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GEOTECHNICAL INVESTIGATION
The ~~Riverton~~ Towers Subdivision
12989 Cactus Berry Drive
Riverton, Utah

Prepared for:

Wasatch Land Company

IGES Job No. 01965-019

July 7, 2015

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GEOTECHNICAL INVESTIGATION RIVERTON TOWERS SUBDIVISION 12989 CACTUS BERRY DRIVE RIVERTON, UTAH

IGES Project No. 01965-019

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APPENDIX

1.0 EXECUTIVE SUMMARY

This report presents the results of a geotechnical investigation conducted for the proposed Riverton Towers Subdivision to be located at 12989 Cactus Berry Drive in Riverton, Utah. Based on the subsurface conditions encountered at the site, the subject site is suitable for the proposed construction provided that the recommendations contained in this report are complied with. A brief summary of the critical recommendations is included below:

- Native soils at the site consisted primarily of topsoil underlain by coarse grained sands and gravels along the western half of the property and Sandy Lean CLAY (CL) that transitioned to Fat CLAY (CH) with depth along the eastern half of the property. No groundwater was encountered within the maximum depths explored (maximum 13 feet).
- Shallow spread or continuous wall footings may be established *entirely* on relatively undisturbed native soils or *entirely* on a minimum of 18 inches of structural fill placed on relatively undisturbed native soils. Footings may be proportioned for a maximum net allowable bearing capacity of **1,600 psf** for dead load plus live load conditions.
- Concrete slabs-on-grade should be constructed over a minimum of 4 inches of compacted gravel overlying undisturbed suitable native subgrade soils. The slab may be designed with a Modulus of Subgrade Reaction of **150 psi/inch**.
- Flexible pavement section alternatives include 3/10 or 3/6/10 (inches of asphalt/road base/sub-base) constructed on 8 inches of reworked native soils.

Recommendations for general site grading, design of foundations, slabs-on-grade, moisture protection and soil corrosivity as well as other aspects of construction are included in this report.

NOTE: The scope of services provided within this report is 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 proposed Riverton Towers Subdivision to be located at 12989 Cactus Berry Drive in Riverton, Utah. The purposes of this investigation were to assess the nature and engineering properties of the subsurface soils, and to provide recommendations for general site grading and design and construction of foundations, slabs-on-grade and pavement.

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 and signed authorization.

The recommendations presented in this report are subject to the limitations presented in the **Limitations** section of this report (Section 7.1).

2.2 PROJECT DESCRIPTION

The subject property is located at 12989 Cactus Berry Drive in Riverton, Utah (see Figure A-1, *Site Vicinity Map*). The property has a total area of approximately 28 acres. It is our understanding that the proposed development will consist of 104 single family residences and 22 multiple family residences. Construction plans were not available for our review at the time this report was prepared; however, we assume that the new structures will be multi-story wood-framed residences with basements founded on conventional continuous and spread footings.

3.0 METHODS OF STUDY

3.1 FIELD INVESTIGATION

As a part of this investigation, subsurface soil conditions were explored by completing 14 exploratory test pits to depths ranging from 11 to 13 feet below the existing site grade. The approximate locations of the explorations are shown on Figure A-2 (*Geotechnical Map*) in Appendix A. Exploration points were placed to provide optimum coverage of the site. Logs of the subsurface conditions as encountered in the explorations were recorded at the time of excavation by a member of our technical staff and are presented as Figures A-3 through A-16 in Appendix A. A *Key to Soil Symbols and Terminology* used on the test pit logs is included as Figure A-17.

The test pits were completed using a rubber tired backhoe. Soil sampling was completed to collect representative samples of the various layers observed at the site. Disturbed samples were placed in plastic baggies 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 (Figures A-3 through A-16).

3.2 LABORATORY INVESTIGATION

Geotechnical laboratory tests were conducted on selected 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:

- Water Content (ASTM D7263)
- Unit Weight (ASTM D2216)
- Atterberg Limits (ASTM D4318)
- No. 200 Sieve Wash (ASTM D1140)
- One-dimensional collapse (ASTM D4546 & 5333)
- Unconsolidated-Undrained Triaxial Compression Test (ASTM D2850)
- One-Dimensional Consolidation (ASTM D2435)
- Maximum dry density and optimum moisture content (ASTM D698)
- California Bearing Ratio (CBR) (ASTM D1883)
- Corrosion Testing-sulfate and chloride concentrations, pH and resistivity (ASTM D4972, D4327, D4327, C1580 and EPA 300.0)

The results of the laboratory tests are presented on the test pit logs in Appendix A (Figures A-3 through A-16) and the laboratory test results 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 methods currently accepted by the geotechnical industry. These methods include settlement, bearing capacity, lateral earth pressures, trench stability and pavement design. 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 subject site is located at an elevation of approximately 4,765 to 4,800 feet above mean sea level. At the time of our investigation there were four existing radio towers located primarily along the northern half and south east corner of the property. An existing substation was centered along the eastern side of the property. The ground surface is covered with grass, weeds and exposed native soils. The site elevation is greatest along the western edge and slopes down towards the east. We understand the existing radio towers and substation will be relocated as part of construction.

4.2 SUBSURFACE CONDITIONS

The subsurface soil conditions were explored at the site by excavating fourteen test pits at representative locations. The subsurface conditions encountered during our investigation are discussed in the following paragraphs.

4.2.1 Earth Materials

Based on our observations, the majority of the site was overlain by approximately 12 to 24 inches of topsoil comprised of Sandy Lean CLAY (CL). The topsoil contained roots in the upper 12 inches. The topsoil was predominantly underlain by coarse grained sands and gravels along the western half of the property and Sandy Lean CLAY (CL) that transitioned to Fat CLAY (CH) with depth along the eastern half of the property. The clay was generally stiff and dry to moist. Fine pinholes were observed in the clay up to 11.5 feet in depth.

The stratification lines shown on the enclosed test pit logs represent the approximate boundary between soil types (Figures A-3 to A-16). The actual in-situ transition may be gradual. Due to the nature and depositional characteristics of the native soils, care should be taken in interpolating subsurface conditions between and beyond the exploration locations. Additional descriptions of these soil units are presented on the boring logs (Figures A-3 through A-16 in Appendix A).

4.2.2 Groundwater

Groundwater was not encountered in any of the test pits completed for our investigation. Seasonal fluctuations in precipitation, surface runoff from adjacent properties, or other on or offsite sources may increase moisture conditions; groundwater conditions can be expected to rise several feet seasonally depending on the time of the year. However, based on our field investigation, we anticipate that groundwater will not impact the proposed construction.

5.0 GEOLOGIC CONDITIONS

5.1 GEOLOGIC SETTING

The site is located at an elevation of approximately 4,765 to 4,800 feet above mean sea level (m.s.l.) in the southwest portion of the Salt Lake Valley. The Salt Lake Valley is a deep, sediment-filled structural basin of Cenozoic age flanked by uplifted mountain blocks (Hintze, 1980) with the eastern foothills largely being created as a result of glacial and canyon outwash as well as Lake Bonneville processes. The Wasatch Range is the easternmost expression of pronounced Basin and Range extension in north-central Utah. The Oquirrh Range marks the westernmost expression of the Salt Lake Valley.

The near-surface geology of the Salt Lake Valley is dominated by sediments, which were deposited within the last 30,000 years by Lake Bonneville (Scott and others, 1983; Personius and Scott, 1992). The lacustrine sediments near the mountain front consist mostly of gravel and sand. As the lake receded, streams began to incise large deltas which had previously formed at the mouths of major canyons along the Wasatch Range, and the eroded material was deposited in shallow lakes and marshes in the basin and in a series of recessional deltas and alluvial fans. Sediments toward the center of the valley are predominately deep-water deposits of clay, silt and fine sand. However, these deep-water deposits are in places covered by a thin post-Bonneville alluvial cover. Most surficial deposits along the northern Wasatch fault zone were deposited during the Bonneville Lake Cycle that was the last cycle of Lake Bonneville between approximately 32 to 10 ka (thousands of years ago) and in the Holocene (10 ka).

5.2 SEISMICITY AND FAULTING

There are no known active faults that pass under or immediately adjacent to the site (Hecker, 1993; Black et al, 2003). An active fault is defined as a fault displaying evidence of movement during Holocene time (eleven thousand years ago to the present). The site is mapped approximately 10.5 miles southwest of the Granger Fault portion of the West Valley fault zone, a north-south trending series of faults that are mapped within the middle of the Salt Lake Valley. The last event reportedly occurred on the West Valley Fault Zone <12,000 years ago, and has a recurrence interval of 6,000 to 12,000 years. The site is located approximately 8.9 miles west of the Salt Lake City Segment of the Wasatch fault zone, which is mapped along the western flank of the Wasatch Mountains. The Salt Lake City segment of the Wasatch Fault Zone was reportedly last active approximately 1,100 years ago, and has a recurrence interval of approximately 1,300 years. The site is also located approximately 10.4 miles east by southeast of the Oquirrh Fault Zone. Analyses of ground shaking hazard along the Wasatch Front suggests that the Wasatch fault zone is the single greatest contributor to the seismic hazard in the region.

Surface sediments at the project site are mapped as Lacustrine gravel and sand related to the Provo (regressive) phase of the Bonneville Lake cycle (Qlgp) (upper Pleistocene) and Lacustrine sand and silt related to the Provo phase of the Bonneville Lake cycle (Qlsp) (upper Pleistocene) based on a published geologic map by Biek et al. (2007). The gravel and sand unit (Qlgp) is described as moderately to well-sorted, moderately to well-rounded, clast supported pebble to cobble gravel and pebbly sand deposited at and below the Provo Shoreline that is typically thin to thick bedded and interbedded with or laterally gradational to lacustrine sand and silt (Biek et al., 2007). The sand and silt unit (Qlsp) is described as fine- to coarse-grained lacustrine sand and silt with minor gravel deposited at and below the Provo shoreline that is typically thick bedded and well sorted (Biek et al., 2007).

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 "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, 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 D (*stiff soils*). Based on IBC criteria, the short-period (F_a) and long-period (F_v) site coefficients are 1.066 and 1.677, respectively. 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 5.2.1; 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 5.2.1 - MCE Seismic Response Spectrum Spectral Acceleration Values for IBC Site Class D [a]

Site Location: **Latitude = 40.5227° N** **Longitude = -112.0063° W**	**Site Class D Site Coefficients:** **Fa = 1.066** **Fv = 1.67**
Spectral Period (sec)	**Response Spectrum Spectral Acceleration (g)**
0.2	S_{MS}=1.157
1.0	S_{M1}= 0.606

[a] IBC 1615.1.3 recommends scaling the MCE values by 2/3 to obtain the design spectral response acceleration values; values reported in the table above have not been reduced.

5.3 OTHER GEOLOGIC HAZARDS

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 hazards considered for this site include liquefaction and hydro-collapsible soils.

5.3.1 Liquefaction

Certain areas within the Intermountain region possess a potential for liquefaction during seismic events. Liquefaction is a phenomenon whereby loose, saturated, granular soil deposits lose a significant portion of their shear strength due to excess pore water pressure buildup resulting from dynamic loading, such as that caused by an earthquake. Among other effects, liquefaction can result in densification of such deposits causing settlements of overlying layers after an earthquake as excess pore water pressures are dissipated. 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) the presence of groundwater.

Referring to the *Liquefaction-Potential Map for Salt Lake County, Utah* published by the Utah Geological Survey, the site is located within an area currently designated as "very low" for liquefaction potential. The upper 13 feet are not considered liquefiable based on our field observations and testing, laboratory testing and a depth to groundwater that is greater than 13 feet.

5.3.2 Collapsible Soils

Collapse is a phenomena where undisturbed native soils under increased loading can exhibit volumetric strain and consolidation upon wetting. Collapsible soils can cause differential settling of structures and roadways. Collapsible soils do not necessarily preclude development and can be mitigated by over-excavating porous, potentially collapsible soils and replacing with engineered fill and by controlling surface drainage and runoff. Collapsible soils are typically characterized by a pinhole structure and relatively light in-situ density. Fine pinholes were observed in the native clay to 13 feet in depth below existing site grade. Collapse testing was completed on three samples, one in test pit 10 at 11 feet, one in test pit 13 at 5 feet, and one in test pit 14 at 8 below existing site grade, collected as part of this investigation. The test results indicate a *minor* collapse potential of approximately 1% to 2.6%; results of the collapse testing are provided in Appendix B.

6.0 ENGINEERING CONCLUSIONS AND RECOMMENDATIONS

6.1 GENERAL CONCLUSIONS

Based on the subsurface conditions encountered at the site, 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. In general, we anticipate the development can be completed using standard construction practices. Footings may be founded entirely on relatively undisturbed native soils or entirely on a zone of structural fill. Due to soils with minor collapse potential the moisture control recommendations contained in section 6.7 of this report should be strictly followed. We also recommend the upper 8 inches of exposed native soil be reworked beneath pavements and concrete flatwork to minimize collapse potential and create a low permeability barrier for moisture. We also recommend that IGES be on site at key points during construction to see that the recommendations in this report are implemented.

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

6.2 EARTHWORK

Prior to the placement of foundations, general site grading is recommended to provide proper support for 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 minimizing the risk of differential settlement of foundations as a result of variations in subgrade conditions.

6.2.1 General Site Preparation

Within the areas to be graded (below proposed structures, fill sections, concrete flatwork, or pavement sections), any existing surface vegetation, debris, and undocumented fill should be removed. The upper 6 to 12 inches should be grubbed to remove the majority of the roots and organic matter. Any existing utilities should be re-routed or protected in-place. The exposed native soils should then be proof-rolled with heavy rubber-tired equipment such as a loader. Any soft/loose areas identified during proof-rolling should be removed and replaced with structural fill.

An IGES representative should observe the site preparation and grading operations to assess whether the recommendations presented in this report have been complied with.

6.2.2 Excavations

Soft, porous, or otherwise unsuitable soils beneath foundations or concrete flatwork may need to be over-excavated and replaced with structural fill. 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.

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. Soil types are expected to consist largely of *Type C* soils (granular soils), however, fine grained soils discussed in section 4.2.1 are classified at *Type A* soil (cohesive soils with unconfined compressive strength greater than 1.5 tsf). 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 3/4 H:1V (53 degrees) in *Type A* soils and 1 ½H:1V (34 degrees) in *Type C* soils may be used as an alternative to shoring or shielding.

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 the on-site native fine-grained soils or an approved imported material. The native fine-grained soils were typically observed to be moisture sensitive and it can be difficult to achieve the desired compaction and moisture content; therefore, it may be more economical to import material that will require less effort. 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 15 percent. 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). Topsoil may not be used as structural fill; this material must be kept segregated from other soils intended to be used as structural fill.

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-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. 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 maximum dry density (MDD) as determined by ASTM D-1557. The moisture content should be at or slightly above the optimum moisture content (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 confirm that unsuitable materials have been removed. In addition, proper grading should precede placement of fill, as described in the General Site Preparation and Grading subsection of this report.

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 a minimum of 90 percent of the MDD (ASTM D-1557).

More stringent specifications from governing authorities such as cities, counties, sewer districts, etc., having their own requirements for backfill and compaction should be followed where applicable.

6.3 FOUNDATIONS

Based on our field observations and laboratory testing, we recommend that footings be established *entirely* on relatively undisturbed native soils or *entirely* on a minimum of 18 inches of structural fill placed on relatively undisturbed native soils; native/fill transition zones are not allowed.

If used, all structural fill should be placed and compacted in accordance with our recommendations presented in Section 6.2.4 of this report. Shallow spread or continuous wall footings constructed as described above may be proportioned utilizing a maximum net allowable bearing pressure of **1,600 pounds per square foot (psf)**. The net allowable bearing values presented above are for dead load plus live load conditions. A one-third increase may be used for transient wind and seismic loads.

All foundations exposed to the full effects of frost should be established at a minimum depth of 30 inches below the lowest adjacent final grade. Interior footings, not subjected to the full effects of frost (e.g., a continuously heated structure), may be established at higher elevations, however, a minimum depth of embedment of 12 inches is recommended for confinement purposes. The minimum recommended footing width is 20 inches for continuous wall footings and 30 inches for isolated spread footings. Do to the minor collapse potential identified on the site, the recommendations contained in the moisture control and surface drainage section of this report (section 6.7) should be strictly followed

6.4 SETTLEMENT

Settlements 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 total settlement over a distance of 30 feet.

6.5 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 0.40 for *native soil* should be used.

Ultimate lateral earth pressures from *granular structural fill* backfill acting against retaining walls and buried structures may be computed from the lateral pressure coefficients or equivalent fluid densities presented in Table 6.5. The coefficients and densities presented in Table 6.5 assume no buildup of hydrostatic pressures. The force of the water should be added to the presented values if hydrostatic pressures are anticipated.

Table 6.5
Recommended Lateral Earth Pressure Coefficients

Condition	**Level Backfill**	
	Lateral Pressure Coefficient	**Equivalent Fluid Density (pcf)**
Active (Ka)	0.33	40
At-rest (Ko)	0.50	60
Passive (Kp)	3.0	360

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 20.

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

6.6 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 8 inches of reworked native subgrade soils. The gravel should consist of free draining gravel with a 3/4-inch maximum particle size and no more than 5 percent passing the No. 200 mesh sieve. The slab may be designed with a Modulus of Subgrade Reaction of **150 psi/inch**.

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 measured above the recommendations contained 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).

6.7 MOISTURE CONTROL AND SURFACE DRAINAGE

Due to the minor collapse potential of the native fine-grained soils and as part of good construction practices, moisture should not be allowed to infiltrate into the soils in the vicinity of the foundations. As such, design strategies to minimize ponding and infiltration near the structure should be implemented as follows

- We recommend that hand watering, desert or Xeriscape landscaping be considered within 5 feet of the foundations.
- Roof runoff devices be installed to direct all runoff a minimum of 10 feet away from the structure.
- Irrigation valves should be placed a minimum of 5 feet from foundations and must be placed beyond the limits of foundation backfill.
- The ground surface within 10 feet of the addition should be constructed so as to slope a minimum of five percent away.

6.8 ASPHALT CONCRETE PAVEMENT DESIGN

A laboratory-determined CBR value of 4.1 was obtained from a representative sample of the near-surface soils during our investigation. This value indicates that the subsurface soils will provide relatively poor pavement support. No traffic information was available at the time this report was prepared, therefore, we have assumed an equivalent single axle load (ESAL) value of approximately 200,000 for a 20-year design life assuming an annual growth rate of 0%.

Table 6.8.1 - Flexible Pavement Section

Asphalt (in.)	Base Course (in.)	Granular Borrow "Subbase" (in.)	Reworked Native Soils (in.)
3	10	-	8
3	6	10	8

Asphalt has been assumed to be a high stability plant mix; base course material should be composed of crushed stone with a minimum CBR of 70. The granular borrow (Subbase) should consist of a 4 inch minus pit run material with a minimum CBR value of 30 and should be compacted to at least 95% of the MDD and at or slightly above the OMC as determined by ASTM D1557. The asphalt should be compacted to a minimum density of 96% of the Marshall value and the base course should be compacted to at least 95% of the MDD of the modified proctor at or slightly above the OMC as determined by ASTM D1557.

If traffic conditions vary significantly from our stated assumptions, IGES should be contacted so we can modify our pavement design parameters accordingly. Specifically, if the traffic counts are significantly higher or lower, we should be contacted to revise the pavement section design as necessary. The pavement section thicknesses above assumes that the majority of construction traffic including cement trucks, cranes, loaded haulers, etc. has ceased. If a significant volume of construction traffic occurs after the pavement section has been constructed, the owner should anticipate maintenance or a decrease in the design life of the pavement area.

The pavement section thicknesses presented above assume that there is no mixing over time between the road base and the fine-grained native layers below. In order to prevent mixing or fines migration, and thereby prolong the life of the pavement section, it is our judgment that placing a geosynthetic between the native soils and the road base, such as the Tencate Mirafi® RS380i woven geosynthetic fabric as described above will be the best option. If this option is not used, IGES recommends using a non-woven filter fabric, such as NW-601 or an IGES-approved equivalent as a minimum. If only a non-woven geosynthetic fabric is used, the values listed in Table 6.8.1 should be used.

6.9 PRELIMINARY SOIL CORROSION POTENTIAL

To evaluate the corrosion potential of concrete in contact with onsite native soil, a representative soil sample was tested in our soils laboratory for soluble sulfate content. Laboratory test results indicate that the sample tested had a sulfate content of less than 5.21 ppm. Based on this result, the onsite native soils are expected to exhibit a *low* potential for sulfate attack on concrete. A conventional Type I/II cement should be used for all concrete in contact with site soils.

To evaluate the corrosion potential of ferrous metal in contact with onsite native soil, a representative soil sample was tested in our soils laboratory for soil resistivity (AASHTO T288), chloride content, and pH. The tests indicated that the onsite soil tested has minimum soil resistivity of 4689 OHM-cm, a chloride content of less than 5.21 ppm, and a pH value of 8.26. Based on these results, the onsite native soil is considered to be *mildly corrosive* when in contact with ferrous metal. Consideration should be given to retaining the services of a qualified corrosion engineer to provide an assessment of any metal such as ancillary water lines, reinforcing steel, valves, and similar improvements in contact with native soils.

7.0 CLOSURE

7.1 LIMITATIONS

The recommendations contained 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 possible that variations in the soil and groundwater conditions could exist between the points explored. The nature and extent of variations may not be evident until construction occurs. If any conditions are encountered at this site that are different from those described in this report, we should be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the scope of the proposed construction changes from that described in this report, IGES should 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 made 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 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 foundation soils to assess their suitability for footing placement.
- Observation of soft/loose soils over-excavation.
- 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

Black, B.D., Hecker, S., Hylland, M.D., Christenson, G.E., and McDonald, G.N., 2003, Quaternary Fault and Fold Database and Map of Utah: Utah Geological Survey Map 193DM.

Hecker, S., 1993, Quaternary Tectonics of Utah with Emphasis on Earthquake-Hazard Characterization: Utah Geological Survey, Figure 1a, Bulletin 127, Quaternary Faults and Folds, Utah.

Hintze, L.F., 1980, Geologic Map of Utah: Utah Geological and Mineral Survey Map-A-1, scale 1:500,000.

Hintze, L.F. 1993, Geologic History of Utah, Brigham Young University Studies, Special Publication 7, 202p.

Intermountain GeoEnvironmental Services, Inc., 2015 *Phase I ESA, Bingham Subdivision in Lehi, Utah,* IGES Project No. 01965-015, *in progress.*

Machette, M.N., 1992, Surficial geologic map of Wasatch fault zone, eastern part of the Utah Valley, Utah County and parts of Salt Lake and Juab Counties, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-2095, scale 1:50,000.

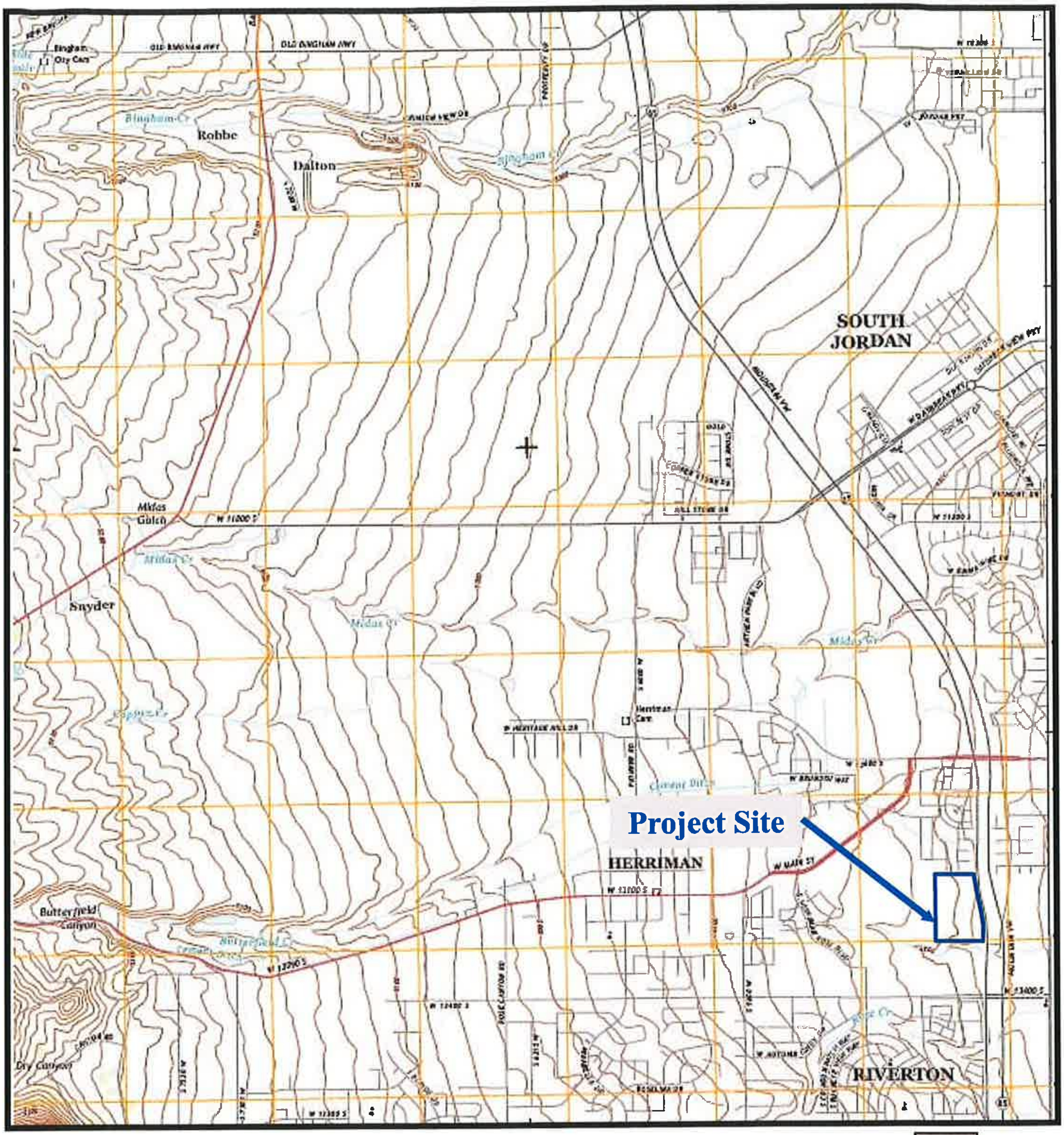
Scott, W.E., McCoy, W.D., Shorba, R.R., and Meyer, R., 1983, Reinterpretation of the exposed record of the last two cycles of Lake Bonneville, western United States: Quaternary Research, v.20, p. 261-285.

United States Geological Survey, Copperton, Utah, Quadrangle Map 7.5 Minute Series.

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

Utah Geological Survey, 1994, "Liquefaction-Potential Map for a Part of Utah County, Utah", Public Information Series 28.

APPENDIX A



Base Maps:
USGS Copperton
7.5-Minute Quadrangle Topographic Map (2014)

0' 1000' 2000'

SCALE 1:24,000

Contour Interval – 40 feet

N

MAP LOCATION

IGES®

Project Number 01965-019

Geotechnical Investigation
Riverton Towers Subdivision
12989 Cactus Berry Drive
Riverton, Utah

SITE VICINITY MAP

Figure

A-1

DATE	
STARTED:	6/2/15
COMPLETED:	6/2/15
BACKFILLED:	6/2/15

Geotechnical Investigation
Riverton Towers Subdivision
12989 Cactus Berry Drive
Riverton, Utah

Project Number 01965-019

IGES Rep: TBL
Rig Type: Backhoe

TEST PIT NO:
TP-2
Sheet 1 of 1

LOCATION
LATITUDE
LONGITUDE
ELEVATION

DEPTH: ELEVATION | FEET | SAMPLES | WATER LEVEL | GRAPHICAL LOG | UNIFIED SOIL CLASSIFICATION

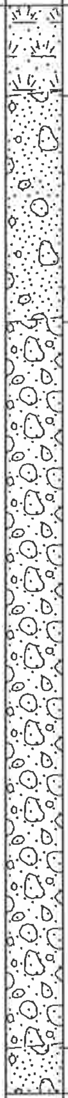
MATERIAL DESCRIPTION

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



FEET	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION
0		Native Topsoil - Sandy Lean CLAY - medium stiff, dry to slightly moist, dark brown
	SP	Poorly Graded SAND with gravel - medium stiff, dry to slightly moist, orange brown
	GP	Poorly Graded GRAVEL with sand - dense, dry, light brown Gravel was subrounded up to 4 inches in diameter with 1/2- to 2-inch diameters typical
5		rust or iron staining increasing with depth
10		
	SP	Poorly Graded SAND with trace gravel - medium dense, dry, light brown

No Groundwater Encountered

Bottom of Test Pit @ 12 Feet

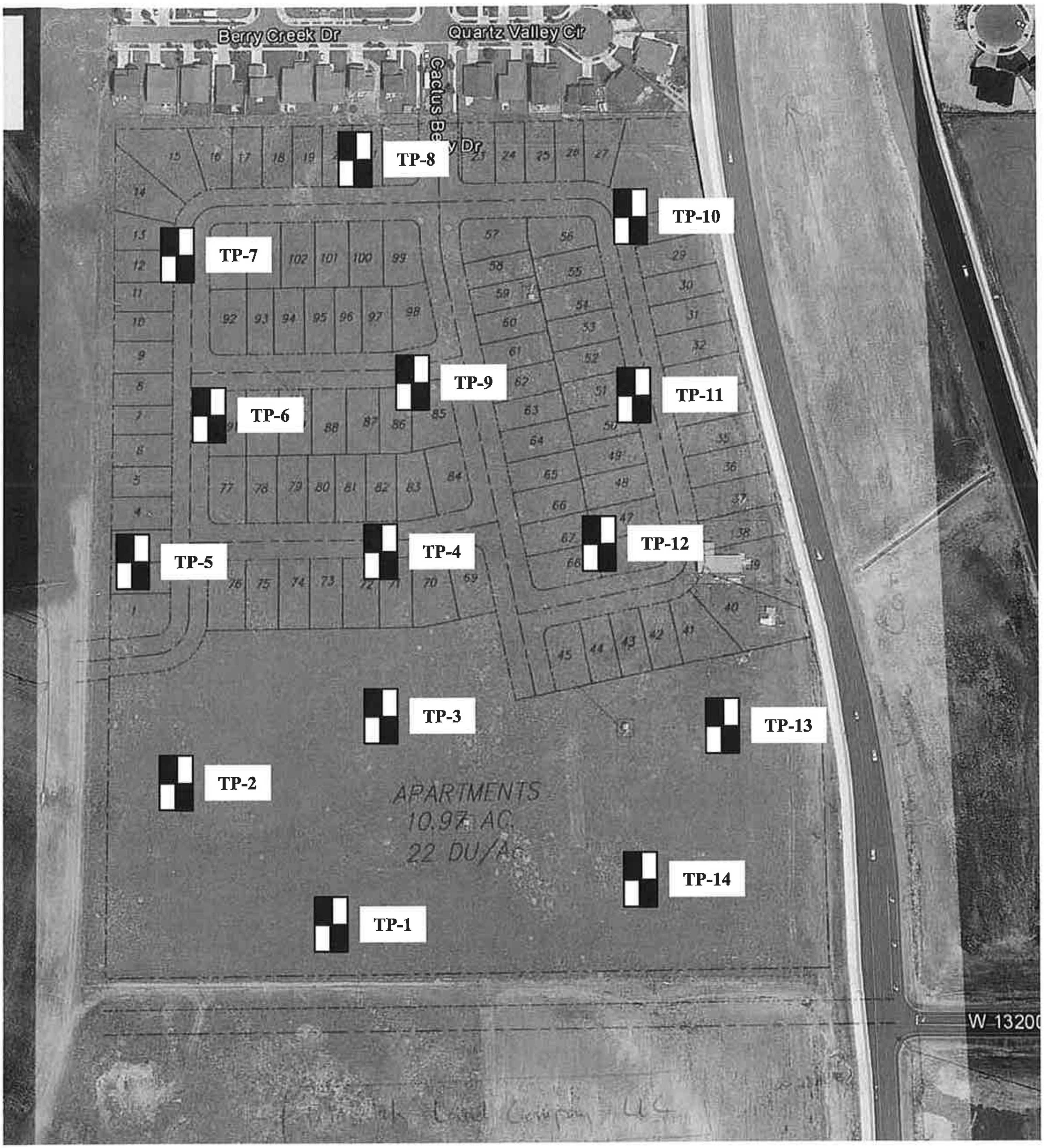
IGES®

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

WATER LEVEL
- ▼- MEASURED
- ▽- ESTIMATED

NOTES:

Figure
A-4



▚ **TP-1** Approximate Test Pit Location

Site Plan provided by Client

N

Not To Scale

IGES®

Project Number – 01965-019

Geotechnical Investigation
Riverton Towers Subdivision
12989 Cactus Berry Drive
Riverton, Utah

GEOTECHNICAL MAP

Figure

A-2

DATE	STARTED: 6/2/15 COMPLETED: 6/2/15 BACKFILLED: 6/2/15	Geotechnical Investigation Riverton Towers Subdivision 12989 Cactus Berry Drive Riverton, Utah Project Number 01965-019	IGES Rep: TBL Rig Type: Backhoe

TEST PIT NO:

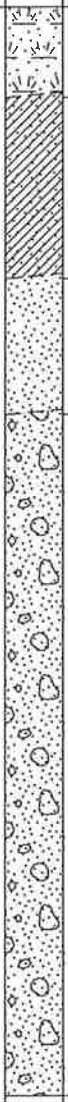
TP-1

Sheet 1 of 1

LOCATION

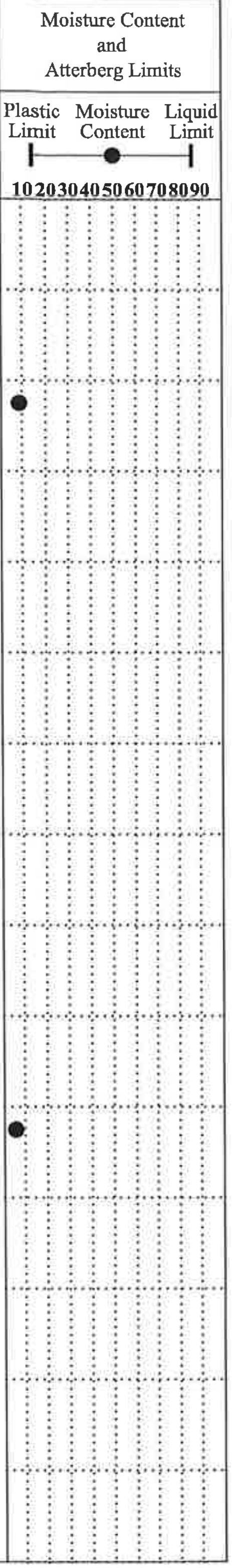
LATITUDE LONGITUDE ELEVATION

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				Native Topsoil - Sandy Lean CLAY - medium stiff, dry to moist, dark brown					
				CL	Sandy Lean CLAY - stiff, dry to slightly moist, light brown, some pinholes Non-Plastic					
		⧗				82.6	8.1			
				SP	Poorly Graded SAND - medium dense, dry to slightly moist, grey					
	5			SP	Poorly Graded SAND with trace gravel - medium dense, dry to slightly moist, light brown					
	10	▯					5.1	39.1		
					No Groundwater Encountered Bottom of Test Pit @ 12 Feet					

Moisture Content and Atterberg Limits



IGES

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

WATER LEVEL
▼ - MEASURED
▽ - ESTIMATED

NOTES:

Figure

A-3

DATE	
STARTED:	6/2/15
COMPLETED:	6/2/15
BACKFILLED:	6/2/15

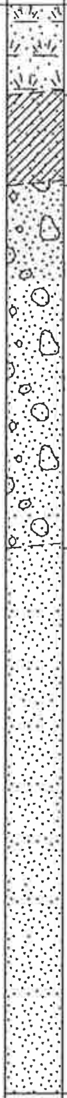
Geotechnical Investigation
Riverton Towers Subdivision
12989 Cactus Berry Drive
Riverton, Utah

Project Number 01965-019

IGES Rep: TBL
Rig Type: Backhoe

TEST PIT NO:
TP-3
Sheet 1 of 1

LOCATION
LATITUDE LONGITUDE ELEVATION



ELEVATION	DEPTH FEET	SAMPLES	WATER LEVEL	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				Native Topsoil - Sandy Lean CLAY - medium stiff, dry to slightly moist, dark brown						
		⧗		CL	Sandy Lean CLAY - stiff, dry to slightly moist, light brown, some pinholes	86.9	14.4				●
	5			SP	Poorly Graded SAND with trace gravel - medium dense, dry, light brown						
	10			SP	Poorly Graded SAND - medium dense, dry, brown						
					No Groundwater Encountered Bottom of Test Pit @ 12 Feet						

LOG OF TEST PITS (A) - (4 LINE HEADER W ELEV) 01965-019.GPJ IGES.GDT 7/7/15

IGES®

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

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

Figure A-5

DATE	
STARTED:	6/2/15
COMPLETED:	6/2/15
BACKFILLED:	6/2/15

Geotechnical Investigation
Riverton Towers Subdivision
12989 Cactus Berry Drive
Riverton, Utah

Project Number 01965-019

IGES Rep: TBL

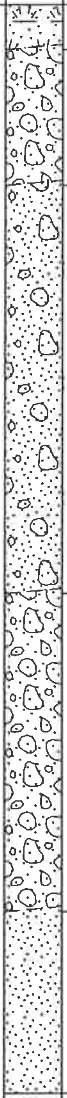
Rig Type: Backhoe

TEST PIT NO:
TP-4
Sheet 1 of 1

LOCATION

LATITUDE LONGITUDE ELEVATION

MATERIAL DESCRIPTION



DEPTH FEET	SAMPLES	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0			Native Topsoil - Sandy Lean CLAY with gravel- stiff, dry to slightly moist, dark brown					
		GP	Poorly Graded GRAVEL with sand - dense, slightly moist, brown					
		SP	Poorly Graded SAND with trace gravel - medium dense, dry, light brown					
			Seams of Lean CLAY					
5								
		GP	Poorly Graded GRAVEL with sand - dense, dry, light brown Gravel was subrounded up to 4 inches in diameter with 1- to 2-inch diameters typical					
	▯				1.8	5.1		
10		SP	Poorly Graded SAND - medium dense, dry, light brown					
			No Groundwater Encountered					
			Bottom of Test Pit @ 12 Feet					

Moisture Content and Atterberg Limits

IGES®

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

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

Figure
A-6

DATE				
STARTED: 6/2/15	Geotechnical Investigation Riverton Towers Subdivision 12989 Cactus Berry Drive Riverton, Utah	IGES Rep: TBL	TEST PIT NO:
COMPLETED: 6/2/15	Project Number 01965-019	Rig Type: Backhoe	**TP-5**
BACKFILLED: 6/2/15			Sheet 1 of 1

LOCATION

LATITUDE LONGITUDE ELEVATION

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					Native Topsoil - Sandy Lean CLAY - medium stiff, dry to slightly moist, dark brown						
					CL	Sandy Lean CLAY - stiff, dry to slightly moist, brown, some pinholes						
		[] ⧗					86.1	8.7				●
					GP	Poorly Graded GRAVEL with sand - dense, dry, brown Gravel was subrounded up to 4 inches in diameter with 1/2- to 1 1/2-inch diameters typical						
	5											
	10											
						No Groundwater Encountered Bottom of Test Pit @ 11 Feet						

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

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

Figure

A-7

DATE
STARTED: 6/2/15
COMPLETED: 6/2/15
BACKFILLED: 6/2/15

Geotechnical Investigation
Riverton Towers Subdivision
12989 Cactus Berry Drive
Riverton, Utah
Project Number 01965-019

IGES Rep: TBL
Rig Type: Backhoe

TEST PIT NO:
TP-6
Sheet 1 of 1

LOCATION
LATITUDE LONGITUDE ELEVATION

DEPTH FEET	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION
0		Native Topsoil - Sandy Lean CLAY with trace gravel - medium stiff, dry to slightly moist, dark brown
	CL	Sandy Lean CLAY with gravel - stiff, dry to slightly moist, light brown, some pinholes
	GP	Poorly Graded GRAVEL with sand - dense, dry, light brown Gravel was subrounded up to 4 inches in diameter with 1/2- to 1 1/2-inch diameters typical
5		
10		
		No Groundwater Encountered Bottom of Test Pit @ 11 Feet

ELEVATION | FEET | SAMPLES | WATER LEVEL | GRAPHICAL LOG | 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

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

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

Figure
A-8

IGES®

DATE	
STARTED:	6/2/15
COMPLETED:	6/2/15
BACKFILLED:	6/2/15

Geotechnical Investigation
Riverton Towers Subdivision
12989 Cactus Berry Drive
Riverton, Utah

Project Number 01965-019

IGES Rep: TBL
Rig Type: Backhoe

TEST PIT NO:
TP-7
Sheet 1 of 1

LOCATION
LATITUDE LONGITUDE ELEVATION

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					Native Topsoil - Sandy Lean CLAY - medium stiff, dry to slightly moist, dark brown						
		▯			CL	Sandy Lean CLAY with gravel - stiff, dry to slightly moist, light brown, some pinholes						
					GP	Poorly Graded GRAVEL with sand - dense, dry, light brown Gravel was subrounded up to 3 inches in diameter with 1- to 2-inch diameters typical						
	5											
		▯			SC	Clayey SAND - medium dense, dry to slightly moist, light brown						
	10											
						No Groundwater Encountered						
						Bottom of Test Pit @ 12 Feet						

IGES®

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

WATER LEVEL
▼- MEASURED
▽- ESTIMATED

NOTES:

Figure
A-9