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
National Ability Center
1000 Ability Way
Park City, UT 84060

IGES Project No. 02763-001

March 29, 2018

Prepared for:

National Ability Center

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

Prepared for:

National Ability Center
1000 Ability Way
Park City, Utah 84060
Attn: Johnny Serio

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Prepared by: Reviewed by:

PROFESSIONAL ENGINEER
29MAR18
No. 4859918
DAVID A. PETERSEN
ELECTRONIC SEAL
STATE OF UTAH

Logan M. Palmer, E.I.T.
Staff Engineer

David A. Petersen, P.E.
Project Engineer

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

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APPENDIX

1.0 EXECUTIVE SUMMARY

This report presents the results of a geotechnical investigation conducted for the proposed Equestrian Center Expansion to be constructed at the National Ability Center located at approximately 1000 Ability Way in Park City, Utah. Based on the subsurface conditions encountered at the site, it is our opinion that the subject site is suitable for the proposed improvements provided that the recommendations contained in this report are incorporated into the design and construction of the project. A summary of the critical recommendations is included below:

- Soft soil and organic topsoil should be removed prior to the placement of any structural fill or foundation elements.
- The upper soils were generally classified as Fat CLAY (CH) and were stiff to very stiff and were underlain by layers of Poorly Graded SAND with clay and gravel (SP-SC) or Clayey GRAVEL with sand (GC).
- Foundations may be placed directly on the native undisturbed Fat CLAY (CH) soils but should be designed for a minimum net allowable bearing capacity of 800 psf and a maximum of **1,800 psf**.
- When fat clay soils are exposed in excavations where footings will be constructed they should not be allowed to dry out and crack but should be kept moist and/or covered until backfilled.
- The expansion potential was highest when the Fat CLAY (CH) soils are remolded (i.e. used as structural fill). Therefore, the Fat CLAY (CH) should not be used as backfill or structural fill below footings.
- The subject site is mapped as having a *very low* liquefaction potential.
- No groundwater was encountered during the explorations at the site to a maximum depth of 9.0 feet (TP-2).

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

This report presents the results of a geotechnical investigation conducted for the proposed Equestrian Center Expansion to be constructed at the National Ability Center located at approximately 1000 Ability Way in Park City, Utah (Figure A-1). The purposes of this investigation were to assess the nature and engineering properties of the subsurface soils at the site and to provide recommendations for excavation considerations, soil bearing values, and information regarding the design and construction of foundations, slabs-on-grade, pavement and exterior concrete flatwork.

The scope of work completed for this study included a site reconnaissance, subsurface exploration, soil sampling, laboratory testing, engineering analyses, and preparation of this report. Our services were performed in accordance with our proposal signed March 1, 2018.

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 site is the property of the National Ability Center and encompasses approximately 26.2 acres. The property is located approximately 0.75 miles west of the I-40 and Kearns Boulevard intersection (Exit 4 off I-40) located in Park City, Utah (see Figure A-2). The site consists of an Indoor Equestrian Arena along with several other buildings used for management and storage. Additionally, several open-air arenas/pastures are spread throughout the site. Most of the site where there are no buildings, parking or walkways has been vegetated with grass or landscaped with landscape bark and small trees.

Construction plans of the proposed development were provided by the National Ability Center and show that the Equestrian Center expansion will consist of a 2-story addition that is expected to add new space for services, program areas, and multi-use areas consisting of meeting rooms, restrooms, a warming kitchen, and open lobby areas. It is anticipated that the expansion will be constructed on conventional strip and spread footings; construction is anticipated to be at grade; no basements are planned.

3.0 METHOD OF STUDY

3.1 FIELD INVESTIGATION

As a part of this investigation, subsurface soil conditions were explored by excavating 3 exploratory test pits to depths of approximately 7.5 to 9 feet below the existing site grade. The approximate locations of the explorations are shown on Figure A-2 (*Geotechnical Map*) in Appendix A. The test pits were spaced to provide information at representative locations where improvements are planned. Photos taken at the time of our investigation are included on Figure A-3. Logs of the subsurface conditions as encountered in the explorations were recorded at the time of exploration by a member of our technical staff and are presented as Figures A-4 through A-6 in Appendix A. A *Key to Soil Symbols and Terminology* used in the test pit logs is included as Figure A-7.

Test pits were completed using a mini-excavator. Soil sampling was completed to collect representative samples of the various layers observed at the site. Disturbed samples were collected in plastic bags and relatively undisturbed soil samples were collected with the use of a 6-inch long brass tube attached to a hand sampler driven with a 2-lb sledge hammer. All samples were transported to our laboratory to evaluate the engineering properties of the various earth materials observed. The soils were classified according to the *Unified Soil Classification System* (USCS) by the Geotechnical Engineer. Classifications for the individual soil units are shown on the attached Test Pit Logs.

No groundwater was encountered during any of the explorations. It is not anticipated that groundwater will impact any construction of the proposed developments, however, the groundwater table can raise and lower with seasonal weather. If groundwater is encountered during construction, IGES should be informed to verify that the recommendations presented in this report are still valid with the new conditions.

3.2 LABORATORY INVESTIGATION

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

- In Situ Density and Moisture Content (ASTM D2216 & D2937)
- Atterberg Limits (ASTM D4318)
- No. 200 Sieve Wash (ASTM D1140)
- Wetting Induced Swell (ASTM D4546)
- Unconsolidated-Undrained Triaxial Compression (ASTM D2850)

Select results of laboratory tests completed for this investigation are presented on the Test Pit Logs in Appendix A and the complete laboratory results are presented in Appendix B.

3.3 ENGINEERING ANALYSIS

Engineering analyses were performed using soil data obtained from the laboratory test results and empirical correlations from material density, depositional characteristics and classifications. Analyses were performed using formulas, calculations and software that represent state-of-the-art methods accepted by the geotechnical industry. These methods include settlement, bearing capacity, lateral earth pressures, and trench stability. 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

At the time of the field investigation the area of the proposed expansion was covered with asphalt pavement, concrete sidewalks, and landscape areas. Test pit locations were performed in the landscape areas to prevent any damage to the sidewalks and pavements at this time. The site gradually slopes to the east. The only major utility that runs through the area of the expansion is a main water line located on the east side of the equestrian center that runs north to south. This line is expected to be relocated so that it is not within the footprint of the expansion. An additional drainage pipe was discovered during the explorations. This line appears to be used to drain excess water from the indoor equestrian arena to the existing open-air arena to the east. This pipe was located just a foot under the existing surface near the southeast corner of the indoor equestrian arena. This pipe will also have to be relocated before the construction of the expansion. This report does not include further suggestions/details about utility relocation plans; this is beyond the scope of our proposed service.

4.2 SUBSURFACE CONDITIONS

4.2.1 Soils

The soils exposed at the site generally consist of 12 to 18 inches of topsoil and undocumented fill with frequent fine roots and organics. Below the topsoil IGES observed alternating layers of stiff to very stiff Fat CLAY (CL) and Sandy Fat CLAY (CL) over dense to very dense Poorly Graded SAND with clay and gravel (SP-SC) or Clayey GRAVEL with sand (GC). The near surface soils were observed to be moist to wet and were frozen which is contributed to recent snow and inclement weather in the area. The moisture content in the soil was observed to decrease in percentage with an increase in depth but remained to be moist throughout. More detailed descriptions of these soil units and thicknesses are shown on the Test Pit Logs (Figure A-4 to A-6). A key to soil symbols and terms is located on Figure A-7.

4.2.2 Groundwater

Groundwater was not encountered at the time of our investigation and is not anticipated to be encountered later during construction. However, groundwater conditions can be expected to rise or fall several feet at different times of the year depending on precipitation, irrigation, and runoff from other offsite sources. Although groundwater is not anticipated to impact construction, if groundwater is encountered during construction, IGES should be made aware of the conditions to assess that the recommendations presented in this report are still valid.

5.0 GEOLOGIC CONDITIONS

5.1 GEOLOGIC SETTING

The site is situated northwest of the Jordanelle Reservoir, and west of Silver Creek in an area characterized by various volcanic and intrusive igneous deposits that overlie Late Paleozoic to Early Mesozoic sediments. The property is located in a highland area that is transitional between the Uinta Mountains and the Wasatch Range, with the surficial deposits known as the Keetley Volcanics. These extrusive igneous rocks were erupted as rhyodacite and andesite flows with associated volcanic breccia and tuffs during the early Oligocene Epoch, between approximately 35 and 32 million years ago (Stokes, 1987; Hintze, 1988). Around the same time, granodiorite intrusions were emplaced as various porphyry stocks in the region, some of which had associated precious metal veins and ore bodies. Quaternary alluvial deposits associated with the cessation of glacial activity and the development of modern drainages flank the margins of Silver Creek.

Bromfield and Crittenden Jr. (1971) displays the entire property as being underlain by Quaternary-aged older alluvium deposits. These deposits are described as generally forming terraces adjacent to larger drainages, with not all of the deposits being of the same age (Bromfield and Crittenden Jr., 1971). At a regional scale, Bryant (1990) mapped the property consistent with the previous mapping efforts (Quaternary older alluvium). The most recent mapping of this area is from Biek (2017) and show the property on Quaternary young stream alluvium and young alluvial fan deposits.

5.2 SEISMICITY AND FAULTING

The site is located approximately 1.75 miles north of the north end of the Frog Valley Fault. Additionally, the site is approximately 2.0 miles east of the Parleys Park Fault. The Frog Valley Fault is a normal fault with a dip direction of northwest and has a known slip rate of less than 0.2 mm/yr. The Parleys Park Faults are two normal faults that intersect with dip directions to the north and to the west. The known slip rate of these two faults is less than 0.2 mm/year.

Following the criteria outlined in the 2015 International Building Code (IBC, 2015), spectral response at the site was evaluated for the *Maximum Considered Earthquake* (MCE) which equates to a probabilistic seismic event having a two percent probability of exceedance in 50 years (2PE50). Spectral accelerations were determined based on the location of the site using the *U.S. Seismic "Design Maps" 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, 2015).

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 D (*stiff soil*). Based on IBC criteria, the short-period (F_a) and long-period (F_v) site coefficients are 1.301 and 1.983, respectively. Based on the design spectral response accelerations for a *Building Risk Category* of I, II, or III, the site's *Seismic Design Category* is D. The short- and long-period *Design Spectral Response Accelerations* are presented in Table 5-1; a summary of the *Design Maps* analysis is presented in Appendix C. The *peak ground acceleration* (PGA) may be taken as $0.4{*}S_{MS}$.

Table 5-1
Short- and Long-Period Spectral Accelerations for MCE

Parameter	**Short Period (0.2 sec)**	**Long Period (1.0 sec)**
Mapped Spectral Acceleration (g)	$S_S = 0.624$	$S_1 = 0.209$
MCE Spectral Response Acceleration Modified for Site Class D (g)	$S_{MS} = 0.812$	$S_{M1} = 0.414$
Design Spectral Response Acceleration (5 percent Damping) (g)	$S_{DS} = 0.541$	$S_{D1} = 0.276$

5.3 OTHER GEOLOGIC HAZARDS AND CONDITIONS

Geologic hazards and conditions can be defined as naturally occurring geologic conditions or processes that could present a danger to human life and property or result in impacts to conventional construction procedures. These hazards and conditions must be considered before development of the site. There are several hazards and conditions in addition to seismicity and faulting that if present at a site, should be considered in the design of critical and essential facilities. The other geologic hazards considered for this site are expansive soils and liquefaction.

5.3.1 Expansive Soils

Laboratory testing indicates that much of the near surface soils encountered in the test pits classify as Fat CLAY (CH). These potentially expansive soils are typically stiff to hard, moist, and are brown in color. Swelling soils can potentially damage foundation elements, crack concrete slabs, and create excess stress in the proposed structures. Although soils classifying as fat clay are often associated with expansive soils, soil classification alone cannot predict the expansive characteristics of clay soils.

Collapse/Swell potential of soils tests (ASTM D4546) were completed on two of the representative clay samples collected as part of this investigation to further assess the expansive characteristics of site soils. One test was completed on a relatively undisturbed sample at the existing (in-situ) moisture content. The other test was completed on a disturbed sample that was compacted (remolded) to a dry density that was approximately 7 percent greater than the in-situ dry density and allowed to air dry before beginning the test. The purpose of testing the remolded sample was to assess the suitability of this soil to be used as backfill or structural fill. The results are summarized in the following table:

Table 5-2
Collapse/Swell Potential of Soils Test Results Summary

Test Pit	Depth (ft.)	Swell (%)	Load (psf)	Notes
TP-2	2.5	26.3	100	Remolded
TP-3	2.0	0.6	800	Undisturbed

These test results suggest that, for this site, the potential for wetting-induced swelling due to the presence of expansive clays is generally low in native undisturbed soils at the in-situ moisture content. However, the swell potential associated with the remolded sample (i.e. structural fill or backfill) is high. This indicates that the on-site Fat CLAY (CH) soils should not be used as structural fill beneath lightly loaded structural elements. A summary of the test results is presented in Appendix B. Recommendations for mitigation of potentially expansive soils underlying foundations are presented in Section 6.3.

5.3.2 Liquefaction

Liquefaction is a phenomenon whereby loose, saturated, granular soil deposits experience a significant decrease in shear strength due to increased pore water pressure. Among other effects, liquefaction can cause soil densification resulting in ground settlement. The primary factors affecting liquefaction potential of a soil deposit are: (1) level and duration of seismic ground motions; (2) soil type and consistency; and (3) depth to groundwater. A full liquefaction study and analysis was beyond this scope of work and beyond the standard of care for developments of this nature. The site is mapped as having a *very low* liquefaction potential (See the Liquefaction Hazard Map in Appendix C.). Based on conditions observed in the test pits completed for this investigation, it is our judgment that there is a low potential for liquefaction-induced settlement in the uppermost 9 feet of subsurface soils at this site.

If additional recommendations are needed, a site-specific liquefaction hazard analysis, which would include additional exploratory borings or cone penetration tests to depths of 50 feet, should be performed.

6.0 ENGINEERING ANALYSIS 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 contained in this report are incorporated into the design and construction of the project. We recommend that as part of the site grading process any undocumented fill or soft, highly organic topsoil present at the site be removed from beneath proposed footings and any fill sections. Footings may be placed on suitable native clayey soils that have not been allowed to dry out after the excavation is completed. The soils exposed in the subgrade should be moisture conditioned to near the in-situ moisture content.

The following sub-sections present our recommendations for general site grading, design of foundations, slabs-on-grade, moisture protection and soil corrosivity.

6.2 EARTHWORK

Prior to the placement of foundations, general site grading is recommended to provide proper support for foundations, exterior concrete flatwork, concrete slabs-on-grade, and pavement sections. Site grading is also recommended to provide proper drainage and moisture control on the subject property and to aid in preventing differential movement in foundation soils 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 may be encountered and should be grubbed-out and replaced with engineered fill if exposed in the foundation excavation. The foundation excavation should be assessed for soft or loose soils; any soft/loose areas should be compacted in place if the depth is less than 6 inches or removed and replaced with structural fill as recommended in this report.

6.2.2 Excavations

Excavations should extend through any undocumented fill or topsoil and into the native soils. If fat clay soils are exposed, they should not be allowed to dry out and crack but should be kept moist and/or covered until backfilled. If these soils dry out, they will need to be over excavated and removed.

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 may be placed to bring the excavation back to desired grade. The native Fat CLAY (CH) soils should not be used as structural fill. All structural fill should be placed and compacted in accordance with the recommendations presented in this report (Section 6.2.4).

An IGES representative should observe the site preparation and grading operations to assess whether the recommendations presented in this report have been complied with. Soft or loose soils observed in the excavation should be removed prior to placing structural fill or constructing footings.

6.2.3 Trench Excavations

Based on our soil observations, visual classifications and laboratory testing, it is our opinion that the native soils at the site classify as Occupational Safety and Health Administration (OSHA) Type B soils. According to OSHA standards, trenches with vertical walls up to 4 feet in depth may be occupied. IGES observed that the soil layers in the upper 4 to 5 feet tended to be moist, stiff to very stiff, and easily maintained a nearly vertical cut. Below 4 to 5 feet the soil layers became more granular and could slough into the bottom of the excavation creating a potentially dangerous undercut in the excavation sidewall. When a trench is deeper than 5 feet, we recommend that the sides of the excavation be sloped back at a 1H:1V slope or that a trench-shield or shoring be used as a protective system for workers in the trench.

The contractor is responsible for trench and site safety. Pertinent OSHA requirements should be met to provide a safe work environment. If site specific conditions arise that require engineering analysis in accordance with OSHA regulations, IGES can respond and provide recommendations as needed. We recommend that an IGES representative observe all excavations to assess exposed foundation soils.

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 should consist of an approved imported granular material. Native Fat CLAY (CH) soils are moisture sensitive with a high potential to expand if used as structural fill and can be very difficult to achieve the desired compaction and moisture content. We recommend that native fine-grained soils such as Fat CLAY (CH) not be used as structural fill in any aspects of this project. Imported soil used as structural fill should be a relatively well-graded granular soil with a maximum of 50 percent passing the No. 4 sieve and a maximum fines content (minus No. 200 mesh sieve) of 20 percent. Structural fill should be relatively free of vegetation and debris and contain no materials larger than 4 inches in nominal size (6 inches in greatest dimension). All structural fill soils should be approved by the geotechnical engineer prior to placement.

All structural fill should be placed in maximum 6-inch loose lifts if compacted by small hand-operated compaction equipment, maximum 8-inch loose lifts if compacted by light- to medium-duty rollers, and maximum 10-inch loose lifts if compacted by heavy-duty compaction equipment that is capable of efficiently compacting the entire thickness of the lift. We recommend that all structural fill be compacted on a horizontal plane.

The moisture content for all structural fill should be near (typically within +/- 2%) the optimum moisture content (OMC) at the time of placement and compaction of any structural fill. Ideally, the moisture content should be slightly above the OMC to minimize the amount of compaction energy required to achieve proper compaction. Also, prior to placing any fill, the excavation should be observed by the geotechnical engineer to evaluate whether all undocumented fill, topsoil, and loose soils 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 (Section 6.2.1). Table 6-1 lists the compaction requirements for different structural fill placements.

Table 6-1
Compaction Requirements

Structural Fill Location	**Percent MMD Required (ASTM D-1557 Modified Proctor)**
Structural Elements (i.e. Below Structures, Footings, Pavement Sections, Concrete Flatwork, Curb and Gutter, and Sidewalks)	95%
Non-Structural Elements (i.e. Landscape Areas, Foundation Wall Backfill)	90%

Failure to properly moisture-condition and compact backfill may result in settlements of up to several inches within the fill if the moisture content of the backfill increases. Only small compaction equipment, such as jumping jacks and walk-behind/remote controlled compacters, should be used near in-place structural elements (i.e. above footings, near foundation walls, etc.). We recommend backfill placement against foundation walls not be completed until floor joists are in place or the basement walls are braced.

The gradation, placement, moisture and compaction recommendations contained in this section meet our minimum requirements. If other governing agencies such as utility, city, county or state entities have more stringent requirements which exceed our recommendations, the more stringent specifications are to be followed.

6.2.5 Soft Soil Stabilization

If soft and/or pumping soils are encountered, stabilization of these soils should be accomplished by using a clean, coarse angular material worked into the soft subgrade. We recommend the coarse angular material be greater than 3 inches in nominal diameter, but less than 6 inches. The stabilization material should be worked (pushed) into the soft subgrade soils until a relatively firm and unyielding surface is established. Once a relatively firm and unyielding surface is achieved, the area may be brought to final design grade using structural fill. Other earth materials not meeting aforementioned criteria may also be suitable; however, such material should be evaluated on a case-by-case basis and should be approved by IGES prior to use.

The placement of a woven geotextile and compacted structural fill may be used as an alternative or in conjunction to the procedures previously described to stabilize soft soils. The woven geotextile should consist of either Mirafi HP 370 or an approved equivalent. The geotextile should be placed to cover the entire excavation bottom where structural fill will be placed. The geotextile should be installed in accordance with the manufacturer's recommendations; seams should be overlapped a minimum of 12 inches. Following placement of the geotextile, compacted structural fill may be placed to the required grade.

6.3 FOUNDATIONS

It is anticipated that the proposed foundation elements of the Equestrian Center expansion will consist of conventional spread footings and strip footings. Strip footings should be a minimum of 24 inches wide, isolated spread footings should be a minimum of 36 inches wide. Exterior footings should be embedded at least 42 inches below final grade for frost protection and confinement. Interior footings not exposed to the full effects of frost should be embedded at least 12 inches for confinement. Settlements of properly designed and constructed conventional footings, founded as described above, are anticipated to be less than 1 inch. Differential settlements should be on the order of half the total settlement over 30 feet.

Based on our field observations and testing results, the expansion potential of on-site, undisturbed native Fat CLAY (CH), is low if they are not allowed to dry out and crack but instead kept moist and/or covered until backfilled. The expansion potential was highest when these fat clay soils were allowed to dry and were remolded (i.e. used as structural fill). Considering these soil conditions, we recommend that footings be founded either *entirely* on undisturbed native soils or *entirely* on a minimum of 24 inches of structural fill extending to undisturbed native soils. In consideration of these soils, IGES recommends that foundations should be designed for a minimum net allowable bearing capacity of 800 psf and a maximum of **1,800 psf** to minimize settlement.

If soft, loose, or otherwise deleterious earth materials are exposed on the foundation subgrade we recommend the material be removed and replaced with structural fill. Fill/native transition zones are not allowed. 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 to assess that the soils are suitable and, if applicable, have not dried out and cracked.

6.4 CONCRETE SLAB-ON-GRADE CONSTRUCTION

Concrete slabs-on-grade should be constructed over suitable dense native soils or a zone of structural fill with a minimum thickness of 12 inches that extends to relatively undisturbed native soils. Below all slabs we recommend 4 inches of clean, compacted, free-draining gravel. Any structural fill placed should meet the requirements in Section 6.2.4 of this report. If soft soils are exposed following the over-excavation, they should be removed or stabilized by the methods discussed in Section 6.2.5.

All concrete slabs should be designed to minimize cracking as a result of shrinkage. This should include appropriate spacing of concrete control joints and saw-cut joints. The maximum joint spacing should be 24 to 36 times the thickness of the slab (in feet) but limited to a maximum of 15 feet. The joints should be square or nearly square (not to exceed 1.5 times the width) (ACI 224.3R). Additionally, consideration should be given to reinforcing the slab with welded wire, re-bar, or fiber mesh, as appropriate. All concrete work should be performed in accordance with the American Concrete Institute (ACI) codes and recommendations.

6.5 EARTH PRESSURE 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.

Based on an internal angle of friction of 32º, the ultimate lateral earth pressures for granular backfill soils acting against retaining walls and buried structures may be computed from the lateral pressure coefficients or equivalent fluid densities presented in the following table:

Condition	Lateral Pressure Coefficient	Equivalent Fluid Density (pounds per cubic foot)
Active*	0.31	36
At-rest**	0.47	55
Passive*	3.25	384

* Based on Coulomb's equation

** Based on Jaky

These coefficients and densities assume level, granular backfill with no buildup of hydrostatic pressures. If sloping backfill, surcharges or groundwater are present, we recommend the geotechnical engineer be consulted to provide more accurate lateral pressure parameters once the design geometry is established.

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.

Walls and structures allowed to rotate slightly should use the active condition. If the element is constrained against rotation (i.e., 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.

6.6 MOISTURE PROTECTION AND SURFACE DRAINAGE

Precautions should be taken during and after construction to minimize the potential for saturation of foundation soils. Over wetting the soils prior to or during construction is likely to result in increased softening, pumping or swelling of the soils, causing equipment mobility problems and difficulty in achieving compaction. Moisture should not be allowed to infiltrate the soils in the vicinity of, or upslope from, the construction location.

Conversely, where fat clays are exposed under proposed pavements, slabs-on-grade, or similar structural elements, the clays should not be allowed to dry out. Where exposed, these soils should be occasionally moistened, or kept covered with plastic sheeting or a few inches of soil to minimize drying-out until just before construction.

We have included the following as minimum recommendations:

- Backfill around foundations should consist of native soils placed in maximum 12-inch loose lifts, moisture conditioned and compacted to approximately 90 percent of the maximum dry density as established by the Modified Proctor (ASTM D1557) in landscaped areas and a minimum of 95 percent beneath concrete slabs or other structural elements. Compacting by means of injecting water or “jetting” is not recommended.

- Rain gutters should be installed around the entire perimeter of the structure to collect and discharge all roof runoff a minimum of 10-feet from foundation elements or as far away as is practically possible. If 10-feet cannot be achieved then a pipe, swale or some other conveyance feature should be installed to carry the water immediately away from the foundation.
- The ground surface within 10-feet of the foundations should be sloped to drain away from the structure with a minimum fall of 6 inches (5%). If this cannot be achieved, then the ground surface should be sloped to the property line or as far as practical and a conveyance feature used to carry the water to the front or rear of the property.
- All pressurized irrigation lines and valves should be placed outside the limits of the foundation backfill. Only hand watering or drip irrigation should be used within this zone and preferably dessert landscaping or xeriscape should be used to eliminate the need for irrigation in this zone.

7.0 CLOSURE

7.1 LIMITATIONS

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

The information contained in this investigation is based on limited field testing and understanding of the project. It is very likely that variations in the soil, rock and groundwater conditions exist between and beyond the points explored. The nature and extent of variations may not be evident until construction occurs and additional explorations are completed. If any conditions are encountered that differ from those described in this report, IGES must be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the scope of the proposed construction changes from that described in this report, our firm must also be notified.

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

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

7.2 ADDITIONAL SERVICES

The recommendations made in this report are based on the assumption that an adequate program of tests and observations will be made during the construction. IGES staff should be on site to verify 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 footing excavations.
- Consultation as may be required during construction.
- Quality control on concrete placement to verify slump, air content, and strength.

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

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

8.0 REFERENCES CITED

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APPENDIX A

BASE MAP: PARK CITY EAST QUADRANGLE UTAH-UTAH CO - U.S.G.S. 7.5 MINUTE QUADRANGLE, 2017

0 1,500 3,000

SCALE 1" = 3,000'

($8\frac{1}{2}$"x11" ONLY)

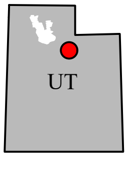
N

IGES®

PROJECT NUMBER: 02763-001

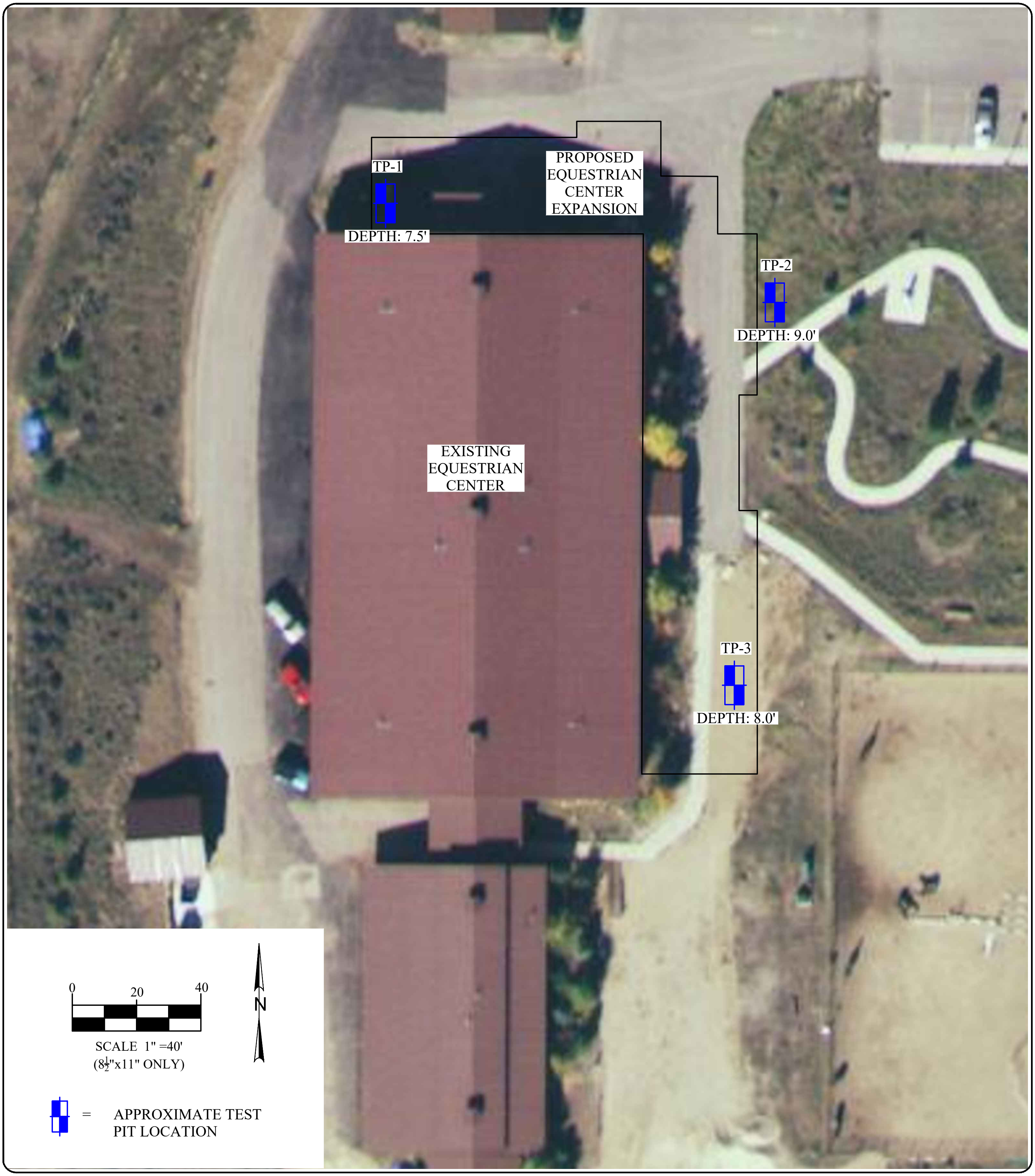
SITE VICINITY MAP

GEOTECHNICAL INVESTIGATION
NATIONAL ABILITY CENTER
1000 ABILITY WAY
PARK CITY, UT 84060



FIGURE

A-1



AERIAL IMAGES FROM UTAH GIS HRO IMAGERY IMAGES *12TVL560000, 12TVL560040, 12TVL600000, AND 12TVL600040*, DATE OF IMAGES SPRING, 2012. PROPERTY LINES BASED FROM MAPS.SUMMITCOUNTY.ORG/FLEXVIEWERS/COUNTYMAP.

IGES®

PROJECT NUMBER: 02763-001

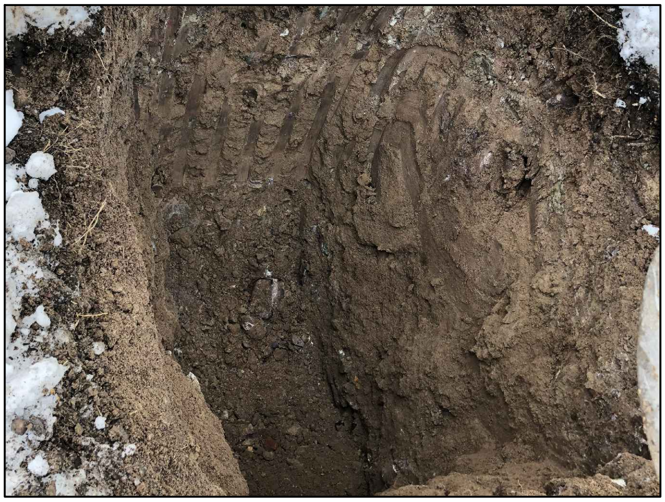
GEOTECHNICAL MAP

GEOTECHNICAL INVESTIGATION
NATIONAL ABILITY CENTER
1000 ABILITY WAY
PARK CITY, UT 84060

THIS PLAN VIEW IS FOR REFERENCE ONLY AND DOES NOT REPRESENT EXACT LOCATIONS OF TEST PITS. NO SURVEY WAS TAKEN OF TEST LOCATIONS.

FIGURE

A-2



TEST PIT 1

MAIN WATER LINE IN RELATION TO TEST PIT 2

TEST PIT 2

TEST PIT 2

TEST PIT 3

DRAINAGE PIPE ENCOUNTERED NEAR TEST PIT 3

PHOTOS TAKEN ON MARCH 9, 2018

IGES®

PROJECT NUMBER: 02763-001

SITE PHOTOS

GEOTECHNICAL INVESTIGATION
NATIONAL ABILITY CENTER
1000 ABILITY WAY
PARK CITY, UT 84060

FIGURE

A-3

DATE	
STARTED:	3/9/18
COMPLETED:	3/9/18
BACKFILLED:	3/9/18

Geotechnical Investigation
National Ability Center
1000 Ability Way
Park City, UT 84060

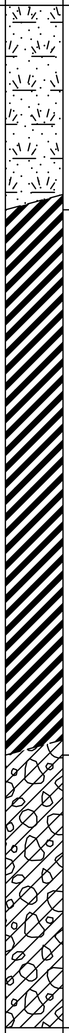
Project Number 02763-001

IGES Rep: LMP
Rig Type: Mini Excavator

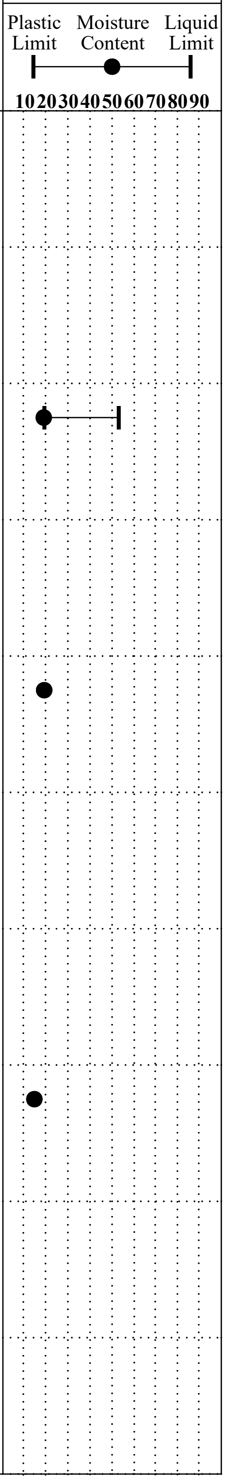
TEST PIT NO:
TP - 1
Sheet 1 of 1

LOCATION
LATITUDE 40.68125 LONGITUDE -111.47600 ELEVATION~6735

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				SC	Top Soil - Clayey SAND - medium dense, moist, dark brown Roots down to 2.5 feet below grade					
	1										
					CH	Sandy Fat CLAY w/ gravel- stiff, moist, brown					
	2	▯						18.7		53	34
	3										
	4	⧗					103.7	18.9			
	5										
					GC	Clayey GRAVEL w/ Sand - very dense, moist, brown Cobbles up to 4 inches in diameter					
	6										
	7	▯						14.4	13.7		
						No Groundwater Encountered					
	8										
	9										



Moisture Content and Atterberg Limits



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

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

IGES

Figure
A-4

DATE		
STARTED:	3/9/18	
COMPLETED:	3/9/18	
BACKFILLED:	3/9/18	

Geotechnical Investigation
National Ability Center
1000 Ability Way
Park City, UT 84060

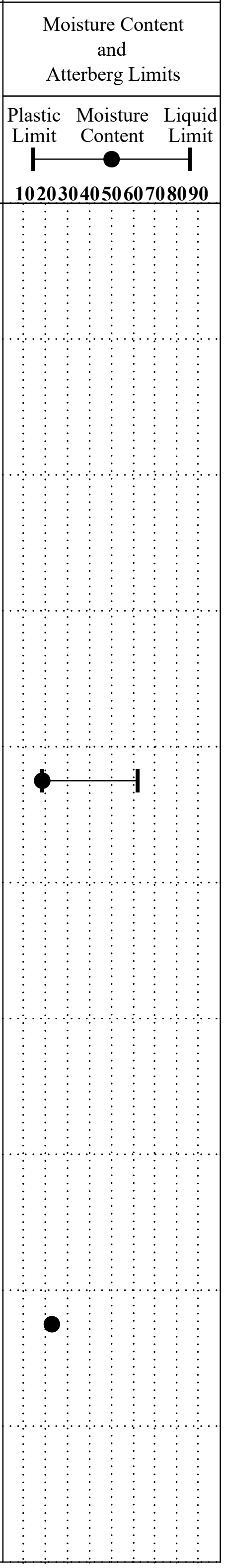
Project Number 02763-001

IGES Rep: LMP
Rig Type: Mini Excavator

TEST PIT NO:
TP - 2
Sheet 1 of 1

LOCATION
LATITUDE 40.68118 LONGITUDE -111.47556 ELEVATION~6732

DEPTH FEET	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0			SC	Top Soil - Clayey SAND - dense, moist, dark brown Roots/rootlets down to 2.5 feet below grade					
1			CH	Fat CLAY - stiff to very stiff, moist, dark brown					
2									
	▯		CH	Sandy Fat CLAY - very stiff, moist, light brown w/ white. Highly calcareous deposits from 2.5 feet to 5.0 feet					
3									
4	▯			Pocket Penetrometer: 5.0+ tsf		18.1		62	44
5									
6									
7									
8	▯			Occasional 4 inch diameter cobbles or greater from 7.5 feet to 9.0 feet		22.5	58.0		
9				No Groundwater Encountered					



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

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

Figure

A-5

DATE
STARTED: 3/9/18
COMPLETED: 3/9/18
BACKFILLED: 3/9/18

Geotechnical Investigation
National Ability Center
1000 Ability Way
Park City, UT 84060

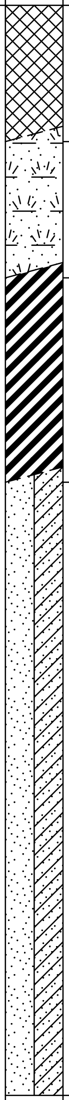
Project Number 02763-001

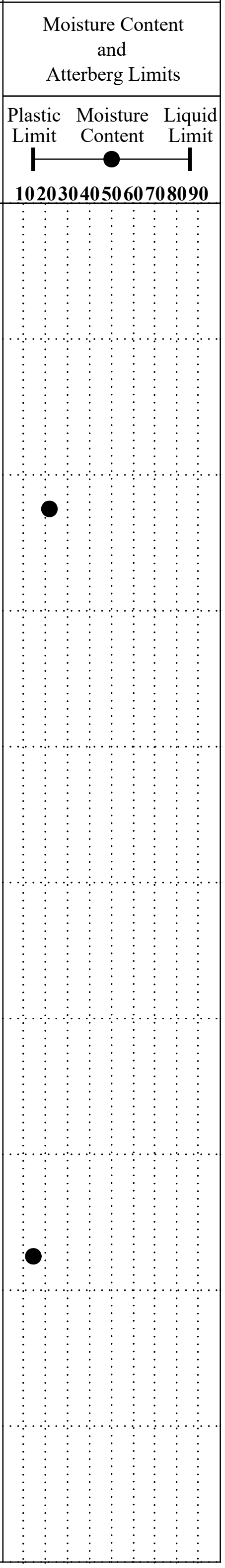
IGES Rep: LMP
Rig Type: Mini Excavator

TEST PIT NO:
TP - 3
Sheet 1 of 1

LOCATION
LATITUDE 40.68082 LONGITUDE -111.47562 ELEVATION~6731

DEPTH FEET	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0			GP	Undocumented Fill - Poorly-graded GRAVEL w/ Sand - dense, wet (Frozen), light brown Frozen from winter weather conditions					
1			CH	Topsoil; Fat CLAY - very stiff, moist, black Pocket Penetrometer: 5.0+ tsf					
2	⧗			Fat CLAY - Stiff, moist, light brown Pocket Penetrometer: 3.5 tsf	97.2	21.4			
3.5	▯		SP-SC	SAND with Clay and Gravel - very dense, moist, light brown Cobbles & Boulders throughout layer Pocket Penetrometer: 5.0+ tsf					
7.5	▯					14.0	7.8		
8				No Groundwater Encountered					





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

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

Figure
A-6

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			USCS SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS (More than half of material is larger than the #200 sieve)	GRAVELS (More than half 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 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

MOISTURE CONTENT

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

STRATIFICATION

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

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

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

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 PENETRATE 12" WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
VERY DENSE	>50	>60	>70	85 - 100	PENETRATED ONLY FEW INCHES WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER

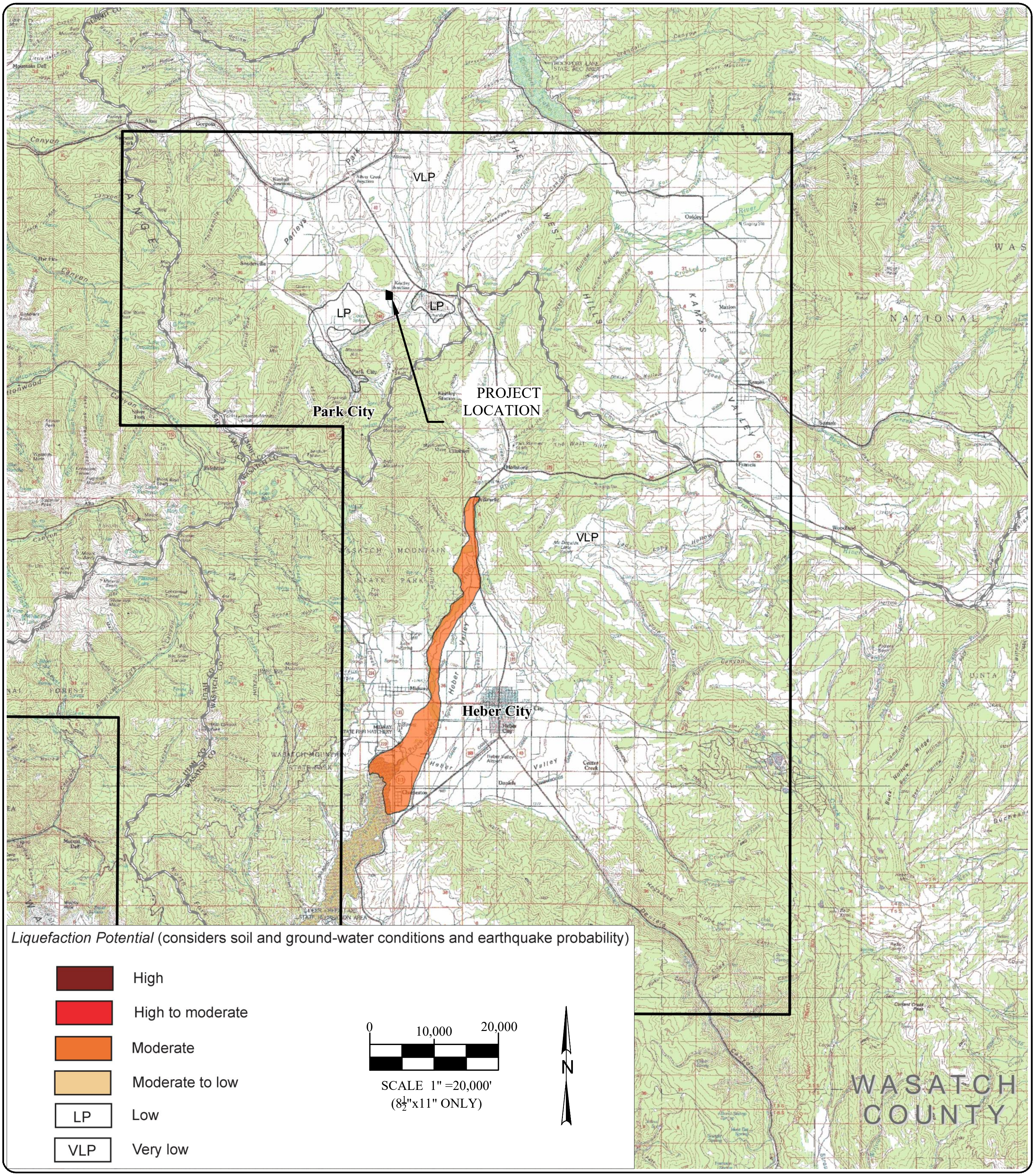
CONSISTENCY - FINE-GRAINED SOIL		TORVANE	POCKET PENETROMETER	FIELD TEST
CONSISTENCY	SPT (blows/ft)	UNTRAINED SHEAR STRENGTH (tsf)	UNCONFINED COMPRESSIVE STRENGTH (tsf)	
VERY SOFT	<2	<0.125	<0.25	EASILY PENETRATED SEVERAL INCHES BY THUMB. EXUDES BETWEEN THUMB AND FINGERS WHEN SQUEEZED BY HAND.
SOFT	2 - 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.

IGES®

KEY TO SOIL SYMBOLS AND TERMINOLOGY

FIGURE

A-7



LIQUEFACTION SPECIAL STUDY AREAS, WASATCH FRONT AND NEARBY AREAS, COMPILED BY GARY E. CHRISTENSON AND LUCAS M. SHAW, 2008. IMAGE FOUND AT GEOLOGY.UTAH.GOV/MAP-PUB/MAPS/GEOLOGIC-HAZARD-MAPS. BASED FROM USGS SURVEY.

IGES®

PROJECT NUMBER: 02763-001

LIQUEFACTION HAZARD MAP

GEOTECHNICAL INVESTIGATION
NATIONAL ABILITY CENTER
1000 ABILITY WAY
PARK CITY, UT 84060

THE UTAH GEOLOGICAL SURVEY (UGS) DOES NOT WARRANTEE THE ACCURACY OR COMPLETENESS OF THE DATA OF THIS HAZARD MAP. THIS MAP DOES NOT PRECLUDE THE NEED FOR A SITE-SPECIFIC STUDY.

APPENDIX B

Water Content and Unit Weight of Soil

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

IGES

Project: **National Ability Center**
No: **02763-001**
Location: Park City, Utah
Date: 3/16/2018
By: EH

Sample Info.	Boring No.	TP-2	TP-3						
	Sample:								
	Depth:	4.0'	2.0'						
Unit Weight Info.	Sample height, H (in)		2.996						
	Sample diameter, D (in)		2.419						
	Sample volume, V (ft^3)		0.0080						
	Mass rings + wet soil (g)		555.64						
	Mass rings/tare (g)		129.22						
	Moist soil, Ws (g)		426.42						
	Moist unit wt., γ_m (pcf)		117.98						
Water Content	Wet soil + tare (g)	482.10	457.39						
	Dry soil + tare (g)	427.86	398.26						
	Tare (g)	127.45	122.30						
Water Content, w (%)		**18.1**	**21.4**						
Dry Unit Wt., γ_d (pcf)			**97.2**						

Entered by:___________

Reviewed:___________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: National Ability Center
No: 02763-001
Location: Park City, Utah
Date: 3/20/2018
By: BRR
Grooving tool type: Plastic
Liquid limit device: Mechanical
Rolling method: Hand

Boring No.: TP-1
Sample:
Depth: 2.0'
Description: Brown fat clay
Preparation method: Air Dry
Liquid limit test method: Multipoint
Screened over No.40: Yes
Larger particles removed: Dry sieved
Approximate maximum grain size: 3/4"
Estimated percent retained on No.40: Not requested
As-received water content (%): Not requested

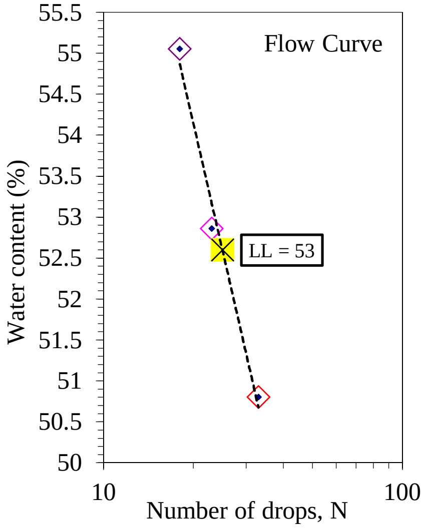
Plastic Limit

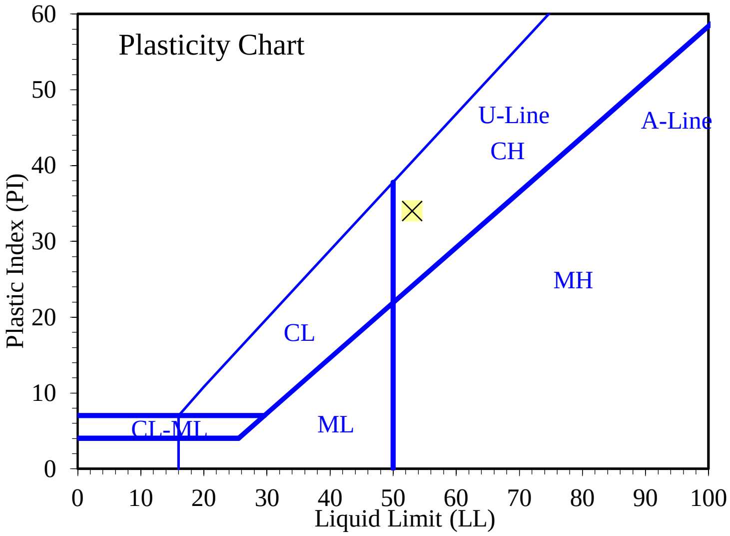
Determination No	1	2			
Wet Soil + Tare (g)	12.77	13.56			
Dry Soil + Tare (g)	11.77	12.54			
Water Loss (g)	1.00	1.02			
Tare (g)	6.45	7.05			
Dry Soil (g)	5.32	5.49			
Water Content, w (%)	18.80	18.58			

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	33	23	18			
Wet Soil + Tare (g)	14.81	14.05	14.90			
Dry Soil + Tare (g)	12.28	11.74	12.23			
Water Loss (g)	2.53	2.31	2.67			
Tare (g)	7.30	7.37	7.38			
Dry Soil (g)	4.98	4.37	4.85			
Water Content, w (%)	50.80	52.86	55.05			
One-Point LL (%)		52				

Liquid Limit, LL (%)	**53**
Plastic Limit, PL (%)	**19**
Plasticity Index, PI (%)	**34**





Entered by:____________
Reviewed:____________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: National Ability Center
No: 02763-001
Location: Park City, Utah
Date: 3/20/2018
By: BRR
Grooving tool type: Plastic
Liquid limit device: Mechanical
Rolling method: Hand

Boring No.: TP-2
Sample:
Depth: 4.0'
Description: Brown fat clay

Preparation method: Air Dry
Liquid limit test method: Multipoint
Screened over No.40: Yes
Larger particles removed: Dry sieved
Approximate maximum grain size: Not requested
Estimated percent retained on No.40: Not requested
As-received water content (%): 18.1

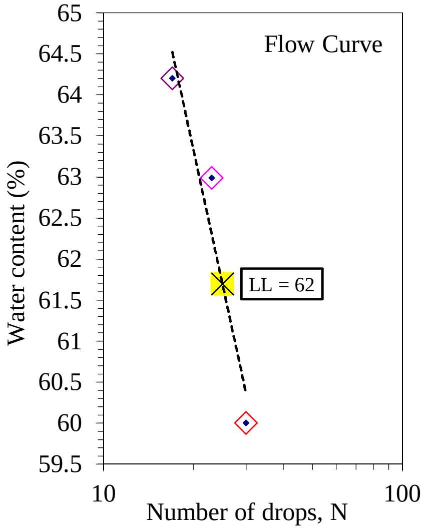
Plastic Limit

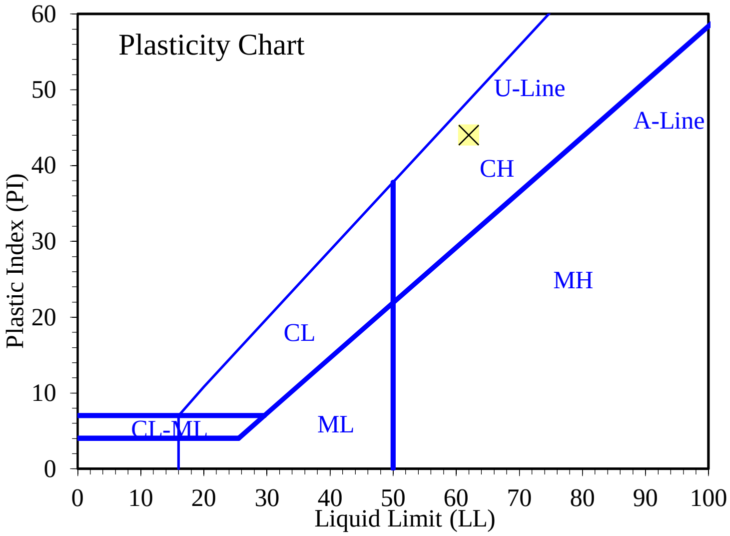
Determination No	1	2				
Wet Soil + Tare (g)	13.13	13.47				
Dry Soil + Tare (g)	12.21	12.48				
Water Loss (g)	0.92	0.99				
Tare (g)	7.07	7.04				
Dry Soil (g)	5.14	5.44				
Water Content, w (%)	17.90	18.20				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	30	23	17			
Wet Soil + Tare (g)	15.02	14.58	15.32			
Dry Soil + Tare (g)	12.02	11.67	12.11			
Water Loss (g)	3.00	2.91	3.21			
Tare (g)	7.02	7.05	7.11			
Dry Soil (g)	5.00	4.62	5.00			
Water Content, w (%)	60.00	62.99	64.20			
One-Point LL (%)	61	62				

Liquid Limit, LL (%)	**62**
Plastic Limit, PL (%)	**18**
Plasticity Index, PI (%)	**44**





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

(ASTM D6913)

IGES

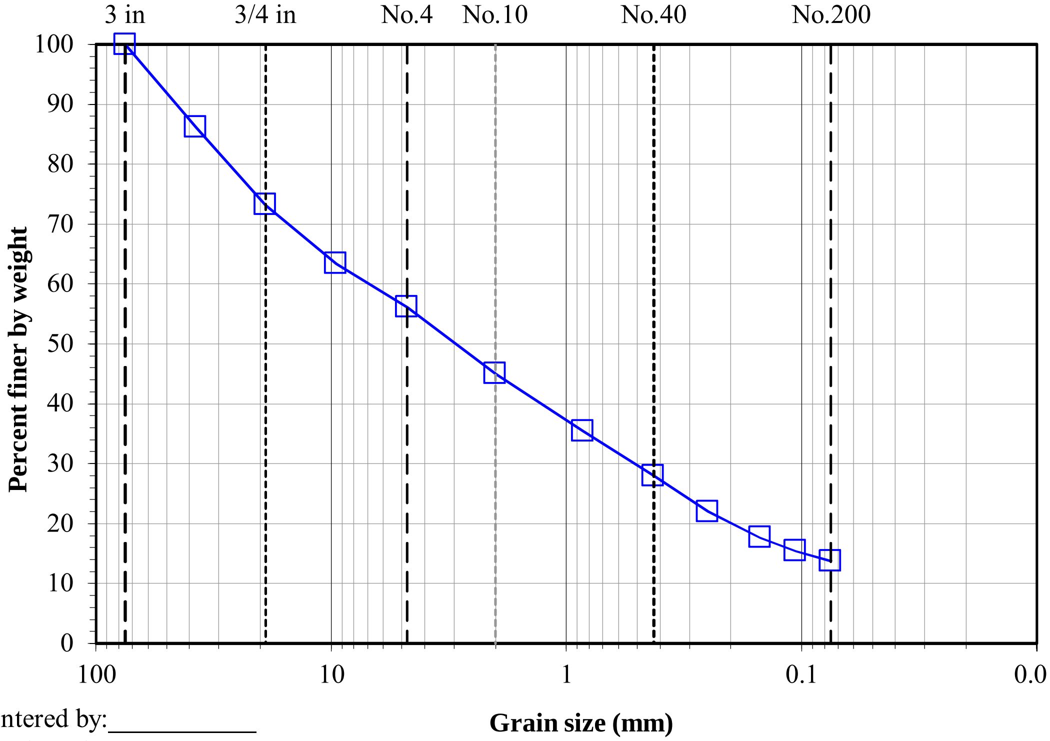
Project: National Ability Center
No: 02763-001
Location: Park City, Utah
Date: 3/19/2018
By: JWB

Boring No.: TP-1
Sample:
Depth: 7.0'
Description: Brown silty, clayey gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	2598.90	2272.31
+3/8" Coarse fraction (g):	890.51	831.85
-3/8" Split fraction (g):	363.89	306.82
Split fraction:	0.634	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	1214.53	569.87
Dry soil + tare (g):	1154.26	512.80
Tare (g):	299.54	205.98
Water content (%):	7.1	18.6

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	314.76	37.5	86.1	
3/4"	608.33	19	73.2	
3/8"	831.85	9.5	63.4	←Split
No.4	35.23	4.75	56.1	
No.10	88.97	2	45.0	
No.20	135.38	0.85	35.4	
No.40	171.47	0.425	28.0	
No.60	200.48	0.25	22.0	
No.100	221.35	0.15	17.7	
No.140	232.19	0.106	15.4	
No.200	240.30	0.075	13.7	



Gravel (%): 43.9
Sand (%): 42.4
Fines (%): 13.7

Entered by:___________
Reviewed:___________

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

(ASTM D6913)

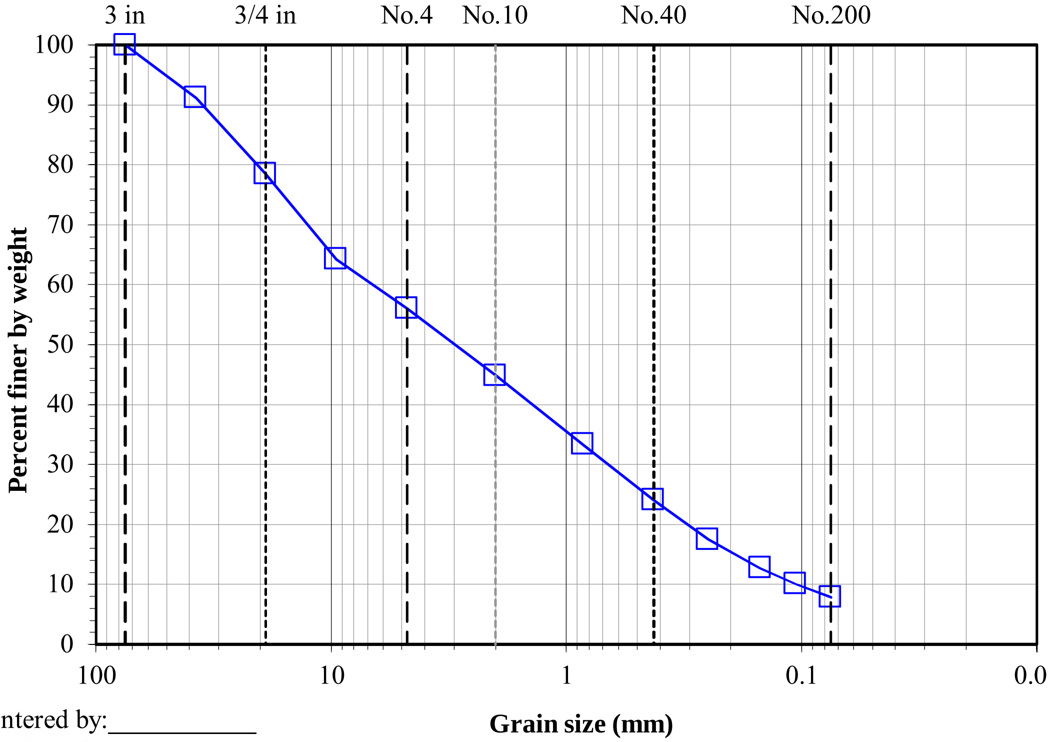
Project: National Ability Center
No: 02763-001
Location: Park City, Utah
Date: 3/19/2018
By: JWB

Boring No.: TP-3
Sample:
Depth: 7.5'
Description: Brown sand with silty clay and gravel

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	1596.53	1400.45
+3/8" Coarse fraction (g):	540.34	500.74
-3/8" Split fraction (g):	303.87	258.85
Split fraction:	0.642	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	661.64	444.20
Dry soil + tare (g):	622.05	399.18
Tare (g):	121.42	140.33
Water content (%):	7.9	17.4

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	123.57	37.5	91.2	
3/4"	301.05	19	78.5	
3/8"	500.74	9.5	64.2	←Split
No.4	33.10	4.75	56.0	
No.10	78.20	2	44.8	
No.20	124.34	0.85	33.4	
No.40	161.92	0.425	24.1	
No.60	188.37	0.25	17.5	
No.100	207.55	0.15	12.7	
No.140	218.38	0.106	10.0	
No.200	227.30	0.075	7.8	



Gravel (%): 44.0
Sand (%): 48.2
Fines (%): 7.8

Entered by:___________
Reviewed:___________

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

(ASTM D1140)

Project: **National Ability Center**
No: **02763-001**
Location: Park City, Utah
Date: 3/19/2018
By: JWB

Sample Info.	Boring No.	TP-2							
	Sample								
	Depth	8.0'							
	Split	Yes							
	Split Sieve*	3/8"							
	Method	B							
	Specimen soak time (min)	230							
	Moist total sample wt. (g)	1027.12							
	Moist coarse fraction (g)	49.14							
	Moist split fraction + tare (g)	311.26							
	Split fraction tare (g)	123.04							
	Dry split fraction (g)	152.49							
	Dry retained No. 200 + tare (g)	181.91							
	Wash tare (g)	123.04							
	No. 200 Dry wt. retained (g)	58.87							
	Split sieve* Dry wt. retained (g)	46.16							
	Dry total sample wt. (g)	838.49							
Coarse Fraction	Moist soil + tare (g)	175.99							
	Dry soil + tare (g)	173.01							
	Tare (g)	126.85							
	Water content (%)	6.46							
Split Fraction	Moist soil + tare (g)	311.26							
	Dry soil + tare (g)	275.53							
	Tare (g)	123.04							
	Water content (%)	23.43							
	Percent passing split sieve* (%)	**94.5**							
	Percent passing No. 200 sieve (%)	**58.0**							

Entered by:___________
Reviewed:___________

Collapse/Swell Potential of Soils

(ASTM D4546 Method B)

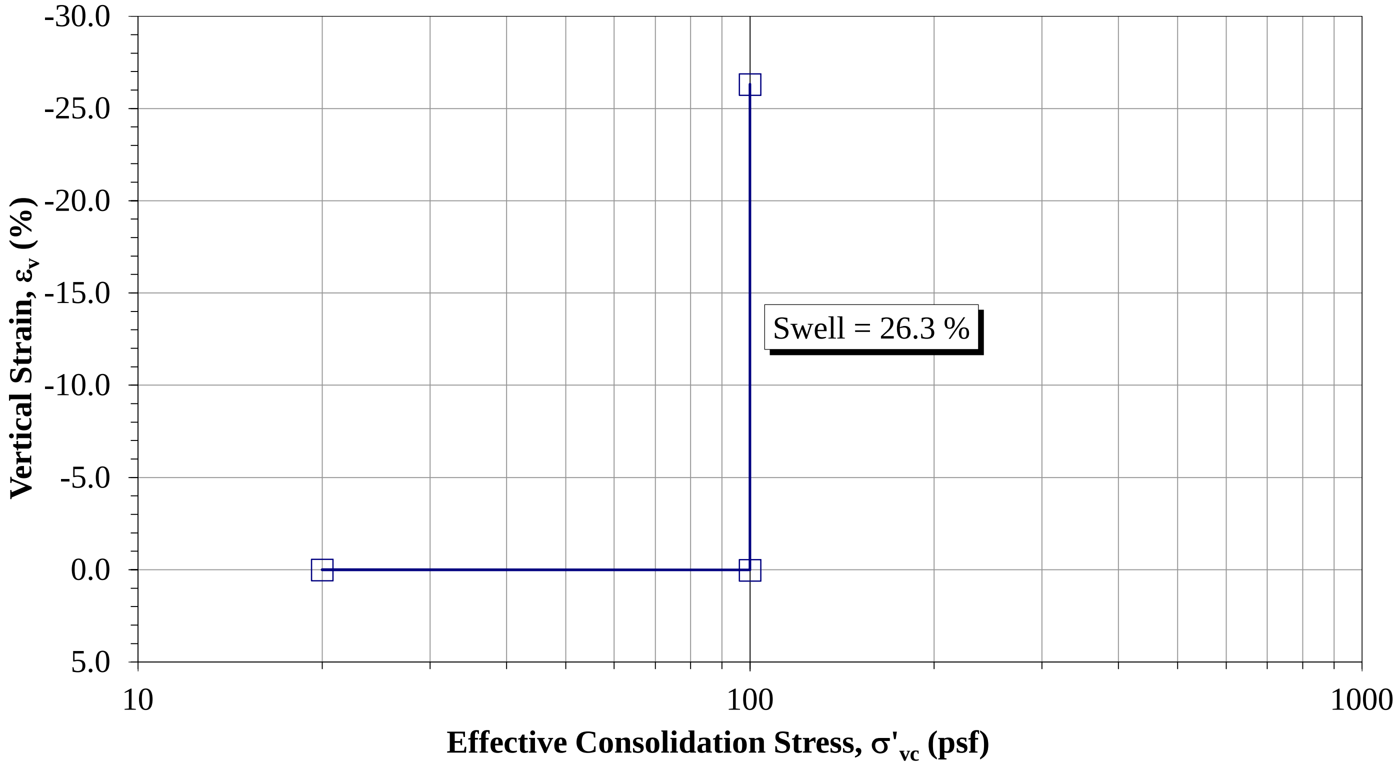
Project: **National Ability Center**
No: **02763-001**
Location: Park City, Utah
Date: 3/21/2018
By: JDF

Boring No.: **TP-2**
Sample:
Depth: **2.0'**
Sample Description: Brown clay
Engineering Classification: Not requested
Sample type: Laboratory compacted
Dry unit weight 107 pcf
at 17.8 (%) w

Compaction specifications: Provided by client
Consolidometer No.: 2
Specific gravity, G_s 2.70 Assumed
Swell (%) 26.3
Swell stress (psf) 100
Water type used for inundation Tap

	Initial (o)	Final (f)
Sample height, H (in.)	0.788	0.9953
Sample diameter, D (in.)	2.344	2.344
Mass rings + wet soil (g)	151.62	181.19
Mass rings/tare (g)	41.78	41.78
Moist unit wt., γ_m (pcf)	123.06	123.65
Wet soil + tare (g)	151.62	261.91
Dry soil + tare (g)	144.05	225.93
Tare (g)	41.78	126.85
Water content, w (%)	7.4	36.3
Dry unit wt., γ_d (pcf)	114.57	90.71
Saturation	42.42	100.00

Stress (psf)	Dial (in.)	1-D ε_v (%)	H_c (in.)	e
Seating	0.2534	0.00	0.7880	0.471
20	0.2534	0.00	0.7880	0.471
100	0.2535	0.01	0.7879	0.471
100	0.0461	-26.31	0.9953	0.858



Comments: Test specimen was compacted to a dry unit weight of 107.0 pcf (110% of TP-3 @2.0') at 17.8% water content and allowed to air dry before testing.

Entered: ________
Reviewed: ________

Collapse/Swell Potential of Soils

(ASTM D4546 Method B)

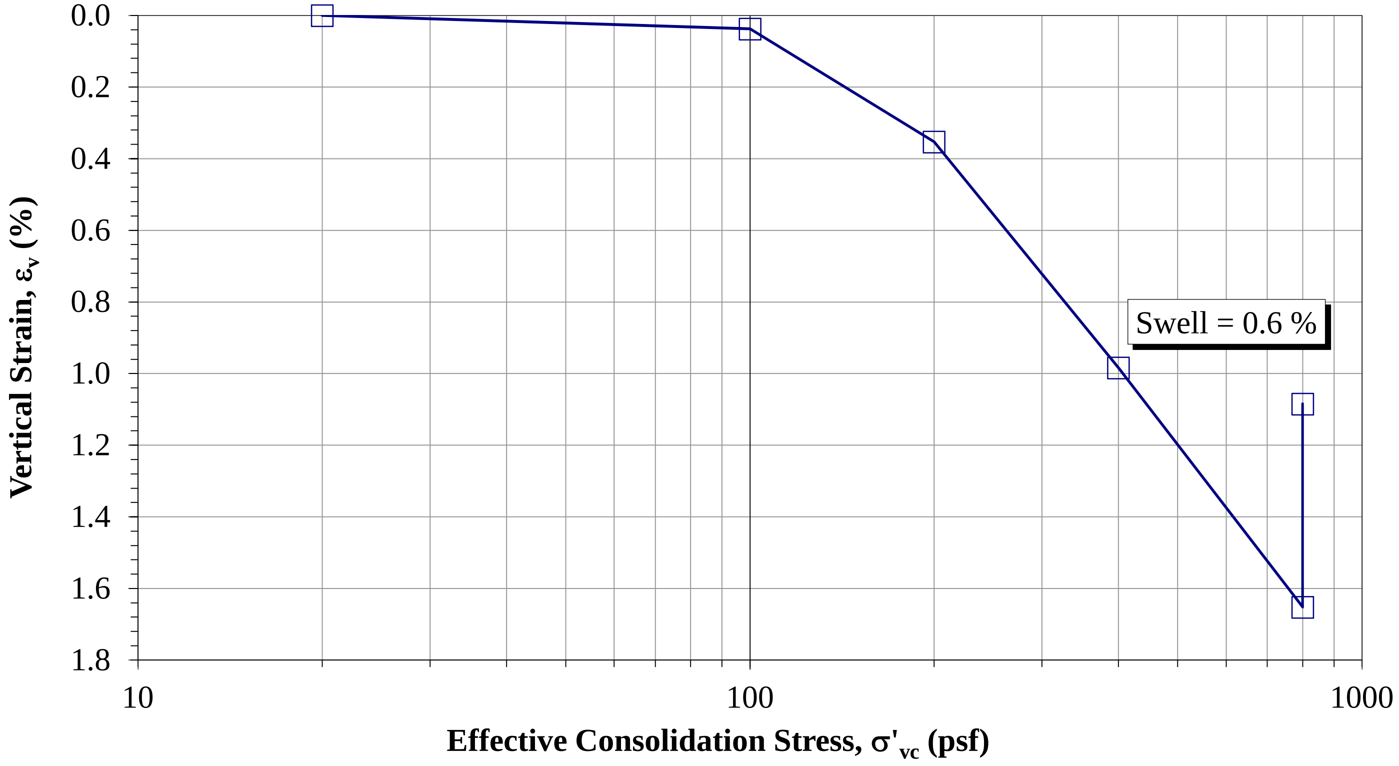
Project: National Ability Center
No: 02763-001
Location: Park City, Utah
Date: 3/16/2018
By: JDF

Boring No.: TP-3
Sample:
Depth: 2.0'
Sample Description: Brown clay
Engineering Classification: Not requested
Sample type: Undisturbed-trimmed from thin-wall

Consolidometer No.:	7	
Specific gravity, G_s	2.70	Assumed
Swell (%)	0.6	
Swell stress (psf)	800	
Water type used for inundation	Tap	

	Initial (o)	Final (f)
Sample height, H (in.)	0.793	0.7844
Sample diameter, D (in.)	2.418	2.418
Mass rings + wet soil (g)	158.03	161.10
Mass rings/tare (g)	41.17	41.17
Moist unit wt., γ_m (pcf)	122.25	126.84
Wet soil + tare (g)	457.39	243.28
Dry soil + tare (g)	398.26	219.77
Tare (g)	122.30	124.28
Water content, w (%)	21.4	24.6
Dry unit wt., γ_d (pcf)	100.68	101.78
Saturation	85.82	100.00

Stress (psf)	Dial (in.)	1-D ε_v (%)	H_c (in.)	e
Seating	0.2590	0.00	0.7930	0.674
20	0.2590	0.00	0.7930	0.674
100	0.2593	0.04	0.7927	0.673
200	0.2618	0.35	0.7902	0.668
400	0.2668	0.98	0.7852	0.658
800	0.2721	1.65	0.7799	0.646
800	0.2676	1.08	0.7844	0.656



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Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils

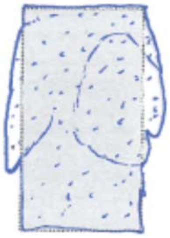
(ASTM D2850)

IGES

Project: National Ability Center
No: 02763-001
Location: Park City, Utah
Date: 3/19/2018
By: EH

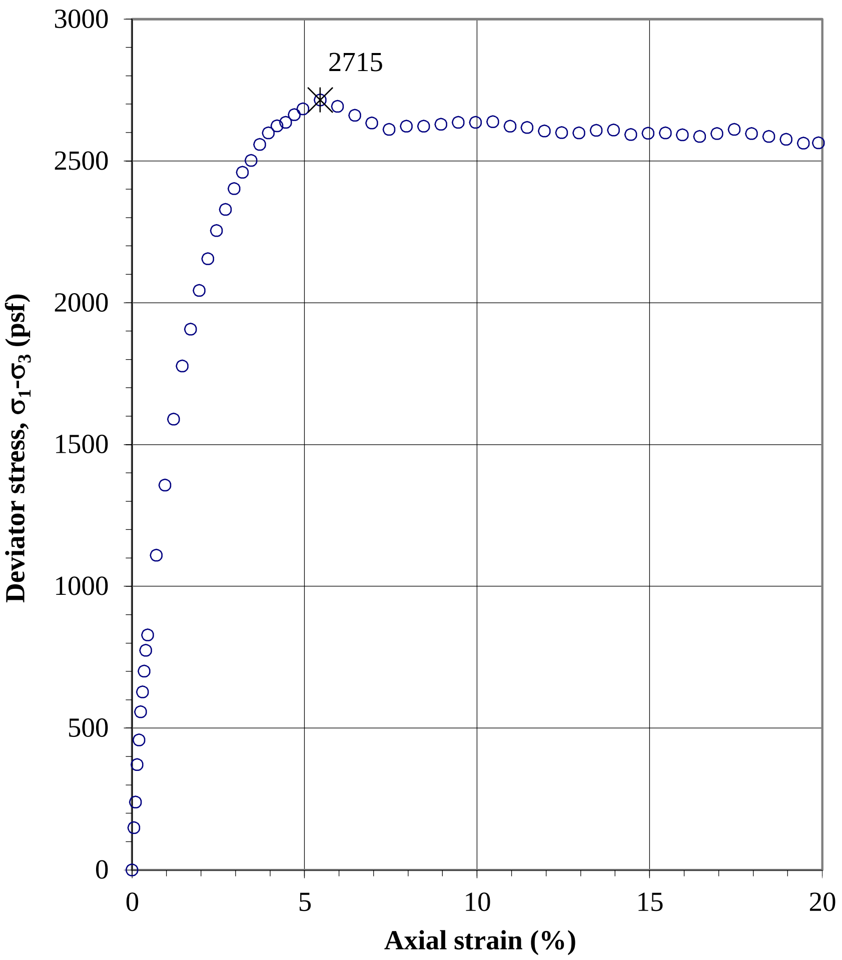
Boring No.: TP-1
Sample:
Depth: 4.0'
Sample Description: Brown sandy clay
Sample type: Undisturbed

Specific gravity, Gs 2.70 Assumed
Sample height, H (in.) 5.275
Sample diameter, D (in.) 2.407
Sample volume, V (ft^3) 0.0139
Wt. rings + wet soil (g) 776.73
Wt. rings/tare (g) 0.00
Moist soil, Ws (g) 776.73
Moist unit wt., γ_m (pcf) 123.3
Dry unit wt., γ_d (pcf) **103.7**
Saturation (%) 81.2
Void ratio, *e* 0.63



Wet soil + tare (g) 794.64
Dry soil + tare (g) 688.77
Tare (g) 128.52
Water content, w (%) **18.9**
Confining stress, σ_3 (psf) 200
Shear rate (in/min) 0.0158
Strain at failure, ε_f (%) 5.45
Deviator stress at failure, $(\sigma_1-\sigma_3)_f$ (psf) 2715
Shear stress at failure, $q_f = (\sigma_1-\sigma_3)_f/2$ (psf) 1358

Axial Strain (%)	σ_d σ_1-σ_3 (psf)	Q 1/2 σ_d (psf)
0.00	0.0	0.0
0.05	149.0	74.5
0.10	239.9	119.9
0.15	372.1	186.0
0.20	458.6	229.3
0.25	557.5	278.7
0.30	627.3	313.7
0.35	701.3	350.6
0.40	775.1	387.5
0.45	828.2	414.1
0.70	1109.6	554.8
0.95	1356.6	678.3
1.20	1590.1	795.0
1.45	1777.5	888.7
1.70	1906.9	953.4
1.95	2043.7	1021.8
2.20	2155.5	1077.7
2.45	2254.5	1127.2
2.71	2328.7	1164.3
2.95	2402.7	1201.3
3.20	2460.2	1230.1
3.45	2501.3	1250.6
3.70	2558.1	1279.0
3.95	2598.7	1299.3
4.20	2623.1	1311.5
4.45	2635.5	1317.7
4.70	2663.6	1331.8
4.95	2683.7	1341.8
5.45	2715.4	1357.7
5.95	2692.2	1346.1
6.45	2661.2	1330.6
6.95	2634.3	1317.1
7.45	2611.3	1305.6
7.95	2622.8	1311.4
8.45	2622.6	1311.3
8.95	2629.7	1314.8
9.45	2636.6	1318.3
9.95	2635.8	1317.9
10.45	2638.6	1319.3
10.95	2622.6	1311.3
11.45	2617.8	1308.9
11.95	2605.5	1302.7
12.45	2600.3	1300.1
12.95	2598.7	1299.3
13.45	2607.7	1303.8
13.95	2609.2	1304.6
14.45	2592.8	1296.4
14.95	2597.6	1298.8
15.45	2598.5	1299.2
15.95	2592.4	1296.2
16.45	2586.1	1293.0
16.95	2596.9	1298.4
17.45	2610.8	1305.4
17.95	2597.1	1298.5
18.45	2586.8	1293.4
18.95	2576.3	1288.1
19.45	2562.5	1281.2
19.89	2563.9	1281.9



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APPENDIX C

Design Maps Summary Report

User–Specified Input

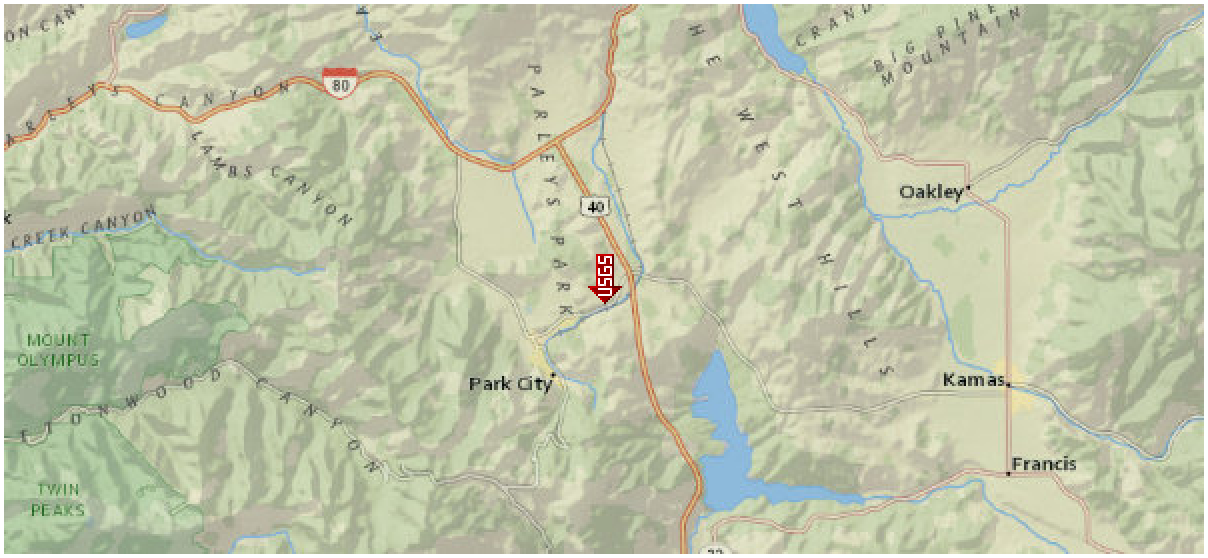
Report Title National Ability Center
Tue March 13, 2018 22:13:50 UTC

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

Site Coordinates 40.6816°N, 111.4747°W

Site Soil Classification Site Class D – "Stiff Soil"

Risk Category I/II/III

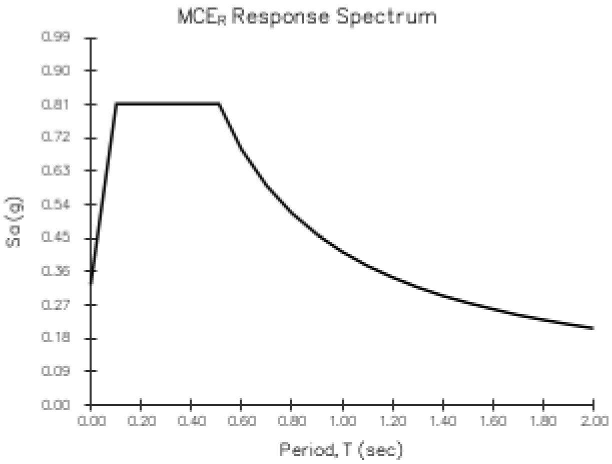


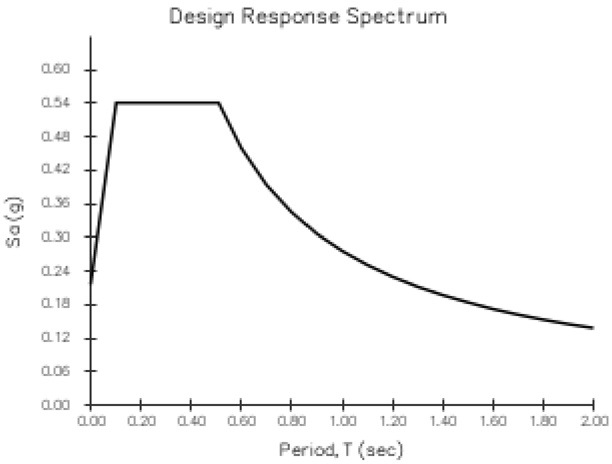
USGS–Provided Output

S_S = 0.624 g
S_{MS} = 0.812 g
S_{DS} = 0.541 g

S_1 = 0.209 g
S_{M1} = 0.414 g
S_{D1} = 0.276 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.


MCE$_R$ Response Spectrum


Design Response Spectrum

USGS Design Maps Detailed Report

2012/2015 International Building Code (40.6816°N, 111.4747°W)

Site Class D – “Stiff Soil”, Risk Category I/II/III

Section 1613.3.1 — Mapped acceleration parameters

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

From Figure 1613.3.1(1) [1]	S_S = 0.624 g
From Figure 1613.3.1(2) [2]	S_1 = 0.209 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 D, 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 = D and S_S = 0.624 g, F_a = 1.301

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 = D and S_1 = 0.209 g, F_v = 1.983

Equation (16-37):	$S_{MS} = F_aS_S = 1.301 \times 0.624 = 0.812$ g
Equation (16-38):	$S_{M1} = F_vS_1 = 1.983 \times 0.209 = 0.414$ g

Section 1613.3.4 — Design spectral response acceleration parameters

Equation (16-39):	$S_{DS} = ⅔ S_{MS} = ⅔ \times 0.812 = 0.541$ g
Equation (16-40):	$S_{D1} = ⅔ S_{M1} = ⅔ \times 0.414 = 0.276$ g

Section 1613.3.5 — Determination of seismic design category

TABLE 1613.3.5(1)
SEISMIC DESIGN CATEGORY BASED ON SHORT-PERIOD (0.2 second) RESPONSE ACCELERATION

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

For Risk Category = I and S_{DS} = 0.541 g, Seismic Design Category = D

TABLE 1613.3.5(2)
SEISMIC DESIGN CATEGORY BASED ON 1-SECOND PERIOD RESPONSE ACCELERATION

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

For Risk Category = I and S_{D1} = 0.276 g, Seismic Design Category = D

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

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

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

References

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