. The new home is expected to have a subterranean component, constructed *into* the slope, not on the slope; therefore, hence a surcharge load from the home was not included in the analysis.

Soil strength parameters were selected based on soil types observed, local experience, correlation with index properties (Atterberg Limits, clay content), and comparisons with soil strength laboratory data from a nearby sites. Based on this assessment, the following soil strength parameters were selected for this analysis:

Table 4.3.1a
Soil Strength Parameters

Earth Materials	Friction angle (degrees)	Cohesion (psf)	Unit Weight (pcf)
Colluvium (Qc)	36	1	125
Bedrock (Tw)	38	150	135
Embankment Fill (Af)	30	100	125

Pseudo-static (seismic screening) analysis of the proposed slope was performed in general conformance with Blake et al. (2002), ASCE 7-16 and AASHTO LRFD for Bridge Design Specifications. The design seismic event was taken as the ground motion with a 2 percent probability of exceedance in 50 years (2PE50). Based on information provided on the ASCE-7-16 *Seismic Hazard Tool*, the Geo-mean Peak Ground Acceleration (PGA) associated with a 2PE50 event is estimated to be 0.419g. Half of the PGA, (0.21g), was taken as the horizontal seismic coefficient (k_h) (Hynes and Franklin, 1984), and used in the pseudo-static seismic screen analysis. The results of the analyses have been summarized in Table 4.3.1b.

Table 4.3.1b
Results of Slope Stability Analyses

Section	Static Factor of Safety	Pseudo-Static Factor of Safety
Existing Condition	1.51	1.02

The results of the analysis indicate the existing conditions meet the minimum required factors-of-safety of 1.5 and 1.0 for both the static and seismic (pseudo-static) case, respectively. A summary of the slope stability analysis is presented in Appendix D.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 GENERAL CONCLUSIONS

Based on the results of the field observations, literature review, and slope stability analyses, **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 Lot 86R project area:

- **The Lot 86R project area does not appear to have geological hazards that are capable of adversely impacting the development as currently proposed under the existing conditions.**

- Though recent geologic mapping shows the site to be located within young landslide deposits, no evidence of landsliding was observed on the surface or subsurface of the property. As such, the landslide hazard for the property is considered to be low to moderate, due to the proximity to mapped landslide deposits.

- Earthquake ground shaking may potentially affect all parts of the project area and is considered to pose a moderate risk.

- Shallow groundwater conditions were not observed in the test pit, though a spring has been identified south of the property, and groundwater seepage has been observed in test pits excavated on nearby properties; therefore, shallow groundwater hazards are considered to be low to moderate for the property.

- 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 engineering geologist or geotechnical engineer should observe the foundation excavation to assess the absence (or presence) of landslide-induced shearing.

- Effort should be made to limit the introduction of water into the subsurface near the proposed residence. Appropriate grading and drainage away from the home and xeriscape or natural landscaping will assist in reducing the risk of landsliding.

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

*not required where bedrock is exposed in the foundation subgrade

5.3.2 Excavations

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

Prior to placing structural 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. 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 18 inches in diameter, 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. 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, the proposed new home may be founded on conventional shallow foundations. The footings may be founded either *entirely* on competent native soils <u>or</u> *entirely* on structural fill. Native/fill transition zones are not allowed. Where soft, loose, or otherwise deleterious earth materials are exposed on the foundation subgrade, IGES recommends a minimum over-excavation of two feet and replacement with structural fill. Alternatively, the foundations may be extended such that the foundations bear directly on competent earth materials (Wasatch Formation, e.g. conglomerate bedrock). It should be noted that Wasatch Formation was encountered at a depth of approximately 2 feet below existing *natural* grade, but may be deeper, or shallower, at specific locations. However, part of the buildable area of the lot consists of a fill embankment associated with Spring Park Road, hence undocumented fill will be encountered in conjunction with the existing road embankment. We recommend that IGES assess the bottom of the foundation excavation prior to the placement of steel or concrete, or structural fill, to identify the competent native earth materials as well as any unsuitable soils or transition zones. Additional over-excavation may be required based on the actual subsurface conditions observed.

Shallow spread or continuous wall footings constructed entirely on structural fill, or entirely on competent, uniform native earth materials (Wasatch Formation clayey gravel with sand) may be proportioned utilizing a maximum net allowable bearing pressure of **3,400 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.

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 of conventional spread footings 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 0.47 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 nearly vertical soil cut and the foundation wall. These coefficients and densities assume no buildup of hydrostatic pressures. The force of water should be added to the presented values if hydrostatic pressures are anticipated.

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

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	41.7	0.53	66.5
At-rest (Ko)	0.50	55	0.80	85
Passive (Kp)	3.0	375	—	—
Seismic Active	0.12	15.1	0.38	47.4
Seismic Passive	-0.33	-40.8	—	—
Seismic At-rest	0.18	22.5	0.57	71.7

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

5.7 CONCRETE SLAB-ON-GRADE CONSTRUCTION

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

All concrete slabs should be designed to minimize cracking as a result of shrinkage. Consideration should be given to reinforcing the slab with a welded wire fabric, re-bar, or fibermesh. Slab reinforcement should be designed by the structural engineer; however, as a minimum, slab reinforcement should consist of 4''×4'' W2.9×W2.9 welded wire mesh within the middle third of the slab. We recommend that concrete be tested to assess that the slump and/or air content is in compliance with the plans and specifications. We recommend that concrete be placed in general accordance with the requirements of the American Concrete Institute (ACI). A Modulus of Subgrade Reaction of **280 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. The builder should be responsible for compacting the exterior backfill soils around the foundation; failure to properly compact the basement backfill can result in excessive settlement and damage to exterior improvements such as pavement or other flatwork. 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. Irrigation valves should be placed a minimum of 5 feet from foundation walls and must not be placed within the basement backfill zone. Over-watering near the foundation walls is discouraged; use of Xeriscape and/or a drip irrigation system should be considered. Pavement sections should be constructed to divert surface water off the pavement into storm drains, curb/gutter, or another suitable location.

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. The foundation perimeter drain be should constructed in accordance with the latest edition of the International Residential Code (IRC).

5.9 SOIL CORROSION POTENTIAL

Laboratory testing of a representative soil sample obtained during our subsurface exploration indicated that the soil sample tested had a sulfate content of 1,890 ppm. Accordingly, the soils are classified as having a ‘moderate potential’ for deterioration of concrete due to the presence of soluble sulfate. As such, conventional Type II Portland cement may be used for all concrete in contact with site soils.

To evaluate the corrosion potential of ferrous metal in contact with onsite native soil a sample was tested for soil resistivity, soluble chloride and pH. The test indicated that the onsite soil tested has a minimum soil resistivity of 6,700 OHM-cm, soluble chloride content of 62 ppm and a pH of 4.77. Based on this result, the onsite native soil is considered to be *moderately corrosive* to ferrous metal. To address the acidic soil conditions, we recommend a lower water/cement ratio, ~0.4, for reinforced concrete. The lower water/cement ratio will reduce permeability of the concrete and reduce the susceptibility of the reinforcing steel to acidic corrosion.

5.10 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 pit; as such, excavation of the basement may generate an abundance of over-size material that may require special handling, processing, or disposal.

6.0 CLOSURE

6.1 LIMITATIONS

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

The information contained in this report is based on limited field testing and our understanding of the project. The subsurface data used in the preparation of this report were obtained largely from the exploration made on Lot 86R. It is very likely that variations in the soil, rock, and groundwater conditions exist between and beyond the point explored. The nature and extent of the variations may not be evident until construction occurs and additional explorations are completed. If any conditions are encountered at this site that are different from those described in this report, IGES must be immediately notified so that we may make any necessary revisions to recommendations presented in this report. In addition, if the scope of the proposed construction or grading changes from those described in this report, our firm must also be notified.

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

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

6.2 ADDITIONAL SERVICES

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

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

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.

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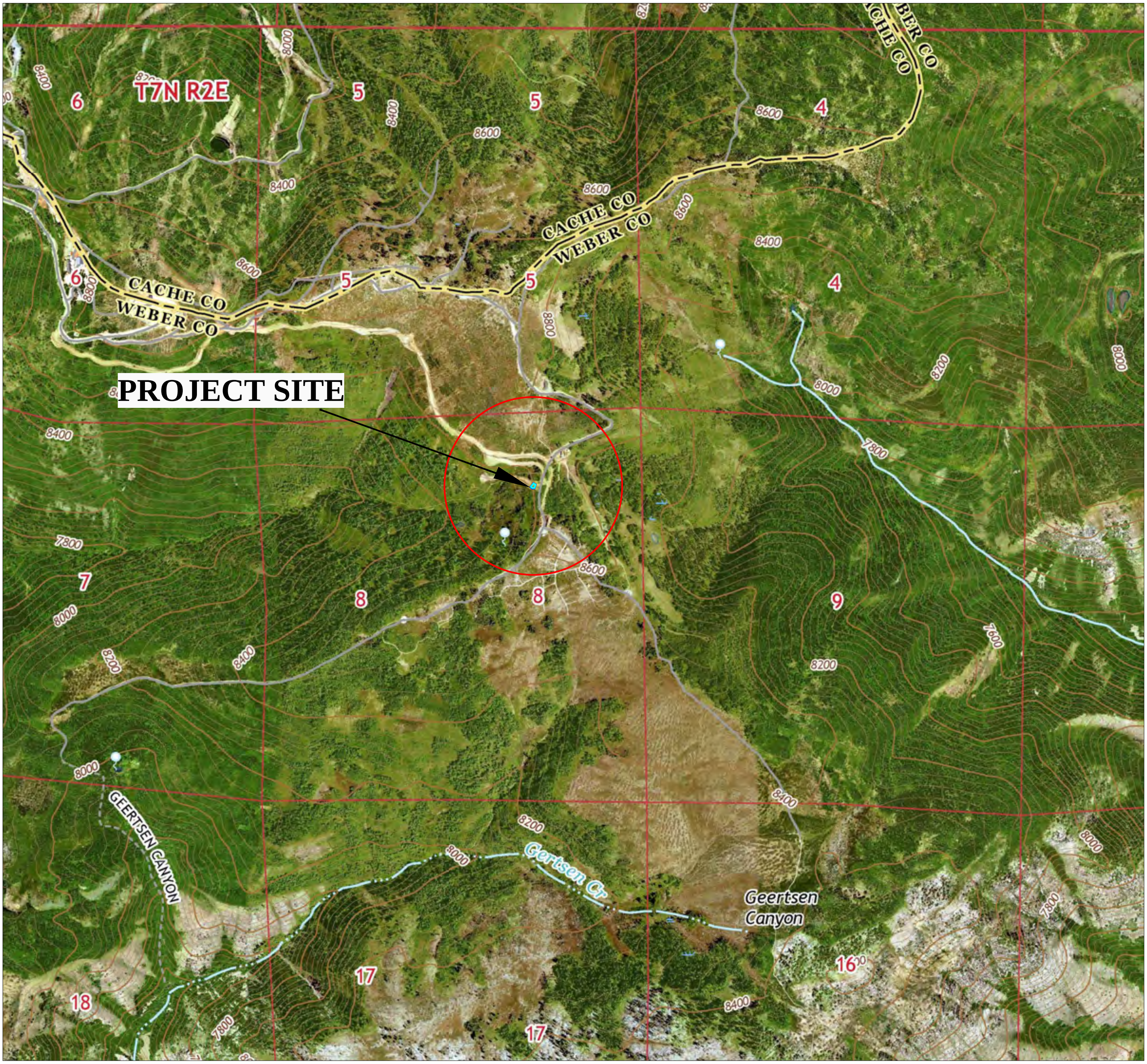
AERIAL PHOTOGRAPHS

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 Maps:

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

N

0 1000 2000
FEET
1" = 2000'

IGES®

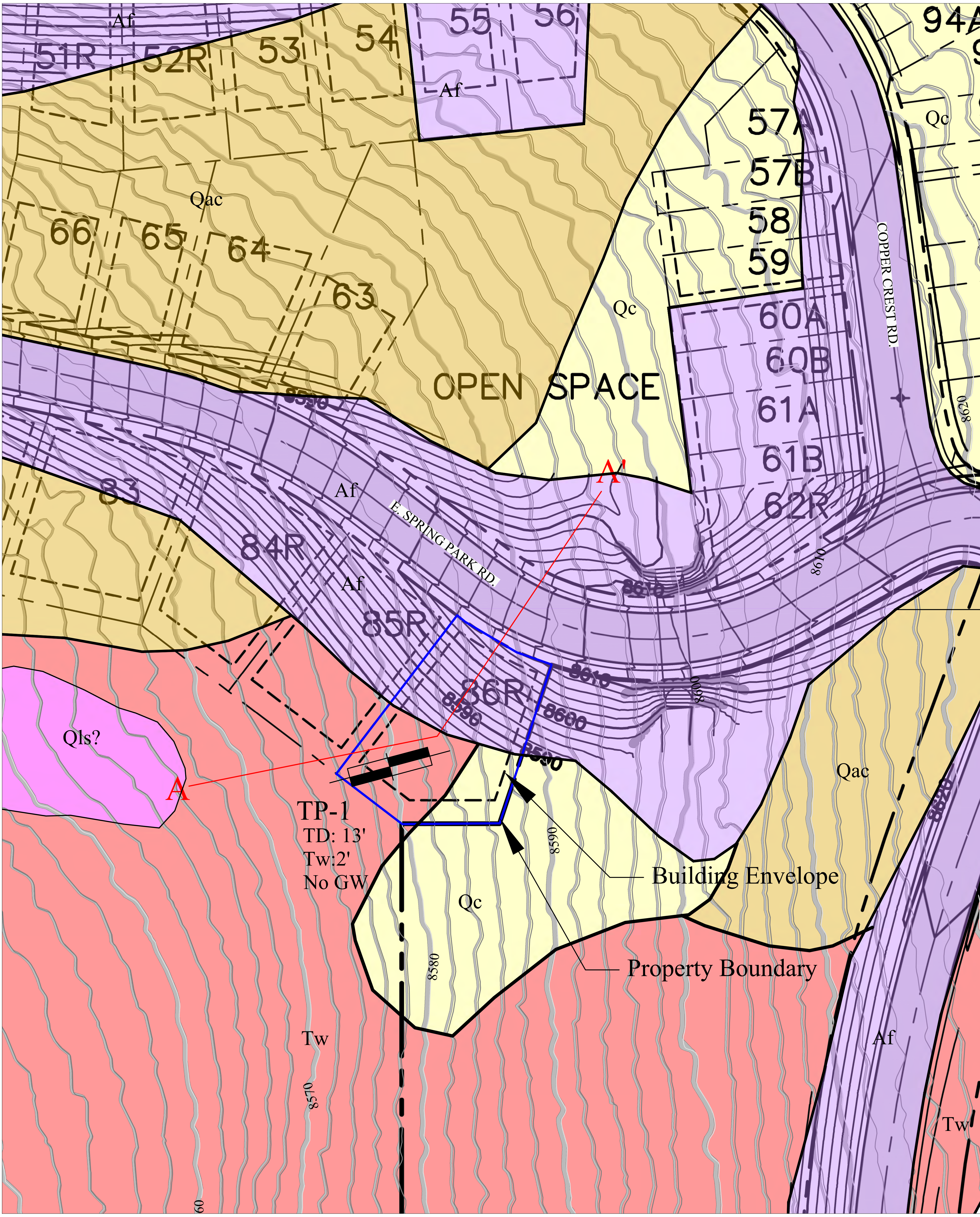
Project No: 03091-001

Geotechnical and Geologic Hazard Investigation
Lot 86R of Summit Eden Phase 1C
Summit Powder Mountain Resort
Weber County, Utah

Site Vicinity Map

Figure

A-1



LEGEND

Base Map:

-Undated 100-Scale Map of Phase 1C-1D Prepared By NV5

Contour Interval: 2'

- Af — Artificial Fill
- Qac — Alluvium & Colluvium
- Qc — Colluvium
- Qls? — Possible Landslide Deposit
- Tw — Wasatch Formation
- All Geologic Contacts Approximate
- TP-1 — Test Pit (TD: Total Depth; Tw: Depth to Wasatch Formation; GW: Depth to Groundwater)
- A–A' — Cross Section
- Property Boundary

N

0 40 80 FEET

1" = 40'

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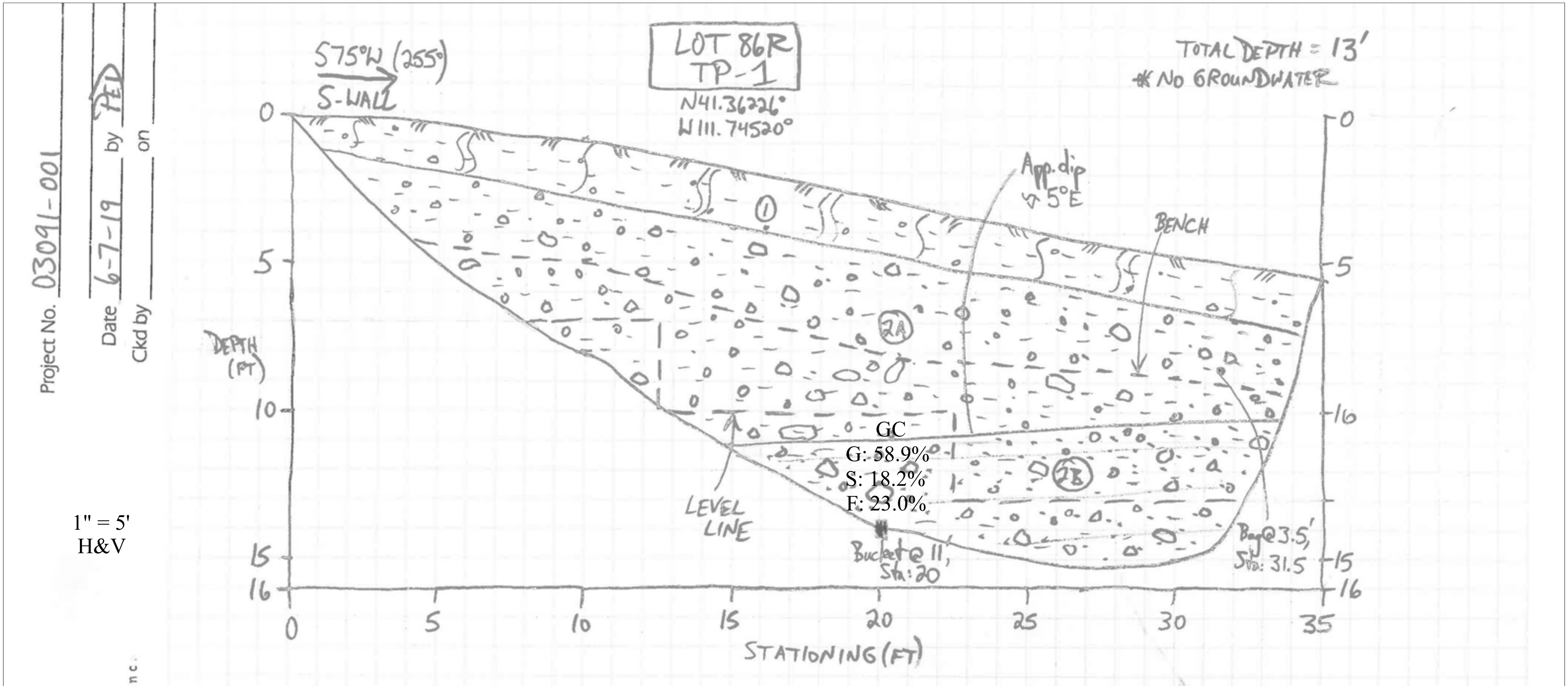
Project No: 03091-001

Geotechnical and Geologic Hazard Investigation
Lot 86R of Summit Eden Phase 1C
Summit Powder Mountain Resort
Weber County, Utah

Geotechnical and Local Geology Map

Figure A-2



LITHOLOGIC UNIT DESCRIPTIONS

1. A/B Soil Horizon: ~1.5-2' thick; grayish brown (5Y 3/2) lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of the unit; clasts are entirely subrounded to subangular medium gray (N5) to pale yellowish orange (10YR 8/6) quartzite up to 7" in diameter, though mode clast size is ~1/2"; clast size increases with depth; abundant plant and tree roots; sharp, irregular basal contact.

2. Wasatch Formation (Tw): >11' thick; 2 subunits; poorly consolidated conglomerate bedrock disggregated to:

2a) Up to ~7' thick; dark yellowish brown (10YR $\frac{4}{2}$) to moderate reddish orange (10R $\frac{6}{6}$) sandy lean CLAY with gravel (CL), medium stiff to stiff, moist, low to moderate plasticity, massive; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are entirely subrounded to subangular quartzite as above up to 14" in diameter, though mode clast size is ~3-4" in a wide range of clast sizes; common 1mm diameter pinholes; sand component is fine-grained to medium-grained; sand proportion increases with depth; occasional to few plant and tree roots.

2b) >5' thick; dark yellowish brown (10YR $\frac{4}{2}$) to moderate reddish orange (10R $\frac{6}{6}$) clayey SAND with gravel (SC), medium dense to dense, moist, low to moderate plasticity fines, weakly thickly bedded; gravel and larger sized clasts comprise ~30-40% of the unit; clasts are entirely subrounded to subangular quartzite as above up to 14" in diameter, though mode clast size is ~3-4" in a wide range of clast sizes; common 1mm diameter pinholes where clayey; sand component is fine-grained to medium-grained; sand proportion increases with depth; few plant and tree roots.

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Project No: 03091-001

Geotechnical and Geologic Hazard Investigation
Lot 86R of Summit Eden Phase 1C
Summit Powder Mountain Resort
Weber County, Utah

TP-1 Log

Figure

A-3

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

OTHER TESTS KEY

C	CONSOLIDATION	SA	SIEVE ANALYSIS
AL	ATTERBURG 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

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.

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

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.

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UNIFIED SOIL CLASSIFICATION SYSTEM

Project Number 03091-001

Figure A-4

TYPICAL ROCK DESCRIPTION AND GRAPHICAL SYMBOLS

CLAYSTONE
SANDSTONE
SILTSTONE
SHALE
LIMESTONE
DOLOMITE
GYPSUM
METAMORPHIC
IGNEOUS
GENERAL BEDROCK

LOG KEY SYMBOLS

BORING OR CORE SAMPLE LOCATION

TEST-PIT SAMPLE LOCATION

WATER LEVEL (level after completion)

WATER LEVEL (level where first encountered)

OTHER TESTS KEY

C	CONSOLIDATION	SA	SIEVE ANALYSIS
AL	ATTERBURG 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
P	POINT LOAD		

WEATHERING

WEATHERING	FIELD TEST
FRESH	NO VISIBLE SIGN OF DECOMPOSITION OR DISCOLORATION. RINGS UNDER HAMMER IMPACT.
SLIGHTLY WEATHERED	SLIGHT DISCOLORATION INWARDS FROM OPEN FRACTURES, OTHERWISE SIMILAR TO FRESH.
MODERATELY WEATHERED	DISCOLORATION THROUGHOUT. WEAKER MINERALS SUCH AS FELDSPAR ARE DECOMPOSED. STRENGTH SOMEWHAT LESS THAN FRESH ROCK BUT CORES CANNOT BE BROKEN BY HAND OR SCRAPED WITH A KNIFE.
HIGHLY WEATHERED	MOST MINERALS SOMEWHAT DECOMPOSED. SPECIMENS CAN BE BROKEN BY HAND WITH EFFORT OR SHAVED WITH A KNIFE. TEXTURE PRESERVED.
COMPLETELY WEATHERED	MINERALS DECOMPOSED TO SOIL BUT FABRIC AND STRUCTURE PRESERVED. SPECIMENS EASILY CRUMBLE OR PENETRATED.

FRACTURING

SPACING	DESCRIPTION
>6 FT	VERY WIDELY
2-6 FT	WIDELY
8-24 IN	MODERATELY
2 1/2 -8 IN	CLOSELY
3/4 - 2 1/2 IN	VERY CLOSELY

RQD

RQD (%)	ROCK QUALITY
90-100	EXCELLENT
75-90	GOOD
50-75	FAIR
25-50	POOR
0-25	VERY POOR

COMPETENCY

CLASS	STRENGTH	FIELD TEST	APPROXIMATE RANGE OF UNCONFINED COMPRESSIVE STRENGTH (TSF)
I	EXTREMELY STRONG	MANY BLOWS WITH GEOLOGIC HAMMER REQUIRED TO BREAK INTACT SPECIMEN.	>2000
II	VERY STRONG	HAND-HELD SPECIMEN BREAKS WITH PICK END OF HAMMER UNDER MORE THAN ONE BLOW.	2000-1000
III	STRONG	CANNOT BE SCRAPED OR PEELED WITH KNIFE, HAND-HELD SPECIMEN CAN BE BROKEN WITH SINGLE MODERATE BLOW WITH PICK END OF HAMMER	1000-500
IV	MODERATELY STRONG	CAN JUST BE SCRAPED OR PEELED WITH KNIFE. INDENTATIONS 1-3 mm SHOW IN SPECIMEN WITH MODERATE BLOW WITH PICK END OF HAMMER	500-250
V	WEAK	MATERIAL CRUMBLES UNDER MODERATE BLOW WITH PICK END OF HAMMER AND CAN BE PEELED WITH KNIFE, BUT IS HARD TO HAND-TRIM FOR TRIAXIAL TEST SPECIMEN.	250-10
VI	FRIABLE	MATERIAL CRUMBLES IN HAND.	N/A

BEDDING OF SEDIMENTARY ROCKS

SPLITTING PROPERTY	THICKNESS	STRATIFICATION
MASSIVE	>4.0 FT	VERY THICK BEDDED
BLOCKY	2.0-4.0 FT	THICK-BEDDED
SLABBY	2 1/2-24 IN	THIN-BEDDED
FLAGGY	1/2-2 1/2 IN	VERY THIN-BEDDED
SHALY OR PLATY	1/8-1/2 IN	LAMINATED
PAPERY	<1/8 IN	THINLY LAMINATED

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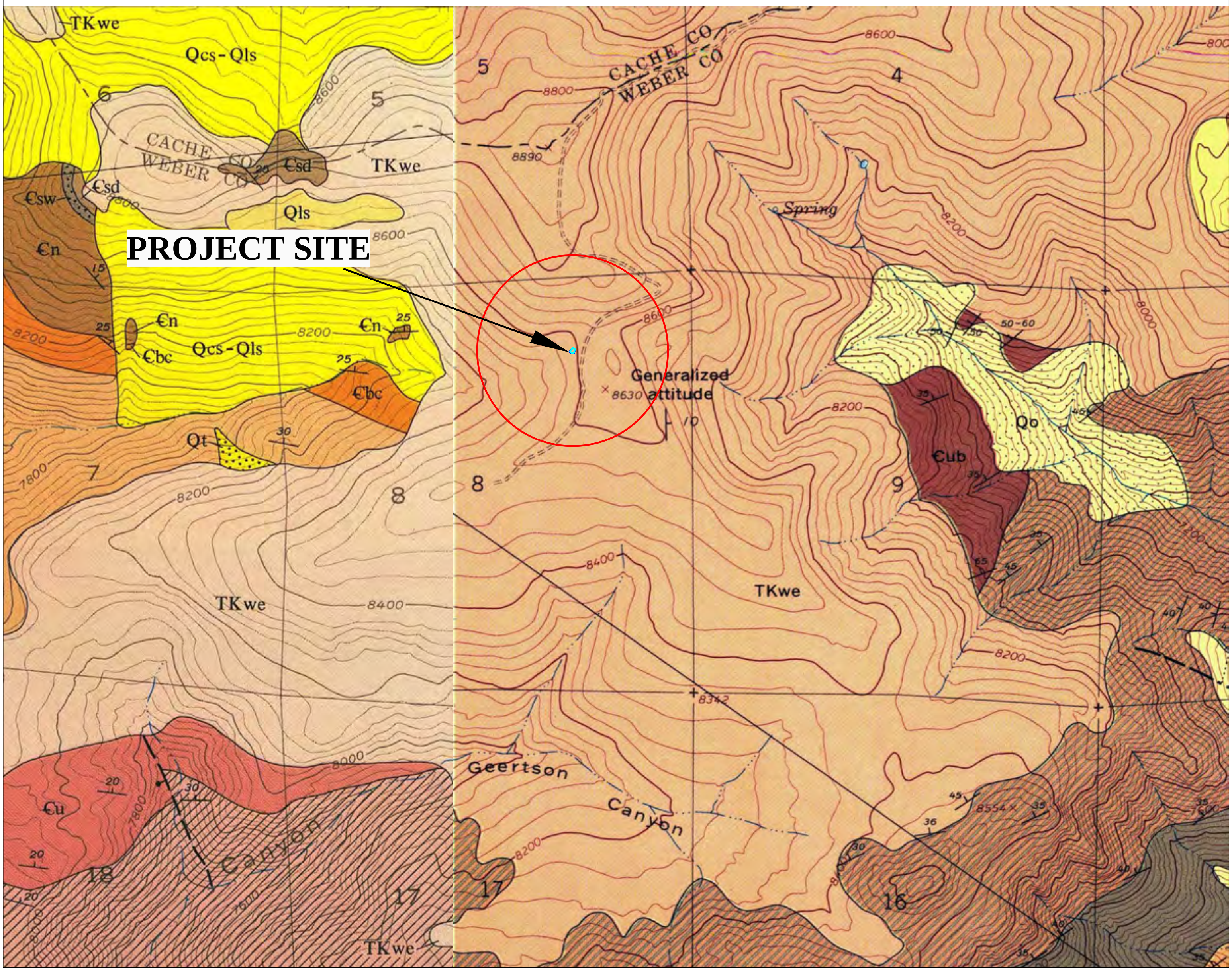
KEY TO PHYSICAL ROCK PROPERTIES

Project Number 03091-001

Figure A-5

Edge of Mapped Area



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)

*Geologic Map Legend on Figures A-2b and A-2c.

N

0 1000 2000
FEET
1" = 2000'

QUADRANGLE LOCATION

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Geotechnical and Geologic Hazard Investigation
Lot 86R of Summit Eden Phase 1C
Summit Powder Mountain Resort
Weber County, Utah

Regional Geology Map 1

Figure A-6a

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

BRIGHAM GROUP (Crittenden and others, 1971) – Includes:

GEERTSEN CANYON QUARTZITE (Lower Cambrian) – Includes:

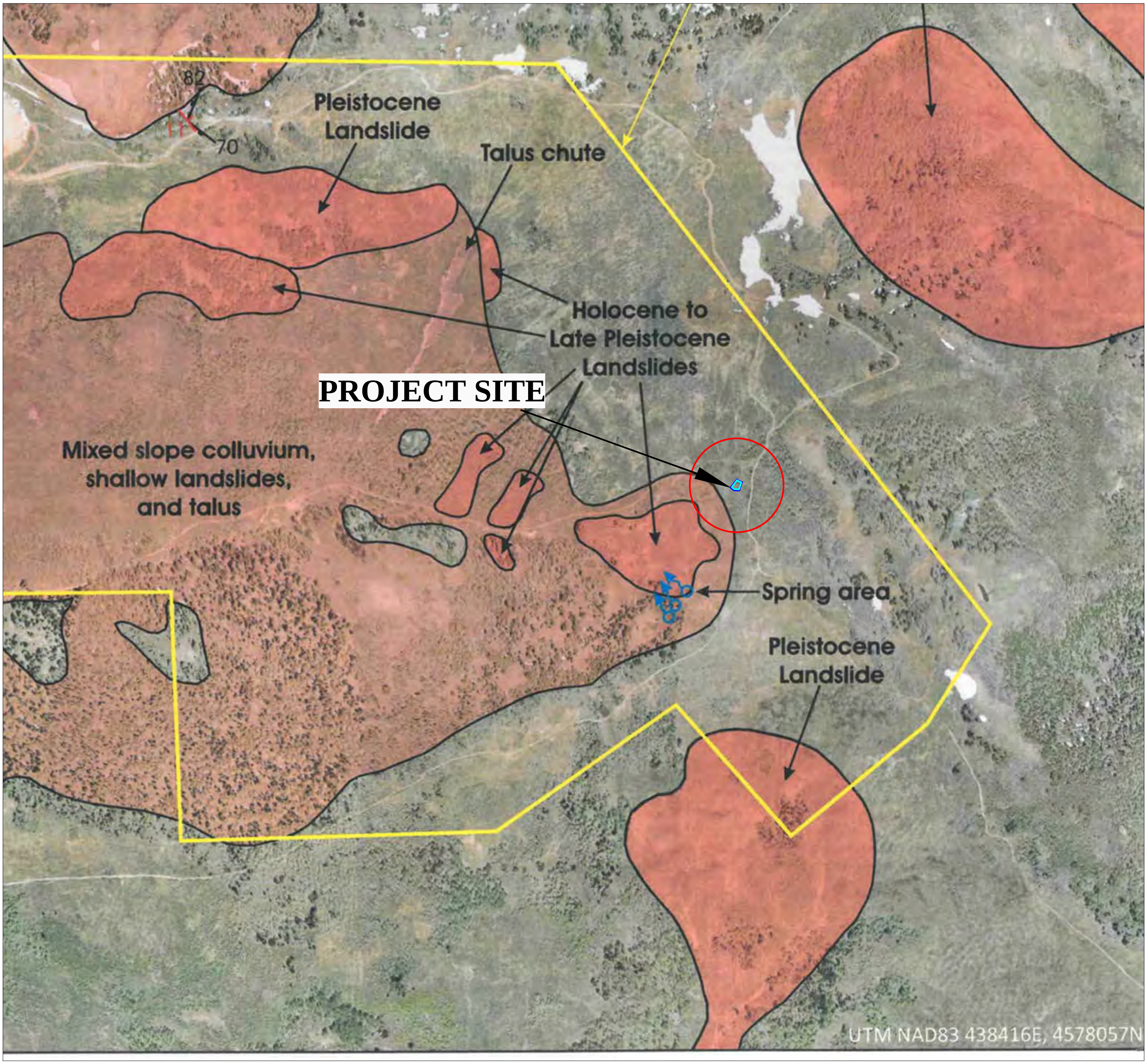
€gcu Upper member – Pale-buff to white or flesh-pink quartzite, locally streaked with pale red or purple. Coarse-grained; small pebbles occur throughout unit and increase in abundance downward. Base marked by zone 30-60 m thick of cobble conglomerate in beds 30 cm to 2 m thick; clasts, 5-10 cm in diameter, 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

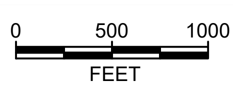
Pre-Tertiary normal fault – Dotted where concealed Bar and ball on downthrown side

Thrust fault – Dashed where inferred Sawteeth on upper plate



Base Maps:

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



1" = 1000'

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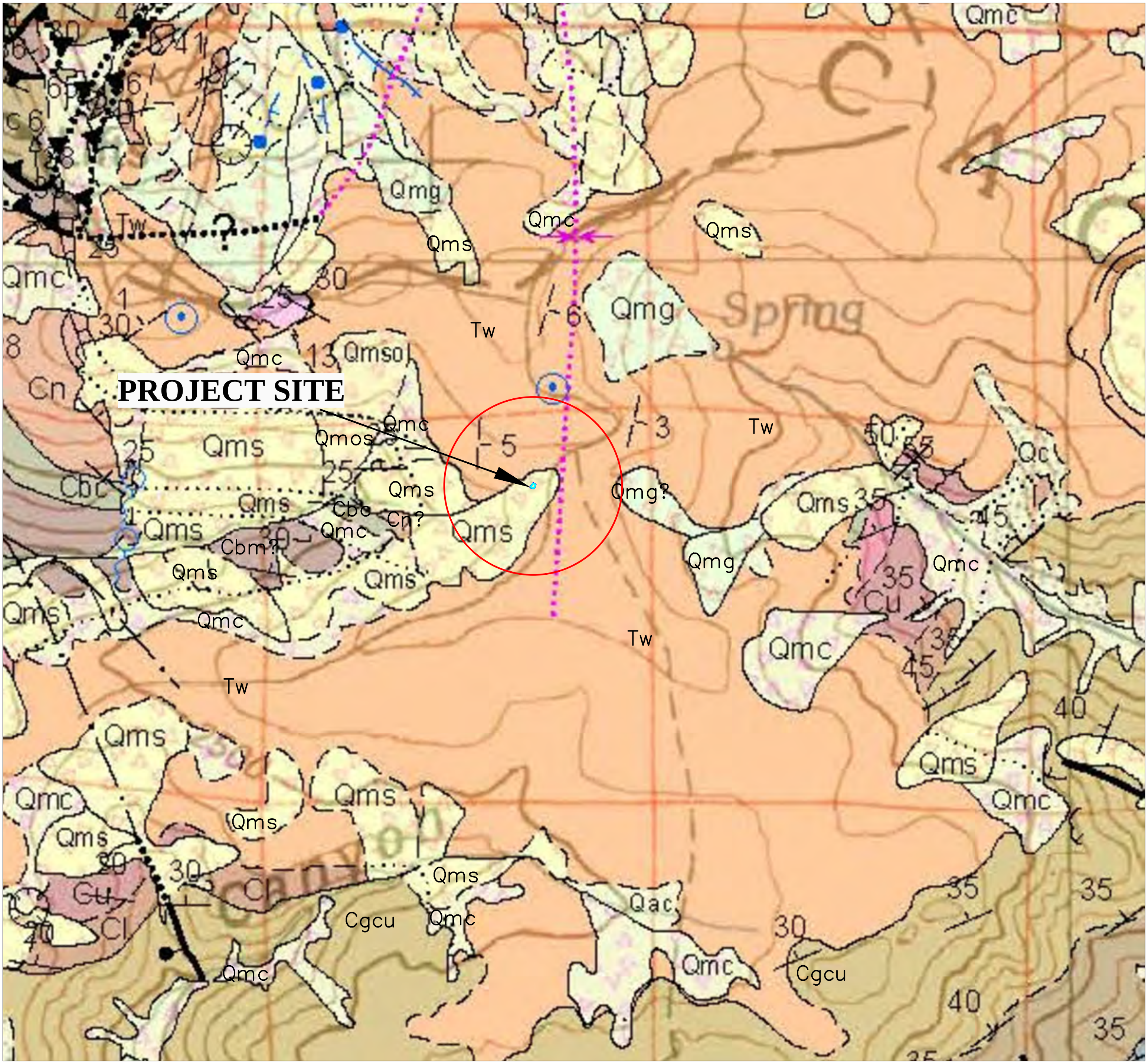
Geotechnical and Geologic Hazard Investigation
Lot 86R of Summit Eden Phase 1C
Summit Powder Mountain Resort
Weber County, Utah

Regional Geology Map 2

Figure A-7



N

0 1000 2000
FEET
1" = 2000'

Base Maps:

-UGS *Ogden* 30' x 60' Geologic Quadrangle Map (OFR-635DM), Coogan and King (2016)

*Geologic Map Legend on Figure A-4b.

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Lot 86R of Summit Eden Phase 1C
Summit Powder Mountain Resort
Weber County, Utah

Regional Geology Map 3

Figure

A-8a

MAP LEGEND

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

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

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).

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.

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.

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 quadrangle; sinkholes indicate karstification of limestone beds; thicknesses on Willard thrust sheet likely up to about 400 to 600 feet (120-180 m) in Sharp Mountain, Dairy Ridge, and Horse Ridge quadrangles (Coogan, 2006a-b), about 1300 feet (400 m) in Monte Cristo Peak quadrangle, about 1100 feet (335 m) in northeast Browns Hole quadrangle, about 2200 feet (670 m) in southwest Causey Dam quadrangle, about 2600 feet (800 m) at Herd Mountain in Bybee Knoll quadrangle, and about 1300 feet (400 m) in northwest Lost Creek Dam quadrangle, estimated by elevation differences between pre-Wasatch rocks exposed in drainages and the crests of gently dipping Wasatch Formation on adjacent ridges (King); thickness varies locally due to considerable relief on basal erosional surface, for example along Right Fork South Fork Ogden River, and along leading edge of Willard thrust; much thicker, about 5000 to 6000 feet (1500-1800 m), south of Willard thrust sheet near Morgan. Wasatch Formation is queried (Tw?) where poor exposures may actually be surficial deposits. The Wasatch Formation is prone to slope failures. Other information on the Wasatch Formation is in Tw descriptions under the heading "Sub-Willard Thrust - Ogden Canyon Area" since Tw strata are extensive near Morgan Valley and cover the Willard thrust, Ogden Canyon, and Durst Mountain areas.

- Contact, well located
- Thrust fault, concealed
- Normal fault, approximately located
- Moraine crest, asymmetrical
- Anticline, overturned, concealed
- Syncline, upright, concealed
- Water well
- Sinkhole
- Select spring

APPENDIX B

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

(ASTM D6913)

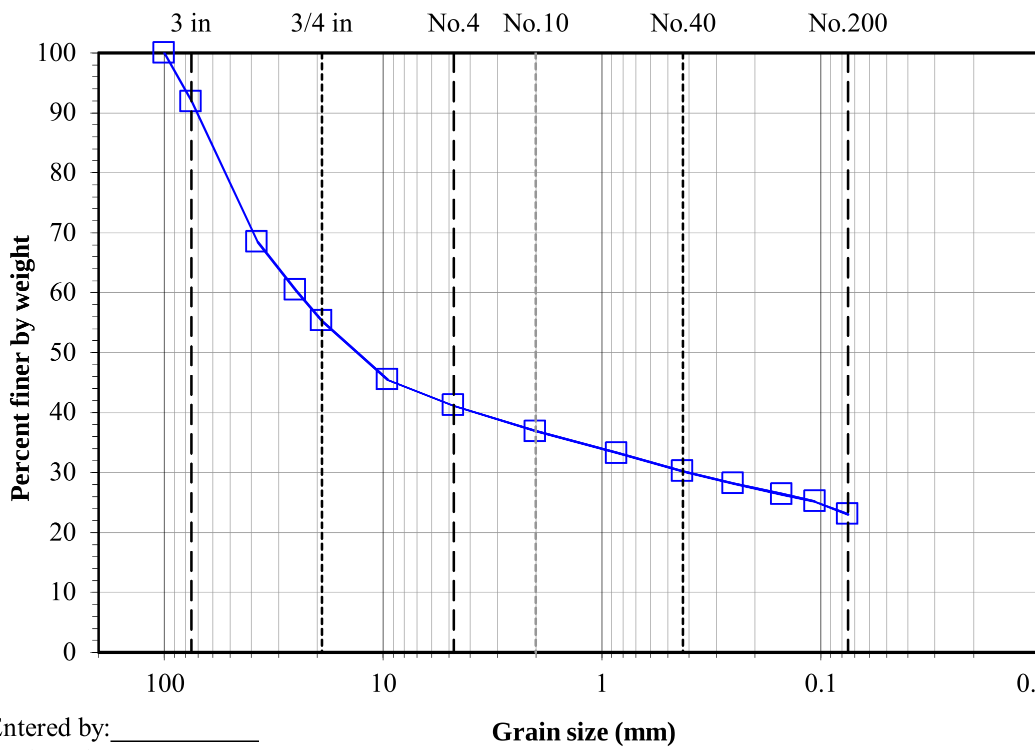
Project: Kingsbury_Lot 86R
No: 03091-001
Location: Powder Mountain
Date: 6/18/2019
By: JP

Boring No.: TP-1
Station: 20
Depth: 11'
Description: Brown clayey gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	25667.5	24117.37
+3/8" Coarse fraction (g):	13458.6	13163.28
-3/8" Split fraction (g):	381.79	342.55
Split fraction:	0.454	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	14424.9	502.76
Dry soil + tare (g):	14129.6	463.52
Tare (g):	967.0	120.97
Water content (%):	2.2	11.5

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
6"	-	150	-	
4"	-	100	100.0	
3"	1966.5	75	91.8	
1.5"	7610.9	37.5	68.4	
1"	9557.4	25	60.4	
3/4"	10786.6	19	55.3	
3/8"	13163.3	9.5	45.4	←Split
No.4	32.28	4.75	41.1	
No.10	64.60	2	36.9	
No.20	92.14	0.85	33.2	
No.40	115.22	0.425	30.1	
No.60	130.47	0.25	28.1	
No.100	143.54	0.15	26.4	
No.140	153.09	0.106	25.1	
No.200	169.25	0.075	23.0	



Gravel (%): 58.9
Sand (%): 18.2
Fines (%): 23.0

Comments:
These results are in nonconformance with Method D6913 because the minimum dry mass was not met.

Entered by:___________
Reviewed:___________

Z:\PROJECTS\03091_Kingsbury\001_Kingsbury_Lot_86R\[GSDv2.xlsm]1

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: Kingsbury_Lot 86R
No: 03091-001
Location: Powder Mountain
Date: 6/18/2019
By: EH

Boring No.: TP-1
Station: 20
Depth: 11'
Sample Description: Reddish brown sandy clay
Sample type: Arbitrary remold

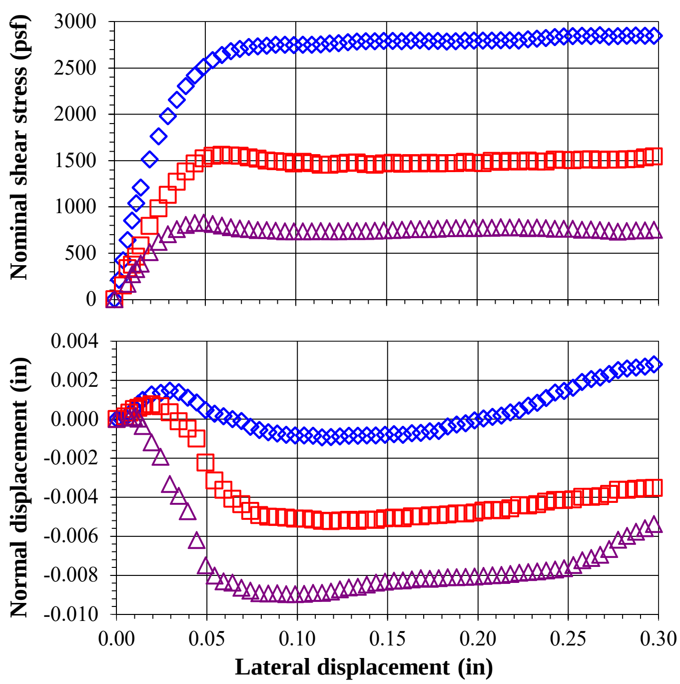
Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0010
Specific gravity, Gs: 2.70 Assumed

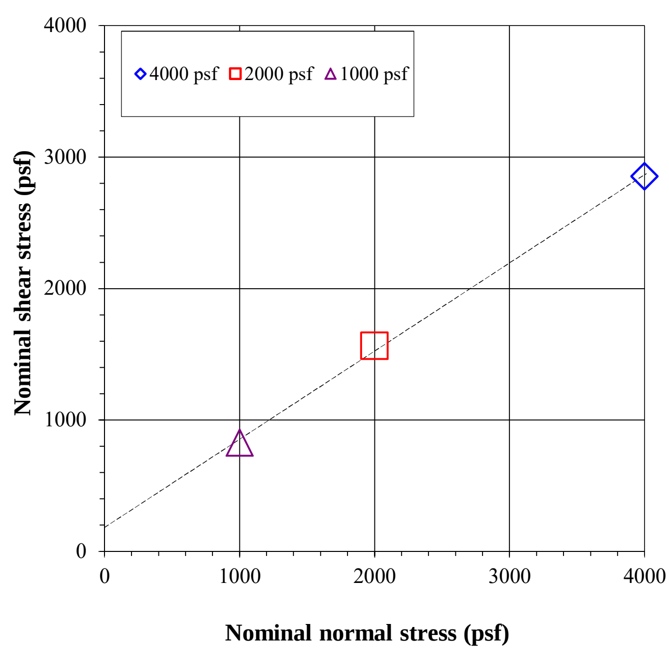
	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	4000		2000		1000	
Peak shear stress (psf)	2854		1562		828	
Lateral displacement at peak (in)	0.268		0.059		0.049	
Load Duration (min)	251		251		251	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	0.998	0.976	0.996	0.979	0.996	0.986
Sample diameter (in)	2.412	2.412	2.416	2.416	2.414	2.414
Wt. rings + wet soil (g)	207.29	208.76	207.74	209.60	207.22	209.65
Wt. rings (g)	44.82	44.82	45.06	45.06	44.83	44.83
Wet soil + tare (g)	318.37		318.37		318.37	
Dry soil + tare (g)	296.19		296.19		296.19	
Tare (g)	119.63		119.63		119.63	
Water content (%)	12.6	13.6	12.6	13.9	12.6	14.2
Dry unit weight (pcf)	120.6	123.3	120.6	122.6	120.6	121.7
Void ratio, e, for assumed Gs	0.40	0.37	0.40	0.37	0.40	0.38
Saturation (%)*	85.3	100.0	85.2	100.0	85.2	100.0

ϕ' (deg)	34
c' (psf)	182

Average of 3 samples	Initial	Pre-shear
Water content (%)	12.6	13.9
Dry unit weight (pcf)	120.6	122.5

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





Comments:
Test specimens compacted to estimated 93% of Modified Proctor at estimated optimum water content.

Entered by:___________
Reviewed:___________

Z:\PROJECTS\03091_Kingsbury\001_Kingsbury_Lot_86R\[DS_GTv1.xlsm]1

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: Kingsbury_Lot 86R **Boring No.:** TP-1

No: 03091-001 **Station:** 20

Location: Powder Mountain **Depth:** 11'

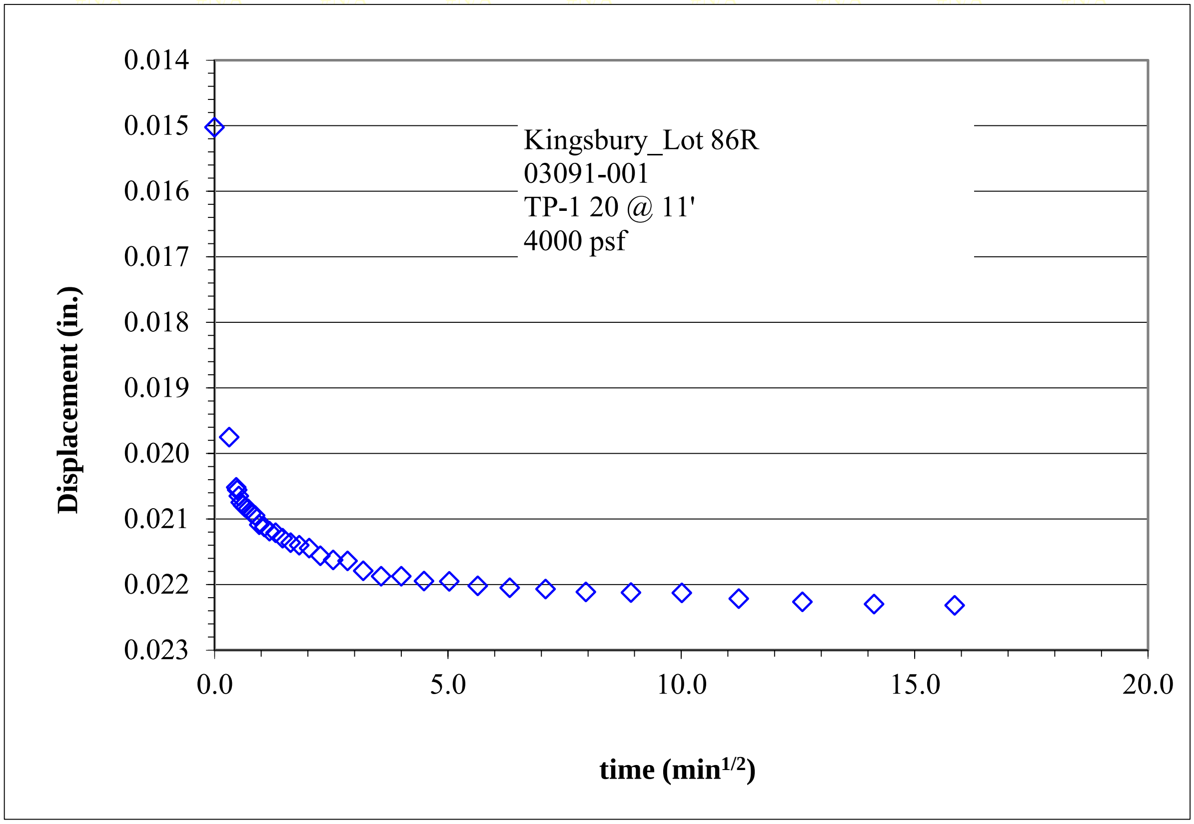
Nominal normal stress = 4000 psf			Nominal normal stress = 2000 psf			Nominal normal stress = 1000 psf		
Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)
0.000	0	0.000	0.000	0	0.000	0.000	0	0.000
0.002	213	0.000	0.005	151	0.000	0.007	166	0.000
0.005	424	0.000	0.007	336	0.000	0.010	270	0.000
0.007	639	0.000	0.010	373	0.001	0.012	327	0.000
0.010	853	0.000	0.012	460	0.001	0.014	384	0.000
0.012	1037	0.001	0.014	584	0.001	0.019	509	-0.001
0.014	1210	0.001	0.019	794	0.001	0.024	622	-0.002
0.019	1513	0.001	0.024	983	0.001	0.029	705	-0.003
0.024	1762	0.001	0.029	1130	0.000	0.034	759	-0.004
0.029	1980	0.001	0.034	1269	0.000	0.039	802	-0.005
0.034	2157	0.001	0.039	1383	0.000	0.044	824	-0.006
0.039	2305	0.001	0.044	1467	-0.001	0.049	828	-0.007
0.044	2418	0.001	0.049	1523	-0.002	0.054	813	-0.008
0.049	2512	0.000	0.054	1551	-0.003	0.059	796	-0.008
0.054	2584	0.000	0.059	1562	-0.004	0.064	780	-0.008
0.059	2639	0.000	0.064	1553	-0.004	0.069	767	-0.009
0.064	2681	0.000	0.069	1550	-0.004	0.074	759	-0.009
0.069	2707	0.000	0.074	1532	-0.005	0.079	748	-0.009
0.074	2727	0.000	0.079	1521	-0.005	0.084	747	-0.009
0.079	2735	-0.001	0.084	1500	-0.005	0.089	741	-0.009
0.084	2741	-0.001	0.089	1491	-0.005	0.094	734	-0.009
0.089	2750	-0.001	0.094	1484	-0.005	0.099	735	-0.009
0.094	2750	-0.001	0.099	1468	-0.005	0.104	735	-0.009
0.099	2748	-0.001	0.104	1483	-0.005	0.109	733	-0.009
0.104	2751	-0.001	0.109	1469	-0.005	0.114	739	-0.009
0.109	2752	-0.001	0.114	1454	-0.005	0.119	735	-0.009
0.114	2753	-0.001	0.119	1454	-0.005	0.124	733	-0.009
0.119	2763	-0.001	0.124	1466	-0.005	0.129	737	-0.009
0.124	2768	-0.001	0.129	1476	-0.005	0.134	739	-0.009
0.129	2778	-0.001	0.134	1476	-0.005	0.139	739	-0.008
0.134	2787	-0.001	0.139	1459	-0.005	0.144	741	-0.008
0.139	2790	-0.001	0.144	1454	-0.005	0.148	744	-0.008
0.144	2790	-0.001	0.148	1467	-0.005	0.153	747	-0.008
0.148	2794	-0.001	0.153	1474	-0.005	0.158	751	-0.008
0.153	2793	-0.001	0.158	1464	-0.005	0.163	757	-0.008
0.158	2789	-0.001	0.163	1470	-0.005	0.168	759	-0.008
0.163	2796	-0.001	0.168	1467	-0.005	0.173	758	-0.008
0.168	2798	-0.001	0.173	1474	-0.005	0.178	762	-0.008
0.173	2789	-0.001	0.178	1468	-0.005	0.183	767	-0.008
0.178	2792	-0.001	0.183	1471	-0.005	0.188	769	-0.008
0.183	2785	0.000	0.188	1470	-0.005	0.193	773	-0.008
0.188	2788	0.000	0.193	1486	-0.005	0.198	769	-0.008
0.193	2795	0.000	0.198	1475	-0.005	0.203	771	-0.008
0.198	2796	0.000	0.203	1470	-0.005	0.208	774	-0.008
0.203	2797	0.000	0.208	1496	-0.005	0.213	778	-0.008
0.208	2796	0.000	0.213	1486	-0.005	0.218	775	-0.008
0.213	2798	0.000	0.218	1495	-0.005	0.223	778	-0.008
0.218	2798	0.000	0.223	1488	-0.004	0.228	770	-0.008
0.223	2796	0.000	0.228	1500	-0.004	0.233	776	-0.008
0.228	2810	0.001	0.233	1489	-0.004	0.238	768	-0.008
0.233	2817	0.001	0.238	1490	-0.004	0.243	763	-0.008
0.238	2824	0.001	0.243	1510	-0.004	0.248	761	-0.008
0.243	2833	0.001	0.248	1505	-0.004	0.253	761	-0.007
0.248	2841	0.001	0.253	1501	-0.004	0.258	753	-0.007
0.253	2844	0.002	0.258	1509	-0.004	0.263	753	-0.007
0.258	2847	0.002	0.263	1513	-0.004	0.268	748	-0.007
0.263	2843	0.002	0.268	1506	-0.004	0.273	741	-0.007
0.268	2854	0.002	0.273	1508	-0.004	0.278	732	-0.006
0.273	2836	0.002	0.278	1507	-0.004	0.282	739	-0.006
0.278	2843	0.003	0.282	1513	-0.004	0.287	743	-0.006
0.282	2849	0.003	0.287	1515	-0.004	0.292	746	-0.006
0.287	2850	0.003	0.292	1533	-0.004	0.297	751	-0.005
0.292	2847	0.003	0.297	1544	-0.004	0.300	749	-0.005
0.297	2847	0.003	0.300	1540	-0.004	#N/A	#N/A	#N/A
0.300	2851	0.003	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

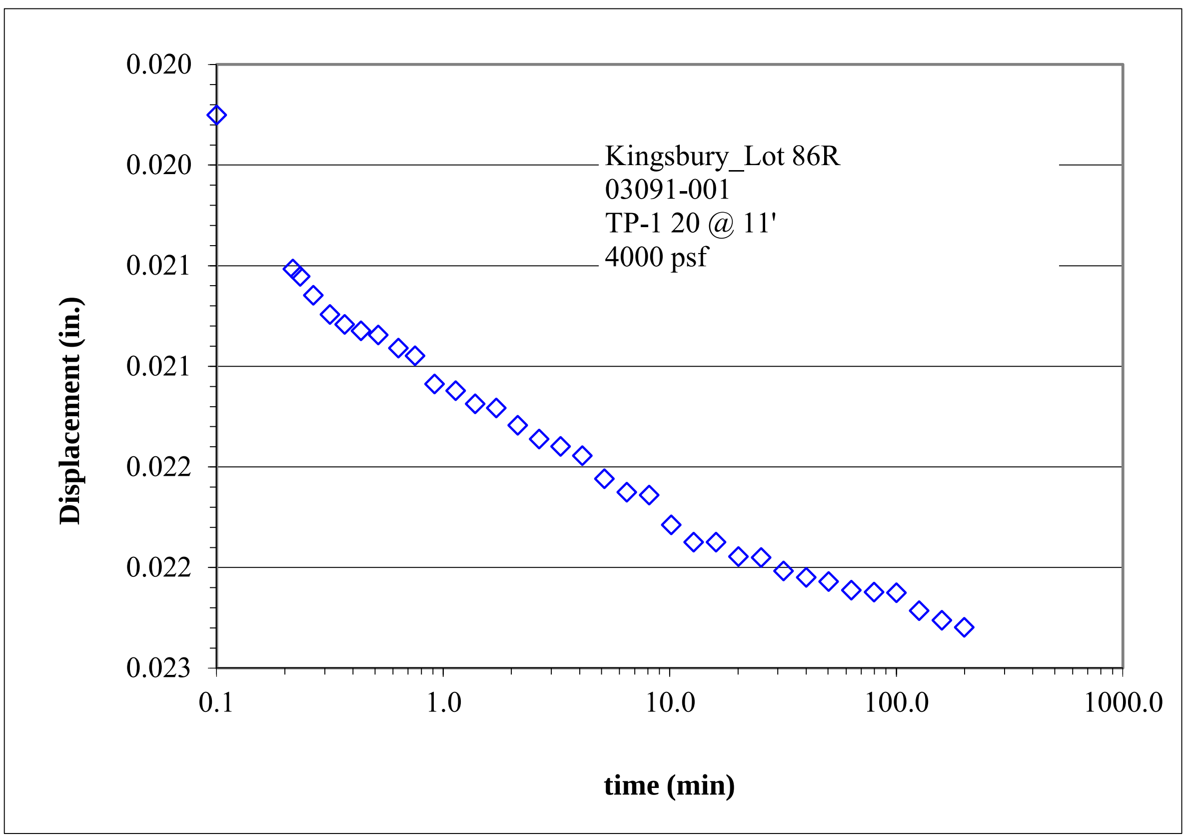
Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: Kingsbury_Lot 86R
No: 03091-001
Location: Powder Mountain

Boring No.: TP-1
Station: 20
Depth: 11'





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: **Kingsbury_Lot 86R**
No: **03091-001**
Location: Powder Mountain
Date: 6/19/2019
By: RT

Sample info.	Boring No.	TP-1							
	Station	31.5							
	Depth	3.5'							
Water content data	Wet soil + tare (g)	99.47							
	Dry soil + tare (g)	90.14							
	Tare (g)	23.56							
	Water content (%)	14.0							
Chem. data	pH*	4.77							
	Soluble chloride* (ppm)	62.4							
	Soluble sulfate** (ppm)	1890							
Resistivity data	Pin method	2							
	Soil box	Miller Small							
		Approximate Soil condition (%)	Resistance Reading (Ω)	Soil Box Multiplier (cm)	Resistivity (Ω-cm)	Approximate Soil condition (%)	Resistance Reading (Ω)	Soil Box Multiplier (cm)	Resistivity (Ω-cm)
		Asis	26640	0.67	17849				
		+3	12230	0.67	8194				
		+6	10000	0.67	6700				
		+9	10450	0.67	7002				
	Minimum resistivity (Ω-cm)	**6700**							

* Performed by AWAL using EPA 300.0

** Performed by AWAL using ASTM C1580

Entered by:___________

Reviewed:___________

APPENDIX C

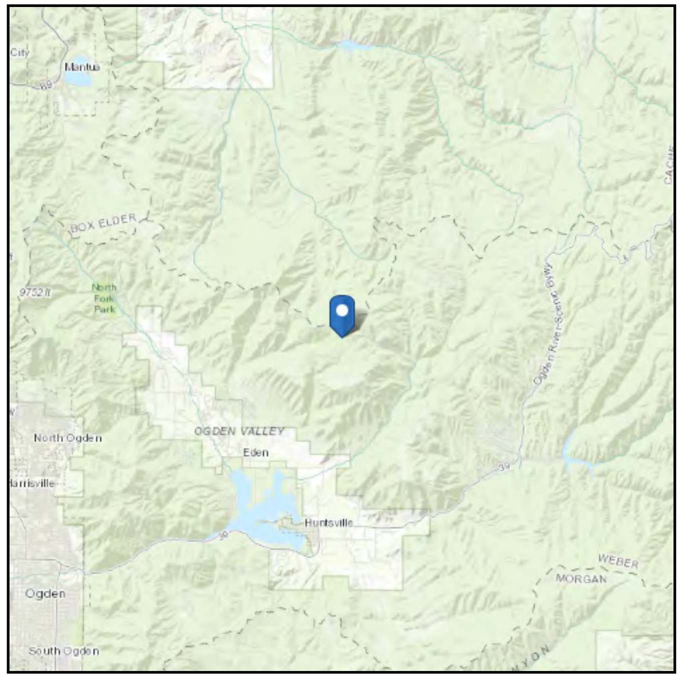
ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

ASCE 7 Hazards Report

Address:
No Address at This Location

Standard: ASCE/SEI 7-16
Risk Category: III
Soil Class: C - Very Dense Soil and Soft Rock

Elevation: 8592.43 ft (NAVD 88)
Latitude: 41.3623
Longitude: -111.7451



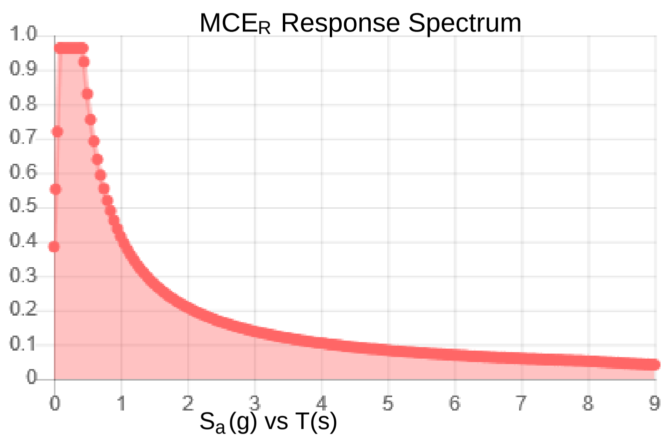
Seismic

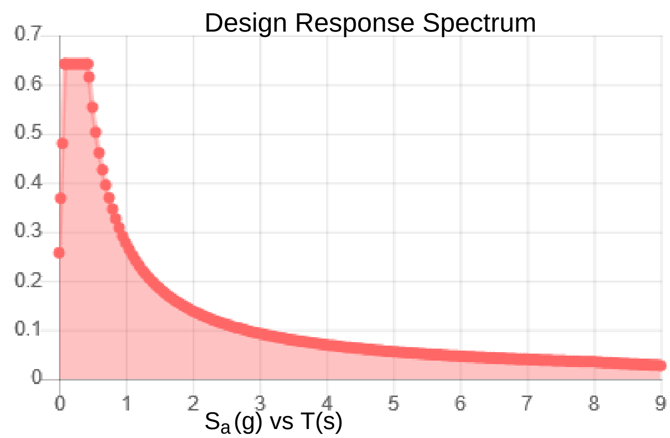
Site Soil Class: C - Very Dense Soil and Soft Rock

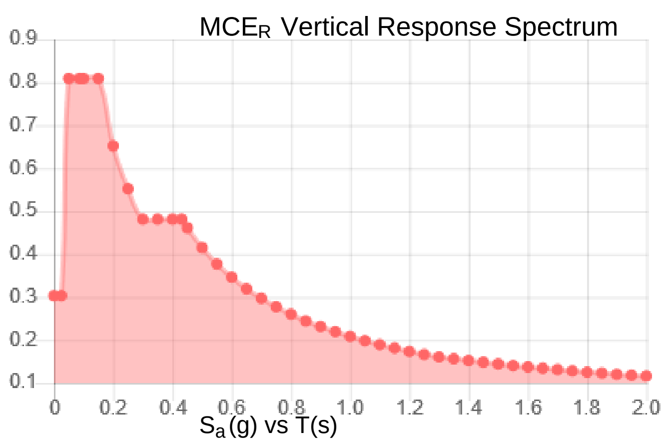
Results:

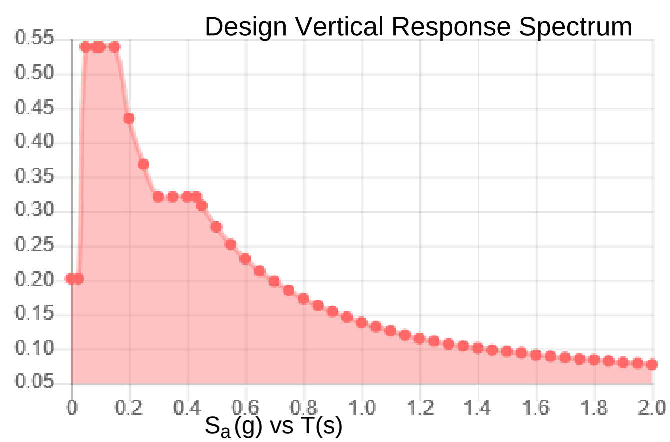
S_S :	0.802	S_{D1} :	0.277
S_1 :	0.277	T_L :	8
F_a :	1.2	PGA :	0.349
F_v :	1.5	PGA_M :	0.419
S_{MS} :	0.963	F_{PGA} :	1.2
S_{M1} :	0.415	I_e :	1.25
S_{DS} :	0.642	C_v :	1.051

Seismic Design Category D









Data Accessed: Wed Jun 26 2019

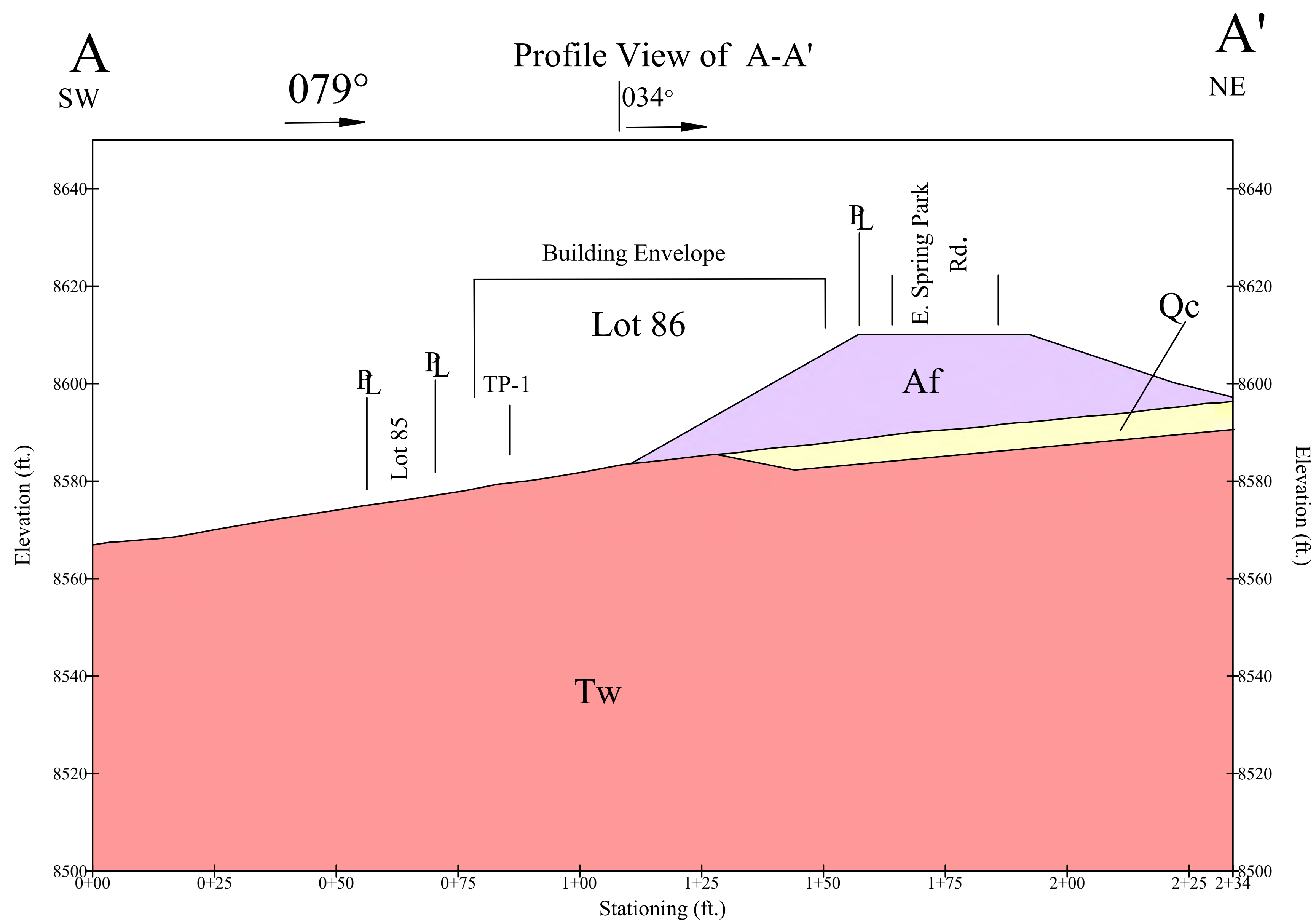
Date Source: USGS Seismic Design Maps based on ASCE/SEI 7-16 and ASCE/SEI 7-16 Table 1.5-2. Additional data for site-specific ground motion procedures in accordance with ASCE/SEI 7-16 Ch. 21 are available from USGS.

The ASCE 7 Hazard Tool is provided for your convenience, for informational purposes only, and is provided "as is" and without warranties of any kind. The location data included herein has been obtained from information developed, produced, and maintained by third party providers; or has been extrapolated from maps incorporated in the ASCE 7 standard. While ASCE has made every effort to use data obtained from reliable sources or methodologies, ASCE does not make any representations or warranties as to the accuracy, completeness, reliability, currency, or quality of any data provided herein. Any third-party links provided by this Tool should not be construed as an endorsement, affiliation, relationship, or sponsorship of such third-party content by or from ASCE.

ASCE does not intend, nor should anyone interpret, the results provided by this Tool to replace the sound judgment of a competent professional, having knowledge and experience in the appropriate field(s) of practice, nor to substitute for the standard of care required of such professionals in interpreting and applying the contents of this Tool or the ASCE 7 standard.

In using this Tool, you expressly assume all risks associated with your use. Under no circumstances shall ASCE or its officers, directors, employees, members, affiliates, or agents be liable to you or any other person for any direct, indirect, special, incidental, or consequential damages arising from or related to your use of, or reliance on, the Tool or any information obtained therein. To the fullest extent permitted by law, you agree to release and hold harmless ASCE from any and all liability of any nature arising out of or resulting from any use of data provided by the ASCE 7 Hazard Tool.

APPENDIX D

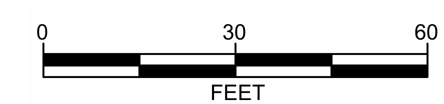


No Vertical Exaggeration

All Geologic Contacts Approximate

LEGEND

Af Artifical Fill | Qc Colluvium | Tw Wasatch Formation



1" = 30'

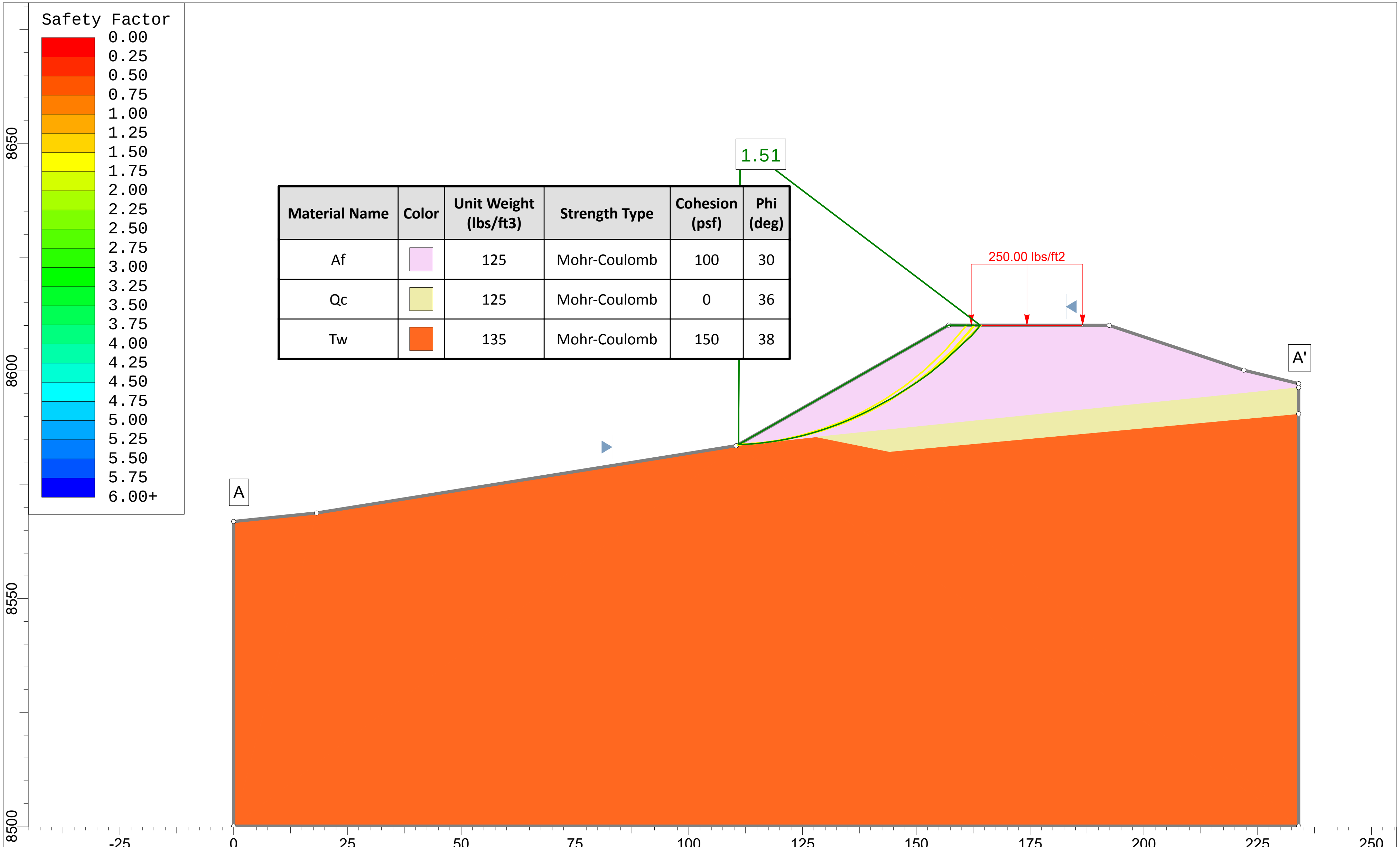
IGES®

Project No: 03091-001

Geotechnical and Geologic Hazard Investigation
Lot 86R of Summit Eden Phase 1C
Summit Powder Mountain Resort
Weber County, Utah

Cross Section

Figure D-1



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Af		125	Mohr-Coulomb	100	30
Qc		125	Mohr-Coulomb	0	36
Tw		135	Mohr-Coulomb	150	38

IGES®

SLIDEINTERPRET 8.008

Project	Lot 86R - Kingsbury
Analysis Description	Method : Spencer
Drawn By	EBF
Scale	1:350
Company	IGES, Inc.
Date	07/01/2019
File Name	A-A'.slim

Slide Analysis Information

Lot 86R - Kingsbury

Project Summary

Slide Modeler Version:	8.008

General Settings

Units of Measurement:	Imperial Units
Time Units:	seconds
Permeability Units:	feet/second
Data Output:	Standard
Failure Direction:	Right to Left

Analysis Options

Slices Type:	Vertical

Analysis Methods Used
Spencer

Number of slices:	30
Tolerance:	0.005
Maximum number of iterations:	50
Check malpha < 0.2:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Groundwater Analysis

Groundwater Method:	Water Surfaces
Pore Fluid Unit Weight [lbs/ft3]:	62.4
Use negative pore pressure cutoff:	Yes
Maximum negative pore pressure [psf]:	0
Advanced Groundwater Method:	None

Random Numbers

Pseudo-random Seed:	10116
Random Number Generation Method:	Park and Miller v.3

Surface Options

Search Method:	Auto Refine Search
Divisions along slope:	20
Circles per division:	10
Number of iterations:	10
Divisions to use in next iteration:	50%
Number of vertices per surface:	12
Minimum Elevation:	Not Defined
Minimum Depth [ft]:	5
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Seismic Loading

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No

Loading

1 Distributed Load present

Distributed Load 1	
Distribution:	Constant
Magnitude [psf]:	250
Orientation:	Vertical

Materials

Property	Af	Qc	Tw
Color			
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	125	125	135
Cohesion [psf]	100	0	150
Friction Angle [°]	30	36	38
Water Surface	None	None	None
Ru Value	0	0	0

Global Minimums

Method: spencer

FS	1.511790
Axis Location:	111.290, 8650.056
Left Slip Surface Endpoint:	110.942, 8583.854
Right Slip Surface Endpoint:	164.043, 8610.057
Resisting Moment:	1.85396e+06 lb-ft
Driving Moment:	1.22633e+06 lb-ft
Resisting Horizontal Force:	24964.6 lb
Driving Horizontal Force:	16513.2 lb
Total Slice Area:	332.78 ft2
Surface Horizontal Width:	53.1007 ft
Surface Average Height:	6.26697 ft

Global Minimum Coordinates

Method: spencer

X	Y
110.942	8583.85
112.962	8583.92
115.237	8584.1
117.512	8584.39
119.87	8584.7
122.223	8585.18
124.619	8585.69
127.015	8586.36
129.41	8587.06
131.805	8587.93
134.424	8588.92
137.042	8590.1
139.661	8591.32
142.28	8592.73
144.898	8594.18
147.54	8595.84
150.181	8597.56
152.823	8599.43
154.942	8601.19
156.247	8602.25
157.578	8603.54
158.802	8604.68
159.89	8605.7
160.978	8606.69
162.066	8607.69
163.154	8608.88
164.043	8610.06

Valid/Invalid Surfaces

Method: spencer

Number of Valid Surfaces: 8214
Number of Invalid Surfaces: 10792

Error Codes:

Error Code -105 reported for 418 surfaces
Error Code -106 reported for 3625 surfaces
Error Code -108 reported for 32 surfaces
Error Code -109 reported for 2 surfaces
Error Code -111 reported for 5 surfaces
Error Code -115 reported for 6621 surfaces
Error Code -123 reported for 89 surfaces

Error Codes

The following errors were encountered during the computation:

-105 = More than two surface / slope intersections with no valid slip surface.
-106 = Average slice width is less than 0.0001 * (maximum horizontal extent of soil region). This limitation is imposed to avoid numerical errors which may result from too many slices, or too small a slip region.
-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).
-109 = Soiltype for slice base not located. This error should occur very rarely, if at all. It may occur if a very low number of slices is combined with certain soil geometries, such that the midpoint of a slice base is actually outside the soil region,even though the slip surface is wholly within the soil region.
-111 = safety factor equation did not converge
-115 = Surface too shallow, below the minimum depth.
-123 = Surface radius equal or less than the internal cutoff of 0.01.

Slice Data

Global Minimum Query (spencer) - Safety Factor: 1.51179

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	2.01916	135.915	1.97012	Af	100	30	109.138	164.993	112.571	0	112.571	116.326	116.326
2	2.25393	458.958	4.45886	Af	100	30	164.717	249.017	258.104	0	258.104	270.949	270.949
3	0.0212252	5.8004	4.45886	Af	100	30	194.663	294.289	336.519	0	336.519	351.698	351.698
4	0.0335153	9.21169	7.29157	Af	100	30	188.102	284.371	319.339	0	319.339	343.407	343.407
5	2.24164	756.309	7.29157	Af	100	30	213.767	323.171	386.542	0	386.542	413.895	413.895
6	2.35775	1093.37	7.3265	Af	100	30	265.485	401.358	521.969	0	521.969	556.103	556.103
7	2.35322	1368.64	11.6645	Af	100	30	295.462	446.677	600.46	0	600.46	661.457	661.457
8	2.39634	1647.93	12.0989	Af	100	30	334.086	505.068	701.596	0	701.596	773.212	773.212
9	2.39537	1877.59	15.5938	Af	100	30	353.343	534.181	752.022	0	752.022	850.636	850.636
10	2.39537	2079.74	16.3196	Af	100	30	380.016	574.504	821.865	0	821.865	933.131	933.131
11	2.3955	2252.47	19.8733	Af	100	30	386.676	584.573	839.304	0	839.304	979.075	979.075
12	2.6184	2623.73	20.7701	Af	100	30	402.674	608.758	881.195	0	881.195	1033.92	1033.92
13	2.61855	2755.54	24.185	Af	100	30	400.611	605.639	875.794	0	875.794	1055.71	1055.71
14	2.61855	2849.91	24.9986	Af	100	30	407.56	616.145	893.992	0	893.992	1084.03	1084.03
15	2.61855	2905.74	28.3257	Af	100	30	396.033	598.718	863.805	0	863.805	1077.28	1077.28
16	2.61855	2924.85	28.8973	Af	100	30	395.134	597.36	861.451	0	861.451	1079.55	1079.55
17	2.64155	2929.69	32.2631	Af	100	30	375.145	567.141	809.11	0	809.11	1045.93	1045.93
18	1.32077	1442.03	33.0253	Af	100	30	366.419	553.948	786.26	0	786.26	1024.45	1024.45
19	1.32077	1424.1	33.0253	Af	100	30	362.642	548.239	776.37	0	776.37	1012.1	1012.1
20	1.32077	1400.04	35.2307	Af	100	30	346.808	524.301	734.907	0	734.907	979.832	979.832
21	1.32077	1369.86	35.2307	Af	100	30	340.664	515.013	718.821	0	718.821	959.407	959.407
22	2.1188	2099.77	39.6916	Af	100	30	308.192	465.922	633.796	0	633.796	889.585	889.585
23	1.30586	1222.48	39.1691	Af	100	30	296.668	448.499	603.617	0	603.617	845.307	845.307
24	1.33028	1166.16	44.0816	Af	100	30	262.185	396.369	513.325	0	513.325	767.238	767.238
25	1.22477	911.567	42.9226	Af	100	30	235.367	355.826	443.104	0	443.104	661.994	661.994
26	1.08766	662.436	43.238	Af	100	30	202.396	305.98	356.769	0	356.769	547.084	547.084
27	1.08812	526.024	42.1659	Af	100	30	175.285	264.994	285.778	0	285.778	444.527	444.527
28	1.08813	390.541	42.7233	Af	100	30	144.345	218.22	204.764	0	204.764	338.071	338.071
29	1.08812	241.483	47.4422	Af	100	30	158.484	239.594	241.784	0	241.784	414.388	414.388
30	0.888693	65.6761	53.0553	Af	100	30	118.417	179.022	136.87	0	136.87	294.331	294.331

Interslice Data

Global Minimum Query (spencer) - Safety Factor: 1.51179

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	110.942	8583.85	0	0	0
2	112.962	8583.92	212.546	98.9651	24.9675
3	115.216	8584.1	538.438	250.707	24.9676
4	115.237	8584.1	542.013	252.371	24.9675
5	115.27	8584.11	546.948	254.669	24.9675
6	117.512	8584.39	915.263	426.163	24.9675
7	119.87	8584.7	1382.98	643.938	24.9675
8	122.223	8585.18	1786.55	831.85	24.9675
9	124.619	8585.69	2226.73	1036.8	24.9674
10	127.015	8586.36	2570.37	1196.81	24.9675
11	129.41	8587.06	2904.23	1352.26	24.9675
12	131.805	8587.93	3103.75	1445.16	24.9675
13	134.424	8588.92	3283.02	1528.63	24.9675
14	137.042	8590.1	3302.1	1537.52	24.9676
15	139.661	8591.32	3277.77	1526.19	24.9676
16	142.28	8592.73	3095.57	1441.35	24.9675
17	144.898	8594.18	2885.14	1343.37	24.9675
18	147.54	8595.84	2526.87	1176.56	24.9676
19	148.86	8596.7	2335.78	1087.58	24.9675
20	150.181	8597.56	2148.19	1000.24	24.9676
21	151.502	8598.49	1920.74	894.332	24.9676
22	152.823	8599.43	1700.19	791.638	24.9675
23	154.942	8601.19	1238.63	576.727	24.9675
24	156.247	8602.25	983.863	458.104	24.9675
25	157.578	8603.54	671.321	312.579	24.9675
26	158.802	8604.68	454.882	211.801	24.9675
27	159.89	8605.7	310.137	144.405	24.9675
28	160.978	8606.69	219.241	102.082	24.9674
29	162.066	8607.69	170.536	79.4047	24.9676
30	163.154	8608.88	56.4528	26.2854	24.9675
31	164.043	8610.06	0	0	0

Entity Information

Distributed Load

X	Y
162.104	8610.06
186.556	8610.04

External Boundary

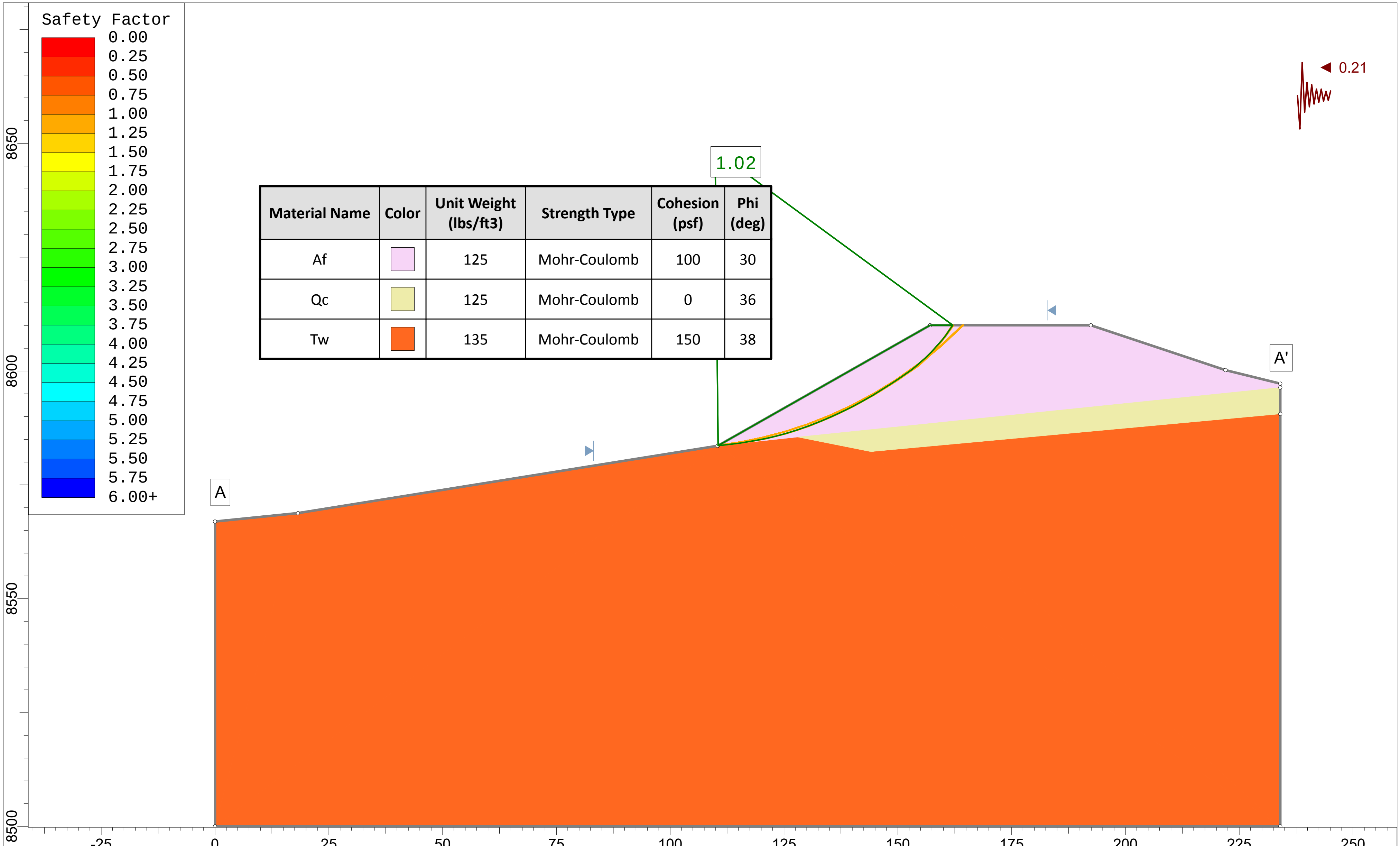
X	Y
234.016	8500
234.016	8590.58
234.016	8596.37
234.016	8597.22
221.947	8600.18
192.389	8610.03
157.101	8610.06
110.466	8583.58
110.42	8583.58
18.2366	8568.79
-3.43045e-06	8566.93
-3.43045e-06	8500

Material Boundary

X	Y
110.466	8583.58
128	8585.49
144.067	8582.27
234.016	8590.58

Material Boundary

X	Y
128	8585.49
234.016	8596.37



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Af		125	Mohr-Coulomb	100	30
Qc		125	Mohr-Coulomb	0	36
Tw		135	Mohr-Coulomb	150	38

IGES®	*Project* Lot 86R - Kingsbury		
	Analysis Description Method : Spencer		
	Drawn By EBF	*Scale* 1:350	*Company* IGES, Inc.
SLIDEINTERPRET 8.008	*Date* 07/01/2019		*File Name* A-A'.slim

Slide Analysis Information

Lot 86R - Kingsbury

Project Summary

Slide Modeler Version:	8.008

General Settings

Units of Measurement:	Imperial Units
Time Units:	seconds
Permeability Units:	feet/second
Data Output:	Standard
Failure Direction:	Right to Left

Analysis Options

Slices Type:	Vertical

Analysis Methods Used
Spencer

Number of slices:	30
Tolerance:	0.005
Maximum number of iterations:	50
Check malpha < 0.2:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Groundwater Analysis

Groundwater Method:	Water Surfaces
Pore Fluid Unit Weight [lbs/ft3]:	62.4
Use negative pore pressure cutoff:	Yes
Maximum negative pore pressure [psf]:	0
Advanced Groundwater Method:	None

Random Numbers

Pseudo-random Seed:	10116
Random Number Generation Method:	Park and Miller v.3

Surface Options

Search Method:	Auto Refine Search
Divisions along slope:	20
Circles per division:	10
Number of iterations:	10
Divisions to use in next iteration:	50%
Number of vertices per surface:	12
Minimum Elevation:	Not Defined
Minimum Depth [ft]:	5
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Seismic Loading

Advanced seismic analysis: No
Staged pseudostatic analysis: No

Seismic Load Coefficient (Horizontal): 0.21

Materials

Property	Af	Qc	Tw
Color			
Strength Type	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	125	125	135
Cohesion [psf]	100	0	150
Friction Angle [°]	30	36	38
Water Surface	None	None	None
Ru Value	0	0	0

Global Minimums

Method: spencer

FS	1.017770
Axis Location:	109.853, 8648.375
Left Slip Surface Endpoint:	110.525, 8583.617
Right Slip Surface Endpoint:	162.063, 8610.059
Resisting Moment:	1.53272e+06 lb-ft
Driving Moment:	1.50596e+06 lb-ft
Resisting Horizontal Force:	21184.2 lb
Driving Horizontal Force:	20814.3 lb
Total Slice Area:	301.456 ft2
Surface Horizontal Width:	51.5373 ft
Surface Average Height:	5.84929 ft

Global Minimum Coordinates

Method: spencer

X	Y
110.525	8583.62
112.235	8583.78
115.247	8584.14
118.302	8584.65
120.515	8585.05
122.778	8585.6
125.075	8586.17
127.461	8586.93
130.076	8587.8
132.857	8588.9
135.15	8589.84
137.443	8590.91
139.736	8592.02
142.029	8593.27
144.323	8594.55
146.337	8595.81
148.351	8597.07
150.365	8598.41
153.164	8600.36
154.608	8601.61
156.052	8602.86
157.307	8604.1
158.684	8605.63
159.908	8607.02
160.626	8607.97
161.344	8609.02
162.063	8610.06

Valid/Invalid Surfaces

Method: spencer

Number of Valid Surfaces: 6022
Number of Invalid Surfaces: 12985

Error Codes:

Error Code -105 reported for 559 surfaces
Error Code -106 reported for 4260 surfaces
Error Code -108 reported for 29 surfaces
Error Code -109 reported for 5 surfaces
Error Code -111 reported for 1490 surfaces
Error Code -115 reported for 6552 surfaces
Error Code -123 reported for 90 surfaces

Error Codes

The following errors were encountered during the computation:

-105 = More than two surface / slope intersections with no valid slip surface.
-106 = Average slice width is less than 0.0001 * (maximum horizontal extent of soil region). This limitation is imposed to avoid numerical errors which may result from too many slices, or too small a slip region.
-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).
-109 = Soiltype for slice base not located. This error should occur very rarely, if at all. It may occur if a very low number of slices is combined with certain soil geometries, such that the midpoint of a slice base is actually outside the soil region,even though the slip surface is wholly within the soil region.
-111 = safety factor equation did not converge
-115 = Surface too shallow, below the minimum depth.
-123 = Surface radius equal or less than the internal cutoff of 0.01.

Slice Data

Global Minimum Query (spencer) - Safety Factor: 1.01777

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.70911	86.5299	5.36031	Af	100	30	180.86	184.073	145.619	0	145.619	162.589	162.589
2	3.01287	558.199	6.93493	Af	100	30	261.386	266.031	287.574	0	287.574	319.367	319.367
3	1.5273	469.804	9.44526	Af	100	30	319.738	325.42	390.439	0	390.439	443.631	443.631
4	1.5273	586.853	9.44526	Af	100	30	365.483	371.978	471.08	0	471.08	531.882	531.882
5	2.21321	1054.31	10.1371	Af	100	30	413.394	420.74	555.537	0	555.537	629.45	629.45
6	2.26253	1303.26	13.6921	Af	100	30	433.49	441.193	590.963	0	590.963	696.573	696.573
7	2.29718	1534.05	13.9184	Af	100	30	479.768	488.293	672.543	0	672.543	791.438	791.438
8	2.38619	1791.46	17.7214	Af	100	30	480.659	489.2	674.114	0	674.114	827.71	827.71
9	1.3072	1055.08	18.3131	Af	100	30	501.21	510.117	710.343	0	710.343	876.23	876.23
10	1.3072	1105.66	18.3131	Af	100	30	519.521	528.753	742.622	0	742.622	914.569	914.569
11	1.39089	1223.84	21.7229	Af	100	30	498.015	506.865	704.709	0	704.709	903.123	903.123
12	1.39089	1264.8	21.7229	Af	100	30	510.86	519.938	727.351	0	727.351	930.882	930.882
13	2.29249	2170.48	22.2608	Af	100	30	521.274	530.537	745.71	0	745.71	959.084	959.084
14	2.29294	2256.18	25.0185	Af	100	30	507.53	516.549	721.482	0	721.482	958.347	958.347
15	2.29294	2317.85	25.6978	Af	100	30	511.273	520.358	728.081	0	728.081	974.116	974.116
16	2.29356	2354.45	28.5854	Af	100	30	488.298	496.975	687.581	0	687.581	953.648	953.648
17	2.29356	2364.35	29.2753	Af	100	30	483.226	491.813	678.639	0	678.639	949.539	949.539
18	2.01403	2063.46	32.0552	Af	100	30	455.248	463.338	629.318	0	629.318	914.4	914.4
19	2.01403	2033.84	32.0552	Af	100	30	450.174	458.174	620.376	0	620.376	902.28	902.28
20	2.01453	1995.58	33.5138	Af	100	30	431.095	438.756	586.743	0	586.743	872.228	872.228
21	1.39914	1353.34	34.936	Af	100	30	411.79	419.107	552.709	0	552.709	840.363	840.363
22	1.39914	1321.34	34.936	Af	100	30	404.391	411.577	539.668	0	539.668	822.153	822.153
23	1.44395	1308.98	40.7202	Af	100	30	350.815	357.049	445.221	0	445.221	747.185	747.185
24	1.44395	1231.86	40.9127	Af	100	30	334.415	340.358	416.313	0	416.313	706.122	706.122
25	1.25521	993.677	44.7828	Af	100	30	294.374	299.605	345.726	0	345.726	637.876	637.876
26	1.37679	893.85	48.0192	Af	100	30	242.287	246.592	253.905	0	253.905	523.174	523.174
27	1.22477	571.689	48.5552	Af	100	30	196.83	200.328	173.774	0	173.774	396.682	396.682
28	0.717899	230.003	53.0261	Af	100	30	150.596	153.273	92.2711	0	92.2711	292.309	292.309
29	0.71823	140.457	55.4326	Af	100	30	119.943	122.074	38.2331	0	38.2331	212.311	212.311
30	0.71823	46.8191	55.4326	Af	100	30	94.3567	96.0334	-6.87034	0	-6.87034	130.074	130.074

Interslice Data

Global Minimum Query (spencer) - Safety Factor: 1.01777

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	110.525	8583.62	0	0	0
2	112.235	8583.78	267.586	191.387	35.5737
3	115.247	8584.14	832.503	595.435	35.5737
4	116.775	8584.4	1122.98	803.192	35.5736
5	118.302	8584.65	1438.25	1028.68	35.5735
6	120.515	8585.05	1911.94	1367.48	35.5735
7	122.778	8585.6	2293.29	1640.24	35.5737
8	125.075	8586.17	2690.39	1924.26	35.5737
9	127.461	8586.93	2947.11	2107.87	35.5736
10	128.768	8587.36	3073.39	2198.2	35.5737
11	130.076	8587.8	3199.03	2288.05	35.5736
12	131.466	8588.35	3244.19	2320.36	35.5737
13	132.857	8588.9	3286.07	2350.31	35.5737
14	135.15	8589.84	3325.52	2378.53	35.5737
15	137.443	8590.91	3243.39	2319.78	35.5736
16	139.736	8592.02	3125.59	2235.53	35.5737
17	142.029	8593.27	2891.8	2068.32	35.5737
18	144.323	8594.55	2631.01	1881.79	35.5737
19	146.337	8595.81	2320.86	1659.96	35.5737
20	148.351	8597.07	2018	1443.34	35.5736
21	150.365	8598.41	1684.62	1204.9	35.5737
22	151.765	8599.39	1436.37	1027.34	35.5736
23	153.164	8600.36	1197.24	856.306	35.5736
24	154.608	8601.61	875.555	626.227	35.5737
25	156.052	8602.86	578.792	413.972	35.5737
26	157.307	8604.1	308.939	220.964	35.5737
27	158.684	8605.63	66.3049	47.4236	35.5737
28	159.908	8607.02	-53.7093	-38.4147	35.5736
29	160.626	8607.97	-81.8851	-58.5671	35.5737
30	161.344	8609.02	-65.0891	-46.5539	35.5736
31	162.063	8610.06	0	0	0

Entity Information

External Boundary

X	Y
234.016	8500
234.016	8590.58
234.016	8596.37
234.016	8597.22
221.947	8600.18
192.389	8610.03
157.101	8610.06
110.466	8583.58
110.42	8583.58
18.2366	8568.79
-3.43045e-06	8566.93
-3.43045e-06	8500

Material Boundary

X	Y
110.466	8583.58
128	8585.49
144.067	8582.27
234.016	8590.58

Material Boundary

X	Y
128	8585.49
234.016	8596.37