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## GEOTECHNICAL REPORT

### Avatar River Bend Crossing Commercial and Residential Development Fountain, Colorado

#### PREPARED FOR:

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JOB NO. 161921

April 2, 2018

Respectfully Submitted,

RMG – Rocky Mountain Group

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Reviewed by,

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Add "PCD File No. SP187, SF1843,  
& SF1844" on the cover sheet.

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#### APPENDIX A

    USGS Seismic Design Parameters

# GENERAL SITE AND PROJECT DESCRIPTION

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## **Project Description and Scope of Work**

RMG has completed a geotechnical investigation for the Avatar Riverbend development in Fountain, Colorado. The purpose of the investigation was to evaluate the subsurface soil conditions and provide geotechnical design and construction criteria for the project. These services were provided in accordance with our Proposal and Project Contract No. 161921 dated February 3, 2018.

The Riverbend development consists of two distinct portions, a new residential development of single family homes, and redevelopment of an adjacent commercial strip mall. We understand the commercial strip mall will be rehabilitated and reconfigured to provide dedicated access to the residential development. This report provides roadway and pavement recommendations for the commercial redevelopment, and foundation and earthwork recommendations for the residential development.

The commercial site is located at approximately 5680 S US Hwy 85/87 in El Paso County near the city limits of Fountain, Colorado. The site consists of several retail businesses in a strip mall configuration. We understand existing buildings may be demolished and the site reconfigured to accommodate access to the residential development. The parking area pavement may be rehabilitated or rebuilt.

The residential development is comprised of two parcels. Parcel A is 34 acres of relatively flat land, and Parcel B is 19 acres bordering Fountain Creek and includes a portion of the Fountain Creek floodplain. The site is proposed to be developed in two filings. Filing 1 will include 136 residential lots, and Filing 2 will include 89 residential lots. A full spectrum stormwater detention will most likely be required for this development, as will a sanitary lift station. The location of the site is shown on the Site Vicinity Map, Figure 1.

## **Existing Site Conditions**

The residential site is currently undeveloped land situated between US highway 85/87 and Fountain Creek. It sits behind the commercial strip mall development and appears to have no developed roadway access. The site is vacant and currently vegetated with native shrubs, grass, and weeds. The southern extent of the site drops down to the floodplain of Fountain Creek.

# FIELD INVESTIGATION AND LABORATORY TESTING

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## **Drilling**

The subsurface conditions on the site were investigated by drilling eleven (11) exploratory test borings to 20 feet depth within the residential property, and five (5) exploratory test borings to 20 feet depth within the boundary of the commercial parcel. In this report commercial borings carry a C-xx designation, while the residential borings carry an R-xx designation. The approximate locations of the test borings are presented in the Test Boring Location Plan, Figure 2.

The test borings were advanced with a power-driven, continuous-flight auger drill rig. Soil 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. Samples

were returned to RMG's materials testing laboratory for testing and analysis. An Explanation of Test Boring Logs is presented in Figure 3. The Test Boring Logs are presented in Figures 4 through 11.

### **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 12. Soil Classification Data are presented in Figures 13 through 16. Swell/Consolidation Test Results are presented in Figure 17.

## **SECTION 1 – RESIDENTIAL DEVELOPMENT**

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### **Subsurface Materials**

Commercial Soil Test Borings (C-01 through C-05) were performed through the existing pavement of the commercial area and will be discussed in **Section 3 - Commercial Development** of this report. Residential Soil Test Borings (R-01 through R-11) were performed in the undeveloped parcels and are discussed below. The subsurface materials were classified by laboratory testing in accordance with the Unified Soils Classification System (USCS).

Referring to Figure 2, Test Boring Location Plan, clay, claystone and shale bedrock were encountered in Test Borings R-05, R-06, R-08, R-10 and R-11 in the southwest portion of the site. Silty sand was encountered in the other residential borings throughout the 20-foot depth tested across the north and eastern portions of the site.

#### Soil Test Borings: R-01, R-02, R-03, R-04, R-07, R-09

0 to 20-feet: Tan to brown, loose to medium dense, moist (wet below the water table), Silty Sand. This soil classifies primarily throughout its depth as SW-SM, well-graded silty sand with gravel.

#### Soil Test Borings: R-05, R-06, R-08, R-10, R-11

0 to 5-14-feet: Tan to brown, loose to medium dense, moist (wet below the water table), Silty Sand. This soil classifies primarily throughout its depth as SW-SM, well-graded silty sand with gravel.

5-14 to 20-feet: Gray, hard to very hard, moist claystone and shale bedrock. These soils classify primarily as CL, lean clay, and CH, fat sandy clay.

Additional descriptions and the interpreted distribution (approximate depths) of the subsurface materials are presented on the Test Boring Logs. The descriptions 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.

## Groundwater

Groundwater was encountered intermittently across the site. The well-graded sand appears to be well-draining with groundwater encountered at 13 to 19-feet depth. In those borings where claystone and shale bedrock were encountered, groundwater was perched as high as 6-feet below ground surface elevation. Depending upon final site grading and finished floor elevations, groundwater may influence the feasibility of certain structures, particularly basement construction. Fluctuations in groundwater and subsurface moisture conditions may occur due to seasonal variations in rainfall and other factors not readily apparent at this time.

## CONCLUSIONS AND RECOMMENDATIONS

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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

Overall, the subsurface soil conditions are favorable for residential development on shallow foundation systems. The well-graded silty sand can be prepared to provide adequate bearing capacity. Claystone and shale are not considered suitable for direct foundation bearing. In those locations where claystone and shale are present overexcavation and replacement with compacted structural fill will be necessary to provide for a minimum of 4-feet of separation between unsuitable soil and foundation elements. The area of the site that may require overexcavation and replacement can be described as the southwest portion of the site roughly defined by Soil Test Borings R-05, R-06, R-08, R-10, and R-11.

The preliminary site plan provided to RMG shows the far southern end of the site reserved for a full spectrum stormwater detention area. Soil Test Borings R-09 and R-10 were performed in this region. Detention area considerations are discussed in **Section 2 – Full Spectrum Detention Area**. The site plan also shows proposed lift station at the extreme southwestern part of the site. Soil Test Boring R-11 was performed in this location.

### Site Preparation

Final grading plans were not available for review. In general, the following site preparation procedures are recommended.

Standard Penetration Test blow counts vary across the site and with depth. Due to this variability we recommend improving the soil under foundations by overexcavating the foundation areas and backfilling with compacted structural fill. The on-site silty sand soil is suitable as structural backfill. The clay and claystone is not recommended as structural backfill. Site preparation should include clearing and grubbing the site of all vegetation, topsoil, and any other deleterious material within the construction area and disposing this material appropriately. Following clearing and grubbing, the area within the foundation footprint, under basements, and a 2-foot perimeter beyond should be overexcavated two (2) feet below the bottom of footing elevation. Excavated sand soil may be stockpiled for reuse as structural backfill. An Open Excavation Observation should be made at this point to verify soil conditions are as reported in the soil boring logs herein.

Upon verification, the upper 6 inches of the exposed subsurface soils should then 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.

After compaction of the subgrade, the native material previously removed may be used as structural backfill to bring the site to bottom of footing grade. The material should not be excessively wet, should be free of organic matter and construction debris, and contain no rock fragments greater than 3-inches in any dimension. Fill material should be placed in ten-inch loose lifts with moisture content within 2 percent of optimum as determined by ASTM D-1557. Each loose lift should be compacted to a minimum of 95 percent of Modified Proctor maximum dry density as determined by ASTM D-1557. Backfill soil should be density tested to verify compaction meets these requirements.

### **Foundation Recommendations**

Structures may be supported on shallow foundations bearing on the onsite soils when prepared in accordance with the recommendations above. When so prepared, a maximum allowable bearing pressure of 2,500 psf with no minimum dead load requirement may be used for design. The foundation design should be prepared by a qualified Colorado Registered Professional Engineer using the recommendations presented in this report. This foundation system should be designed to span a minimum of 10 feet under the design loads. The bottoms of exterior foundations should be at least 30 inches below finished grade for frost protection. When prepared and properly compacted, total settlement of 1-inch or less with differential settlement on the order of ½ inch or less is estimated. Settlement in granular material will occur relatively rapidly with construction loads. Long term consolidation settlement should not be an issue in the site material if prepared as recommended above.

All foundation and site preparation recommendations contained herein apply equally to the proposed sanitary lift station.

### **Open Excavation Observations**

As referenced above, 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 particular if claystone is encountered within 4-feet of foundation elements, additional overexcavation will be recommended. In the case of differences, the Open Excavation Observation report shall be considered to be the governing document to be used to modify the site preparation recommendations as necessary.

### **Floor Slabs**

The in-situ silty sand soil is non-plastic and should be stable at its natural moisture content. The onsite soil is suitable as backfill material. Any fill material from outside sources used to bring the site to grade should be non-expansive granular material to control slab movement.

Soil for interior floor slabs should be prepared in a manner similar to foundations above. Areas under floor slabs should be overexcavated a minimum of 1-foot and the upper 6 inches of the exposed subsurface soils should then 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. Floor slabs should bear upon a minimum of 1-foot of structural backfill compacted to a minimum of 95 percent of Modified Proctor maximum dry density as determined by ASTM D-1557. Non-structural slabs should be isolated from foundation members with expansion material. To reduce the possibility of capillary rise of groundwater into the floor slab, and to reduce the potential for concrete curling, a minimum 3-inch layer of  $\frac{3}{4}$ -inch crushed stone may be placed atop the compacted structural fill. A 6-mil vapor retarder may be installed above the crushed stone.

### **Exterior Concrete Flatwork**

Reinforced concrete exterior slabs should be constructed similarly to floor slabs on compacted structural fill, with the additional caveat they be isolated from the building with expansion material, and have a downturned reinforced thickened edge.

### **Lateral Earth Pressures**

Foundation and basement walls should be designed to resist lateral pressures. For non-expansive backfill materials, we recommend an equivalent fluid pressure of 40 pcf for design. Expansive soils or bedrock should not be used as backfill against walls. The above lateral pressure applies to level, drained backfill conditions. Equivalent Fluid Pressures for sloping/undrained conditions should be determined on an individual basis.

## **CONSTRUCTION CONSIDERATIONS**

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### **Surface Grading and Drainage**

A contributing factor to foundation settlement and floor slab heave in Colorado Front Range soils is the introduction of excess water. Improper site grading and irrigation water are respectively the most common cause and source of excess water. 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. Future homeowners should be informed to maintain the surface grading and drainage recommendations herein 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 excess water will increase the likelihood of slab and foundation movements.



## Perimeter Drain

The overburden site soil is well draining, but groundwater was encountered at varying depths across the site. A subsurface perimeter drain is recommended around portions of structures which will have habitable or storage space located below the finished ground surface. This includes crawlspace areas if applicable. Where main level slab-on-grade foundation systems are utilized, a subsurface perimeter drain will not be required around the foundation.

## Underslab Drain

Shallow groundwater conditions were encountered in Test Borings R-06 and R-10, and may be present at other locations. Depending on the conditions observed at the time of the Open Excavation Observation, an underslab drainage layer may also be recommended 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. Careful attention should be paid to grade and discharge of the drain pipe.

## 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.

plat note for under  
drain?

## Exterior Backfill

Backfill around foundation stemwalls and other buried structures should be placed in loose lifts of 10-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 appropriate government/utility specifications should be used for fill placed in utility trenches. If material is imported for backfill, the material should be approved by the Geotechnical Engineer prior to hauling it to the site.

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.

## Structural Fill - General

Except as discussed above for foundations and slab support, 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 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 be placed in loose lifts of 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.

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

To verify the condition of the compacted soils, density tests should be performed during placement. The first density tests should be conducted when 24 inches of fill have been placed.

## SECTION 2 - FULL SPECTRUM DETENTION AREA

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Full spectrum detention ponds are typically designed and constructed with embankments and control structures to store stormwater above the natural grade of the land. Our investigation included two Soil Test Borings in this region to characterize the subsurface soils pertinent to embankment construction, and to provide recommendations regarding embankment construction. These recommendations have been prepared in accordance with the requirements outlined in the El Paso County Land Development Code (LDC), the Engineering Criteria Manual (ECM) Section 2.2.6 and Appendix C.3.2.B, and the El Paso County (EPC) Drainage Criteria Manual, Volume 1 Section 11.3.3.

### Detention Storage Criteria

Detention pond embankments that impound water above the natural grade of the land are considered dams under rules and regulation promulgated by the State of Colorado Department of Natural Resources. Rules and Regulations for Dam Safety and Dam Construction have been developed to provide guidance to design engineers and constructors. Dams are regulated as jurisdictional dams or non-jurisdictional dams. In accordance with El Paso County Drainage Criteria Manual, Volume 1, Section 6.6, embankments in this development will most likely qualify as **non-jurisdictional, minor dams, with a Class III hazard rating.**

The purpose of our recommendations is to provide information to comply with the referenced guidelines and provide pertinent geotechnical information upon which to base the design and construction of pond embankments. This section presents the findings of the investigation performed by RMG and our recommendations regarding detention pond construction.

### General Physiographic Setting

The site is located within the western flank of the Colorado Piedmont section of the Great Plains physiographic province. The Colorado Piedmont which formed during Late Tertiary and Early Quaternary time (approximately 2,000,000 years ago) is a broad, erosional trench which separates the Southern Rocky Mountains from the High Plains. During the Late Mesozoic and Early Cenozoic

Periods (approximately 70,000,000 years ago), intense tectonic activity occurred, causing the uplifting of the Front Range and associated downwarping of the Denver Basin to the east. Relatively flat uplands and broad valleys characterize the present-day topography of the Colorado Piedmont in this region. More particularly, the site is located on alluvial deposits with bedrock intrusions above Fountain Creek.

## **Topography**

The ground surface generally slopes gently down to the south and southwest across the entire site and drops precipitously into Fountain Creek at the south end. Fountain Creek is adjacent to and forms the western property line.

## **Vegetation**

Vegetation across the site generally consists of native grasses, shrubs, and weeds.

## **General Soil Types**

The general geology of the area is typically stream terrace deposits and alluvium soils overlying the Pierre Shale. Samples from each Soil Test Boring exhibited characteristics of the general geology. The subsurface conditions can be characterized by describing two geologic units that were mapped in the vicinity of the site identified (Morgan, et al., 2003) as:

- al: alluvium is loose, unconsolidated (not cemented together into a solid rock) soil or sediments, which has been eroded, reshaped by water in some form, and redeposited in a non-marine setting. Alluvium is typically made up of a variety of materials, including fine particles of silt and clay and larger particles of sand and gravel.
- Kp: Pierre Shale – (Upper Cretaceous) Underlain by the Piney Creek Alluvium. Permeability is generally low, excavation and compaction generally easy. Foundation stability is less than fair. The majority of the formation has low to high swell potential. Slope stability is generally poor and slopes steeper than 5 degrees may slide, if the toe of the slope is removed.

## **Subsurface Materials**

The subsurface materials encountered in Test Borings R-09 and R-10 were classified using the Unified Soils Classification System (USCS) and the materials were grouped into the general categories of silty sand and shale. These soils classify as SW-SM, well-graded silty sand, and CH, sandy fat clay. It is anticipated that subgrade foundations for embankments will be in alluvial material, and that the embankments themselves will be constructed from on-site alluvial material. Embankments are not anticipated to be constructed directly upon or built up from shale bedrock.

## **Groundwater**

Groundwater was not encountered in R-09. Groundwater was encountered in R-10 at 6-feet below the existing ground surface. Groundwater may influence detention pond embankment design and construction.

# CONCLUSIONS AND RECOMMENDATIONS

## Soil and Rock Design Parameters

RMG has performed numerous laboratory tests of soil similar to the soils encountered in the Soil Test Borings. Based upon field and laboratory testing, the following soil and rock parameters are typical for the soils likely to be encountered, and are recommended for use in detention pond embankment design.

Soil Description	Unit Weight (lb/ft <sup>3</sup> )	Friction Angle (degree)	Active Earth Pressure, Ka	Passive Earth Pressure, Kp	At Rest Earth Pressure, Ko	Unconfined compressive Strength (kip/ft <sup>2</sup> )
Alluvial Soil SW-SM	115	30	0.33	3.0	0.50	-
Shale Bedrock CH	124	-	-	-		72

## 6.2 Seismic Design

In accordance with the International Building Code, 2012/2015, seismic design parameters have been determined for this site. The Seismic Site Class has been interpreted from the results of the soil test borings drilled within the project site. The USGS seismic design tool has been used to determine the seismic response acceleration parameters. USGS output is presented in Appendix B. The soil on this site is not considered susceptible to liquefaction. The following recommended Seismic Design Parameters are based upon Seismic Site Class D, and a 2 percent probability of exceedance in 50 years. The Seismic Design Category is “B”.

Period (sec)	Mapped MCE Spectral Response Acceleration (g)		Site Coefficients		Adjusted MCE Spectral Response Acceleration (g)		Design Spectral Response Acceleration (g)	
0.2	S <sub>s</sub>	0.175	F <sub>a</sub>	1.6	S <sub>ms</sub>	0.280	S <sub>ds</sub>	0.187
1.0	S <sub>1</sub>	0.060	F <sub>v</sub>	2.4	S <sub>m1</sub>	0.145	S <sub>d1</sub>	0.097

Notes: MCE = Maximum Considered Earthquake  
g = acceleration due to gravity

## 6.3 Embankment Recommendations

Development plans providing detention pond details were not available. In general, embankments should be constructed with 4:1 slopes. Embankments should be constructed in accordance with applicable sections of the El Paso County Engineering Criteria Manual, the El Paso County Drainage Criteria Manual, and the El Paso County Land Development Manual. The following recommendations are in accordance with the El Paso county DCM Volume 2, Extended Detention Basin (EDB), Design Procedure and Criteria, paragraph 8.

The ground area to receive embankments should be cleared and grubbed to a minimum depth of two-feet to remove grass, shrubs, trees, roots, stumps, and other organic material. The exposed soil should be 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 prepared surface should present a firm and stable condition.

Embankment should be constructed as structural fill on a prepared stable base. On-site native soil when screened of all deleterious material and cobbles greater than 6-inches in any dimension is suitable for embankment construction. Structural fill should be placed in 10-inch loose lifts 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).

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. To verify the condition of the compacted soils, density tests should be performed during placement. The first density tests should be conducted when 24 inches of fill have been placed.

## SECTION 3 - COMMERCIAL DEVELOPMENT

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The discussion presented below is based on the subsurface conditions encountered in the Soil Test Borings performed through the existing pavement in the commercial development area. These borings are designated C-01 through C-05. During development if the subsurface conditions are different from those described in this report or the project characteristics change, RMG should be retained to review our recommendations and modify them, if necessary. The conclusions and recommendations presented in this report should be verified by RMG during construction.

## SUBSURFACE CONDITIONS

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### **Subsurface Materials**

Commercial Soil Test Borings (C-01 through C-05) were performed through the existing pavement of the commercial area. The subsurface materials were classified by laboratory testing in accordance with the Unified Soils Classification System (USCS).

Similar soil conditions were encountered in each of the five borings.

0 to 2-inches: Asphalt Pavement

2" to 20-feet: Tan to brown, loose to medium dense, moist, Silty Sand. This soil classifies primarily throughout its depth as SW-SM, well-graded silty sand with gravel.

Additional descriptions and the interpreted distribution (approximate depths) of the subsurface materials are presented on the Test Boring Logs. The descriptions 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.

## **Groundwater**

Groundwater was not encountered in any of the borings through the depths investigated. Fluctuations in groundwater and subsurface moisture conditions may occur due to seasonal variations in rainfall and other factors not readily apparent at this time.

## **CONCLUSIONS AND RECOMMENDATIONS**

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Based upon preliminary site plans provided to RMG, we understand some of the existing structures in the commercial strip mall area may be demolished or reconfigured to construct a roadway leading to the residential development. We also understand the existing pavement may be rehabilitated or reconstructed. New buildings may also be constructed on the site. Recommendations for commercial building foundations and for pavement design are presented below.

### **Geotechnical Considerations**

Overall, the subsurface soil conditions are favorable for commercial development on shallow foundation systems. The well-graded silty sand found throughout the site can be prepared to provide adequate bearing capacity. Claystone and shale were not encountered in any of the test borings. Development recommendations are similar to those above for residential, but will be re-stated below.

### **Site Preparation**

Final grading plans were not available for review. In general, the following site preparation procedures are recommended.

Standard Penetration Test blow counts indicate the in situ soil is in a relatively dense condition, but this can change with demolition and other development activities. We recommend improving the soil under foundations by overexcavating the foundation areas and backfilling with compacted structural fill. The on-site material is suitable as structural backfill. Site preparation should include clearing and grubbing the site of all vegetation, topsoil, pavement, old foundation elements, and any other deleterious material within the construction area and disposing this material appropriately. Following clearing and grubbing, the area within the foundation footprint and a 2-foot perimeter beyond should be overexcavated two (2) feet below the bottom of footing elevation. The excavated material may be stockpiled for reuse as structural backfill. An Open Excavation Observation should be made at this point to verify soil conditions are as reported in the soil boring logs herein.

Upon verification, the upper 6 inches of the exposed subsurface soils should then 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.

After compaction of the subgrade, the native material previously removed may be used as structural backfill to bring the site to bottom of footing grade. The material should not be excessively wet, should be free of organic matter and construction debris, and contain no rock fragments greater than 3-inches in any dimension. Fill material should be placed in ten-inch loose lifts with moisture content within 2 percent of optimum as determined by ASTM D-1557. Each loose lift should be compacted to a

minimum of 95 percent of Modified Proctor maximum dry density as determined by ASTM D-1557. Backfill soil should be density tested to verify compaction meets these requirements.

### **Foundation Recommendations**

Commercial structures may be supported on shallow foundations bearing on the onsite soils when prepared in accordance with the recommendations above. When so prepared, a maximum allowable bearing pressure of 2,500 psf with no minimum dead load requirement may be used for design. The foundation design should be prepared by a qualified Colorado Registered Professional Engineer using the recommendations presented in this report. This foundation system should be designed to span a minimum of 10 feet under the design loads. The bottoms of exterior foundations should be at least 30 inches below finished grade for frost protection. When prepared and properly compacted, total settlement of 1-inch or less with differential settlement on the order of ½ inch or less is estimated. Settlement in granular material will occur relatively rapidly with construction loads. Long term consolidation settlement should not be an issue in the site material if prepared as recommended above.

### **Open Excavation Observations**

As referenced above, 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 to be used to modify the site preparation recommendations as necessary.

### **Floor Slabs**

The in-situ silty sand soil is non-plastic and should be stable at its natural moisture content. The onsite soil is suitable as backfill material. Any fill material from outside sources used to bring the site to grade should be non-expansive granular material to control slab movement.

Soil for interior floor slabs should be prepared in a manner similar to foundations above. Areas under floor slabs should be overexcavated a minimum of 1-foot and the upper 6 inches of the exposed subsurface soils should then 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. Floor slabs should bear upon a minimum of 1-foot of structural backfill compacted to a minimum of 95 percent of Modified Proctor maximum dry density as determined by ASTM D-1557. Non-structural slabs should be isolated from foundation members with expansion material. To reduce the possibility of capillary rise of groundwater into the floor slab, and to reduce the potential for concrete curling, a minimum 3-inch layer of ¾-inch crushed stone may be placed atop the compacted structural fill. A 6-mil vapor retarder may be installed above the crushed stone.

### **Exterior Concrete Flatwork**

Reinforced concrete exterior slabs should be constructed similarly to floor slabs on compacted structural fill, with the additional caveat they be isolated from the building with expansion material, and have a downturned reinforced thickened edge.

## **Lateral Earth Pressures**

Foundation and basement walls should be designed to resist lateral pressures. For non-expansive backfill materials, we recommend an equivalent fluid pressure of 40 pcf for design. Expansive soils or bedrock should not be used as backfill against walls. The above lateral pressure applies to level, drained backfill conditions. Equivalent Fluid Pressures for sloping/undrained conditions should be determined on an individual basis.

## **SECTION 4 - PAVEMENT RECOMMENDATIONS**

---

### **Pavement Design**

The development area appears to be just beyond the City of Fountain city limits in El Paso County. Presuming the development will be annexed into the City of Fountain, the governing specification for roadway design will be The City of Colorado Springs Engineering Criteria Manual (if the development remains in the County, the El Paso County Engineering Manual will govern; the two documents produce similar pavement designs).

The following information is provided for general consideration and applicable to residential roadways serving the subdivision, commercial roadways providing access to the subdivision, and commercial parking pavements. Final pavement designs will be required for jurisdictional acceptance, and are typically performed with soil samples obtained from roadway areas after the deepest public utilities have been installed. Typical pavement sections based upon RMG's experience with the soils encountered on this site are presented below.

The silty sand encountered in the Test Borings will form the subgrade of pavement sections, and its stability and strength are critical to pavement design. The soil consists of well-graded silty sand. This material will typically classify as A-1 or A-2 soils in accordance with the American Association of State Highway and Transportation Officials (AASHTO) classification system. These soils are considered "excellent to good" as subgrade material.

The California Bearing Ratio, CBR, is an indication of the mechanical strength of pavement subgrades and is a key factor in determining pavement section thicknesses. A-1 and A-2 soils will typically produce CBR's of 10 or higher. At these values the minimum pavement sections prescribed in the Engineering Criteria Manuals will be sufficient for expected traffic loading in the proposed developments.

### **Pavement Thickness**

Assuming an adequate subgrade CBR, typical pavement sections for residential roadways, paved parking areas, and for heavy vehicle loading areas are presented below, where HMA is Hot Mix Asphalt, and ABC is Aggregated Base Course.



<b>Typical Hot-Mix Asphalt Pavement Section</b>	
<b>Traffic Level</b>	<b>HMA over ABC (inches)</b>
Moderate Traffic / Some Trucks	4.0 / 6.0
Heavy Vehicles with Turning Motions	6.0 / 6.0

As an alternative to the HMA section above, Rigid Concrete Pavements are often employed in areas where heavy vehicle loading is expected. These areas include drop-off/pick-up areas, loading docks, trash pick-up areas, and other locations where heavy trucks will be making frequent turning and braking movements. Rigid pavements may be constructed directly on proof-rolled non-expansive granular subgrade, the top one foot of which has been compacted to a minimum of 95% of maximum dry density as determined by ASTM D1557.

<b>Typical Rigid Concrete Pavement Section</b>	
<b>Traffic Level</b>	<b>Portland Cement Concrete (in.)</b>
Heavy Vehicles with Turning Motions	5.0 in.

This pavement information is for preliminary planning purposes only. CBR values will be based on the materials encountered at the time of development and will be dependent upon the soil material used for site fill and subgrade construction. We suggest evaluating the soil conditions after site grading and pavement layout to perform a proper design.

## 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 **Avatar Fountain, LP** 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



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

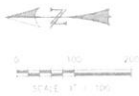
## SITE VICINITY MAP

RESIDENTIAL / RETAIL  
RIVER BEND CROSSING  
FOUNTAIN, CO  
AVATAR FOUNTAIN, LP

JOB No. 161921

FIG No. 1

DATE 3-21-2018



REFERENCE  
NOT TO SCALE

R: RESIDENTIAL  
C: COMMERCIAL

 DENOTES APPROXIMATE  
LOCATION OF TEST BORINGS



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## TEST BORING LOCATION PLAN

RESIDENTIAL / RETAIL  
RIVER BEND CROSSING  
FOUNTAIN, CO  
AVATAR FOUNTAIN, LP

JOB No. 161921

FIG No. 2







DATE 3-21-2018

## SOILS DESCRIPTION

	ASPHALT
	CLAYSTONE
	SHALE
	SILTY 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 (%)

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## EXPLANATION OF TEST BORING LOGS

JOB No. 161921

FIGURE No. 3

DATE 4/2/18

TEST BORING: C01 DATE DRILLED: 3/12/18 ELEVATION (FT): NO GROUNDWATER ON 3/12/18					TEST BORING: C02 DATE DRILLED: 3/12/18 ELEVATION (FT): NO GROUNDWATER ON 3/12/18				
DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
2" ASPHALT SAND, SILTY, with gravel, brwon, medium dense to dense, moist					2" ASPHALT SAND, SILTY, with gravel, brown, medium dense, moist				
5			17	2.8	5			19	2.4
10			20	2.1	10				3.5
15			17	3.8	15				3.4
20			32	4.2	20				3.4
					BORING CAVED AT 9' DUE TO LOOSE SANDS, BULK SAMPLES TAKEN				

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## TEST BORING LOGS

JOB No. 161921

FIGURE No. 4

DATE 4/2/18

TEST BORING: C03 DATE DRILLED: 3/12/18 ELEVATION (FT): NO GROUNDWATER ON 3/12/18					TEST BORING: C04 DATE DRILLED: 3/12/18 ELEVATION (FT): NO GROUNDWATER ON 3/12/18				
DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
2" ASPHALT SAND, SILTY, with gravel, brown, medium dense, moist					2" ASPHALT SAND, SILTY, with gravel, brown, medium dense, moist				
5			19	9.1	5			18	2.1
10			29	2.9	10			10	3.5
15			25	3.5	15			17	2.1
20			28	2.6	20				2.3

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





## TEST BORING LOGS

JOB No. 161921

FIGURE No. 5

DATE 4/2/18



TEST BORING: <b>C05</b> DATE DRILLED: 3/12/18 ELEVATION (FT): NO GROUNDWATER ON 3/12/18	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %	TEST BORING: <b>R01</b> DATE DRILLED: 3/2/18 ELEVATION (FT): GROUNDWATER @ 19.0 ' 3/2/18	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
2" ASPHALT  SAND, SILTY, with gravel, brown, loose to medium dense, moist	5			8	3.4	SAND, SILTY TO CLAYEY, with gravel and cobbles, brown to reddish brown, medium dense to dense, moist to wet	5			17	4.3
	10			24	3.4		10			32	4.1
	15			21	2.9		15				3.4
	20			25	4.3		20			17	13.6

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## TEST BORING LOGS

JOB No. 161921

FIGURE No. 6

DATE 4/2/18

TEST BORING: R02 DATE DRILLED: 3/2/18 ELEVATION (FT): GROUNDWATER @ 13.0 ' 3/5/18					TEST BORING: R03 DATE DRILLED: 3/2/18 ELEVATION (FT): GROUNDWATER @ 13.0 ' 3/5/18				
DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
SAND, SILTY TO CLAYEY, with gravel, brown, loose, moist					SAND, SILTY TO CLAYEY, brown, loose, moist				
5			9	11.5	5			7	7.7
SAND, SILTY, with gravel and cobbles, tan and reddish brown to gray, medium dense, moist to wet									
10			17	1.6	10			19	2.4
BORING CAVED AT 14' DUE TO LOOSE SANDS, BULK SAMPLES TAKEN									
15				3.5	15			15	14.4
20				12.8	20			19	8.2

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## TEST BORING LOGS

JOB No. 161921

FIGURE No. 7

DATE 4/2/18

<p>ROCKY MOUNTAIN GROUP</p> <p>ARCHITECTS <b>RMG</b> ENGINEERS</p> <p><i>Colorado Springs (Corporate Office)</i> 2010 Austin Bluffs Parkway Colorado Springs, CO 80918 (719) 548-0600</p> <p>SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO</p> <p>Architectural Structural Forensics</p> <p>Geotechnical Materials Testing Civil, Planning</p>	<p><b>TEST BORING LOGS</b></p>	<p>JOB No. 161921</p> <p>FIGURE No. 8</p> <p>DATE 4/2/18</p>
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TEST BORING: <b>R06</b> DATE DRILLED: 3/2/18 ELEVATION (FT): GROUNDWATER @ 7.0' 3/5/18	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %	TEST BORING: <b>R07</b> DATE DRILLED: 3/2/18 ELEVATION (FT): NO GROUNDWATER ON 3/2/18	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
SAND, SILTY, with gravel and cobbles, brown, medium dense, moist	5			22	20.6	SAND, SILTY, with gravel and cobbles, brown to reddish brown, loose, moist	5			9	3.8
CLAYSTONE, SILTY, gray to dark gray with rust staining, firm, moist to wet	10			27	5.3	BORING CAVED AT 9' DUE TO LOOSE SANDS, BULK SAMPLES TAKEN	10				3.0
SHALE, SILTY, gray to dark gray, very hard, moist to wet	15				31.0		15				2.1
	20			50/5"	20.5		20				2.7

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## TEST BORING LOGS

JOB No. 161921

FIGURE No. 9

DATE 4/2/18

TEST BORING: R08 DATE DRILLED: 3/2/18 ELEVATION (FT): GROUNDWATER @ 19.5' 3/1/18					TEST BORING: R09 DATE DRILLED: 3/2/18 ELEVATION (FT): NO GROUNDWATER ON 3/2/18				
DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
SAND, SILTY, with gravel and cobbles, medium dense, moist					SAND, SILTY, with gravel and cobbles, brown to reddish brown, loose to medium dense, moist				
5			17	13.4	5		6		1.7
CLAYSTONE, SILTY, brown to gray, hard, moist									
10			50/11"	23.0	10		14		3.3
SHALE, SILTY, gray to dark gray, very hard, moist to wet									
15			50/6"	13.6	15		18		3.9
20				13.1	20		17		2.8

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## TEST BORING LOGS

JOB No. 161921

FIGURE No. 10

DATE 4/2/18

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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
C01	4.0	2.8								
C01	9.0	2.1		NP	NP	44.7	3.4			SW
C01	14.0	3.8								
C01	19.0	4.2								
C02	4.0	2.4								
C02	9.0	3.5								
C02	14.0	3.4		NP	NP	21.3	7.1			SW-SM
C02	19.0	3.4								
C03	4.0	9.1		NP	NP	20.5	15.1			SM
C03	9.0	2.9								
C03	14.0	3.5								
C03	19.0	2.6								
C04	4.0	2.1								
C04	9.0	3.5		NP	NP	22.7	7.0			SW-SM
C04	14.0	2.1								
C04	19.0	2.3								
C05	4.0	3.4								
C05	9.0	3.4								
C05	14.0	2.9		NP	NP	28.3	3.3			SW
C05	19.0	4.3								
R01	4.0	4.3								
R01	9.0	4.1		NP	NP	34.8	3.1			SP
R01	14.0	3.4								
R01	19.0	13.6								
R02	4.0	11.5								
R02	9.0	1.6								
R02	14.0	3.5		NP	NP	33.4	8.7			SP-SM
R02	19.0	12.8								
R03	4.0	7.7		NP	NP		79.6			ML
R03	9.0	2.4								
R03	14.0	14.4								
R03	19.0	8.2								
R04	4.0	3.0		NP	NP	23.5	3.7			SW
R04	9.0	1.8								

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## SUMMARY OF LABORATORY TEST RESULTS

JOB No. 161921  
FIGURE No. 12  
PAGE 1 OF 2  
DATE 4/2/18

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
R04	14.0	3.5								
R04	19.0	3.0								
R05	4.0	9.4								
R05	9.0	2.5								
R05	14.0	31.4		55	37		56.9			CH
R05	19.0	29.3								
R06	4.0	20.6								
R06	9.0	5.3								
R06	14.0	31.0		53	33		88.5			CH
R06	19.0	20.5								
R07	4.0	3.8								
R07	9.0	3.0		NP	NP	48.9	3.9			GP
R07	14.0	2.1								
R07	19.0	2.7								
R08	4.0	13.4								
R08	9.0	23.0	105.2	53	29		91.6		3.0	CH
R08	14.0	13.6								
R08	19.0	13.1								
R09	4.0	1.7								
R09	9.0	3.3								
R09	14.0	3.9		NP	NP	20.4	5.7			SW-SM
R09	19.0	2.8								
R10	4.0	4.0								
R10	9.0	17.7	109.6	43	30		85.6		- 0.1	CL
R10	14.0	14.5								
R10	19.0	35.5								
R11	4.0	11.1		37	23		66.2			CL
R11	9.0	8.3								
R11	14.0	28.3								
R11	19.0	19.1								

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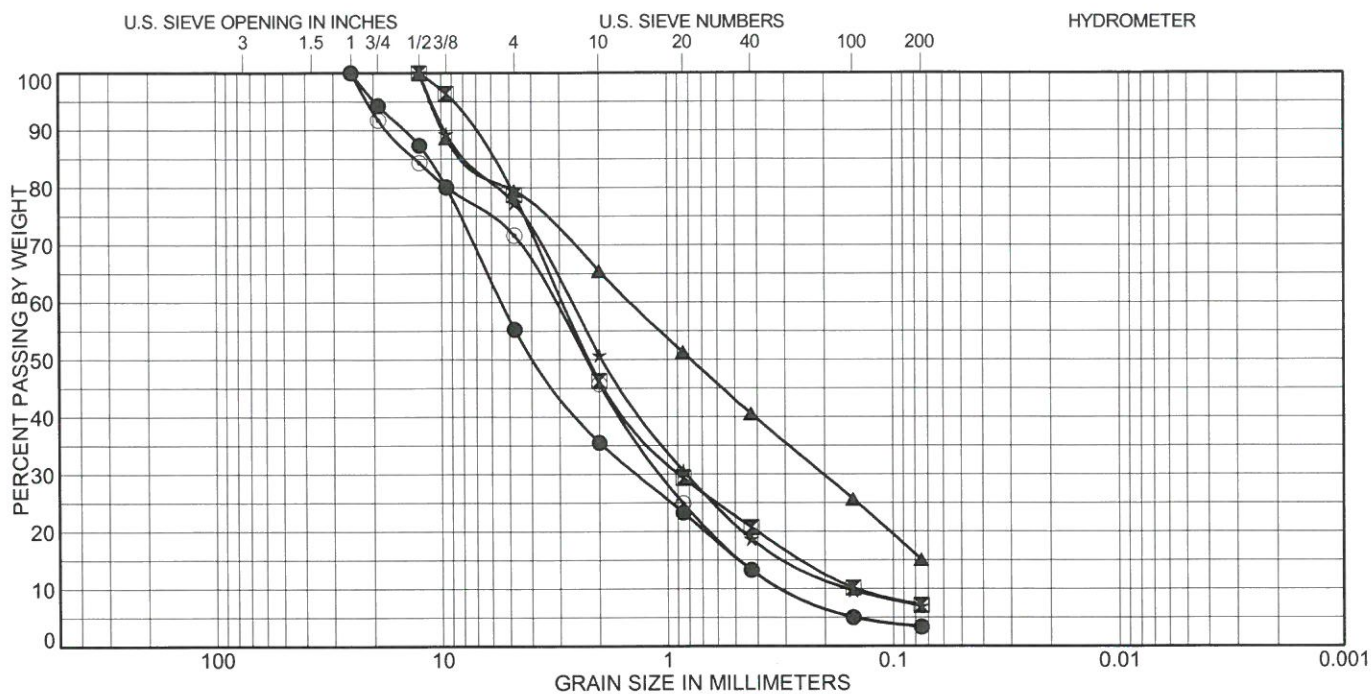
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## SUMMARY OF LABORATORY TEST RESULTS

JOB No. 161921  
FIGURE No. 12  
PAGE 2 OF 2  
DATE 4/2/18





COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Test Boring	Depth (ft)	Classification	LL	PL	PI
● C01	9.0	WELL-GRADED SAND with GRAVEL(SW)	NP	NP	NP
⊠ C02	14.0	WELL-GRADED SAND with SILT and GRAVEL(SW-SM)	NP	NP	NP
▲ C03	4.0	SILTY SAND with GRAVEL(SM)	NP	NP	NP
★ C04	9.0	WELL-GRADED SAND with SILT and GRAVEL(SW-SM)	NP	NP	NP
⊙ C05	14.0	WELL-GRADED SAND with GRAVEL(SW)	NP	NP	NP

Test Boring	Depth (ft)	%Gravel	%Sand	%Silt	%Clay
● C01	9.0	44.7	51.9	3.4	
⊠ C02	14.0	21.3	71.6	7.1	
▲ C03	4.0	20.5	64.4	15.1	
★ C04	9.0	22.7	70.3	7.0	
⊙ C05	14.0	28.3	68.4	3.3	

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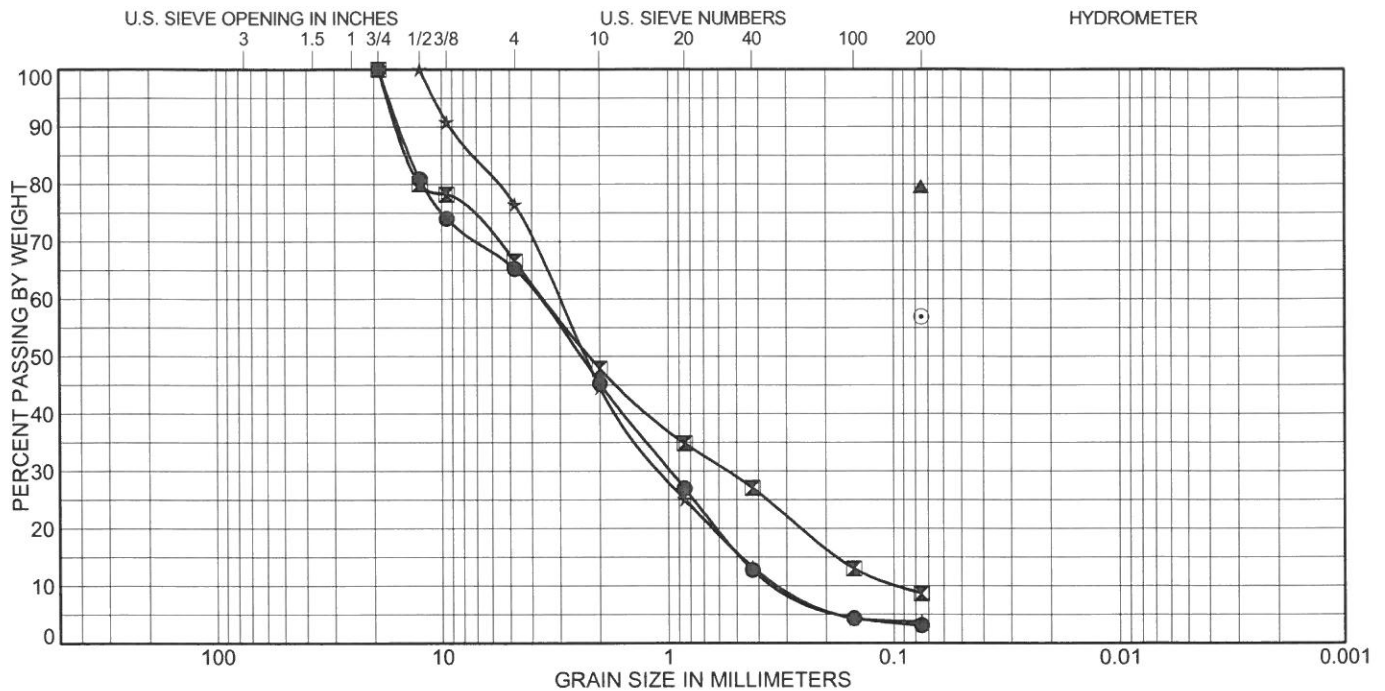
Geotechnical  
Materials Testing  
Civil, Planning

## SOIL CLASSIFICATION DATA

JOB No. 161921

FIGURE No. 13

DATE 4/2/18



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Test Boring	Depth (ft)	Classification	LL	PL	PI
● R01	9.0	POORLY GRADED SAND with GRAVEL(SP)	NP	NP	NP
⊠ R02	14.0	POORLY GRADED SAND with SILT and GRAVEL(SP-SM)	NP	NP	NP
▲ R03	4.0	SILT with SAND(ML)	NP	NP	NP
★ R04	4.0	WELL-GRADED SAND with GRAVEL(SW)	NP	NP	NP
⊙ R05	14.0	SANDY FAT CLAY(CH)	55	18	37

Test Boring	Depth (ft)	%Gravel	%Sand	%Silt	%Clay
● R01	9.0	34.8	62.1	3.1	
⊠ R02	14.0	33.4	57.9	8.7	
▲ R03	4.0			79.6	
★ R04	4.0	23.5	72.8	3.7	
⊙ R05	14.0			56.9	

ROCKY MOUNTAIN GROUP



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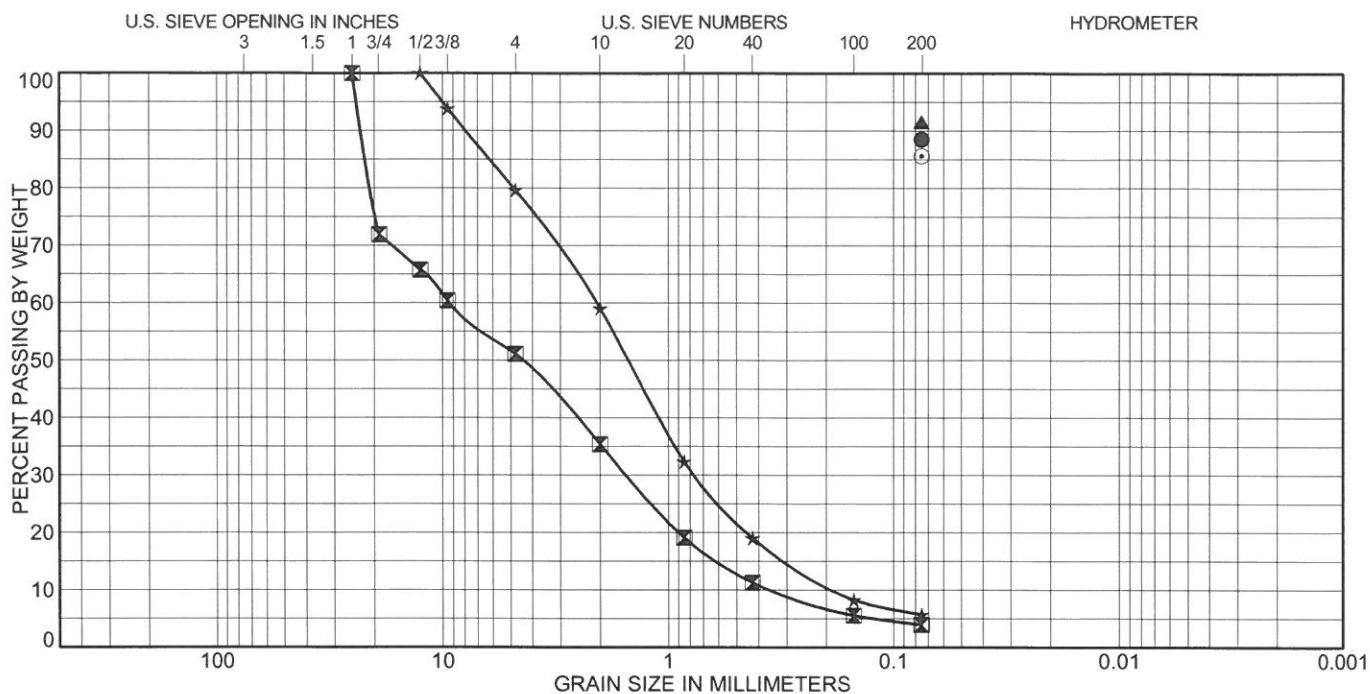
Geotechnical  
Materials Testing  
Civil, Planning

## SOIL CLASSIFICATION DATA

JOB No. 161921

FIGURE No. 14

DATE 4/2/18



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Test Boring	Depth (ft)	Classification	LL	PL	PI
● R06	14.0	FAT CLAY(CH)	53	20	33
⊠ R07	9.0	POORLY GRADED GRAVEL with SAND(GP)	NP	NP	NP
▲ R08	9.0	FAT CLAY(CH)	53	24	29
★ R09	14.0	WELL-GRADED SAND with SILT and GRAVEL(SW-SM)	NP	NP	NP
⊙ R10	9.0	LEAN CLAY(CL)	43	13	30

Test Boring	Depth (ft)	%Gravel	%Sand	%Silt	%Clay
● R06	14.0			88.5	
⊠ R07	9.0	48.9	47.2	3.9	
▲ R08	9.0			91.6	
★ R09	14.0	20.4	73.9	5.7	
⊙ R10	9.0			85.6	

ROCKY MOUNTAIN GROUP

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Structural  
Forensics



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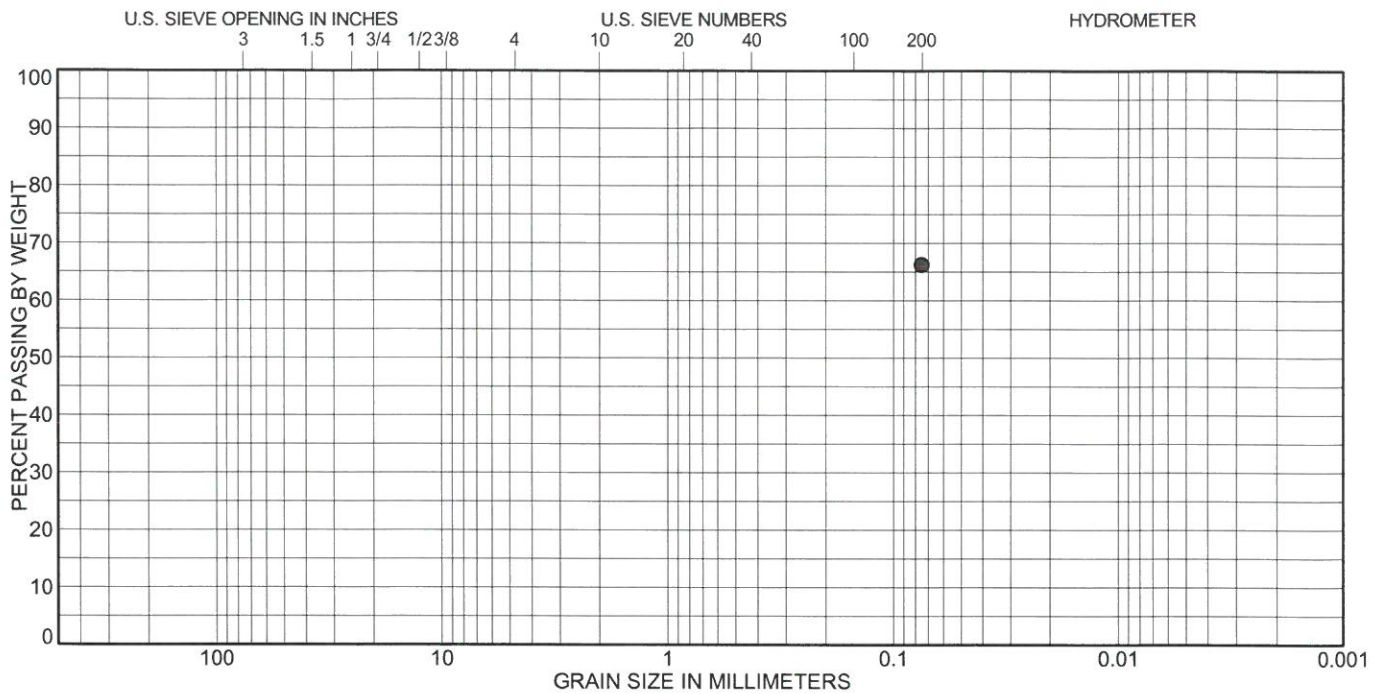
Geotechnical  
Materials Testing  
Civil, Planning

## SOIL CLASSIFICATION DATA

JOB No. 161921

FIGURE No. 15

DATE 4/2/18



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Test Boring	Depth (ft)	Classification	LL	PL	PI
● R11	4.0	SANDY LEAN CLAY(CL)	37	14	23

Test Boring	Depth (ft)	%Gravel	%Sand	%Silt	%Clay
● R11	4.0			66.2	

ROCKY MOUNTAIN GROUP

Architectural  
Structural  
Forensics



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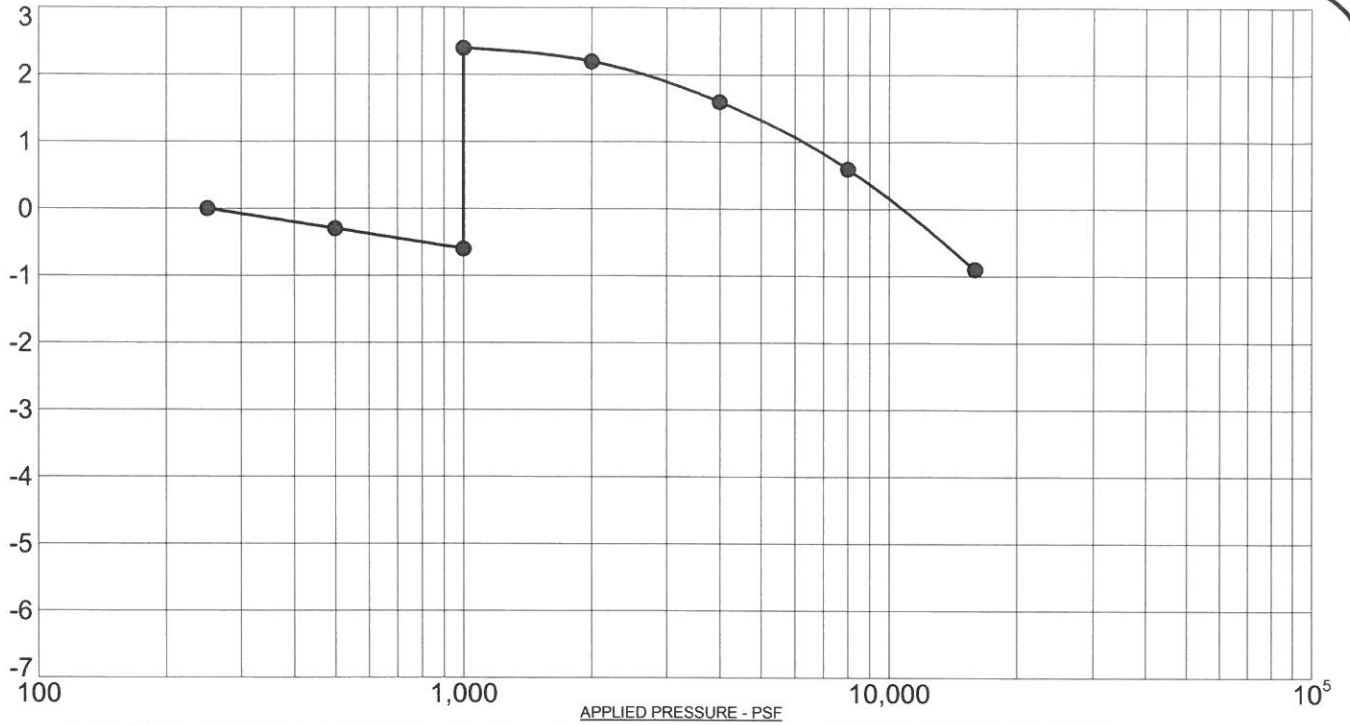
## SOIL CLASSIFICATION DATA

JOB No. 161921

FIGURE No. 16

DATE 4/2/18

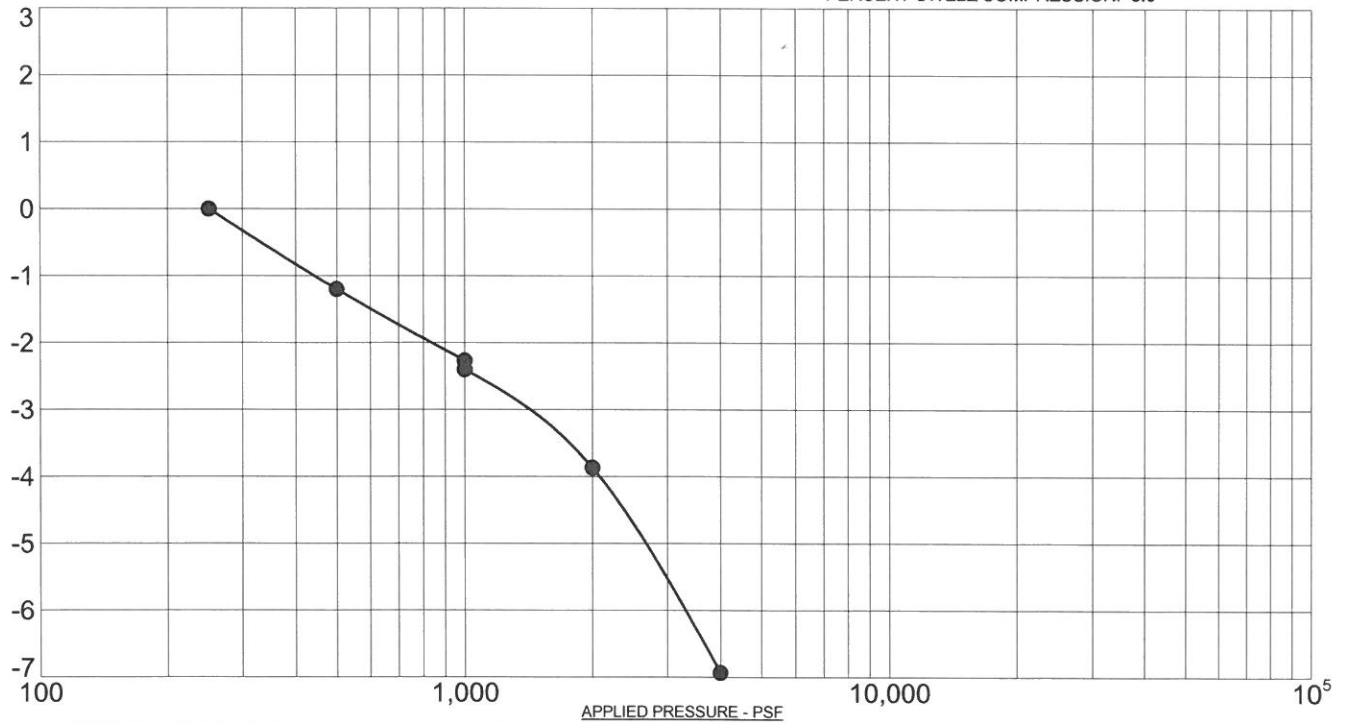
COMPRESSION % EXPANSION



PROJECT: 5680 S U.S. Highway 85/87, Fountain, Colorado  
SAMPLE DESCRIPTION: CLAYSTONE, SILTY  
NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF

SAMPLE LOCATION: R08 @ 9 FT  
NATURAL DRY UNIT WEIGHT: 105.2 PCF  
NATURAL MOISTURE CONTENT: 23.0%  
PERCENT SWELL/COMPRESSION: 3.0

COMPRESSION % EXPANSION



PROJECT: 5680 S U.S. Highway 85/87, Fountain, Colorado  
SAMPLE DESCRIPTION: SAND, SILTY TO CLAYEY  
NOTE: SAMPLE WAS INUNDATED WITH WATER AT 1,000 PSF

SAMPLE LOCATION: R10 @ 9 FT  
NATURAL DRY UNIT WEIGHT: 109.6 PCF  
NATURAL MOISTURE CONTENT: 17.7%  
PERCENT SWELL/COMPRESSION: -0.1

ROCKY MOUNTAIN GROUP

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## SWELL/CONSOLIDATION TEST RESULTS

JOB No. 161921

FIGURE No. 17

DATE 4/2/18

## APPENDIX A



# USGS Design Maps Summary Report

## User-Specified Input

**Report Title** Avatar - Riverbend Fountain  
Sat March 31, 2018 19:11:19 UTC

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

**Site Coordinates** 38.74696°N, 104.74483°W

**Site Soil Classification** Site Class D - "Stiff Soil"

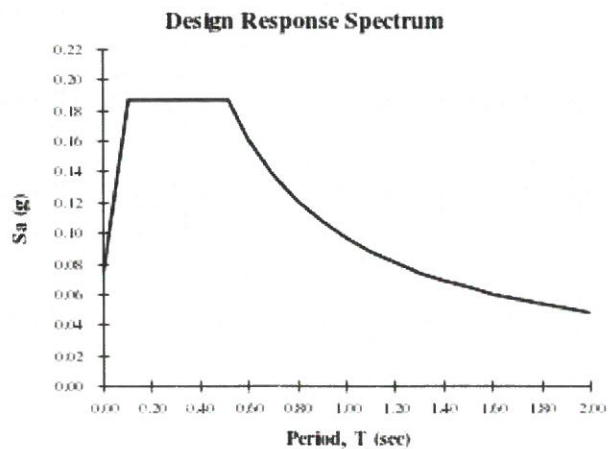
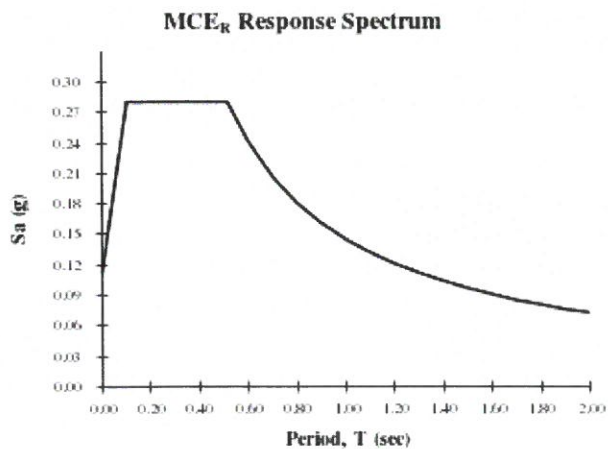
**Risk Category** I/II/III



## USGS-Provided Output

$S_s = 0.175 \text{ g}$	$S_{MS} = 0.280 \text{ g}$	$S_{DS} = 0.187 \text{ g}$
$S_1 = 0.060 \text{ g}$	$S_{M1} = 0.145 \text{ g}$	$S_{D1} = 0.097 \text{ g}$

For information on how the  $S_s$  and  $S_1$  values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please return to the application and select the "2009 NEHRP" building code reference document.



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