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GEOTECHNICAL INVESTIGATION
Royal Farms Residential Development
12064 South 3600 West
Riverton, Utah

IGES Project No. 01709-001

March 12, 2013

Prepared for:

Bowler Properties, L.C.

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ROYAL FARMS RESIDENTIAL DEVELOPMENT
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RIVERTON, UTAH

IGES Project No. 01709-001

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1.0 EXECUTIVE SUMMARY

This report presents the results of our geotechnical investigation conducted for the Royal Farms residential development to be located at 12064 South 3600 West in Riverton, Utah. 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.

- The site is mantled by approximately 12 inches of disced/tilled clayey soil overlying lacustrine deposits consisting of mostly lean clay, with occasional discontinuous sand and gravel lenses.

- Footings for the proposed residential structures be founded either *entirely* on competent native soils <u>or</u> *entirely* on structural fill. Native/fill transition zones are not allowed. If soft, loose, potentially collapsible, or otherwise deleterious earth materials are exposed in the footing excavations, then the footings should be deepened such that all footings bear on relatively uniform, competent native earth materials. Alternatively, the building pad may be over-excavated a minimum of 2 feet below the bottom of proposed footings and replaced with structural fill, such that the footings bear entirely on a uniform fill blanket.

- Shallow spread or continuous wall footings constructed on competent native soil or a minimum of two feet of structural fill 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.

- Based on soil classifications and a laboratory obtained CBR value of 4.0 for the native soil tested, the near surface soils are expected to provide poor pavement support. Pavement sections should consist of *3 inches of asphalt over 13 inches of road base* for interior roadways. The road base section may be reduced if a stabilization fabric is incorporated into the design of the pavement section (see Table 6.7). We recommend that the owner give consideration to placing a separation fabric between the native soils and the road base.

NOTICE: 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 our geotechnical investigation conducted for the Royal Farms residential development to be located at 12064 South 3600 West in Riverton, Utah. The purposes of this investigation were to assess the nature and engineering properties of the subsurface soils at the subject site and to provide recommendations for design of conventional shallow spread foundations, general site grading, and design of pavement sections for construction of the proposed roadways. In addition, we have assessed the geologic hazards at the site.

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 dated January 16, 2013. 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 located between Bangerter Highway and 3600 West, at approximately 12000 South, in Riverton, Utah. The site is bounded on the west by Bangerter Highway, on the north by Midas Creek, on the south by existing residential property, and on the east by 3600 West Street. The project site is shown on the *Site Vicinity Map* included in Appendix A at the end of this report (Figure A-1). The proposed improvements are illustrated on Figure A-2, *Geotechnical Map.*

Our understanding of the project is based on the *Conceptual Site Plan*, Sheet C-1 (printed 2/8/13), prepared by Ensign Engineering, and information provided by the Client. We understand that a new residential subdivision will be developed at the 34-acre property. Currently, about 29 acres are planned for development; roughly 5 acres along Midas Creek has been set aside as non-buildable. The development is expected to consist of 80 lots ranging is size from ¼ acre to ½ acre – each lot will be developed for a single-family residence. The project will also include interior roadways, joint utilities, and landscaping.

Construction plans were not available for our review; however, we assume that the new homes will be one- or two-story structures, with approximate footprints of 2,000 sqft, founded on conventional shallow spread footings with slab-on-grade flooring. The homes are expected to have basements.

3.0 METHOD OF STUDY

3.1 SUBSURFACE INVESTIGATION

As a part of this investigation, subsurface soil conditions were explored by excavating fifteen test pits to depths ranging up to 15 feet below the existing surface. Figure A-2 in Appendix A shows the approximate locations of the test pits. Exploration points were placed to provide a representative cross section of the subsurface conditions in areas anticipated for development. Subsurface conditions as encountered in the explorations were logged at the time of our investigation by a member of our technical staff and are presented on the enclosed test pit logs, Figures A-3 through A-17 in Appendix A. A *Key to Soil Symbols and Terminology* is presented on Figure A-18.

The test pits were excavated with the aid of a CAT 312C tracked excavator. Both bulk and relatively "undisturbed" soil samples were obtained in the test pit explorations. Relatively "undisturbed" soil samples were obtained with the use of a hand sampler attached to a 6-inch long brass tube driven into the soil with a 2 pound sledge. All samples were transported to our laboratory for testing to evaluate engineering properties of the various earth materials observed. The soils observed in the explorations were logged and classified in general accordance with the *Unified Soil Classification System* (USCS). Classifications for the individual soil units are shown on the attached test pit logs (Figures A-3 through A-17).

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:

- In situ dry density and moisture content
- Atterberg Limits
- Maximum dry density and optimum moisture content
- CBR for pavement recommendations
- Collapse potential
- Water-soluble sulfate concentration for cement type recommendations
- Resistivity and pH to evaluate corrosion potential of ferrous metals in contact with site soils

Results of the in situ dry density and moisture content tests are shown on the test pit logs (Appendix A). The results of remaining laboratory tests are presented on the test pit logs in Appendix A (Figures A-3 through A-17) and on the laboratory test results figures presented in Appendix B and in the *Summary of Laboratory Test Results Table* (Table B-1, Appendix B).

4.0 GEOLOGIC CONDITIONS

4.1 GEOLOGIC SETTING

The site is located at an elevation of about 4,625 feet within the southern portion of the Salt Lake Valley. The Salt Lake Valley is a deep, sediment-filled structural basin of Cenozoic age flanked by two uplifted blocks, the Wasatch Range on the east and the Oquirrh Mountains to the west (Hintze, 1980; Hintze, 1993). The northern portion of the Salt Lake Valley is bordered on the northwest by the southeast shore of the Great Salt Lake. The Wasatch Range is the easternmost expression of pronounced Basin and Range extension in north-central Utah.

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 and the Great Salt Lake (Scott et al., 1983). As the lake receded, streams began to incise large deltas 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 (Scott et al., 1983). However, these deep-water deposits are in places covered by a thin post-Bonneville alluvial cover.

Based on the published geologic map by Davis (2000), surface sediments at the project site are mapped as late Pleistocene lacustrine silts and clays, deep-water sediments related to transgressive/regressive phases of the Bonneville Lake Cycle.

4.2 SEISMICITY AND FAULTING

The site lies within the north-south trending belt of seismicity known as the Intermountain Seismic Belt (ISB) (Hecker, 1993). The ISB extends from northwestern Montana through southwestern Utah. An active fault is defined as a fault that has had activity within the Holocene (<11ka). No active faults are mapped through or immediately adjacent to the site (Black et. al, 2003, and Bryant, 1992). The closest mapped active fault is the Salt Lake City segment of the Wasatch Fault Zone, located about 11 km west of the site.

Seismic hazard maps depicting probabilistic ground motions and spectral response have been 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, 2009). Spectral responses for the Maximum Considered Earthquake (MCE) are shown in Table 4.2. These values generally correspond to a two percent probability of exceedance in 50 years (2PE50) for a "firm rock" site. To account for site effects, site coefficients which vary with the magnitude of spectral acceleration are used. Based on our field exploration, it is our opinion that this location is best described as a Site Class D (firm soil). The spectral accelerations are shown in Table 4.2. The spectral accelerations are calculated based on the site's approximate latitude and longitude of 40.5319° and -111.9809° respectively. Based on IBC, the site coefficients are F_a=1.061 and F_v= 1.564. From this procedure the peak ground acceleration (PGA) is estimated to be 0.466g. The MCE PGA and design response spectrum are presented in Appendix C on Figure C-1.

Table 4.2
MCE Seismic Response Spectrum Spectral Acceleration Values for IBC Site Class D [a]

Site Location: Latitude = 40.5319 N Longitude = -111.9809 W	**Site Class D Site Coefficients: Fa = 1.061 Fv = 1.564**
Spectral Period (sec)	**Response Spectrum Spectral Acceleration (g)**
0.2	1.098xFa = 1.165
1.0	0.436xFv = 0.682

[a] IBC 1615.1.3 recommends scaling the MCE values by 2/3 to obtain the design spectral response acceleration values.

4.3 OTHER GEOLOGIC HAZARDS

Geologic hazards can be defined as naturally occurring geologic conditions or processes that could present a danger to human life and property. These hazards must be considered before development of the site. There are several hazards in addition to seismicity and faulting that may be present at the site, and which should be considered in the design of roads and critical facilities such as water tanks and structures designed for human habitation. Other geologic hazards considered significant for this site include stream flooding and liquefaction.

4.3.1 Stream Flooding

Stream flooding is a hazard related to spring snowmelt, run-off and flash-flooding from summer rainstorms. Flood hazards should be considered when planning for the development of habitable structures and essential and critical facilities located within areas having a potential flood risk.

Midas Creek runs approximately east-west along the northern boundary of the property. The design engineer should assess the flooding potential for the creek.

4.3.2 Liquefaction

Liquefaction is the loss of soil strength or stiffness due to a buildup of excess pore-water pressure during strong ground shaking. Liquefaction is associated primarily with loose (low density), granular, saturated soil. Effects of severe liquefaction can include sand boils, excessive settlement, bearing capacity failures, and lateral spreading.

The geologic hazards map titled *Surface Rupture, Liquefaction Potential Special Study Areas, Salt Lake County, Utah*, dated July 1993, indicates that the subject property is located within an area designated as having a *very low* liquefaction potential (less than 5% probability that the critical ground acceleration needed to trigger liquefaction will be exceeded within 100 years). As such, the potential for liquefaction occurring at the site is considered low. A liquefaction hazard study, which would include multiple borings and/or CPT soundings to depths of 50 feet, was not performed and is beyond our scope of services for this project.

5.0 GENERALIZED SITE CONDITIONS

5.1 SURFACE CONDITIONS

The Royal Farms property is an L-shaped site and is roughly 35 acres in size. The site is relatively flat, draining to the east. Maximum topographic relief across the site is approximately 35 feet. The site has been primarily used for agriculture; there are no structures presently within the areas planned for development. Access to the site is gained from 3600 West Street.

5.2 SUBSURFACE CONDITIONS

The subsurface soil conditions were explored at the subject property by excavating fifteen test pits across the site. Subsurface soil conditions were logged during our field investigation and are included in the test pit logs in Appendix A at the end of this report (Figures A-3 through A-17). The soil and moisture conditions encountered during our investigation are discussed below.

5.2.1 Soils

Tilled Earth: The upper 9 to 12 inches of soil consisted of tilled/disced soil; where encountered, this soil generally consisted of dark brown Lean CLAY (CL). The upper tilled layer was characterized by an abundance of organic matter (roots, etc.), a dark, loamy appearance, and was generally very moist.

Native Surficial Soils: The majority of the shallow surficial soils encountered in the explorations consisted of Lean CLAY (CL), which are presumed to be lacustrine deposits associated with ancient Lake Bonneville. Intermittent lenses and sand and gravel were identified in several test pits. The lone exception was TP-7 – the soils observed within this test pit consisted of sand and gravel to a depth of approximately 12 feet. It is presumed that the sands and gravels are related to nearby Midas Creek.

Undocumented Fill: Undocumented fill was not identified in any of our test pits and is not expected to significantly impact the proposed development; however, some undocumented fill may be present as a result of past farming practices.

Test pit logs of the subsurface soil profiles are presented in Appendix A (Figures A-3 through A-17). The stratification lines shown on the enclosed test pit logs represent the approximate boundary between soil types. 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.

5.2.2 Groundwater

Groundwater was not encountered in any of the exploratory test pits and is not expected to impact the proposed development. During construction the groundwater elevation may increase locally due to precipitation, surface runoff from adjacent properties, irrigation or other sources.

5.2.3 Expansive Soil

Expansive soils contain significant amounts of clay particles that change volume as a result of varying moisture conditions. Foundations and hardscape/pavements constructed on these soils may be subject to uplifting forces caused by the swelling. Without proper measures taken, heaving and cracking of building foundations, slabs-on-grade, or pavements could result. Soils that are potentially expansive typically exhibit a high degree of plasticity, i.e. Fat CLAY (CH) and Elastic SILT (ML). Although Fat CLAY and Elastic SILT are potentially expansive, the correlation between Atterberg Limits and expansion potential is crude at best; a soil that classifies as Fat CLAY or Elastic SILT is not necessarily expansive.

Based on Atterberg limits testing, the fine-grained soils encountered generally classified as Lean CLAY (CL). Based on the results of Atterberg Limits testing and our experience in the area, the onsite native soils are expected to have a low expansion potential.

5.2.4 Collapsible Soil

Collapse (often referred to as "hydro-collapse") is a phenomena where undisturbed soils 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.

Collapse/swell tests (ASTM D4546 & D5333) were performed on four relatively undisturbed samples of native clayey soil; the results are summarized in the following table:

Table 5.2.4
Summary of Collapse Test Results

Test Specimen	Load at Inundation (psf)	Collapse (%)
TP-1 @ 5 feet	2,000	0.5
TP-3 @ 5 feet		7.2
TP-6 @ 5 feet		1.8
TP-12 @ 5 feet		0.4

The results of the tests suggest that the native soils will, in general, experience minor volumetric strain under increased moisture conditions (about 1 percent strain). However, the test at TP-3 indicates about 7 percent volumetric strain. Based on these results, collapsible soils are not expected to be widely distributed across the proposed development; however, at some locations, highly collapsible soils may be present. The results of the collapse/swell tests are presented in Appendix B.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 GENERAL CONCLUSIONS

Supporting data upon which the following recommendations are based have been presented in the previous sections of this report. The recommendations presented herein are governed by the physical properties of the soils encountered in the exploratory test pits and the anticipated design data discussed in the PROJECT DESCRIPTION section. If subsurface conditions other than those described herein are encountered in conjunction with construction, and/or if design and layout changes are initiated, IGES must be informed so that our recommendations can be reviewed and revised as necessary.

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 implemented into the design and construction of the project. In general, we anticipate the development can be completed using standard construction practices. We anticipate that the foundation for the proposed residential structures will consist of conventional shallow spread footings founded entirely on competent native earth materials or entirely on a minimum of two feet of structural fill. Potentially collapsible soils was identified at the site; if potentially collapsible or otherwise deleterious soils are identified within the foundation subgrade, an minimum two feet over-excavation and replacement with structural fill is recommended.

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 improvements, general site grading is recommended to provide proper support for foundations, exterior concrete flatwork, concrete slabs-on-grade, and asphalt pavement sections. Site grading is also recommended to provide proper drainage and moisture control and to aid in minimizing the potential for differential movement in foundation soils resulting from variations in moisture conditions.

6.2.1 General Site Preparation and Grading

Below proposed structures, fills, and man-made improvements, all vegetation, topsoil, debris, and undocumented fill soils should be removed. Any existing utilities should be re-routed or protected in-place. The exposed native soils should then be proof-rolled with heavy rubber-tired equipment such as a scraper or loader. Any soft/loose areas identified during proof-rolling should be removed and replaced with structural fill. Areas to receive structural fill should be benched to allow placement and compaction of the material on a horizontal plane. All excavation bottoms should be observed by an IGES representative prior to placement of engineered fill to evaluate whether soft, loose, or otherwise deleterious earth materials have been removed and that recommendations contained in this report have been complied with.

6.2.2 Over-Excavation

Based on our field observations, tilled earth is expected to overly the majority of the site with thicknesses generally ranging from 9 to 12 inches. Localized areas of relatively deep tilled earth (or undocumented fill) may be encountered; as such, IGES staff or other qualified personnel should be on site during the clearing and grubbing process to assess the adequacy of the grubbing activities.

Any soft, porous, or unsuitable soils identified beneath areas to receive structural fill should be over-excavated and replaced with structural fill. If over-excavation is required, the excavations should extend 1 foot laterally for every foot of depth of over-excavation, with a minimum lateral distance of 4 feet from the footings. Excavations should extend laterally at least two feet beyond flatwork, pavements, and slabs-on-grade. Structural fill should consist of granular materials and should be placed and compacted in accordance with the recommendations contained in this report.

Prior to placing engineered fill, all excavation bottoms should be scarified to at least 4 inches, moisture conditioned as necessary to at or slightly above optimum moisture content (OMC), and compacted to at least 90 percent of the maximum dry density (MDD) as determined by ASTM D-1557 (Modified Proctor).

6.2.3 Temporary Excavations

The contractor is responsible for site safety, including all temporary trenches excavated at the site and design of any required temporary shoring. The contractor is responsible for providing the "competent person" required by *Occupational Safety and Health*

Administration (OSHA) standards to evaluate soil conditions. Soil types are expected to consist primarily of Type B soils (cohesive silts and clays with an unconfined compressive strength greater than 1,000 psf). Close coordination between the competent person and IGES should be maintained to facilitate construction while providing safe excavations.

Based on OSHA guidelines for excavation safety, trenches with vertical walls up to 5 feet in depth may be occupied. Where very moist soil conditions are 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 the sides at one horizontal to 1 vertical (1H:1V) (45 degrees) in accordance with OSHA Type B soils may be used as an alternative to shoring or shielding. Where granular soils are exposed on the trench walls, stability should be evaluated on a case-by-case basis by the "competent person".

6.2.4 Structural Fill and Compaction

All fill placed for the support of structures, flatwork or pavements, should consist of structural fill. Structural fill may consist of excavated onsite soils; however, due to anticipated clayey soil conditions, the contractor may wish to consider importing structural fill (clay soils may be used as structural fill, but may be difficult to properly moisture-condition and compact). Imported structural fill should be a granular material with less than 30 percent fines having and an Expansion Index less than 20. Prior to importing, all structural fill should be approved by IGES. Import material not meeting the aforementioned criteria may be suitable for use as structural fill; however, such material should be evaluated on a case-by-case basis and should be approved by IGES prior to use. In all cases structural fill should be relatively free of vegetation and debris, and contain no rocks larger than 4 inches in nominal size (6 inches in greatest dimension). All structural fill should be 1-inch minus material when within 1 foot of any base coarse material.

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 12-inch loose lifts if compacted by heavy duty compaction equipment that is capable of efficiently compacting the entire thickness of the lift. Additional lift thickness may be permitted by IGES provided the contractor can demonstrate sufficient compaction can be achieved with the methods used. We recommend that all structural fill be compacted on a horizontal plane, unless otherwise approved by IGES. Structural fill placed beneath footings and pavements should be compacted to at least 95 percent of the MDD as determined by ASTM D-1557. The moisture content should be at, or slightly above, the OMC for all structural fill. Prior to placing any fill, the excavations should be observed by IGES to confirm that unsuitable materials have been removed and/or the excavation bottom has been properly prepared. In addition, proper grading should precede placement of fill, as described in the *General Site Preparation and Grading* subsection of this report.

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

6.2.5 Utility Trench Backfill

Utility trenches should be backfilled with structural fill in accordance with Section 6.2.4 of this report. Utility trenches can be backfilled with the onsite soils substantially free of debris, organic and oversized material. Prior to backfilling the trench, pipes should be bedded in and covered with a uniform granular material that has a Sand Equivalent (SE) of 30 or greater. Pipe bedding should *not* be water-densified in-place (jetting). Alternatively, pipe bedding and shading may consist of clean ¾-inch gravel, which generally does not require densification. Native earth materials can be used as backfill over the pipe bedding zone. All utility trenches backfilled below pavement sections, curb and gutter, and sidewalks, should be backfilled with structural fill compacted to at least 95 percent of the MDD as determined by ASTM D-1557. All other trenches, including landscape areas, should be backfilled and compacted to approximately 90 percent of the MDD (ASTM D-1557). Specifications from governing authorities having their own precedence for backfill and compaction should be followed where applicable.

6.3 FOUNDATIONS

Based on our field observations and considering the presence of relatively competent native earth materials, we recommend that the footings for the proposed residential structures be founded either *entirely* on competent native soils <u>or</u> *entirely* on structural fill. Native/fill transition zones must be avoided. If soft, loose, porous, potentially collapsible, or otherwise deleterious earth materials are exposed in the footing excavations, then the footings should be deepened such that all footings bear on relatively uniform, competent native earth materials. Alternatively, the building pad may be over-excavated a minimum of 2 feet below the bottom of proposed footings and replaced with structural fill, such that the footings bear entirely on a uniform fill blanket.

If required, all fill beneath the foundations should consist of structural fill and should be placed and compacted in accordance with our recommendations contained in Section 6.2.4 of this report. Shallow spread or continuous wall footings constructed on competent native soils or structural fill 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.

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 (i.e., a continuously heated structure), may be established at higher elevations, however, a minimum depth of embedment of 12 inches is recommended for confinement purposes. The minimum recommended footing width is 20 inches for continuous wall footings and 30 inches for isolated spread footings.

6.4 SETTLEMENT

6.4.1 Static Settlement

Static settlement of properly designed and constructed conventional footings, 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.

6.4.2 Dynamic Settlement

Based on the field data collected for this site, it is our opinion that the onsite clayey native soils encountered throughout the site will exhibit negligible seismically induced settlement during a MCE seismic event. Similarly, properly compacted structural fill is expected to exhibit negligible seismically induced settlement during a MCE seismic event.

6.5 LATERAL EARTH PRESSURES

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 0.35 for clayey native soils or structural fill should be used.

Ultimate lateral earth pressures from natural soils and *clayey* backfill acting against retaining walls and buried structures may be computed from the lateral pressure coefficients or equivalent fluid densities presented in the following table:

Table 6.5
Lateral Earth Pressure

Condition	Level Backfill	
	Lateral Pressure Coefficient	Equivalent Fluid Density (pcf)
Active (Ka)	0.45	54.6
At-rest (Ko)	0.62	75
Passive (Kp)	1.5	180

These coefficients and densities assume no buildup of hydrostatic pressures. The force of the water should be added to the presented values if hydrostatic pressures are anticipated.

Walls and structures allowed to rotate slightly should use the active condition. If the element is constrained against rotation (i.e., a basement wall), the at-rest condition should be used. These values should be used with an appropriate factor of safety against overturning and sliding. A value of 1.5 is typically used. Additionally, if passive resistance is calculated in conjunction with frictional resistance, the passive resistance should be reduced by ½.

6.6 CONCRETE SLABS-ON-GRADE CONSTRUCTION

To minimize settlement and cracking of slabs, and to aid in drainage beneath the concrete floor slabs, all concrete slabs should be founded on a minimum 4-inch layer of compacted gravel overlying structural fill or competent native earth materials. The gravel should consist of free-draining gravel or road base with a ¾-inch maximum particle size and no more than 5 percent passing the No. 200 mesh sieve. The layer should be compacted to at least 95 percent of the MDD as determined by ASTM D-1557. Gravel materials not meeting the aforementioned criteria may be appropriate for construction; alternate materials should be evaluated on a case-by-case basis and should be approved by IGES prior to use.

All concrete slabs should be designed to minimize cracking as a result of shrinkage. Consideration should be given to reinforcing the slab with a welded wire fabric, re-bar, or fibermesh. Slab reinforcement should be designed by the structural engineer; however, as a minimum, slab reinforcement should consist of #4 bars placed 24 inches on-center within the middle third of the slab (or, use 4"x4" W2.9xW2.9 welded wire mesh). We recommend a minimum slab thickness of 4 inches. We recommend that concrete be tested to assess that the slump and/or air content is in compliance with the plans and specifications. If slump and/or air content are beyond the recommendations as specified in the plans and specifications, the concrete may not perform as desired. We recommend that concrete be placed in general accordance with the requirements of the American Concrete Institute (ACI).

6.7 PAVEMENT SECTION DESIGN

Based on soil classifications and a laboratory obtained CBR value of 4.0 for the native soil tested, the near surface soils are expected to provide relatively poor pavement support. Anticipated traffic volumes were not available at the time this report was prepared. However, based on our understanding of the project development we assume traffic on the roadways would consist primarily of passenger cars with occasional heavy vehicles associated with construction, municipal waste collection, school buses, etc. The following pavement designs have been developed for a 20-year design life assuming a 0 percent annual growth rate, and our assumed equivalent single axle load (ESAL) of 200,000 ESALs for interior roadways. Based on the information obtained and the assumptions listed above, we recommend the following pavement section be constructed on properly prepared subgrade:

Table 6.7
Conventional Pavement Design

Material Type	Option 1	Option 2	Option 3
Asphalt Concrete Pavement (inches)	3	3	3
Untreated Road Base (inches)	13	9	8
***Stabilization Fabric**	none	Mirafi RS380i	Mirafi RS580i

*Stabilization fabric is placed between the subgrade and the road base.

The pavement section thicknesses above assume that there is no mixing over time between the road base and the softer native layers below. In order to prevent mixing or fines migration, and thereby prolong the life of the pavement section, we recommend that the owner give consideration to placing an inexpensive filter fabric between the native soils and the road base, such as the Propex Geotex NW-401 or an IGES-approved equivalent as a minimum. This recommendation only applies to Option 1, since the *Stabilization Fabric* used in conjunction with Options 2 and 3 also serves as a separation fabric.

During construction, a significant amount of heavy construction traffic occurs. Some distress may manifest on pavement sections during this initial construction time period. Maintenance may need to be performed after completion of construction.

Asphalt has been assumed to be a high stability plant mix and base course material composed of crushed stone with a minimum CBR of 70. Road base should be compacted to a minimum density of 95 percent as determined by ASTM D-1557 (Modified Proctor). Asphalt should be compacted to a minimum of 96 percent of the Marshall maximum density. Asphalt and aggregate base material should conform to local requirements.

Where Portland Cement Concrete (PCC) pavements are planned, such as near trash enclosures or other areas expected to support heavy truck traffic, the pavement is recommended to be a minimum of 5 inches in thickness. Concrete pavement should be underlain by a minimum 6 inches of aggregate base course.

If conditions vary significantly from our stated assumptions, IGES should be contacted so we can modify our pavement design parameters accordingly. The County or other governing authority may have pavement requirements over and above those listed and these should be adhered to where applicable.

6.8 MOISTURE PROTECTION AND SURFACE DRAINAGE

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

Residential Structures: Moisture should not be allowed to infiltrate into the soils in the vicinity of the foundations. As such, design strategies to minimize ponding and infiltration near the home should be implemented. We recommend that hand watering, desert landscaping or Xeriscape be considered within 5 feet of the foundations. We further recommend roof runoff devices be installed to direct all runoff a minimum of 10 feet away from structures. The home builder should be responsible for compacting the exterior backfill soils around the foundation. Additionally, the ground surface within 10 feet of the house should be constructed so as to slope a minimum of five percent away from the home. Pavement sections should be constructed to divert surface water off of the pavement into storm drains. Parking strips and roadway shoulder areas should be constructed to prevent infiltration of water into the surrounding pavement.

Foundation Drainage: The prevailing clayey soils are expected to provide poor drainage; as such, for residential structures with habitable or usable space located below grade (e.g., a basement), IGES recommends a foundation drainage system be incorporated into the design of the homes. The foundation drainage system should be designed in accordance with the guidelines presented in the 2012 *International Residential Code* (IRC), Section R405, *Foundation Drainage*.

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 165 ppm. Based on this result, the onsite native soils are expected to exhibit a low potential for sulfate attack to concrete. We anticipate that conventional Type I/II cement may be used for all concrete in contact with site soils.

To evaluate the corrosion potential of ferrous metal in contact with onsite native soil, a representative soil sample was tested in our soils laboratory for soil resistivity (AASHTO T288), chloride content, and pH. The tests indicated that the onsite soil tested has minimum soil resistivity of 910 OHM-cm, a soluble chloride content of 86.4 ppm, and a pH value of 6.4. Based on these results, the onsite native soil is considered severely corrosive to ferrous metal. Consideration should be given to retaining the services of a qualified corrosion engineer to provide an assessment of any metal that may be associated with construction of ancillary water lines and reinforcing steel, valves, and similar improvements in contact with native soils.

6.10 CONSTRUCTION CONSIDERATIONS

6.10.1 Collapsible Soils

Collapsible soils are typically identified in the field by a porous, open soil structure ('pinholes'), relatively low moisture content, and low insitu dry density. Based on our laboratory tests of onsite soils, there is some minor collapse potential onsite. Prior to placement of steel or concrete, an IGES representative should assess the foundation subgrade for the presence of potentially collapsible soils. If potentially collapsible soils are identified, the foundation soils should be over-excavated and re-compacted as structural fill. As a minimum, two feet of over-excavation is typically prescribed; however, additional over-excavation may be necessary, depending on the extent of the problematic soils.

6.10.2 Foundation Drainage

The prevailing site soils are expected to consist of lean clay, which drains poorly. Although proper grading, surface drainage, irrigation practices will typically mitigate meaningful water infiltration into the foundation soils, it is not possible to predict all potential water sources (e.g., leaking utilities, water from off-site sources). Furthermore, there is no assurance that the home owner (or future owners) will not inadvertently change the grading or surface drainage, thereby increasing water infiltration into foundation soils. Therefore, IGES recommends a foundation drainage system be incorporated into the design of the homes. The foundation drainage system should be designed in accordance with the guidelines presented in the 2012 *International Residential Code* (IRC), Section R405, *Foundation Drainage*. Typical drainage systems will consist of a continuous free-draining material (crushed stone or a pre-fabricated drainage composite) placed on the outer basement wall, a heel drain around the perimeter of the exterior foundation, and drainage within the gravel layer under the basement slab-on-grade. All drainage elements are typically tied-together, and are discharged via a sump pump or by daylighting to an approved water collection system (e.g., sewer, storm drain).

7.0 CLOSURE

7.1 LIMITATIONS

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

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

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

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 or other qualified personnel should be on site to verify compliance with these recommendations. These tests and observations should include at a minimum the following:

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

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

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APPENDIX A

BASE MAPS:
USGS *Midvale* and *Copperton* 7.5-Minute Quadrangle Topographic Maps (2011)


MAP LOCATION

0' 1000' 2000'
SCALE 1:24,000
CONTOUR INTERVAL 5 FEET

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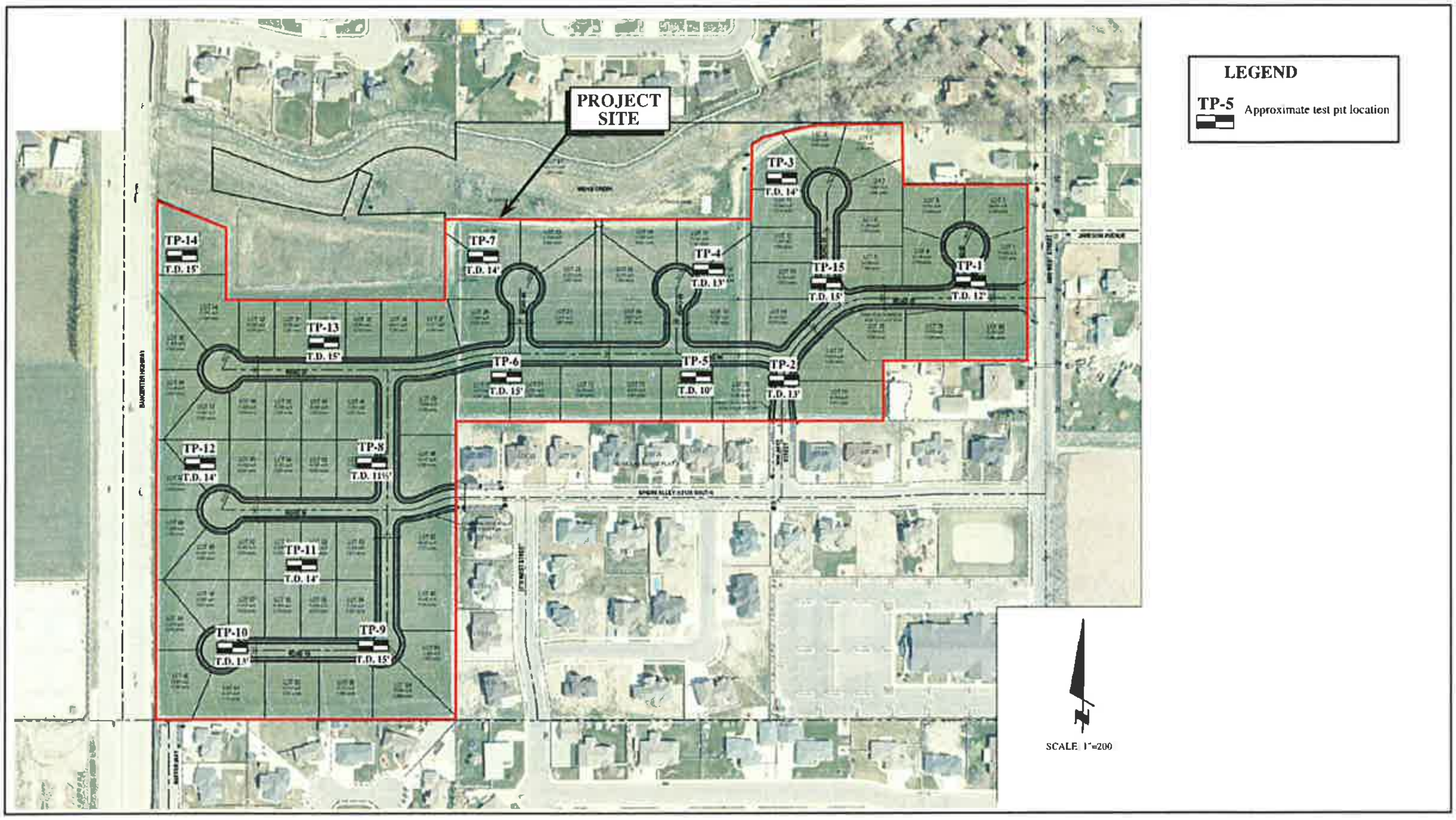
Geotechnical Investigation
Royal Farms Residential Development
12064 South 3600 West
Riverton, Utah

SITE VICINITY MAP

Figure

A-1



Base Map
Conceptual Site Plan, Sheet C-1, prepared by Ensign Engineering, dated 02/08/13

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Geotechnical Investigation
Royal Farms Residential Development
12064 South 3600 West
Riverton, Utah

GEOTECHNICAL MAP

Figure
A-2

DATE		
STARTED:	2/13/13	
COMPLETED:	2/13/13	
BACKFILLED:	2/13/13	

Geotechnical Investigation
Bowler/Royal Farms
12064 South 3600 West
Riverton, Utah

Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO: **TP-01**
Sheet 1 of 1

LOCATION
LATITUDE | LONGITUDE | ELEVATION (ft) 4,600

DEPTH (METERS)	DEPTH (FEET)	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0	0				CL	@ 0' Lean CLAY, low plasticity, very moist, dark brown, homogenous, disced/tilled appearance @ ~12" Lean CLAY, low plasticity, stiff, moist, moderate yellowish brown, homogenous, trace fine rounded gravel (<5%), trace porosity, <PL					
1		Grab sample									
	5	3" O.D. thin-walled hand sampler					86.3	19.8			
2						~8' porous soils noted (pinholes)					
3	10					@ 11' Lean CLAY, stiff, low plasticity, moist, light olive brown, mottled with abundant iron staining, blocky texture, pinholes					
4						Total Depth 13 feet No Groundwater Bucket sample 0-5 feet Bottom of test pit @ 12 Feet					
5	15										
6											

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:

IGES

Figure A - 3

DATE	
STARTED:	2/13/13
COMPLETED:	2/13/13
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Riverton, Utah

Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO: TP-02
Sheet 1 of 1

LOCATION
LATITUDE | LONGITUDE | ELEVATION (ft) 4,609

Depth (Feet)	Samples	USCS	MATERIAL DESCRIPTION	Dry Density (pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0		CL	@ 0' Lean CLAY, soft, low plasticity, very moist, moderate brown, homogenous/blocky texture, upper 12" tilled					
		GC	@ 1½' Gravelly CLAY, ~18" layer of clay with sand and gravel, lower 4 to 6 inches is a discrete lens of coarse sand with gravel, slight imbrication texture					
		CL	@ 2½' Lean CLAY, soft, low plasticity, very moist, moderate brown, homogenous, <PL					
5	3" O.D. thin-walled hand sampler		tube sample pushed by hand - soft	84.1	27.2			
			~ 7' transitions to moderate yellowish brown, reduced plasticity (CL-ML), very moist					
10			~ 10' becomes light olive brown, moist, medium stiff, blocky, mottled appearance					
	Grab sample							

Total Depth 13 feet
No Groundwater

Bottom of test pit @ 13 Feet

Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (scale 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 - 4

DATE	
STARTED:	2/13/13
COMPLETED:	2/13/13
BACKFILLED:	2/13/13

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Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO: **TP-03**
Sheet 1 of 1

LOCATION
LATITUDE | LONGITUDE | ELEVATION (ft) 4,612

Depth (feet)	Samples	USCS	MATERIAL DESCRIPTION	Dry Density (pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0		CL	@ 0' Lean CLAY, low plasticity, moist, dark brown, disced/tilled for upper 12 inches					
1		GC	@ 1' Clayey GRAVEL with sand, loose, coarse, well-rounded gravel to 3 in., moist, medium brown, imrecated appearance					
2		ML	@ 2' Sandy SILT, non-plastic, soft, moist, moderate yellowish brown, homogenous, very fine sand					
3		CL	@ 3' Lean CLAY, medium stiff, low plasticity, moist, moderate brown, homogenous, blocky texture, >PL					
			~4.2' gravelly/sandy lens, about 4- to 6-in. thick					
5	3" O.D. thin-walled hand sampler		~ 5' clay becomes increasingly moist	78.9	24.1		32	12
12			@ 12' transitions to light olive gray, moist, mantled by about 12-in. dark brown clay (paleosol?)					
14			Total Depth 14 feet No Groundwater Bottom of test pit @ 14 Feet					

Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (scale 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 - 5

DATE	
STARTED:	2/13/13
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Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO: **TP-04**
Sheet 1 of 1

LOCATION
LATITUDE LONGITUDE ELEVATION (ft)4,616

MATERIAL DESCRIPTION

DEPTH (METERS)	DEPTH (FEET)	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0	0				CL	@ 0' Lean CLAY, soft, low plastity, moist, moderate grayish brown, disced upper 12 in. - becomes moderate yellowish brown, moist, <PL, trace coarse gravel					
1		Grab sample			GC	@ 3' Lean CLAY with gravel and sand, about 30% coarse fraction, moderate yellowish brown, moist @ 4' a 9-in. lens of clayey gravel with sand, imbricated, well-rounded gravel to 2 in., loose/friable					
	5	3" O.D. thin-walled hand sampler			CL	@ 4¾' Lean CLAY, stiff, low plasticity, moist, moderate yellowish brown, low density, homogenous, massive	82.8	23.5			
2						~ 7-8' less moisture, >PL					
3	10					transitions to light olive gray clay, medium stiff, mottled, blocky texture, root channels					
4						Total depth 13 feet No groundwater Bucket sample taken 0-5 feet					
	15					Bottom of test pit @ 13 Feet					
5											
6											

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

IGES

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

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

Figure A - 6

DATE		
STARTED:	2/13/13	
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BACKFILLED:	2/13/13	

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Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO: **TP-05**
Sheet 1 of 1

LOCATION
LATITUDE | LONGITUDE | ELEVATION (ft) 4,614

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit / Moisture Content / Liquid Limit; 10 20 30 40 50 60 70 80 90)
0	0				CL	@ 0' Lean CLAY, low plasticity, very moist, dark brown, disced, rootlets, trace rounded gravel to 1 in. @ 14" transitions to stiff, moderate yellowish brown, >PL, homogenous, uniform appearance, blocky texture, trace pinhole porosity						
	5	3" O.D. thin-walled hand sampler						27.0				● (~27)
2						- less moisture, <PL						
						@ 8½' transitions to grayish brown lean clay, mottled, blocky texture, <PL						
3	10					Total Depth 10 feet No groundwater Bottom of test pit @ 10 Feet						
4	15											
5												
6												

IGES

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

WATER LEVEL
- ▼ - MEASURED
- ▽ - ESTIMATED

NOTES:

Figure A - 7

DATE	
STARTED:	2/13/13
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Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO:
TP-06
Sheet 1 of 1

LOCATION
LATITUDE   LONGITUDE   ELEVATION (ft) 4,620

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit, Moisture Content, Liquid Limit; 10 20 30 40 50 60 70 80 90)
0	0				CL	@ 0' Lean CLAY, low plasticity, moist, dark brown, upper 12 in. disced/tilled - transitions to moderate yellowish brown, homogenous, uniform color, trace rootlets, moderate porosity (pinholes)						
	5	3" O.D. thin-walled hand sampler					88.8	24.4				●
2						- about 6 to 8 feet becomes increasingly moist, >PL						
3	10	Grab sample				@ 10' transitions to light olive brown, <PL, blocky texture, mottled appearance, medium stiff		28.0				●
	15					Total Depth 15 feet No groundwater Bottom of test pit @ 15 Feet						

Depth scale: METERS 0–6; FEET 0, 5, 10, 15.

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

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

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DATE	
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Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO: **TP-07**
Sheet 1 of 1

LOCATION
LATITUDE | LONGITUDE | ELEVATION (ft) 4,624

MATERIAL DESCRIPTION

Depth (ft)	USCS	Material Description
0	CL	@ 0' Lean CLAY with sand and gravel, low plasticity, coarse sand and gravel to 3 in., upper 12 in. disced/tilled
2½	GC	@ 2½' Silty/Clayey GRAVEL with sand, subrounded gravel to 4 in., imbricated, appears to be stream alluvium, rootlets, moist, moderate yellowish brown, loose/friable
7	SM	@ 7' Silty SAND with gravel, coarse, 40% pea-size gravel, caving/ravelling on test pit wall, moderate yellowish brown, low moisture, medium dense, well-rounded gravel
12	CL	@ 12' Lean CLAY, medium stiff, moist, light olive gray, low plasticity, homogenous, mottled appearance

Columns: DEPTH (METERS, FEET), SAMPLES, WATER LEVEL, GRAPHICAL LOG, UNIFIED SOIL CLASSIFICATION, 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)

Depth scale: METERS 0, 1, 2, 3, 4, 5, 6; FEET 0, 5, 10, 15

Total Depth 14 feet
No groundwater

Bottom of test pit @ 14 Feet

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

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

IGES

Figure
A - 9

DATE	
STARTED:	2/13/13
COMPLETED:	2/13/13
BACKFILLED:	2/13/13

Geotechnical Investigation
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Project Number 01709-001

IGES Rep: DAG

Rig Type: CAT 312C

TEST PIT NO:

TP-08

Sheet 1 of 1

LOCATION

LATITUDE LONGITUDE ELEVATION (ft) 4,623

DEPTH METERS	DEPTH FEET	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit, Moisture Content, Liquid Limit) 10 20 30 40 50 60 70 80 90
0	0			▨	CL	@ 0' Lean CLAY, medium stiff, low plasticity, moist, moderate yellowish brown, trace rootlets for upper 5 feet, upper 12 in. disced, homogenous, uniform color						
1	5	⧗		▨			82.1	27.4				●
2				▨		@ 8½' transitions to light olive brown, moist, >PL, medium stiff, subtle mottling, homogenous, blocky texture						
3	10			▨								
4						Total Depth 11½ feet No groundwater Bottom of test pit @ 11.5 Feet						
	15											
5												
6												

LOG OF TEST PITS (A) - (4 LINE HEADER) 01709-001 TEST PIT LOGS.GPJ IGES.GDT 3/4/13

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

WATER LEVEL
- ▼ - MEASURED
- ▽ - ESTIMATED

NOTES:

Figure A - 10

DATE	
STARTED:	2/13/13
COMPLETED:	2/13/13
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Geotechnical Investigation
Bowler/Royal Farms
12064 South 3600 West
Riverton, Utah

Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO: **TP-09**
Sheet 1 of 1

LOCATION
LATITUDE | LONGITUDE | ELEVATION (ft) 4,620

Depth (Meters)	Depth (Feet)	Samples	Water Level	USCS	Material Description	Dry Density (pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0	0			CL	@ 0' Lean CLAY, very moist, dark brown, upper 14-16 in. disced/tilled					
					@ 2' grades to moderate yellowish brown, moist, >PL, low plasticity, med. stiff					
	5	3" O.D. thin-walled hand sampler			@ 5' grades to light olive brown, mottled, homogenous	87.3	28.5			
3	10			CL-ML	@ 10' grades to Silty CLAY, low plasticity, 2-ft lens of non-plastic Silt (ML)					
					@ 12' 1-ft lens of sand and gravel, well-rounded gravel to 4 in.					
4				CL	@ 13' Lean CLAY, becomes heavily mottled with iron staining, low plasticity, grades to CL-ML					
	15				Total Depth 15 feet No groundwater Bottom of test pit @ 15 Feet					

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

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

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

IGES

Figure A - 11

DATE	
STARTED:	2/13/13
COMPLETED:	2/13/13
BACKFILLED:	2/13/13

Geotechnical Investigation
Bowler/Royal Farms
12064 South 3600 West
Riverton, Utah

Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO:
TP-10
Sheet 1 of 1

LOCATION

LATITUDE | LONGITUDE | ELEVATION (ft) 4,625

Depth (feet)	Samples	Unified Soil Classification	Material Description	Dry Density (pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0		CL	@ 0' Lean CLAY, soft, low plasticity, very moist, dark brown, upper 12 in. disced/tilled - grades to moderate yellowish brown					
~4			@ ~4' some gravel and cobble, well-rounded, some coarse sand					
5	3" O.D. thin-walled hand sampler	CL	@ 5' Lean CLAY, medium stiff, low plasticity, moderate yellowish brown, moist, grades to CL-ML	96.2	19.2			
10		GM	@ 10' Silty GRAVEL with sand, coarse gravel, subrounded gravel to 3 in., coarse sand, low to non-plastic silt, moist, moderate yellowish brown, dense, about 15% fines					

Total Depth 13 feet
No Groundwater
Bucket Sample at 0-5 feet

Bottom of test pit @ 13 Feet

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

IGES

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

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

Figure A - 12

DATE	
STARTED:	2/13/13
COMPLETED:	2/13/13
BACKFILLED:	2/13/13

Geotechnical Investigation
Bowler/Royal Farms
12064 South 3600 West
Riverton, Utah

Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO: **TP-11**
Sheet 1 of 1

LOCATION
LATITUDE | LONGITUDE | ELEVATION (ft) 4,624

DEPTH (METERS)	DEPTH (FEET)	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0	0			CL	@ 0' Lean CLAY, medium stiff, low plasticity, moist, >PL, moderate yellowish brown, homogenous, uniform appearance, upper 12 in. disced					
	5	3" O.D. thin-walled hand sampler			@ 5' grades to dark yellowish brown	79.4	27.2		49	24
2					@ 7' grades to light olive brown, about 20% subrounded gravel and cobble, quartzite clasts					
3	10			GM	@ 11' Silty GRAVEL with sand, coarse gravel, subrounded to 8 in., coarse sand, medium dense, moderate yellowish brown, moist					
					Total Depth 14 feet No groundwater Bottom of test pit @ 14 Feet					

Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (scale 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:

IGES

Figure A - 13

DATE	
STARTED:	2/13/13
COMPLETED:	2/13/13
BACKFILLED:	2/13/13

Geotechnical Investigation
Bowler/Royal Farms
12064 South 3600 West
Riverton, Utah

Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO: **TP-12**
Sheet 1 of 1

LOCATION: LATITUDE | LONGITUDE | ELEVATION (ft) 4,629

Depth (Feet)	Samples	Unified Soil Classification	Material Description	Dry Density (pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0		CL	@ 0' Lean CLAY, soft, low plasticity, moist, moderate yellowish brown, <PL, homogenous, uniform appearance, trace rootlets in upper 2 feet					
3		CL-ML	@ 3' Grades to Silty CLAY					
4½		CL	@ 4½' becomes Lean CLAY, >PL, trace porosity					
~5.5	3" O.D. thin-walled hand sampler			88.4	27.4			
11			@ 11' grades to light olive brown					
14			Total Depth 14 feet No groundwater Bottom of test pit @ 14 Feet					

Depth scale: METERS 0–6; FEET 0, 5, 10, 15

Moisture Content and Atterberg Limits (Plastic Limit – Moisture Content – Liquid Limit), scale 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:

IGES

Figure A - 14

DATE	
STARTED:	2/13/13
COMPLETED:	2/13/13
BACKFILLED:	2/13/13

Geotechnical Investigation
Bowler/Royal Farms
12064 South 3600 West
Riverton, Utah

Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO:
TP-13
Sheet 1 of 1

LOCATION
LATITUDE LONGITUDE ELEVATION (ft) 4,627

DEPTH (METERS)	DEPTH (FEET)	SAMPLES	WATER LEVEL	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0	0			CL	@ 0' Lean CLAY, medium stiff, low plasticity, moist, >PL, dark brown, upper 12 in. and then transitions to moderate yellowish brown, rootlets in upper 2 feet					
1					- increasing moisture 3 to 4 feet, becomes soft					
	5	Grab sample					29.0			
2										
					@ 9' grades to light olive brown					
3	10									
4										
				CL-ML	@ 14' grades to Silty CLAY with about 15% subrounded gravel to 3 in.					
	15				Total Depth 15 feet No groundwater Bottom of test pit @ 15 Feet					
5										
6										

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:

IGES

Figure
A - 15

DATE		
STARTED:	2/13/13	
COMPLETED:	2/13/13	
BACKFILLED:	2/13/13	

Geotechnical Investigation
Bowler/Royal Farms
12064 South 3600 West
Riverton, Utah

Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO: **TP-14**
Sheet 1 of 1

LOCATION
LATITUDE | LONGITUDE | ELEVATION (ft) 4,633

DEPTH (METERS)	DEPTH (FEET)	SAMPLES	WATER LEVEL	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	Dry Density(pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit, Moisture Content, Liquid Limit; 10 20 30 40 50 60 70 80 90)
0	0				CL	@ 0' Lean CLAY, soft, low plasticity, very moist, soft, homogenous, uniform appearance, roots to 2 feet						
		Grab sample						27.0				● (27.0)
						- about 8 to 10 feet grades to light olive brown						
						@ 12' some coarse soils, fine gravel, about 20-30% gravel						
	15					Total Depth 15 feet No groundwater Bottom of test pit @ 15 Feet						

Depth scale: 0–6 meters; 0, 5, 10, 15 feet.

IGES

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

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

Figure A - 16

DATE	
STARTED:	2/13/13
COMPLETED:	2/13/13
BACKFILLED:	2/13/13

Geotechnical Investigation
Bowler/Royal Farms
12064 South 3600 West
Riverton, Utah

Project Number 01709-001

IGES Rep: DAG
Rig Type: CAT 312C

TEST PIT NO:
TP-15
Sheet 1 of 1

LOCATION

LATITUDE LONGITUDE ELEVATION (ft) 4,608

Depth (Meters)	Depth (Feet)	Samples	Water Level	Graphical Log	Unified Soil Classification	Material Description	Dry Density (pcf)	Moisture Content %	Percent minus 200	Liquid Limit	Plasticity Index
0	0				CL	@ 0' Lean CLAY, low plasticity, moist, dark brown, <PL, trace gravel - grades to moderate yellowish brown					
						@ 2½' 3 in. lens of sand and gravel with clay					
1						@ 3' Lean CLAY, medium stiff, low plasticity, very moist, homogenous, uniform appearance					
	5	Grab sample						22.0			
2											
3	10										
						@ 11' grades to light olive brown, mottled appearance, some iron staining, >PL					
4											
	15					Total Depth 15 feet No groundwater Bottom of test pit @ 15 Feet					
5											
6											

Moisture Content and Atterberg Limits

Plastic Limit — Moisture Content — Liquid Limit

10 20 30 40 50 60 70 80 90

IGES

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

WATER LEVEL
- MEASURED
- ESTIMATED

NOTES:

Figure A - 17

UNIFIED SOIL CLASSIFICATION SYSTEM

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

LOG KEY SYMBOLS

BORING SAMPLE LOCATION

TEST-PIT SAMPLE LOCATION

WATER LEVEL (level after completion)

WATER LEVEL (level where first encountered)

CEMENTATION

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

OTHER TESTS KEY

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

MODIFIERS

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

MOISTURE CONTENT

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

STRATIFICATION

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

GENERAL NOTES

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

APPARENT / RELATIVE DENSITY - COARSE-GRAINED SOIL

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

CONSISTENCY - FINE-GRAINED SOIL

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

IGES

Key to Soil Symbols and Terminology

Figure A-18

Project Number 01709-001

APPENDIX B

SUMMARY OF LABORATORY TEST RESULTS

Bowler/Royal Farms | **Project Number : 01709-001**

SAMPLE LOCATION		INSITU DRY DENSITY (pcf)	INSITU MOISTURE CONTENT %	GRADATION (%)			ATTERBERG LIMITS		SWELL-COLLAPSE POTENTIAL			PROCTOR		CBR (%)	CHEMICAL TESTS				UNIFIED SOILS CLASSIFICATION
Point No.	Depth (ft)			Gravel >#4	Sand	Silt and Clay <#200	Liquid Limit	Plasticity Index	Swell (%)	Collapse (%)	Pressure (psf)	Maximum Dry Density (pcf) STD	Optimum Moisture (%) STD		Soluable Sulfate (ppm)	Resistivity (Minimum ohm-cm)	Soluable Chloride (ppm)	pH	
TP-1	0-5											100.8	22.2	4.0					Lean CLAY (CL)
	5	86.3	19.8							0.48	2,000								Lean CLAY (CL)
TP-2	5	84.1	27.2																Lean CLAY (CL)
TP-3	5	78.9	24.1				32	20		7.21	2,000								Lean CLAY (CL)
TP-4	5	82.8	23.5																Lean CLAY (CL)
TP-5	5		26.9												165	910	86	6.4	Lean CLAY (CL)
TP-6	5	88.8	24.4							1.77	2,000								Lean CLAY (CL)
	10		27.7																Lean CLAY (CL)
TP-8	5	82.1	27.4																Lean CLAY (CL)
TP-9	5	87.3	28.5																Lean CLAY (CL)
TP-10	5	96.2	19.2																Lean CLAY (CL)
TP-11	5	79.4	27.2				49	25											Lean CLAY (CL)
TP-12	5	88.4	27.4							0.39	2,000								Lean CLAY (CL)
TP-13	5		28.9																Lean CLAY (CL)
TP-14	5		26.7																Lean CLAY (CL)
TP-15	5		22.0																Lean CLAY (CL)

TABLE B-1

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

IGES

Project: Bowler/Royal Farms
No: 01709-001
Location: Riverton
Date: 2/28/2013
By: BRR

Boring No.: TP-3
Sample:
Depth: 5'
Description: Brown lean clay

Preparation method: Air Dry
Liquid limit test method: Multipoint

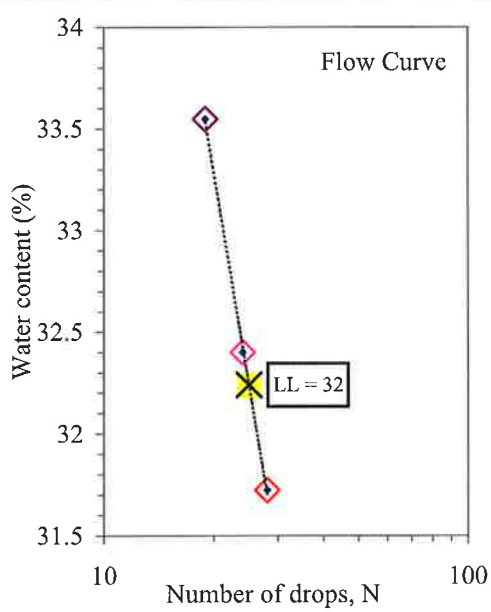
Plastic Limit

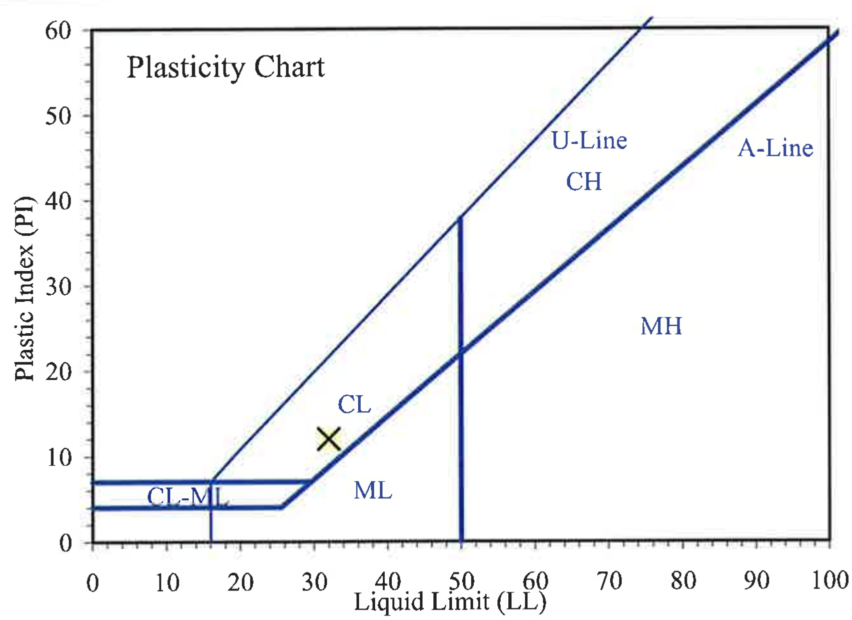
Determination No	1	2				
Wet Soil + Tare (g)	32.33	31.68				
Dry Soil + Tare (g)	30.60	29.99				
Water Loss (g)	1.73	1.69				
Tare (g)	21.89	21.46				
Dry Soil (g)	8.71	8.53				
Water Content, w (%)	19.86	19.81				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	28	24	19			
Wet Soil + Tare (g)	32.03	32.56	32.11			
Dry Soil + Tare (g)	29.60	29.90	29.51			
Water Loss (g)	2.43	2.66	2.60			
Tare (g)	21.94	21.69	21.76			
Dry Soil (g)	7.66	8.21	7.75			
Water Content, w (%)	31.72	32.40	33.55			
One-Point LL (%)	32	32				

Liquid Limit, LL (%)	**32**
Plastic Limit, PL (%)	**20**
Plasticity Index, PI (%)	**12**





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Reviewed:____________

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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

IGES

Project: Bowler/Royal Farms
No: 01709-001
Location: Riverton
Date: 2/28/2013
By: BRR

Boring No.: TP-11
Sample:
Depth: 5'
Description: Dark brown lean clay

Preparation method: Air Dry
Liquid limit test method: Multipoint

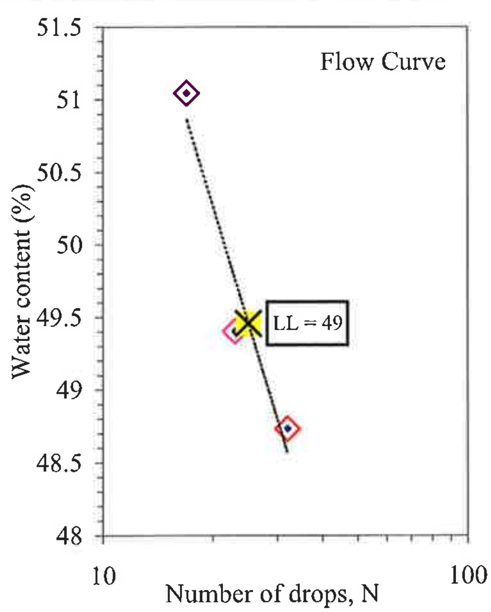
Plastic Limit

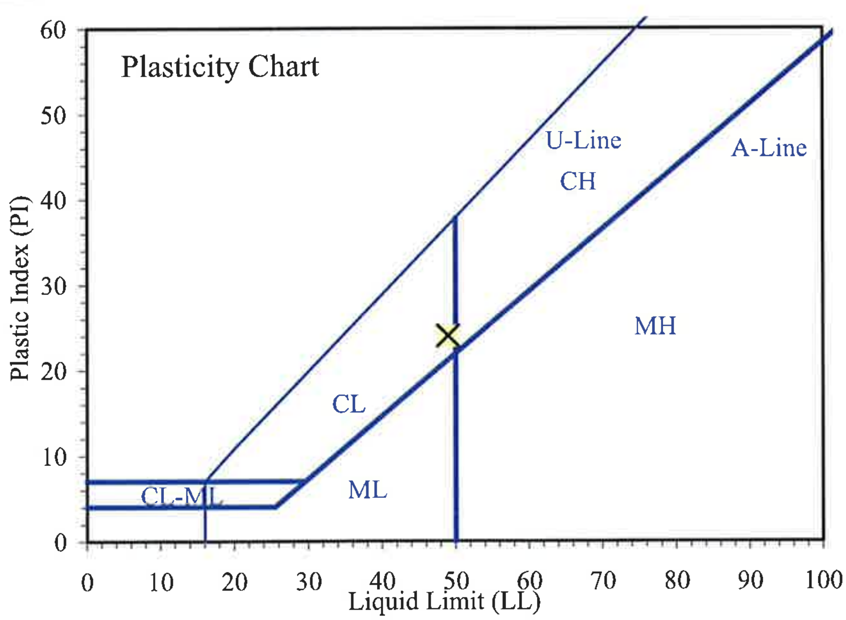
Determination No	1	2				
Wet Soil + Tare (g)	30.85	30.59				
Dry Soil + Tare (g)	29.05	28.79				
Water Loss (g)	1.80	1.80				
Tare (g)	21.84	21.77				
Dry Soil (g)	7.21	7.02				
Water Content, w (%)	24.97	25.64				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	32	23	17			
Wet Soil + Tare (g)	29.12	30.66	30.40			
Dry Soil + Tare (g)	26.62	27.77	27.47			
Water Loss (g)	2.50	2.89	2.93			
Tare (g)	21.49	21.92	21.73			
Dry Soil (g)	5.13	5.85	5.74			
Water Content, w (%)	48.73	49.40	51.05			
One-Point LL (%)		49				

Liquid Limit, LL (%)	**49**
Plastic Limit, PL (%)	**25**
Plasticity Index, PI (%)	**24**





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Laboratory Compaction Characteristics of Soil

(ASTM D698 / D1557)

IGES

Project: Bowler/Royal Farms
No: 01709-001
Location: Riverton
Date: 2/19/2013
By: DKS

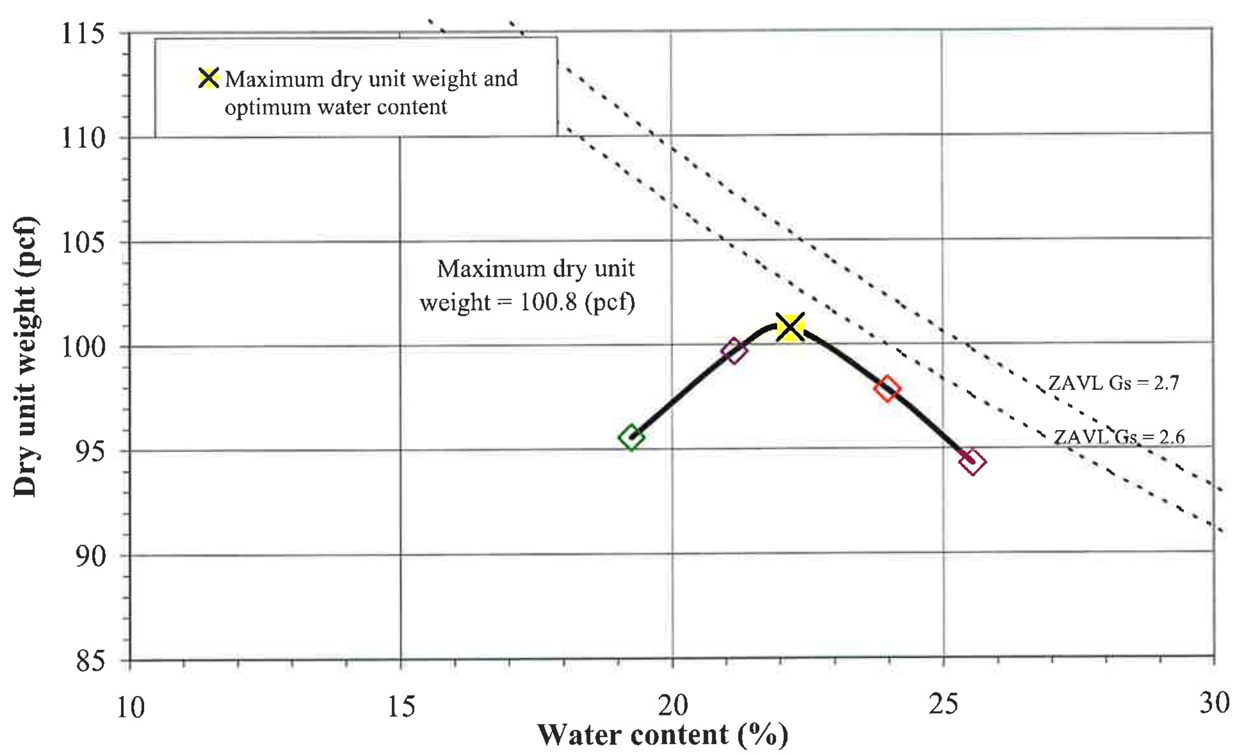
Boring No.: TP-1
Sample:
Depth: 0-5'
Sample Description: Brown clay
Engineering Classification: Not requested
As-received water content (%): Not requested

Method: ASTM D698 B
Mold Id. Inc 2
Mold volume (ft^3): 0.0332

Preparation method: Moist
Rammer: Mechanical-circular face
Rock Correction: No

Optimum water content (%): 22.2
Maximum dry unit weight (pcf): 100.8

Point Number	+2%	+4%	As Is	+6%				
Wt. Sample + Mold (g)	5983.3	5990.9	5880.4	5947.2				
Wt. of Mold (g)	4163.3	4163.3	4163.3	4163.3				
Wet Unit Wt., γ_m (pcf)	120.8	121.3	114.0	118.4				
Wet Soil + Tare (g)	904.75	720.09	965.81	900.00				
Dry Soil + Tare (g)	768.75	604.48	838.90	742.21				
Tare (g)	126.14	122.42	179.72	124.50				
Water Content, w (%)	**21.2**	**24.0**	**19.3**	**25.5**				
Dry Unit Wt., γ_d (pcf)	**99.7**	**97.8**	**95.6**	**94.3**				



Entered by:____________

Reviewed:____________

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California Bearing Ratio
(ASTM D 1883)

Project: Bowler/Royal Farms
Number: 01709-001
Location: Riverton
Date: 2/25/2013
By: DKS

Boring No.: TP-1
Sample:
Depth: 0-5'
Original Method: ASTM D698 B
Engineering Classification: Not requested
Condition of Sample: Soaked
Scalp and Replace: No

Maximum Dry Unit Weight (pcf): 100.8
Optimum Water Content (%): 22.2
Relative Compaction (%): 100.3
0.1 in. Corrected CBR (%): 3.5
0.2 in. Corrected CBR (%): 4.0

As Compacted Data			Before	After
Mold Id.	CBR-7	Wet Soil + Tare (g)	348.48	313.30
Wt. of Mold + Sample (g)	10874.6	Dry Soil + Tare (g)	309.09	279.67
Wt. of Mold (g)	6689.8	Tare (g)	128.52	124.01
Dry Unit Weight (pcf)	101.1	Water Content (%)	21.8	21.6

After Soaking Data			Average	Top 1 in.
Wt. of Mold + Sample (g)	10947.7	Wet Soil + Tare (g)	836.61	833.41
Dry Unit Weight (pcf)	100.0	Dry Soil + Tare (g)	698.58	690.47
		Tare (g)	126.98	128.37
		Water Content (%)	24.1	25.4

Swell Data

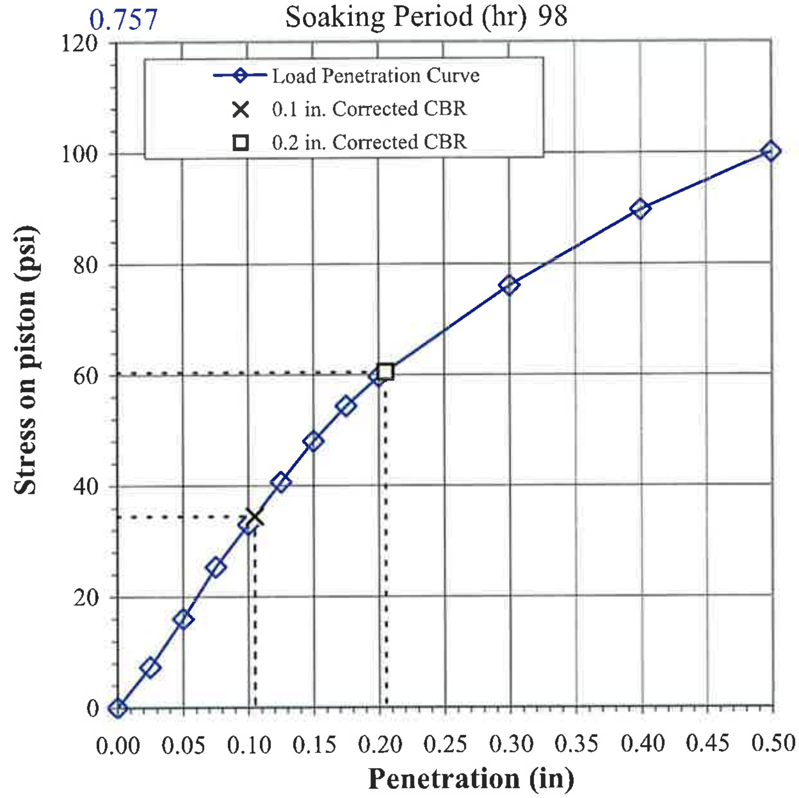
Date	Time	Dial
2/19/2013	11:00	0.708
2/23/2013	13:15	0.757

Surcharge (psf) 50
Swell (%) 1.07
Soaking Period (hr) 98

Penetration Data

Zero load (lb) = 0
Area of Piston (in^2) = 3

Penetration (in.)	Raw Load (lb)	Piston Stress (psi)	Std. Stress (psi)
0.000	0	0	
0.025	22	7	
0.050	48	16	
0.075	76	25	
0.100	99	33	1000
0.125	122	41	1125
0.150	144	48	1250
0.175	163	54	1375
0.200	179	60	1500
0.300	228	76	1900
0.400	269	90	2300
0.500	300	100	2600



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Reviewed:___________

Collapse/Swell Potential of Soils
(ASTM D4546 Method B)

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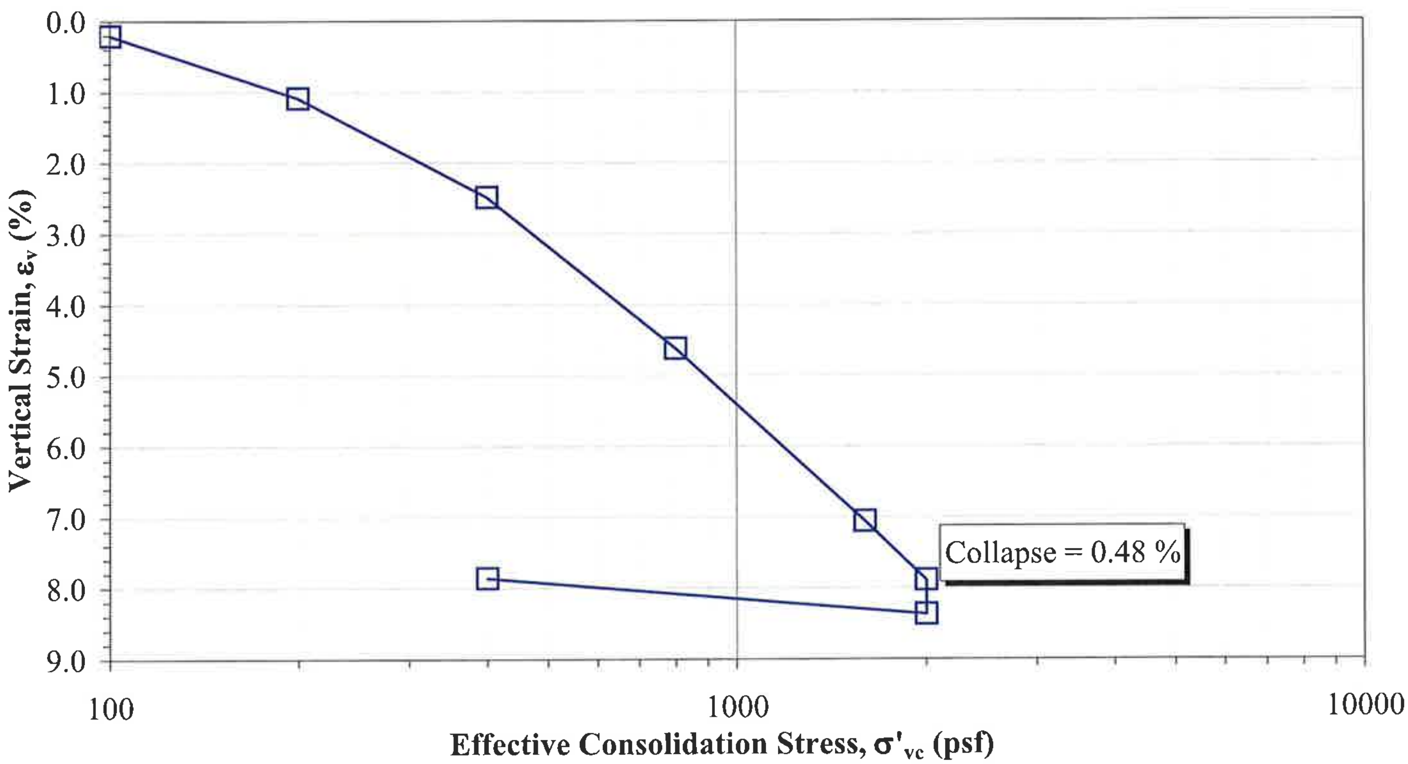
Project: Bowler/Royal Farms
No: 01709-001
Location: Riverton, UT
Date: 3/4/2013
By: JDF/MP

Boring No.: TP-1
Sample:
Depth: 5'
Sample Description: Brown clay
Engineering Classification: Not requested
Sample type: Undisturbed-trimmed from thin-wall

Specific gravity, G_s: 2.67 Assumed
Collapse (%): 0.48
Collapse stress (psf): 2000
Water type used for innundation: Tap

	Initial (o)	Final (f)
Sample height, H (in.)	1.000	0.9214
Sample diameter, D (in.)	2.416	2.416
Mass rings + wet soil (g)	167.59	177.18
Mass rings/tare (g)	43.19	43.19
Moist unit wt., γ_m (pcf)	103.4	120.8
Wet soil + tare (g)	234.14	
Dry soil + tare (g)	215.85	
Tare (g)	123.40	
Water content, w (%)	19.8	29.0
Dry unit wt., γ_d (pcf)	86.3	93.7
Saturation	0.57	0.99

Stress (psf)	Dial (in.)	1-D ε_v (%)	H_c (in.)	e
Seating	0.0322	0.00	1.0000	0.931
100	0.0343	0.21	0.9979	0.927
200	0.0431	1.09	0.9891	0.910
400	0.0571	2.49	0.9751	0.883
800	0.0784	4.62	0.9538	0.842
1600	0.1028	7.06	0.9294	0.795
2000	0.1111	7.89	0.9211	0.779
2000	0.1159	8.37	0.9163	0.770
400	0.1108	7.86	0.9214	0.780



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Collapse/Swell Potential of Soils

(ASTM D4546 Method B)

IGES

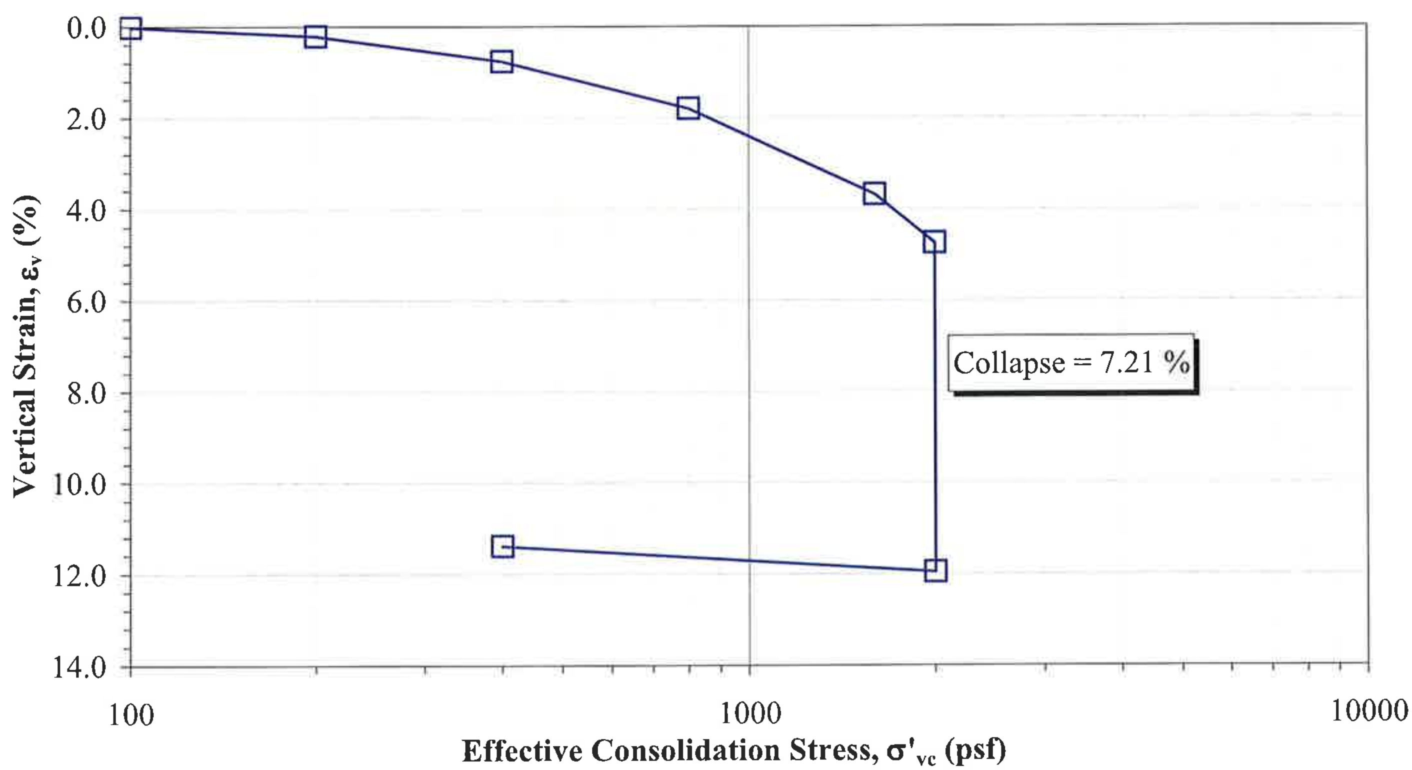
Project: Bowler/Royal Farms
No: 01709-001
Location: Riverton, UT
Date: 3/4/2013
By: JDF/MP

Boring No.: TP-3
Sample:
Depth: 5'
Sample Description: Brown clay
Engineering Classification: Not requested
Sample type: Undisturbed-trimmed from thin-wall

Specific gravity, G_s	2.67	Assumed
Collapse (%)	7.21	
Collapse stress (psf)	2000	
Water type used for innundation	Tap	

	Initial (o)	Final (f)
Sample height, H (in.)	1.000	0.8861
Sample diameter, D (in.)	2.416	2.416
Mass rings + wet soil (g)	160.10	166.87
Mass rings/tare (g)	42.37	42.37
Moist unit wt., γ_m (pcf)	97.8	116.8
Wet soil + tare (g)	265.63	
Dry soil + tare (g)	238.28	
Tare (g)	124.60	
Water content, w (%)	24.1	31.2
Dry unit wt., γ_d (pcf)	78.9	89.0
Saturation	0.58	0.95

Stress (psf)	Dial (in.)	1-D ε_v (%)	H_c (in.)	e
Seating	0.0287	0.00	1.0000	1.114
100	0.0289	0.02	0.9998	1.113
200	0.0309	0.22	0.9978	1.109
400	0.0364	0.77	0.9923	1.097
800	0.0467	1.80	0.9820	1.076
1600	0.0656	3.69	0.9631	1.036
2000	0.0762	4.75	0.9525	1.013
2000	0.1483	11.96	0.8804	0.861
400	0.1426	11.39	0.8861	0.873



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Collapse/Swell Potential of Soils

(ASTM D4546 Method B)

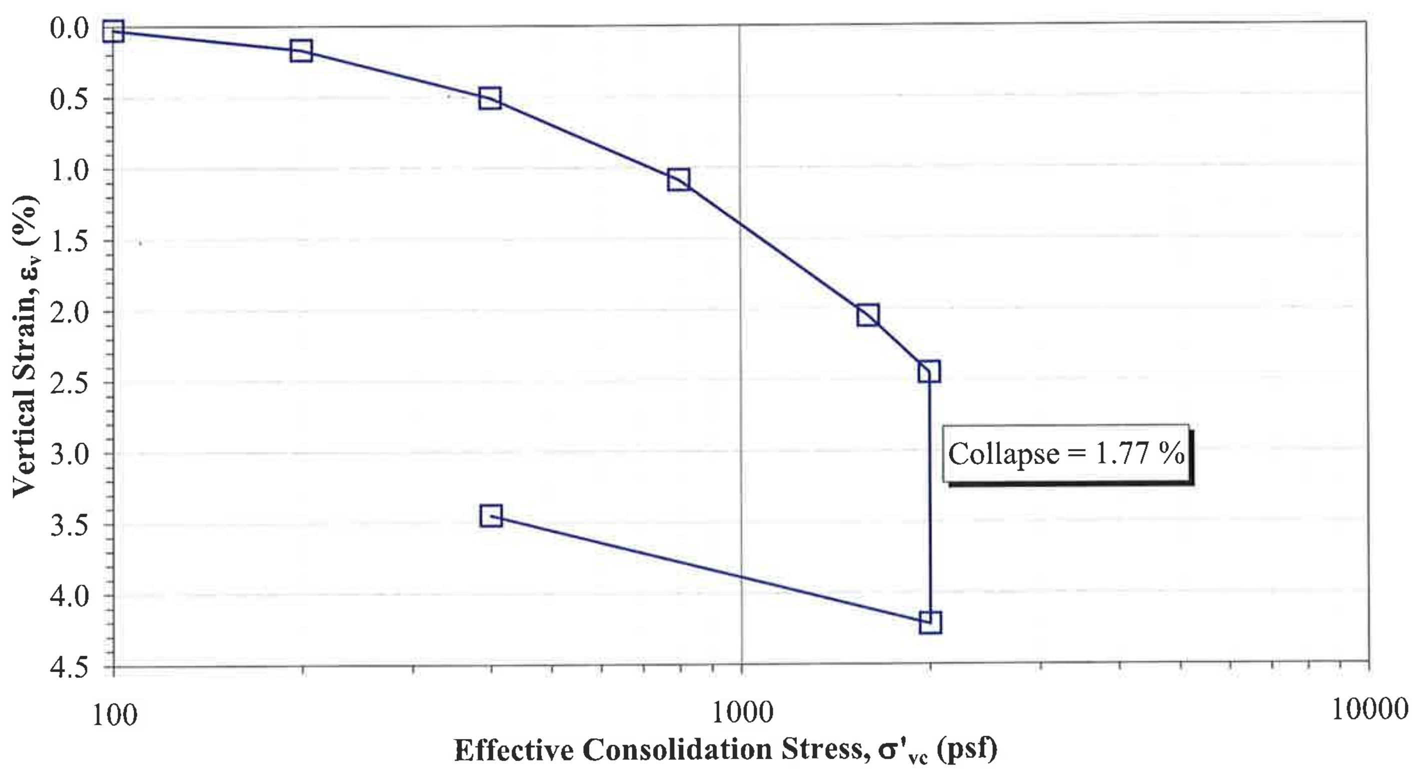
Project: Bowler/Royal Farms
No: 01709-001
Location: Riverton, UT
Date: 3/4/2013
By: JDF/MP

Boring No.: TP-6
Sample:
Depth: 5'
Sample Description: Brown clay
Engineering Classification: Not requested
Sample type: Undisturbed-trimmed from thin-wall

Specific gravity, G_s	2.67	Assumed
Collapse (%)	1.77	
Collapse stress (psf)	2000	
Water type used for innundation	Tap	

	Initial (o)	Final (f)
Sample height, H (in.)	1.000	0.9655
Sample diameter, D (in.)	2.416	2.416
Mass rings + wet soil (g)	176.15	181.70
Mass rings/tare (g)	43.28	43.28
Moist unit wt., γ_m (pcf)	110.4	119.1
Wet soil + tare (g)	433.18	
Dry soil + tare (g)	371.86	
Tare (g)	120.54	
Water content, w (%)	24.4	29.6
Dry unit wt., γ_d (pcf)	88.8	91.9
Saturation	0.74	0.97

Stress (psf)	Dial (in.)	1-D ε_v (%)	H_c (in.)	e
Seating	0.0633	0.00	1.0000	0.878
100	0.0636	0.03	0.9997	0.877
200	0.0650	0.17	0.9983	0.875
400	0.0684	0.51	0.9949	0.868
800	0.0742	1.09	0.9891	0.857
1600	0.0838	2.05	0.9795	0.839
2000	0.0878	2.45	0.9755	0.832
2000	0.1055	4.22	0.9578	0.799
400	0.0978	3.45	0.9655	0.813



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Collapse/Swell Potential of Soils

(ASTM D4546 Method B)

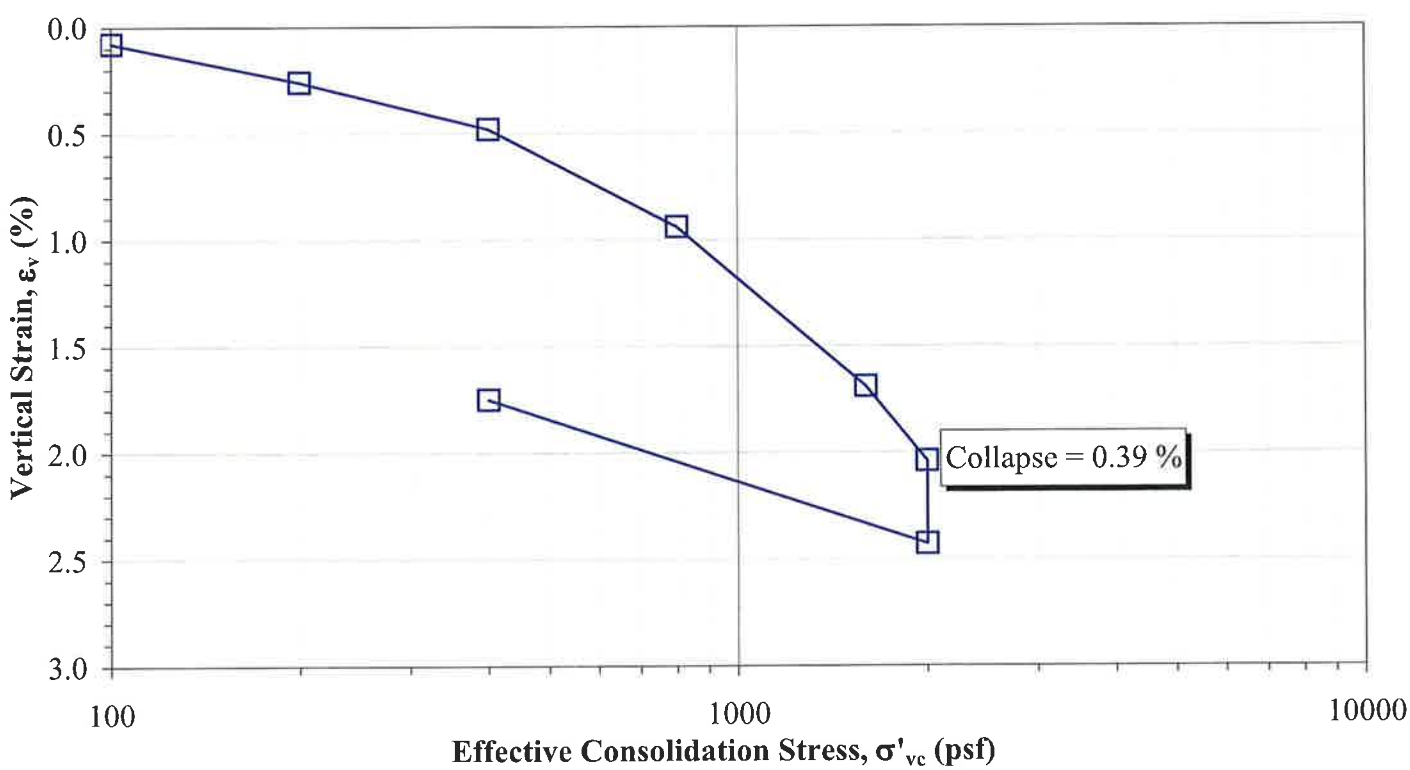
Project: Bowler/Royal Farms
No: 01709-001
Location: Riverton, UT
Date: 3/4/2013
By: JDF/MP

Boring No.: TP-12
Sample:
Depth: 5'
Sample Description: Brown clay
Engineering Classification: Not requested
Sample type: Undisturbed-trimmed from thin-wall

Specific gravity, G_s	2.67	Assumed
Collapse (%)	0.39	
Collapse stress (psf)	2000	
Water type used for innundation	Tap	

	Initial (o)	Final (f)
Sample height, H (in.)	1.000	0.9825
Sample diameter, D (in.)	2.416	2.416
Mass rings + wet soil (g)	178.37	181.96
Mass rings/tare (g)	42.94	42.94
Moist unit wt., γ_m (pcf)	112.5	117.6
Wet soil + tare (g)	309.49	
Dry soil + tare (g)	269.58	
Tare (g)	123.76	
Water content, w (%)	27.4	30.7
Dry unit wt., γ_d (pcf)	88.4	89.9
Saturation	0.82	0.96

Stress (psf)	Dial (in.)	1-D ε_v (%)	H_c (in.)	e
Seating	0.0491	0.00	1.0000	0.886
100	0.0499	0.08	0.9992	0.885
200	0.0517	0.26	0.9974	0.882
400	0.0539	0.48	0.9952	0.877
800	0.0585	0.94	0.9906	0.869
1600	0.0660	1.69	0.9831	0.855
2000	0.0695	2.04	0.9796	0.848
2000	0.0734	2.43	0.9757	0.841
400	0.0666	1.75	0.9825	0.853



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

IGES

Project: Bowler/Royal Farms
No: 01709-001
Location: Riverton
Date: 2/26/2013
By: BRR

Sample info.	Boring No.	TP-5							
	Sample								
	Depth	5'							
Water content data	Wet soil + tare (g)	77.13							
	Dry soil + tare (g)	69.29							
	Tare (g)	29.41							
	Water content (%)	19.7							
Chem. data	pH	6.4							
	Soluble chloride* (ppm)	86.4							
	Soluble sulfate** (ppm)	165							
Resistivity data		Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)
		As Is	2600						
		+3	1300						
		+6	920						
		+9	910						
		+12	910						
	Minimum resistivity (Ω-cm)	**910**							

* Performed by AWAL using EPA 300.0

** Performed by AWAL using ASTM C1580

Entered by:__________

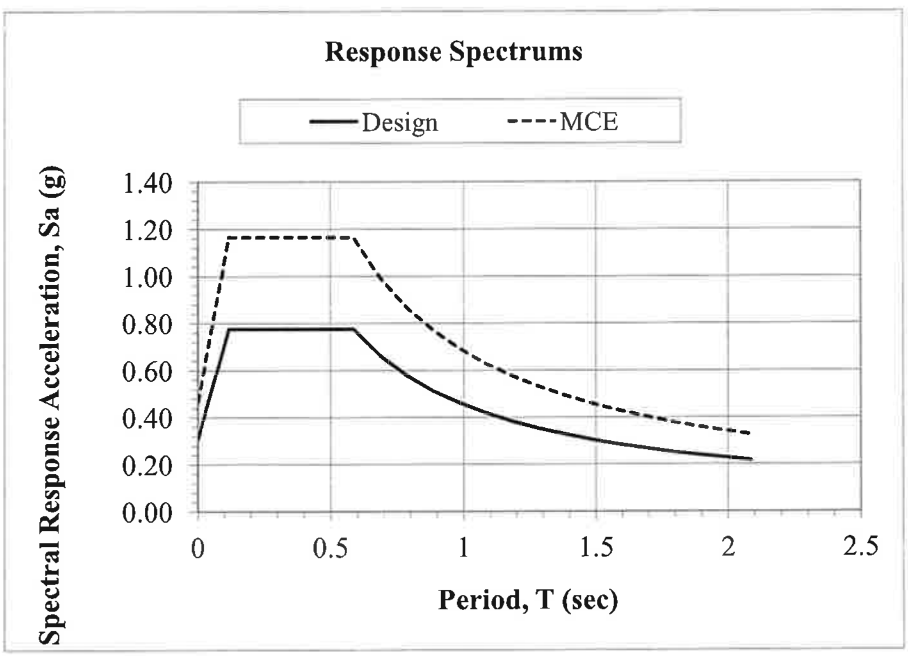
Reviewed:__________

APPENDIX C

SITE GROUND MOTION [IBC SECTION 1613]

Project:	**Royal Farms, Riverton, UT**	**Number:**	**01709-001**
Latitude =	**40.5319**	**Date:**	**2/25/13**
Logitude =	**-111.981**	**By:**	**DAG**

Ss =	1.098 (g)	The mapped spectral accleration for short periods	[1613.5]
S_1 =	0.436 (g)	The mapped spectral accleration for a 1-second period	
Site Class =	D	Table 16.13.5.2	
Fa =	1.06	Table 1613.5.3(1)	
Fv =	1.56	Table 1613.5.3(2)	
S_{MS} =	1.165	S_{MS} = Fa*Ss	*The maximum considered E.Q. spectral resonse accelerations
S_{M1} =	0.682	S_{M1} = Fv*S_1	for short and 1-second periods [1613.5.3]
MCE/PGA =	**0.466**	**0.4*S_{MS} [In accordance with 1802.2.7]**	
S_{DS} =	0.777	S_{DS} = 2/3*S_{MS}	*The design spectral response acceleration
S_{D1} =	0.455	S_{D1} = 2/3*S_{M1}	at short and 1-second periods
T_0 =	0.117	T_0 = 0.2*S_{D1}/S_{DS}	
T_s =	0.585	T_s = S_{D1}/S_{DS}	
ΔT =	0.1	Time step for diagram	



T (sec)	Sa (g)	Sa (MCE) (g)
0	0.31	0.47
0.12	0.78	1.16
0.59	0.78	1.16
0.69	0.66	0.99
0.79	0.58	0.87
0.89	0.51	0.77
0.99	0.46	0.69
1.09	0.42	0.63
1.19	0.38	0.58
1.29	0.35	0.53
1.39	0.33	0.49
1.49	0.31	0.46
1.59	0.29	0.43
1.69	0.27	0.40
1.79	0.25	0.38
1.89	0.24	0.36
1.99	0.23	0.34
2.09	0.22	0.33

FIGURE C-1

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

March 15, 2013

Bowler Properties, L.C.
c/o Mr. Randy Bowler
6663 South 2200 West
P.O. Box 2111
West Jordan, Utah 84084

IGES Project No. 01709-001

Subject: Addendum to Geotechnical Report – Pavement Design
Royal Farms Residential Development
12064 South 3600 West
Riverton, Utah

Reference: IGES, Inc., 2013, Geotechnical Investigation, Royal Farms Residential Development, 12064 South 3600 West, Riverton, Utah, Project No. 01709-001, dated March 12, 2013

Mr. Bowler:

As requested, IGES has prepared the following addendum to the referenced geotechnical report for the Royal Farms residential development located in Riverton, Utah. The purpose of our addendum is to provide additional recommendations/options for pavement design that incorporates a subbase layer.

Recommendations

From our referenced geotechnical report, our recommended pavement section(s) are as follows:

Table 6.7a
Conventional Pavement Design – No Subbase

Material Type	Option 1	Option 2	Option 3
Asphalt Concrete Pavement (inches)	3	3	3
Untreated Road Base (inches)	13	9	8
***Stabilization Fabric**	none	Mirafi RS380i	Mirafi RS580i

*Stabilization fabric is placed between the subgrade and the road base.

The pavement sections presented in Table 6.7a do not include the use of a subbase layer (e.g., a coarse, angular pit-run material with a minimum CBR of 30). If a subbase layer is used, the following pavement sections may also be considered:

Table 6.7b
Conventional Pavement Design – with Subbase

Material Type	Option 4	Option 5
Asphalt Concrete Pavement (inches)	3	3
Untreated Road Base (inches)	8	6
Subbase (inches) (min. CBR of 30)	6	6
***Stabilization Fabric**	none	Mirafi RS380i

*Stabilization fabric is placed between the subgrade and the road base.

All other recommendations presented in our referenced geotechnical report remain valid and should be implemented into the design and construction of the project.

Closure

We appreciate the opportunity to provide you with our services. If you have any questions please contact the undersigned at your convenience (801) 748-4044.

Respectfully Submitted,
IGES, Inc.

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