Intermountain GeoEnvironmental Services, Inc.
12429 South 300 East, Suite 100, Draper, Utah 84020
Phone (801) 748-4044 | Fax (801) 748-4045
www.igesinc.com

GEOTECHNICAL INVESTIGATION
Summit Eden Phases 1E, 1F, and 1G
Summit at Powder Mountain Resort
Weber County, Utah

IGES Project No. 01628-011

September 30, 2015

Prepared for:

Summit Mountain Holding Group

IGES®

Intermountain GeoEnvironmental Services, Inc.
12429 South 300 East, Suite 100, Draper, Utah 84020 ~ T: (801) 748-4044 ~ F: (801) 748-4045

Prepared for:

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

GEOTECHNICAL INVESTIGATION
SUMMIT EDEN PHASES 1E, 1F, AND 1G
SUMMIT AT POWDER MOUNTAIN RESORT
WEBER COUNTY, UTAH

IGES Project No. 01628-011

Prepared by:

PROFESSIONAL ENGINEER
No. 6370734
DAVID A. GLASS
09-30-15
ELECTRONIC SEAL
STATE OF UTAH

David Glass

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

Reviewed by:

Jared A. Hawes, P.E.
Senior Geotechnical Engineer

IGES, Inc.
12429 South 300 East, Suite 100
Draper, Utah 84020
(801) 748-4044

September 30, 2015

TABLE OF CONTENTS

APPENDICES

1.0 EXECUTIVE SUMMARY

This report presents the results of a geotechnical investigation conducted for the *Summit Eden Phase 1E, 1F, and 1G* development, a part of the greater Summit at Powder Mountain resort expansion project in Weber County, Utah. Based on the subsurface conditions encountered across the property, it is our opinion that the property is suitable for development provided that the recommendations presented in this report are incorporated into the design and construction of the project.

- Based on our observations, the site is generally covered by topsoil ranging in depth from a few inches to as much as three feet. The topsoil is generally underlain by coarse colluvium of varying thickness, which in turn is underlain by bedrock consisting of dolomite. At several locations the bedrock was observed on the surface (bedrock outcrops).
- No recent landslide-related features, faults or other adverse geologic structures were identified during our investigation.
- Based on our field observations and considering the presence of coarse surficial soils overlying relatively hard bedrock over the majority of the site, we recommend that the footings residential structures be founded either *entirely* on bedrock, *entirely* on colluvium, or *entirely* on a minimum of 2 feet of structural fill. Bedrock/soil or fill/native transition zones are not allowed. If the foundation excavation exposes two different earth materials (e.g., partially on colluvium, partially on bedrock), then the footings should be deepened such that all footings bear on competent bedrock. Alternatively, the building pad may be over-excavated a minimum of 2 feet below the bottom of proposed footings and replaced with structural fill, such that the footings bear entirely on a uniform fill blanket.
- Shallow spread or continuous wall footings constructed on competent coarse native colluvium may be proportioned utilizing a maximum net allowable bearing pressure of **3,500 pounds per square foot (psf)**. However, if the foundations are underlain by a minimum of 2 feet of structural fill or competent native soils, a maximum net allowable bearing pressure of **2,600 psf** should be used for design. The net allowable bearing values presented above are for dead load plus live load conditions.
- Pavement for the main access road may consist of 4 inches of asphalt over 5 inches of roadbase over 4 inches of granular borrow (subbase). Where bedrock is exposed, the granular borrow section may be deleted.

NOTE: The scope of services provided within this report are limited to the assessment of the subsurface conditions at the subject site. The executive summary is provided solely for purposes of overview and is not intended to replace the report of which it is part and should not be used separately from the report.

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical investigation conducted for the *Summit Eden Phase 1E, 1F, and 1G* development, a part of the greater Summit at Powder Mountain resort expansion project in Weber County, Utah. The purposes of this investigation were to assess the nature and engineering properties of the subsurface soils across the site and to provide recommendations for general site grading and design and construction of roadways, earth retention (walls, rockeries), foundations, slab-on-grades, exterior concrete flatwork, and to provide a preliminary assessment of geologic hazards that may impact the site.

The scope of work completed for this study included subsurface exploration, soil sampling, laboratory testing, engineering analyses, and preparation of this report. Our services were performed in accordance with our proposal dated May 20, 2015 and your signed authorization. The recommendations contained in this report are subject to the limitations presented in the "Limitations" section of this report (Section 7.1).

2.2 PROJECT DESCRIPTION

The Summit at Powder Mountain project consists of developing approximately 200 of 2,000 acres of lightly forested land just south of the existing ski resort. Powder Mountain is undergoing a major expansion that will include golf courses, ski lifts, residential, and commercial property development. Site development will include site infrastructure such as roads and bridges, retaining structures, and associated underground utilities. IGES has previously completed a geotechnical investigation for the project as a whole, as well as provided recommendations and construction observation services for several individual structures currently being developed or in planning stages.

We understand that Phase 1E will include six large estate lots and associated infrastructure including roadways and utilities over an approximately 100-acre site. The site is on a hillside with a natural gradient generally ranging between 3.5H:1V to 4H:1V; as such, access roads will be constructed with a series of cuts and fills, necessitating a series of cut slopes and fill slopes ranging in height up to 30 feet. Construction drawings prepared by NV5 illustrate a 20-foot tall, 3-tiered rockery near the entrance to the project area; this rockery is expected to have an area of roughly 10,000 square feet. The tallest rockery planned will have four tiers, accommodating a 30-foot grade change. In addition, seven smaller rockeries are planned along the private drives to accommodate various utilities.

3.0 METHODS OF STUDY

3.1 LITERATURE REVIEW

The earliest geotechnical report for the area is by AMEC (2001), which was a reconnaissance-level geotechnical and geologic hazard study. IGES later completed a geotechnical investigation for the Powder Mountain Resort expansion in 2012 (2012a, 2012b). Our previous work included twenty-two test pits and one soil boring excavated at various locations across the 200-acre development; however, neither the report by AMEC nor the reports by IGES included subsurface exploration within the Eden Phase 1E project area.

Western Geologic (2012) completed a geologic hazard study for the greater 200-acre Powder Mountain expansion project – this report was reviewed to assess the potential impact of geologic hazards on the Eden Phase 1E project area. The report indicates that portions of the project area, including Lot 9 and a part of Lot 10R, are located in an area mapped as “mass movement deposits” and are described as “mixed slope colluvium, shallow landslides, and talus.” The balance of the site to the east is mapped as undivided Cambrian bedrock consisting largely of dolomite.

3.2 FIELD INVESTIGATION

Our field investigation was conducted on June 16 and June 17, 2015. Seventeen test pits were excavated to depths generally ranging from 8 feet to 11 feet below existing grade, although some test pits were deeper, or shallower, as soil conditions allowed. The test pits were excavated with the aid of a CAT 315C tracked excavator. In sixteen of the seventeen test pits we encountered bedrock consisting of dolomite. The *Geotechnical Map*, Figure A-2 in Appendix A, shows the approximate locations of the test pits. The test pits were located to provide representative coverage of the proposed roadway alignment, and to provide an assessment of subsurface conditions within the buildable envelope on the six lots. Subsurface conditions as encountered in the test pits were logged at the time of our investigation by a member of our technical staff and are presented on the attached *Test Pit Logs*, Figures A-3 through A-19, in Appendix A. A *Key to Soil Symbols and Terminology* is presented as Figure A-20 and a *Key to Physical Rock Properties* is presented as Figure A-21.

Bulk soil samples were obtained in the test pit explorations; due to the coarse, rocky nature of the prevailing overburden soils, only bulk samples of the native colluvial deposits could be obtained. All samples were transported to our laboratory for testing to evaluate engineering properties of the earth materials observed.

3.3 LABORATORY INVESTIGATION

Geotechnical laboratory tests were conducted on selected bulk soil samples obtained during our field investigation. The laboratory testing program was designed to evaluate the engineering characteristics of onsite earth materials and consisted primarily of index testing to assess soil types. Laboratory tests conducted during this investigation include:

- In situ moisture content (ASTM D7263)
- Atterberg Limits (ASTM D4318)
- Fines Content (% passing the #200 sieve) (ASTM D1140)
- Gradation (ASTM D6913)
- Water-soluble sulfate concentration for cement type recommendations, water-soluble chloride concentration, resistivity and pH to evaluate corrosion potential of ferrous metals in contact with site soils (AASHTO T288, AASHTO T289, ASTM D4327 and C1580)
- California Bearing Ratio (CBR) (ASTM D1883)
- Modified Proctor (ASTM D1557)

Results of the laboratory testing are included with this report in Appendix B.

3.4 ENGINEERING ANALYSIS

Engineering analyses were performed using soil data obtained from the laboratory test results and empirical correlations from index testing, depositional characteristics and classification. Appropriate factors of safety were applied to the results consistent with industry standards and the accepted standard of care.

4.0 GENERALIZED SITE CONDITIONS

4.1 SURFACE CONDITIONS

The site is in a relatively natural state and is currently vegetated with a variety of native flora, including several stands of mature trees (pines and aspens primarily), sage brush, and numerous native shrubs and grasses. The project area is on the side of a mountain hillside; maximum topographic relief across the site is roughly 500 feet, with a typical site gradient of about 3H:1V. The site drains to the southwest toward the Wolf Creek drainage. The topography of the site appears to be unaltered by past grading activities, with the exception of the rough track-road created during the subsurface exploration. Several bedrock outcrops were observed throughout the site; where observed, these outcrops were noted on Figure A-2. It should be noted that additional bedrock outcrops are likely present; only bedrock outcrops observed are identified on the figure, a comprehensive mapping of bedrock outcrops was not performed and is beyond our scope of services.

4.2 SUBSURFACE CONDITIONS

The subsurface soils were investigated by excavating seventeen test pits at representative locations across the site. Generally, the depth of exploration trenches ranged from 8 feet to 11 feet below existing grade, although some test pits were deeper, or shallower, as soil conditions allowed. The locations of the trenches are illustrated on Figure A-2, *Geotechnical Map*; detailed test pits are presented on Figures A-3 through A-19. The earth materials encountered in the test pits were visually classified and logged by a member of our technical staff. The subsurface conditions encountered during our investigation are discussed in the following paragraphs:

4.2.1 Earth Materials

Based on our observations, the site is generally covered by topsoil ranging in depth from a few inches to as much as three feet. The topsoil is generally underlain by coarse colluvium of varying thickness, which in turn is underlain by bedrock consisting of dolomite. Descriptions of the geologic units encountered are presented in the following paragraphs:

Topsoil: Topsoil was encountered throughout the site and consisted of a variety of soils ranging from lean clay to silty/clayey sand; in all cases, the topsoil encountered was characterized by an abundance of organic matter (roots, etc.), a dark, loamy appearance, and in many instances was poorly developed and had a rocky texture. The thickness of topsoil observed ranged from zero (at bedrock outcrops) to as much as 3 feet. Localized areas of deeper topsoil deposits may exist, particularly in shallow drainages with relatively moderate slope.

Colluvium: Underlying the topsoil, the soils generally consisted of coarse, rocky colluvium. The colluvium generally consisted of loose to medium dense silty/clayey gravel with cobbles and boulders to 18 inches; at a few locations, boulders to 3 feet in diameter were observed. The colluvium was generally clast-supported, although not in all cases. The rocks observed were generally subangular to angular, largely derived from the underlying bedrock unit. The colluvium did not appear to be particularly difficult to excavate with the equipment used (CAT 315C tracked excavator).

<u>Bedrock</u>: The underlying bedrock unit consist of undifferentiated Cambrian-age dolomite (Ꞓr) (Western Geologic, 2012). As encountered, the bedrock was moderately to highly weathered, closely fractured, generally had a bluish-gray fresh surface, and reacted weakly to dilute HCl. The dolomite generally appeared to be homogenous and isotropic – bedding was not observed, and there did not appear to be a distinct jointing pattern with the exception of the exposed outcrop on Lot 2. This rock unit is fairly hard – samples could only be reduced with a firm blow from a rock hammer. Excavation in this unit was usually difficult and time-consuming, the bedrock becoming increasingly competent with depth.

<u>Mass Movement Deposits</u>: The eastern portion of the site is mapped as “mass movement deposits” (Qm) consisting of “mixed slope colluvium, shallow landslides, and talus.” This area is delineated on the *Geotechnical Map* (Figure A-2) and in the geologic map presented in the report by Western Geologic (2012). The soils observed in Test Pit 1 were described by IGES as ‘chaotic’, a term that is often associated with either landslide materials, or debris flow deposits. The term ‘chaotic’ was also used to describe colluvium deposits identified in TP-06 and TP-14, both of which are located outside of the mapped Qm area. Geomorphic expressions of landslides were not observed by IGES in these areas, and were not identified by Western Geologic (2012); as such, these deposits are currently thought to be localized debris flow/flood deposits.

The lines shown on the enclosed logs represent the approximate boundary between the different earth materials. Due to the nature and deposition characteristics of natural earth materials, care should be taken in interpolating subsurface conditions between and beyond the exploration locations.

4.2.2 Groundwater

Groundwater was not encountered in any of the test pits completed during this investigation, and is not expected to impact the development. Due to the season of our investigations (summer), we anticipate groundwater levels to be below their seasonal low. It is our experience that during snowmelt, runoff, irrigation on the property and surrounding properties, high precipitation events, and other activities the groundwater level can rise several feet. Fluctuations in the groundwater level should be expected over time.

4.3 SLOPE STABILITY

4.3.1 Stability of Natural Slopes

In aggregate, the project area consists of a natural mountain slope with an approximate average gradient of 3H:1V. Earth materials generally consist of hard, relatively intact bedrock consisting of dolomite; IGES did not observe adverse geologic conditions such as out-of-slope bedding or jointing patterns, groundwater, seeps or springs, or other conditions that would adversely impact slope stability. The dolomite unit is overlain by surficial materials (colluvium) to depths of up to 13 feet, but is generally on the order of 4 to 8 feet. Deeper colluvial deposits may occur locally but is not expected to be wide-spread.

In consideration of the forgoing, the project site is not expected to be impacted by large-scale slope instability (e.g., deep-seated failures or project-wide instability).

4.3.2 Surficial Stability

Our subsurface investigation indicates that the near-surface soils consist largely of topsoil underlain by coarse, angular, rocky colluvium. IGES assessed the potential for the overlying surficial soils to become mobilized under saturated parallel seepage conditions, which could occur during spring run-off or a particularly wet/rainy period. Our assessment is based on an infinite slope analysis and assumes three feet of saturation, with varying slope geometries intended to model both natural slopes and engineered slopes (it is presumed that any slope steeper than about 2.5H:1V is either a fill or cut slope). Considering that the overlying surficial soils generally consist of angular, coarse, clast-supported colluvium, our model assumes an effective friction angle of 44 degrees, a cohesion of 0 psf, and a saturated unit weight of 140 pcf. For fill slopes, it is presumed that the fill will consist of processed on-site material that will be fairly coarse, with abundant angular gravel; for engineered slopes, our model assumes an effective friction angle of 36 degrees and a cohesion of 50 psf (apparent cohesion), and a saturated unit weight of 135 pcf. A sample calculation is presented in Appendix C. The results of our analysis are summarized in Table 4.3.2:

Table 4.3.2
Infinite Slope Stability Analysis Summary

Slope Gradient	Factor of Safety	
	Natural or Cut Slopes	Fill Slope
3H:1V (18.4°)	1.61	1.59
2.5H:1V (21.8°)	1.34	1.33
2H:1V (26.6°)	1.07	1.09
1.5H:1V (33.7°)	0.80	0.85

This analysis suggests that slopes with gradients of 2.5H:1V or flatter should perform reasonably well during periods of saturation. The analysis also indicates that slopes of 2H:1V, both cut an fill, will be stable but only marginally so. Based on the analysis, a 1.5H:1V slope is expected to experience distress under saturated conditions. This analysis is considered somewhat conservative for *natural slopes*, as the analysis does not take into account the stabilizing effect of tree and plant roots, and conservatively neglects apparent cohesion. However, for cut slopes, and particularly fill slopes, this does not apply.

It should be noted that several cut slopes have been constructed throughout the greater Powder Mountain expansion project within the past two years, primarily for road cuts. In general, where cut slopes have maintained a 2H:1V gradient or flatter, the slopes have performed well. However, where 1.5H:1V cut slopes have been constructed, slope stability issues have occurred, particularly in the spring. Instability issues with fill slopes are not known to have occurred.

4.3.3 Stability of Engineered Slopes and Rockeries

The stability of specific engineered slopes, both fill and cut, and the rockeries will be addressed in a separate submittal.

5.0 GEOLOGIC CONDITIONS

5.1 GEOLOGY AND GEOLOGIC HAZARDS

Geology and geologic hazards have been previously addressed by Western Geologic in a separate submittal (Western Geologic, 2012). The report by Western Geologic indicates that the eastern portion of the project area is mapped as “mass movement deposits” (Qm) consisting of “mixed slope colluvium, shallow landslides, and talus.” This area is delineated on the *Geotechnical Map* (Figure A-2) and in the geologic map presented in the report by Western Geologic (2012). The area to the east is mapped as as undivided Cambrian bedrock consisting largely of dolomite.

Specific geologic hazards are addressed in the following paragraphs:

5.1.1 Landslides

During our subsurface investigation, potentially adverse geologic structures (e.g., evidence of landslides) were not evident in the test pits. Also, geomorphic expressions of shallow, surficial landslides were not observed within the site. Within TP-01, TP-06, and TP-14, some jumbled, chaotic soil textures were identified within the upper four feet, which are presumed to be associated with past debris flow deposition owing to the lack of obvious signs of past landslide activity (see Section 5.1.5). Based on currently available data and our observations, the potential for existing landslides impacting the site is considered low.

5.1.2 Liquefaction

The site is underlain by a bedrock unit comprised of hard, moderately weathered dolomite. Where surficial soil units exist, the soil generally consists of clast-supported silty/clayey gravel. Groundwater was not observed during our subsurface exploration, nor were seeps or springs observed. Liquefaction occurs in loose, saturated sand and some silts, whereas bedrock does not liquefy. Based on our current understanding of the geologic and hydrologic conditions within the project site, the potential for the site to be affected by liquefaction is low.

5.1.3 Rockfall

IGES observed that there are no cliffs or exposed outcrops on steep slopes or other geomorphic features that would result in a rock fall hazard at the site; therefore, the rock fall hazard is considered low.

5.1.4 Surface Fault Rupture

An active fault is generally defined as a fault that has experienced movement with the Holocene (11,000 years before present) (Stokes 1986). There are no known active faults that pass though the subject site (Coogan and King, 2001, Western Geologic, 2012). Therefore the risk associated with surface fault rupture is considered low.

5.1.5 Debris Flow and Flooding

Debris flow is a potential hazard that may exist on areas containing Holocene deposits. This type of flooding typically occurs as a debris flood consisting of a mixture of soil, organic material, and rock debris transported by fast-moving flood water. Similar to stream flooding, debris floods and debris flows can occur as a result of runoff from spring snowmelt and cloudburst rainstorms. Landslides can also mobilize a debris flow.

Debris flows have not been mapped on the site (Elliott and Harty, 2010). Subsurface data collected for this site indicates that the site are covered with a relatively thin veneer of topsoil (½ to 3 feet), underlain by coarse colluvium likely deposited as slope wash or consisting of in-place decomposed bedrock. Within TP-01, TP-06, and TP-14, some jumbled, chaotic soil textures were identified within the upper four feet, which are presumed to be associated with past debris flow deposition owing to the lack of obvious signs of past landslide activity and the relatively shallow nature of these jumbled deposits. Due to the limited evidence of debris flows deposits observed and the prevailing topography, we anticipate any fan-style debris flow would be relatively small and consist mainly of a thin sheet-flow of mud and water. While this hazard could cause flooding of basements and damage to landscaping, sheet-flow flooding would not pose a significant hazard to structures or human life. This hazard can be minimized by proper site grading and drainage design.

5.2 SEISMICITY

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

To account for site effects, site coefficients that vary with the magnitude of spectral acceleration and *Site Class* are used. Site Class is a parameter that accounts for site amplification effects of soft soils and is based on the average shear wave velocity of the upper 100 feet; based on our field exploration and our understanding of the geology in this area, the subject site is appropriately classified as Site Class B (*rock*). Based on IBC criteria, the short-period (F_a) and long-period (F_v) site coefficients are both 1.0. Based on the design spectral response accelerations for a *Building Risk Category* of I, II, III, or IV, the site's *Seismic Design Category* is D. The short- and long-period *Design Spectral Response Accelerations* are presented in Table 5.2; a summary of the

Design Maps analysis is presented in Appendix D. The *peak ground acceleration* (PGA) may be taken as $0.4{*}S_{MS}$.

Table 5.2
Short- and Long-Period Spectral Accelerations for MCE

Parameter	Short Period (0.2 sec)	Long Period (1.0 sec)
MCE Spectral Response Acceleration (g)	$S_S = 0.841$	$S_1 = 0.280$
MCE Spectral Response Acceleration Site Class B (g)	$S_{MS} = S_sF_a = 0.841$	$S_{M1} = S_1F_v = 0.280$
Design Spectral Response Acceleration (g)	$S_{DS} = S_{MS}{*}{}^2/_3 = 0.561$	$S_{D1} = S_{M1}{*}{}^2/_3 = 0.187$

6.0 ENGINEERING CONCLUSIONS AND RECOMMENDATIONS

6.1 GENERAL CONCLUSIONS

Based on the subsurface conditions encountered at the site, it is our opinion that the subject site is suitable for the proposed development provided that the recommendations presented in this report are incorporated into the design and construction of the project. Due to the presence of shallow bedrock at the site, heavy duty excavators may be required for the foundation and utility excavations, and potentially for some of the roadway cuts; some isolated areas may require heavy duty rippers. The foundation for residential structures may consist of conventional shallow spread footings founded either entirely on competent native earth materials or entirely on a zone of structural fill at least 2 feet thick. Building foundations over a bedrock/soil transition zone is not allowed.

The following sub-sections present our recommendations for general site grading, roadway design, design of foundations, slabs-on-grade, lateral earth pressures and soil corrosion.

6.2 EARTHWORK

General site grading is recommended to provide proper support for pavement, foundations, exterior concrete flatwork and concrete slabs-on-grade. Site grading is also recommended to provide proper drainage and moisture control on the subject property and to aid in preventing differential settlement of foundations as a result of variations in subgrade conditions.

6.2.1 General Site Preparation and Grading

Below proposed structures, fills, and man-made improvements, all vegetation, topsoil, debris and undocumented fill (if any) should be removed. Any existing utilities should be re-routed or protected in-place. Tree roots will be encountered and should be grubbed-out and replaced with engineered fill if exposed in any foundation excavation or pavement subgrade. Foundation excavations should be assessed for soft or loose soils; any soft/loose areas should be compacted in place if the depth of the problem area is less than 12 inches or removed and replaced with structural fill as recommended in this report.

6.2.2 Excavations

Loose or otherwise unsuitable soils beneath foundations or concrete flatwork may need to be over-excavated and replaced with structural fill. If over-excavation is required, the excavations should extend a minimum of 1 foot laterally for every foot of depth of over-excavation. Excavations should extend laterally at least two feet beyond slabs-on-grade. Structural fill should consist of granular materials and should be placed and compacted in accordance with the recommendations presented in this report.

Prior to placing engineered fill, all excavation bottoms should be scarified to at least 6 inches, moisture-conditioned as necessary to at or slightly above optimum moisture content (OMC) and compacted to at least 95 percent of the maximum dry density (MDD) as determined by ASTM D-1557 (modified Proctor). The scarification recommendation need not apply where competent bedrock or particularly rocky soil is exposed.

6.2.3 Excavation Stability

The contractor is responsible for site safety, including all temporary slopes and trenches excavated at the site and design of any required temporary shoring. The contractor is responsible for providing the "competent person" required by OSHA standards to evaluate soil conditions. Based on our observations, soil types are expected to consist primarily of *Type C* soils (sand and gravel), although it is likely that shallow bedrock will be encountered locally. Close coordination between the competent person and IGES should be maintained to facilitate construction while providing safe excavations.

Based on Occupational Safety and Health (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. Sloping of the sides at 1.5H:1V (33.7 degrees) in *Type C* soils may be used as an alternative to shoring or shielding. Near-vertical cuts greater than 5 feet may be feasible within the prevailing bedrock, subject to approval by IGES or the OSHA “competent person” upon site inspection. If surficial soils are exposed in the temporary trenches, the sides should be laid-back at 1.5H:1V or shored, unless otherwise directed by IGES or the OSHA “competent person”.

6.2.4 Structural Fill and Compaction

All fill placed for the support of structures, flatwork or pavements, should consist of structural fill. Structural fill may consist of excavated onsite soils and/or bedrock, or an approved imported granular soil. Structural fill should be free of vegetation and debris, and contain no rocks larger than 4 inches in nominal size (6 inches in greatest dimension). Soils not meeting the aforementioned criteria may be suitable for use as structural fill but must be approved by IGES prior to use.

All structural fill should be placed in maximum 8-inch loose lifts if compacted by small hand-operated compaction equipment, maximum 10-inch loose lifts if compacted by light-duty rollers, and maximum 12-inch loose lifts if compacted by heavy duty compaction equipment that is capable of efficiently compacting the entire thickness of the lift. These values are *maximums*; the Contractor should be aware that thinner lifts may be necessary to achieve the required compaction criteria. We recommend that all structural fill be compacted on a horizontal plane, unless otherwise approved by IGES. Structural fill placed beneath 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 – compacting dry of optimum is discouraged. Any imported fill materials should be approved by IGES prior to importing. Also, prior to placing any fill, the excavations should be observed by IGES to assess whether 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.

In addition, all utility trenches backfilled below pavement sections, curb and gutter and concrete flatwork, should be backfilled with structural fill compacted to at least 95 percent of the MDD as determined by ASTM D-1557. All other trenches, including landscape areas, should be backfilled and compacted to approximately 90 percent of the MDD (ASTM D-1557).

Backfill around basement walls should be compacted to approximately 90 percent MDD as determined by ASTM D-1557. Failure to properly water-condition and compact basement wall backfill may result in settlements of several inches should the backfill become wet. Only small compaction equipment should be used near basement walls.

Specifications from governing authorities having their own precedence for backfill and compaction should be followed where applicable.

6.2.5 Oversized Material

If desired, oversize material (cobbles and boulders, at least 6 inches in greatest dimension) may be included in structural fill if they are placed in a manner that will not result in voids, loose soils, or uncompacted soils. These oversized particles should not be placed within 5 feet of the top of any embankment or within 5 feet of the outer slope of the embankment. If oversized particles are used in structural fill as discussed above, it is imperative that the contractor place and compact fill around oversized particles in accordance with the recommendations presented in the previous paragraphs. In addition to these recommendations, it is likely that the contractor will be required to use small compaction equipment such as hand operated jumping jack compactors to compact the structural fill within 2-feet of the oversized particle. We also recommend that a qualified geotechnical engineer or technician observe placement and compaction around oversized particles. Alternatively, the oversize particles may be crushed and incorporated into the structural fill.

6.2.6 Erosion Control

Consideration should be given to the use of erosion control fabrics/waddles to facilitate the growth of vegetation on all cut and fill slopes. We recommend that the contractor give consideration to covering embankment fill, fill slopes, or cut slopes with topsoil that was removed during clearing and grubbing activities. The surface of the slope should be rough so that when the topsoil is placed, it will not be easily eroded and transported during snowmelt or wet seasons. The topsoil should be placed in a single 4-inch thick lift and track-walked with a dozer or hoe. Topsoil should be placed on slopes that are no steeper than 2H:1V. The track marks left by the dozer should not be flattened and should serve as areas to collect water and seeds to aid in growing native vegetation on the man-made slopes. An approved seed mix should be used in growing vegetation on man-made slopes, cuts, and other disturbed areas.

6.3 FOUNDATIONS

Bearing capacity values were calculated using Meyerhof and others' modifications to Terzaghi's original bearing capacity formula. Strength parameters for the bearing strata were assigned based on laboratory shear strength parameters obtained from samples obtained during field work and field observations. A factor of safety of 3 is generally used in developing allowable bearing values; however, additional reduction of allowable bearing is typically warranted to account for static settlement and inconsistent construction practices.

Based on our field observations and considering the presence of coarse surficial soils overlying relatively hard bedrock over the majority of the site, we recommend that the footings residential structures be founded either *entirely* on bedrock, *entirely* on colluvium, or *entirely* on a minimum of 2 feet of structural fill. Bedrock/soil or fill/native transition zones are not allowed. If the foundation excavation exposes two different earth materials (e.g., partially on colluvium, partially on bedrock), then the footings should be deepened such that all footings bear on competent bedrock. Alternatively, the building pad may be over-excavated a minimum of 2 feet below the bottom of proposed footings and replaced with structural fill, such that the footings bear entirely on a uniform fill blanket. Where utilized, all fill beneath the foundations should consist of structural fill and should be placed and compacted in accordance with our recommendations presented in Section 6.2.4 of this report. IGES should observe all foundation subgrade prior to placement of steel or concrete; if potentially adverse conditions or transitions zones are identified, additional over-excavation or other remedial measures may be required.

Shallow spread or continuous wall footings constructed on competent coarse native colluvium may be proportioned utilizing a maximum net allowable bearing pressure of **3,500 pounds per square foot (psf)**. However, if the foundations are underlain by a minimum of 2 feet of structural fill or competent native soils, a maximum net allowable bearing pressure of **2,600 psf** should be used for design. The net allowable bearing values presented above are for dead load plus live load conditions. The minimum recommended footing width is 20 inches for continuous wall footings and 30 inches for isolated spread footings. The allowable bearing capacity may be increased by one-third for short-term loading (wind and seismic).

Additional bearing capacity may be available for structures that will be founded entirely on bedrock; if desired, the structural engineer may contact IGES to evaluate additional bearing capacity for specific cases.

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. Exception: where the foundations will be poured directly on rock (dolomite), the minimum depth below nearest adjacent grade may be reduced to 24 inches.

6.4 SETTLEMENT

6.4.1 Static Settlement

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

6.4.2 Dynamic Settlement

Based on the field data collected for this site, it is our opinion that the onsite native bedrock and/or rocky colluvium will exhibit negligible seismically-induced settlement during a MCE seismic event. Similarly, properly compacted structural fill is expected to exhibit negligible seismically induced settlement during a MCE seismic event.

6.5 SLOPE GRADING RECOMMENDATIONS

The following generalized recommendations are for engineered slopes (cut slopes and fill slopes). Recommendations for grading of engineered slopes are intended to minimize the potential for future surficial failures. For purposes of this report, surficial failure includes excessive erosion, sloughing, slumping, mass wasting, rockfall, and similar relatively shallow failures.

We recommend fill slopes taller than 10 feet be constructed as a buttress fill, as illustrated on Figure F-1. General recommendations for construction of buttress fills are presented in the following sections:

6.5.1 General Specifications

Cut and fill slopes should be constructed no steeper than 2H:1V. All cut slopes should be assessed geologically by IGES during grading to verify the geologic conditions upon which the following recommendations were made. It is feasible that cut and fill slopes may be constructed at slopes steeper than 2H:1V provided the slope is structurally stabilized; stabilization measures may include products such as an *Anchor Reinforced Vegetated System* (ARVS) (e.g., Xtreme Armor System by Western Excelsior), gabions, anchored shotcrete, or another similar system. If slopes steeper than 2H:1V are desired, IGES should be consulted to provide slope-specific recommendations and design guidelines.

Buttress fills should be constructed with a keyway (see Figure F-1). In general, the keyway back cut should be constructed no steeper than 1.5H:1V gradient, assuming the back cut will have a minimum factor of safety of 1.2. Flatter back cuts will reduce the potential for back cut failures. In order to decrease the risk of back cut failure, cut slopes should be off-loaded prior to excavating the buttress back cut. In addition, the amount of time the back cut remains exposed and unsupported should be minimized to reduce the risk of back cut failure. All stability fills should be a minimum of 10 feet wide (equipment width) at the top of the slope and at all mid-slope terraces.

6.5.2 Keyway Sizing

As a minimum, keyways should be excavated 2 feet below toe grade; deeper keyway excavations may be necessary, depending on the height of the slope and prevailing geologic conditions. The width of a keyway is measured horizontally from the toe of slope (top of front cut) to the toe of the back cut (heel), with a 2 percent drop to the heel. The depth of a keyway is measured from the toe of the fill slope to the bottom of the keyway. The minimum width of a keyway is 8 feet, except as allowed by IGES for specific cases; wider keyways may be needed if geologic conditions warrant. Adjustments to keyway width may be allowed if shallow bedrock is encountered; IGES should approve any adjustments and should evaluate bedrock/grading conflicts on a case-by-case basis.

6.5.3 Drainage

All excavations for buttress fills (fill slopes) taller than 15 feet should be provided with subdrains at the heel to reduce the potential for infiltrating water to perch and migrate toward the slope face. Local areas of particularly abundant groundwater may require subdrainage in addition to the typical heel subdrains as detailed on Figure F-1. Subdrains placed along the back cut of buttress fills and/or fill slopes may be constructed with 4-inch perforated PVC pipe, surrounded by approximately 6 cubic feet per lineal foot of ¾ inch gravel, wrapped in permeable filter material. Subdrains should be provided with outlet drains every 100 feet. In addition, backdrains consisting of 4-inch perforated PVC pipe, surrounded by approximately 6 cubic feet per lineal foot of ¾ inch gravel, wrapped in permeable filter material, with outlets provided every 100 feet laterally should be constructed every 25 vertical feet along the back cut for buttress fills and fill slopes. All subdrains and backdrains should be surveyed by a land surveyor/civil engineer for line and grade after installation and prior to burial. Sufficient time should be allowed by the Contractor for these surveys. Some modification to the drainage recommendations presented herein may be feasible; however, any change should be approved by IGES prior to implementation.

6.5.4 Benching

Where fills are to be placed on ground with slopes steeper than 5H:1V, the ground shall be stepped or benched (see Figure F-2 for a graphic illustration). At a minimum, benches should be constructed every four (4) vertical feet. Benches shall be excavated a minimum lateral depth of four (4) feet into competent material or as otherwise recommended by IGES. However, the *lowest* bench should be excavated a minimum lateral depth of 8 feet into competent material (effectively creating a keyway).

6.5.5 Slope Protection

Slope planting and other measures should be provided immediately following construction. Slope protection polymers, straw waddles, and/or jute mesh should also be considered to limit the amount of erosion on slopes subject to erosion until landscaping and other permanent erosion protection measures are fully in place. Additional slope protection recommendations are presented in Section 6.2.6 and Section 6.9.

6.5.6 Earthwork Recommendations

In addition to the normal compaction procedures for structural fill specified in Section 6.2.4, compaction of fill slopes shall be accomplished by backrolling of slopes with sheepsfoot rollers at increments of 3 to 4 feet in fill elevation, or by other methods producing satisfactory results acceptable to IGES. As an alternative to slope compaction, slopes may be constructed 2 to 3 feet ‘fat’ and trimmed back using a bulldozer with a slope board or similar equipment. Upon completion of grading, relative compaction of the fill out to the slope face shall be at least 90 percent of the maximum dry density per ASTM D 1557 (modified Proctor).

6.5.7 Rockeries

For rockeries with a single tier up to 8 feet in height, or a two-tier rockery where neither tier is taller than 8 feet and having a relatively flat backlope, the Contractor may follow the *Rockery Construction Guidelines* letter prepared by IGES (2013). For taller rockeries, or rockeries having more than two tiers, project-specific design will be required. Rockery design and associated slope stability will be addressed in a separate submittal.

6.7 EARTH PRESSURES AND LATERAL RESISTANCE

Lateral forces imposed upon conventional foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footing and the supporting soils. In determining the frictional resistance against concrete, a coefficient of friction of 0.45 for undisturbed earth materials or structural fill should be used. If it is known that the concrete will be poured directly on bedrock, a coefficient of friction of 0.60 may be used.

Ultimate lateral earth pressures from natural soils and *granular* backfill acting against retaining walls and buried structures may be computed from the lateral pressure coefficients or equivalent fluid densities presented in Table 6.7. The coefficients and densities presented in Table 6.7 assume no buildup of hydrostatic pressures. The force of the 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 either native granular soil or sandy imported material with an Expansion Index (EI) less than 25.

Walls and structures allowed to rotate slightly should use the active condition; if the element is 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 6.7
Recommended Lateral Earth Pressure Coefficients

Condition	**Level Backfill**		**2:1 Backfill**	
	Lateral Pressure Coefficient	**Equivalent Fluid Density (pcf)**	**Lateral Pressure Coefficient**	**Equivalent Fluid Density (pcf)**
Active (Ka)	0.283	35.4	0.417	52.1
At-rest (Ko)	0.44	55	0.648	81.0
Passive (Kp)	3.5	438	-	-

6.8 CONCRETE SLAB-ON-GRADE CONSTRUCTION

To minimize settlement and cracking of slabs, and to aid in drainage beneath the concrete floor slabs, all concrete slabs should be founded on a minimum 4-inch layer of compacted gravel overlying structural fill or competent native earth materials. 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. We recommend that concrete be tested to assess that the slump and/or air content is in compliance with the plans and specifications. If slump and/or air content are beyond the recommendations as specified in the plans and specifications, the concrete may not perform as desired. We recommend that concrete be placed in general accordance with the requirements of the American Concrete Institute (ACI).

A capillary break consisting of clean gravel or 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 should be covered with 2 inches of clean sand.

6.9 MOISTURE PROTECTION AND SURFACE DRAINAGE

During Construction: Over-wetting the soils prior to, during, or after construction may result in softening and pumping, causing equipment mobility problems and difficulty in achieving compaction. Every effort should be taken to ensure positive drainage away from roadway areas to reduce the potential for water to migrate below pavements and concrete flatwork. The recommended minimum slope is two percent (2%) in pavement areas. Moisture should not be allowed to infiltrate the soils in the vicinity of, or upslope from, the roadways.

Slope Protection: To aid in maintaining surficial slope stability, we recommend that a water interceptor swale be constructed at the top of all engineered slopes (cut slopes, fill slopes). This swale should be designed to intercept all uphill slope drainage and divert the drainage around the slopes. The drainage should be controlled as it travels around the slopes and should be tied into the curb and gutter or other drainage system associated with the road. In addition, drainage swales should be constructed every 25 vertical feet on the face of fill slopes.

Residential Structures: 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 home should be implemented. Structures that are located near the toe of ascending slopes may be subject to sheet flow during periods of heavy rain or snow melt. Therefore, the Civil Engineer may also wish to consider construction of additional surface drainage to intercept surface runoff, or a curtain drain to intercept seasonal groundwater flow, if any.

We recommend that desert or Xeriscape landscaping be considered within 5 feet of foundations. We further recommend roof runoff devices be installed to direct all runoff a minimum of 10 feet away from structures or beyond the limits of backfill (whichever distance is greater). Irrigation valves should be placed a minimum of 5 feet from foundations and should always be placed beyond the limits of foundation backfill. The builder should be responsible for compacting the exterior backfill soils around the foundation in lifts no greater than 12 inches to 90 percent of the maximum dry density (ASTM D1557). Additionally, the ground surface within 10 feet of structures should be constructed so as to slope a minimum of five percent away. Pavement sections should be constructed to divert surface water off of the pavement into storm drains. Parking strips and roadway shoulder areas should be constructed to prevent infiltration of water into the areas surrounding pavement.

If a drain is provided in the mechanical room (assumed to be in the basement), the drain should be outlet to a suitable off-site location such as the sanitary sewer. Do not allow the basement drain to outlet into the foundation soils.

Foundation Drains: IGES recommends a perimeter foundation drain be constructed for any proposed habitable structure with a subterranean component (e.g., a basement); the perimeter drain should be designed in accordance with guidelines presented in the International Residential Code (IRC).

6.10 SOIL CORROSION POTENTIAL

Laboratory test results indicate that near surface native soils had a sulfate content of 19.2 ppm. Based on soil conditions encountered during our field investigation and results of chemical testing, the soils are classified as having a ‘low’ potential for deterioration of concrete due to the presence of soluble sulfate. We recommend that conventional Type I/II Portland cement be used for all concrete in contact with site soils.

To evaluate the corrosion potential of ferrous metal in contact with onsite native soil, a representative soil sample was tested in our soils laboratory for soil resistivity (AASHTO T288), soluble chloride content, and pH. The test indicated that the onsite soil tested has a minimum soil resistivity of 2,476 OHM-cm, a soluble chloride content of 5.4 ppm, and a pH of 6.5. Based on this result, the onsite native soil is considered *moderately* corrosive to ferrous metal. Consideration should be given to retaining the services of a qualified corrosion engineer to provide an assessment of any metal that will be in contact with native clay soils.

6.11 PAVEMENT DESIGN

Three California Bearing Ratio (CBR) tests were completed on near-surface soils obtained at various locations within the property. The CBR values ranged from a low of 23.0 to a high of 34.8, with an average of approximately 30 (see Appendix B). Anticipated traffic volumes were not available at the time this report was prepared; therefore, based on our understanding of the project development we have estimated pavement loading based on the number and type of structures as well as anticipated construction traffic. For passenger traffic we have assumed that half of the residential structure will be occupied at any one time during the year. Construction traffic will be seasonal, with peak truck traffic only being experience for 5-6 months per year (averaged over the pavement's design life), although owning to the limited number of lots we anticipate primary build-out to be complete within 5 to 10 years. Based on our assumptions, the main access road will be subjected to approximately 195,000 ESAL's over its 20-year design life (assuming 0 percent annual growth rate).

Based on our assessment of the subgrade soils, using a CBR of 25 and assumed traffic for the interior roadways, several alternative pavement sections are presented in Table 6.11 to provide a

20-year design life for the subject roads. It should be noted that construction traffic will account for the majority of the loading during the life of the road.

We understand that Weber County standards call for a minimum pavement section consisting of 3 inches of asphalt, 6 inches of road base and 8 inches of "pit-run" gravel. Given anticipated weather, maintenance (plowing, salt) and the potential for construction traffic throughout the life of the road, we do not recommend that this section be utilized for the main access road. This section may be utilized on private driveways; however, based on our experience we recommend that a minimum of 4 inches of asphalt be used on the main public road.

Table 6.11
Pavement Recommendations

Roadway/Area	Main Access			Private Residential Drive	
	Recommended	Alternate 1	Alternate 2	Recommended	Alternate
Asphalt Concrete Pavement (inches)	4	3.5	3	3.5	3
Untreated Road Base (inches)	5	5	6	4	6
Granular Borrow (inches)	4*	6*	8*	6*	6*

*where dolomite is exposed, granular borrow is not required

The selected pavement section should be constructed on properly prepared subgrade. Material cost will likely play a factor in selecting the preferred pavement section. Additional variation in pavement layer thickness may also be acceptable if they can provide equal or greater structural capacity to the sections presented in Table 6.11. The coarse fraction of the native soils will likely be suitable for generating gravel (i.e., ¾-minus) and/or a coarse pit-run material. Site materials would have to be processed to segregate coarse (cobbles and boulders) for crushing. However, for road base much of the native colluvium probably contains too much silt and clay for generation of a "state spec" road base; separating the fines from the coarse fraction may not be practical. You may wish to consult a materials expert (e.g., a person at a local pit) to see if a portable batch plant could effectively and economically generate road base from native site soils. However, the coarse, granular colluvium is expected to be ideal for generating granular borrow (subbase).

During construction, a significant amount of heavy construction traffic is typical. Some distress may occur on the pavement during construction. Over the life of the main access we anticipate that pavement distress from construction traffic will occur and need to be addressed.

Asphalt has been assumed to be a high stability plant mix and base course material composed of crushed stone with a minimum CBR of 70, granular borrow should have a minimum CBR of 30. Road base and granular borrow should be compacted to 95% of MDD as determined by ASTM D-1557 (Modified Proctor). Asphalt should be compacted to a minimum of 96 percent of the Marshall maximum density. Asphalt and aggregate base material should conform to local requirements. Subgrade should be scarified to a depth of 8 inches and compacted to 95% of MDD as determined by ASTM D-1557. Positive drainage away from roadways must be provided to minimize the potential for saturation of subgrade soils beneath constructed pavements.

Where Portland Cement Concrete (PCC) pavements are planned, such as near trash enclosures or other areas expected to support heavy truck traffic, we recommend a minimum of 6 inches PCC underlain by a minimum 6 inches of aggregate base course.

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

Granular Borrow: site soils are commonly coarse and may be particularly well-suited for use as granular borrow once processed. At a minimum, processing will consist of sieving over-size particles (generally particles greater than 2 inches or 3 inches, depending on the specification), with additional processing to meet the gradation requirement of the end product. In general, granular borrow or granular backfill borrow has to meet AASHTO M145 and classify as A-1-a material (UDOT specifications). Based on sieve analysis testing, the sample obtained from TP-03 at 4 feet classifies as A-1-a material. Other sieve analyses reveal that the soils tested generally do not classify as A-1-a material, but are fairly close and may require a minimum of processing to achieve the desired gradation. To classify as A-1-a, the fines content must be equal or less than 15 percent; in almost all cases, the soils sampled across the site have a fines that meets this criteria. In some cases, A-1-a classification may be achieved by simply blending different granular soils encountered at various locations across the site.

6.12 CONSTRUCTION CONSIDERATIONS

The following items of note should be brought to the attention of the Contractor who will be performing earthwork and/or building the roadway or foundations within the project area:

1. Transition Zones: *For all foundations*, prior to placement of steel, concrete, or structural fill, IGES should assess the subgrade for the presence of adverse conditions, which may include (but not necessarily be limited to): a) transitions zones, b) soft/loose soil, or c) potentially adverse geologic structure. Item a) is of particular concern for this area. If identified, potentially adverse geologic structures will be brought to the attention of the Client for to discuss the implications of the adverse conditions and to assess potential mitigation measures.

2. Excavation Difficulty: Bedrock has been identified throughout the site; in general, bedrock is typically located about 6 to 10 feet below existing grade, but bedrock will be located at shallower depths locally, and in some areas bedrock is located at existing grade. Based on conversations with contractors currently working in the Powder Mountain area, this rock is expected to be relatively difficult to remove. Special heavy-duty excavation equipment will likely be required, such as a hoe ram.

3. Oversize Material: Most of the site consists of bedrock outcrop (surface exposures of dolomite); as such, development of most of the lots is expected to generate a substantial amount of over-size material (rocks larger than 6 inches in greatest dimension). Large rocks may require special handling, such as segregation from structural fill, and disposal. Bedrock is expected to require specialized equipment for removal during excavation of the basement. Please refer to Figure A-2 for a map of bedrock exposures.

4. Testing Frequency: Native soils used as structural fill should be tested for density and moisture. Imported fill soils should be tested in accordance with the recommendations presented in this report. Attached are Testing Frequency Tables to be used as a **guideline** for the testing frequency during construction (Appendix G). It is possible that minimum testing requirements recommended by local regulating agencies may exceed those included in this report. Testing should be completed to the higher standard presented in Appendix G or local governing agencies such as Weber County.

7.0 CLOSURE

7.1 LIMITATIONS

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

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

It is the Client's responsibility to see that all parties to the project including the Designer, Contractor, Subcontractors, etc. are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

7.2 ADDITIONAL SERVICES

The recommendations presented in this report are based on the assumption that an adequate program of tests and observations will be made during construction. IGES staff should be on site to assess compliance with these recommendations. These tests and observations should include, but not necessarily be limited to, the following:

- Observations and testing during site preparation, earthwork and structural fill placement.
- Observation of foundation soils to assess their suitability for footing placement.
- Observation of soft/loose soils overexcavation.
- Observation of temporary excavations and shoring.
- Consultation as may be required during construction.
- Quality control and observation of concrete placement.

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.

8.0 REFERENCES CITED

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

Coogan, J.C., King, J. 2001 Progress Report: Geologic Map of the Ogden 30’ X 60’ Quadrangle, Utah and Wyoming.

Elliott , A. H., Harty, K.M,. 2010 Landslide Maps of Utah. Ogden 30’ x 60’ Quadrangle.

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

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

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

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

IGES, Inc., 2013, Rockery Construction Guidelines, Powder Mountain Resort, Weber County, Utah, Project No. 01628-005, dated May 8, 2013.

International Building Code [IBC], 2012, International Code Council, Inc.

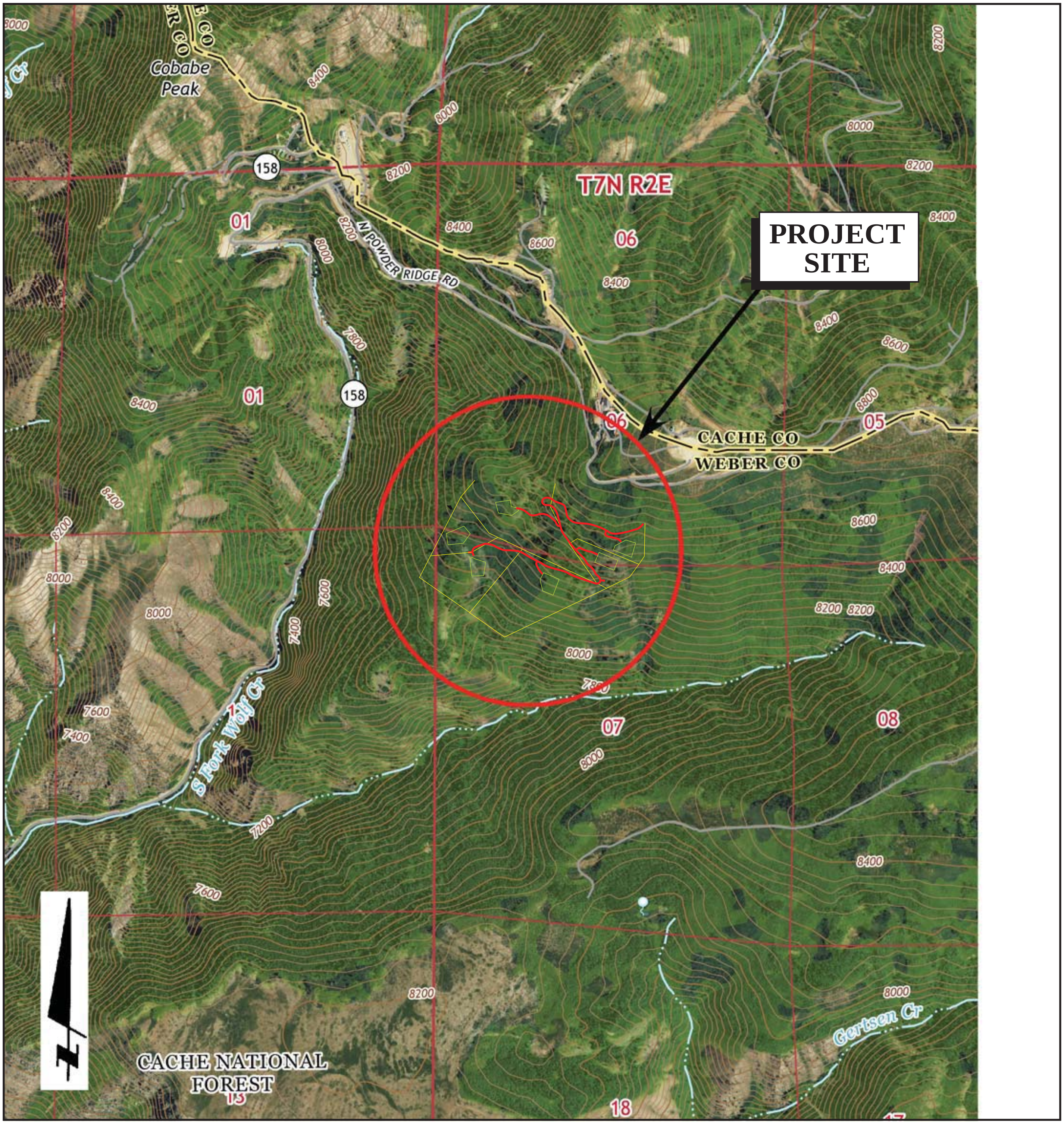
PSI, 2012, Geophysical ReMi Investigation, Powder Mountain Resort, Phase 1A, Weber County, Utah, PSI Project No. 0710375, dated September 18, 2012.

Stokes, W.L, 1986, Geology of Utah, Utah Museum of Natural History (University of Utah) and Utah Geological and Mineral Survey (publishers), Utah Geological Survey Miscellaneous Publication S, Second Printing 1988.

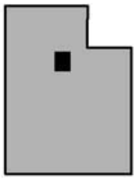
U.S. Geological Survey, 2012, U.S. *Seismic “Design Maps” Web Application*, site: https://geohazards.usgs.gov/secure/designmaps/us/application.php.

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

APPENDIX A



Base Maps:
USGS *Huntsville* and *James Peak*
7.5-Minute Quadrangle Topographic Maps (2014)


MAP LOCATION

0 1000' 2000'
SCALE 1:24,000

IGES®

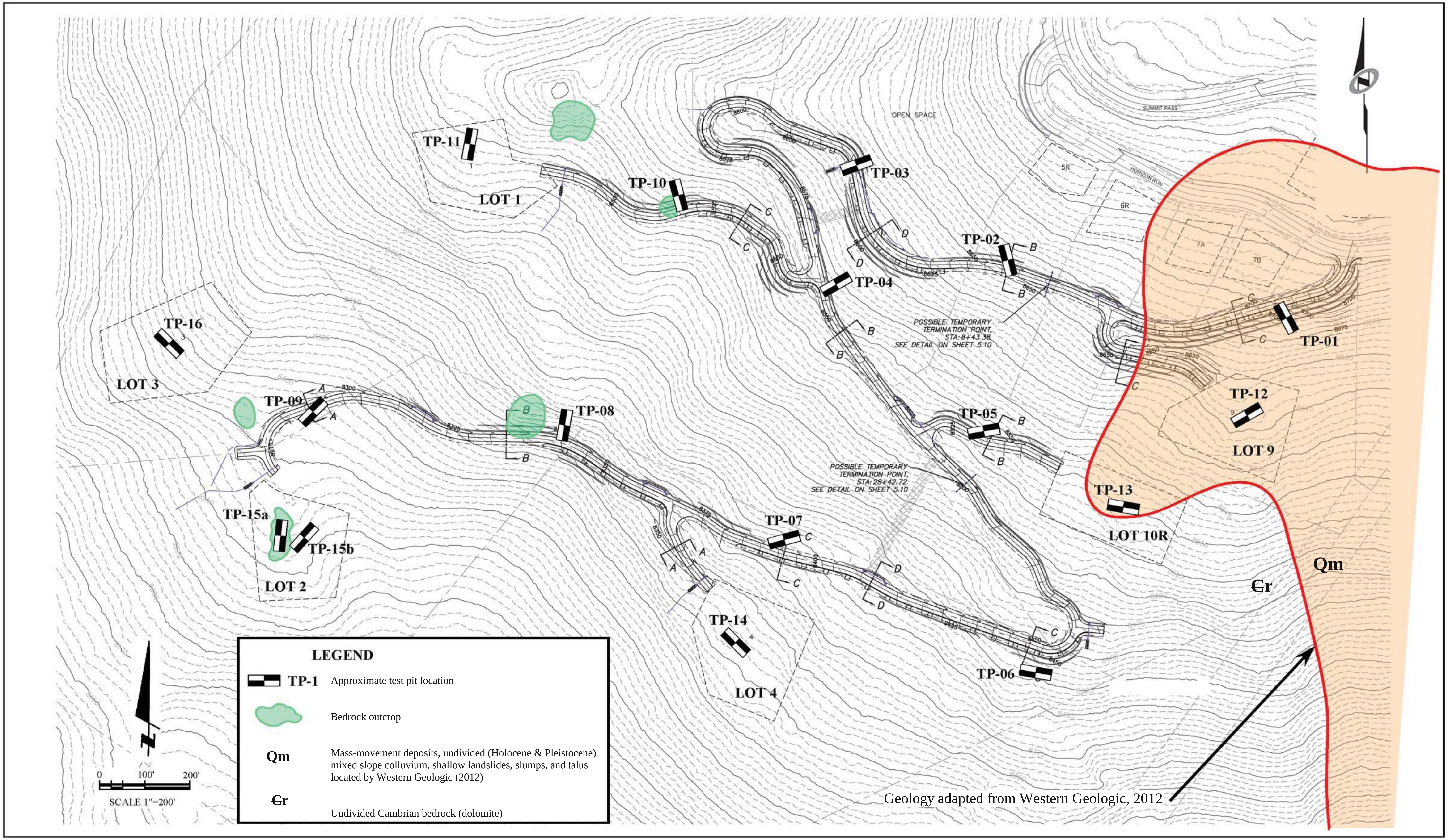
Project No. 01628-011

Geotechnical Investigation Summit
Eden Phases 1E, 1F, & 1G
Powder Mountain Resort Weber
County, Utah

SITE VICINITY MAP

Figure

A-1



Basemap: 100-scale plan titled “Summit Eden Phase 1E Construction, Overall Grading Plan”, Sheet 1.04, dated 09-18-15, prepared by NV5

IGES®

Project No. 01628-011

Geotechnical Investigation
Eden Phases 1E, 1F, & 1G
Powder Mountain Resort Weber
County, Utah

GEOTECHNICAL MAP

Figure

A-2

DATE
STARTED: 6/16/15
COMPLETED: 6/16/15
BACKFILLED: 6/16/15

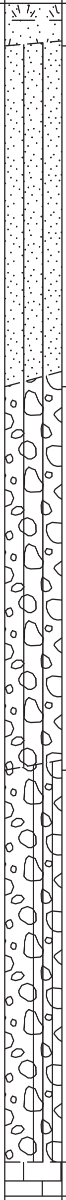
Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

Project Number 01628-011

IGES Rep: DAG
Rig Type: 315C

TEST PIT NO:
TP-01
Sheet 1 of 1

LOCATION
LATITUDE 41.36680 LONGITUDE -111.76740 ELEVATION 8,690
Roadway/Rockery

DEPTH ELEVATION	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits Plastic Limit, Moisture Content, Liquid Limit 10 20 30 40 50 60 70 80 90
	0					@ 0' Topsoil, dark loamy appearance, mostly organic, well-rooted, about 3-6 in. thick						
						@ ½' **COLLUVIUM** Silty SAND, loose, fine-grained, about 30% coarse/angular gravel to 3 in., non-plastic fines, moist, chaotic appearance, transitions to fine grayish-blue silty sand at 4 feet and reddish-brown iron staining at 5 feet						
8685	5					@ 4½' Silty GRAVEL with sand, medium dense, coarse/angular gravel in a silty/sandy matrix, soil is matrix-supported, non-plastic fines, moderate yellowish brown, moist, homogenous appearance			10.3			
						~7' increasingly dense, coarse - some cobble- and boulder-size rocks						
8680	10											
						@ 12' very rocky, rocks to 10 inches, angular						
						@ 14' **BEDROCK** hitting top of bedrock, highly weathered, ripping out rock fragments to 8 inches suggesting highly fractured bedrock, gray, hard, reacts weakly to HCl (dolomite)						
8675	15					Total depth 14 feet Bedrock at 14 feet No groundwater Bucket sample taken at 5 feet						

Bottom of Test Pit @ 14 Feet

SAMPLE TYPE
- ▯ - GRAB SAMPLE
- ☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- ▼ - MEASURED
- ▽ - ESTIMATED

NOTES:
Roadway/Rockery

Figure
A-3

DATE	
STARTED:	6/17/15
COMPLETED:	6/17/15
BACKFILLED:	6/17/15

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

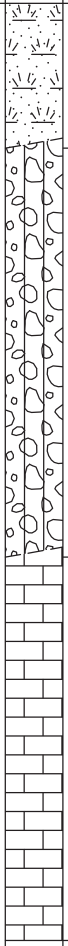
Project Number 01628-011

IGES Rep: DAG
Rig Type: 315C

TEST PIT NO:
TP-02
Sheet 1 of 1

LOCATION
LATITUDE 41.36700 LONGITUDE -111.76960 ELEVATION 8,654
Roadway/Rockery

DEPTH: ELEVATION	DEPTH: FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
	0					@ 0' Topsoil, silty clay, dark brown, loamy appearance, abundant fine rootlets, about 20 in. thick					
						@ 1.7' **COLLUVIUM** Silty GRAVEL with sand, angular gravel to 4 in. in a silty sand matrix, borderline clast-supported, moderate yellowish brown with iron staining, moist, medium dense to dense, roots to 3 feet, fine-grained sand, non-plastic fines, moderately easy to excavate, 54% gravel, 32% sand, 14% fines					
8650		▯							14.2		
	5										
						@ 6½' **BEDROCK** Dolomite, highly weathered/decomposed, tight fractures, hard, disaggregates to angular rocks within a sandy matrix, blue-gray fracture, reddish-brown sand, most rocks range from 1 in. to 6 in. but a few larger rocks to 36 in.					
8645											
	10										
						Total depth 11 feet Bedrock at 6½ feet No groundwater Bottom of Test Pit @ 11 Feet					
8640											
	15										



Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
10 20 30 40 50 60 70 80 90

SAMPLE TYPE
▯ - GRAB SAMPLE
☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼ - MEASURED
▽ - ESTIMATED

NOTES:
Slight organic odor (similar to sewage)

Figure A-4

DATE	
STARTED:	6/17/15
COMPLETED:	6/17/15
BACKFILLED:	6/17/15

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

Project Number 01628-011

IGES Rep: DAG

Rig Type: 315C

TEST PIT NO:

TP-03

Sheet 1 of 1

LOCATION

LATITUDE 41.36780 LONGITUDE -111.77100 ELEVATION 8,640

Roadway/Rockery

DEPTH ELEVATION	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
	0					@ 0' Topsoil, dark brown silty clay, abundant roots, loamy appearance					
					GP-GM	@ 2' **COLLUVIUM** angular to subangular rocks to 10 in. in a silty sand matrix, clast-supported, loose/friable sandy matrix, moderately easy to excavate, few fines, pale brown with iron staining, moist, medium dense			9.4		
8635	5				SP-SM	~5' may be top of decomposed bedrock? transitions to poorly-graded sand with silt and gravel		3.7	6.8		
						@ 7½' **BEDROCK** Dolomite, highly weathered/decomposed, tightly fractured/jointed, hard, disaggregates to angular rocks to 18 in., w/ fine-grained sand, pale brown, light blue-gray fracture, difficult to excavate at 9 feet					
8630	10					Total depth 9 feet Bedrock at 7½ feet No groundwater Bucket sample obtained at 4 feet Bottom of Test Pit @ 9 Feet					
8625	15										

Moisture Content and Atterberg Limits

Plastic Limit — Moisture Content ● — Liquid Limit

10 20 30 40 50 60 70 80 90

LOG OF TEST PITS (A) -(4 LINE HEADER W ELEV) 01628-011.GPJ IGES.GDT 8/10/15

IGES®

SAMPLE TYPE
- ▯ - GRAB SAMPLE
- ☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- ▼- MEASURED
- ▽- ESTIMATED

NOTES:
Several boulders to 36 in. in spoils pile

Figure

A-5

DATE	
STARTED:	6/17/15
COMPLETED:	6/17/15
BACKFILLED:	6/17/15

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

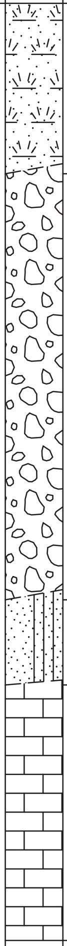
Project Number 01628-011

IGES Rep: DAG
Rig Type: 315C

TEST PIT NO:
TP-04
Sheet 1 of 1

LOCATION
LATITUDE 41.36690 LONGITUDE -111.77100 ELEVATION 8,570
Roadway/Intersection

MATERIAL DESCRIPTION



ELEVATION	DEPTH FEET	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
	0				@ 0' Topsoil, clayey sand, dark brown, loamy appearance, abundant roots and rootlets, moist, low plasticity, fine sand					
				GP	@ 2' **COLLUVIUM** Poorly-Graded GRAVEL with sand, subangular gravel and cobble in a silty sand matrix, fine sand, loose to medium dense, light brown w/ abundant iron staining, friable, easy to excavate, minor caving/raveling, few fines					
		▯						5.8		
8565	5									
					@7' 6 in. clay seam underlain by poorly-graded SAND with silt and gravel, friable, pale brown w/ iron staining, med. to coarse-grained, medium dense, may be top of decomposed bedrock					
					@ 8' **BEDROCK** Dolomite, coarse, angular rocks to 4 in. with fine-grained and filling fractures, moderately easy to excavate, light blue-gray w/ iron staining on fractures, decomposed bedrock, some caving					
8560	10									
					Total depth 11 feet Bedrock at 7 feet No groundwater Bucket sample obtained at 3½ feet Bottom of Test Pit @ 11 Feet					
8555	15									

Moisture Content and Atterberg Limits

Plastic Limit ├── Moisture Content ● ── Liquid Limit ┤

10 20 30 40 50 60 70 80 90

LOG OF TEST PITS (A) -(4 LINE HEADER W ELEV) 01628-011.GPJ IGES.GDT 8/10/15

IGES®

SAMPLE TYPE
▯ - GRAB SAMPLE
☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:
Roadway/Intersection

Figure

A-6

DATE	
STARTED:	6/16/15
COMPLETED:	6/16/15
BACKFILLED:	6/16/15

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

Project Number 01628-011

IGES Rep: DAG

Rig Type: 315C

TEST PIT NO:

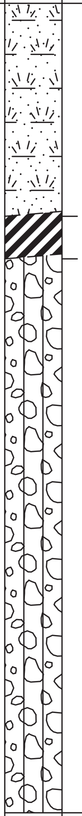
TP-05

Sheet 1 of 1

LOCATION

LATITUDE 41.36600 LONGITUDE -111.76940 ELEVATION 8,540

Roadway/Rockery



DEPTH ELEVATION	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit ├─●─┤ Liquid Limit; Moisture Content) 10 20 30 40 50 60 70 80 90
	0					@ 0' Topsoil, dark brown, loamy appearance, well-rooted, abundant organic material, moist						
						@ 2½' reddish-brown clay, high plasticity, moist						
						@ 3' **COLLUVIUM** Coarse angular rocks to 36 in. in a sandy matrix (SP-SM), clast-supported, abundant iron staining within the matrix, light brown, moist						
8535	5					~5' some caving, difficult to excavate, coarse and angular rocks						
		▯				@ 7' GSD on sandy matrix, classifies as Silty SAND with gravel, 20% gravel, 67% sand, 13% fines			12.7			
8530	10					Total depth 9½ feet No groundwater Bottom of Test Pit @ 9.5 Feet						
8525	15											

SAMPLE TYPE
▯ - GRAB SAMPLE
☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:
Roadway/Rockery

Figure

A-7

DATE	
STARTED:	6/17/15
COMPLETED:	6/17/15
BACKFILLED:	6/17/15

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

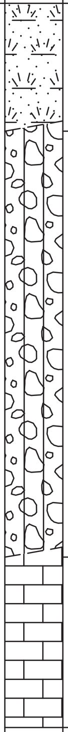
Project Number 01628-011

IGES Rep: DAG
Rig Type: 315C

TEST PIT NO:
TP-06
Sheet 1 of 1

LOCATION
LATITUDE 41.35000 LONGITUDE -111.76930 ELEVATION 8,430
Roadway/Rockery

DEPTH ELEVATION	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (10 20 30 40 50 60 70 80 90)
	0					@ 0' Topsoil, dark brown clay, loamy appearance, well-rooted, moist						
						@ 1½' **COLLUVIUM** subrounded cobbles and boulders to 16 in. in a reddish-brown clay matrix, high plasticity, very moist, clast-supported, roots extend about 3 feet into colluvium, jumbled/chaotic appearance						
8425	5											
						@ 6' **BEDROCK** Dolomite, reddish-brown w/ gray-blue fracture, hard, closely-spaced fractures, highly weathered, disaggregates to angular rocks to 4 in., reddish-brown silty/clayey sand along fractures, difficult to excavate at 8 feet						
8420	10											
8415	15											



Total depth 8½ feet
Bedrock at 6 feet
No groundwater

Bottom of Test Pit @ 8.5 Feet

SAMPLE TYPE
- ▯ - GRAB SAMPLE
- ☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- ▼ - MEASURED
- ▽ - ESTIMATED

NOTES:
Slight organic odor (similar to sewage)

Figure A-8

DATE	
STARTED:	6/17/15
COMPLETED:	6/17/15
BACKFILLED:	6/17/15

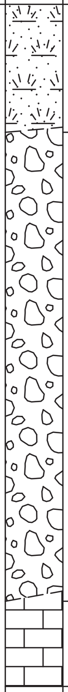
Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

Project Number 01628-011

IGES Rep: DAG
Rig Type: 315C

TEST PIT NO:
TP-07
Sheet 1 of 1

LOCATION
LATITUDE 41.36540 LONGITUDE -111.77150 ELEVATION 8,395
Roadway



DEPTH ELEVATION	DEPTH FEET	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
	0				@ 0' Topsoil, low plasticity silt, moderate to dark brown, moist, loamy appearance, well-rooted					
					@ 1½' **COLLUVIUM** Poorly-Graded GRAVEL, angular gravel and cobble to 6 in. in a silty sand matrix, matrix-supported, light brown w/ iron staining, moist, friable matrix, fine-grained, non-plastic fines					
8390	5	▯						4.3		
					@ 7' **BEDROCK** Dolomite, highly weathered/fractured, blue-gray fracture, hard, disaggregate to angular rocks to 16 in.					
					Total depth 8 feet Bedrock at 7 feet No groundwater					
8385	10				Bottom of Test Pit @ 8 Feet					
8380	15									

Moisture Content and Atterberg Limits
Plastic Limit ├──●──┤ Moisture Content, Liquid Limit
10 20 30 40 50 60 70 80 90

IGES®

SAMPLE TYPE
▯ - GRAB SAMPLE
☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:
Slight organic odor (similar to sewage)

Figure
A-9

DATE	
STARTED:	6/17/15
COMPLETED:	6/17/15
BACKFILLED:	6/17/15

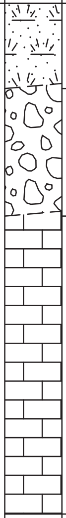
Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

Project Number 01628-011

IGES Rep: DAG
Rig Type: 315C

TEST PIT NO:
TP-08
Sheet 1 of 1

LOCATION
LATITUDE 41.36610 LONGITUDE -111.77310 ELEVATION 8,355
Roadway

DEPTH ELEVATION	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit, Moisture Content, Liquid Limit) 10 20 30 40 50 60 70 80 90
	0					@ 0' Topsoil, dark brown clay, 'bony', abundant angular rocks to 3 in., well-rooted						
						@ 1' **COLLUVIUM** angular rocks to 6 inches in a lean clayey matrix, clast-supported, moist, moderate brown						
						@ 2½' **BEDROCK** Dolomite, highly weathered, closely fractured, clay-filled fractures, rooted in upper 2 feet, disaggregates to 2- to 3-in. angular rocks (rubble), on uphill-side of trench rock is more fresh, competent, blue-gray, moderately difficult to excavate, outcrops observed uphill and to the north of the trench nearby						
8350	5											
						Total depth 6 feet Bedrock at 2½ feet No groundwater Bucket sample obtained from spoils pile (disaggregated rock) Bottom of Test Pit @ 6 Feet						
8345	10											
8340	15											

IGES

SAMPLE TYPE
▯ - GRAB SAMPLE
☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:
Roadway

Figure A-10

DATE	
STARTED:	6/17/15
COMPLETED:	6/17/15
BACKFILLED:	6/17/15

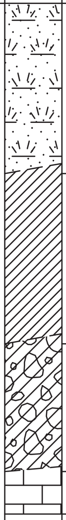
Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

Project Number 01628-011

IGES Rep: DAG
Rig Type: 315C

TEST PIT NO:
TP-09
Sheet 1 of 1

LOCATION
LATITUDE 41.36610 LONGITUDE -111.77520 ELEVATION 8,290
Roadway



ELEVATION	DEPTH FEET	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
	0				@ 0' Topsoil, dark brown clay, low plasticity, well-rooted, loamy appearance, moist					
				CL	@ 2' grades to lean clay, soft, moderate brown, moist, low plasticity, homogenous, slight mottling					
				GC	@ 4' grades to clayey gravel, about 40% subrounded gravel and cobble to 6 in. in a clay matrix, matrix-supported					
8285	5									
					@ 5½' **BEDROCK** Dolomite, highly weathered, moderately fractured, fractures filled with clay, disaggregates to angular rocks to 36 inches, very difficult to excavate					
8280	10									
8275	15									

Refusal at 6 feet
Bedrock at 5½ feet
No groundwater

Bottom of Test Pit @ 6 Feet

Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
10 20 30 40 50 60 70 80 90

SAMPLE TYPE
▯ - GRAB SAMPLE
☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:
Roadway

Figure A-11

DATE		
	STARTED:	6/16/15
	COMPLETED:	6/16/15
	BACKFILLED:	6/16/15

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

Project Number 01628-011

IGES Rep: DAG

Rig Type: 315C

TEST PIT NO:

TP-10

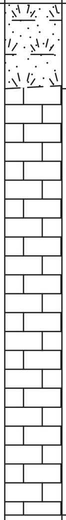
Sheet 1 of 1

LOCATION

LATITUDE 41.36730 LONGITUDE -111.77220 ELEVATION 8,530

Road to Lot 1

DEPTH												
ELEVATION	FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits Plastic Limit – Moisture Content – Liquid Limit 10 20 30 40 50 60 70 80 90
	0					@ 0' Topsoil, thin, rocky, poor development on rock, abundant thin roots in upper 8 to 12 in.						
						@ 1' **BEDROCK** Dolomite, bluish-gray, hard, moderately weathered, highly fractured, close-spaced fractures (<3 in.), disaggregates to angular rock to 20 in., one 36-in. boulder in spoils, difficult to excavate below 3 feet						
8525	5											
						Total depth 6 feet Bedrock at surface No groundwater Bottom of Test Pit @ 6 Feet						
8520	10											
8515	15											



Copyright (c) 2015, IGES, INC.

SAMPLE TYPE

▯ - GRAB SAMPLE

☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL

▼- MEASURED

▽- ESTIMATED

NOTES:

Bedrock outcrop along alignment in this area, poorly exposed

Figure

A-12

DATE	
STARTED:	6/16/15
COMPLETED:	6/16/15
BACKFILLED:	6/17/15

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

Project Number 01628-011

IGES Rep: DAG

Rig Type: 315C

TEST PIT NO:

TP-11

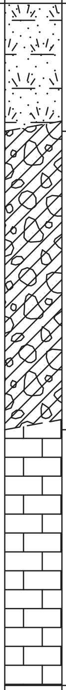
Sheet 1 of 1

LOCATION

LATITUDE 41.36770 LONGITUDE -111.77390 ELEVATION 8,495

Lot 1

MATERIAL DESCRIPTION

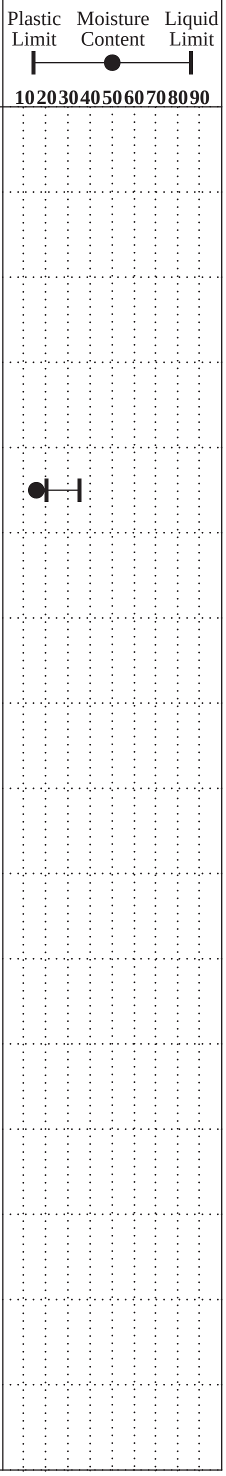


ELEVATION	DEPTH FEET	SAMPLES	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
	0		@ 0' Topsoil, silty sand, dark brown, well-rooted					
			@ 1½' **COLLUVIUM** Clayey GRAVEL, coarse angular gravel to 4 in. in a clayey matrix, dark yellowish orange, moist, roots in upper 12 in., insitu moisture content at PL					
		▯			15.3		35	15
8490	5		@ 5' **BEDROCK** Dolomite, highly fractured/weathered, blue-gray, hard, iron staining on old fracture surfaces, can be excavated with difficulty, closely-spaced fractures/jointing, disaggregates to angular rock fragments to 18 inches but mostly 4 to 8 inches					
8485	10							
8480	15							

Total depth 8 feet
Bedrock at 5 feet
No groundwater

Bottom of Test Pit @ 8 Feet

Moisture Content and Atterberg Limits



IGES®

SAMPLE TYPE
▯ - GRAB SAMPLE
☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼ - MEASURED
▽ - ESTIMATED

NOTES:
Lot 1

Figure

A-13

DATE
STARTED: 6/16/15
COMPLETED: 6/16/15
BACKFILLED: 6/17/15

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

Project Number 01628-011

IGES Rep: DAG
Rig Type: 315C

TEST PIT NO:
TP-12
Sheet 1 of 1

LOCATION
LATITUDE 41.36620 LONGITUDE -111.76770 ELEVATION 8,630
Lot 9

ELEVATION	DEPTH FEET	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
	0				@ 0' Topsoil, 'bony', rocky, thin topsoil, abundant roots, dark brown					
					@ ½' **COLLUVIUM** cobbles and boulders in a silty sand matrix, very dense, angular rock fragments, moist, moderate yellowish brown, few fines, roots persist to 3 feet, some iron staining					
		▯			- #200 on SM matrix			15.6		
8625	5									
					- appears to be clast-supported, abundant cobble-size rocks, angular, to 8 in., some boulders to 2½ feet on surface but not observed in test pit					
					@ 8' **BEDROCK** Dolomite, highly fractured/weathered, disaggregates to 3-in. to 12-in. angular fragments in a sandy matrix, dark yellowish orange, difficult to excavate					
8620	10									
					Total depth 10 feet Bedrock at 8 feet No groundwater Bottom of Test Pit @ 10 Feet					
8615	15									

Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content ● — Liquid Limit
10 20 30 40 50 60 70 80 90

SAMPLE TYPE
▯ - GRAB SAMPLE
☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼ - MEASURED
▽ - ESTIMATED

NOTES:
Poorly exposed outcrop between test pit and point 4073, abundant angular boulders to 36 in., large rocks on surface

Figure
A-14

DATE	
STARTED:	6/16/15
COMPLETED:	6/16/15
BACKFILLED:	6/17/15

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah
Project Number 01628-011

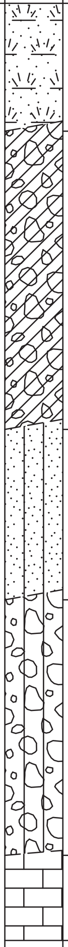
IGES Rep: DAG
Rig Type: 315C

TEST PIT NO:
TP-13
Sheet 1 of 1

LOCATION
LATITUDE 41.36560 LONGITUDE -111.76910 ELEVATION 8,550
Lot 10R

ELEVATION	DEPTH FEET	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
	0				@ 0' Topsoil, clayey sand, low plasticity, moist, moderate to dark brown, well-rooted, soft/loose					
		▯		GC	@ 1½' **COLLUVIUM** Clayey GRAVEL, coarse/angular gravel in a clay matrix, matrix-supported, high plasticity (fat clay, CH), dense, reddish-brown, moist, angular rocks to 8 in. w/ occasional boulders to 24 in.		31.2		102	74
8545	5	▯		SM	@ 5' Silty SAND with gravel, medium dense, medium-grained, light bluish-gray with iron staining, about 30% angular gravel and cobbles to 6 in., friable (easy to excavate)			12.1		
					~7' boulders to 24 in. coming out of trench, difficult to excavate					
8540	10				@ 10' **BEDROCK** Dolomite, bluish-gray fracture, highly fractured/weathered, difficult to excavate, disaggregates to 4 to 10 in. angular rocks, hard, close-spaced fractures/joints 4 to 8 in.					
8535	15									

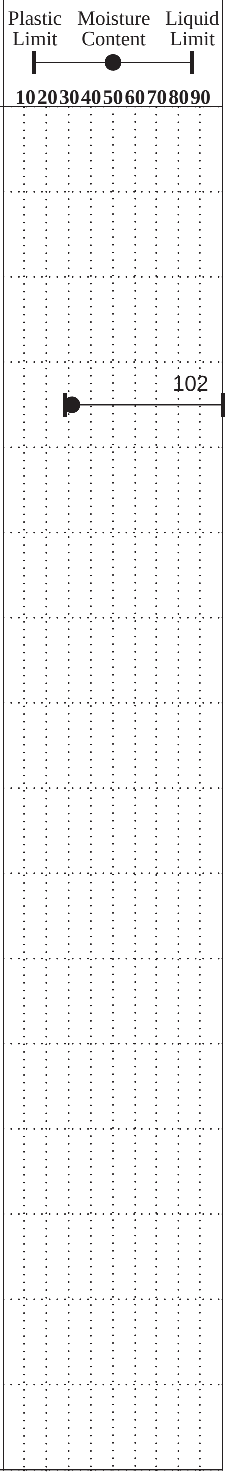
GRAPHICAL LOG



Total depth 11 feet
Bedrock at 10 feet
No groundwater

Bottom of Test Pit @ 11 Feet

Moisture Content and Atterberg Limits



IGES®

SAMPLE TYPE
▯ - GRAB SAMPLE
☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:
Lot 10R

Figure
A-15

DATE	
STARTED:	6/16/15
COMPLETED:	6/16/15
BACKFILLED:	6/17/15

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

Project Number 01628-011

IGES Rep: DAG

Rig Type: 315C

TEST PIT NO:

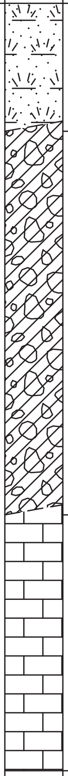
TP-14

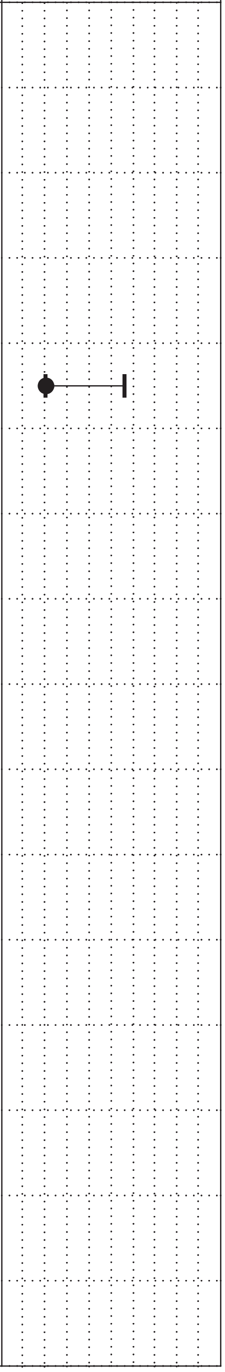
Sheet 1 of 1

LOCATION

LATITUDE 41.36470 LONGITUDE -111.77175 ELEVATION 8,337

Lot 4





ELEVATION	DEPTH FEET	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
	0				@ 0' Topsoil, dark brown clayey soil, abundant roots, loamy appearance, moist					
8335				GC	@ 1½' **COLLUVIUM** Clayey GRAVEL, subangular to subrounded rocks to 4 in. within a reddish-brown clay matrix, matrix-supported, high plasticity, moist, chaotic appearance, some trace pockets of bluish-gray sand, trace faint slickensides (shiny surfaces with little or no shear fabric)					
	5	▯					20.2		56	36
8330					@ 6' **BEDROCK** Dolomite, blue-gray fracture, hard, closely fractured, highly jointed, disaggregates to large fragments to 36 in. or larger, platy, clay-filled fractures, difficult to excavate, excavator has to break rocks out, bedrock appears intact					
	10				Total depth 9 feet Bedrock at 6 feet No groundwater Bottom of Test Pit @ 9 Feet					
8325										
	15									

IGES

SAMPLE TYPE
- ▯ - GRAB SAMPLE
- ☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- ▼ - MEASURED
- ▽ - ESTIMATED

NOTES:
Lot 4

Figure

A-16

DATE	
STARTED:	6/17/15
COMPLETED:	6/17/15
BACKFILLED:	6/17/15

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

Project Number 01628-011

IGES Rep: DAG
Rig Type: 315C

TEST PIT NO:
TP-15A
Sheet 1 of 1

LOCATION
LATITUDE 41.36530 LONGITUDE -111.77545 ELEVATION 8,260
Lot 2

DEPTH: ELEVATION	DEPTH: FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit, Moisture Content, Liquid Limit) 10 20 30 40 50 60 70 80 90
	0					@ 0' **BEDROCK** Dolomite (outcrop), moderately weathered, blue-gray, well-jointed, close-spaced fracture, can be ripped with difficulty, disaggregates to angular rocks to 40 in., hard						
						Total depth 3 feet No groundwater Bottom of Test Pit @ 3 Feet						
8255	5											
8250	10											
8245	15											

SAMPLE TYPE
▯ - GRAB SAMPLE
☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:
Lot 2

Figure

A-17

DATE	
STARTED:	6/17/15
COMPLETED:	6/17/15
BACKFILLED:	6/17/15

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

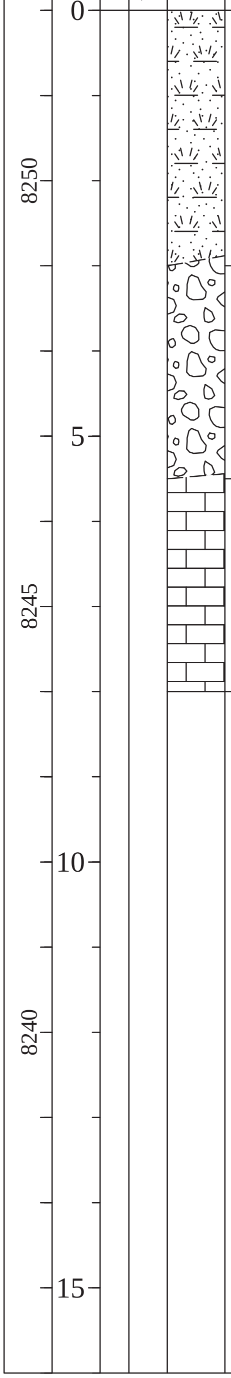
Project Number 01628-011

IGES Rep: DAG
Rig Type: 315C

TEST PIT NO:
TP-15B
Sheet 1 of 1

LOCATION
LATITUDE 41.36540 LONGITUDE -111.77520 ELEVATION 8,252
Lot 2

DEPTH												
ELEVATION	FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits Plastic Limit — Moisture Content ● — Liquid Limit 10 20 30 40 50 60 70 80 90



@ 0' Topsoil, dark brown lean clay w/ abundant rootlets, loamy appearance, low plasticity, moist, some angular rocks mixed in

@ 3' **COLLUVIUM**
coarse, angular rocks to 18 in. within a clayey matrix, clast-supported

@ 5½' **BEDROCK**
Dolomite, blue-gray fracture, highly weathered/fractured with clay-filled fractures, disaggregates to 8-in. to 36-in. rock fragments, difficult to excavate
primary jointing/bedding orientation is A178°/26°S

Total depth 8 feet
Bedrock at 5½ feet
No groundwater

Bottom of Test Pit @ 8 Feet

SAMPLE TYPE
▯ - GRAB SAMPLE
☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
▼ - MEASURED
▽ - ESTIMATED

NOTES:
Lot 2

Figure
A-18

DATE		
STARTED:	6/17/15	
COMPLETED:	6/17/15	
BACKFILLED:	6/17/15	

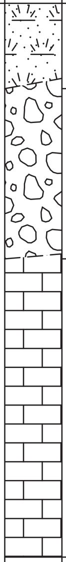
Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah

Project Number 01628-011

IGES Rep: DAG
Rig Type: 315C

TEST PIT NO:
TP-16
Sheet 1 of 1

LOCATION
LATITUDE 41.36650 LONGITUDE -111.77630 ELEVATION 8,290
Lot 3

DEPTH: ELEVATION	DEPTH: FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit, Moisture Content, Liquid Limit) 10 20 30 40 50 60 70 80 90
	0					@ 0' Topsoil, dark brown silty clay, low plasticity, moist, well-rooted, loamy appearance, some angular rocks to 4 in.						
						@ 1' **COLLUVIUM** coarse, angular rocks to 6 in. within a clay matrix, reddish brown, moist						
						@ 3' **BEDROCK** Dolomite, highly weathered/jointed with clay-filled fractures, abundant roots along fractures, blue-gray fresh surface, hard						
8285	5					~5' becomes more competent, less weathered, difficult to excavate, disaggregates to angular rocks to 24 inches						
						Total depth 6½ feet Bedrock at 3 feet No groundwater Bottom of Test Pit @ 6.5 Feet						
8280	10											
8275	15											

Copyright (c) 2015, IGES, INC.

SAMPLE TYPE
- ▯ - GRAB SAMPLE
- ☒ - 3" O.D. THIN-WALLED HAND SAMPLER

WATER LEVEL
- ▼ - MEASURED
- ▽ - ESTIMATED

NOTES:
jointing/bedding does not match TP-15A surface exposure

Figure
A-19

UNIFIED SOIL CLASSIFICATION SYSTEM

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

LOG KEY SYMBOLS

⊕ BORING SAMPLE LOCATION

⧗ TEST-PIT SAMPLE LOCATION

▼ WATER LEVEL (level after completion)

▽ WATER LEVEL (level where first encountered)

CEMENTATION

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

OTHER TESTS KEY

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

MODIFIERS

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

MOISTURE CONTENT

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

STRATIFICATION

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

GENERAL NOTES

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

APPARENT / RELATIVE DENSITY - COARSE-GRAINED SOIL

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

CONSISTENCY - FINE-GRAINED SOIL

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

KEY TO SOIL SYMBOLS AND TERMINOLOGY

Project No. **01628-011**
Engr. **DAG**
Drafted By **DAG**
Date **August 2015**

IGES
Intermountain Geo-Environmental Services, Inc.

Figure A-20

Rock Classification Should Include:

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

Weathering

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

Fracturing

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

Bedding of Sedimentary Rocks

Splitting Property	Thickness	Stratification
Massive	>4.0 ft	Very thick bedded
Blocky	2.0-4.0 ft	Thick-bedded
Slabby	2 ½-24 in	Thin-bedded
Flaggy	½-2 ½ in	Very thin-bedded
Shaly or platy	⅛ – ½ in	Laminated
Papery	< ⅛ in	Thinly laminated

RQD

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

Competency

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

KEY TO PHYSICAL ROCK PROPERTIES

Project No. 016328-011
Engr. DAG
Drafted By DAG
Date August 2015

IGES
Intermountain Geo-Environmental Services, Inc.

Figure A-21

APPENDIX B

Water Content and Unit Weight of Soil

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

IGES

Project: Summit Eden Phase 1E
No: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 6/26/2015
By: LF

Sample Info.	Boring No.	TP-3	TP-11	TP-13	TP-14				
	Sample								
	Depth	5.0'	3.0'	3.0'	4.0'				
	Split	Yes	No	No	No				
	Split sieve	3/8"							
	Total sample (g)	4534.74							
	Moist coarse fraction (g)	1810.74							
	Moist split fraction (g)	2724.00							
	Sample height, H (in)								
	Sample diameter, D (in)								
	Mass rings + wet soil (g)								
	Mass rings/tare (g)								
	Moist unit wt., γ_m (pcf)								
Coarse Fraction	Wet soil + tare (g)	2138.85							
	Dry soil + tare (g)	2090.71							
	Tare (g)	328.11							
	Water content (%)	2.7							
Split Fraction	Wet soil + tare (g)	913.71	337.59	418.77	432.09				
	Dry soil + tare (g)	888.26	313.08	347.63	381.06				
	Tare (g)	312.18	153.21	119.63	128.32				
	Water content (%)	4.4	15.3	31.2	20.2				
	Water Content, w (%)	**3.7**	**15.3**	**31.2**	**20.2**				
	Dry Unit Wt., γ_d (pcf)								

Entered by:____________

Reviewed:____________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: Summit Eden Phase 1E
No: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 7/7/2015
By: BRR

Boring No.: TP-11
Sample:
Depth: 3.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

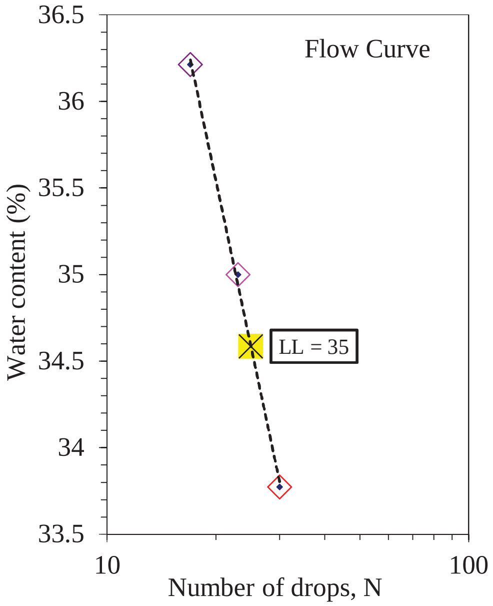
Plastic Limit

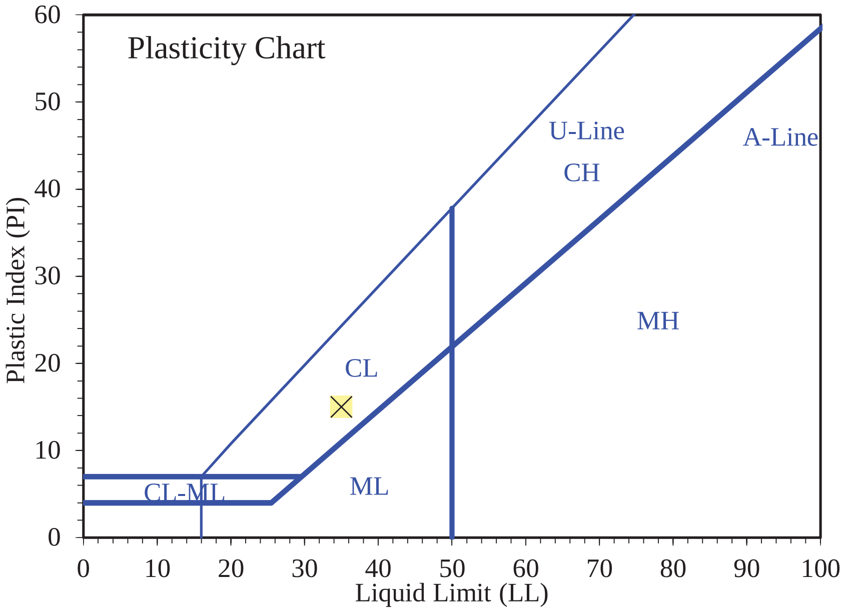
Determination No	1	2				
Wet Soil + Tare (g)	28.37	29.18				
Dry Soil + Tare (g)	27.34	27.98				
Water Loss (g)	1.03	1.20				
Tare (g)	22.14	22.05				
Dry Soil (g)	5.20	5.93				
Water Content, w (%)	19.81	20.24				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	30	23	17			
Wet Soil + Tare (g)	31.92	31.34	29.43			
Dry Soil + Tare (g)	29.36	28.96	27.46			
Water Loss (g)	2.56	2.38	1.97			
Tare (g)	21.78	22.16	22.02			
Dry Soil (g)	7.58	6.80	5.44			
Water Content, w (%)	33.77	35.00	36.21			
One-Point LL (%)	35	35				

Liquid Limit, LL (%)	**35**
Plastic Limit, PL (%)	**20**
Plasticity Index, PI (%)	**15**





Entered by:____________
Reviewed:____________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: Summit Eden Phase 1E
No: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 7/8/2015
By: BRR

Boring No.: TP-13
Sample:
Depth: 3.0'
Description: Reddish brown fat clay

Preparation method: Wet
Liquid limit test method: Multipoint

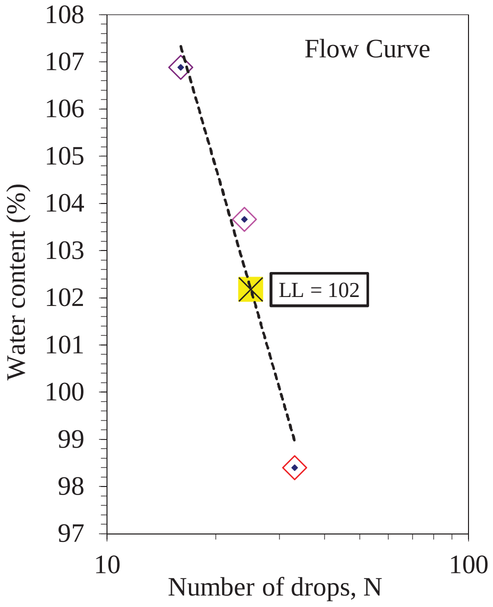
Plastic Limit

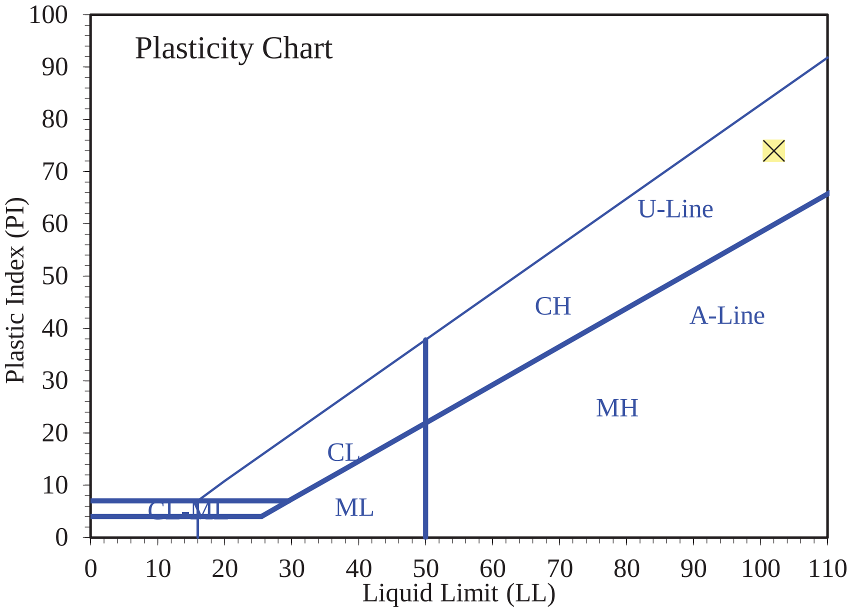
Determination No	1	2				
Wet Soil + Tare (g)	28.28	28.38				
Dry Soil + Tare (g)	26.87	26.99				
Water Loss (g)	1.41	1.39				
Tare (g)	21.78	21.94				
Dry Soil (g)	5.09	5.05				
Water Content, w (%)	27.70	27.52				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	33	24	16			
Wet Soil + Tare (g)	28.13	29.60	29.48			
Dry Soil + Tare (g)	25.05	25.64	25.60			
Water Loss (g)	3.08	3.96	3.88			
Tare (g)	21.92	21.82	21.97			
Dry Soil (g)	3.13	3.82	3.63			
Water Content, w (%)	98.40	103.66	106.89			
One-Point LL (%)		103				

Liquid Limit, LL (%)	**102**
Plastic Limit, PL (%)	**28**
Plasticity Index, PI (%)	**74**





Entered by:___________

Reviewed:___________

Z:\PROJECTS\01628_Powder_Mountain\011_Summit_Eden\[ALv1.xlsm]2

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: Summit Eden Phase 1E
No: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 7/8/2015
By: BRR

Boring No.: TP-14
Sample:
Depth: 4.0'
Description: Reddish brown fat clay

Preparation method: Wet
Liquid limit test method: Multipoint

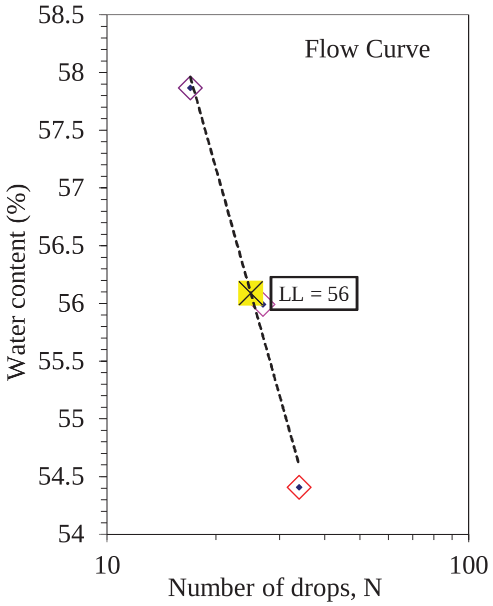
Plastic Limit

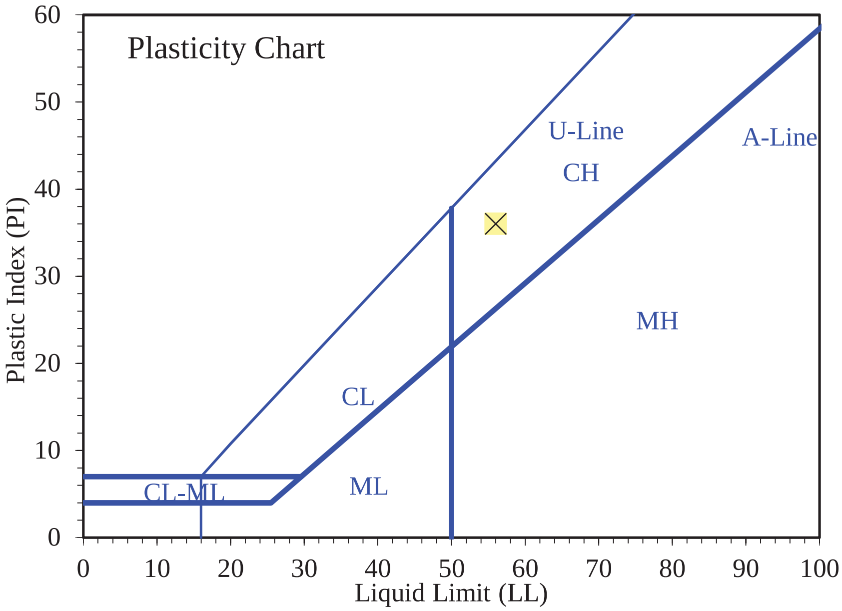
Determination No	1	2				
Wet Soil + Tare (g)	28.76	28.67				
Dry Soil + Tare (g)	27.59	27.57				
Water Loss (g)	1.17	1.10				
Tare (g)	21.67	22.02				
Dry Soil (g)	5.92	5.55				
Water Content, w (%)	19.76	19.82				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	34	27	17			
Wet Soil + Tare (g)	28.15	30.06	31.60			
Dry Soil + Tare (g)	25.99	27.21	28.18			
Water Loss (g)	2.16	2.85	3.42			
Tare (g)	22.02	22.12	22.27			
Dry Soil (g)	3.97	5.09	5.91			
Water Content, w (%)	54.41	55.99	57.87			
One-Point LL (%)		57				

Liquid Limit, LL (%)	**56**
Plastic Limit, PL (%)	**20**
Plasticity Index, PI (%)	**36**





Entered by:____________
Reviewed:____________

Z:\PROJECTS\01628_Powder_Mountain\011_Summit_Eden\[ALv1.xlsm]3

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

(ASTM D1140)

Project: **Summit Eden Phase 1E**
No: **01628-011**
Location: Powder Mtn. Resort, Utah
Date: 6/26/2015
By: LF

Sample Info.	Boring No.	TP-1	TP-7	TP-13					
	Sample								
	Depth	5.0'	4.0'	6.0'					
	Split	Yes	Yes	Yes					
	Split Sieve*	3/8"	3/8'	3/4"					
	Method	A	A	A					
	Moist total sample wt. (g)	3841.66	2628.40	1014.41					
	Moist coarse fraction (g)	1541.37	1238.20	53.95					
	Moist split fraction + tare (g)	1002.19	891.08	1175.86					
	Split fraction tare (g)	315.10	215.42	215.40					
	Dry split fraction (g)	641.47	643.83	862.90					
	Dry retained No. 200 + tare (g)	844.66	806.21	967.76					
	Wash tare (g)	315.10	215.42	215.40					
	No. 200 Dry wt. retained (g)	529.56	590.79	752.36					
	Split sieve* Dry wt. retained (g)	1472.35	1209.54	49.47					
	Dry total sample wt. (g)	3619.91	2534.25	912.37					
Coarse Fraction	Moist soil + tare (g)	1949.66	1453.53	178.46					
	Dry soil + tare (g)	1880.64	1424.87	173.98					
	Tare (g)	408.29	215.33	124.51					
	Water content (%)	4.69	2.37	9.06					
Split Fraction	Moist soil + tare (g)	1002.19	891.08	1175.86					
	Dry soil + tare (g)	956.57	859.25	1078.30					
	Tare (g)	315.10	215.42	215.40					
	Water content (%)	7.11	4.94	11.31					
	Percent passing split sieve* (%)	**59.3**	**52.3**	**94.6**					
	Percent passing No. 200 sieve (%)	**10.3**	**4.3**	**12.1**					

Entered by:____________

Reviewed:____________

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

(ASTM D6913)

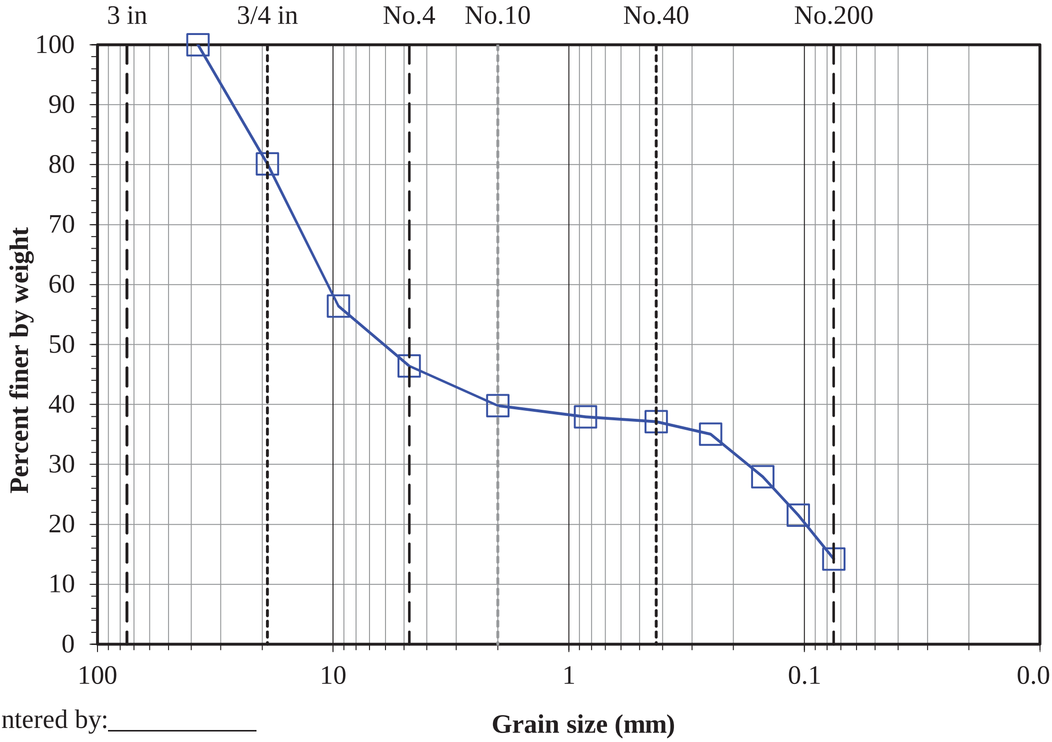
Project: Summit Eden Phase 1E
No: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 6/29/2015
By: LF

Boring No.: TP-02
Sample:
Depth: 4.0'
Description: Reddish brown silty gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	1675.76	1607.75
+3/8" Coarse fraction (g):	716.02	700.97
-3/8" Split fraction (g):	959.74	906.78
Split fraction:	0.564	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	1026.65	1269.20
Dry soil + tare (g):	1011.60	1216.24
Tare (g):	310.63	309.46
Water content (%):	2.1	5.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	100.0	
3/4"	319.18	19	80.1	
3/8"	700.97	9.5	56.4	←Split
No.4	160.45	4.75	46.4	
No.10	266.97	2	39.8	
No.20	297.32	0.85	37.9	
No.40	310.04	0.425	37.1	
No.60	343.20	0.25	35.1	
No.100	457.82	0.15	27.9	
No.140	560.68	0.106	21.5	
No.200	678.41	0.075	14.2	



Gravel (%): 53.6
Sand (%): 32.2
Fines (%): 14.2

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01628_Powder_Mountain\011_Summit_Eden\[GSDv2.xlsx]1

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

(ASTM D6913)

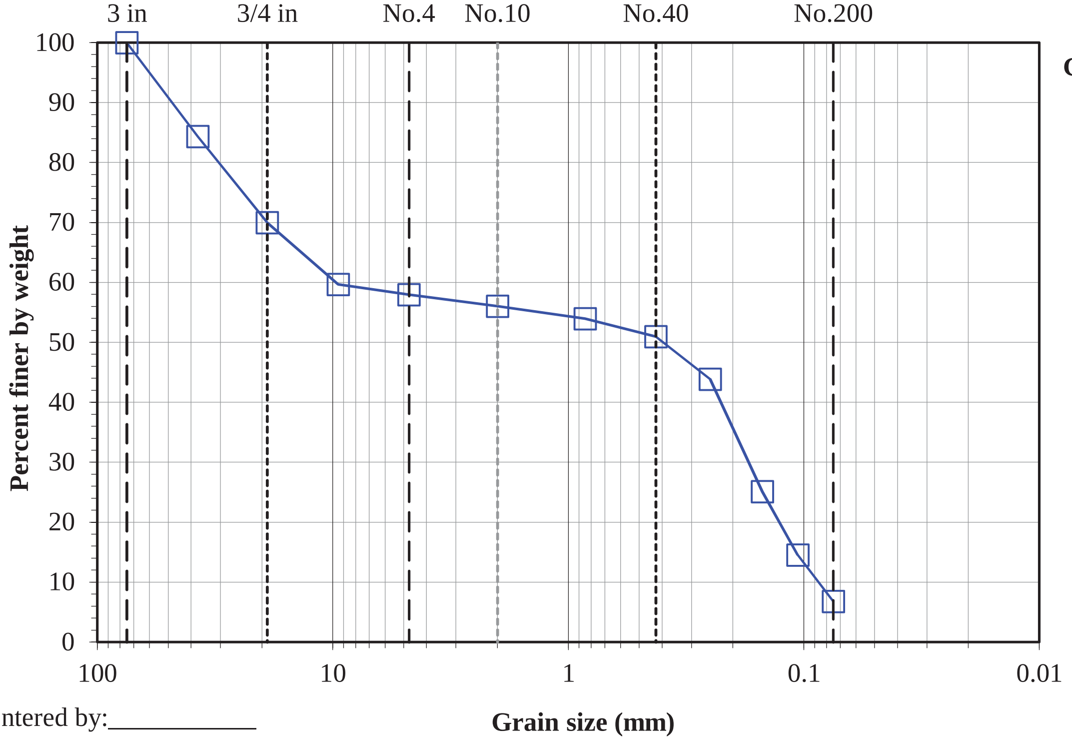
Project: Summit Eden Phase 1E
No: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 6/29/2015
By: LF

Boring No.: TP-03
Sample:
Depth: 5.0'
Description: Light brown sand with silt and gravel

	Moist	Dry
Split:	Yes	
Split sieve:	3/8"	
Total sample wt. (g):	4534.74	4371.35
+3/8" Coarse fraction (g):	1810.74	1762.60
-3/8" Split fraction (g):	601.53	576.08
Split fraction:	0.597	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	2138.85	913.71
Dry soil + tare (g):	2090.71	888.26
Tare (g):	328.11	312.18
Water content (%):	2.7	4.4

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	683.52	37.5	84.4	
3/4"	1311.20	19	70.0	
3/8"	1762.60	9.5	59.7	←Split
No.4	16.73	4.75	57.9	
No.10	35.13	2	56.0	
No.20	55.18	0.85	54.0	
No.40	84.28	0.425	50.9	
No.60	152.94	0.25	43.8	
No.100	333.58	0.15	25.1	
No.140	436.04	0.106	14.5	
No.200	510.75	0.075	6.8	



Gravel (%): 42.1
Sand (%): 51.2
Fines (%): 6.8

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

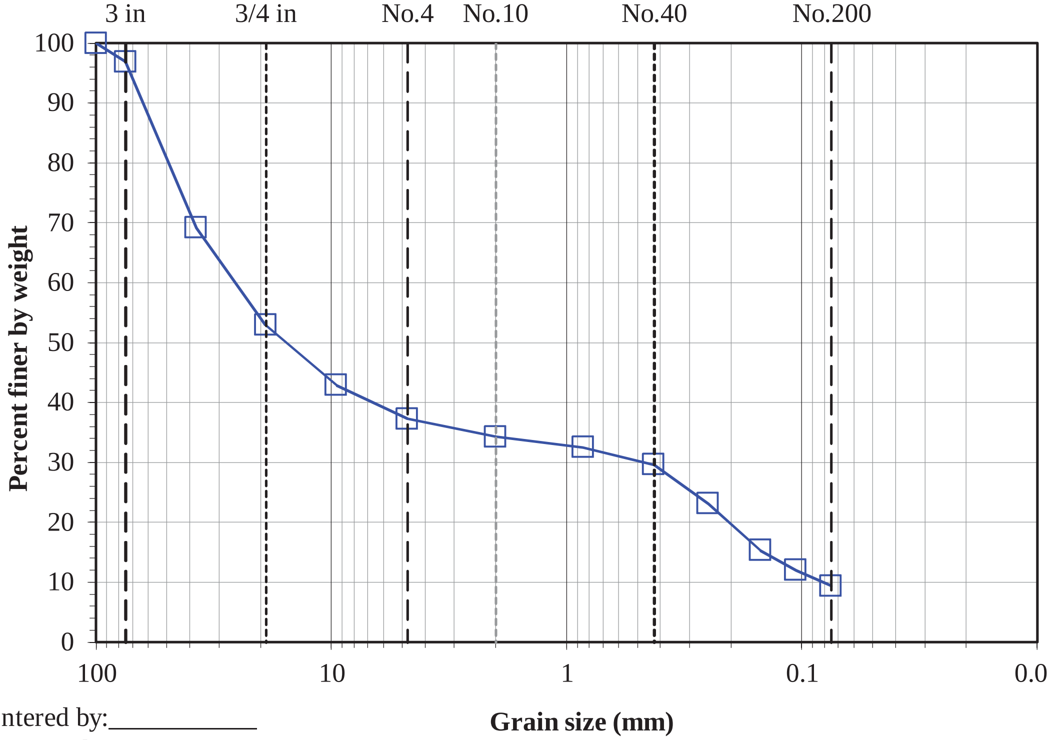
Project: Summit Eden Phase 1E
No: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 7/9/2015
By: DKS

Boring No.: TP-03
Sample:
Depth: 4.0'
Description: Brown gravel with silt and sand

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	29335.70	28453.07
+3/4" Coarse fraction (g):	13548.20	13403.23
-3/4" Split fraction (g):	679.30	647.56
Split fraction:	0.529	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	1978.84	995.90
Dry soil + tare (g):	1962.62	964.16
Tare (g):	462.95	316.60
Water content (%):	1.1	4.9

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	100.0	
3"	893.83	75	96.9	
1.5"	8780.93	37.5	69.1	
3/4"	13403.23	19	52.9	←Split
3/8"	122.95	9.5	42.9	
No.4	191.48	4.75	37.3	
No.10	228.32	2	34.2	
No.20	249.32	0.85	32.5	
No.40	284.90	0.425	29.6	
No.60	364.88	0.25	23.1	
No.100	460.18	0.15	15.3	
No.140	500.82	0.106	12.0	
No.200	532.93	0.075	9.4	



Gravel (%): 62.7
Sand (%): 27.9
Fines (%): 9.4

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

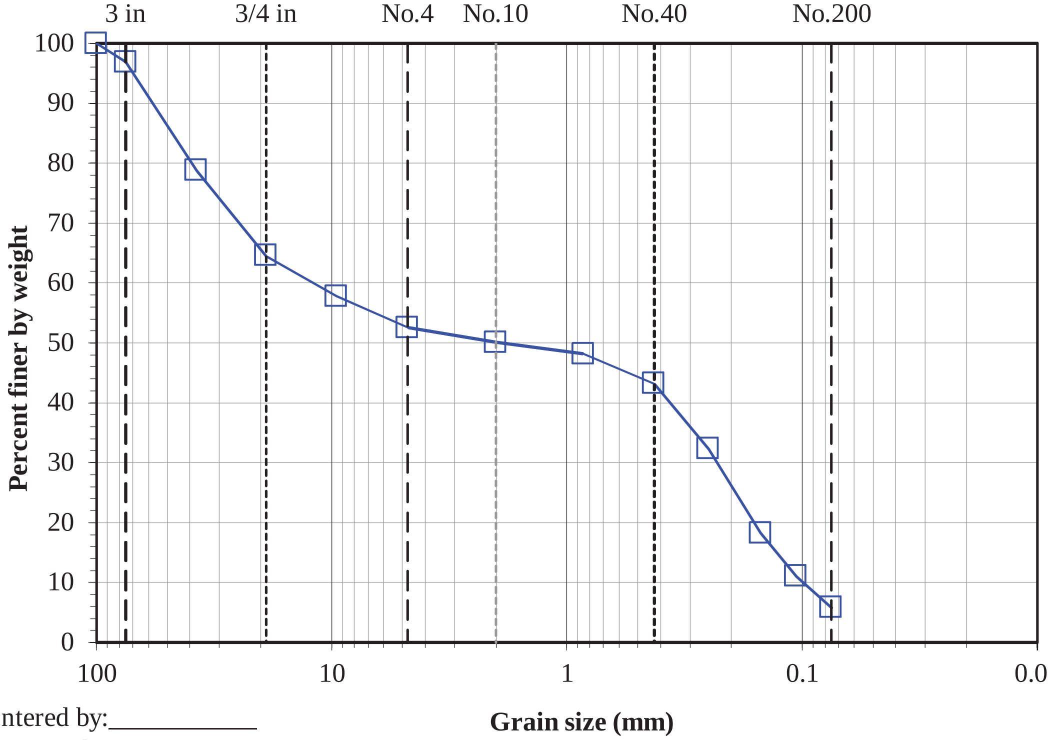
Project: Summit Eden Phase 1E
No: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 7/10/2015
By: DKS

Boring No.: TP-04
Sample:
Depth: 3.5'
Description: Reddish brown gravel with silt and sand

Split:	Yes	
Split sieve:	3/4"	
	Moist	Dry
Total sample wt. (g):	29462.90	28649.69
+3/4" Coarse fraction (g):	10223.80	10151.70
-3/4" Split fraction (g):	653.13	627.97
Split fraction:	0.646	

Water content data	C.F.(+3/4")	S.F.(-3/4")
Moist soil + tare (g):	2070.32	983.36
Dry soil + tare (g):	2059.00	958.22
Tare (g):	465.23	330.73
Water content (%):	0.7	4.0

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	100.0	
3"	892.86	75	96.9	
1.5"	6081.21	37.5	78.8	
3/4"	10151.70	19	64.6	←Split
3/8"	66.24	9.5	57.8	
No.4	116.96	4.75	52.5	
No.10	141.08	2	50.1	
No.20	159.43	0.85	48.2	
No.40	208.10	0.425	43.2	
No.60	313.81	0.25	32.3	
No.100	450.31	0.15	18.3	
No.140	520.86	0.106	11.0	
No.200	571.56	0.075	5.8	



Gravel (%): 47.5
Sand (%): 46.7
Fines (%): 5.8

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

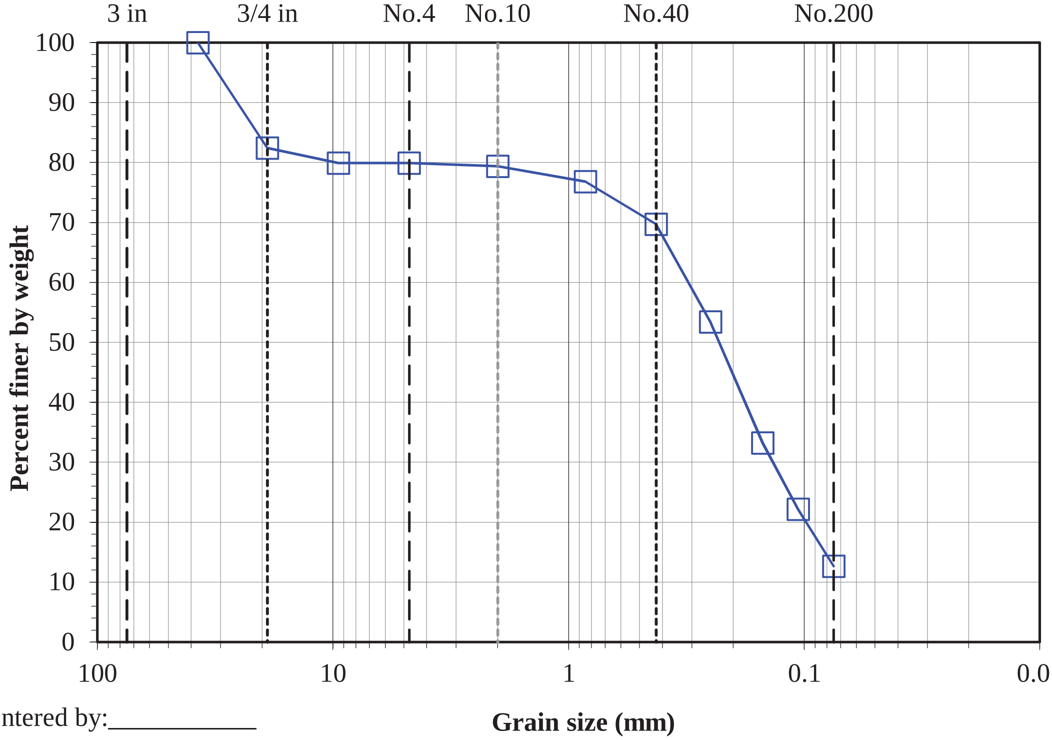
Project: Summit Eden Phase 1E
No: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 6/29/2015
By: LF

Boring No.: TP-05
Sample:
Depth: 7.0'
Description: Reddish brown silty sand with gravel

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	1537.34	1455.79
+3/8" Coarse fraction (g):	306.14	292.02
-3/8" Split fraction (g):	613.52	579.92
Split fraction:	0.799	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	424.55	1022.53
Dry soil + tare (g):	410.43	988.93
Tare (g):	118.41	409.01
Water content (%):	4.8	5.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	100.0	
3/4"	255.85	19	82.4	
3/8"	292.02	9.5	79.9	←Split
No.4	0.38	4.75	79.9	
No.10	4.09	2	79.4	
No.20	22.61	0.85	76.8	
No.40	74.18	0.425	69.7	
No.60	192.25	0.25	53.4	
No.100	338.91	0.15	33.2	
No.140	418.99	0.106	22.2	
No.200	488.14	0.075	12.7	



Gravel (%): 20.1
Sand (%): 67.2
Fines (%): 12.7

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

Project: Summit Eden Phase 1E
No: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 6/29/2015
By: LF

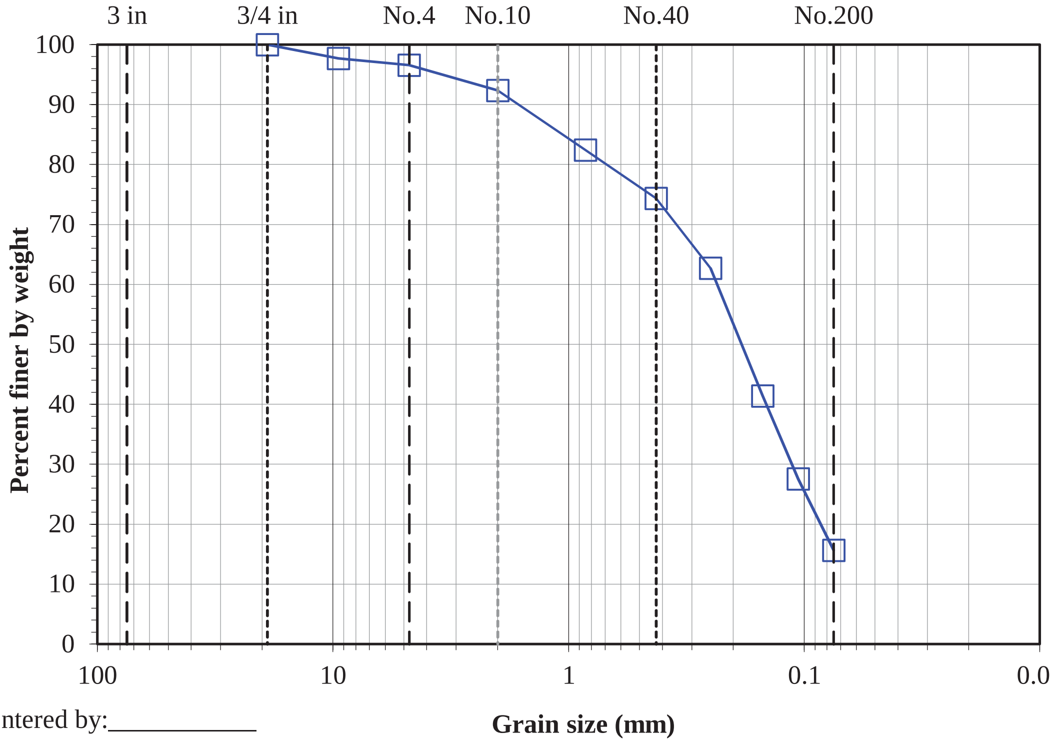
Boring No.: TP-12
Sample:
Depth: 4.0'
Description: Reddish brown silty sand

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	820.21	741.73
Split fraction:	1.000	

Water content data

Moist soil + tare (g):	-	1042.16
Dry soil + tare (g):	-	963.68
Tare (g):	-	221.95
Water content (%):	0.0	10.6

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	100.0
3/8"	17.19	9.5	97.7
No.4	25.24	4.75	96.6
No.10	56.56	2	92.4
No.20	130.36	0.85	82.4
No.40	190.01	0.425	74.4
No.60	276.45	0.25	62.7
No.100	434.59	0.15	41.4
No.140	537.39	0.106	27.5
No.200	625.79	0.075	15.6



Gravel (%): 3.4
Sand (%): 81.0
Fines (%): 15.6

Entered by:____________
Reviewed:____________

Laboratory Compaction Characteristics of Soil

(ASTM D698 / D1557)

Project: Summit Eden Phase 1E
No: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 7/10/2015
By: DKS

Boring No.: TP-04
Sample:
Depth: 3.5'
Sample Description: Reddish brown gravel with silt and sand
Engineering Classification: Not requested
As-received water content (%): Not requested

Method: ASTM D1557 C
Mold Id. Inc 4
Mold volume (ft^3): 0.0752

Preparation method: Moist
Rammer: Mechanical-sector face
Rock Correction: Yes * See results below
Percent fraction retained, Pc (%) 30.0
Percent fraction passing, Pf (%) 70.0

Optimum water content (%): 11
Maximum dry unit weight (pcf): 118.8

Point Number	As Is	+2%	+4%	+6%	+8%	+10%		
Wt. Sample + Mold (g)	9621.3	9685.5	9853.7	10034.7	10111.7	10143.0		
Wt. of Mold (g)	5586.2	5586.2	5586.2	5586.2	5586.2	5586.2		
Wet Unit Wt., γ_m (pcf)	118.3	120.2	125.1	130.5	132.7	133.6		
Wet Soil + Tare (g)	801.11	1003.06	1044.95	1058.00	1043.78	1087.45		
Dry Soil + Tare (g)	776.35	956.89	985.06	977.09	949.44	977.99		
Tare (g)	128.76	172.20	171.27	168.11	167.63	165.97		
Water Content, w (%)	**3.8**	**5.9**	**7.4**	**10.0**	**12.1**	**13.5**		
Dry Unit Wt., γ_d (pcf)	**114.0**	**113.5**	**116.6**	**118.6**	**118.4**	**117.8**		

*Correction of Unit Weight and Water Content for Soils Containing Oversize Particles

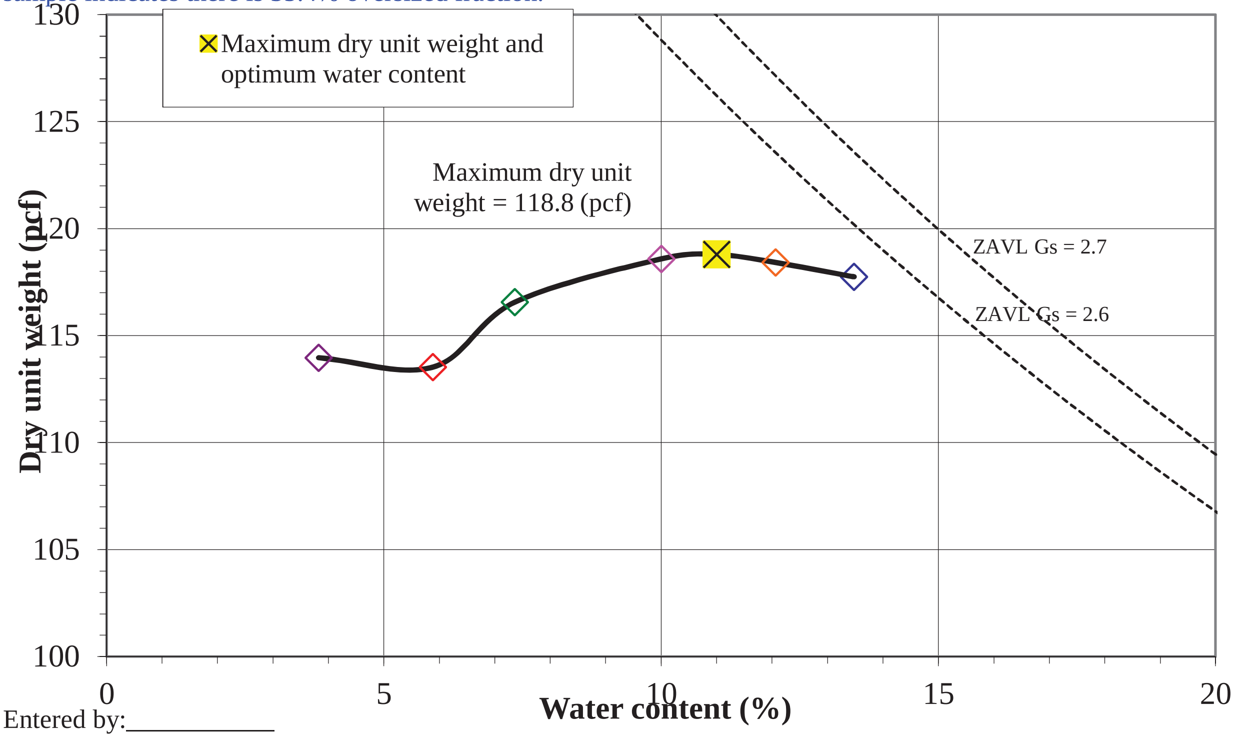
(ASTM D4718)

Oversized fraction, +3/4-in. (%): 30.0
Water content, +3/4-in. (%): 0.7
Sieve for oversized fraction: 3/4-in.
Bulk specific gravity, Gs: 2.65 Assumed

Corrected water content (%): 7.9
Corrected dry unit weight (pcf): 129.8

Comments:

Due to insufficient sample, points +2%, +4%, +6, +8 and +10% contain previously compacted soil broken down over the 3/4" screen. According to ASTM D4718 the maximum allowable oversized fraction is 30%, the Sieve analysis of the sample indicates there is 35.4% oversized fraction.



Entered by:___________

Reviewed:___________

California Bearing Ratio

(ASTM D 1883)

Project: Summit Eden Phase 1E
Number: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 7/21/2015
By: DKS

Boring No.: TP-01
Sample:
Depth: 3.0'
Original Method: ASTM D1557 C
Engineering Classification: Not requested
Condition of Sample: Soaked
Scalp and Replace: No

Maximum Dry Unit Weight (pcf): 132.7
Optimum Water Content (%): 8.6
Relative Compaction (%): 94.9
0.1 in. Corrected CBR (%): 27.8
0.2 in. Corrected CBR (%): 34.8

As Compacted Data			Before	After
Mold Id.	A	Wet Soil + Tare (g)	808.46	812.05
Wt. of Mold + Sample (g)	11917.1	Dry Soil + Tare (g)	757.01	759.20
Wt. of Mold (g)	7255	Tare (g)	165.99	171.28
Dry Unit Weight (pcf)	126.0	Water Content (%)	8.7	9.0

After Soaking Data			Average	Top 1 in.
Wt. of Mold + Sample (g)	12070.5	Wet Soil + Tare (g)	1175.48	707.13
Dry Unit Weight (pcf)	125.8	Dry Soil + Tare (g)	1070.22	647.94
		Tare (g)	168.12	123.45
		Water Content (%)	11.7	11.3

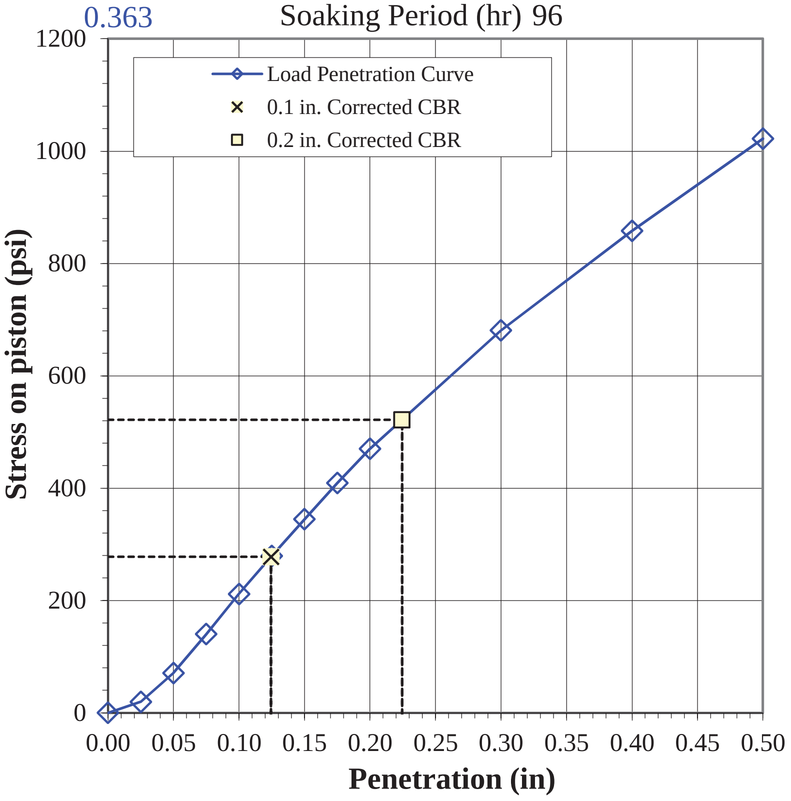
Swell Data

Date	Time	Dial		
			Surcharge (psf)	50
7/16/2015	08:50	0.355	Swell (%)	0.17
7/20/2015	08:58	0.363	Soaking Period (hr)	96

Penetration Data | Piston ID CBR T1

Zero load (lb) = 3
Area of Piston (in^2) = 3.0

Penetration (in.)	Raw Load (lb)	Piston Stress (psi)	Std. Stress (psi)
0.000	0	0	
0.025	59	20	
0.050	213	71	
0.075	420	140	
0.100	634	212	1000
0.125	837	279	1125
0.150	1033	345	1250
0.175	1226	409	1375
0.200	1410	470	1500
0.300	2042	681	1900
0.400	2573	858	2300
0.500	3065	1022	2600



Entered By:___________
Reviewed:___________

California Bearing Ratio

(ASTM D 1883)

IGES

Project: Summit Eden Phase 1E
Number: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 7/21/2015
By: DKS

Boring No.: TP-03
Sample:
Depth: 4.0'
Original Method: ASTM D1557 C
Engineering Classification: Not requested
Condition of Sample: Soaked
Scalp and Replace: No

Maximum Dry Unit Weight (pcf): 127.4
Optimum Water Content (%): 8.3
Relative Compaction (%): 94.9
0.1 in. Corrected CBR (%): 24.0
0.2 in. Corrected CBR (%): 30.7

As Compacted Data			Before	After
Mold Id.	6	Wet Soil + Tare (g)	752.36	829.79
Wt. of Mold + Sample (g)	11424.1	Dry Soil + Tare (g)	708.90	776.45
Wt. of Mold (g)	6963.6	Tare (g)	167.62	168.11
Dry Unit Weight (pcf)	120.9	Water Content (%)	8.0	8.8
After Soaking Data			**Average**	**Top 1 in.**
Wt. of Mold + Sample (g)	11651.1	Wet Soil + Tare (g)	1336.14	659.64
Dry Unit Weight (pcf)	121.4	Dry Soil + Tare (g)	1203.84	601.11
		Tare (g)	169.91	127.51
		Water Content (%)	12.8	12.4

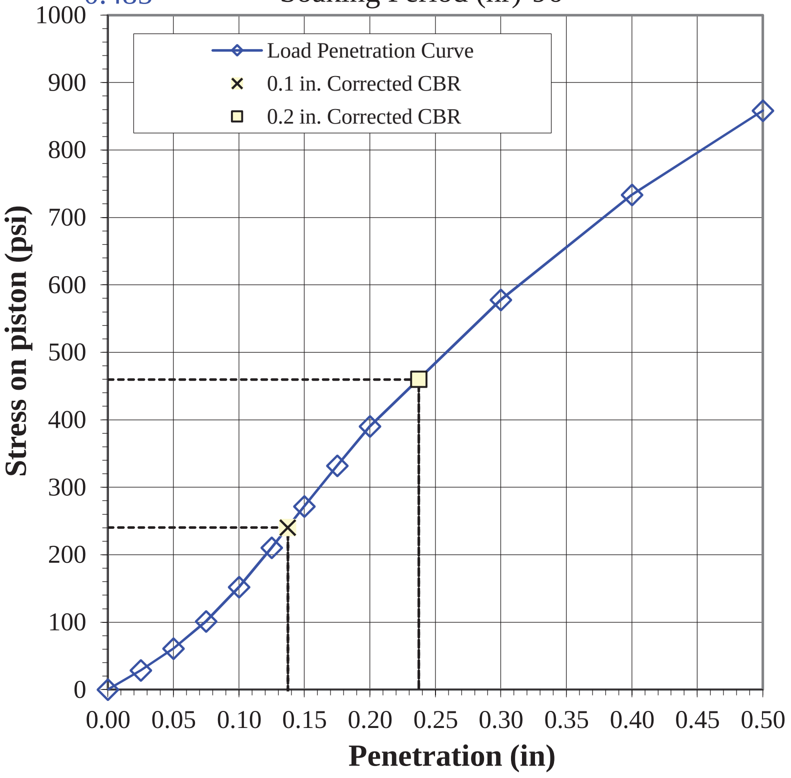
Swell Data

Date	Time	Dial		
			Surcharge (psf)	50
7/16/2015	10:10	0.504	Swell (%)	-0.41
7/20/2015	10:10	0.485	Soaking Period (hr)	96

Penetration Data | Piston ID: CBR T1

Zero load (lb) = 3
Area of Piston (in^2) = 3.0

Penetration (in.)	Raw Load (lb)	Piston Stress (psi)	Std. Stress (psi)
0.000	0	0	
0.025	85	28	
0.050	183	61	
0.075	304	101	
0.100	455	152	1000
0.125	630	210	1125
0.150	815	272	1250
0.175	996	332	1375
0.200	1170	390	1500
0.300	1732	578	1900
0.400	2199	733	2300
0.500	2575	859	2600



Entered By:___________

Reviewed:___________

California Bearing Ratio

(ASTM D 1883)

Project: Summit Eden Phase 1E
Number: 01628-011
Location: Powder Mtn. Resort, Utah
Date: 7/16/2015
By: DKS

Boring No.: TP-04
Sample:
Depth: 3.5'
Original Method: ASTM D1557 C
Engineering Classification: Not requested
Condition of Sample: Soaked
Scalp and Replace: No

Maximum Dry Unit Weight (pcf): 118.8
Optimum Water Content (%): 11
Relative Compaction (%): 95.3
0.1 in. Corrected CBR (%): 18.4
0.2 in. Corrected CBR (%): 23.0

As Compacted Data			Before	After
Mold Id.	4	Wet Soil + Tare (g)	894.49	867.36
Wt. of Mold + Sample (g)	11473.7	Dry Soil + Tare (g)	822.04	791.05
Wt. of Mold (g)	7185.3	Tare (g)	172.19	168.43
Dry Unit Weight (pcf)	113.2	Water Content (%)	11.1	12.3

After Soaking Data			Average	Top 1 in.
Wt. of Mold + Sample (g)	11647.0	Wet Soil + Tare (g)	1141.04	762.78
Dry Unit Weight (pcf)	113.2	Dry Soil + Tare (g)	1012.25	682.78
		Tare (g)	168.43	127.89
		Water Content (%)	15.3	14.4

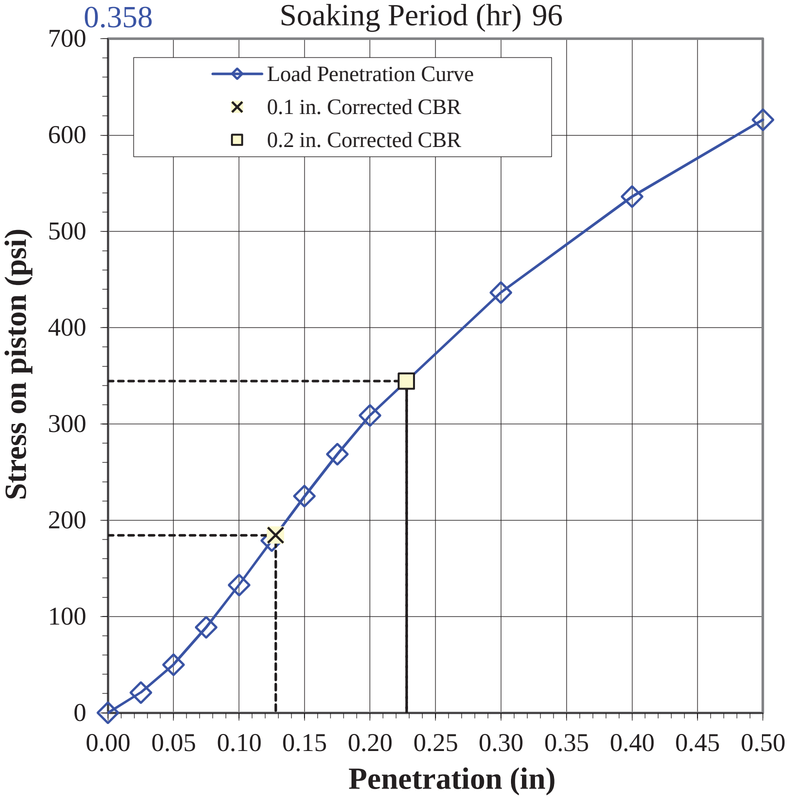
Swell Data

Date	Time	Dial		
7/16/2015	11:10	0.36	Surcharge (psf)	50
7/20/2015	11:14	0.358	Swell (%)	-0.04
			Soaking Period (hr)	96

Penetration Data | Piston ID CBR T1

Zero load (lb) = 3
Area of Piston (in^2) = 3.0

Penetration (in.)	Raw Load (lb)	Piston Stress (psi)	Std. Stress (psi)
0.000	0	0	
0.025	63	21	
0.050	150	50	
0.075	267	89	
0.100	398	133	1000
0.125	537	179	1125
0.150	675	225	1250
0.175	805	269	1375
0.200	926	309	1500
0.300	1309	437	1900
0.400	1608	536	2300
0.500	1846	616	2600



Entered By:___________
Reviewed:___________

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)*

Project: **Summit Eden Phase 1E**
No: **01628-011**
Location: Powder Mtn. Resort, Utah
Date: 7/15/2015
By: JMG

Sample info.	Boring No.	TP-11							
	Sample								
	Depth	3.0'							
Water content data	Wet soil + tare (g)	88.39							
	Dry soil + tare (g)	71.03							
	Tare (g)	22.49							
	Water content (%)	35.8							
Chem. data	pH	6.48							
	Soluble chloride* (ppm)	<5.42							
	Soluble sulfate** (ppm)	19.2							
Resistivity data	Pin method	2							
	Soil box	Miller Small							
		Approximate Soil condition (%)	Resistance Reading (Ω)	Soil Box Multiplier (cm)	Resistivity (Ω-cm)	Approximate Soil condition (%)	Resistance Reading (Ω)	Soil Box Multiplier (cm)	Resistivity (Ω-cm)
		As Is	43330	0.67	29031				
		+3	14650	0.67	9816				
		+6	4455	0.67	2985				
		+9	3782	0.67	2534				
		+12	3695	0.67	2476				
		+15	3783	0.67	2535				
	Minimum resistivity (Ω-cm)	**2476**							

* Performed by AWAL using EPA 300.0

** Performed by AWAL using ASTM C1580

Comments: Moisture content taken at point +15%.

Entered by:___________

Reviewed:___________

APPENDIX C

Summit Eden Phase 1E
01628-011
8/9/2015
Sample Calculation

c'	0	psf	Effective Cohesion
ϕ'	44	deg	Effective Friction Angle
Y_{sat}	140	pcf	Saturated Unit Weight of Soil
Y_w	62.4	pcf	Unit weight of water
h	3	ft	Depth to shear surface
β	26.6	deg	Slope Gradient (2H:1V)

FS 1.07

🟨	Input Variable
🟩	Calculated Value

This model assumes c>0 and the face of the slope is saturated to depth h

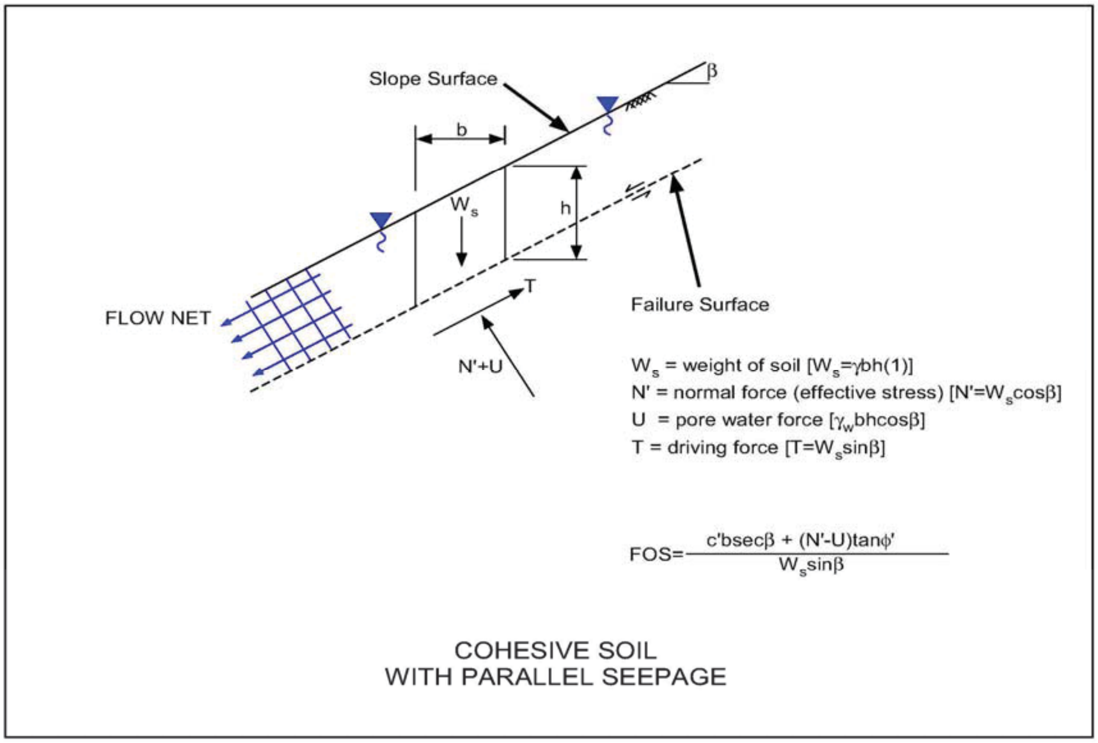


Figure C-1

APPENDIX D

USGS Design Maps Detailed Report

2012 International Building Code (41.3662°N, 111.7714°W)

Site Class B – “Rock”, Risk Category I/II/III

Section 1613.3.1 — Mapped acceleration parameters

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

From Figure 1613.3.1(1) [1] $S_S = 0.841$ g

From Figure 1613.3.1(2) [2] $S_1 = 0.280$ g

Section 1613.3.2 — Site class definitions

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

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

Site Class	$\bar{v}_s$	$\bar{N}$ or $\bar{N}_{ch}$	$\bar{s}_u$
A. Hard Rock	>5,000 ft/s	N/A	N/A
B. Rock	2,500 to 5,000 ft/s	N/A	N/A
C. Very dense soil and soft rock	1,200 to 2,500 ft/s	>50	>2,000 psf
D. Stiff Soil	600 to 1,200 ft/s	15 to 50	1,000 to 2,000 psf
E. Soft clay soil	<600 ft/s	<15	<1,000 psf
	Any profile with more than 10 ft of soil having the characteristics: • Plasticity index *PI* > 20, • Moisture content *w* ≥ 40%, and • Undrained shear strength $\bar{s}_u$ < 500 psf		
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.3.1		

For SI: 1ft/s = 0.3048 m/s 1lb/ft² = 0.0479 kN/m²

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

TABLE 1613.3.3(1)
VALUES OF SITE COEFFICIENT F_a

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

Note: Use straight–line interpolation for intermediate values of S_S

For Site Class = B and S_S = 0.841 g, F_a = 1.000

TABLE 1613.3.3(2)
VALUES OF SITE COEFFICIENT F_v

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

Note: Use straight–line interpolation for intermediate values of S_1

For Site Class = B and S_1 = 0.280 g, F_v = 1.000

Equation (16-37): $S_{MS} = F_aS_S = 1.000 \times 0.841 = 0.841$ g

Equation (16-38): $S_{M1} = F_vS_1 = 1.000 \times 0.280 = 0.280$ g

Section 1613.3.4 — Design spectral response acceleration parameters

Equation (16-39): $S_{DS} = ⅔\ S_{MS} = ⅔ \times 0.841 = 0.561$ g

Equation (16-40): $S_{D1} = ⅔\ S_{M1} = ⅔ \times 0.280 = 0.187$ g

Section 1613.3.5 — Determination of seismic design category

TABLE 1613.3.5(1)

SEISMIC DESIGN CATEGORY BASED ON SHORT-PERIOD (0.2 second) RESPONSE ACCELERATION

VALUE OF S_{DS}	**RISK CATEGORY**		
	I or II	**III**	**IV**
$S_{DS} < 0.167g$	A	A	A
$0.167g \leq S_{DS} < 0.33g$	B	B	C
$0.33g \leq S_{DS} < 0.50g$	C	C	D
$0.50g \leq S_{DS}$	D	D	D

For Risk Category = I and S_{DS} = 0.561 g, Seismic Design Category = D

TABLE 1613.3.5(2)

SEISMIC DESIGN CATEGORY BASED ON 1-SECOND PERIOD RESPONSE ACCELERATION

VALUE OF S_{D1}	**RISK CATEGORY**		
	I or II	**III**	**IV**
$S_{D1} < 0.067g$	A	A	A
$0.067g \leq S_{D1} < 0.133g$	B	B	C
$0.133g \leq S_{D1} < 0.20g$	C	C	D
$0.20g \leq S_{D1}$	D	D	D

For Risk Category = I and S_{D1} = 0.187 g, Seismic Design Category = C

Note: When S_1 is greater than or equal to 0.75g, the Seismic Design Category is **E** for buildings in Risk Categories I, II, and III, and **F** for those in Risk Category IV, irrespective of the above.

Seismic Design Category ≡ “the more severe design category in accordance with Table 1613.3.5(1) or 1613.3.5(2)” = D

Note: See Section 1613.3.5.1 for alternative approaches to calculating Seismic Design Category.

References

1. *Figure 1613.3.1(1)*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(1).pdf
2. *Figure 1613.3.1(2)*: http://earthquake.usgs.gov/hazards/designmaps/downloads/pdfs/IBC-2012-Fig1613p3p1(2).pdf

USGS Design Maps Summary Report

User–Specified Input

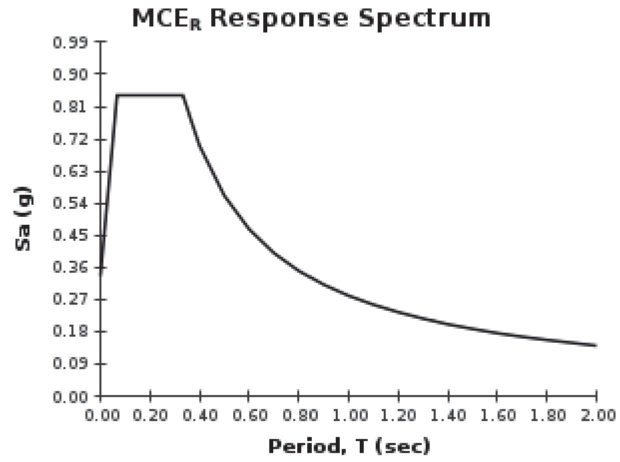
Report Title	Eden Phase 1E Sun August 9, 2015 20:57:26 UTC
Building Code Reference Document	2012 International Building Code (which utilizes USGS hazard data available in 2008)
Site Coordinates	41.3662°N, 111.7714°W
Site Soil Classification	Site Class B – "Rock"
Risk Category	I/II/III

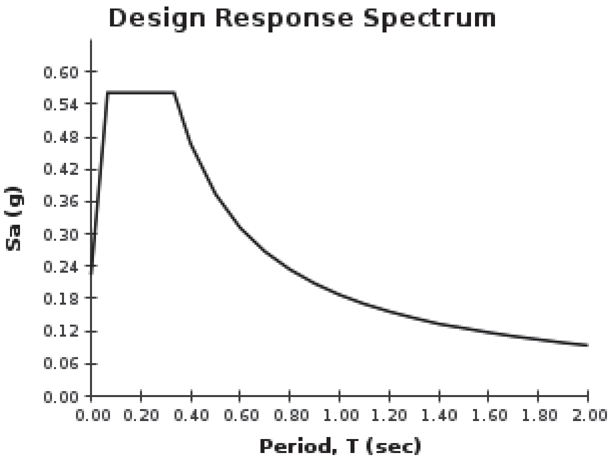
USGS–Provided Output

$S_S =$ 0.841 g $S_{MS} =$ 0.841 g $S_{DS} =$ 0.561 g

$S_1 =$ 0.280 g $S_{M1} =$ 0.280 g $S_{D1} =$ 0.187 g

For information on how the SS and S1 values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.





APPENDIX E

Allowable Bearing Capacity Calculations

Modified Meyerhof (1963)

IGES Project No.: 01628-011
Date: 8/9/2015

c	0	psf
ϕ	44	deg.
γ	125	pcf
B	1.67	ft.
D	3	ft.
L	65	ft.
β	0	deg.
FS	3	
FS_{shear}	1.5	

c	cohesion
ϕ	friction angle
γ	wet unit weight of soil
B	width of footing
D	depth of footing
β	inclination of the load on the foundation with respect to the vertical
L	length of footing

Note[1]: if round footing, L=B=diameter of footing
Note[2]: you may want to neglect depth factors for shallow foundations

Bearing Capacity Factors

Nq	115.3	(Reissner, 1924)
Nc	118.4	(Prandtl, 1921)
Ny	224.6	(Vesic, 1973)

Modified Bearing Capacity Factors (Shear)

c_d	0	psf
ϕ_d	32.8	deg.
Nq'	25.4	
Nc'	37.9	
Ny'	34.0	

Shape Factors (De Beer, 1970)

F_{cs}	1.0
F_{qs}	1.0
F_{ys}	0.99

Depth Factors (Hansen, 1970)

F_{cd}	1.4
F_{qd}	1.2
F_{yd}	1

Incliniation Factors (Meyerhof 1963; Hanna and Meyerhof 1981)

F_{ci}	1.00
F_{qi}	1.00
F_{yi}	1.00

Bearing Capacity

gross			net		
q_u	q_{all}	$q_{all(shear)}$	q_u	q_{all}	$q_{all(shear)}$
76,000	25,333	15,138	75,625	25,208	14,763

$q_u=cNcF_{cs}F_{cd}F_{ci}+\gamma DNqF_{qs}F_{qd}F_{qi}+0.5\gamma BNyF_{ys}F_{yd}F_{yi}$

$q_{all}=qu/FS$

$q_{all(shear)}=c_dNc'F_{cs}F_{cd}F_{ci}+\gamma DNq'F_{qs}F_{qd}F_{qi}+0.5\gamma BNy'F_{ys}F_{yd}F_{yi}$ where $c_d=c/FS_{shear}$ and $\phi_d=\tan^{-1}(\tan(\phi/FS_{shear}))$

Note: net values do not take into account removal of existing overburden (Dγ)

Figure E-1

Static Settlement Calculations
Simplified Schmertmann Method

For continuous footings (L/B≥10)

$$\delta = \frac{C_1 C_2 C_3 \left(q - \sigma'_{zD}\right)\left(2I_{\in p}\right.}{E_s}$$

For square and circular foundations (L/B=1)

$$\delta = \frac{C_1 C_2 C_3 \left(q - \sigma'_{zD}\right)\left(I_{\in p} + 0.025\right)B}{E_s}$$

$$C_1 = 1 - 0.5\left(\frac{\sigma'_{zD}}{q - \sigma'_{zD}}\right)$$

$$C_2 = 1 + 0.2\log\left(\frac{t}{0.1}\right)$$

$$C_3 = 1.03 - \frac{0.03L}{B} \geq 0.73$$

$$I_{\in p} = 0.5 + 0.1\sqrt{\frac{q - \sigma'_{zD}}{\sigma'_{zp}}}$$

where…

δ = total static settlement (inches)
q = bearing pressure (psf)
D = depth to bottom of footing measured from original grade (ft)
σ'_{zD} = vertical effective stress at depth D below the ground surface (psf)
σ'_{zp} = initial vertical effective stress at depth of peak strain influence factor*
$I_{\in p}$ = peak strain influence factor (no units)
B = width of footing (ft)
L = length of footing (ft)
E_s = equivalent modulus of elasticity in soil layer (ksf)
C_1 = depth factor
C_2 = secondary creep factor
C_3 = shape factor (equals 1 for square and circular foundations)
t = time since application of load (yr, typically taken as a 50-year design life)

*(for square and circular foundations, compute at a depth of D+B/2 below the ground surface; for continuous footings (L/B>10), compute at a depth of D+B)

Input:

q = 3,500 psf
D = 3 ft (assume zero for engineered fill)
B = 1.7 ft
L = 50 ft
E_s = 500 ksf (conservative estimate for clast-supported colluvium)
t = 50 years
Y' = 135 unit weight, pcf

Calculated Values:

σ'_{zD} = 0 psf
σ'_{zp} = 634.5 psf
C_1 = 1
C_2 = 1.54
C_3 = 0.73
$I_{\in p}$ = 0.73

δ = 0.25 inches

Figure E-2

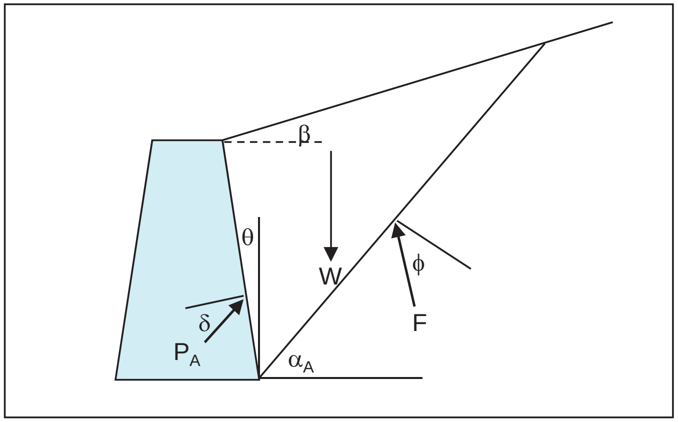
Lateral Earth Pressure Calculations (Coulomb Theory)

IGES Project No.: 01628-011
Date: 8/9/2015

	2:1 slope			Flat Backfill			Flat Backfill	
Y	125	pcf	Y	125	pcf	Y	125	pcf
ϕ	34		ϕ	34		ϕ	34	
θ	0		θ	0		θ	0	
β	26.5		β	0		β	0	
δ	0		δ	0		δ	0	
K_A=	0.42		K_A=	0.28		K_P=	3.5	
EFP=	52	pcf	EFP=	35	pcf	EFP=	442	pcf

$$Ka = \frac{\cos^2(\phi - \theta)}{\cos^2\theta\cos(\delta + \varphi)\left[1 + \sqrt{\frac{\sin(\delta + \varphi)\sin(\phi - \beta)}{\cos(\delta + \varphi)\cos(\beta - \theta)}}\right]^2}$$

$$Kp = \frac{\cos^2(\phi + \theta)}{\cos^2\theta\cos(\delta + \varphi)\left[1 - \sqrt{\frac{\sin(\delta + \varphi)\sin(\phi + \beta)}{\cos(\delta - \varphi)\cos(\beta - \theta)}}\right]^2}$$



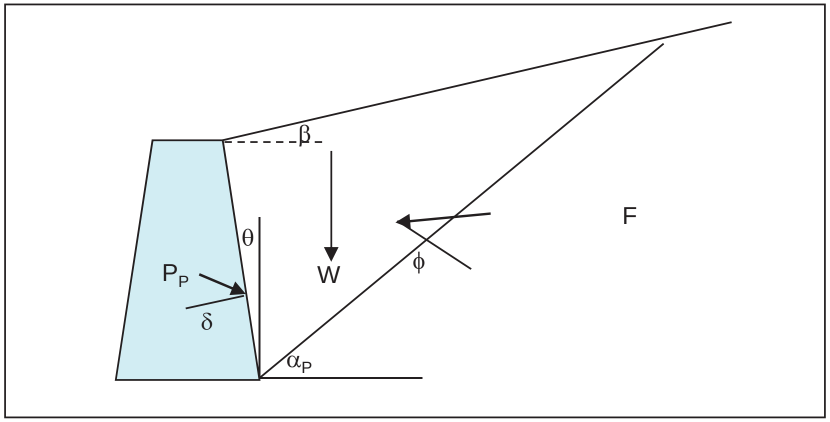
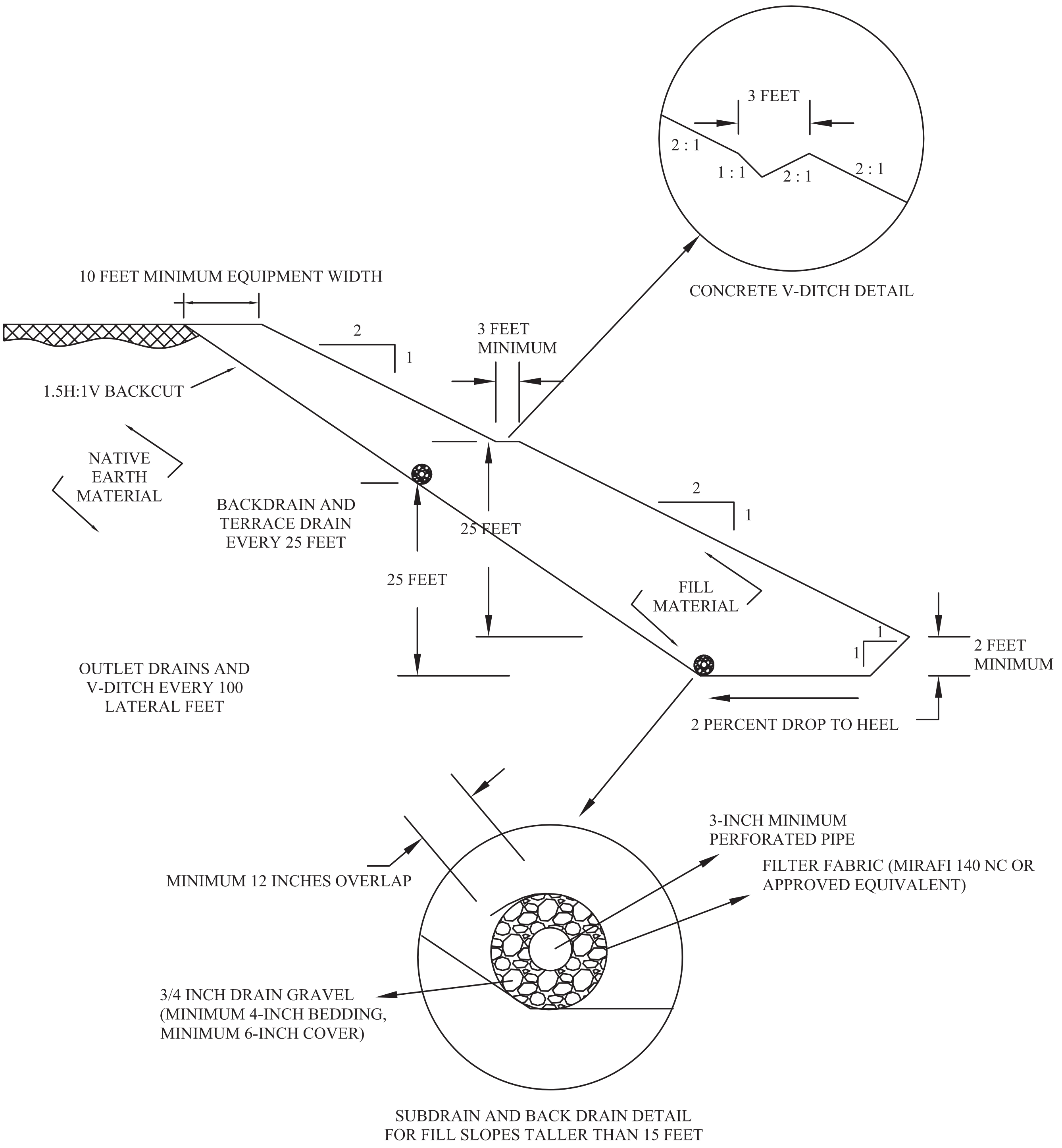


Figure E-3

APPENDIX F

BUTTRESS STABILITY FILL DETAIL



4/4/08

dap

IGES®

No.

Revision/Issue

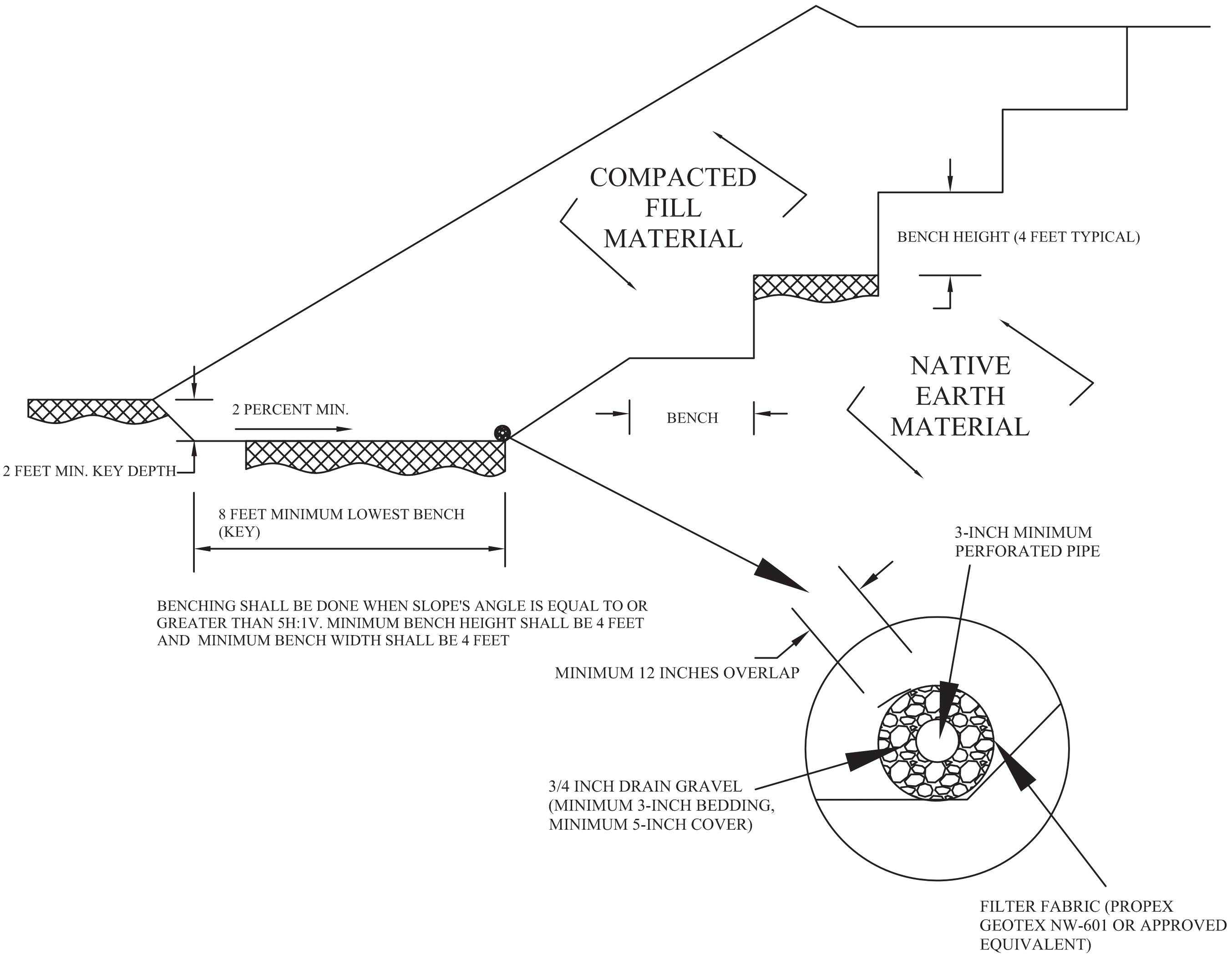
Date

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Weber County, Utah
Project Number 01628-011

Drawing Notes

Figure
F-1

KEYING AND BENCHING DETAIL



BENCHING SHALL BE DONE WHEN SLOPE'S ANGLE IS EQUAL TO OR GREATER THAN 5H:1V. MINIMUM BENCH HEIGHT SHALL BE 4 FEET AND MINIMUM BENCH WIDTH SHALL BE 4 FEET

SUBDRAIN DETAIL
FOR FILL SLOPES TALLER THAN 15 FEET

dap 4/4/08

IGES

No. | Revision/Issue | Date

Geotechnical Investigation
Summit Eden Phase 1E
Powder Mountain Resort
Draper, Utah
Project Number 01628-011

Drawing Notes

Figure
F-2

APPENDIX G

Testing Frequency Tables

MINIMUM STANDARD COMPACTION REQUIREMENTS			
	% Compaction Modified Proctor	Depth of Lifts	Frequency of Tests
Mass Excavation			
General	95	8"	One test per 500 cy moved or one test per 10,000 SF per lift
Roads	95	8"	One test per 500 cy moved or one test per 7,000 SF per lift
Lots	95	8"	One test per lot per lift
Utilities			
Trenches	95	8"	One test per 100 LF per lift
MH & Structures	95	8"	3 to 4 test per lift randomly around structure
Paved Areas			
Subbase	95	8"	One test per 2000 SF
Road Base	95	8"	One test per 2000 SF
C&G	95	8"	One test per 100 LF
Paving	95	4"	One test per 2000 SF
Landscaping	90	10"	One test per 10,000 SF per lift

Mass Grading	
Soil Classification:	One per material source
Soil Proctor:	One determination for each significant change in soil type as necessary to provide required compaction testing.
Earth Fill Moisture/Density Determination:	One test per 500 cubic yards of fill placed in an embankment.
Subgrade Moisture/Density Determination:	One test per 7,000 sq. feet of surface area.
Laboratory Test Method:	Proctors for all earthwork compaction shall be determined using ASTM D1557 modified Proctor method.
Trench Backfill Testing:	The following tests are for structural backfill for every 100 lineal feet of trench or portion thereof:
Pipe Zone:	One test
Backfill Zone:	One test per 2 feet of depth measured from the bottom of the subgrade to the top of the pipe zone. Test shall be evenly spaced vertiaclly through the trench backfill.
Subgrade:	One test
Manholes and Structures:	Three to four tests per lift around each structure
Cutoff Walls:	Every 100' for slopes > 10% and every 500' for slopes <10%

Additional testing may be required by the City Engineer or testing lab to verify compaction.

Base Course Gravel

Gradation Tests:	
Roadway	One test per 15,000 sq. feet of surface area of fraction thereof
Curb & Gutter	One test per 500 lineal feet (each side) or fraction thereof
Sidewalk & Drives	One test per 1,350 sq. feet (combination of sidewalk and driveway) or fraction thereof
Moisture/Density Tests:	One test per 2,000 sq. feet of roadway surface area or fractio nthereof. Moisture content shall be at potimum plus or minus 2 percent for test to pass and shall be maintained until prime coat is applied.
Thickness:	One test per 5,000 sq. feet of surface area or fraction thereof to verify required thickness. If sufficent inspection has been made by an inspector to verify required thickness testing for the base course gravel placed in public roadway construction. No single measured thickness shall be less than the required design thickness.

Bitumious Surface Course

Material Certification:	Each project shall submit independent written certification through the material supplier that surface course materials comply with specifications. Certification for a material source previously approved for the currient construction season will be acceptable provided sources of the individual components of the combined surface course mix have not changed
Extraction Gradation Test:	One test per 500 tons of material placed or one per day whichever is less
Density Tests:	One per 2,000 sq. ft. of surface area or fraction thereof.
Thickness Tests:	At the discretion of the geotechnical engineer, thickness testing may be waived for material placed in public roadway construction if sufficient inspection has been made by an inspector to verify required thinkness. One core sample from each section of approximately 9.000 sq. ft. or fraction thereof.