ROCKY MOUNTAIN GROUP

# GEOLOGY AND SOILS REPORT

## Bent Grass Residential, Filing No. 2
## El Paso County, Colorado

## PREPARED FOR:

**Challenger Colorado, LLC**
**8605 Explorer Drive, Suite 250**
**Colorado Springs, CO 80920**

## JOB NO. 169845

## October 21, 2019


**Respectfully Submitted,**

**RMG – Rocky Mountain Group**

**Kelli Zigler**
**Project Geologist**

**Reviewed by,**

**RMG – Rocky Mountain Group**

COLORADO REGISTERED ANTHONY P. MUNGER 10/21/19 39818 PROFESSIONAL ENGINEER

**Tony Munger, P.E.**
**Geotechnical Project Manager**

# TABLE OF CONTENTS

# GENERAL SITE AND PROJECT DESCRIPTION

### 1.1 Project Location

The project lies in the west half of Section 1, Township 13 South, Range 65 West, of the 6th Principal Meridian, located in El Paso County, State of Colorado. The approximate location of the site is shown on the Site Vicinity Map, Figure 1.

### 1.2 Existing Land Use

The site currently consists of portions of three parcels. The combined total area of the proposed site is to be approximately 50.795 acres. The three parcels included are:

- Schedule No. 5301000021 which consists of approximately 16.54 acres and is located on the northern portion of the site. The parcel is currently not developed.
- Schedule No. 5301000037 which consists of approximately 20 acres and is located along the southeastern portion of the site. The parcel is currently not developed.
- A portion of Schedule No. 5301000036 which consists of approximately 16.12 acres and is located along the southwestern portion of the site. The parcel is currently not developed.

The parcels are zoned "PUD" (Planned Unit Development).

An "Unnamed Tributary to Black Squirrel Creek No. 2" is included in this development, but is to be platted outside of the buildable lots.

### 1.3 Project Description

The majority of the site is to be developed as a single-family residential subdivision and is proposed to contain 179 single family lots. The proposed development will consist of the replat of portions of the three existing parcels into one parcel totaling 50.795 acres.

Rocky Mountain Group - RMG was retained to explore the subsurface conditions at the site and develop geotechnical engineering recommendations for the proposed land development operations.

# 2.0 QUALIFICATIONS OF PREPARERS

This Geology and Soils report was prepared by a professional geologist as defined by Colorado Revised Statutes section 34-1-201(3) and by a qualified geotechnical engineer as defined by policy statement 15, "Engineering in Designated Natural Hazards Areas" of the Colorado State Board of Registration for Professional Engineers and Professional Land Surveyors. (Ord. 96-74; Ord. 01-42)

The principle investigators for this study are Kelli Zigler, P.G. and Anthony P. Munger, P.E. Ms. Zigler is a Professional Geologist as defined by State Statute (C.R.S 34-1-201) with over19 years of experience in the geological and geotechnical engineering field. Ms. Kelli Zigler holds a B.S. in Geology from the University of Tulsa. Ms. Zigler has supervised and performed numerous geological and geotechnical field investigations in Colorado.

Tony Munger, P.E. is a licensed Professional Engineer with over 19 years of experience in the structural and geotechnical engineering fields. Mr. Munger is a professional engineer and holds a Bachelor's degree from the University of Wyoming. Mr. Munger has supervised and performed numerous geological and geotechnical field investigation programs in Colorado.

# 3.0 STUDY OVERVIEW

The purpose of this investigation is to characterize the general geotechnical and geologic site conditions, and present our opinions of the potential effect of these conditions on the proposed development of single-family residences within the referenced site. As such, our services exclude evaluation of the environmental and/or human, health-related work products or recommendations previously prepared, by others, for this project.

Revisions to the conclusions presented in this report may be issued based upon submission of the development plan. This study has been prepared in accordance with the requirements outlined in Chapter 8 of the El Paso County Land Development Code (LDC), specifically section 8.4.9, last updated July 9, 2019 and Appendix C of the El Paso County Engineering Criteria Manual (ECM) last updated 2019.

This report presents the findings of the study performed by RMG relating to the geotechnical and geologic conditions of the above-referenced site. Revisions and modifications to the conclusions and recommendations presented in this report may be issued subsequently by RMG based upon additional observations made during grading and construction which may indicate conditions that require re-evaluation of some of the criteria presented in this report.

### 3.1 Scope and Objective

The scope of this study is to include a physical reconnaissance of the site and a review of pertinent, publically available documents including (but not limited to) previous geologic and geotechnical reports, overhead and remote sensing imagery, published geology and/or hazard maps, design documents, etc. Our services exclude the evaluation of the environmental and/or human, health-related work products or recommendations previously prepared, by others, for this project.

The objectives of our study are to:

- Identify geologic conditions that are present on this site,
- Analyze the potential negative impacts of these conditions on the proposed site development,
- Analyze the potential negative impacts to the surrounding properties and/or public services resulting from the proposed site development as it relates to existing geologic hazards,
- Provide our opinion of suitable techniques that may be utilized to mitigate the potential negative impacts identified herein.

This report presents the findings of the study performed by RMG relating to the geologic conditions of the above-referenced site. Revisions and modifications to this report may be issued subsequently by RMG, based upon:

- Additional observations made during grading and construction which may indicate conditions that require re-evaluation of some of the criteria presented in this report,
- Review of pertinent documents (development plans, plat maps, drainage reports/plans, etc.) not available at the time of this study,

- Comments received from the governing jurisdiction and/or their consultants subsequent to submission of this document.

### 3.2 Site Evaluation Techniques

The information included in this report has been compiled from:

- Field reconnaissance
- Geologic and topographic maps
- Review of selected publicly available, pertinent reports
- Available aerial photographs
- Exploratory borings
- Laboratory testing of representative site soil and rock samples
- Geologic research and analysis
- Site development plans prepared by others

Geophysical investigations were not considered necessary for characterization of the site geology. Monitoring programs, which typically include instrumentation and/or observations for changes in groundwater, surface water flows, slope stability, subsidence, and similar conditions, are not known to exist and were not considered applicable for the scope of this report.

### 3.3 Previous Studies and Field Investigation

Reports of previous geotechnical engineering/geologic investigations for this site were available for our review and are listed below:

1. *Preliminary Subsurface Soil Investigation, Bent Grass Meadows Filing No. 2,* prepared by RMG – Rocky Mountain Group, Job No. 169845, last revised August 6, 2019.
2. *Geologic Hazard / Land Use Study and Preliminary Subsurface Soil investigation, Bent Grass – 201-acre site, El Paso County, Colorado*, prepared by Entech Engineering, Inc., Entech Job No. 40515 (Old Job No. 99214), originally dated March 15, 2004 and last revised September 28, 2006.

# 4.0 SITE CONDITIONS

### 4.1 Proposed Land Use and Zoning

It is our understanding that the project is to consist of single-family residential construction on 178 lots at the Bent Grass Residential subdivision, Filing No. 2. The residential structures are anticipated to be one to two-stories in height with multi-car garages. The homes may be constructed with or without basements.

*Figure 2 presents the general boundaries of our investigation.*

### 4.2 Topography

Based on our site observations, the ground surface generally slopes gently down to the south across the entire site. The elevation difference across the site from north to south is approximately 40 to 50 feet.

An "Unnamed Tributary to Black Squirrel Creek No. 2" runs along the western boundary of the site. The "Unnamed Tributary" was dry at the time of the site reconnaissance on October 8, 2019.

### 4.3 Vegetation

The majority of the site consists of tall native grasses and weeds. One deciduous tree is present near the middle of the site, and several more were present along the western boundary. Vegetation is denser along the "Unnamed Tributary", particularly where it intersects the northern property boundary.

# 5.0 FIELD INVESTIGATION

### 5.1 Drilling

The subsurface conditions within the property were explored by drilling twelve exploratory borings on April 3, 5, 15, and 18, 2019 extending to depths of approximately 15 to 30 feet below the existing ground surface. The test borings were performed to explore the subsurface soils underlying an area that encompasses this proposed development and an adjacent site to the west. 14 of the test borings performed for that investigation were located within the currently proposed development. That number of borings is in excess of the minimum one test boring per 10 acres of development up to 100 acres and one additional boring for every 25 acres of development above 100 acres as required by the ECM, Section C.3.3.

The test borings were drilled with a power-driven, continuous-flight auger drill rig. Samples were obtained during drilling of the test borings in general accordance with ASTM D-1586 utilizing a 2-inch O.D. split barrel sampler or in general accordance with ASTM D-3550 utilizing a 2½-inch OD modified California sampler. Results of the penetration tests are shown on the drilling logs. The Test Boring Logs are presented in Figures 4 through 16 of the *Preliminary Subsurface Soil Investigation* report by RMG, referenced above and attached in Appendix B.

### 5.2 Laboratory Testing

Soil laboratory testing was performed as part of the *Preliminary Subsurface Soil Investigation* report by RMG, referenced above. The laboratory tests included moisture content, dry density, grain-size analyses, Atterberg Limits and Swell/Consolidation tests. The report presenting the findings is included and attached as Appendix B.

# 6.0 GEOLOGIC AND SUBSURFACE CONDITIONS

### 6.1 Geologic Conditions

Based upon review of the *Falcon Quadrangle Geologic Map, El Paso County, Colorado*, the site reconnaissance and exploratory drilling, the site and surrounding area generally consists of a silty to clayey sand and sandy clay overlying the Dawson Arkose. The Dawson Arkose was encountered in the Test Borings at the time of drilling.

## 6.2 General Geology

Our field investigation included a site reconnaissance with consideration given to geologic features and significant surficial deposits. The general geology of the area is typically stream terrace deposits, alluvium soils and windblown deposits overlying the Dawson Arkose. Seven general geology units were mapped in the vicinity of the site and are identified (Morgan, et al., 2012) as:

- af: Man-placed fill – associated with the construction operations during development/construction of the lots in the adjacent filing to the east.

- Qes: Eolian sand (Holocene to upper Pleistocene) – Yellowish-brown to tan, fine- to coarse-grained, frosted sand and silt deposited by wind. Typically this unit is faintly stratified and non-cohesive; dune forms are not present. The unit is likely deposited as a sandsheet by winds capable of moving very fine gravel-sized clasts. Eolian sand is moderately compacted, easily excavated, and drains well.
- Qa1: Alluvium one (Holocene) – Mainly poorly sorted, clast supported, unconsolidated, sandy gravel of all sizes, gravelly sand, silty sand, and sandy silt in modern channels, floodplains, and adjacent low-lying terraces that are approximately 5 ft (1.5 m) or less above modern channels. Most deposits in alluvial unit one are stratified and may have cut-and-fill channels. Beds of organic-rich sediment or peat are locally present. Most gravel clasts within the unit are unweathered to slightly weathered. Clasts are subround to subangular and rarely round or angular. Clast composition is polymictic, dominated by Paleozoic quartzite, sandstone, and felsic and intermediate igneous rocks with lesser amounts of granite and gneiss. Areas underlain with this unit are prone to frequent and seasonal flooding. Thickness of the unit is estimated to range from about 3 to 15 ft (1 to 5 m) but could be greater in places.

- Qa2: Alluvium two (lower Holocene) – Dark gray to brown, poorly to well sorted, moderately consolidated, silt, sand, gravel, and minor clay and occasional boulders in stream terrace deposits approximately 6-12 feet above the modern flood plain or as non-terrace forming alluvium in valley headwaters. Clasts are subrounded to well rounded and the dominant sediment is sandy gravel with a silty sand matrix.

- Qa3: Alluvium three (upper Pleistocene) – Tan to reddish brown to grayish brown, poorly sorted, moderately consolidated, poorly to moderately stratified silt, sand, gravel, and cobbly gravel and occasional boulders in stream terrace deposits approximately 10-20 feet above the modern flood plain or as non-terrace forming alluvium in valley headwaters that underlies the younger alluviums. The unit contains dark gray clay beds that may be expansive. Clasts are subrounded to well rounded and the dominant sediment is sandy gravel with a sandy matrix.

- sw – seasonally wet area – area where near-surface moisture conditions may occasionally occur, as indicated by historical aerial photos.

- da – area that appears to have had vegetation removed and leveled. Artificial fill is not evident.

  *The general geology is presented in the Engineering and Geology Map, Figure 3.*

## 6.3 U.S. Soil Conservation Service

The U.S. Soil Conservation Service along with United States Department of Agriculture (USDA) has identified the soils on the property as:

- 8 – Blakeland loamy sand, 1 to 9% slopes. Properties of the Blakeland loamy sand include, somewhat excessively drained soils, depth of the water table is anticipated to be greater than 6.5 feet, run-off is anticipated to be low, frequency of flooding and/or ponding is none, and landforms include hills and flats.

- 9 – Blakeland-Fluvaquentic Haplaquolls, 1 to 2% slopes. Properties of the Blakeland-Fluvaquentic Haplaquolls include, somewhat excessively drained soils, depth of the water table is anticipated to be greater than 6.5 feet, run-off is anticipated to be low, frequency of flooding and/or ponding is none, and landforms include hills and flats.

- 19 – Columbine gravelly sandy loam, 0 to 3 percent slopes. Properties of the Columbine gravelly sandy loam include, well-drained soils, depth of the water table is anticipated to be greater than 6.5 feet, runoff is anticipated to be very low, frequency of flooding and/or ponding is none, and landforms include flood plains, fan terraces, and fans.

  *The USDA Soil Survey Map is presented in Figure 4.*

### 6.4 Subsurface Materials

The subsurface materials encountered in the test borings were classified using the Unified Soils Classification System (USCS) and the materials were grouped into the general categories of native silty to clayey sand (SM-SC), native well-graded sand with silt (SW-SM) and sandy lean clay (CL).

Additional descriptions and the interpreted distribution (approximate depths) of the subsurface materials are presented on the Test Boring Logs. The classifications shown on the logs are based upon the engineer's classification of the samples at the depths indicated. Stratification lines shown on the logs represent the approximate boundaries between material types and the actual transitions may be gradual and vary with location.

### 6.5 Bedrock Conditions

Bedrock was encountered in all of the test borings performed for the above-referenced investigation by RMG. The bedrock beneath the site is considered to be part of the Dawson Arkose and consists of sandy claystone and silty to clayey sandstone.

### 6.6 Structural Features

Structural features such as schistocity, folds, zones of contortion or crushing, joints, shear zones or faults were not observed on the site, surrounding the site or in the soil samples collected for laboratory testing.

### 6.7 Surficial (Unconsolidated) Deposits

Various lake and pond sediments, swamp accumulations, sand dunes, marine and non-marine terrace deposits, talus accumulations, creep or slope wash were not observed along the "Unnamed Tributary" or elsewhere on the site. Slump and slide debris were not observed on the site.

## 6.8 Drainage of Water and Groundwater

The overall topography of the site slopes down to the south. Groundwater was encountered in seven of the test borings at depths ranging from approximately 14 to 28 feet at the time of drilling.

The "Unnamed Tributary" is currently a defined drainage way located along the western boundary of the site. Review of the historical photos provided by Google Earth depict that the "Unnamed Tributary" adjacent to the site has remained relatively undisturbed since at least 1947. Based on the review of the *GEC (Grading and Erosion Control) Plans* it appears that the majority of the "Unnamed Tributary" is to remain relatively undisturbed. However, portions of the "Unnamed Tributary" west of the currently proposed development are to undergo additional grading and drainage improvements to allow for a future extension of Bent Grass Meadows Drive. Additionally, several outfalls are to be installed to divert drainage water from the proposed development into the "Unnamed Tributary".

## 6.9 Features of Special Significance

Features of special significance such as accelerated erosion, (advancing gully head, badlands or cliff reentrants) were not observed on the property. Features indicating settlement or subsidence such as fissures, scarplets and offset reference features were also not observed on the property.

Features indicating creep, slump or slide masses in bedrock and surficial deposits were also not observed on the property.

## 6.10 Engineering Geology

The Engineering Geology is presented below. Charles Robinson and Associates have mapped three environmental engineering units the site as:

- 2A: Stable alluvium, colluvium and bedrock on gentle to moderate slopes (5%-12%).
- 2D: Eolian deposits generally on flat to gentle slopes of upland areas.
- 7A: Physiographic floodplain where erosion and deposition presently occur and is generally subject to recurrent flooding. Includes 100-year floodplain along major streams where floodplain studies have been conducted and Base Flood Elevations have been determined.

*The engineering geology is presented in the Engineering and Geology Map, Figure 3.*

## 6.11 Mineral Resources

Under the provision of House Bill 1529, it was made a policy by the State of Colorado to preserve for extraction commercial mineral resources located in a populous county. Review of the *Master Plan for Mineral Extraction*, *Map 2* indicates the site is not identified as an aggregate resource. Extraction of the sand and sandstone resources are not considered to be economical compared to materials available elsewhere within the county.

## 6.12 Permeability

The permeability of a soil measures how well air and water can flow within the soil. Soil permeability varies according to the type of soil and other factors.

The infiltration rate of a soil refers to how much water a type of soil can absorb over a specific time period. Infiltration rates are determined by soil permeability and surface conditions, and usually are measured in inches per hour.

The materials encountered in the test borings at the time of drilling were silty to clayey sand, sandy clay, silty to clayey sandstone, and sandy claystone. The permeability of the sands is anticipated to be moderate to high. The permeability of the sandstone is anticipated to range from low to high. The permeability of the clay and claystone is anticipated to be low.

# 7.0 POTENTIAL GEOLOGIC CONDITIONS

The El Paso County Engineering Criteria Manual recognizes and delineates the difference between hazards and constraints. A geologic hazard is one of several types of adverse geologic conditions capable of causing significant damage or loss of property and life. Geologic hazards are defined in Section C.2.2 Sub-section E.1 of the ECM. A geologic constraint is one of several types of adverse geologic conditions capable of limiting or restricting construction on a particular site. Geologic constraints are defined in Section C.2.2 Sub-section E.2 of the ECM.

The following is a list of potential geologic hazards and conditions that commonly exist within El Paso County, Colorado, but that are not anticipated to impact the site:

- Landslides
- Rockfall
- Steeply dipping bedrock
- Ground subsidence
- Unstable or Potentially Unstable Slopes
- Debris Flow and Debris Fans

The following sections discuss potential geologic conditions that are anticipated to impact the subject site:

## 7.1 Hydrocompactive and/or Potentially Expansive Soils (Moisture Sensitive Soils)

The subsurface materials at the site generally consist of silty to clayey sand and sandy clay. Based on the *Preliminary Subsurface Soil Investigation* report referenced above, the soils and bedrock encountered at the site generally possess low to moderate swell potential and the soils at the site generally possess low to moderate compressibility potential. It is anticipated that if these materials are encountered in the excavations for the proposed residences, they can readily be mitigated with typical construction practices common to this region of El Paso County, Colorado.

Mitigation

Shallow foundations are anticipated for structures within this development. Foundation design and construction are typically adjusted for expansive or compressible soils. Mitigation of expansive soils is typically accomplished by overexcavation and replacement with structural fill, or subexcavation and/or replacement with on-site moisture-conditioned soils. Mitigation of compressible soils is typically accomplished by removal and recompaction, or subexcavation and/or replacement with on-site moisture-conditioned soils.

## 7.2 Faults and Seismicity

Review of the *Geologic Map of the Colorado Springs Quadrangle* and *Map of Areas Susceptible to Differential Heave in Expansive, Steeply Dipping Bedrock, City of Colorado Springs, Colorado* indicates the Rampart Range Fault lies approximately 12.5 miles to the west of the proposed residential development, and the Ute Pass Fault lies approximately 15 miles to the south and west of the proposed residential development. According to the CGS, these faults are not considered to be recently active. However, they have been active during geologic times and could affect the site if they did rupture.

Information presented by the CGS indicates that several recent earthquakes have occurred in the vicinity of the Ute Pass Fault near Colorado Springs and Woodland Park. The earthquakes, with magnitudes in the range of 3.0 to 3.9, occurred approximately from 1962 to 2007.

Earthquakes felt at this site will most likely result from minor shifting of the granite mass within the Pikes Peak Batholith which includes pull from minor movements along faults found in the Denver basin. Ground motions resulting from small earthquakes are more likely to affect structures at this site and will likely only affect slopes stability to a minimal degree.

Mitigation

The Pikes Peak Regional Building Code, 2017 Edition, indicates maximum considered earthquake spectral response accelerations of 0.185g for a short period ($S_s$) and 0.059g for a 1-second period ($S_1$). Based on the results of our experience with similar subsurface conditions, we recommend the site be classified as Site Class B, with average shear wave velocities ranging from 2,500 to 5,000 feet per second for the materials in the upper 100 feet.

## 7.3 Radon

***"Radon Act 51** passed by Congress set the natural outdoor level of radon gas (0.4 pCi/L) as the target radon level for indoor radon levels.*

The 80931 zip code located in El Paso County, has an EPA assigned Radon Zone of 1. A radon zone of 1 predicts an average indoor radon screening level greater than 4 pCi/L, which is above the recommended levels assigned by the EPA. Black Forest is located in a high risk area of the country. *The EPA recommends you take corrective measures to reduce your exposure to radon gas.*

Most of Colorado is generally considered to have the potential of high levels of radon gas, based on the information provided at: http://county-radon.info/CO/El_Paso.html. There is not believed to be unusually hazardous levels of radon from naturally occurring sources at this site.

Mitigation

Radon hazards are best mitigated at the building design and construction phases. Providing increased ventilation of basements, crawlspaces, creating slightly positive pressures within structures, and sealing of joints and cracks in the foundations and below-grade walls can help mitigate radon hazards.

## 7.4 Flooding and Surface Drainage

The "Unnamed Tributary" resides along the western property boundary. Per the Flood Insurance Study report and Flood Insurance Rate Map for FEMA Map Number 08041C0553G dated December 7, 2018,

the "Unnamed Tributary" resides in Zone AE, which is defined by FEMA as areas subject to inundation by the 1-percent-annual chance-flood event determined by detailed methods. This area is shown hatched on the Engineering and Geology Map, Figure 3.

The remainder of the site now lies in the Zone X. Zone X is defined by FEMA as an area of minimal flood hazard that is determined to be outside the Special Flood Hazard Area and higher than the elevation of the 0.2-percent-annual-chance (or 500-year) flood.

### 7.5 Springs and High Groundwater

Based on the site observations, review of USGS topographic maps dating back to 1951, and Google Earth images dating back to September 1999, springs do not appear to originate on the subject site. Groundwater was encountered at depths ranging from 14 to 28 feet in the test borings at the time of drilling for the previous investigation by RMG, referenced above.

Fluctuations in groundwater and subsurface moisture conditions may occur due to variations in rainfall and other factors not readily apparent at this time. Development of the property and adjacent properties may also affect groundwater levels.

Mitigation:
If shallow groundwater conditions are encountered during the site specific Subsurface Soil Investigations and/or Open Excavation Observations, mitigations can include a combination of surface and subsurface drainage systems, vertical drainboard, etc.

In general, if groundwater was encountered within 4 to 6 feet of the proposed basement slab elevation, an underslab drain should be anticipated in conjunction with the perimeter drain. Perimeter drains are anticipated for each individual lot to prevent the infiltration of water and to help control wetting of potentially expansive and hydrocompactive soils in the immediate vicinity of foundation elements. It must be understood that the drain is designed to intercept some types of subsurface moisture and not others. Therefore, the drain could operate properly and not mitigate all moisture problems relating to foundation performance or moisture intrusion into the basement area.

### 7.6 Erosion and Corrosion

The upper sands encountered at the site are susceptible to erosion by wind and flowing water. The sandstone and claystone at this site typically have low resistivity values (less than 2,000 ohm-cm) and are likely to be potentially corrosive to buried, ferrous metal piping and other structures.

Mitigation:
Due to the nature of the soils on the site it is anticipated that the majority of the surficial soils (silty to clayey sand and sandy clay) is subject to erosion by wind or water. The majority of the site has low lying vegetation that is reducing the potential for erosion. During development and construction, disturbance of the site most likely will occur and may require regrading and revegetation.

### 7.7 Surface Grading and Drainage

The recommendations listed in this report are intended to address normal surface drainage conditions, assuming the presence of groundcover (established vegetation, paved surfaces, and/or structures) throughout the regions upslope from this structure. However, groundcover may not be present due to a

variety of factors (ongoing construction/development, wildfires, etc.). During periods when groundcover is not present in the "upslope" regions, higher than normal surface drainage conditions may occur, resulting in perched water tables, excess runoff, flash floods, etc. In these cases, the surface drainage recommendations presented herein (even if properly maintained) may not mitigate all groundwater problems or moisture intrusion into the structure. We recommend that the site plan be prepared with consideration of increased runoff during periods when groundcover is not present on the upslope areas.

Mitigation:
The ground surface should be sloped from the buildings with a minimum gradient of 10 percent for the first 10 feet. This is equivalent to 12 inches of fall across this 10-foot zone. If a 10-foot zone is not possible on the upslope side of the structure, then a well-defined swale should be created a minimum 5 feet from the foundation and sloped parallel with the wall with a minimum slope of 2 percent to intercept the surface water and transport it around and away from the structure. Roof drains should extend across backfill zones and landscaped areas to a region that is graded to direct flow away from the structure. Homeowners should maintain the surface grading and drainage recommended in this report to help prevent water from being directed toward and/or ponding near the foundations.

Landscaping should be selected to reduce irrigation requirements. Plants used close to foundation walls should be limited to those with low moisture requirements and irrigated grass should not be located within 5 feet of the foundation. To help control weed growth, geotextiles should be used below landscaped areas adjacent to foundations. Impervious plastic membranes are not recommended.

Irrigation devices should not be placed within 5 feet of the foundation. Irrigation should be limited to the amount sufficient to maintain vegetation. Application of more water will increase the likelihood of slab and foundation movements.

### 7.8 Fill Soils

Fill soils were not encountered at the time of drilling. However, some fill soils (in the form of stockpiles) were observed south and west of the current termination of Bent Grass Meadows Drive. These stockpiles raised above the original ground surface approximately 6 to 8 feet. This area is shown on the Engineering and Geology Map, Figure 3. To date, no documentation has been received indicating that this fill was placed and compacted as indicated herein. As such, these materials are considered to be non-engineered fill and are unsuitable for direct support of the proposed residences.

Mitigation
Where non-engineered (or otherwise unsuitable) fill is encountered during development, they should be removed (overexcavated) and replaced with compacted structural fill as indicated herein. The zone of overexcavation shall extend to the bottom of the unsuitable fill zone and shall extend at least that same distance beyond the proposed building perimeter (or lateral extent of any fill, if encountered first). Provided that this recommendation is implemented, the presence of this fill is not considered to pose a risk to the proposed new structures.

### 7.9 Proposed Grading, Erosion Control, Cuts and Masses of Fill

Preliminary grading plans were provided (referenced herein) and reviewed at the time the report was issued. It is assumed based on the test borings for this investigation that the excavations will encounter silty to clayey sands, sandy clay, silty to clayey sandstone, and sandy claystone.

Mitigation

The on-site soils can be used as site grading fill, though the clay and claystone should be avoided in areas where the proposed foundations are not anticipated to penetrate through the grading fill.

The on-site soils are mildly susceptible to wind and water erosion. Minor wind erosion and dust may be an issue for a short time during and immediately after construction. Should the problem be considered severe during construction, watering of the cut areas may be required. Once construction is complete, vegetation should be re-established.

Prior to placement of overlot fill or removal and recompaction of the existing materials, topsoil, low-density native soil, fill and organic matter should be removed from the fill area. The subgrade should be scarified, moisture conditioned to within 2% of the optimum moisture content, and recompacted to the same degree as the overlying fill to be placed. The placement and compaction of fill should be periodically observed and tested by a representative of RMG during construction.

***Guideline Site Grading Specifications are included in the Appendix A.***

### 7.10 On-site Wastewater Disposal

It is our understanding that on-site wastewater treatment systems are not proposed. Based on the Final Plat by Galloway & Company dated March 14, 2019, sewer services will be dedicated to Woodmen Hills Metropolitan District.

# 8.0 BEARING OF GEOLOGIC CONDITIONS UPON PROPOSED DEVELOPMENT

Geologic hazards (as described in section 7.0 of this report) and geologic constraints (also as described in section 7.0 of this report) were found to be present at this site.

The geologic hazards anticipated to affect this site are faults/seismicity and radioactivity/radon gas. The most significant geologic constraints to development recognized at this site are non-engineered fill soils and expansive/compressible soils. The geologic conditions encountered at this site are relatively common to the immediate area and mitigation can be accomplished by implementing common engineering and construction practices. None of these conditions are anticipated to preclude the proposed development.

# 9.0 BURIED UTILITIES

Based upon the conditions encountered in the exploratory test borings, we anticipate that the soils encountered in the utility trench excavations will consist of silty to clayey sands, (SM and SC) sandy silt (ML) and sandy clay (CL and CH). It is anticipated that the sands will be encountered at loose to medium dense relative densities, the clays at medium stiff to very stiff consistencies. Depending on the depth of excavations, temporary shoring and hydraulic water pumps may be required to prevent the collapse of trenches and the accumulation of water at the bottom of the excavation.

We believe the sand and clays will classify as Type C materials as defined by OSHA in 29 CFR Part 1926. OSHA requires that temporary excavations made in Type B and C materials be laid back at ratios no steeper than 1:1 (horizontal to vertical) and 1½:1 (horizontal to vertical), respectively, unless the excavation is shored and braced. Excavations deeper than 20 feet, or when water is present, should always be braced or the slope designed by a professional engineer.

Utility mains such as water and sanitary sewer lines are typically placed beneath paved roadways. The settlement of the utility trench backfill can have a detrimental effect on pavements and roadway surfaces. We recommend that utility trench backfill be placed in thin loose lifts, moisture conditioned as required and compacted to the recommendations outlined in the **Backfill** section of this report. The placement and compaction of utility trench backfill should be observed and tested by a representative of RMG Engineers during construction.

It is a common local practice for underdrains to be placed at the bottom of sanitary sewer trenches within drive lanes. Underdrains placed in the sanitary sewer trenches in areas where groundwater is anticipated will likely be the "active" type, which uses a perforated drain pipe. In areas where groundwater is not anticipated, “passive” type underdrains may be used. Typical underdrain details are presented in Figures 22 and 23. If an underdrain system is used, it will likely necessitate construction and maintenance of a pumping station to collect and redirect the discharge from the underdrain system. At this time an underdrain system is not anticipated. One potential alternative to this approach would be to provide individual sump pits and pumps for each residence to collect and redirect discharge water from all recommended subsurface foundation drains. If this option is selected, care should be taken to ensure that the sump pumps have outfall to a location that is graded to direct the discharge water away from the surrounding structures and to a suitable collection or drainage area.

# 10.0 PAVEMENTS

Preliminary Roadway Layout plans were provided prior to the report issue date. Roadways throughout the proposed development are classified as “Local” (Local low volume) and are anticipated to have 50 to 80-foot Public Right of Ways. ***The actual pavement section design for individual streets will be completed following overlot grading and rough cutting of the street subgrade.***

For purposes of this report (preliminary planning), we anticipate the subgrade soils will primarily have an American Association of State Highway and Transportation Officials (AASHTO) Soil Classification of A-2-4, A-4, A-6, and A-7-6 with an estimated California Bearing Ratio (CBR) value of approximately 5 to 15.

The above value is for preliminary planning purposes and may vary upon final design, dependent upon the soil material used for subgrade construction.

# 11.0 ANTICIPATED FOUNDATION SYSTEMS

Based on the information presented previously, conventional shallow foundation systems consisting of standard spread footings/stemwalls are anticipated to be suitable for the proposed residential structures. It is assumed that the deepest excavation cuts will be approximately 6 to 8 feet below the final ground surface not including overexcavation which may be required on a lot-by-lot basis.

Due to its swell potential, the sandy clay is generally not suitable for support of spread footing foundations or floor slabs. Where expansive soils are encountered near spread footing foundation or floor slab levels, they should be removed and replaced with granular, non-expansive structural fill. Foundation systems which may reduce or eliminate the need for overexcavation include (but are not limited to) post-tension slabs-on-grade, integral stiffened (ribbed) slab foundations, driller pier (caisson) foundations with or without a structural floor, etc.

If loose or hydrocompactive sands are encountered, they may require additional compaction. In some cases, removal and recompaction may be required for loose soils. Similarly, if shallow groundwater conditions result in unstable soils, unsuitable for bearing of residential foundations, these soils may require stabilization or overexcavation and replacement prior to construction of foundation components.

***The foundation system for each lot should be designed and constructed based upon recommendations developed in a detailed Subsurface Soil Investigation completed after site development activities are complete.*** The recommendations presented in the Subsurface Soil Investigation should be verified by an Open Excavation Observation following the excavation on each lot.

### 11.1 Subexcavation and Moisture-Conditioned Fill

Based upon the field exploration and laboratory testing, subexcavation and replacement is not anticipated. However, prior to performing excavation and/or filling operations, vegetation, organic and deleterious material shall be cleared and disposed of in accordance with applicable requirements. The excavation should extend to a minimum depth below and laterally beyond the bottom of foundations as determined based on final grading plans.

### 11.2 Foundation Stabilization

Groundwater and loose soils were encountered at the time of drilling, if moisture conditions encountered at the time of the foundation excavation result in water flow into the excavation and/or destabilization of the foundation bearing soils, stabilization techniques should be implemented. Various stabilization methods can be employed, and can be discussed at the time of construction. However, a method that affords potentially a reduced amount of overexcavation (versus other methods) and provides increased performance under moderately to severely unstable conditions is the use of a layered geogrid and structural fill system.

Additionally, dependent upon the rate of groundwater flow into the excavation, a geosynthetic vertical drain and an overexcavation perimeter drain may be required around the lower portions of the excavation to allow for installation of the layered geogrid and structural fill system.

### 11.3 Foundations Drains

A subsurface perimeter drain is recommended around portions of the structure which will have habitable or storage space located below the finished ground surface. This includes crawlspace areas but not the walkout trench, if applicable.

Groundwater conditions were encountered in the test borings at the time of field exploration. The proposed detention ponds appear to be located at proposed basement foundation elevations. Depending on the conditions encountered during the lot specific Subsurface Soil Investigation and the conditions

observed at the time of the Open Excavation Observation, additional subsurface drainage systems may be recommended.

One such system is an underslab drainage layer to help intercept groundwater before it enters the slab area should the groundwater levels rise. In general, if groundwater was encountered within 4 to 6 feet of the proposed basement slab elevation, an underslab drain should be anticipated. Another such system would consist of a subsurface drain and/or vertical drain board placed around the perimeter of the overexcavation to help intercept groundwater and allow for proper placement and compaction of the replacement structural fill. Careful attention should be paid to grade and discharge of the drain pipes of these systems.

It must be understood that the drain systems are designed to intercept some types of subsurface moisture and not others. Therefore, the drains could operate properly and not mitigate all moisture problems relating to foundation performance or moisture intrusion into the basement area.

### 11.4 Structural Fill

Areas to receive structural fill should have topsoil, organic material, or debris removed. The upper 6 inches of the exposed surface soils should be scarified and moisture conditioned to facilitate compaction (usually within 2 percent of the optimum moisture content) and compacted to a minimum of 95 percent of the maximum dry density as determined by the Standard Proctor test (ASTM D-698) or to a minimum of 92 percent of the maximum dry density as determined by the Modified Proctor test (ASTM D-1557) prior to placing structural fill.

Structural fill placed on slopes should be benched into the slope. Maximum bench heights should not exceed 4 feet, and bench widths should be wide enough to accommodate compaction equipment.

Structural fill shall consist of granular, non-expansive material. It should be placed in loose lifts not exceeding 8 to 12 inches, moisture conditioned to facilitate compaction (usually within 2 percent of the optimum moisture content) and compacted to a minimum of 92 percent of the maximum dry density as determined by the Modified Proctor test, ASTM D-1557. The materials should be compacted by mechanical means.

Materials used for structural fill should be approved by RMG prior to use. Structural fill should not be placed on frozen subgrade or allowed to freeze during moisture conditioning and placement.

### 11.5 Design Parameters

The allowable bearing pressure of the subsurface soils should be determined by a detailed site specific Subsurface Soil Investigation and verified by and Open Excavation Observation, as noted above.

## 12.0 ADDITIONAL STUDIES

The findings, conclusions and recommendations presented in this report were provided to evaluate the suitability of the site for future development. Unless indicated otherwise, the test borings, laboratory test results, conclusions and recommendations presented in this report are not intended for use for design and construction. ***A site specific Subsurface Soil Investigation will be required for all proposed structures including (but not limited to) residences, retaining walls and pumphouses, commercial buildings, etc.***

To develop recommendations for construction of the proposed roadways, a pavement design investigation should be performed. This investigation should consist of additional test borings, soil laboratory testing and specific recommendations for the design and construction of roadway pavement sections.

# 13.0 CONCLUSIONS

Based upon our evaluation of the geologic conditions, it is our opinion that the proposed development is feasible. The potential for hydrocompactive and expansive soils and flooding, the geologic hazards identified are not considered unusual for the Front Range region of Colorado. Mitigation of geologic hazards is most effectively accomplished by avoidance. However, where avoidance is not a practical or acceptable alternative, geologic hazards should be mitigated by implementing appropriate planning, engineering, and local construction practices.

Potential mitigation alternatives include (but are not limited to) overexcavation and replacement of unsuitable soils and the design and construction of surface and subsurface drainage systems which are commonly used in the El Paso County vicinity.

Revisions and modifications to the conclusions and recommendations presented in this report may be issued subsequently by RMG based upon additional observations made during grading and construction which may indicate conditions that require re-evaluation of some of the criteria presented in this report.

# 14.0 CLOSING

This report is for the exclusive purpose of providing geologic hazards information and preliminary geotechnical engineering recommendations. The scope of services did not include, either specifically or by implication, evaluation of wild fire hazards, environmental assessment of the site, or identification of contaminated or hazardous materials or conditions. Development of recommendations for the mitigation of environmentally related conditions, including but not limited to, biological or toxicological issues, are beyond the scope of this report. If the owner is concerned about the potential for such contamination or conditions, other studies should be undertaken.

This report has been prepared for **Challenger Colorado, LLC** in accordance with generally accepted geotechnical engineering and engineering geology practices. The conclusions and recommendations in this report are based in part upon data obtained from review of available topographic and geologic maps, review of available reports of previous studies conducted in the site vicinity, a site reconnaissance, and research of available published information, soil test borings, soil laboratory testing, and engineering analyses. The nature and extent of variations may not become evident until construction activities begin. If variations then become evident, RMG should be retained to re-evaluate the recommendations of this report, if necessary.

Our professional services were performed using that degree of care and skill ordinarily exercised, under similar circumstances, by geotechnical engineers and engineering geologists practicing in this or similar localities. RMG does not warrant the work of regulatory agencies or other third parties supplying information which may have been used during the preparation of this report. No warranty, express or implied, is made by the preparation of this report. Third parties reviewing this report should draw their

own conclusions regarding site conditions and specific construction techniques to be used on this project.

If we can be of further assistance in discussing the contents of this report or analysis of the proposed development, from a geotechnical engineering and/or geologic hazards point-of-view, please feel free to contact us.

# 15.0 REFERENCES


1. Bing, Street Map, downloaded October 15, 2019.
1. El Paso County, updated thru July 9, 2019, Section 8.4.9, *El Paso County Land Development Code*.
2. El Paso County, revise July 9, 2019, *Appendix C, Soils Investigation Reports and Mitigation*, *Engineering Criteria Manual*.
3. Google Maps, Aerial Photograph, downloaded October 8, 2019.
4. El Paso County, February 8, 1996, *Master Plan for Mineral Extraction, Map 2.*
5. Kirkham, R.M. and Rogers, W.P., 1981, *Earthquake Potential in Colorado, A Preliminary Evaluation*, Colorado Geological Survey, Bulletin 43.
6. Colorado Geological Survey, 1991, *Results of the 1987-88 EPA Supported Radon Study in Colorado, with a discussion on Geology*, Open file Report 91-4.
7. Dames and Moore, 1985, *Colorado Springs Subsidence Investigation, State of Colorado Mined Land Reclamation*. (Reviewed to verify project location)
8. Federal Emergency Management Agency (FEMA), dated December 7, 2018, *Flood Insurance Rate Map, El Paso County, Colorado and Unincorporated Areas, Community Panel No.* 08041C0553G.
9. United States Department of Agriculture Soils Conservation Service, 1980, *Soil Survey of El Paso County Area, Colorado.* http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx
10. On-site Wastewater Treatment Systems (OWTS) Regulations, El Paso County, Colorado, Chapter 8, effective April 10, 2014 amended July 7, 2018.
11. Wait, T.C. & White, J.L., 2006. *Rockfall Hazard Susceptibility in Colorado Springs*, El Paso County, Colorado. Colorado Geological Survey, Open-File Report 06-3
12. Colorado Geologic Survey, Colorado Landslide Inventory:
13. https://cologeosurvey.maps.arcgis.com/apps/webappviewer/index.html?id=5e7484a637c4432e84f4f16d0af306d3
14. Himmelreich, J.W. & Noe, D.C., 1999, *Map of Areas Susceptible to Differential Heave in Expansive, Steeply Dipping Bedrock*, City of Colorado Springs, Colorado. Colorado Geological Survey, Map Series 32. (Reviewed to verify project location)
15. Charles S. Robinson and Associates, Inc., 1977, El Paso County, Colorado – *Potential Geologic Hazards and Surficial Deposits, Environmental and Engineering Geologic Maps and Tales for Land Use.*
16. Morgan, M.L., and White, J.L., 2012, Geologic Map of the Falcon Quadrangle, El Paso County, Colorado, Colorado Geological Survey, Open File Report 12-05.

# FIGURES


REFERENCE
NOT TO SCALE

ARCHITECTS RMG ENGINEERS
ROCKY MOUNTAIN GROUP

*Southern Office*
Colorado Springs,CO
80918
(719) 548-0600
*Central Office:*
Englewood, CO 80112
(303) 688-9475
*Northern Office:*
Greeley / Evans, CO 80620
(970) 330-1071

# SITE VICINITY MAP

BENT GRASS RESIDENTIAL
FILING NO. 2
EL PASO COUNTY, CO
CHALLENGER COLORADO, LLC

JOB No. 169845

FIG No. 1

DATE 10-21-2019


● DENOTES APPROXIMATE LOCATION OF TEST BORINGS PERFORMED FOR THE PRELIMINARY SUBSURFACE SOILS INVESTIGATION BY RMG - ROCKY MOUNTAIN GROUP (JOB NO. 169845)

NOT TO SCALE

BASE MAP PROVIDED BY: GALLOWAY

JOB No. 169845


ARCHITECTS RMG ENGINEERS

ROCKY MOUNTAIN GROUP

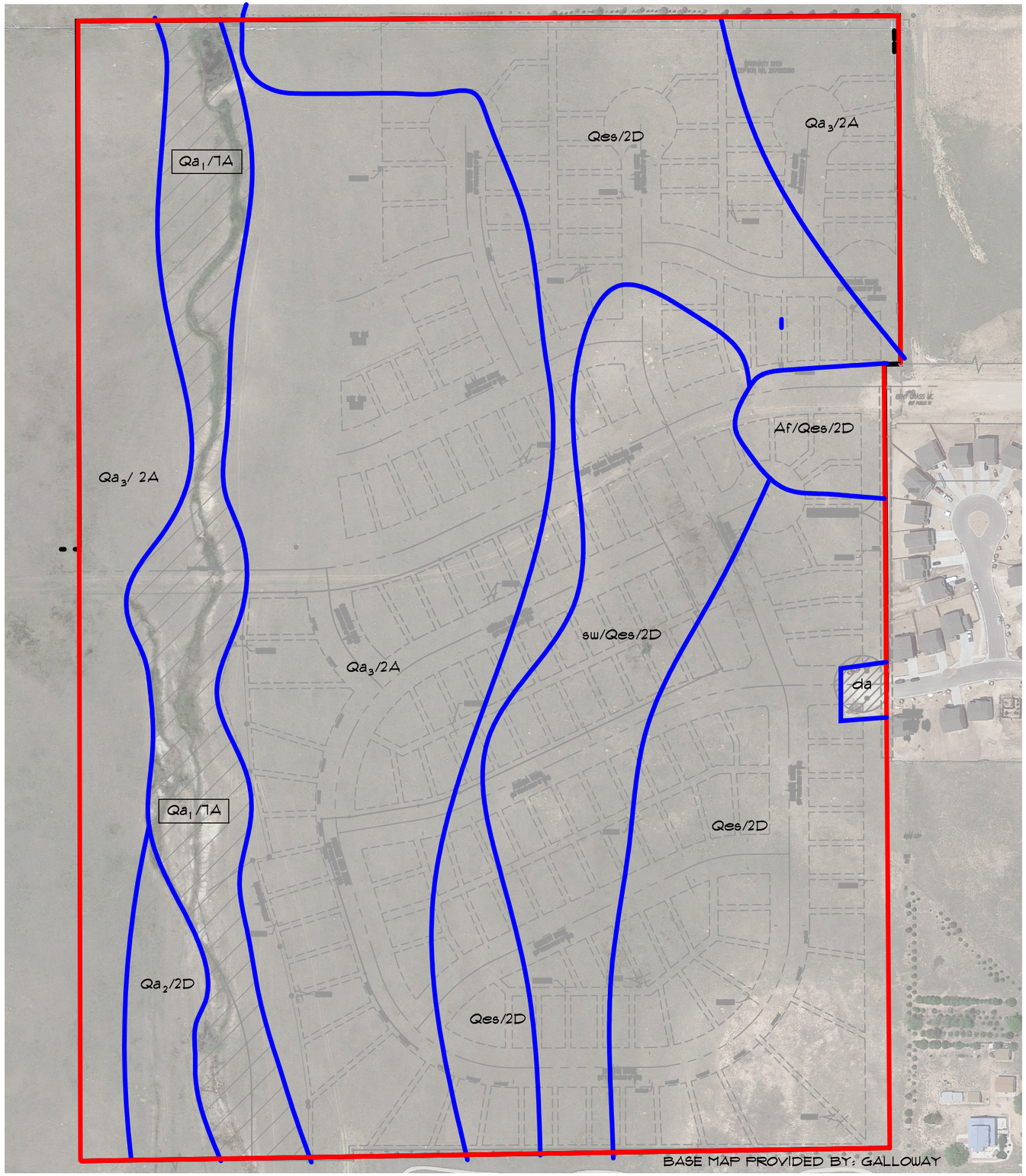
*Southern Office*
Colorado Springs, CO 80918
(719) 548-0600
*Central Office:*
Englewood, CO 80112
(303) 688-9475
*Northern Office:*
Greeley / Evans, CO 80620
(970) 330-1071
*Woodland Park Office:*
(719) 687-6077
*Monument Office:*
(719) 488-2145
*Pueblo / Canon City:*
(719) 544-7750


# BENT GRASS RESIDENTIAL FILING NO. 2
EL PASO COUNTY, CO
CHALLENGER COLORADO, LLC

| | |
|---|---|
| ENGINEER: | TPM |
| DRAWN BY: | KZ |
| CHECKED BY: | TPM |
| ISSUED: | 10-21-2019 |
| REVISION: | DATE: / JOB #: |

SITE PLAN WITH PRELIMINARY TEST BORING LOCATIONS

SHEET No.
FIG-2




NOT TO SCALE

## Geologic

af - man-placed fill: associated with the construction operations during development/construction of the lots in the adjacent filing to the east.

Qes - Eolian Sand: likely deposited as a sandsheet by winds capable of moving very fine gravel-sized clasts

$Qa_1$ - Alluvium one: sandy gravel, gravelly sand, silty sand, and sandy silt in modern channels, floodplains, and adjacent low-lying terraces that are approximately 5 feet or less above modern channels. Thickness of the unit is estimated to range from about 2 to 15 feet but could be greater in places.

$Qa_2$ - Alluvium two: straem terrace deposits approximately 6-12 feet above the modern flood plain or as non-terrace forming alluvium in valley headwaters.

$Qa_3$ - Alluvium three: stream deposits approximately 10-20 feet above the modern floodplain or as non-terrace forming alluvium in valley headwaters that underlies the younger alluviums

sw - seasonally wet area where near-surface moisture conditions may occasionally occur

da - disturbed are that has had vegetation removed and artificial fill is not evident

## Engineering

2A - Stable alluvium, colluvium and bedrock on gentle to moderate slopes

2D - Eolian deposits generally on flat to gentle slopes of upland areas

7A - Physiographic floodplain where erosion and deposition presently occur and is generally subject to recurrent flooding. Includes 100-year floodplain along major streams where floodplain studies have been conducted and Base Floor Elevations have been determined

Area defined as subject to inundation by the 1-percent annual chance flood event.

JOB No. 169845

ARCHITECTS RMG ENGINEERS
ROCKY MOUNTAIN GROUP

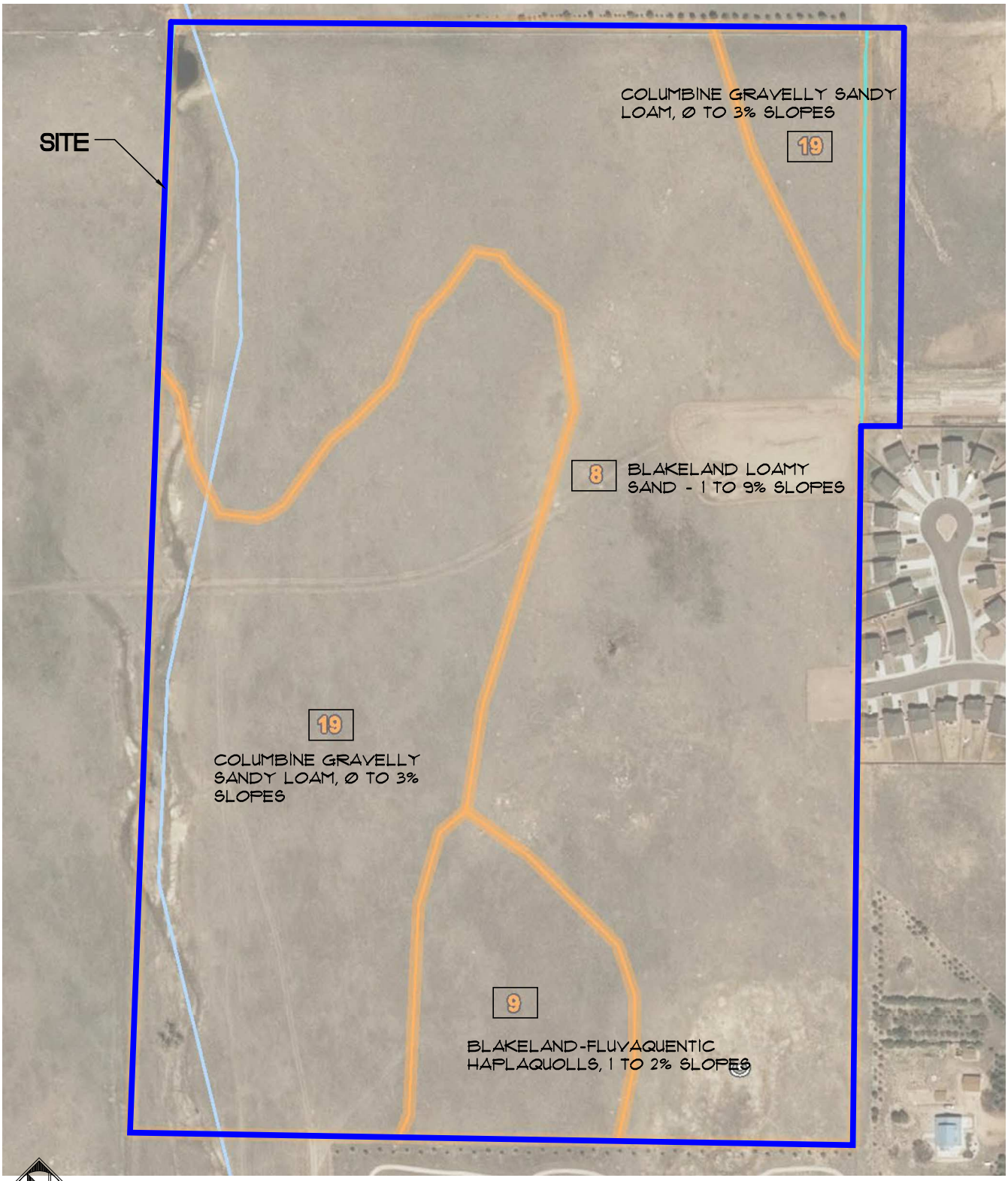
*Southern Office*
Colorado Springs, CO 80918
(719) 548-0600
*Central Office:*
Englewood, CO 80112
(303) 688-9475
*Northern Office:*
Greeley / Evans, CO 80620
(970) 330-1071
*Woodland Park Office:*
(719) 687-6077
*Monument Office:*
(719) 488-2145
*Pueblo / Canon City:*
(719) 544-7750

BENT GRASS RESIDENTIAL
FILING NO. 2
EL PASO COUNTY, CO
CHALLENGER COLORADO, LLC

| | |
|---|---|
| ENGINEER: | TPM |
| DRAWN BY: | KZ |
| CHECKED BY: | TPM |
| ISSUED: | 10-21-2019 |
| REVISION: | DATE: / JOB #: |

ENGINEERING AND GEOLOGY MAP

SHEET No.
FIG-3




NOT TO SCALE
BASE MAP PROVIDED BY: USDA

ARCHITECTS RMG ENGINEERS
ROCKY MOUNTAIN GROUP

*Southern Office*
Colorado Springs,CO 80918
(719) 548-0600
*Central Office:*
Englewood, CO 80112
(303) 688-9475
*Northern Office:*
Greeley / Evans, CO 80620
(970) 330-1071

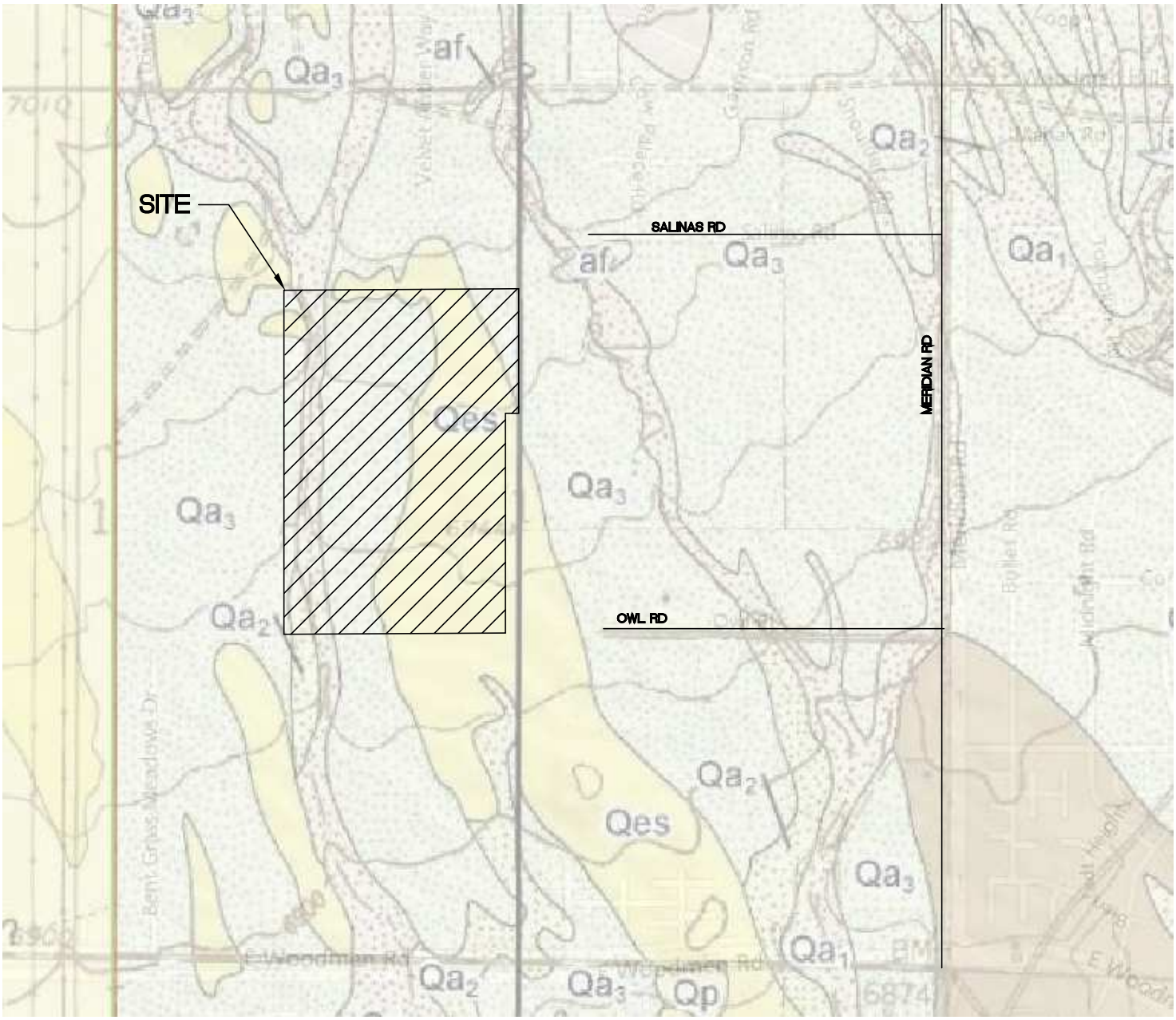
# USDA SOIL SURVEY MAP

**BENT GRASS RESIDENTIAL**
**FILING NO. 2**
**EL PASO COUNTY, CO**
**CHALLENGER COLORADO, LLC**

**JOB No. 169845**

**FIG No. 4**

**DATE 10-21-2019**




NOT TO SCALE
BASE MAP PROVIDED BY: CGS

ARCHITECTS RMG ENGINEERS
ROCKY MOUNTAIN GROUP

*Southern Office*
Colorado Springs,CO
80918
(719) 548-0600
*Central Office:*
Englewood, CO 80112
(303) 688-9475
*Northern Office:*
Greeley / Evans, CO 80620
(970) 330-1071

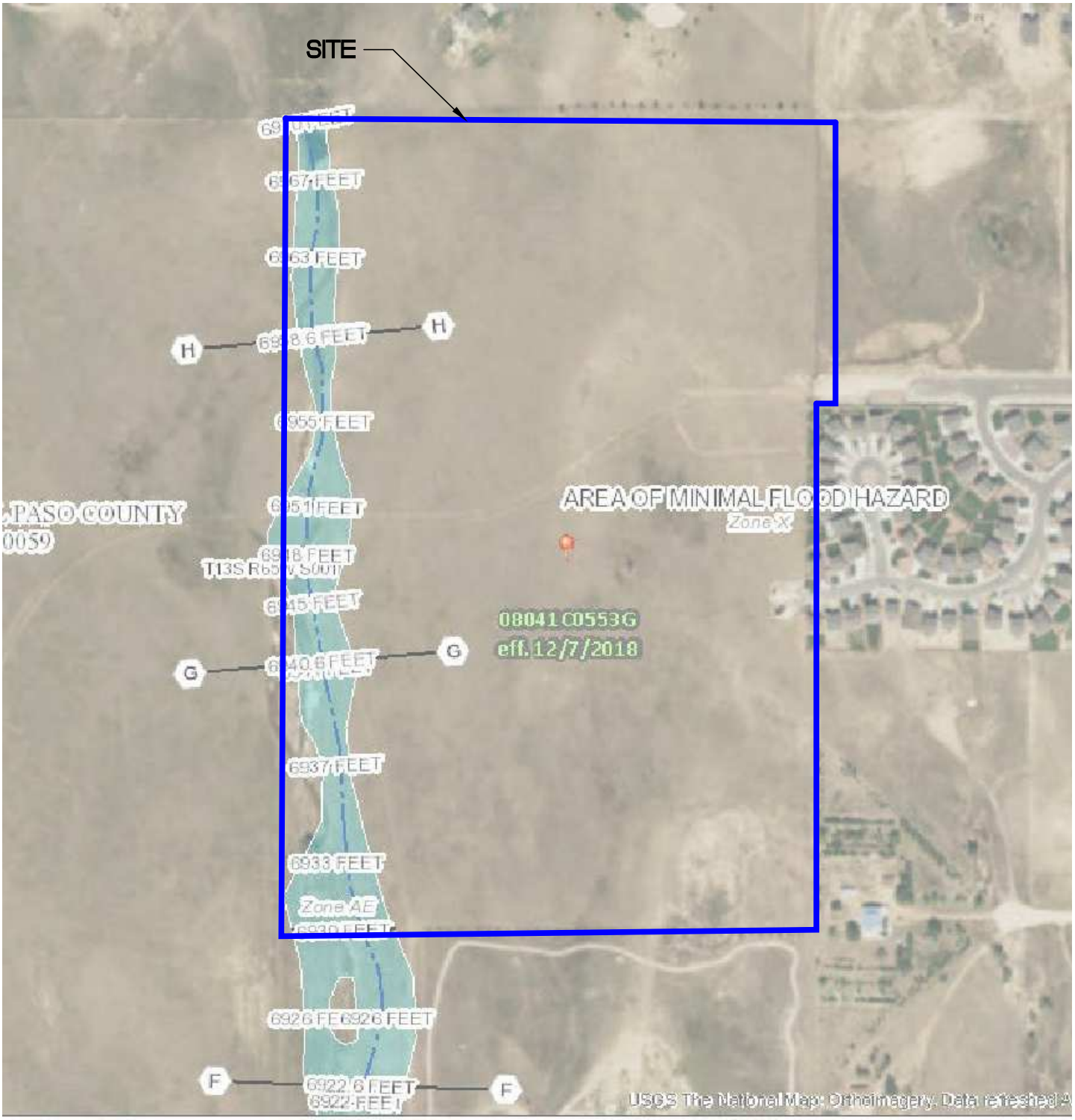
# FALCON QUADRANGLE

BENT GRASS RESIDENTIAL
FILING NO. 2
EL PASO COUNTY, CO
CHALLENGER COLORADO, LLC

JOB No. 169845

FIG No. 5

DATE 10-21-2019




NOT TO SCALE

BASE MAP PROVIDED BY: FEMA

ARCHITECTS RMG ENGINEERS
ROCKY MOUNTAIN GROUP

*Southern Office*
Colorado Springs,CO
80918
(719) 548-0600
*Central Office:*
Englewood, CO 80112
(303) 688-9475
*Northern Office:*
Greeley / Evans, CO 80620
(970) 330-1071

# FEMA MAP

BENT GRASS RESIDENTIAL
FILING NO. 2
EL PASO COUNTY, CO
CHALLENGER COLORADO, LLC

JOB No. 169845

FIG No. 6

DATE 10-21-2019

# APPENDIX A
# GUIDELINE SITE GRADING SPECIFICATIONS

## Guideline Site Grading Specifications

**Description:** Unless specified otherwise by local or state regulatory agencies, these guideline specifications are for the excavation, placement and compaction of material from locations indicated on the plans, or staked by the Engineer, as necessary to achieve the required elevations. These specifications shall also apply to compaction of materials that may be placed outside of the project.

**General:** The Geotechnical Engineer shall approve fill materials, method of placement, moisture contents and percent compactions, and shall give written approval of the compacted fill.

**Clearing Site:** The Contractor shall remove trees, brush, rubbish, vegetation, topsoil and existing structures before excavation or fill placement is commenced. The Contractor shall dispose of the cleared material to provide the Owner with a clean job site. Cleared material shall not be placed in areas to receive fill or where the material will support structures. Clearing shall also include removal of existing fills that do not meet the requirements of this specification and existing structures.

**Preparation of Slopes or Drainage Areas to Receive Fill:** Natural slopes or slopes of drainage gullies where grades are 20 percent (5:1, horizontal to vertical) or steeper shall be benched prior to fill placement. Benches shall be at least 10 feet wide. Benches may require additional width to accommodate excavation or compaction equipment. At least one bench shall be provided for each 5 feet or less of vertical elevation difference. The bench surface shall be essentially horizontal perpendicular to the slope or at a slight incline into the slope.

**Scarifying:** Topsoil and vegetation shall be removed from the ground surface in areas to receive fill. The surface shall be plowed or scarified a minimum of 12 inches until the surface is free from ruts, hummocks or other uneven features which would prevent uniform compaction by the equipment to be used.

**Compacting Area to Receive Fill:** After the area to receive fill has been cleared and scarified, it shall be disked or bladed until it is free from large clods, moisture conditioned to a proper moisture content and compacted to the maximum density as specified for the overlying fill. Areas to receive fill shall be worked, stabilized, or removed and replaced, if necessary, in accordance with the Geotechnical Engineer's recommendations in preparation for fill.

**Fill Materials:** Fill material shall be free from organic material or other deleterious substances, and shall not contain rocks or lumps having a diameter greater than six inches. Fill materials shall be obtained from cut areas shown on the plans or staked in the field by the Engineer or imported to the site and shall be approved by the Geotechnical Engineer prior to placement. It is recommended that the fill materials have nil to low expansion potential, i.e., consist of silty to slightly clayey sand.

- The moisture-conditioned materials should be placed in maximum 6" compacted lifts. These materials should be compacted to a minimum of 92 percent of the maximum Modified Proctor

**Density Testing:** Field density testing shall be performed by the Geotechnical Engineer at locations and depths of his choosing. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests shall be taken in compacted material below the disturbed surface. When density tests indicate the density or moisture content of any layer of fill or portion thereof is below that required, the particular layer or portion shall be reworked until the required density or moisture content has been achieved.

**Observation and Testing of Fill:** Observation by the Geotechnical Engineer shall be sufficient during the placement of fill and compaction operations so that he can declare the fill was placed in general conformance with Specifications. All observations necessary to test the placement of fill and observe compaction operations will be at the expense of the Owner.

**Seasonal Limits:** No fill material shall be placed, spread or rolled while it is frozen, thawing, or during unfavorable weather conditions. When work is interrupted by heavy precipitation, fill operations shall not be resumed until the Geotechnical Engineer indicates the moisture content and density of previously placed materials are as specified.

**Reporting of Field Density Tests:** Density tests made by the Geotechnical Engineer shall be submitted progressively to the Owner. Dry density, moisture content, percent compaction, and approximate location shall be reported for each test taken.

- dry density or 95 percent of the maximum Standard Proctor dry density. Material not meeting the above requirements shall be reprocessed.

Materials used for moisture-conditioned structural fill should be approved by RMG prior to use. Moisture-conditioned structural fill should not be placed on frozen subgrade or allowed to freeze during moisture conditioning and placement.

**Moisture Content:** Fill materials shall be moisture conditioned to within limits of optimum moisture content specified. Sufficient laboratory compaction tests shall be made to determine the optimum moisture content for the various soils encountered in borrow areas or imported to the site.

The contractor may be required to add moisture to the excavation materials in the borrow area if, in the opinion of the Geotechnical Engineer, it is not possible to obtain uniform moisture content by adding water to the fill material during placement. The Contractor may be required to rake or disk the fill soils to provide uniform moisture content through the soils.

The application of water to embankment materials shall be made with watering equipment, approved by the Geotechnical Engineer, which will give the desired results. Water jets from the spreader shall not be directed at the embankment with such force that fill materials are eroded.

Should too much water be added to the fill, such that the material is too wet to permit the desired compaction to be obtained, compacting and work on that section of the fill shall be delayed until the material has been allowed to dry to the required moisture content. The Contractor will be permitted to rework the wet material in an approved manner to hasten its drying.

**Compaction of Fill Areas:** Selected fill material shall be placed and mixed in evenly spread layers. After each fill layer has been placed, it shall be uniformly compacted to not less than the specified percentage of maximum density. Fill materials shall be placed such that the thickness of loose material does not exceed 10 inches and the compacted lift thickness does not exceed 6 inches.
Compaction, as specified above, shall be obtained by the use of sheepsfoot rollers, multiple-wheel pneumatic-tired rollers, or other equipment approved by the Geotechnical Engineer. Granular fill shall be compacted using vibratory equipment or other equipment approved by the Geotechnical Engineer. Compaction shall be accomplished while the fill material is at the specified moisture content. Compaction of each layer shall be continuous over the entire area.

**Moisture Content and Density Criteria:**

A. Fill placed in roadways and utility trenches should be moisture conditioned and compacted in accordance with El Paso County Specifications.
B. Fill placed outside of roadways and utility trenches should be compacted to at least 92% of the maximum Modified Proctor density (ASTM D-1557) or at least 95% of the maximum Standard Proctor density (ASTM D-698) at a moisture content within 2% of optimum.

**Compaction of Slopes:** Fill slopes shall be compacted by means of sheepsfoot rollers or other suitable equipment. Compaction operations shall be continued until slopes are stable, but not too dense for planting, and such that there is no appreciable amount of loose soil on the slopes. Compaction of slopes may be done progressively in increments of three to five feet in height or after the fill is brought to its total height. Permanent fill slopes shall not exceed 3:1 (horizontal to vertical).

# APPENDIX B

*Preliminary Subsurface Soil Investigation, Bent Grass Meadows Filing No. 2,* prepared by RMG – Rocky Mountain Group, Job No. 169845, last revised August 6, 2019

Architecture
Structural
Geotechnical

Materials Testing
Forensic
Civil/Planning

**ROCKY MOUNTAIN GROUP**
**EMPLOYEE OWNED**

# PRELIMINARY SUBSURFACE SOIL INVESTIGATION

## Bent Grass Meadows Filing No. 2
## Colorado Springs, Colorado

## PREPARED FOR:

**Challenger Colorado, LLC**
**8605 Explorer Drive, Suite 250**
**Colorado Springs, CO 80920**

## JOB NO. 169845

**May 15, 2019**
**Revised August 6, 2019**

**Respectfully Submitted,**

**RMG – Rocky Mountain Group**

**Brian Griffith, E.I.**
**Geotechnical Staff Engineer**

**Reviewed by,**

**RMG – Rocky Mountain Group**

**Geoff Webster, P.E.**
**Sr. Geotechnical Project Engineer**

COLORADO LICENSED
GEOFF WEBSTER
8/7/19
45046
PROFESSIONAL ENGINEER

# TABLE OF CONTENTS

# GENERAL SITE AND PROJECT DESCRIPTION

**Project Description**

The site is located northeast of Colorado Springs, Colorado, generally north of the intersection of Woodmen Road and Meridian Road. The approximate location of the site is shown on the Site Vicinity Map, Figure 1.

The site is being considered for residential development. RMG – Rocky Mountain Group was retained to explore the subsurface conditions at the site and provide preliminary information to assess the suitability of the land for development.

**Existing Site Conditions**

The site is undeveloped ranch land bounded by and connecting to the developed Bent Grass Meadows Filing No. 1 to the east.

# FIELD INVESTIGATION AND LABORATORY TESTING

**Drilling**

The subsurface conditions on the site were investigated by drilling twenty-five (25) exploratory test borings. The approximate locations of the test borings are presented in the Test Boring Location Plan Figure 2. The areas where overexcavation of cohesive soils is anticipated (based on our preliminary investigation) for stiffened slab-on-grade foundations and basement foundations are presented in Figure 2-1 and Figure 2-2.

The test borings were advanced with a power-driven, continuous-flight auger drill rig to depths of 15 to 30-feet below the existing ground surface. Samples were obtained in general accordance with ASTM D-1586 utilizing a 2-inch OD split-barrel sampler or in general accordance with ASTM D-3550 utilizing a 2½-inch OD modified California sampler. An Explanation of Test Boring Logs is presented in Figure 3. The Test Boring Logs are presented in Figures 4 through 16.

**Laboratory Testing**

The moisture content for the recovered samples was obtained in the laboratory. Grain-size analysis, Atterberg Limits, and Denver Swell/Consolidation tests were performed on selected samples for purposes of classification and to develop pertinent engineering properties. A Summary of Laboratory Test Results is presented in Figure 17 (three pages). Soil Classification Data are presented in Figures 18 through 22. Swell/Consolidation Test Results are presented in Figures 23 through 27.

# SUBSURFACE CONDITIONS

**Subsurface Materials**

The subsurface materials encountered in the Test Borings are typical for this region of Colorado. The Dawson Formation is characterized by layers of alluvial soil of varying thickness overlying alternating layers of sandstone and claystone. The bedding of the soils is irregular and discontinuous and each soil profile was different in the arrangement of strata. In general the surficial soils were comprised of silty to clayey sand underlain by sandstone and claystone bedrock. The bedrock was encountered at the ground surface in some locations and at shallow depths across the site.

Subsurface soils encountered in the test borings classified in accordance with the Unified Soils Classification System (USCS) as native SM-SC, silty to clayey sand, SW-SM, well-graded sand with silt, and CL, sandy lean clay. The surficial soils exhibited almost no expansive characteristics, whereas the claystone exhibited low swell potential.

Additional descriptions and the interpreted distribution (approximate depths) of the subsurface materials are presented on the Test Boring Logs. The descriptions in the logs are based upon the engineer's visual classification of the samples at the depths indicated. Stratification lines shown on the logs represent the approximate boundaries between material types and the actual transitions may be gradual and vary with location.

**Groundwater**

Groundwater was observed in several of the test borings at the time of field exploration sporadically across the site. Depth to groundwater in the various Test Borings is presented in the table below. Fluctuations in groundwater and subsurface moisture conditions may occur due to variations in rainfall and other factors not readily apparent at this time. Depending upon depths of excavations, groundwater may be a factor in foundation construction. The Contractor should always be prepared to control groundwater during construction.

| Groundwater | |
|---|---|
| Test Boring | Depth Below Ground Surface (feet) |
| 1 | 27 |
| 5 | 14 |
| 14 | 14 |
| 16 | 28 |
| 19 | 14 |
| 23 | 19 |
| 25 | 19 |

# CONCLUSIONS AND RECOMMENDATIONS

The following discussion is based on the subsurface conditions encountered in the test borings and on the project characteristics previously described. If conditions are different from those described in this report or the project characteristics change, RMG should be retained to review our recommendations and adjust them, if necessary.

**Geotechnical Considerations**

Preliminary grading plans were not provided or reviewed by RMG at the time this report was issued. The relationship of existing ground surface where soil test borings were performed may differ from final grades, and this could affect the depth to groundwater and the depth to bedrock and / or expansive soil layers.

The site is generally characterized as surficial soils of medium dense silty and clayey sand overlying hard silty sandstone and medium hard weathered to formational claystone bedrock at varying depths. Sandstone was encountered at or near the ground surface in Test Borings 8, 13, 16, 22, and 25. Claystone was encountered at or near the ground surface in Test Borings 20 and 21.

Final site grading will determine the extent to which sandstone and claystone may affect foundation construction, but in general, if basement construction is proposed, overexcavation of bedrock may be anticipated. Claystone exhibited low expansion potential in laboratory testing, but as always a minimum of 3-feet separation from foundation elements should be anticipated. If sandstone is encountered, 12-inches of sandstone removal and replacement with structural fill may be necessary to ensure foundations bear upon soil of equal bearing capacity.

Foundation design considerations, based on the field investigation and laboratory testing, are presented below. It must be understood that these considerations should be verified after the excavation for individual structures is completed.

**Overexcavation and Replacement**

The claystone at this site exhibited low swell potential and should not be considered suitable for direct bearing of shallow foundations. Where claystone is encountered under building sites a minimum 3-foot of separation from foundation components and floor slabs may be necessary to provide stable support. Based on our preliminary investigation, we anticipate that overexcavation of cohesive soils will be required for stiffened slab-on-grade foundations on approximately 41 lots and for basement foundations on approximately 131 lots as demonstrated in Figures 2-1 and 2-2.

If loose soils are encountered, they may require additional compaction to achieve the allowable bearing capacity indicated in this report. Structures should not be supported atop soil/bedrock of significantly different bearing capacities such as silty sand and sandstone bedrock. Where any portion of a structure is to be supported atop compacted structural fill, the remaining portions of the excavation should have the top 12-inches of exposed sandstone scarified and compacted, or removed and replaced with structural fill.

## Open Excavation Observations

During construction, foundation excavations should be observed by RMG prior to placing structural fill, forms, or concrete to verify the foundation bearing conditions for each structure. Based on the conditions observed in the foundation excavation, the recommendations made at the time of construction may vary from those contained herein. In the case of differences, the Open Excavation Observation report shall be considered to be the governing document. The recommendations presented herein are intended only as preliminary guidelines to be used for interpreting the subsurface soil conditions exposed in the excavation and determining the final recommendations for foundation construction.

## Proposed Grading, Cuts and Masses of Fill

Preliminary grading plans were not provided or reviewed by RMG at the time the report was issued. Based on the test borings for this investigation soils that will be encountered include native silty and clayey sand, silty sandstone, and claystone. The on-site sand soils can generally be used as site grading fill or structural fill. Any clay or claystone encountered is not recommended for use as structural fill or for use as site grading fill in areas that will be below or directly adjacent to the proposed structures. Prior to placement of overlot fill or removal and recompaction of the existing materials, topsoil, fill and organic matter should be removed from fill areas. The subgrade should be scarified and moisture conditioned to within 2% of the optimum moisture content and recompacted to the same degree as the overlying fill to be placed. The placement and compaction of fill should be periodically observed and tested by a representative of RMG during construction.

- ***Guideline Site Grading Specifications are included in the Appendix A.***

## Anticipated Foundation Concepts

Final grades as they relate to the top of soil test borings were not available at the time this report was prepared. The in situ site soil encountered in the test borings is generally suitable to support conventional shallow foundation systems consisting of standard spread footings/stemwalls or stiffened slabs. Alternative foundation systems are not anticipated. It is assumed that the deepest excavation cuts will be approximately 6 to 8 feet below the final ground surface, not including overexcavation or subexcavation which may be required. The native silty sand is generally suitable as structural fill when prepared in accordance with recommendations herein.

<u>Foundations in general</u>
Structures should not be supported atop soils and bedrock of significantly different bearing capacities. Formational sandstone bedrock for instance, if encountered at bottom of footing grade, should be overexcavated 12-inches and either recompacted or replaced with structural fill.

The foundation system for each proposed structure should be designed based upon recommendations developed in a detailed Subsurface Soil Investigation completed after overlot grading and site development activities are complete. The results presented in this Preliminary Subsurface Soils Investigation should be verified following the excavation for each structure and evaluation of the building loads.

The allowable bearing pressures to be used for design of foundation components should be determined by a detailed site specific Subsurface Soils Investigation. An allowable bearing pressure of 2,500 psf is anticipated for the native granular, non-expansive soils or imported structural fill compacted as indicated

herein. The foundation design should be prepared by a qualified Colorado Registered Professional Engineer using the recommendations presented in this report. Bottoms of foundations should be at least 30 inches below finished grade for frost protection. Settlements of 1-inch or less overall and ½-inch or less differential may be anticipated. Settlement in granular soil will occur immediately upon construction loads. Long term consolidation settlement is not anticipated.

Foundation and basement walls should be designed to resist lateral pressures. For granular, non-expansive soils used as exterior backfill around foundations, an equivalent fluid pressure (EFP) of 40 pcf may be used for design in addition to any lateral pressure from high groundwater conditions. Expansive soils as exterior backfill around foundations should typically be avoided. However, if the client elects to use expansive soils (claystone bedrock is not recommended) as backfill against foundation walls, higher lateral pressures should be anticipated. The lateral pressures presented herein apply to level, drained backfill conditions. Lateral pressures for sloping/undrained conditions or for expansive backfill soils should be determined on an individual basis.

Stiffened Slab-on-grade Foundations

The native silty sand soil is suitable for stiffened slab-on-grade foundations. When site soil is properly prepared a maximum allowable bearing pressure of 2,500 psf may be used for design. Expansive soils should not be used beneath slabs-on-grade as the potential for swell can lead to slab movement and heaving and cracking of slabs.

**Floor Slabs**

Floor slabs should be supported on 12-inches of structural fill to control slab movement due to potential moisture changes in the supporting soil. Structural fill material for support of the floor slab should be placed in 6-inch loose lifts near optimum moisture content and compacted to 95 percent of Standard Proctor maximum dry density (ASTM D698). To provide uniform support and to aid controlling moisture consideration may be given to installing 4-inches of free-draining gravel beneath concrete slabs. Depending upon interior floor finish, the use of a vapor retarding barrier over the gravel may be considered. Floor slabs should be separated from all bearing walls, columns, mechanical equipment and piping with an expansion joint that allows unrestrained vertical movement. Contraction joints should be placed in the slab in accordance with American Concrete Institute (ACI) guidelines.

**Structural Fill - General**

Areas to receive structural fill should have topsoil, organic material, or debris removed. The upper 6 inches of the exposed surface soils should be scarified and moisture conditioned to facilitate compaction (usually within 2 percent of the optimum moisture content) and compacted to a minimum of 95 percent of the maximum dry density as determined by the Modified Proctor test (ASTM D-1557) prior to placing structural fill.

Structural fill shall consist of granular, non-expansive material. It should be placed in loose lifts not exceeding 10-inches, moisture conditioned to facilitate compaction (usually within 2 percent of the optimum moisture content) and compacted to a minimum of 95 percent of the maximum dry density as determined by the Modified Proctor test, ASTM D-1557. The materials should be compacted by mechanical means.

Structural fill placed on slopes should be benched into the slope. Maximum bench heights should not exceed 4 feet, and bench widths should be wide enough to accommodate compaction equipment.

Structural fill should not be placed on frozen subgrade or allowed to freeze during moisture conditioning and placement. The on-site clay soils are not recommended for use as structural fill below foundation components.

**Foundations Drains**

A subsurface perimeter drain is recommended around portions of the structure which will have habitable or storage space located below the finished ground surface. This includes crawlspace areas but not walkout trenches, if applicable. Groundwater encountered during the subsurface investigation was intermittent in the borings and showed at 14 to 29 feet below existing ground surface where present. Depending on the conditions encountered during the lot specific Subsurface Soils Investigation and the conditions observed at the time of the Open Excavation Observation, additional subsurface drainage systems may be recommended.

One such system is an underslab drainage layer to help intercept groundwater before it enters the slab area should the groundwater levels rise. In general, if groundwater was encountered within 4 to 6 feet of the proposed basement slab elevation, an underslab drain should be anticipated. Another such system would consist of a subsurface drain and/or vertical drain board placed around the perimeter of the overexcavation to help intercept groundwater and allow for proper placement and compaction of the replacement structural fill. Careful attention should be paid to grade and discharge of the drain pipes of these systems.

Drain systems are designed to intercept some types of subsurface moisture and not others. Therefore, the drains could operate properly and not mitigate all moisture problems relating to foundation performance or moisture intrusion into the basement area.

**Surface Grading and Drainage**

The ground surface should be sloped from the building with a minimum gradient of 10 percent for the first 10 feet. This is equivalent to 12 inches of fall across this 10-foot zone. If a 10-foot zone is not possible on the upslope side of the structure, then a well-defined swale should be created a minimum 5 feet from the foundation and sloped parallel with the wall with a minimum slope of 2 percent to intercept the surface water and transport it around and away from the structure. Roof drains should extend across backfill zones and landscaped areas to a region that is graded to direct flow away from the structure. Owners should maintain the surface grading and drainage recommended in this report to help prevent water from being directed toward and/or ponding near the foundations.

Landscaping should be selected to reduce irrigation requirements. Plants used close to foundation walls should be limited to those with low moisture requirements and irrigated grass should not be located within 5 feet of the foundation. To help control weed growth, geotextiles should be used below landscaped areas adjacent to foundations. Impervious plastic membranes are not recommended.

Irrigation devices should not be placed within 5 feet of the foundation. Irrigation should be limited to the amount sufficient to maintain vegetation. Application of more water will increase the likelihood of slab and foundation movements.

The recommendations listed in this report are intended to address normal surface drainage conditions, assuming the presence of groundcover (established vegetation, paved surfaces, and/or structures)

throughout the regions upslope from this structure. However, groundcover may not be present due to a variety of factors (ongoing construction/development, wildfires, etc.). During periods when groundcover is not present in the "upslope" regions, higher than normal surface drainage conditions may occur, resulting in perched water tables, excess runoff, flash floods, etc. In these cases, the surface drainage recommendations presented herein (even if properly maintained) may not mitigate all groundwater problems or moisture intrusion into the structure. We recommend that the site plan be prepared with consideration of increased runoff during periods when groundcover is not present on the upslope areas.

**Concrete**

Type I/II cement is recommended for concrete in contact with the subsurface materials. Calcium chloride should be used with caution for soils with high sulfate contents. The concrete should not be placed on frozen ground. If placed during periods of cold temperatures, the concrete should be kept from freezing. This may require covering the concrete with insulated blankets and heating. Concrete work should be completed in accordance with the latest applicable guidelines and standards published by ACI.

**Exterior Backfill**

Backfill should be placed in loose lifts not exceeding 8 to 12 inches, moisture conditioned to facilitate compaction (usually within 2 percent of the optimum moisture content) and compacted to 85 percent of the maximum dry density as determined by the Modified Proctor test, ASTM D-1557 on exterior sides of walls in landscaped areas. In areas where backfill supports pavement and concrete flatwork, the materials should be compacted to 95 percent of the maximum dry density.

Fill placed on slopes should be benched into the slope. Maximum bench heights should not exceed 4 feet, and bench widths should be wide enough to accommodate compaction equipment. The backfill should not be placed on frozen subgrade or allowed to freeze during moisture conditioning and placement. Backfill should be compacted by mechanical means, and foundation walls should be braced during backfilling and compaction.

# BURIED UTILITIES

Based upon the conditions encountered in the exploratory test borings, we anticipate that the soils encountered in the individual utility trench excavations will consist of native silty to clayey sand sandy lean clay, silty sandstone and sandy claystone. It is anticipated that the sand and sandstone will be encountered at loose to hard relative densities and the clays and claystone at stiff to hard consistencies.

We believe the sand and sandstone will classify as Type C materials and the clay and claystone will classify as Type B materials as defined by OSHA in 29 CFR Part 1926. OSHA requires that temporary excavations made in Type B and C materials be laid back at ratios no steeper than 1:1 (horizontal to vertical) and 1½:1 (horizontal to vertical), respectively, unless the excavation is shored and braced. Excavations deeper than 20 feet, or when water is present, should always be braced or the slope designed by a professional engineer.

Utility mains such as water and sanitary sewer lines are typically placed beneath paved roadways. The settlement of the utility trench backfill can have a detrimental effect on pavements and roadway

surfaces. We recommend that utility trench backfill be placed in thin loose lifts, moisture conditioned as required and compacted to the recommendations outlined in the **Structural Fill** section of this report. The placement and compaction of utility trench backfill should be observed and tested by a representative of RMG Engineers during construction. Use of "flowable fill," (i.e., a controlled low strength material (CLSM), or a similar material) should be considered in lieu of compacted soil backfill for areas with low tolerances for surface settlements in deep excavations and areas with difficult access.

It is a common local practice for underdrains to be placed at the bottom of sanitary sewer trenched within drive lanes. Underdrains placed in the sanitary sewer trenches in areas where groundwater is anticipated will likely be the "active" type, which uses a perforated drain pipe. In areas where groundwater is not anticipated, "passive" type underdrains may be used. The outfall for the sanitary sewer trench underdrain was not known at the time of this investigation because the development plan and grading plan were not available for our review.

# PRELIMINARY PAVEMENT RECOMMENDATIONS

Roadway plans had not been provided at the time of the report issue date. However, roadways throughout the proposed development are anticipated to be classified mainly as Local in accordance with the Colorado Springs Engineering Criteria Manual. The actual pavement section design for individual streets will be completed following overlot grading and installation of utilities. A site specific pavement design should be conducted to determine the design pavement sections for the proposed roadways.

# ADDITIONAL STUDIES

The findings, conclusions and recommendations presented in this report were provided to evaluate the suitability of the site for future development. Unless indicated otherwise, the test borings, laboratory test results, conclusions and recommendations presented in this report are not intended for use for design and construction. **We recommend that a site specific Subsurface Soil Investigation be performed for all proposed structures including (but not limited to) residences, community or common buildings, retaining walls and pumphouses, commercial buildings, etc.**

To develop recommendations for construction of the proposed roadways, a pavement design investigation should be performed. This investigation should consist of additional test borings, soil laboratory testing and specific recommendations for the design and construction of roadway pavement sections.

# CLOSING

This report has been prepared for the exclusive purpose of providing geotechnical engineering information and recommendations for development described in this report. RMG should be retained to review the final construction documents prior to construction to verify our findings, conclusions and recommendations have been appropriately implemented.

This report has been prepared for the exclusive use by **Challenger Colorado, LLC** for application as an aid in the design and construction of the proposed development in accordance with generally accepted geotechnical engineering practices. The analyses and recommendations in this report are based in part

upon data obtained from test borings, site observations and the information presented in referenced reports. The nature and extent of variations may not become evident until construction. If variations then become evident, RMG should be retained to review the recommendations presented in this report considering the varied condition, and either verify or modify them in writing.

Our professional services were performed using that degree of care and skill ordinarily exercised, under similar circumstances, by geotechnical engineers practicing in this or similar localities. RMG does not warrant the work of regulatory agencies or other third parties supplying information which may have been used during the preparation of this report. No warranty, express or implied is made by the preparation of this report. Third parties reviewing this report should draw their own conclusions regarding site conditions and specific construction techniques to be used on this project.

The scope of services for this project does not include, either specifically or by implication, environmental assessment of the site or identification of contaminated or hazardous materials or conditions. Development of recommendations for the mitigation of environmentally related conditions, including but not limited to biological or toxicological issues, are beyond the scope of this report. If the Client desires investigation into the potential for such contamination or conditions, other studies should be undertaken.

If we can be of further assistance in discussing the contents of this report or analysis of the proposed development, from a geotechnical engineering point-of-view, please feel free to contact us.

# FIGURES


REFERENCE
NOT TO SCALE

ARCHITECTS RMG ENGINEERS
ROCKY MOUNTAIN GROUP

*Southern Office*
Colorado Springs,CO
80918
(719) 548-0600
*Central Office:*
Englewood, CO 80112
(303) 688-9475
*Northern Office:*
Greeley / Evans, CO 80620
(970) 330-1071

# SITE VICINITY MAP

PRELIMINARY SUBSURFACE SOILS
INVESTIGATION
BENT GRASS, FILING NO. 2
EL PASO COUNTY, CO
CHALLENGER COLORADO, LLC

JOB No. 169845

FIG No. 1

DATE 5-14-2019


NOT TO SCALE

DENOTES APPROXIMATE LOCATION OF TEST BORINGS

JOB No. 169845

ARCHITECTS RMG ENGINEERS
ROCKY MOUNTAIN GROUP

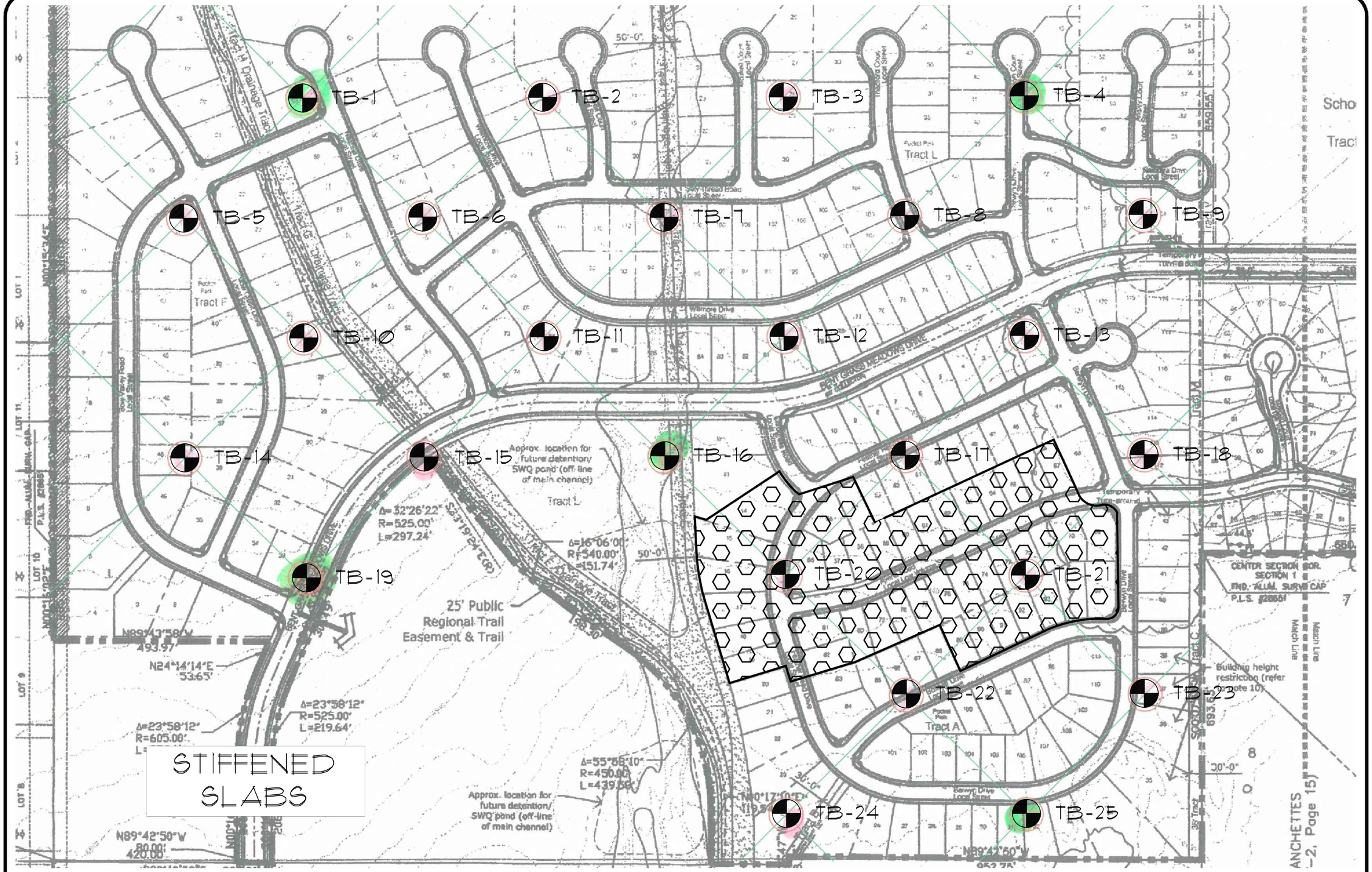
*Southern Office*
Colorado Springs, CO
80918
(719) 548-0600
*Central Office:*
Englewood, CO 80112
(303) 688-9475
*Northern Office:*
Greeley / Evans, CO 80620
(970) 330-1071
*Woodland Park Office:*
(719) 687-6077
*Monument Office:*
(719) 488-2145
*Pueblo / Canon City:*
(719) 544-7750

PRELIMINARY SUBSURFACE SOILS INVESTIGATION
THE MEADOWS, FILING NO. 3
EL PASO COUNTY, CO
CHALLENGER COLORADO, LLC

| | |
|---|---|
| ENGINEER: | CR |
| DRAWN BY: | BG |
| CHECKED BY: | CR |
| ISSUED: | 5-14-19 |
| REVISION: | DATE: / JOB #: |
| REVISION: | |
| REVISION: | |

TEST BORING LOCATION PLAN

SHEET No.
FIG-2




AREAS WHERE IT IS ANTICIPATED THAT OVEREXCAVATION WILL BE REQUIRED FOR COHESIVE SOILS WITHIN 3 FEET OF STIFFENED SLAB-ON-GRADE FOUNDATION COMPONENTS

41 LOTS IMPACTED

DENOTES APPROXIMATE LOCATION OF TEST BORINGS

NOT TO SCALE

JOB No. 169845


ARCHITECTS RMG ENGINEERS

ROCKY MOUNTAIN GROUP

*Southern Office*
Colorado Springs, CO 80918
(719) 548-0600
*Central Office:*
Englewood, CO 80112
(303) 688-9475
*Northern Office:*
Greeley / Evans, CO 80620
(970) 330-1071
*Woodland Park Office:*
(719) 687-6077
*Monument Office:*
(719) 488-2145
*Pueblo / Canon City:*
(719) 544-7750


PRELIMINARY SUBSURFACE SOILS INVESTIGATION
THE MEADOWS, FILING NO. 3
EL PASO COUNTY, CO
CHALLENGER COLORADO, LLC

| | |
|---|---|
| ENGINEER: | GW |
| DRAWN BY: | BG |
| CHECKED BY: | GW |
| ISSUED: | 5-14-19 |
| | 8-6-19 |
| REVISION: | 169645 |
| | |
| | |

ANTICIPATED OVEREXCAVATION AREAS - STIFFENED SLABS

SHEET No.
FIG-2-1

# BASEMENTS

TB-1 TB-2 TB-3 TB-4 TB-5 TB-6 TB-7 TB-8 TB-9 TB-10 TB-11 TB-12 TB-13 TB-14 TB-15 TB-16 TB-17 TB-18 TB-19 TB-20 TB-21 TB-22 TB-23 TB-24 TB-25

AREAS WHERE IT IS ANTICIPATED THAT OVEREXCAVATION WILL BE REQUIRED FOR COHESIVE SOILS WITHIN 3 FEET OF BASEMENT FOUNDATION COMPONENTS

131 LOTS IMPACTED

DENOTES APPROXIMATE LOCATION OF TEST BORINGS

NOT TO SCALE

JOB No. 169845


ARCHITECTS RMG ENGINEERS

ROCKY MOUNTAIN GROUP

*Southern Office*
Colorado Springs, CO
80918
(719) 548-0600
*Central Office:*
Englewood, CO 80112
(303) 688-9475
*Northern Office:*
Greeley / Evans, CO 80620
(970) 330-1071
*Woodland Park Office:*
(719) 687-6077
*Monument Office:*
(719) 488-2145
*Pueblo / Canon City:*
(719) 544-7750


PRELIMINARY SUBSURFACE SOILS INVESTIGATION
THE MEADOWS, FILING NO. 3
EL PASO COUNTY, CO
CHALLENGER COLORADO, LLC

| | |
|---|---|
| ENGINEER: | GW |
| DRAWN BY: | BG |
| CHECKED BY: | GW |
| ISSUED: | 5-14-19 |
| | 8-6-19 |
| REVISION: | 169645 |

ANTICIPATED OVEREXCAVATION AREA - BASEMENTS

SHEET No.
FIG-2-2

# SOILS DESCRIPTION


CLAYEY SAND


CLAYSTONE


SANDSTONE


SANDY CLAY


SILTY SAND


SILTY TO CLAYEY SAND

UNLESS NOTED OTHERWISE, ALL LABORATORY
TESTS PRESENTED HEREIN WERE PERFORMED BY:
RMG - ROCKY MOUNTAIN GROUP
2910 AUSTIN BLUFFS PARKWAY
COLORADO SPRINGS, COLORADO

# SYMBOLS AND NOTES


XX — STANDARD PENETRATION TEST - MADE BY DRIVING A SPLIT-BARREL SAMPLER INTO THE SOIL BY DROPPING A 140 LB. HAMMER 30", IN GENERAL ACCORDANCE WITH ASTM D-1586. NUMBER INDICATES NUMBER OF HAMMER BLOWS PER FOOT (UNLESS OTHERWISE INDICATED).


XX — UNDISTURBED CALIFORNIA SAMPLE - MADE BY DRIVING A RING-LINED SAMPLER INTO THE SOIL BY DROPPING A 140 LB. HAMMER 30", IN GENERAL ACCORDANCE WITH ASTM D-3550. NUMBER INDICATES NUMBER OF HAMMER BLOWS PER FOOT (UNLESS OTHERWISE INDICATED).


FREE WATER TABLE


DEPTH AT WHICH BORING CAVED


BULK — DISTURBED BULK SAMPLE


AUG — AUGER "CUTTINGS"

4.5 — WATER CONTENT (%)

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

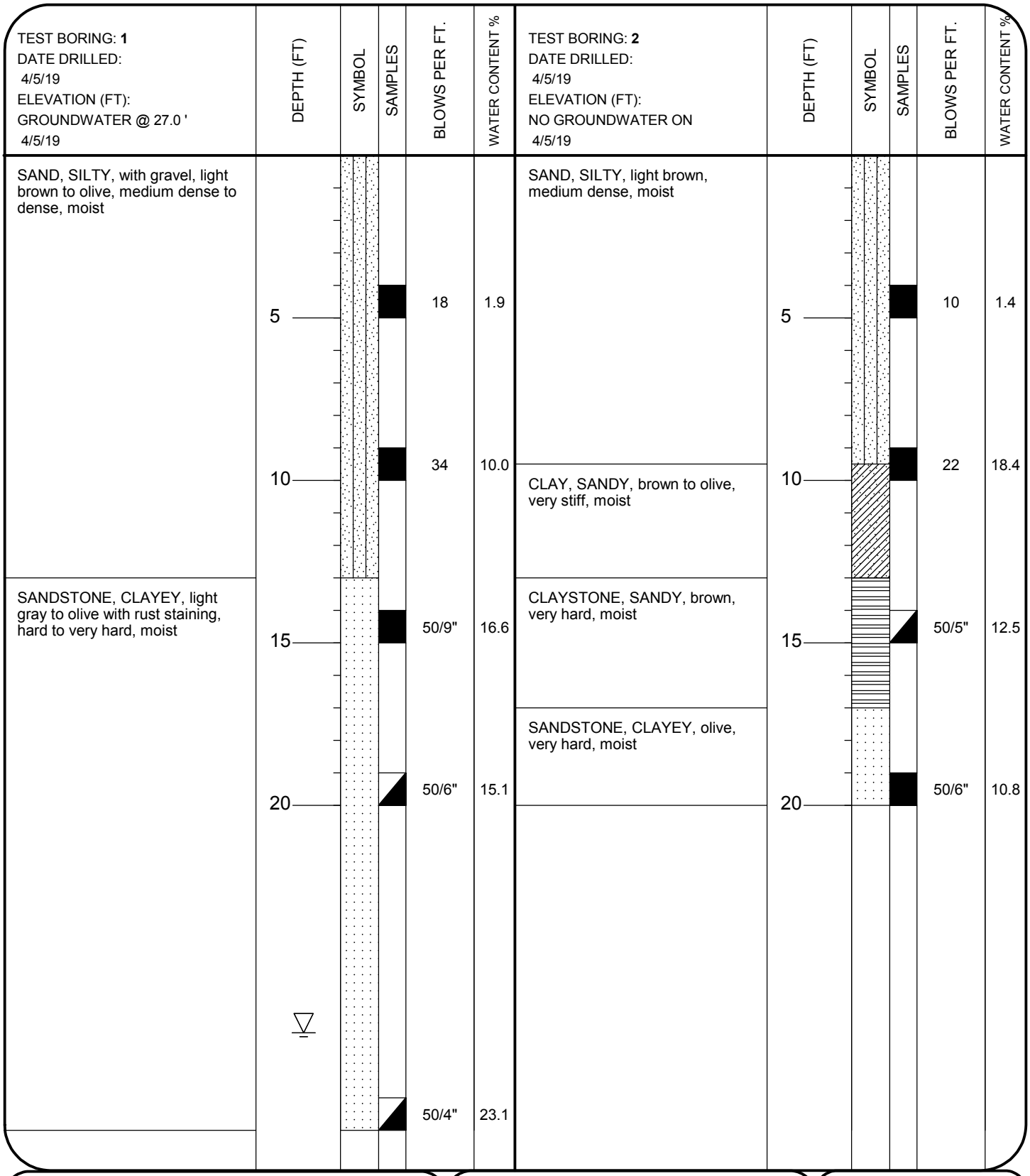
*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

**EXPLANATION OF TEST BORING LOGS**

JOB No. 169845

FIGURE No. 3

DATE 5/14/19




ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

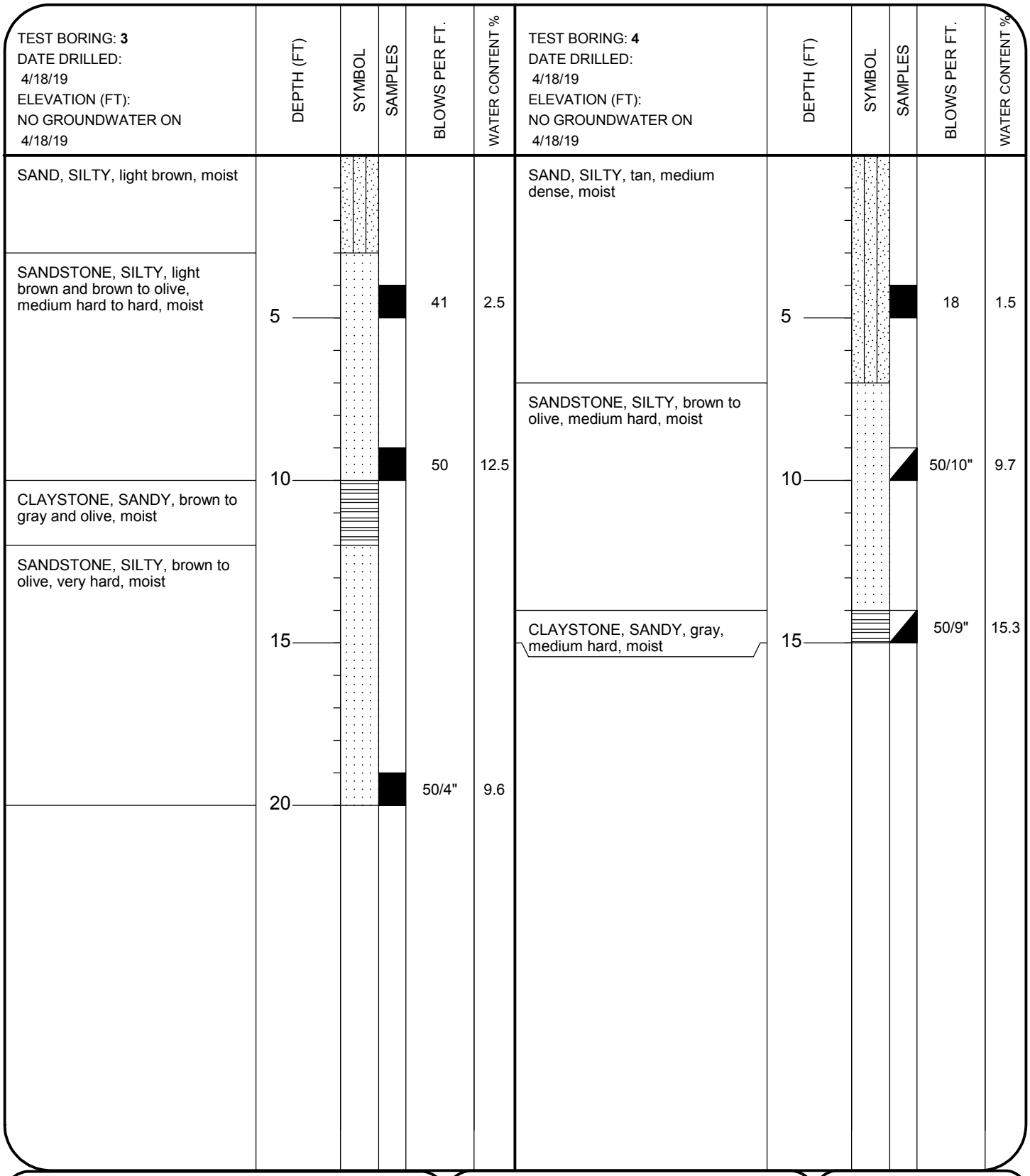
Colorado Springs: (Corporate Office)
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# TEST BORING LOG

JOB No. 169845

FIGURE No. 4

DATE 5/14/19




ROCKY MOUNTAIN GROUP

ARCHITECTS RMG ENGINEERS

Architectural
Structural
Forensics

Geotechnical
Materials Testing
Civil, Planning

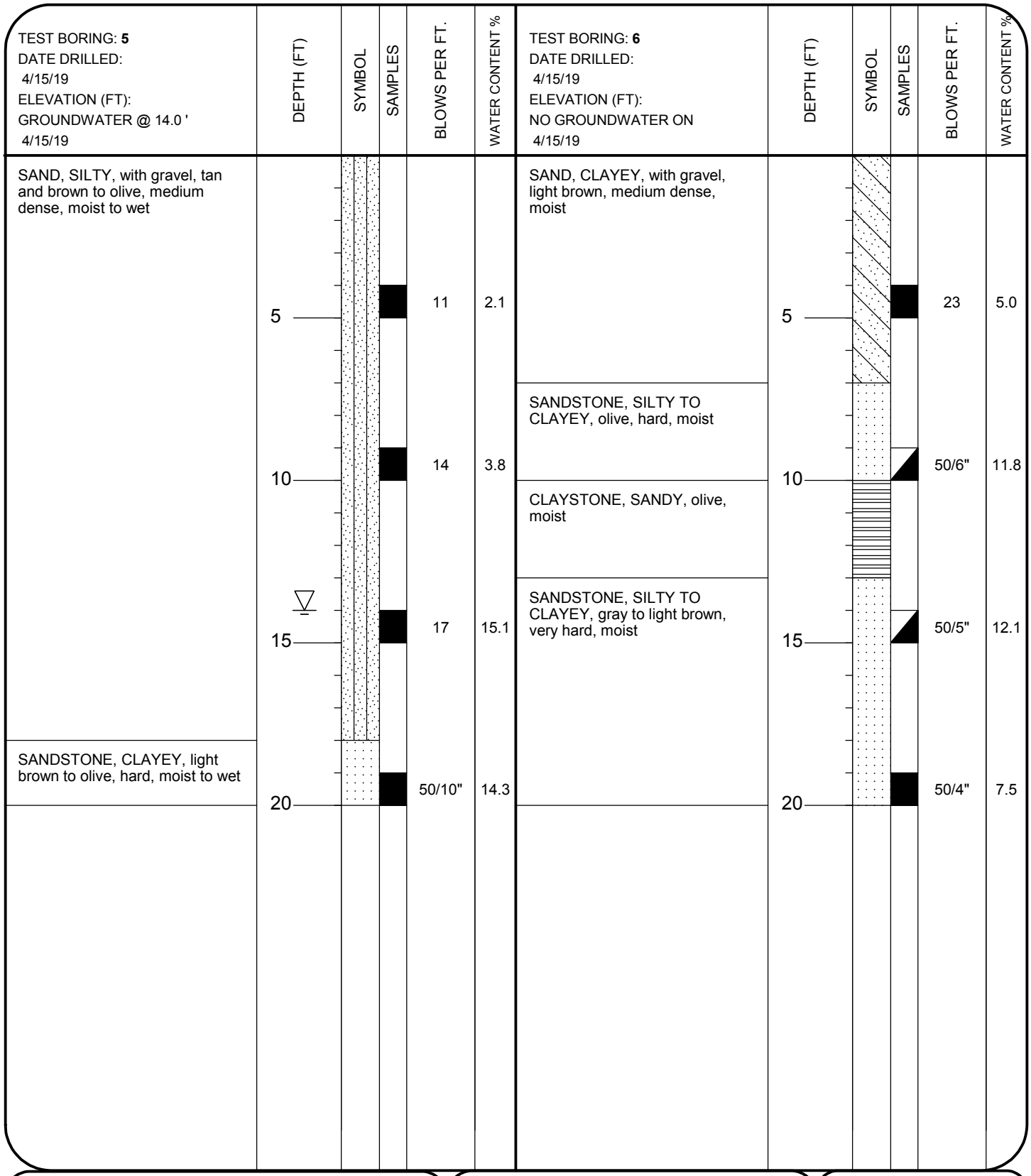
*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# TEST BORING LOG

JOB No. 169845

FIGURE No. 5

DATE 5/14/19




ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

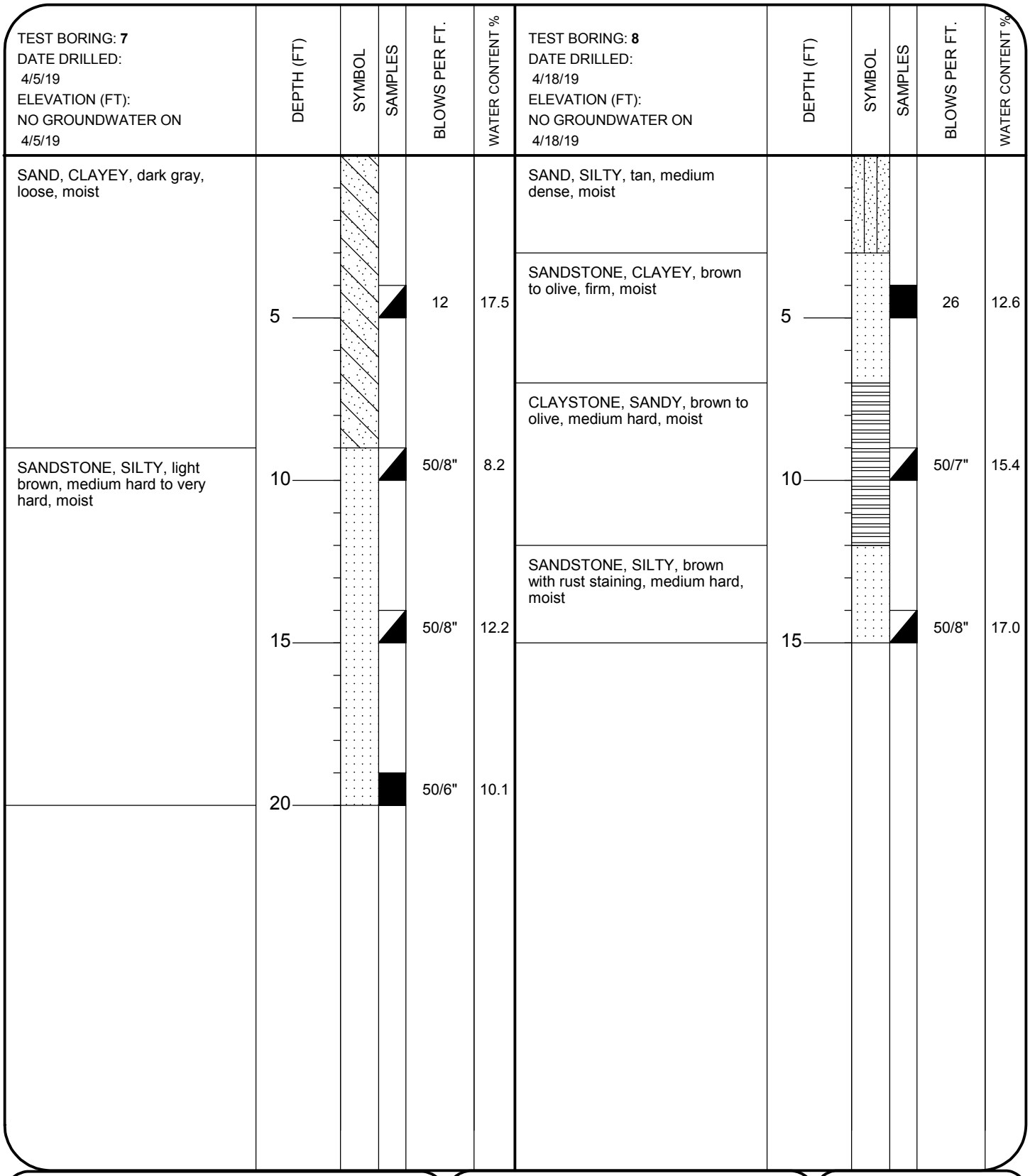

*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO


# TEST BORING LOG

JOB No. 169845

FIGURE No. 6

DATE 5/14/19




ROCKY MOUNTAIN GROUP

ARCHITECTS RMG ENGINEERS

Architectural
Structural
Forensics

Geotechnical
Materials Testing
Civil, Planning

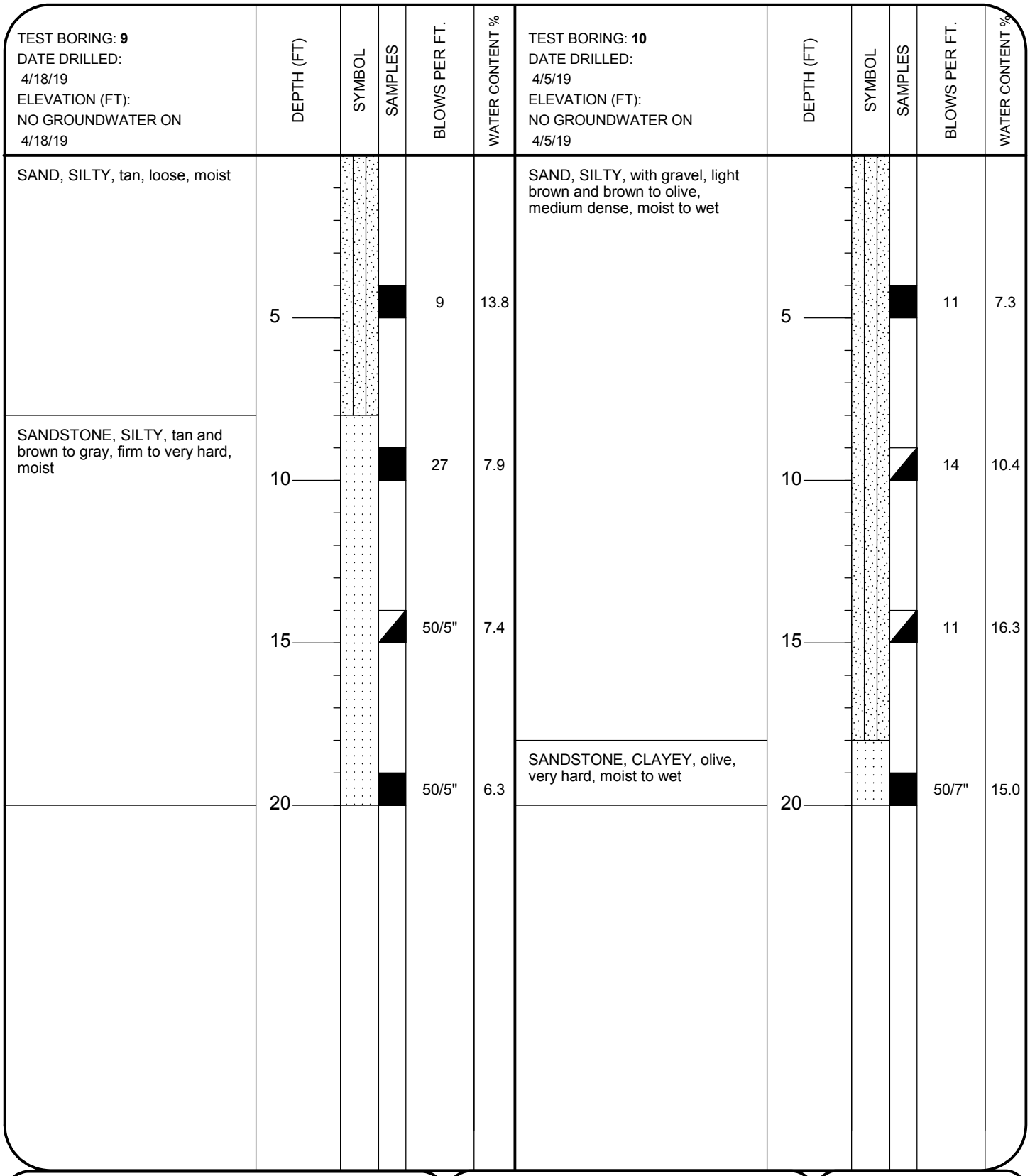
*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# TEST BORING LOG

JOB No. 169845

FIGURE No. 7

DATE 5/14/19




ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# TEST BORING LOG

JOB No. 169845

FIGURE No. 8

DATE 5/14/19

TEST BORING: **11**
DATE DRILLED:
4/5/19
ELEVATION (FT):
NO GROUNDWATER ON
4/5/19

| DEPTH (FT) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|
| | SAND, SILTY TO CLAYEY, tan to olive, loose, moist | | | |
| 5 | | | 13 | 19.6 |
| | SANDSTONE, CLAYEY, brown to olive with rust staining, medium hard, moist | | | |
| 10 | | | 50/7" | 16.5 |
| | CLAYSTONE, SANDY, brown to gray and olive with rust staining, medium hard, moist | | | |
| 15 | | | 50/7" | 14.1 |
| | SANDSTONE, CLAYEY, gray, very hard, moist | | | |
| 20 | | | 50/6" | 9.1 |

TEST BORING: **12**
DATE DRILLED:
4/18/19
ELEVATION (FT):
NO GROUNDWATER ON
4/18/19

| DEPTH (FT) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|
| | SAND, SILTY, tan, medium dense, moist | | | |
| 5 | | | 15 | 2.5 |
| | SANDSTONE, SILTY TO CLAYEY, brown to gray, hard to very hard, moist | | | |
| 10 | | | 50/11" | 9.0 |
| 15 | | | | |
| 20 | | | 50/4" | -- |


ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

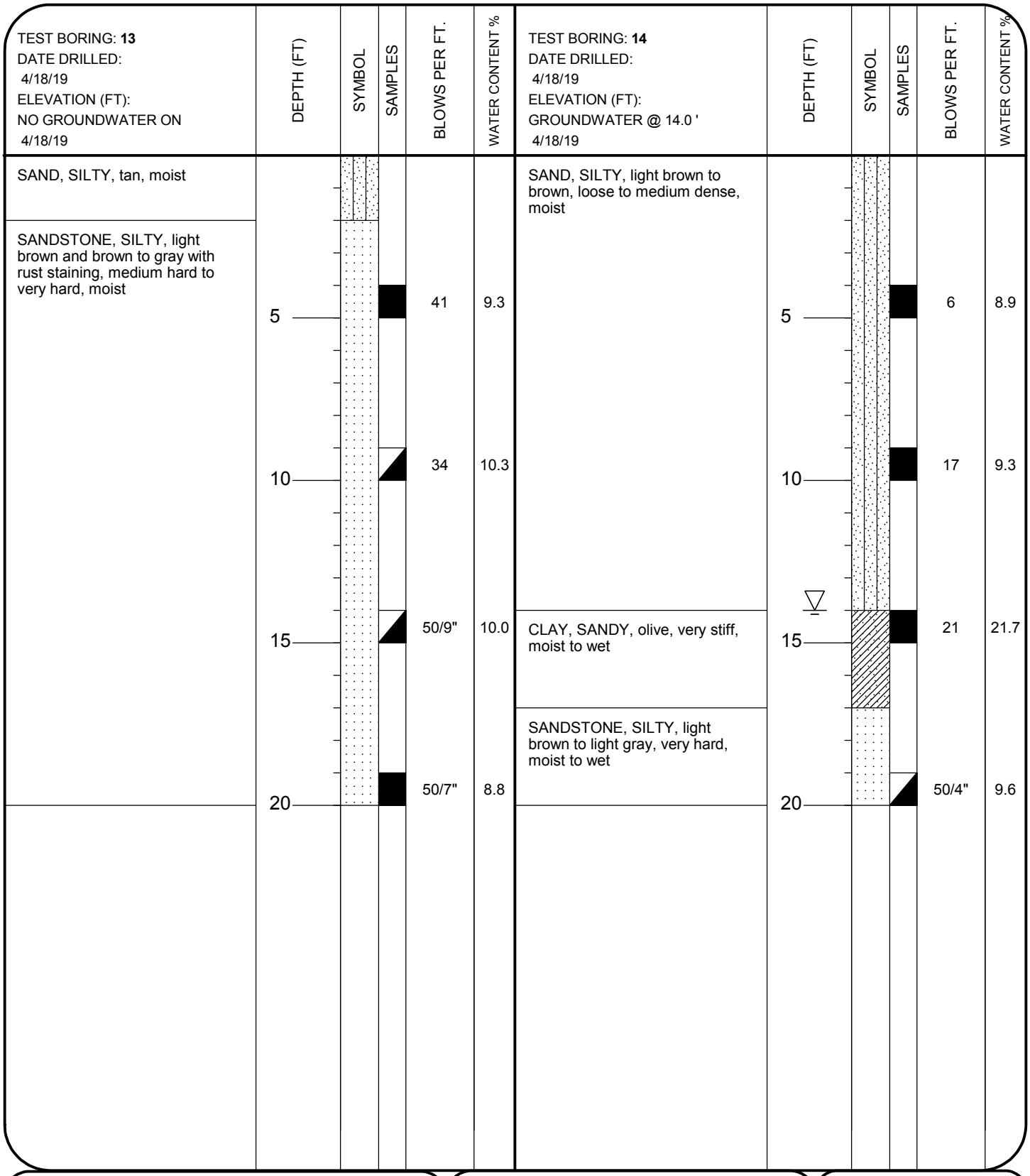
*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO


# TEST BORING LOG

JOB No. 169845

FIGURE No. 9

DATE 5/14/19




ROCKY MOUNTAIN GROUP

ARCHITECTS RMG ENGINEERS

Architectural
Structural
Forensics

Geotechnical
Materials Testing
Civil, Planning

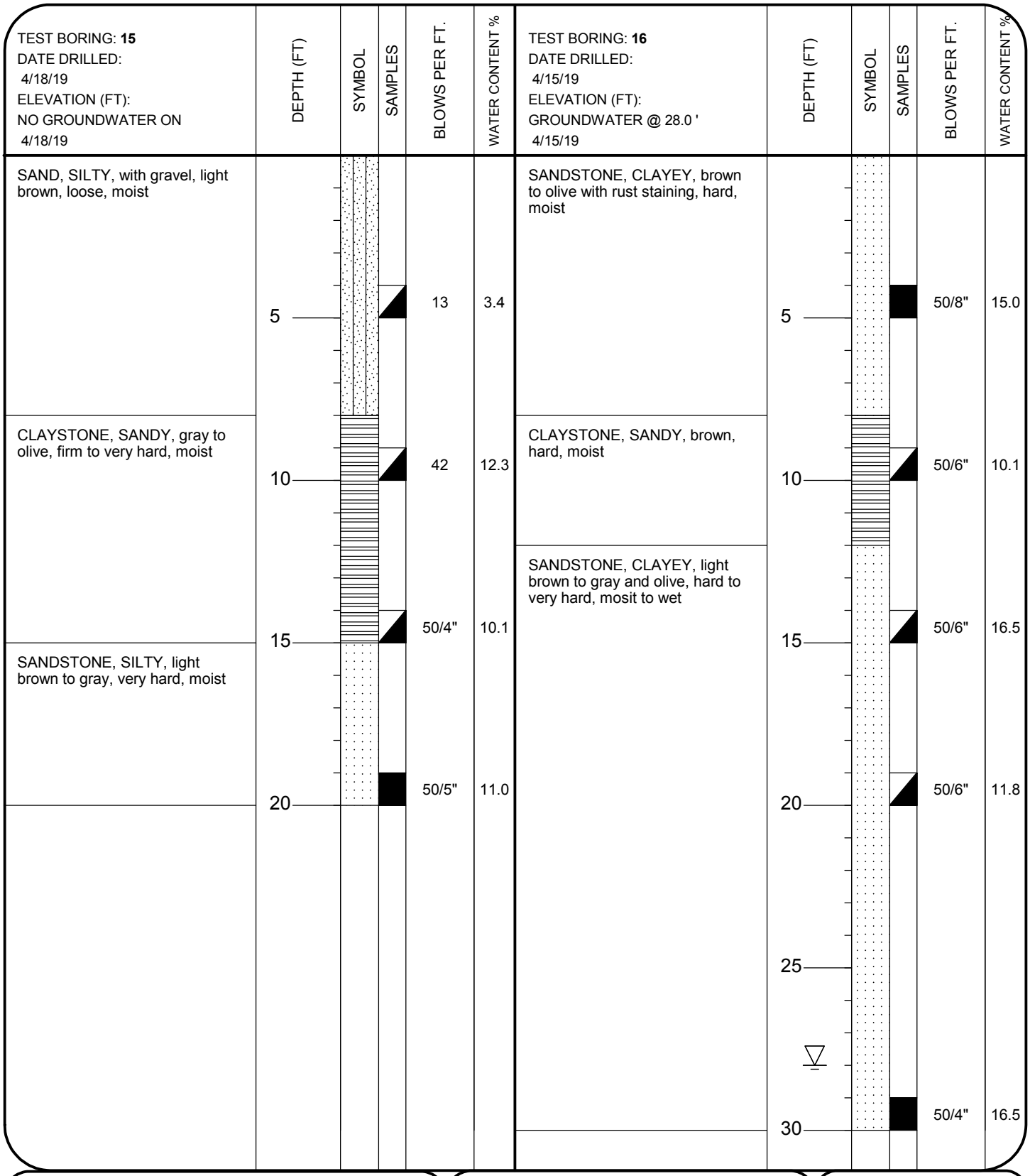
Colorado Springs: (Corporate Office)
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# TEST BORING LOG

JOB No. 169845

FIGURE No. 10

DATE 5/14/19




ROCKY MOUNTAIN GROUP

ARCHITECTS RMG ENGINEERS

Architectural
Structural
Forensics

Geotechnical
Materials Testing
Civil, Planning

Colorado Springs: (Corporate Office)
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# TEST BORING LOG

JOB No. 169845

FIGURE No. 11

DATE 5/14/19

| TEST BORING: **17**<br>DATE DRILLED:<br>4/18/19<br>ELEVATION (FT):<br>NO GROUNDWATER ON<br>4/18/19 | DEPTH (FT) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|---|
| SAND, SILTY, tan to brown, medium dense, moist | 5 | | | 24 | 5.0 |
| SANDSTONE, SILTY TO CLAYEY, gray to olive, medium hard, moist | 10 | | | 50/8" | 10.0 |
| | 15 | | | | |

| TEST BORING: **18**<br>DATE DRILLED:<br>4/18/19<br>ELEVATION (FT):<br>NO GROUNDWATER ON<br>4/18/19 | DEPTH (FT) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|---|
| SAND, SILTY, tan, medium dense, moist | 5 | | | 30 | 2.9 |
| SANDSTONE, SILTY, brown to olive, firm to hard, moist | 10 | | | 13/6" | 8.4 |
| | 15 | | | 50/6" | 18.3 |
| SANDSTONE, CLAYEY, light brown, hard, moist | 20 | | | 50/9" | 9.6 |


ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO


# TEST BORING LOG

JOB No. 169845

FIGURE No. 12

DATE 5/14/19

TEST BORING: **19**
DATE DRILLED:
4/18/19
ELEVATION (FT):
GROUNDWATER @ 14.0 '
4/18/19

| DEPTH (FT) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|
| | SAND, SILTY, with gravel, tan, medium dense, moist | | | |
| 5 | | | 25 | 3.3 |
| 10 | | | 25 | 4.6 |
| | | ▽ | | |
| 15 | SANDSTONE, CLAYEY, light brown to olive, medium hard, moist to wet | | 50/11" | 10.6 |
| 20 | CLAYSTONE, SANDY, gray to olive, medium hard, moist to wet | | 35 | 15.7 |
| | SANDSTONE, CLAYEY, light brown to olive, hard, moist to wet | | | |
| 25 | | | 50/6" | 15.2 |

TEST BORING: **20**
DATE DRILLED:
4/18/19
ELEVATION (FT):
NO GROUNDWATER ON
4/18/19

| DEPTH (FT) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|
| | CLAYSTONE, SANDY, olive, medium hard, moist | | | |
| 5 | | | 50/11" | 14.6 |
| | SANDSTONE, CLAYEY, light brown to olive, medium hard to very hard, moist | | | |
| 10 | | | 50/8" | 15.5 |
| 15 | | | 50/5" | 8.3 |
| 20 | | | 50/6" | 10.0 |


ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS
RMG
ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO


# TEST BORING LOG

JOB No. 169845

FIGURE No. 13

DATE 5/14/19

| TEST BORING: **21**<br>DATE DRILLED:<br>4/18/19<br>ELEVATION (FT):<br>NO GROUNDWATER ON<br>4/18/19 | DEPTH (FT) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|---|
| SAND, CLAYEY, with gravel, brown to olive, medium dense, moist | 5 | | | 28 | 7.4 |
| CLAYSTONE, SANDY, brown to olive, medium hard to hard, moist | 10 | | | 50/11" | 17.1 |
| | 15 | | | 50/6" | 12.1 |

| TEST BORING: **22**<br>DATE DRILLED:<br>4/18/19<br>ELEVATION (FT):<br>NO GROUNDWATER ON<br>4/18/19 | DEPTH (FT) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|---|
| SANDSTONE, SILTY TO CLAYEY, light brown to light gray, hard to very hard, moist | 5 | | | 50/9" | 6.3 |
| | 10 | | | 50/4" | 7.7 |
| | 15 | | | 50/4" | 9.2 |


ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO


# TEST BORING LOG

JOB No. 169845

FIGURE No. 14

DATE 5/14/19

TEST BORING: **23**
DATE DRILLED:
4/18/19
ELEVATION (FT):
GROUNDWATER @ 19.0 '
4/18/19

| DEPTH (FT) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|
| | SAND, CLAYEY, light brown, medium dense, moist | | | |
| 5 | | | 10 | 12.6 |
| | SANDSTONE, SILTY TO CLAYEY, with gravel, light brown to light gray and gray, hard to very hard, moist to wet | | | |
| 10 | | | 50/6" | 6.0 |
| 15 | | | 50/5" | 7.8 |
| | | | | |
| 20 | | | 50/3" | 14.0 |

TEST BORING: **24**
DATE DRILLED:
4/18/19
ELEVATION (FT):
NO GROUNDWATER ON
4/18/19

| DEPTH (FT) | SYMBOL | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|---|
| | SAND, SILTY, with gravel, tan, medium dense, moist | | | |
| 5 | | | 21 | 2.2 |
| | SANDSTONE, SILTY, light brown, medium hard to hard, moist | | | |
| 10 | | | 46 | 8.0 |
| 15 | | | 50/6" | 11.1 |


ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO


# TEST BORING LOG

JOB No. 169845

FIGURE No. 15

DATE 5/14/19

TEST BORING: **25**
DATE DRILLED:
4/3/19
ELEVATION (FT):
GROUNDWATER @ 19.0 '
4/3/19

| DEPTH (FT) | SAMPLES | BLOWS PER FT. | WATER CONTENT % |
|---|---|---|---|
| SANDSTONE, SILTY, light brown, hard to very hard, moist to wet | | | |
| 5 | | 50/10" | 6.7 |
| 10 | | 50/7" | 6.4 |
| 15 | | 50/7" | 9.7 |
| 20 ▽ | | 50/6" | 12.7 |
| CLAYSTONE, SANDY, dark gray, very hard, moist to wet | | | |
| 25 | | | |
| 30 | | 50/6" | 15.7 |


ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO


# TEST BORING LOG

JOB No. 169845

FIGURE No. 16

DATE 5/14/19

| Test Boring No. | Depth | Water Content (%) | Dry Density (pcf) | Liquid Limit | Plasticity Index | % Retained No.4 Sieve | % Passing No. 200 Sieve | FHA Expansion Pressure (psf) | % Swell/ Collapse | USCS Classification |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.0 | 1.9 | | | | | | | | |
| 1 | 9.0 | 10.0 | | NP | NP | 4.1 | 25.0 | | | SM |
| 1 | 14.0 | 16.6 | | | | | | | | |
| 1 | 19.0 | 15.1 | | | | | | | | |
| 1 | 29.0 | 23.1 | | | | | | | | |
| 2 | 4.0 | 1.4 | | | | | | | | |
| 2 | 9.0 | 18.4 | | | | | | | | |
| 2 | 14.0 | 12.5 | | 33 | 19 | 0.7 | 52.6 | | | CL |
| 2 | 19.0 | 10.8 | | | | | | | | |
| 3 | 4.0 | 2.5 | | | | | | | | |
| 3 | 9.0 | 12.5 | | NP | NP | 0.3 | 36.4 | | | SM |
| 3 | 19.0 | 9.6 | | | | | | | | |
| 4 | 4.0 | 1.5 | | | | | | | | |
| 4 | 9.0 | 9.7 | | NP | NP | 3.9 | 13.8 | | | SM |
| 4 | 14.0 | 15.3 | | | | | | | | |
| 5 | 4.0 | 2.1 | | | | | | | | |
| 5 | 9.0 | 3.8 | | NP | NP | 9.0 | 6.2 | | | SW-SM |
| 5 | 14.0 | 15.1 | | | | | | | | |
| 5 | 19.0 | 14.3 | | | | | | | | |
| 6 | 4.0 | 5.0 | | | | | | | | |
| 6 | 9.0 | 11.8 | 107.8 | 35 | 21 | 0.2 | 48.7 | | - 0.4 | SC |
| 6 | 14.0 | 12.1 | | | | | | | | |
| 6 | 19.0 | 7.5 | | | | | | | | |
| 7 | 4.0 | 17.5 | 100.5 | 51 | 36 | 3.9 | 48.8 | | 1.3 | SC |
| 7 | 9.0 | 8.2 | | | | | | | | |
| 7 | 14.0 | 12.2 | | | | | | | | |
| 7 | 19.0 | 10.1 | | | | | | | | |
| 8 | 4.0 | 12.6 | | | | | | | | |
| 8 | 9.0 | 15.4 | 112.1 | 36 | 18 | 1.1 | 54.3 | | 0.6 | CL |
| 8 | 14.0 | 17.0 | | | | | | | | |
| 9 | 4.0 | 13.8 | | | | | | | | |
| 9 | 9.0 | 7.9 | | NP | NP | 13.5 | 9.2 | | | SW-SM |
| 9 | 14.0 | 7.4 | | | | | | | | |
| 9 | 19.0 | 6.3 | | | | | | | | |

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SUMMARY OF LABORATORY TEST RESULTS

JOB No. 169845
FIGURE No. 17

DATE 5/14/19

| Test Boring No. | Depth | Water Content (%) | Dry Density (pcf) | Liquid Limit | Plasticity Index | % Retained No.4 Sieve | % Passing No. 200 Sieve | FHA Expansion Pressure (psf) | % Swell/ Collapse | USCS Classification |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 4.0 | 7.3 | | | | | | | | |
| 10 | 9.0 | 10.4 | | NP | NP | 5.7 | 18.4 | | | SM |
| 10 | 14.0 | 16.3 | | | | | | | | |
| 10 | 19.0 | 15.0 | | | | | | | | |
| 11 | 4.0 | 19.6 | | | | | | | | |
| 11 | 9.0 | 16.5 | 109.2 | 39 | 20 | 0.4 | 48.2 | | 0.3 | SC |
| 11 | 14.0 | 14.1 | | | | | | | | |
| 11 | 19.0 | 9.1 | | | | | | | | |
| 12 | 4.0 | 2.5 | | | | | | | | |
| 12 | 9.0 | 9.0 | | | | | | | | |
| 12 | 14.0 | 9.0 | | | | | | | | |
| 13 | 4.0 | 9.3 | | | | | | | | |
| 13 | 9.0 | 10.3 | | NP | NP | 15.9 | 10.0 | | | SW-SM |
| 13 | 14.0 | 10.0 | | | | | | | | |
| 13 | 19.0 | 8.8 | | | | | | | | |
| 14 | 4.0 | 8.9 | | | | | | | | |
| 14 | 9.0 | 9.3 | | NP | NP | 6.0 | 15.7 | | | SM |
| 14 | 14.0 | 21.7 | | | | | | | | |
| 14 | 19.0 | 9.6 | | | | | | | | |
| 15 | 4.0 | 3.4 | | | | | | | | |
| 15 | 9.0 | 12.3 | 124.0 | 25 | 14 | 0.2 | 47.7 | | - 0.6 | SC |
| 15 | 14.0 | 10.1 | | | | | | | | |
| 15 | 19.0 | 11.0 | | | | | | | | |
| 16 | 4.0 | 15.0 | | | | | | | | |
| 16 | 9.0 | 10.1 | 107.3 | 29 | 17 | 0.4 | 53.2 | | - 1.3 | CL |
| 16 | 14.0 | 16.5 | 96.9 | 37 | 17 | 0.0 | 39.7 | | - 1.3 | SC |
| 16 | 19.0 | 11.8 | | | | | | | | |
| 16 | 29.0 | 16.5 | | | | | | | | |
| 17 | 4.0 | 5.0 | | NP | NP | 18.8 | 10.0 | | | SP-SM |
| 17 | 9.0 | 10.0 | | | | | | | | |
| 17 | 19.0 | 10.4 | | | | | | | | |
| 18 | 4.0 | 2.9 | | | | | | | | |
| 18 | 9.0 | 8.4 | | | | | | | | |
| 18 | 14.0 | 18.3 | 102.6 | 43 | 16 | 4.0 | 49.0 | | - 1.1 | SM |

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SUMMARY OF LABORATORY TEST RESULTS

JOB No. 169845
FIGURE No. 17

DATE 5/14/19

| Test Boring No. | Depth | Water Content (%) | Dry Density (pcf) | Liquid Limit | Plasticity Index | % Retained No.4 Sieve | % Passing No. 200 Sieve | FHA Expansion Pressure (psf) | % Swell/ Collapse | USCS Classification |
|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 19.0 | 9.6 | | | | | | | | |
| 19 | 4.0 | 3.3 | | NP | NP | 10.3 | 6.6 | | | SW-SM |
| 19 | 9.0 | 4.6 | | | | | | | | |
| 19 | 14.0 | 10.6 | | | | | | | | |
| 19 | 19.0 | 15.7 | | | | | | | | |
| 19 | 24.0 | 15.2 | | | | | | | | |
| 20 | 4.0 | 14.6 | 117.0 | 39 | 22 | 1.9 | 56.3 | | 0.3 | CL |
| 20 | 9.0 | 15.5 | | | | | | | | |
| 20 | 14.0 | 8.3 | | | | | | | | |
| 20 | 19.0 | 10.0 | | | | | | | | |
| 21 | 4.0 | 7.4 | | | | | | | | |
| 21 | 9.0 | 17.1 | 106.8 | 38 | 22 | 0.0 | 73.1 | | - 0.6 | CL |
| 21 | 14.0 | 12.1 | | | | | | | | |
| 22 | 4.0 | 6.3 | | | | | | | | |
| 22 | 9.0 | 7.7 | | | | | | | | |
| 22 | 14.0 | 9.2 | | | | | | | | |
| 23 | 4.0 | 12.6 | | 25 | 12 | 6.6 | 12.7 | | | SC |
| 23 | 9.0 | 6.0 | | | | | | | | |
| 23 | 14.0 | 7.8 | | | | | | | | |
| 23 | 19.0 | 14.0 | | | | | | | | |
| 24 | 4.0 | 2.2 | | NP | NP | 9.0 | 5.2 | | | SP-SM |
| 24 | 9.0 | 8.0 | | | | | | | | |
| 24 | 14.0 | 11.1 | | | | | | | | |
| 25 | 4.0 | 6.7 | | | | | | | | |
| 25 | 9.0 | 6.4 | | NP | NP | 5.6 | 10.3 | | | SW-SM |
| 25 | 14.0 | 9.7 | | | | | | | | |
| 25 | 19.0 | 12.7 | | | | | | | | |
| 25 | 29.0 | 15.7 | | | | 0.0 | 58.4 | | | CL |

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

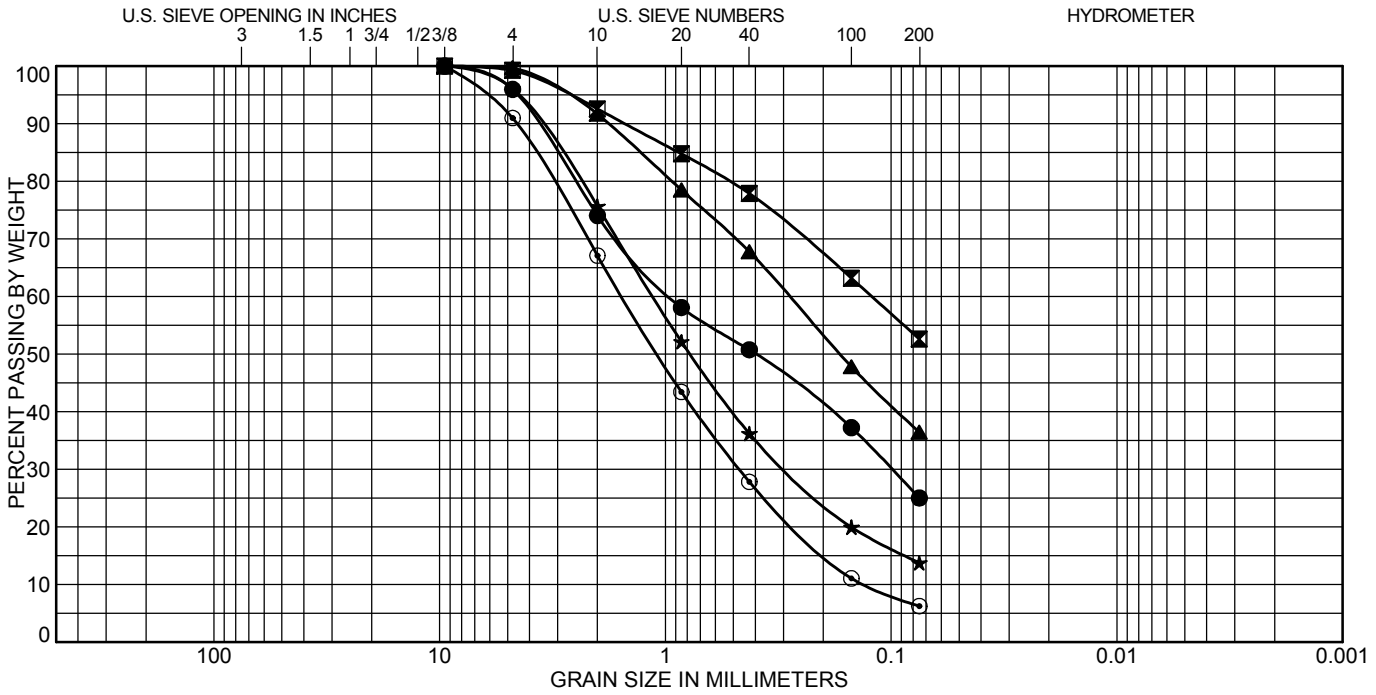
ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SUMMARY OF LABORATORY TEST RESULTS

JOB No. 169845
FIGURE No. 17
PAGE 3 OF 3
DATE 5/14/19




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Test Boring | | Depth (ft) | Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | 1 | 9.0 | SILTY SAND(SM) | NP | NP | NP |
| ⊠ | 2 | 14.0 | SANDY LEAN CLAY(CL) | 33 | 14 | 19 |
| ▲ | 3 | 9.0 | SILTY SAND(SM) | NP | NP | NP |
| ★ | 4 | 9.0 | SILTY SAND(SM) | NP | NP | NP |
| ⊙ | 5 | 9.0 | WELL-GRADED SAND with SILT(SW-SM) | NP | NP | NP |

| Test Boring | | Depth (ft) | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|
| ● | 1 | 9.0 | 4.1 | 70.9 | 25.0 | |
| ⊠ | 2 | 14.0 | 0.7 | 46.7 | 52.6 | |
| ▲ | 3 | 9.0 | 0.3 | 63.3 | 36.4 | |
| ★ | 4 | 9.0 | 3.9 | 82.3 | 13.8 | |
| ⊙ | 5 | 9.0 | 9.0 | 84.7 | 6.2 | |

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

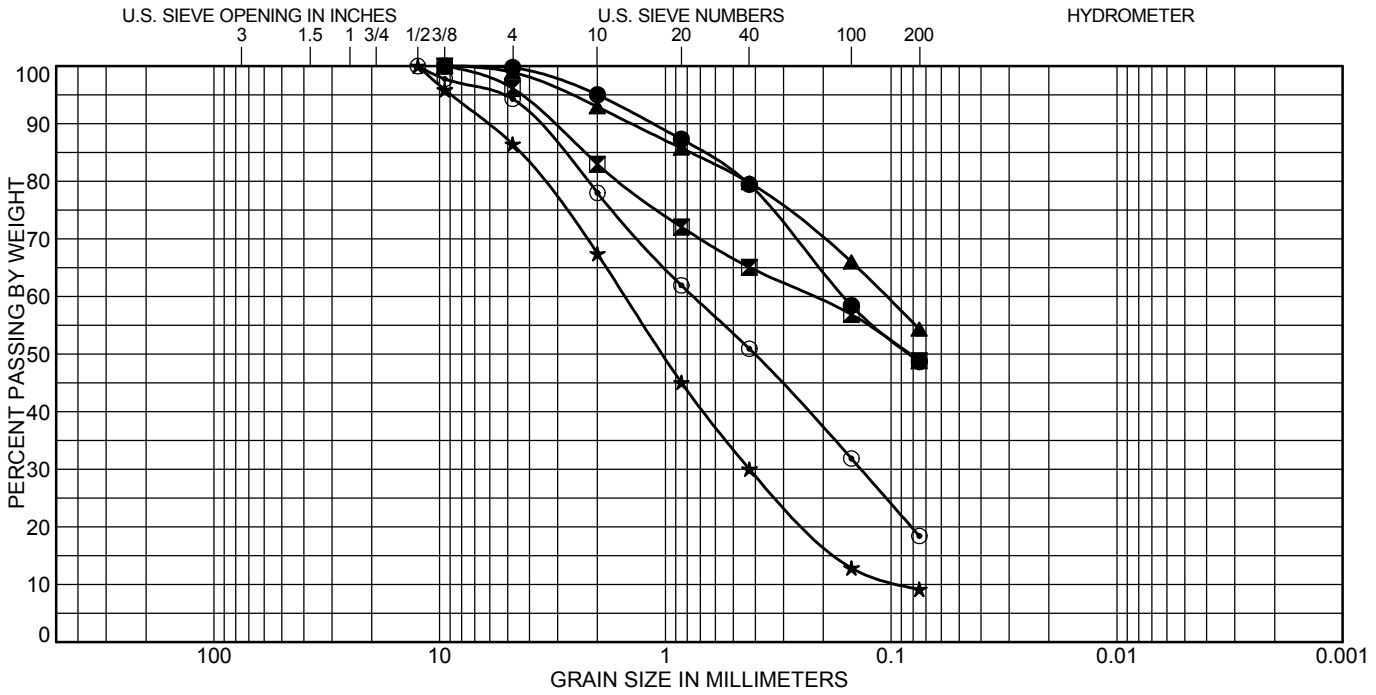
*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SOIL CLASSIFICATION DATA

JOB No. 169845

FIGURE No. 18

DATE 5/14/19




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Test Boring | | Depth (ft) | Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | 6 | 9.0 | **CLAYEY SAND(SC)** | 35 | 14 | 21 |
| ⊠ | 7 | 4.0 | **CLAYEY SAND(SC)** | 51 | 15 | 36 |
| ▲ | 8 | 9.0 | **SANDY LEAN CLAY(CL)** | 36 | 18 | 18 |
| ★ | 9 | 9.0 | **WELL-GRADED SAND with SILT(SW-SM)** | NP | NP | NP |
| ⊙ | 10 | 9.0 | **SILTY SAND(SM)** | NP | NP | NP |

| Test Boring | | Depth (ft) | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|
| ● | 6 | 9.0 | 0.2 | 51.1 | 48.7 | |
| ⊠ | 7 | 4.0 | 3.9 | 47.3 | 48.8 | |
| ▲ | 8 | 9.0 | 1.1 | 44.6 | 54.3 | |
| ★ | 9 | 9.0 | 13.5 | 77.3 | 9.2 | |
| ⊙ | 10 | 9.0 | 5.7 | 75.9 | 18.4 | |

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

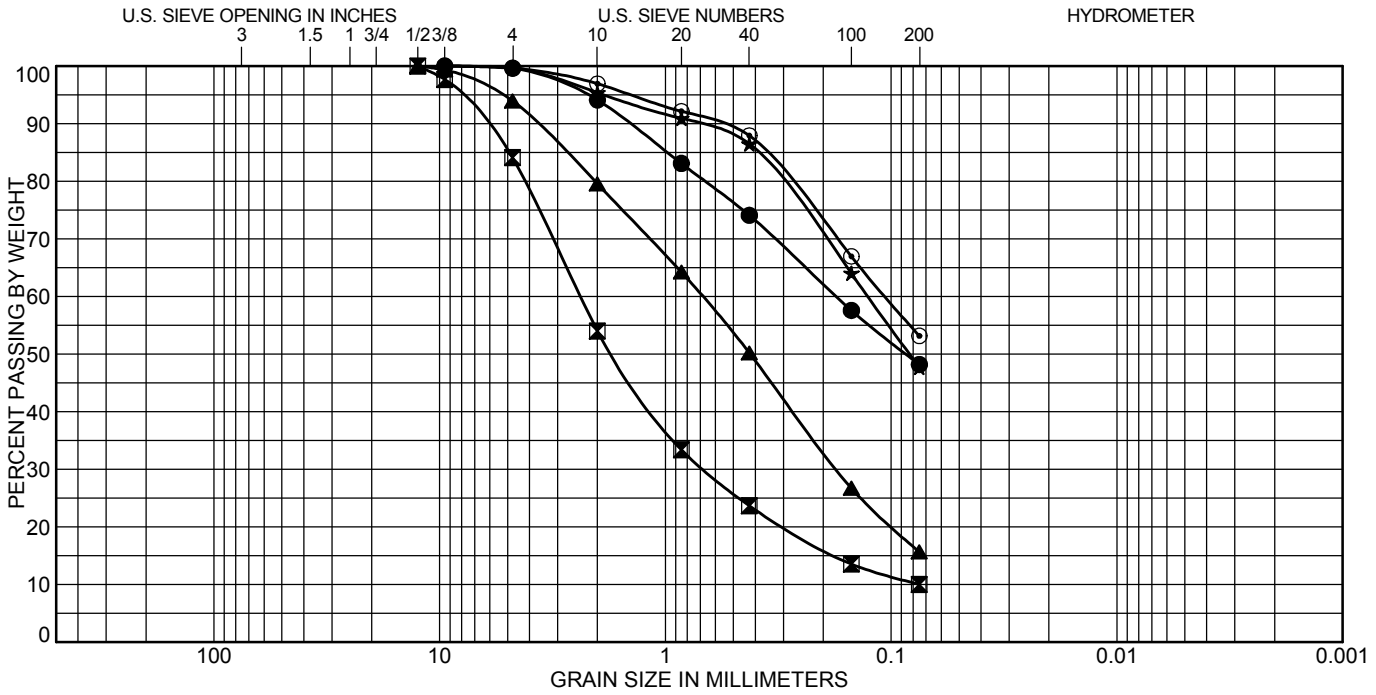
*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SOIL CLASSIFICATION DATA

JOB No. 169845

FIGURE No. 19

DATE 5/14/19




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Test Boring | | Depth (ft) | Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | 11 | 9.0 | CLAYEY SAND(SC) | 39 | 19 | 20 |
| ⊠ | 13 | 9.0 | WELL-GRADED SAND with SILT and GRAVEL(SW-SM) | NP | NP | NP |
| ▲ | 14 | 9.0 | SILTY SAND(SM) | NP | NP | NP |
| ★ | 15 | 9.0 | CLAYEY SAND(SC) | 25 | 11 | 14 |
| ⊙ | 16 | 9.0 | SANDY LEAN CLAY(CL) | 29 | 12 | 17 |

| Test Boring | | Depth (ft) | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|
| ● | 11 | 9.0 | 0.4 | 51.4 | 48.2 | |
| ⊠ | 13 | 9.0 | 15.9 | 74.1 | 10.0 | |
| ▲ | 14 | 9.0 | 6.0 | 78.3 | 15.7 | |
| ★ | 15 | 9.0 | 0.2 | 52.1 | 47.7 | |
| ⊙ | 16 | 9.0 | 0.4 | 46.5 | 53.2 | |

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

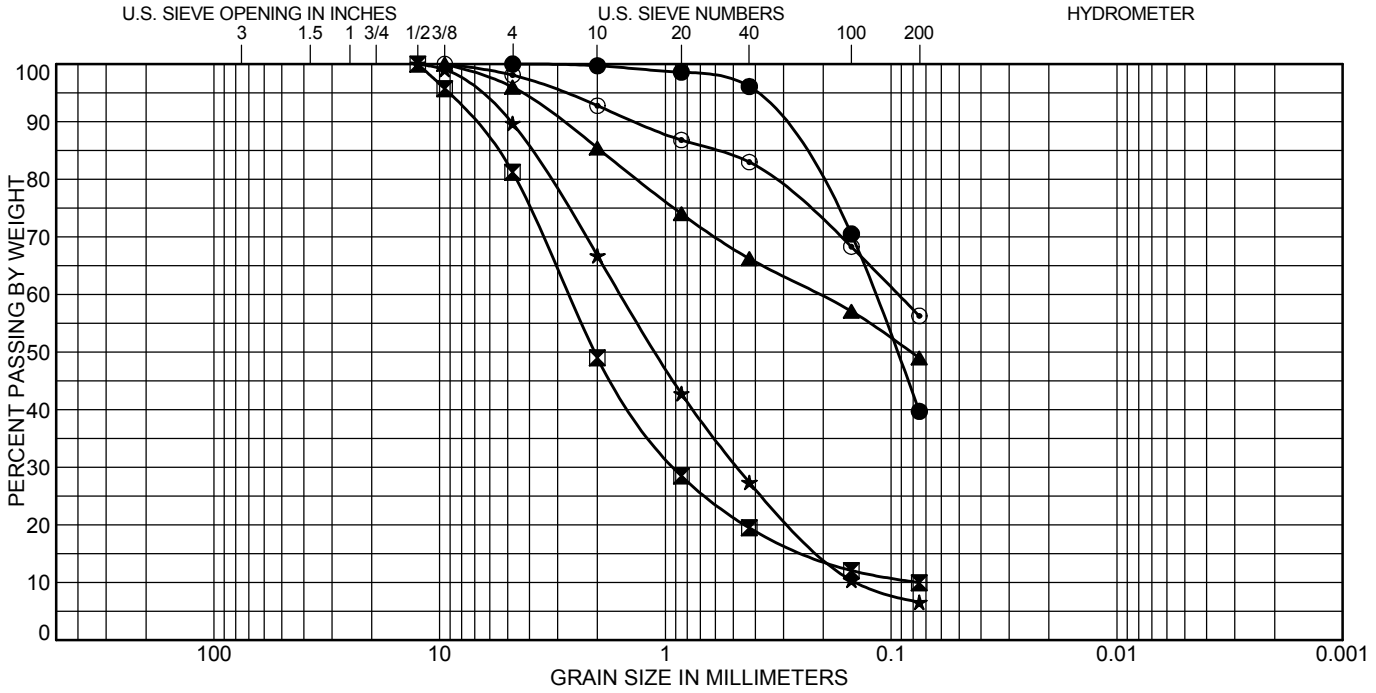
*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SOIL CLASSIFICATION DATA

JOB No. 169845

FIGURE No. 20

DATE 5/14/19




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Test Boring | | Depth (ft) | Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | 16 | 14.0 | CLAYEY SAND(SC) | 37 | 20 | 17 |
| ⧓ | 17 | 4.0 | POORLY GRADED SAND with SILT and GRAVEL(SP-SM) | NP | NP | NP |
| ▲ | 18 | 14.0 | SILTY SAND(SM) | 43 | 27 | 16 |
| ★ | 19 | 4.0 | WELL-GRADED SAND with SILT(SW-SM) | NP | NP | NP |
| ⊙ | 20 | 4.0 | SANDY LEAN CLAY(CL) | 39 | 17 | 22 |

| Test Boring | | Depth (ft) | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|
| ● | 16 | 14.0 | 0.0 | 60.3 | 39.7 | |
| ⧓ | 17 | 4.0 | 18.8 | 71.3 | 10.0 | |
| ▲ | 18 | 14.0 | 4.0 | 47.0 | 49.0 | |
| ★ | 19 | 4.0 | 10.3 | 83.1 | 6.6 | |
| ⊙ | 20 | 4.0 | 1.9 | 41.8 | 56.3 | |

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

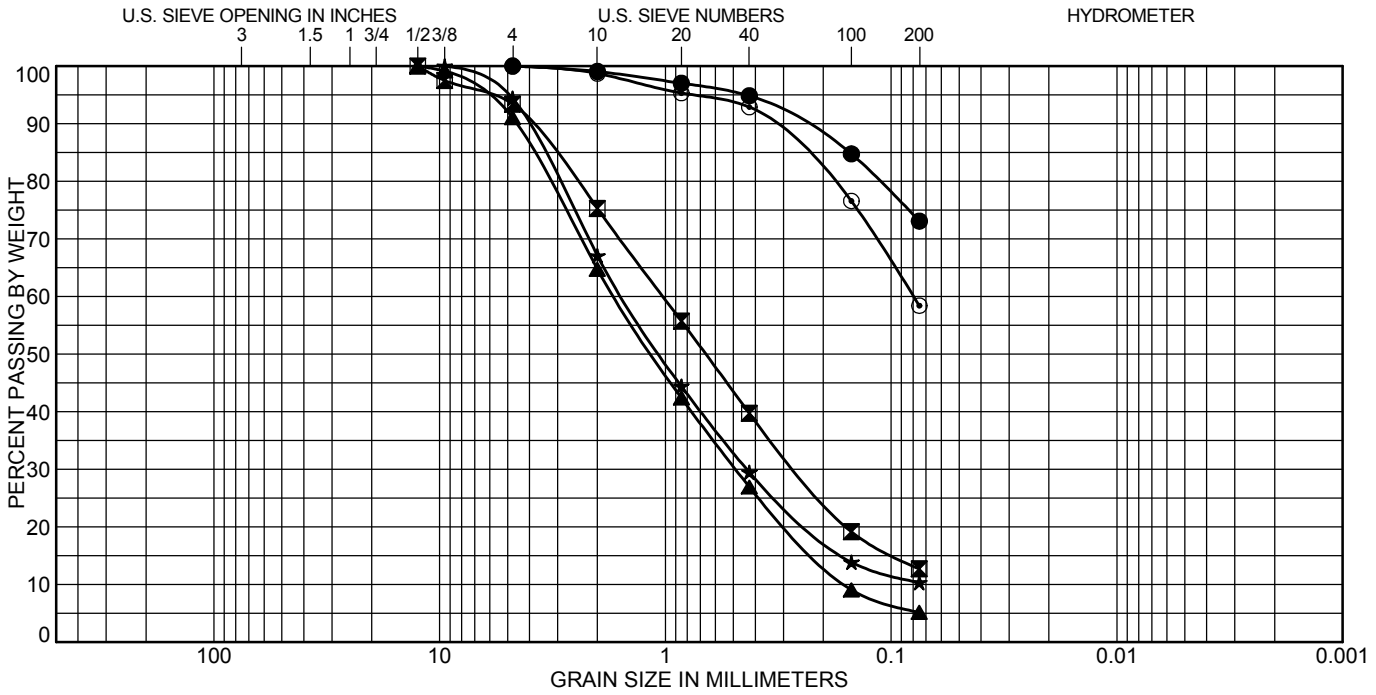
*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SOIL CLASSIFICATION DATA

JOB No. 169845

FIGURE No. 21

DATE 5/14/19




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| Test Boring | | Depth (ft) | Classification | LL | PL | PI |
|---|---|---|---|---|---|---|
| ● | 21 | 9.0 | LEAN CLAY with SAND(CL) | 38 | 16 | 22 |
| ⊠ | 23 | 4.0 | CLAYEY SAND(SC) | 25 | 13 | 12 |
| ▲ | 24 | 4.0 | POORLY GRADED SAND with SILT(SP-SM) | NP | NP | NP |
| ★ | 25 | 9.0 | WELL-GRADED SAND with SILT(SW-SM) | NP | NP | NP |
| ⊙ | 25 | 29.0 | LEAN CLAY with SAND(CL) | | | |

| Test Boring | | Depth (ft) | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|
| ● | 21 | 9.0 | 0.0 | 26.9 | 73.1 | |
| ⊠ | 23 | 4.0 | 6.6 | 80.7 | 12.7 | |
| ▲ | 24 | 4.0 | 9.0 | 85.9 | 5.2 | |
| ★ | 25 | 9.0 | 5.6 | 84.1 | 10.3 | |
| ⊙ | 25 | 29.0 | 0.0 | 41.6 | 58.4 | |

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

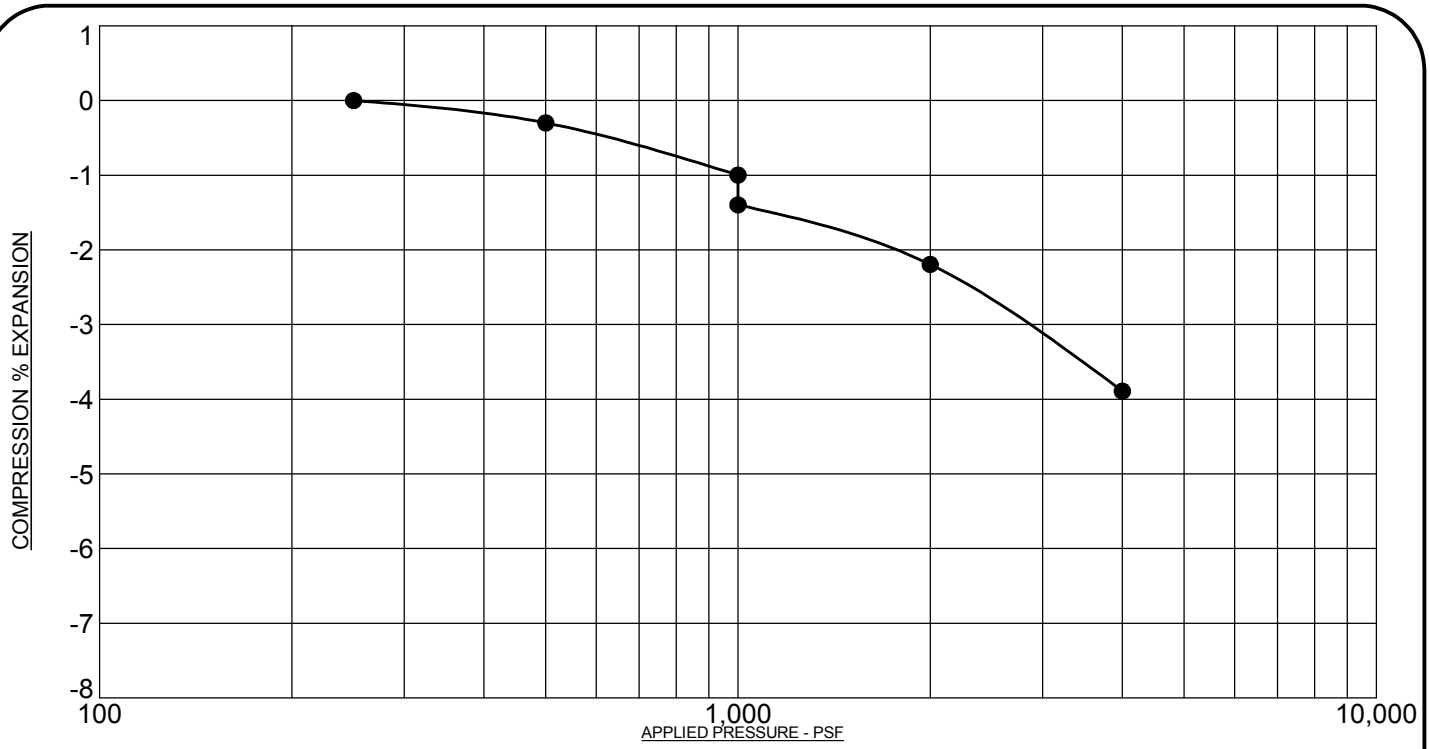
*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SOIL CLASSIFICATION DATA

JOB No. 169845

FIGURE No. 22

DATE 5/14/19




PROJECT: **Bent Grass Meadows, Filing No. 2, El Paso County, Colorado**
SAMPLE DESCRIPTION: **SANDSTONE, SILTY TO CLAYEY**
**NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF**

SAMPLE LOCATION: **6 @ 9 FT**
NATURAL DRY UNIT WEIGHT: **107.8 PCF**
NATURAL MOISTURE CONTENT: **11.8%**
PERCENT SWELL/COMPRESSION: **- 0.4**


PROJECT: **Bent Grass Meadows, Filing No. 2, El Paso County, Colorado**
SAMPLE DESCRIPTION: **SAND, CLAYEY**
**NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF**

SAMPLE LOCATION: **7 @ 4 FT**
NATURAL DRY UNIT WEIGHT: **100.5 PCF**
NATURAL MOISTURE CONTENT: **17.5%**
PERCENT SWELL/COMPRESSION: **1.3**

ROCKY MOUNTAIN GROUP

ARCHITECTS RMG ENGINEERS

Architectural
Structural
Forensics

Geotechnical
Materials Testing
Civil, Planning

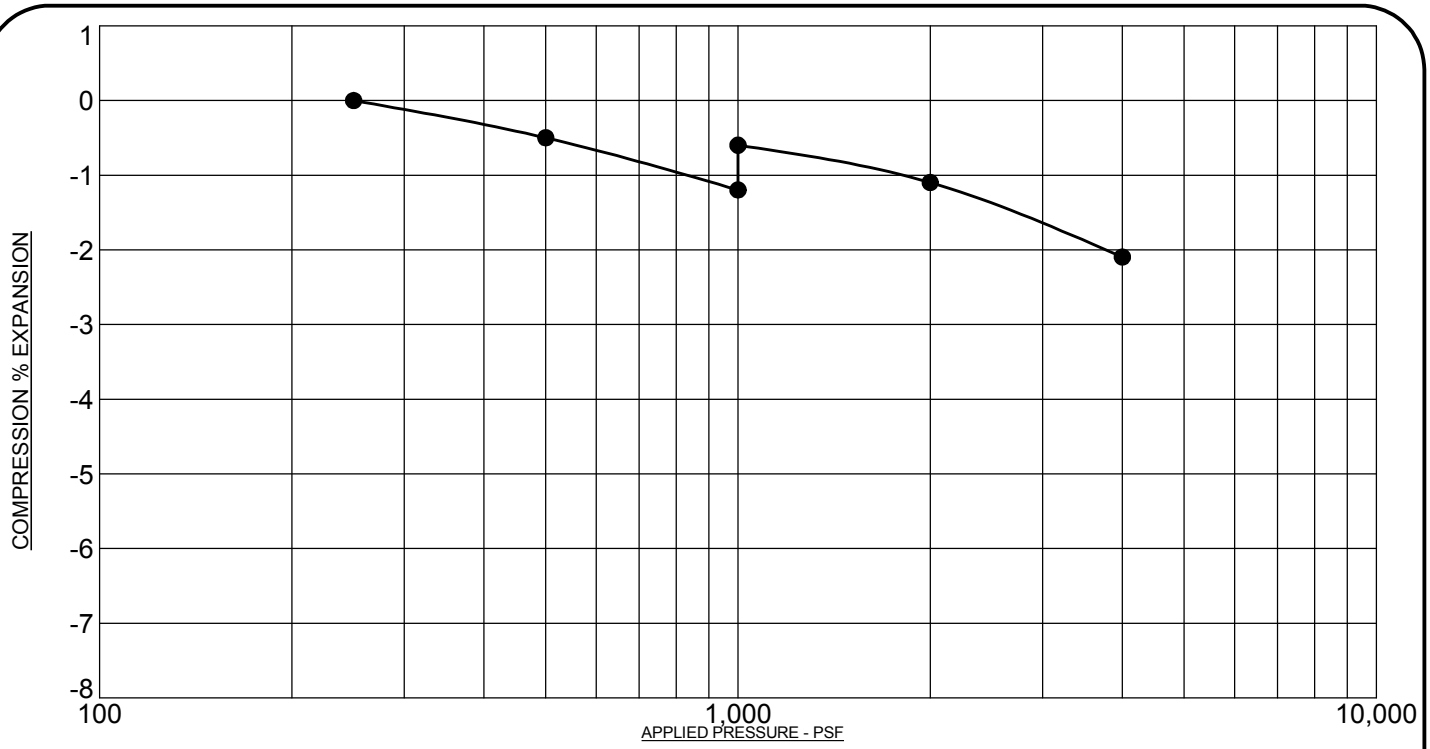
*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SWELL/CONSOLIDATION TEST RESULTS

JOB No. 169845

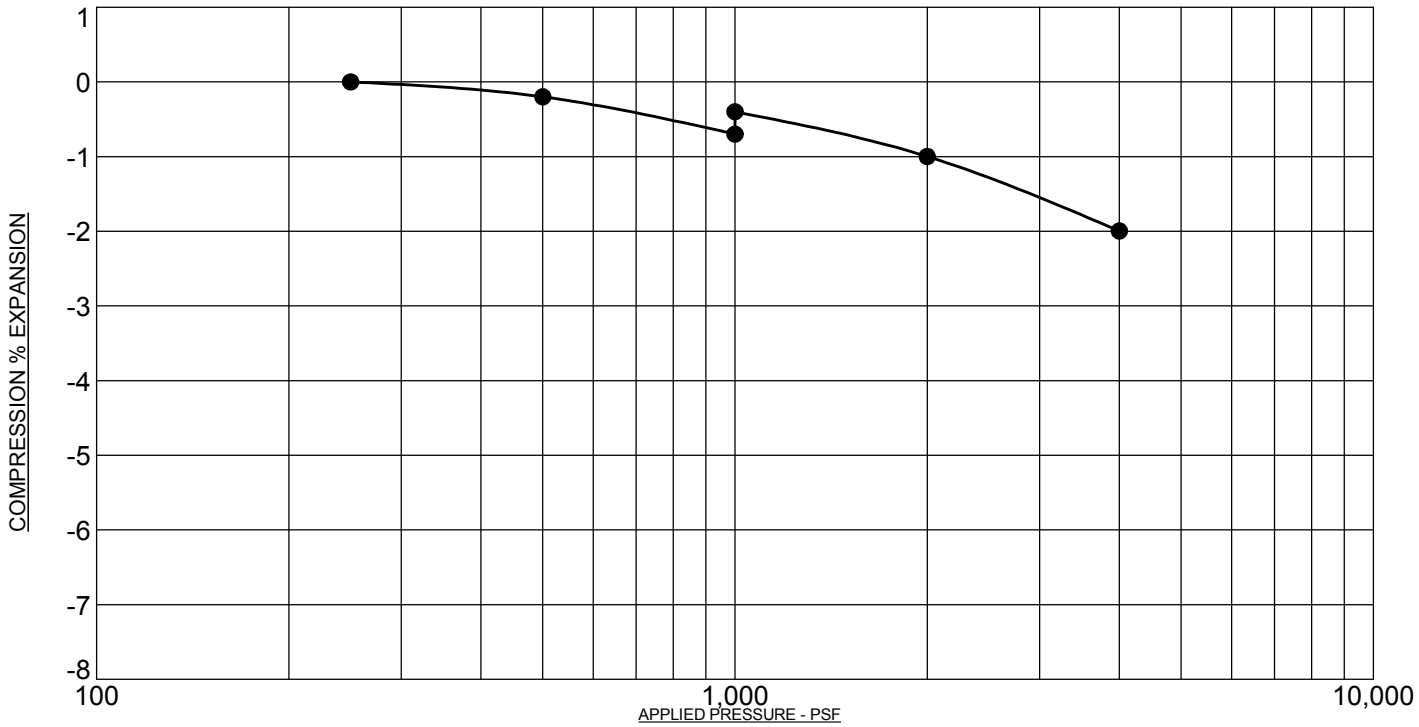
FIGURE No. 23

DATE 5/14/19




PROJECT: **Bent Grass Meadows, Filing No. 2, El Paso County, Colorado**
SAMPLE DESCRIPTION: **CLAYSTONE, SANDY**
**NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF**

SAMPLE LOCATION: **8 @ 9 FT**
NATURAL DRY UNIT WEIGHT: **112.1 PCF**
NATURAL MOISTURE CONTENT: **15.4%**
PERCENT SWELL/COMPRESSION: **0.6**




PROJECT: **Bent Grass Meadows, Filing No. 2, El Paso County, Colorado**
SAMPLE DESCRIPTION: **SANDSTONE, CLAYEY**
**NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF**

SAMPLE LOCATION: **11 @ 9 FT**
NATURAL DRY UNIT WEIGHT: **109.2 PCF**
NATURAL MOISTURE CONTENT: **16.5%**
PERCENT SWELL/COMPRESSION: **0.3**

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS
RMG
ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

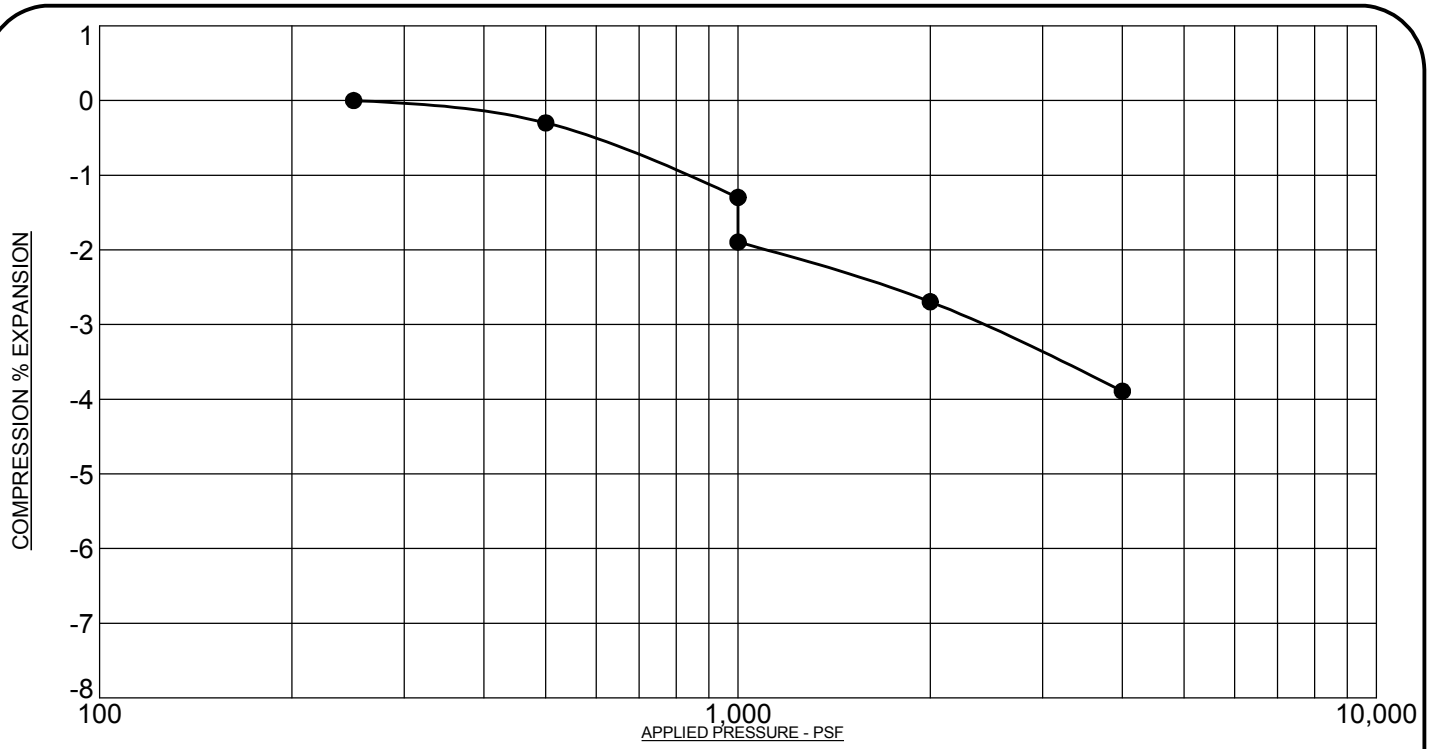
*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SWELL/CONSOLIDATION TEST RESULTS

JOB No. 169845

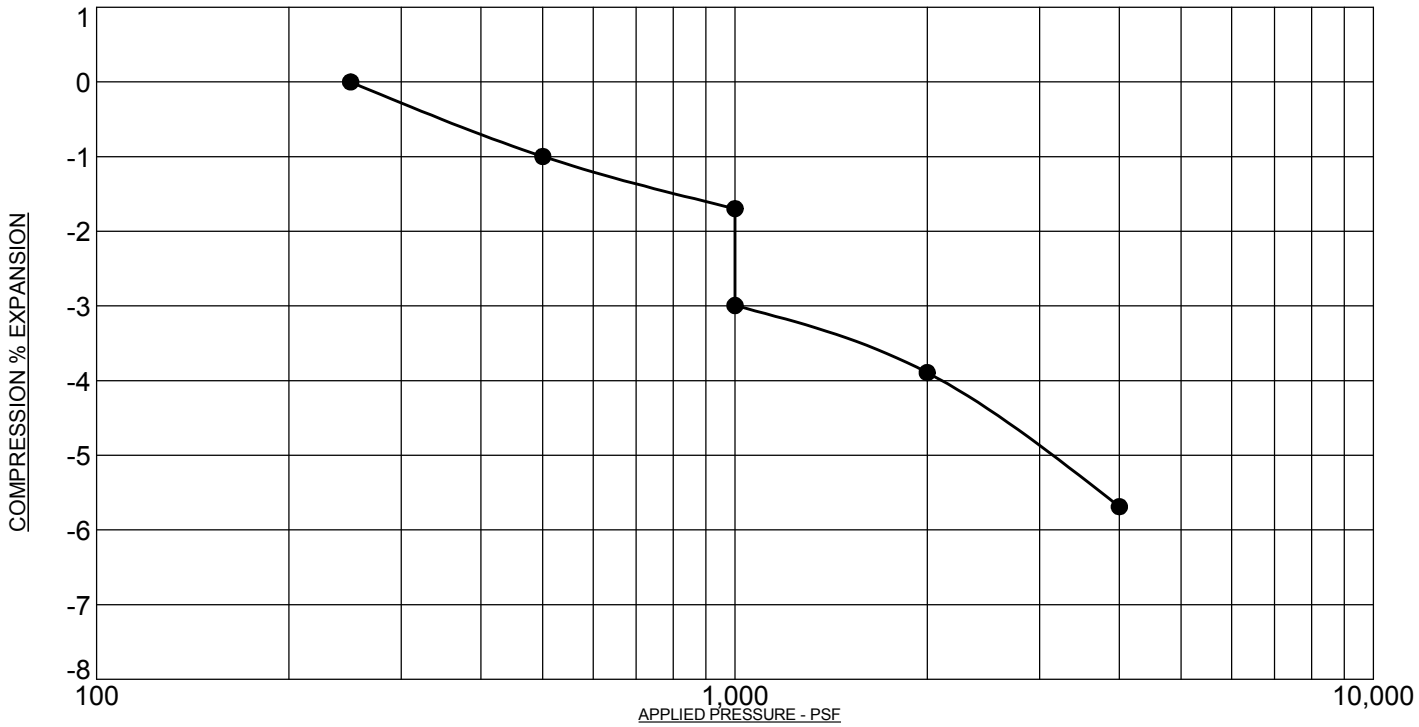
FIGURE No. 24

DATE 5/14/19




PROJECT: **Bent Grass Meadows, Filing No. 2, El Paso County, Colorado**
SAMPLE DESCRIPTION: **CLAYSTONE, SANDY**
**NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF**

SAMPLE LOCATION: **15 @ 9 FT**
NATURAL DRY UNIT WEIGHT: **124.0 PCF**
NATURAL MOISTURE CONTENT: **12.3%**
PERCENT SWELL/COMPRESSION: **- 0.6**




PROJECT: **Bent Grass Meadows, Filing No. 2, El Paso County, Colorado**
SAMPLE DESCRIPTION: **CLAYSTONE, SANDY**
**NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF**

SAMPLE LOCATION: **16 @ 9 FT**
NATURAL DRY UNIT WEIGHT: **107.3 PCF**
NATURAL MOISTURE CONTENT: **10.1%**
PERCENT SWELL/COMPRESSION: **- 1.3**

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

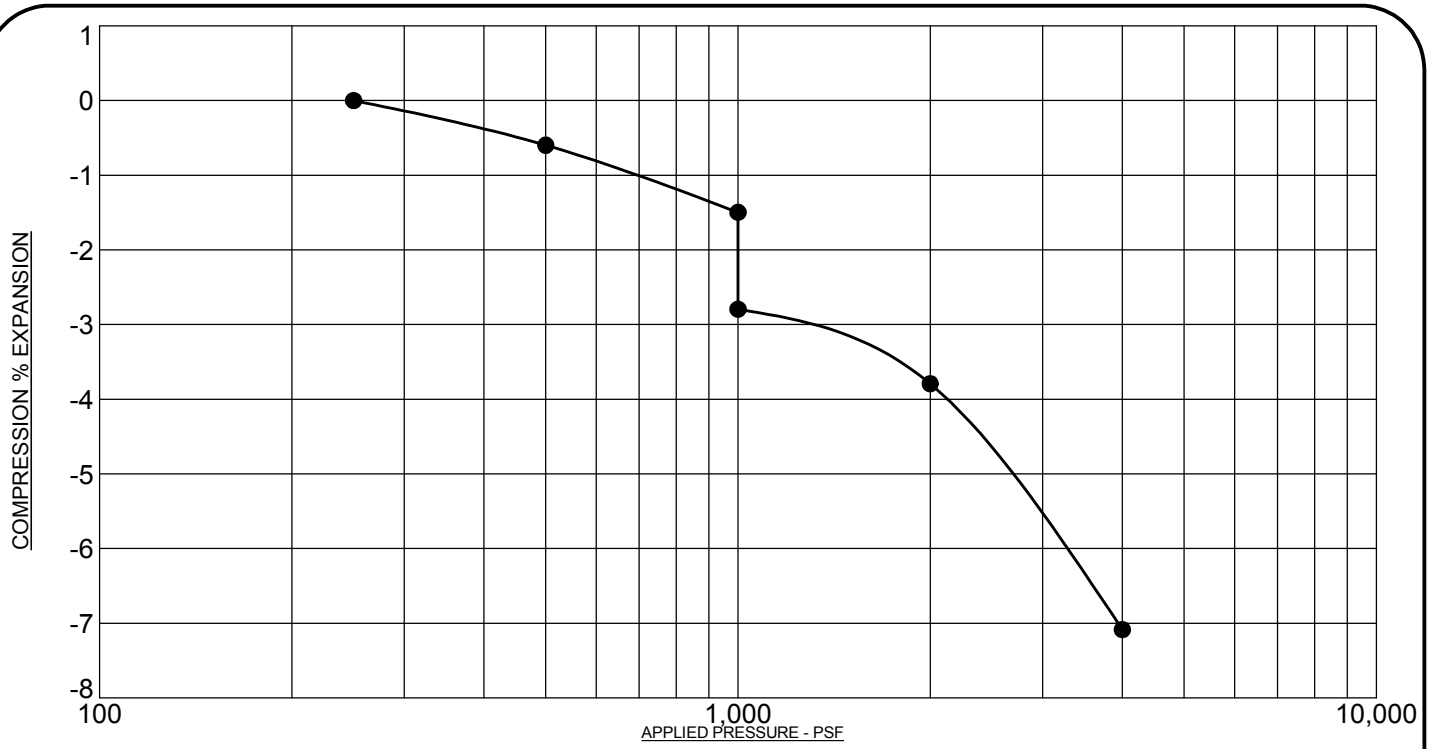
*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SWELL/CONSOLIDATION TEST RESULTS

JOB No. 169845

FIGURE No. 25

DATE 5/14/19




PROJECT: **Bent Grass Meadows, Filing No. 2, El Paso County, Colorado**
SAMPLE DESCRIPTION: **SANDSTONE, CLAYEY**
**NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF**

SAMPLE LOCATION: **16 @ 14 FT**
NATURAL DRY UNIT WEIGHT: **96.9 PCF**
NATURAL MOISTURE CONTENT: **16.5%**
PERCENT SWELL/COMPRESSION: **- 1.3**


PROJECT: **Bent Grass Meadows, Filing No. 2, El Paso County, Colorado**
SAMPLE DESCRIPTION: **SANDSTONE, CLAYEY**
**NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF**

SAMPLE LOCATION: **18 @ 14 FT**
NATURAL DRY UNIT WEIGHT: **102.6 PCF**
NATURAL MOISTURE CONTENT: **18.3%**
PERCENT SWELL/COMPRESSION: **- 1.1**

ROCKY MOUNTAIN GROUP

ARCHITECTS RMG ENGINEERS

Architectural
Structural
Forensics

Geotechnical
Materials Testing
Civil, Planning

*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SWELL/CONSOLIDATION TEST RESULTS

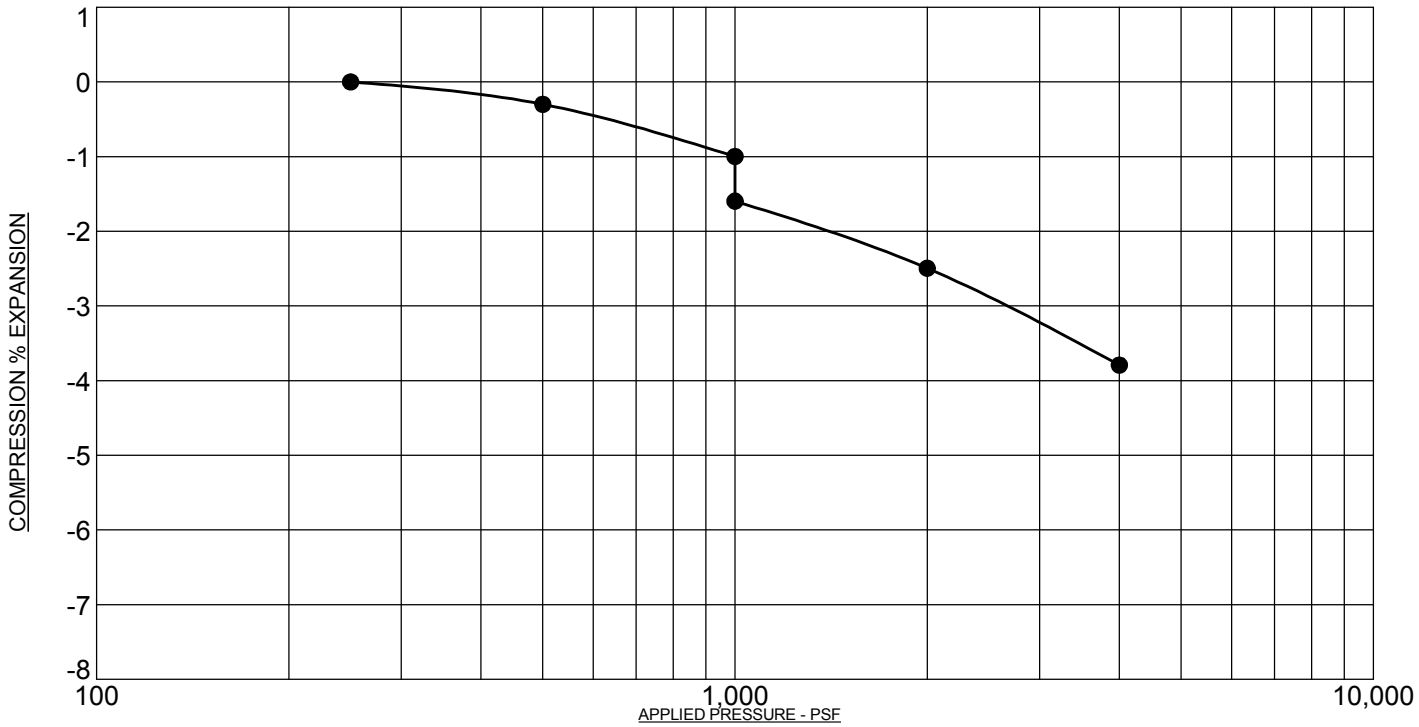
JOB No. 169845

FIGURE No. 26

DATE 5/14/19


PROJECT: **Bent Grass Meadows, Filing No. 2, El Paso County, Colorado**
SAMPLE DESCRIPTION: **CLAYSTONE, SANDY**
**NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF**

SAMPLE LOCATION: **20 @ 4 FT**
NATURAL DRY UNIT WEIGHT: **117.0 PCF**
NATURAL MOISTURE CONTENT: **14.6%**
PERCENT SWELL/COMPRESSION: **0.3**




PROJECT: **Bent Grass Meadows, Filing No. 2, El Paso County, Colorado**
SAMPLE DESCRIPTION: **CLAYSTONE, SANDY**
**NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF**

SAMPLE LOCATION: **21 @ 9 FT**
NATURAL DRY UNIT WEIGHT: **106.8 PCF**
NATURAL MOISTURE CONTENT: **17.1%**
PERCENT SWELL/COMPRESSION: **- 0.6**

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

*Colorado Springs: (Corporate Office)*
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

# SWELL/CONSOLIDATION TEST RESULTS

JOB No. 169845

FIGURE No. 27

DATE 5/14/19

# APPENDIX A

# Guideline Site Grading Specifications

**Description:** Unless specified otherwise by local or state regulatory agencies, these guideline specifications are for the excavation, placement and compaction of material from locations indicated on the plans, or staked by the Engineer, as necessary to achieve the required elevations. These specifications shall also apply to compaction of materials that may be placed outside of the project.

**General:** The Geotechnical Engineer shall approve fill materials, method of placement, moisture contents and percent compactions, and shall give written approval of the compacted fill.

**Clearing Site:** The Contractor shall remove trees, brush, rubbish, vegetation, topsoil and existing structures before excavation or fill placement is commenced. The Contractor shall dispose of the cleared material to provide the Owner with a clean job site. Cleared material shall not be placed in areas to receive fill or where the material will support structures. Clearing shall also include removal of existing fills that do not meet the requirements of this specification and existing structures.

**Preparation of Slopes or Drainage Areas to Receive Fill:** Natural slopes or slopes of drainage gullies where grades are 20 percent (5:1, horizontal to vertical) or steeper shall be benched prior to fill placement. Benches shall be at least 10 feet wide. Benches may require additional width to accommodate excavation or compaction equipment. At least one bench shall be provided for each 5 feet or less of vertical elevation difference. The bench surface shall be essentially horizontal perpendicular to the slope or at a slight incline into the slope.

**Scarifying:** Topsoil and vegetation shall be removed from the ground surface in areas to receive fill. The surface shall be plowed or scarified a minimum of 12 inches until the surface is free from ruts, hummocks or other uneven features which would prevent uniform compaction by the equipment to be used.

**Compacting Area to Receive Fill:** After the area to receive fill has been cleared and scarified, it shall be disked or bladed until it is free from large clods, moisture conditioned to a proper moisture content and compacted to the maximum density as specified for the overlying fill. Areas to receive fill shall be worked, stabilized, or removed and replaced, if necessary, in accordance with the Geotechnical Engineer's recommendations in preparation for fill.

**Fill Materials:** Fill material shall be free from organic material or other deleterious substances, and shall not contain rocks or lumps having a diameter greater than six inches. Fill materials shall be obtained from cut areas shown on the plans or staked in the field by the Engineer or imported to the site and shall be approved by the Geotechnical Engineer prior to placement. It is recommended that the fill materials have nil to low expansion potential, i.e., consist of silty to slightly clayey sand.

**Moisture Content:** Fill materials shall be moisture conditioned to within limits of optimum moisture content specified. Sufficient laboratory compaction tests shall be made to determine the optimum moisture content for the various soils encountered in borrow areas or imported to the site.

The contractor may be required to add moisture to the excavation materials in the borrow area if, in the opinion of the Geotechnical Engineer, it is not possible to obtain uniform moisture content by adding water to the fill material during placement. The Contractor may be required to rake or disk the fill soils to provide uniform moisture content through the soils.

The application of water to embankment materials shall be made with watering equipment, approved by the Geotechnical Engineer, which will give the desired results. Water jets from the spreader shall not be directed at the embankment with such force that fill materials are eroded.

Should too much water be added to the fill, such that the material is too wet to permit the desired compaction to be obtained, compacting and work on that section of the fill shall be delayed until the material has been allowed to dry to the required moisture content. The Contractor will be permitted to rework the wet material in an approved manner to hasten its drying.

**Compaction of Fill Areas:** Selected fill material shall be placed and mixed in evenly spread layers. After each fill layer has been placed, it shall be uniformly compacted to not less than the specified percentage of maximum density. Fill materials shall be placed such that the thickness of loose material does not exceed 10 inches and the compacted lift thickness does not exceed 6 inches.

Compaction, as specified above, shall be obtained by the use of sheepsfoot rollers, multiple-wheel pneumatic-tired rollers, or other equipment approved by the Geotechnical Engineer. Granular fill shall be compacted using vibratory equipment or other equipment approved by the Geotechnical Engineer. Compaction shall be accomplished while the fill material is at the specified moisture content. Compaction of each layer shall be continuous over the entire area.

**Moisture Content and Density Criteria:**

A. For on-site, structural fills and fills supporting utilities, roadways and buildings, 95% maximum Standard Proctor dry density at 2% ± of optimum moisture content.

B. For imported, granular, structural fills and granular fills supporting utilities, roadways and buildings, 90% maximum Modified Proctor dry density at 2% ± of optimum moisture content.

C. For general grading fills, 92% maximum Standard Proctor dry density at 2% ± of optimum moisture content.

**Compaction of Slopes:** Fill slopes shall be compacted by means of sheepsfoot rollers or other suitable equipment. Compaction operations shall be continued until slopes are stable, but not too dense for planting, and such that there is no appreciable amount of loose soil on the slopes. Compaction of slopes may be done progressively in increments of three to five feet in height or after the fill is brought to its total height. Permanent fill slopes shall not exceed 3:1 (horizontal to vertical).

**Density Testing:** Field density testing shall be performed by the Geotechnical Engineer at locations and depths of his choosing. Where sheepsfoot rollers are used, the soil may be disturbed to a depth of several inches. Density tests shall be taken in compacted material below the disturbed surface. When density tests indicate the density or moisture content of any layer of fill or portion thereof is below that required, the particular layer or portion shall be reworked until the required density or moisture content has been achieved.

**Observation and Testing of Fill:** Observation by the Geotechnical Engineer shall be sufficient during the placement of fill and compaction operations so that he can declare the fill was placed in general conformance with Specifications. All observations necessary to test the placement of fill and observe compaction operations will be at the expense of the Owner.

**Seasonal Limits:** No fill material shall be placed, spread or rolled while it is frozen, thawing, or during unfavorable weather conditions. When work is interrupted by heavy precipitation, fill operations shall not be resumed until the Geotechnical Engineer indicates the moisture content and density of previously placed materials are as specified.

**Reporting of Field Density Tests:** Density tests made by the Geotechnical Engineer shall be submitted progressively to the Owner. Dry density, moisture content, percent compaction, and approximate location shall be reported for each test taken.