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FINAL REPORT
GEOTECHNICAL ENGINEERING STUDY
DEER CREEK ROAD, BASE CAMP ROAD, AND MICROSCOPE WAY
EL PASO COUNTY, COLORADO

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Project No. 19-2-195

August 29, 2019
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SUMMARY

1. The existing asphalt pavement thickness ranged from approximately 0.5 to 2.5 inches in our boring locations. Below the pavement materials, the native subgrade soils encountered generally consisted of clayey sand and silty sand, with less frequently occurring well-graded sand with silt and sandy fat clay. Silty-clayey sand fill was encountered in one of the borings to an approximate depth of 6 feet. Sandstone bedrock was encountered below the pavement or overburden soils in seven of the nine borings, and claystone was encountered below the sandstone in one of the borings.

2. At the time of drilling, groundwater was encountered in Boring 3 at an approximate depth of 19 feet. It is possible for groundwater to be present at different elevations during other times of the year. We anticipate areas along the roadway may have soils with elevated moisture contents, particularly immediately below the existing pavement, at or near the bedrock surface, near drainages, and in areas where the adjacent roadway drainage is poor.

3. The pavement sections developed include: composite HMA over ABC, and HMA over cement treated subgrade. The existing asphalt can be pulverized and blended into the subgrade, provided it can be reduced to a maximum particle size of 1.5 inches. This alternative provides the advantage of not having to remove the existing asphalt material from the project site. Recommended pavement section thicknesses are presented on Page 6.

4. Based on visual observations during our site visit, in our opinion the existing pavement condition for each of the roads is poor and not suitable for an overlay. In areas where pavement distress is occurring, unless the subgrade is properly addressed prior to paving, an overlay will develop reflective cracking and will have a shortened life expectancy.

PURPOSE AND SCOPE OF STUDY

This report presents the results of a geotechnical engineering study for the proposed roadway improvements, to include the western approximately 0.3 miles of Deer Creek Road and the two connecting cul-de-sacs, Base Camp Road and Microscope Way. The study was conducted in general accordance with our Proposal No. C19-216 dated June 18, 2019, to provide recommendations for site grading and pavement section thickness design, as well as subsurface information in the vicinity of the drainage crossing along Deer Creek Road. The project site is shown on Fig. 1. As requested, this revision has been made to provide updated pavement section recommendations for Deer Creek Road, based on the recently provided updated 20-year 18-kip ESALs.

This report has been prepared to summarize the data obtained during this study and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to the proposed roadway improvements are included in the report.

PROPOSED CONSTRUCTION

We understand the project will consist of the improvements for approximately 0.3 miles of Deer Creek Road, from Monument Hill Road east to Woodmoor Drive, and the two connecting cul-de-sacs that extend to the north, Base Camp Road and Microscope Way, which extend approximately 700 feet and 600 feet, respectively. Improvements may potentially include overlay/rehabilitation or complete reconstruction, widening for shoulders, and improvements to drainage, as appropriate. We have assumed site grading will consist of cuts and fills on the order of 5 feet or less. The pavement section alternatives being considered include a composite section of hot mix asphalt (HMA) over aggregate base course (ABC), and HMA over cement treated subgrade. At the drainage crossing along Deer Creek Road, improvements to the drainage had not been defined at the time of our study. We have assumed the drainage crossing could include installation of new corrugated steel or concrete storm pipe.

If locations or conditions are significantly different from those described above or depicted in this report, we should be notified to reevaluate the recommendations provided.

SITE CONDITIONS

The study area is surrounded by commercial development, with Lewis-Palmer Middle School located at the east end of the study area south of Deer Creek Road, and Palmer Ridge High School located to the north (north of the cul-de-sacs). Woodmoor Lake is located nearby, roughly 1,000 feet southeast of the east end of the project area. Regionally, the topography within the project area consists of rolling hills, with overall slopes that trend gently to moderately down to the south. An unnamed poorly defined drainage flows north to south thru the study area, crossing under Deer Creek Road in the vicinity of Boring 3. There was standing water and marsh type vegetation at both sides of the crossing at the time of our study. Elsewhere, vegetation along the roadway corridors primarily consists of grasses, weeds and occasional trees and shrubs.

Each of the roadways studied consisted of a 2-lane configuration, with little to no defined shoulder. Poorly defined drainage ditches parallel the outer portions of the embankment in some areas along the roadways. A majority of the asphalt pavement appeared to be in generally poor to very poor condition, with significant fatigue (alligator) cracking throughout, potholes that had been patched, and surface spalling or raveling present in many areas. In some areas, we observed very thin asphalt (<1-inch thick), and occasional areas with exposed subgrade.

FIELD EXPLORATION

The field exploration of subsurface conditions consisted of drilling 9 borings at the approximate locations shown on Fig. 1. The borings were completed on August 12 and 13, 2019. The boring logs are presented on Fig. 2, with the corresponding legend and notes included on Fig. 3.

The borings were drilled with 4-inch diameter continuous flight augers and were logged by a representative of Kumar & Associates, Inc. Samples of the soils were taken with a 2-inch I.D. California sampler. The samplers were driven into the various strata with blows from a 140-pound hammer falling 30 inches. Penetration resistance values, when properly evaluated, provide an indication of the relative density or consistency of the soils. Depths at which the samples were taken and the penetration resistance values are shown on the boring logs.

LABORATORY TESTING

Samples obtained from the exploratory borings were visually classified in the laboratory by the project engineer and samples were selected for laboratory testing. Laboratory testing included index property tests such as in-situ moisture content and dry unit weight, grain size analysis, and Atterberg limits. Additional testing performed included swell-consolidation, concentration of water soluble sulfates, Hveem's stabilometer (R-value), moisture-density relationships (standard Proctor), and remolded swell-consolidation. The testing was conducted in general accordance with recognized test procedures, primarily those of the American Society for Testing of Materials (ASTM). Results of the laboratory testing program are shown on Figs. 2 and 4 thru 15, and are summarized in Table I.

SUBSURFACE CONDITIONS

The following subsurface descriptions are of a generalized nature to highlight the major stratification features encountered in the borings. The boring logs should be referenced for more detailed information.

Pavement Sections: The borings were drilled within the existing roadways at the approximate locations indicated on Fig. 1. Full depth asphalt was encountered in each of the borings, and the thickness ranged from approximately 0.5 to 2.5 inches. Measurements of the thickness at each boring location are presented adjacent to the boring logs on Fig. 2.

Subgrade Conditions: Fill consisting of silty-clayey sand was encountered in one of the borings (Boring 3) to an approximate depth of 6 feet. This study did not determine the lateral or vertical extent of the fill.

Native soils encountered mainly consisted of clayey sand and silty sand, with less frequently occurring well-graded sand with silt and sandy fat clay. The overburden soils were encountered in seven of the nine borings, extending to depths ranging from approximately 6 feet to 13 feet in five of the borings and to the maximum 10-foot depths explored in two of the borings. Sampler penetration blow counts indicate the granular soils (clayey sand, silty sand and well-graded sand with silt) are loose to medium dense, and the sandy fat clay is medium stiff.

Sandstone bedrock was encountered below the asphalt pavement in two of the borings (Borings 2 and 9), and below the overburden soils in five of the borings, beginning at depths ranging from approximately 6 feet to 13 feet, and extending to the maximum 10 to 20-foot depths explored. In Boring 3, the sandstone was underlain by claystone, beginning at a depth of 17 feet and extending to the 25-fot depth explored. The sandstone was generally clayey and non-cemented. Sampler penetration blow counts indicate the bedrock is weathered to very hard.

Swell-consolidation test results presented on Figs. 4 and 5 indicate the tested samples of clayey sandstone, clayey sand and sandy fat clay had a nil to very low swell potential at the moisture contents tested. Of the samples tested, a maximum swell of 0.2% was measured upon wetting with a 150 psf surcharge. Additional swell-consolidation tests were performed on samples of the clayey sand remolded to approximately 95% of their maximum standard Proctor density (ASTM D 698) at a moisture content approximately equal to the optimum value. Under a 150-psf surcharge, the samples were non-expansive to slightly expansive (nil to +0.7%). The soil moisture-density relationships (Proctors) are presented on Figs. 13 and 14, and remolded swell consolidation test results are presented on Fig. 15.

At the time of drilling, groundwater was encountered in Boring 3 at an approximate depth of 19 feet. It is possible for ground water to be present at different elevations during other times of the year. The borings were backfilled/patched upon completion of drilling.

Overall, the in-situ moisture content of the granular soils and bedrock encountered were visually moist, with in-situ moisture contents ranging from 5.4% to 11.4% for the tested samples of granular soils and sandstone. The sandy fat clay appeared moist to very moist, and a tested sample of clay had a moisture content of 34.0%. We anticipate areas along the roadway may have soils with elevated moisture contents, particularly immediately below the existing pavement, at or near the bedrock surface, near drainages, and in areas where the adjacent roadway drainage is poor.

SITE GRADING

Fill placed for support of pavements should consist of a low to non-expansive material. Excluding the clay soils, the on-site materials encountered will be suitable for reuse as fill; however, the top 2 feet of subgrade will be required to have the minimum R-value specified in the design or greater. Fill should not contain concentrations of organic matter or other deleterious substances. Proposed import materials should be approved by the geotechnical engineer. All pavement subgrade fill should be placed and compacted to the criteria presented in Appendix K of the El Paso County Engineering Criteria Manual.

We recommend the following criteria be used when preparing the site grading plans. Permanent cut and fill slopes should not be steeper than 3:1 (horizontal to vertical), should not exceed 20 feet in height, and should be protected from erosion by vegetation or other suitable means. Slopes constructed in cohesive materials will generally be stable at 2:1; however, 2:1 slopes will be prone to increased surface erosion and it will be difficult to maintain vegetation on them. Cut and fill slopes of greater heights are feasible; however, they should be investigated on an individual basis. The risk of slope instability will be significantly increased if seepage is encountered in cuts. We do not anticipate seepage will be encountered, however, if it is, a stability investigation should be conducted to determine if the seepage will adversely affect the cut. No formal stability analyses were performed to evaluate the slopes; however, published literature and our experience with similar cuts and fills indicate the recommended slopes should have adequate factors of safety. If a detailed stability analysis is required, we should be notified.

Good surface drainage should be provided around all permanent cuts and fills to direct surface runoff away from the slope faces. Fill slopes, cut slopes and other stripped areas should be protected against erosion by revegetation or other methods.

PAVEMENT DESIGN

Subgrade Materials: The upper subgrade materials encountered generally included silty to clayey sand and sandstone bedrock, and classify as A-1-b, A-2-4, A-2-6, A-6 with a group index between 0 and 5 in accordance with the American Association of State Highway Transportation Officials (AASHTO) soil classification system. Other materials encountered at depth included sandy fat clay (A-7-5), but were not considered in the design because of the limited occurrence and depth at which they were encountered. The A-2-6 and A-6 soils are generally considered to have fair support characteristics for pavements, and the A-1-b and A-2-4 soils are considered to have good support characteristics. Hveem stabilometer test results presented on Figs. 11 and 12 indicate R-values of 16 and 25 for the tested sample of A-6 and A-2-6, respectively. Based on our experience in the area and or laboratory test results, for our pavement design, we assumed a minimum R-value of 16 for design of flexible pavements.

Design Traffic: We understand the roadways for this study classify as listed below. Design traffic 18-kip equivalent single axle load (ESAL) values used for our design include the estimated value for Deer Creek Road provided to us (based on a traffic study performed by others), and the default ESALs listed in the El Paso Engineering Criteria Manual for Base Camp Road and Microscope Way, which are summarized in the table below.

	Road Classification	20-Year 18-kip ESAL	Source
Deer Creek Road	Rural – Minor Collector	875,000	Traffic Study
Base Camp Road	Rural – Local	36,500	El Paso ECM
Microscope Way	Rural – Local	36,500	El Paso ECM

If it is determined that actual traffic is significantly different from that provided, we should be contacted to reevaluate the pavement thickness design.

Pavement Sections: Recommended pavement sections were determined using the El Paso County Engineering Criteria Manual, and the DARWin 3.01 pavement design software based on the 1993 AASHTO pavement design procedures. The parameters used for the design analyses and the detailed results of the pavement design analyses are presented in the Appendix. Based on the results of the analysis, we recommend the following pavement sections:

Location	Pavement Section Thickness (in.)	
	Composite HMA over Base Course	HMA over Cement Treated Subgrade (1)
Deer Creek Road	6 over 9	6 over 8
Base Camp Road and Microscope Way	4 over 5	3.5 over 8(2)

(1) Assumes the upper pavement subgrade will be treated with cement, with a 7-day unconfined compressive strength of 200 psi. Per El Paso County Criteria, if testing during construction shows the cement treated subgrade strength to be greater than 275 psi, then the subgrade should be micro fractured prior to paving.

(2) Value of calculated cement treated subgrade thickness was lower, and rounded up to County required minimum 8 inches.

Cement Treated Subgrade: With proper construction practices, the blending of cement into the subgrade should result in an adequate strength gain to allow use of the layer as part of the structural section. The existing asphalt can be pulverized and blended into the subgrade during the treatment process (sometimes referred to as Full Depth Reclamation), provided it can be reduced to a maximum particle size of 1.5 inches. This alternative provides the advantage of not having to remove the existing asphalt material from the project site. The option to utilize FDR without cement treated subgrade was considered, but given the relatively thin existing pavement, it is considered to provide no significant structural improvement. If it is preferred to use FDR without cement treatment of the subgrade, the thickness recommendations for a composite asphalt and aggregate base course section should be followed.

Disadvantages to chemically treated subgrade include construction difficulties during winter months, and the required cure time before construction traffic can be permitted on the treated subgrade. A specialty contractor will be required to complete the process correctly. A laboratory soil-cement mix design will be required prior to construction to determine the required blend of cement that will produce the specified strength. Estimated cement percentages required are discussed below.

If this alternative is selected, the minimum cement content by dry weight of the soil, as determined by laboratory trial mix testing, should be metered onto the subgrade. The upper 12 inches of subgrade materials should then be thoroughly mixed with a rotary mixer. The moisture content of the subgrade materials should be approximately 2 percent above the optimum moisture content. Final compaction of the chemically treated layer should occur within 60 to 90 minutes of the addition and mixing of the cement.

The cement treated subgrade layer should be cured for a minimum of 5 days before pavement courses are added or traffic is permitted. The cemented treated subgrade layer should meet an unconfined compressive strength of 200 psi at the end of a 7-day cure period. Testing should be in accordance with ASTM D1633 Method A for pozzolanic agents. During the cure period, the surface of the cemented treated layer should be cured by periodic water application to maintain moisture content, preventing sloughing or cracking in the surface of the stabilized subgrade, or by using a bituminous seal. The minimum application rate for a bituminous seal is 0.12 gallons per square yard.

We recommend a laboratory soil-cement mix design be performed prior to construction to determine the required blend of cement that will produce the specified strength. Based on the soil types encountered, we anticipate a minimum concentration of cement will be on the order of 3% to 4%.

The estimated percentages required are based on the dry weight of soil. The specified cement percentage should be at least 3 percent or 0.5 percentage points above the laboratory mix design percentage whichever is larger, to account for waste, inert materials, and construction variability. We recommend observation and testing be performed at the time of construction to confirm the treated depth, application percentage and minimum strength requirements are met.

Asphalt Overlay Alternative: In our opinion, the existing pavement condition for each of the roads is poor and not suitable for an overlay. In areas where pavement distress is occurring, unless the subgrade is properly addressed prior to paving, an overlay will develop reflective cracking and will have a shortened life expectancy. In areas where the distress is severe, with fatigue (alligator) cracking, the underlying subgrade will likely require some amount of stabilization prior to paving. Recommendations for subgrade stabilization are included in the “Subgrade Stabilization” subsection below.

Shoulders: It is difficult to model the traffic expected for the roadway shoulders; however, we anticipate the traffic volume will be infrequent and very low. Based on our understanding for what is typically used in the area, and based on experience, we recommend a minimum aggregate thickness of 6 inches be considered. For ease of construction, some jurisdictions will construct the shoulder thickness to match the roadway pavement thickness.

Expansive Soil Considerations: The El Paso County Engineering Criteria Manual requires mitigation of expansive soils when the measured swell is greater than 2% with a 100 or 150 psf surcharge pressure. Based on the subsurface conditions encountered in the borings and the measured in-situ and remolded swell testing performed, the swell potential within the project area is estimated to be low. Therefore, we anticipate special mitigation of expansive soils will not be required.

Subgrade Preparation: Topsoil and excessive organic matter present below the proposed pavement grade should be removed in its entirety prior to placement of embankment fill or pavement materials. The suitability of existing fill materials and compaction should be evaluated prior to placement of new fill and/or pavement materials.

Prior to placing the pavement section, the entire subgrade area should be scarified to a depth of 12 inches, adjusted to within two percent of the optimum moisture content and compacted to the minimum criteria presented in the “Site Grading” section of the report. The pavement subgrade should be proofrolled with a heavily loaded pneumatic-tired vehicle. Pavement design procedures assume a stable subgrade. Areas which deform excessively under heavy wheel loads are not stable and should be removed and replaced to achieve a stable subgrade prior to paving.

Subgrade Stabilization: Given the conditions encountered, it should be anticipated that some unstable subgrade areas will be encountered during construction. As discussed previously, we anticipate portions of the roadway will have soils with moisture contents above the optimum, particularly immediately below the existing pavement, in low-lying areas near drainage ditches, near the bedrock surface, and in areas where the adjacent roadway drainage is poor. Subgrade soils with elevated moisture contents are expected to be unstable and prone to deflections and rutting.

We anticipate stabilization may be achieved by methods such as scarification of the subgrade to accelerate partial drying of the materials; excavation and replacement of unstable soils with drier materials; or stabilization using geogrid reinforcement (Type 2 Biaxial geogrid) in combination with 1 to 2 feet of aggregate base course. The use of dry cement or fly ash blended into the subgrade can also be used to stabilize subgrade. Specific stabilization requirements should be evaluated at the time of construction. Given the amount of subsurface information collected, we cannot predict or quantify areas where unstable subgrade conditions may occur. However, we recommend this work activity, if required, be included as a line item in the bid schedule to avoid cost overruns.

Drainage: The collection and diversion of surface drainage away from paved areas is extremely important to the satisfactory performance of the pavement. Drainage design should provide for the removal of water from paved areas and prevent wetting of the subgrade soils. Landscape vegetation which requires irrigation should be avoided adjacent to pavements.

Pavement Materials: The HMA should conform to the requirements of Pikes Peak Region Asphalt Paving Specifications. Given the traffic ESAL provided, we recommend the mix have a binder grade of PG 58-28 or PG 64-22, and a design gyration (Ndes) of 75. The mix grading should consist of a Grading S for the lower lifts, and a grading SX for the top lift. As an alternate, the use of grading SX for the entire section may be used, depending on the County's preference.

Aggregate base course should be a Class 6 material conforming to the requirements presented in Appendix D of the El Paso County Engineering Criteria Manual. Table D-7 of the Criteria Manual provides a specification for gravel used on gravel roads, which we recommend for gravel surfaced shoulders.

EXCAVATION CONSIDERATIONS

In our opinion, excavation of the overburden soils and near surface bedrock should be possible with heavy-duty conventional excavation equipment. Rippers or other methods may be required for deeper excavations that extend into bedrock, particularly in confined trenches.

All excavations should be in accordance with OSHA, state and local requirements. The contractor should follow appropriate safety precautions. In accordance with OSHA guidelines, the native and fill overburden soils classify as a Type C material, and the sandstone and claystone should be considered a Type B material. Depending on the fracturing and bedding of the bedrock and the timeframe that the excavation remains unretained, the bedrock may classify as a Type C.

Per OSHA criteria, unless excavations are shored, temporary unretained excavations in Type C materials should have slopes no steeper than 1½:1 (H:V), and Type B materials should have slopes no steeper than 1:1. Flatter slopes will be required where ground-water seepage is encountered. Surface drainage should be diverted away from all temporary cut slopes in order to reduce the potential for slope erosion and instability. OSHA regulations require that excavations greater than 20 feet in depth be designed by a professional engineer.

Groundwater was encountered in Boring 3 at approximate depth of 19 feet at the time of drilling. Because water level measurements were not performed over a period of time, the groundwater depth should be considered unstabilized and should also be assumed to vary seasonally, and after precipitation events. Depending on the depths of excavations planned, groundwater may impact the proposed construction. If groundwater is encountered in excavations, we believe the dewatering can be accomplished by pumping from sumps installed within the excavation. The pits should be constructed well below the base of the excavation to avoid loss of supporting capacity of the soils. The dewatering system should be properly designed, installed and maintained. The bottom and sides of the excavation may become unstable if the ground-water level is not maintained at a sufficient depth below the bottom of the excavation. Overly moist soils may also contribute to unstable subgrade conditions when preparing roadway embankment. Refer to the “Pavement Design – Subgrade Stabilization” section for additional discussions.

DEER CREEK ROAD DRAINAGE CROSSING

Boring 3 was drilled in the vicinity of the drainage crossing, and encountered approximately 6 feet of silty-clayey sand fill, followed by sandy fat clay to a depth of 13 feet, then clayey sandstone to a depth of 17 feet, followed by claystone which extended to the 25-foot depth explored. We anticipate the native soils and sandstone bedrock will be suitable for support of corrugated metal pipe, or precast or cast-in-place concrete culvert. Any fill or areas of loose material encountered within the base of excavations should be removed and replaced with properly compacted nonexpansive fill material.

Depending on the depth of excavation and time of year excavations are performed, the subgrade soils may be unstable and require stabilization before pipe/structure placement and backfill. The soils at the base of the excavations extending near the groundwater level may become unstable due to construction traffic and the presence of water. Construction equipment should be as light as possible to avoid this difficulty. The use of track-mounted excavation equipment in these areas would help reduce disturbance of the subgrade soils. Placement of a relatively thin layer (6 to 12 inches) of crushed gravel at the base of the excavations would also help to reduce disturbance of the soils at the base of the excavations. All disturbed soils should be removed and replaced with compacted, crushed gravel. Other methods to stabilize the subgrade include using a relatively thick layer of cobble size angular rock in combination with the crushed aggregate, or by using geogrid in combination with crushed aggregate. Specific stabilization requirements should be evaluated at the time of construction.

The on-site granular soils and sandstone minus any organics or other deleterious materials would be suitable for reuse if properly moisture conditioned. The on-site soils may contain excessive moisture and require drying before reuse. Import soils, if used, should meet the requirements of a CDOT Class I structure backfill, and defined in Section 703.08 of the CDOT Standard Specifications for Road and Bridge Construction. Fill material should be placed and compacted to a minimum 95% of the standard Proctor maximum dry density (ASTM D 698), at a moisture content within 2% of the optimum.

WATER SOLUBLE SULFATES

The concentration of water soluble sulfates measured in samples obtained from the exploratory borings ranges from less than 0.01% to approximately 0.02%. These concentrations of water soluble sulfates represent a Class 0 severity of exposure to sulfate attack on concrete exposed to these materials. The degree of attack is based on a range of Class 0 to Class 3 severity of exposure as presented in ACI 201. Based on this information and our experience with the soil types encountered, we believe special sulfate resistant cement will not be required for concrete exposed to the on-site soils.

DESIGN AND CONSTRUCTION SUPPORT SERVICES

Kumar & Associates, Inc. should be retained to review the project plans and specifications for conformance with the recommendations provided in our report. We are also available to assist the design team in preparing specifications for geotechnical aspects of the project, and performing additional studies, if necessary, to accommodate possible changes in the proposed construction.

We recommend that Kumar & Associates, Inc. be retained to provide observation and testing services to document that the intent of this report and the requirements of the plans and specifications are being followed during construction, and to identify possible variations in subsurface conditions from those encountered in this study so that we can re-evaluate our recommendations, if needed.

LIMITATIONS

This study has been conducted for exclusive use by the client for geotechnical related design and construction criteria for the project. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings at the locations indicated on Fig. 1 or as described in the report, and the proposed type of construction. This report may not reflect subsurface variations that occur, and the nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, Kumar & Associates, Inc. should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of subsurface data by others.

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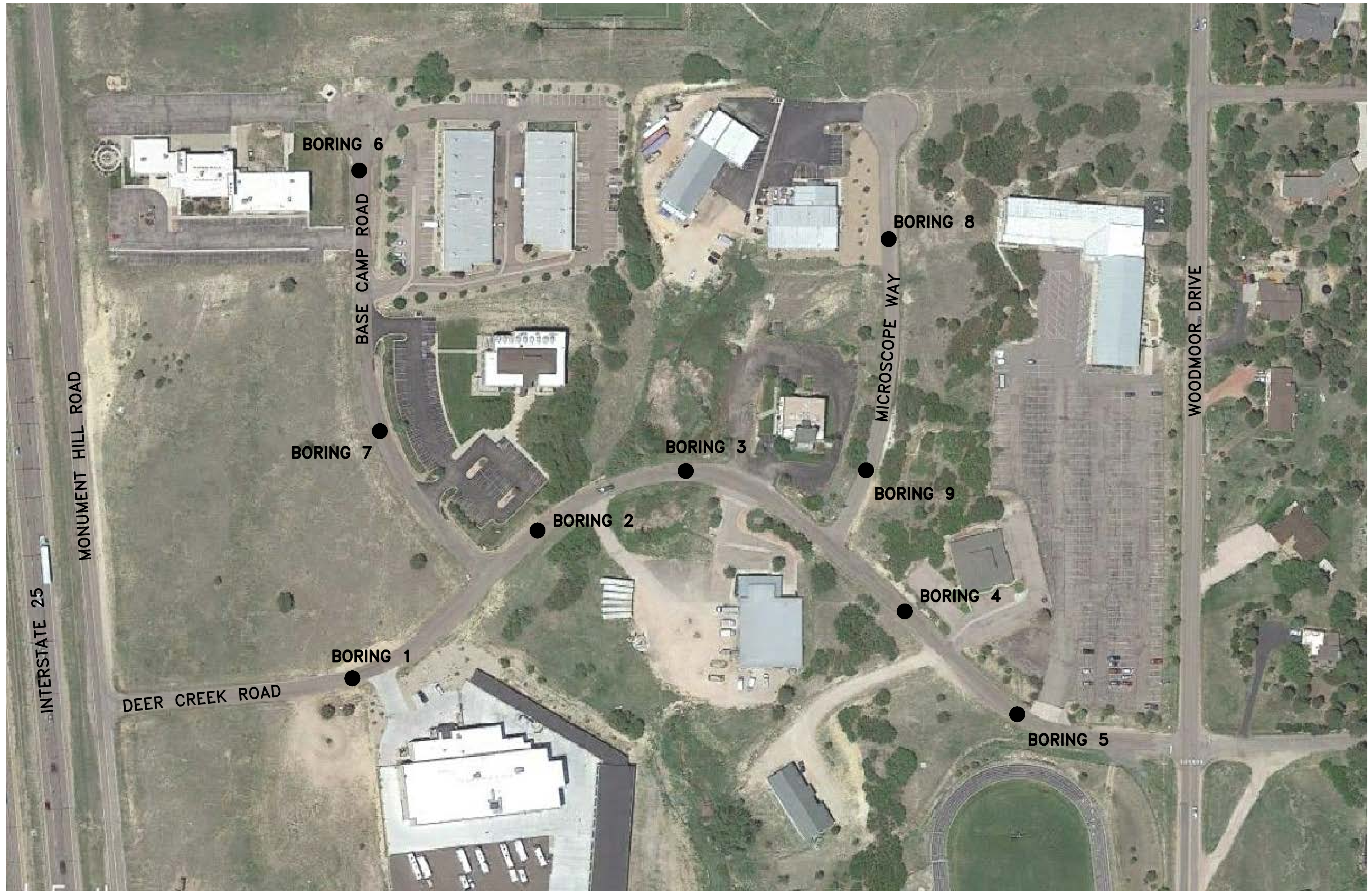

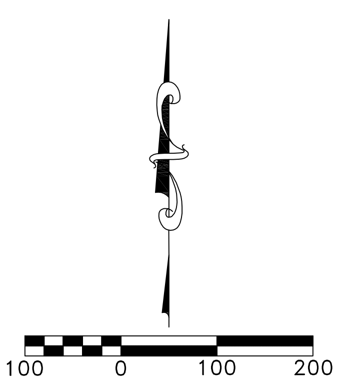

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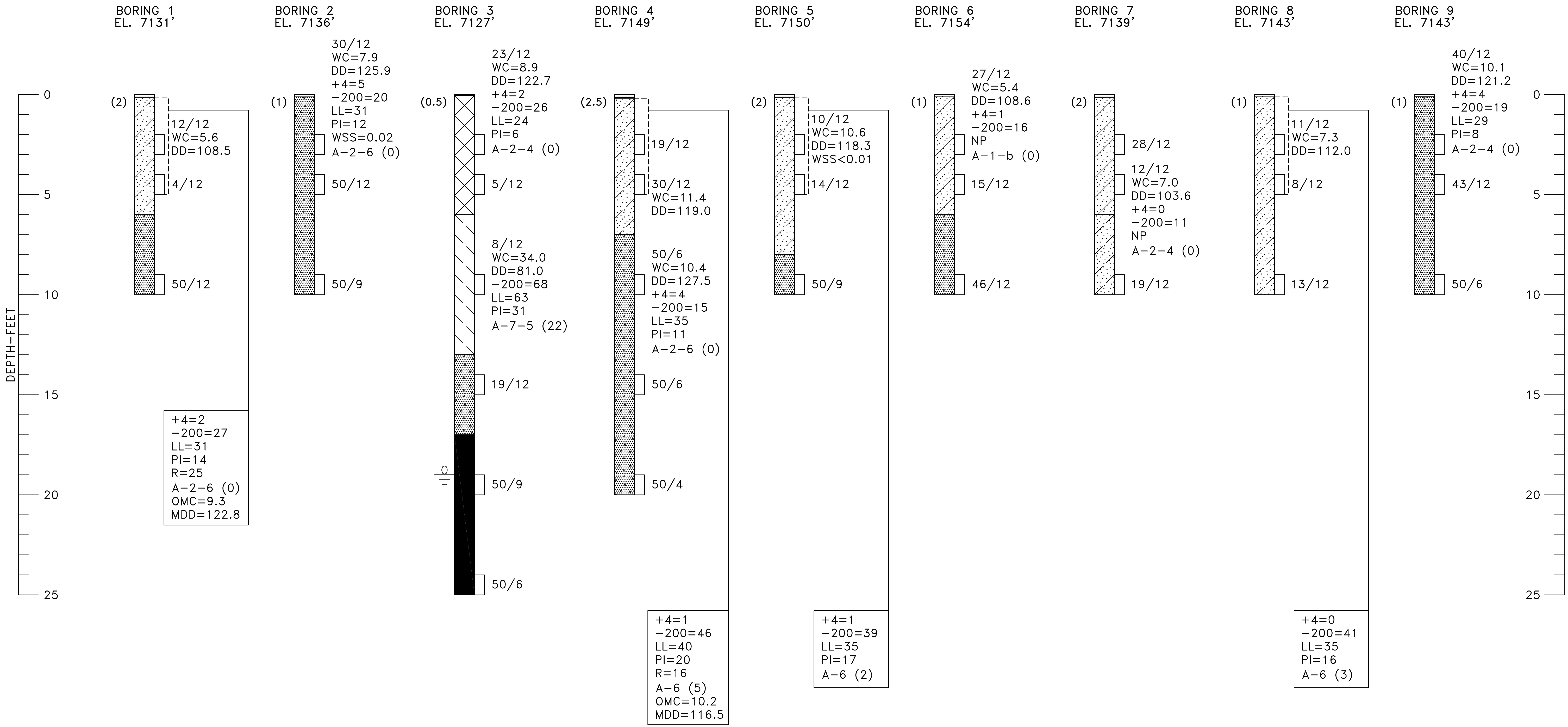
19-2-195	Kumar & Associates		LOCATION OF EXPLORATORY BORINGS	Fig. 1



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19-2-195	Kumar & Associates		LOGS OF EXPLORATORY BORINGS	Fig. 2

LEGEND

(2) ASPHALT, THICKNESS IN INCHES SHOWN IN PARENTHESES TO LEFT OF THE LOG.

FILL: SILTY TO CLAYEY SAND (SM, SC, SC–SM), MOIST, BROWN TO LIGHT BROWN.

CLAYEY SAND (SC), WITH OCCASIONAL SILTY SAND LAYERS (SM), LOOSE TO MEDIUM DENSE, MOIST, BROWN TO LIGHT BROWN.

SILTY SAND (SM), WITH OCCASIONAL WELL–GRADED SAND WITH SILT (SW–SM), MEDIUM DENSE, MOIST, BROWN TO LIGHT BROWN.

SANDY FAT CLAY (CH), MEDIUM STIFF, MOIST TO VERY MOIST, DARK BROWN.

SANDSTONE BEDROCK, CLAYEY, NON CEMENTED, WEATHERED TO VERY HARD, MOIST, LIGHT BROWN TO GRAY.

CLAYSTONE BEDROCK, HARD TO VERY HARD, MOIST, BROWN TO GRAY.

DRIVE SAMPLE, 2–INCH I.D. CALIFORNIA LINER SAMPLE.

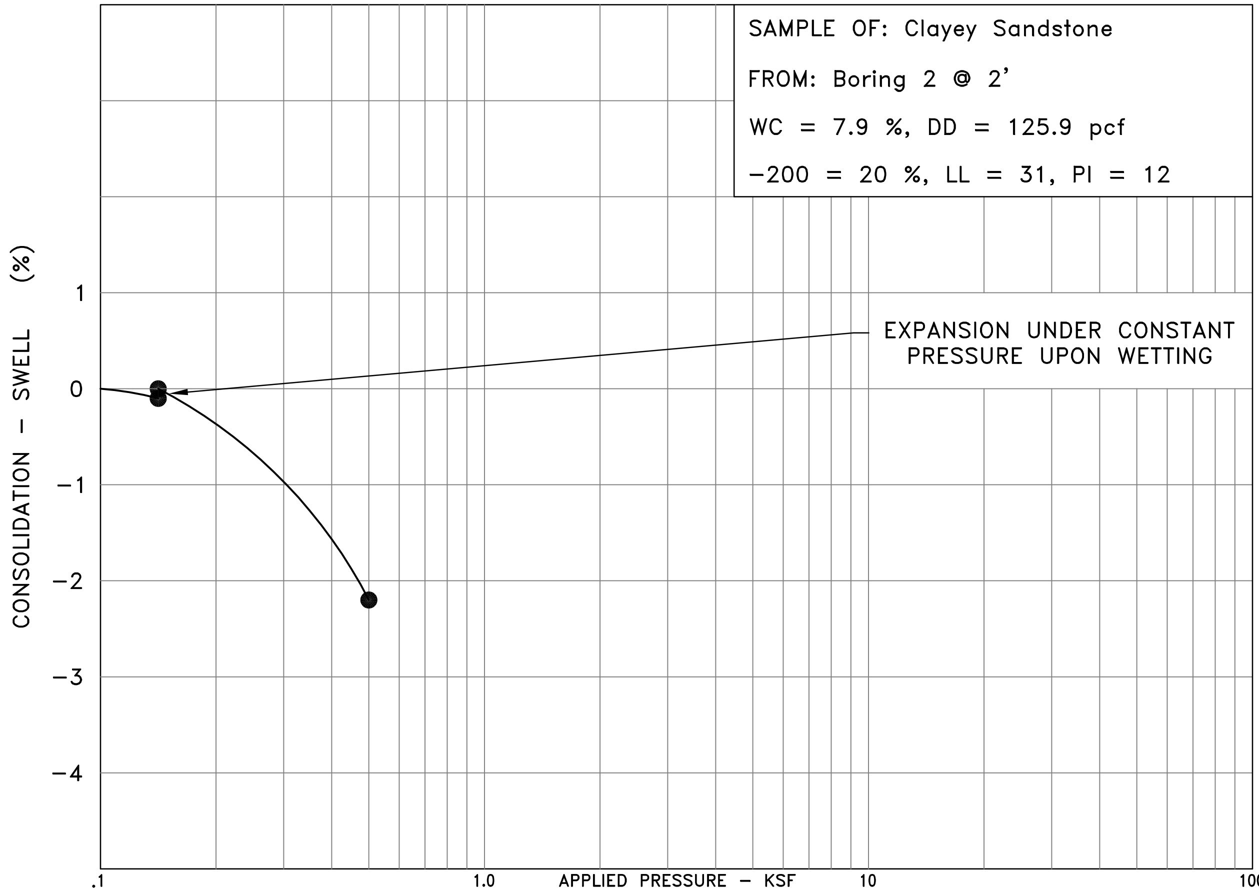
DISTURBED BULK SAMPLE.

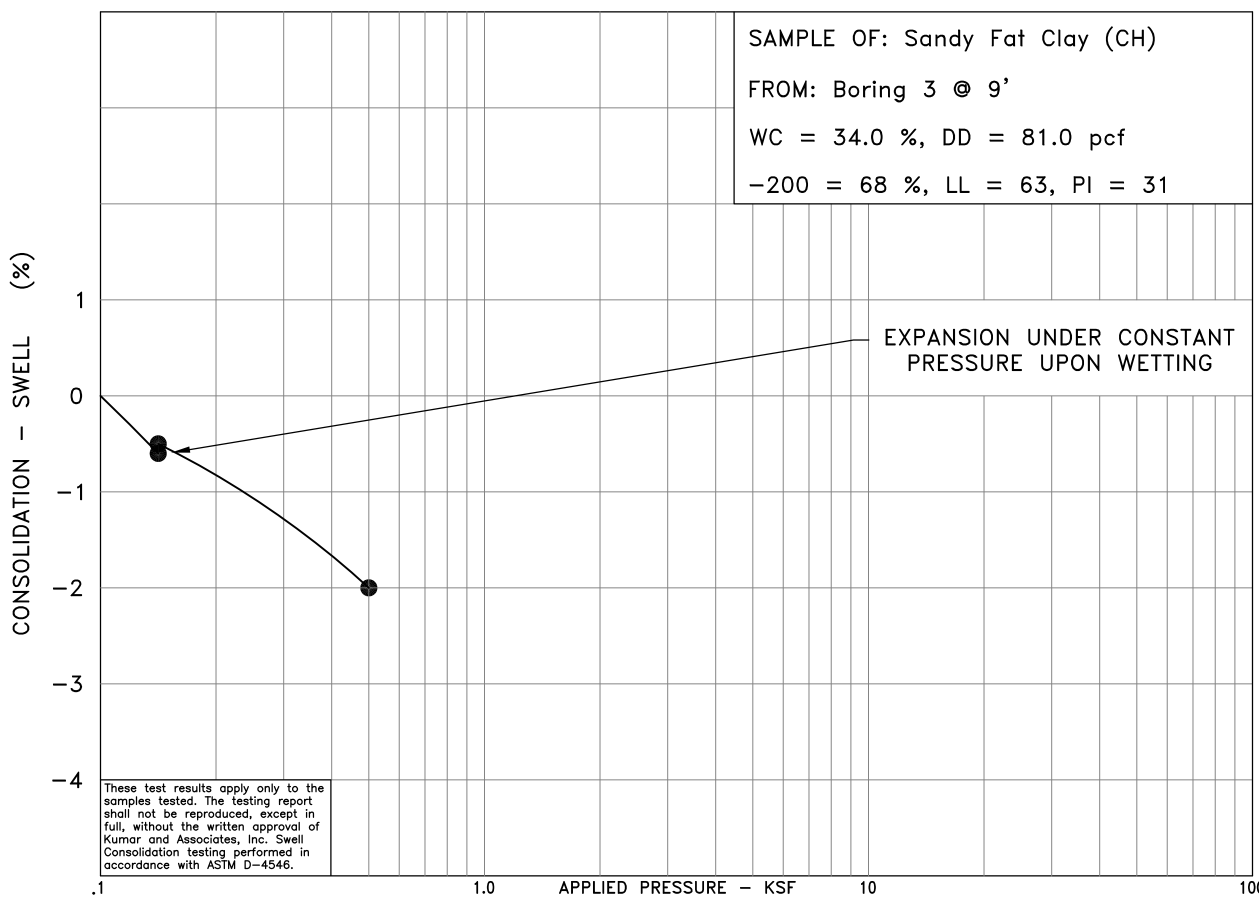
12/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 12 BLOWS OF A 140–POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

DEPTH TO WATER LEVEL ENCOUNTERED AT THE TIME OF DRILLING.

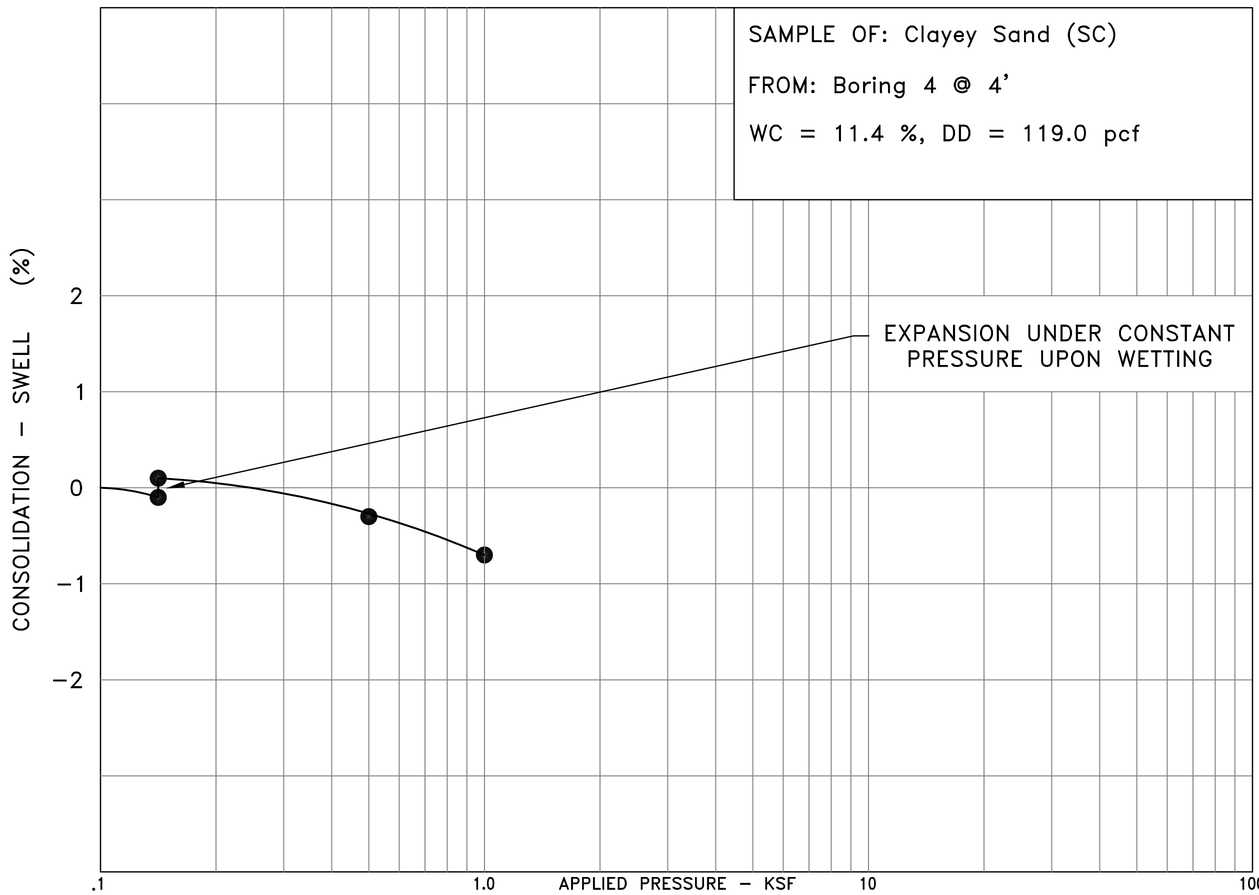
NOTES

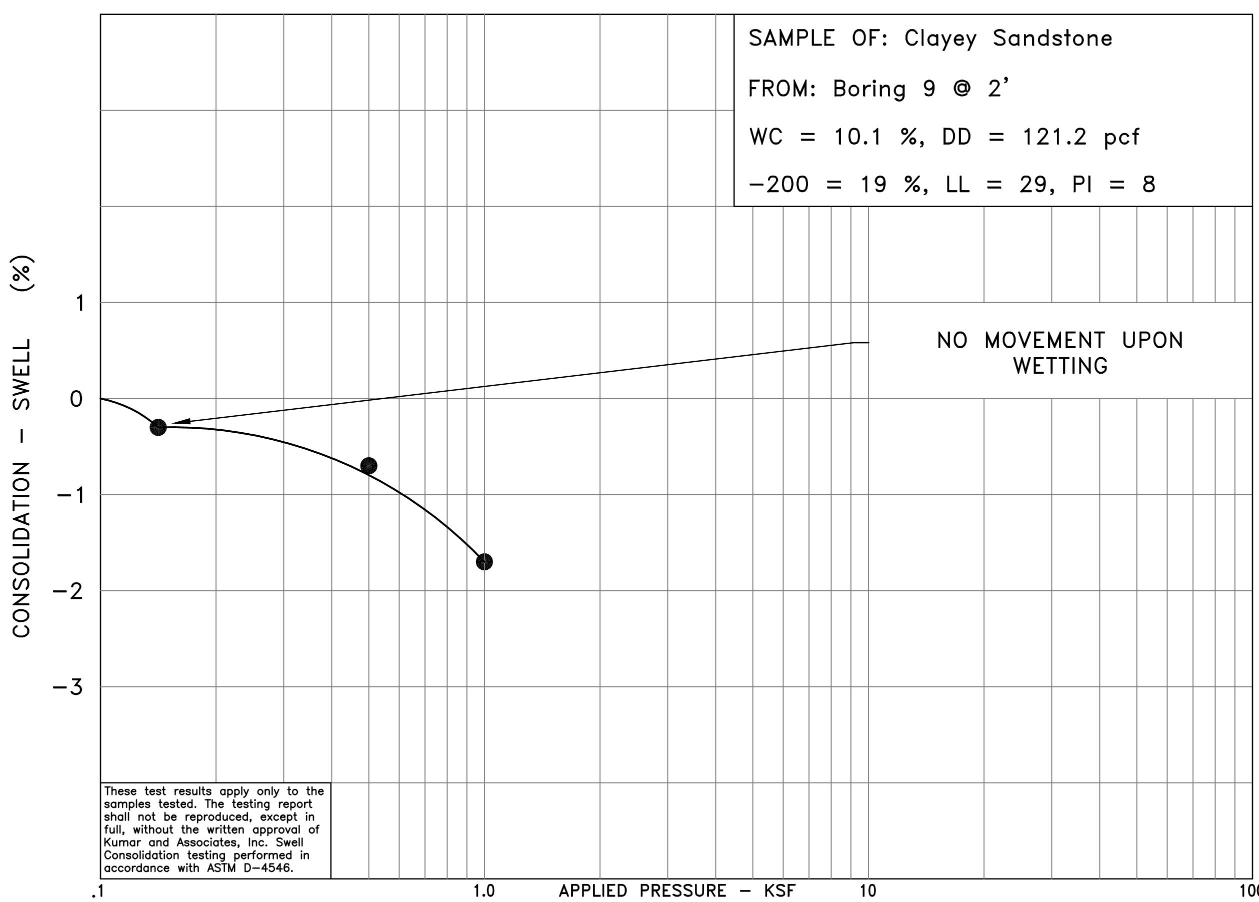
1. THE EXPLORATORY BORINGS WERE DRILLED ON AUGUST 12 AND 13, 2019 WITH A 4–INCH–DIAMETER CONTINUOUS–FLIGHT POWER AUGER.
2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE MEASURED APPROXIMATELY BY PACING FROM FEATURES SHOWN ON THE SITE PLAN PROVIDED.
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE MEASURED WITH A HAND HELD GPS.
4. THE BORINGS LOCATIONS AND ELEVATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.
5. THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING LOGS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.
6. GROUNDWATER LEVELS SHOWN ON THE LOGS WERE MEASURED AT THE TIME OF DRILLING. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.
7. LABORATORY TEST RESULTS:
   WC = WATER CONTENT (%) (ASTM D2216);
   DD = DRY DENSITY (pcf) (ASTM D2216);
   +4 = PERCENTAGE RETAINED ON NO. 4 SIEVE (ASTM D6913);
   –200= PERCENTAGE PASSING NO. 200 SIEVE (ASTM D1140);
   LL = LIQUID LIMIT (ASTM D4318);
   PI = PLASTICITY INDEX (ASTM D4318);
   NP = NON–PLASTIC (ASTM D 4318);
   WSS = WATER SOLUBLE SULFATES (%) (CP–L 2103);
   R = HVEEM R–VALUE (AT 300 psi) (ASTM D2844);
   A–2–6 (0) = AASHTO CLASSIFICATION (GROUP INDEX) (AASHTO M145);
   OMC = OPTIMUM MOISTURE CONTENT (%) (ASTM D698);
   MDD = MAXIMUM DRY DENSITY (pcf) (ASTM D698).



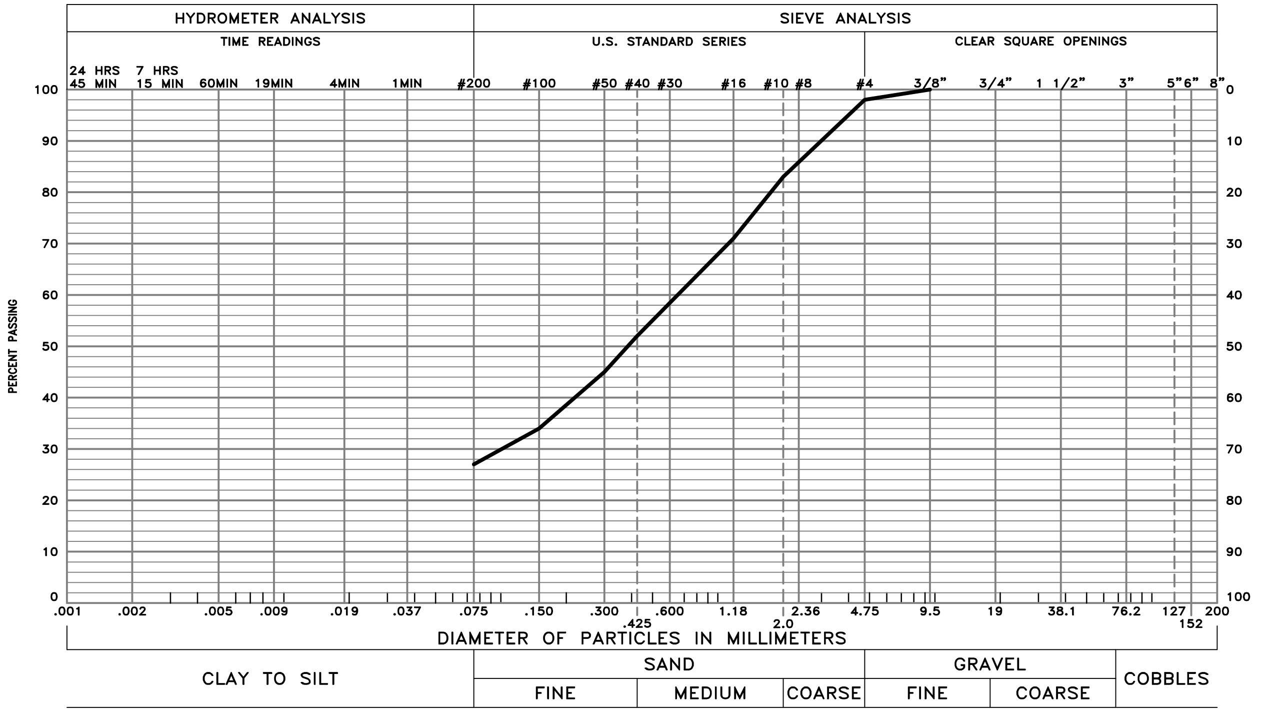


19−2−195	Kumar & Associates	SWELL−CONSOLIDATION TEST RESULTS	Fig. 4





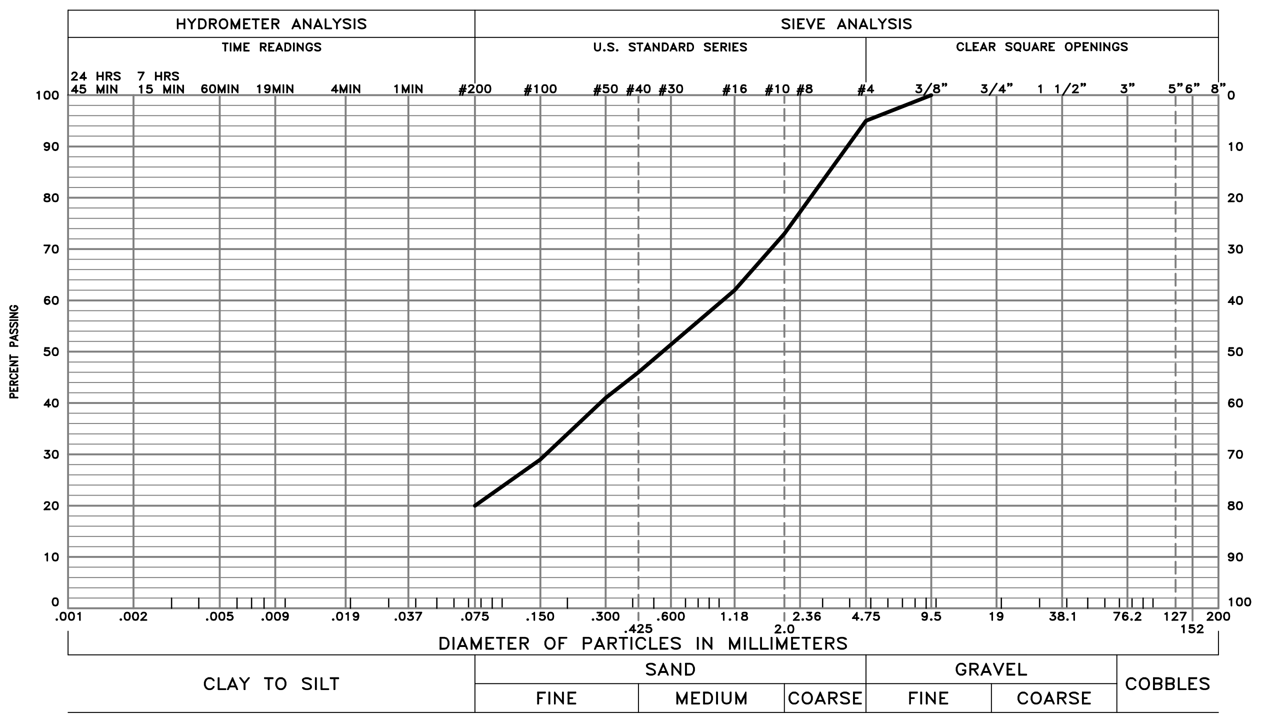
19-2-195	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 5



GRAVEL 2 % SAND 71 % SILT AND CLAY 27 %

LIQUID LIMIT 31 PLASTICITY INDEX 14

SAMPLE OF: Clayey Sand (SC) FROM: Boring 1 @ 2"–5'

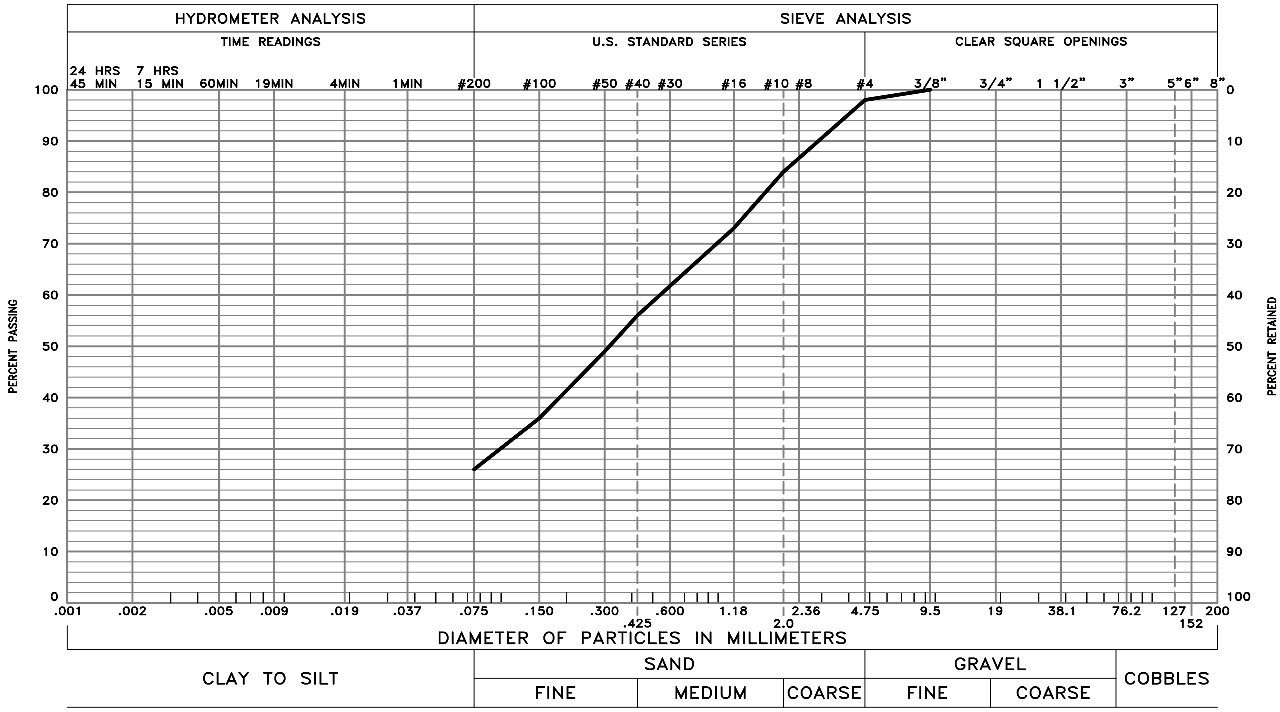


GRAVEL 5 % SAND 75 % SILT AND CLAY 20 %

LIQUID LIMIT 31 PLASTICITY INDEX 12

SAMPLE OF: Clayey Sandstone FROM: Boring 2 @ 2'

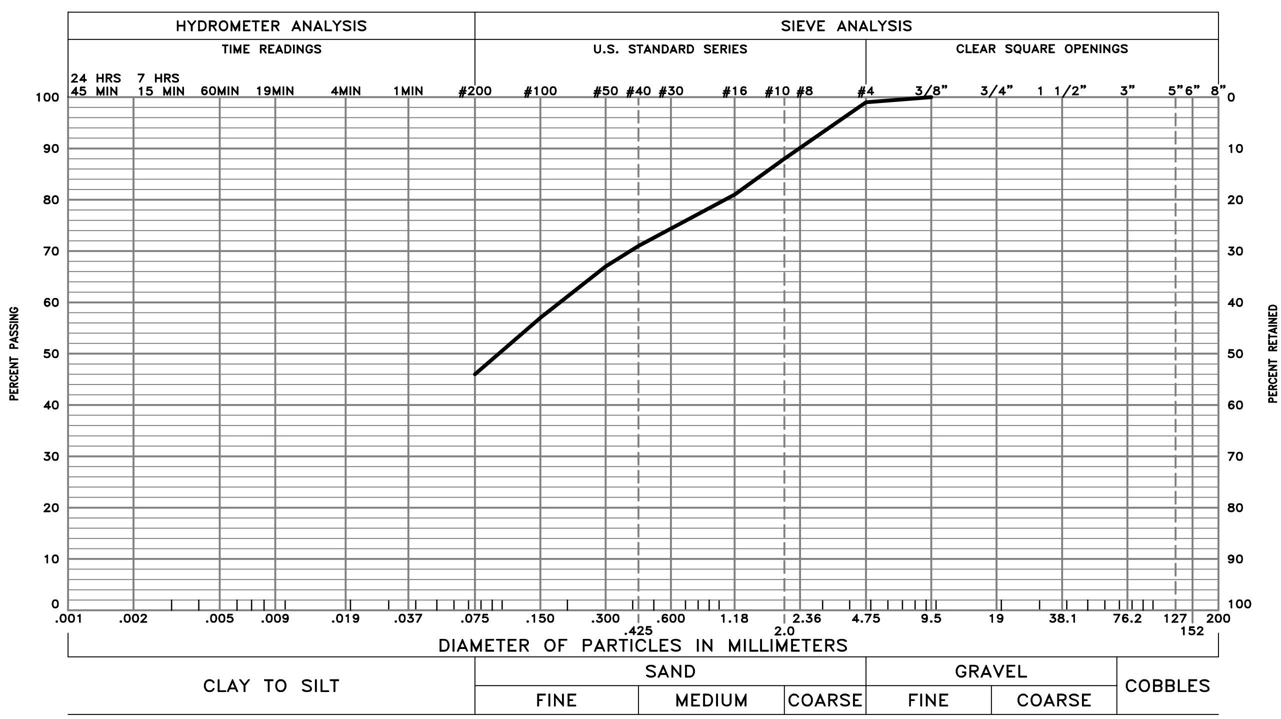
These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D6913, ASTM D7928, ASTM C136 and/or ASTM D1140.



GRAVEL 2 % SAND 72 % SILT AND CLAY 26 %

LIQUID LIMIT 24 PLASTICITY INDEX 6

SAMPLE OF: Fill: Silty Clayey Sand (SC–SM) FROM: Boring 3 @ 2'



GRAVEL 1 % SAND 53 % SILT AND CLAY 46 %

LIQUID LIMIT 40 PLASTICITY INDEX 20

SAMPLE OF: Clayey Sand (SC) FROM: Boring 4 @ 2.5"–5'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D6913, ASTM D7928, ASTM C136 and/or ASTM D1140.

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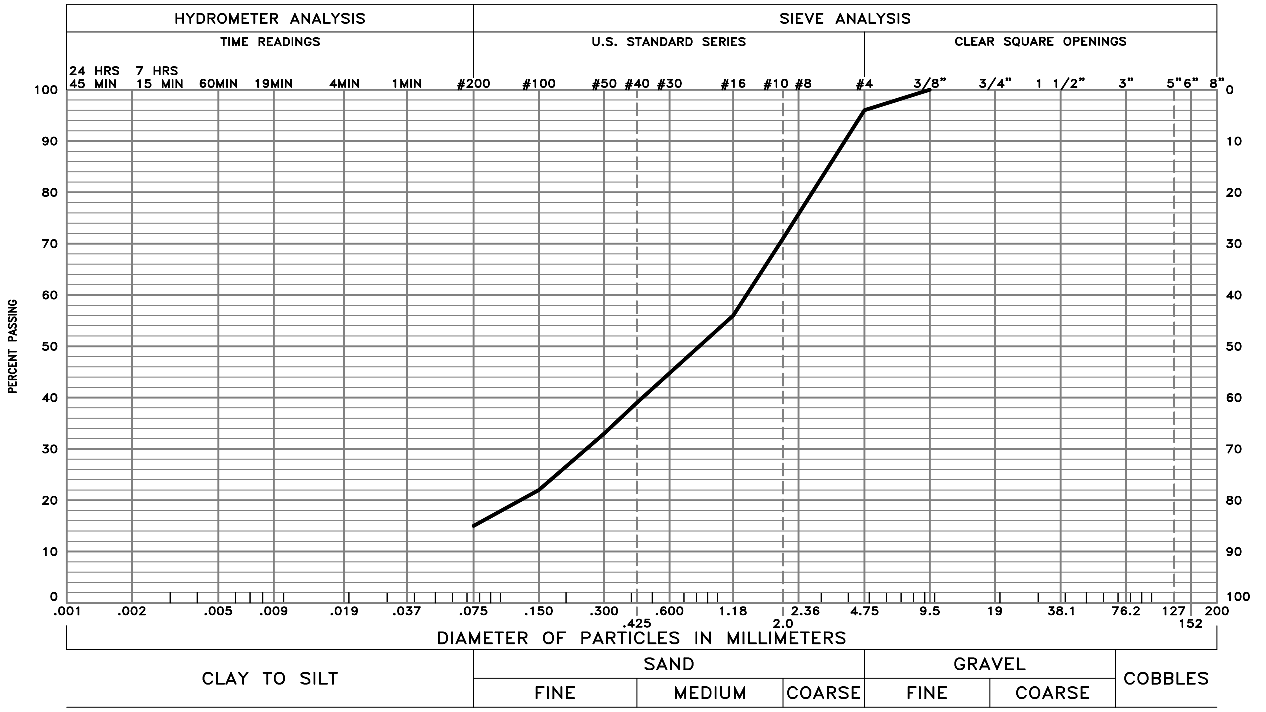
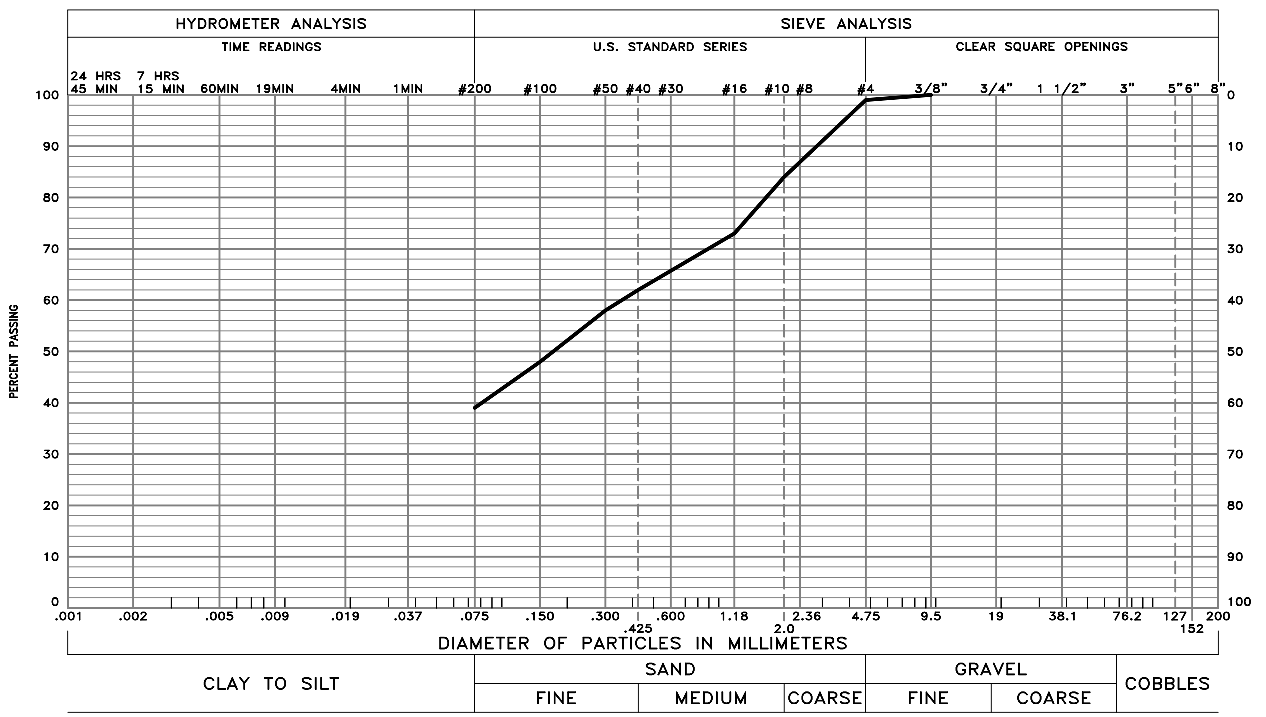
19–2–195	Kumar & Associates	GRADATION TEST RESULTS	Fig. 7



GRAVEL 4 % SAND 81 % SILT AND CLAY 15 %

LIQUID LIMIT 35 PLASTICITY INDEX 11

SAMPLE OF: Clayey Sandstone FROM: Boring 4 @ 9'



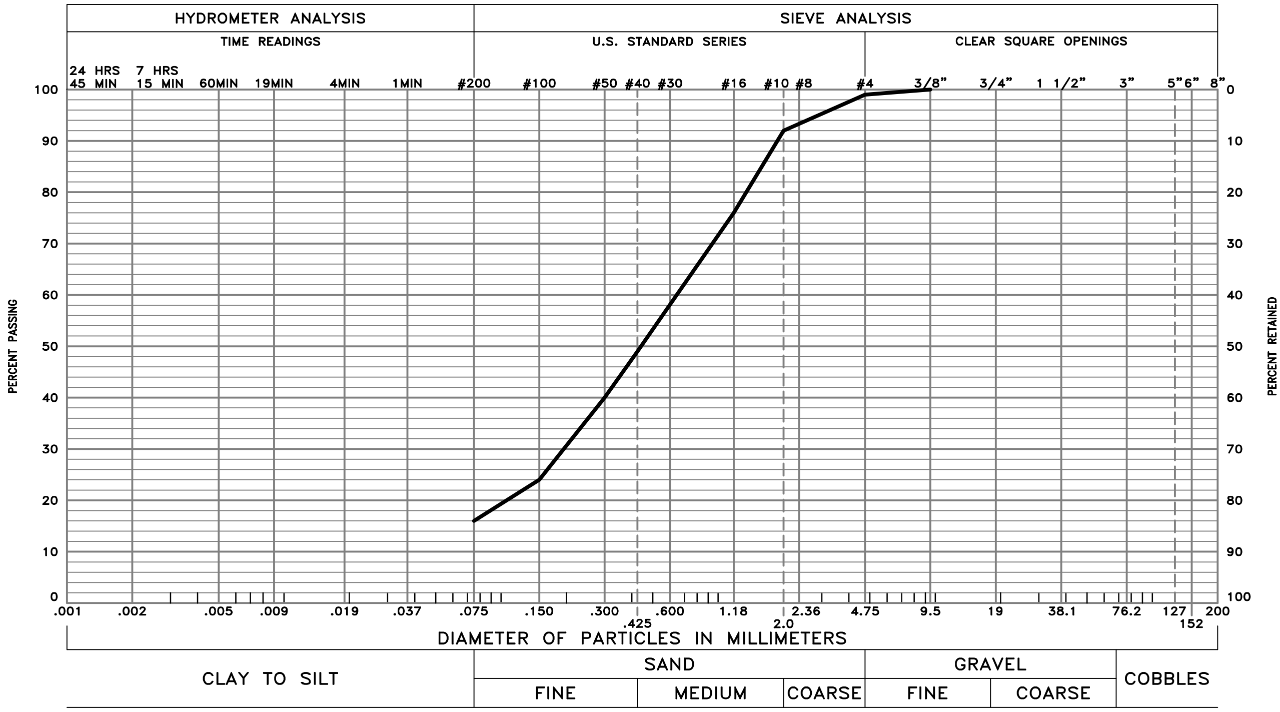
GRAVEL 1 % SAND 60 % SILT AND CLAY 39 %

LIQUID LIMIT 35 PLASTICITY INDEX 17

SAMPLE OF: Clayey Sand (SC) FROM: Boring 5 @ 2"–5'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D6913, ASTM D7928, ASTM C136 and/or ASTM D1140.

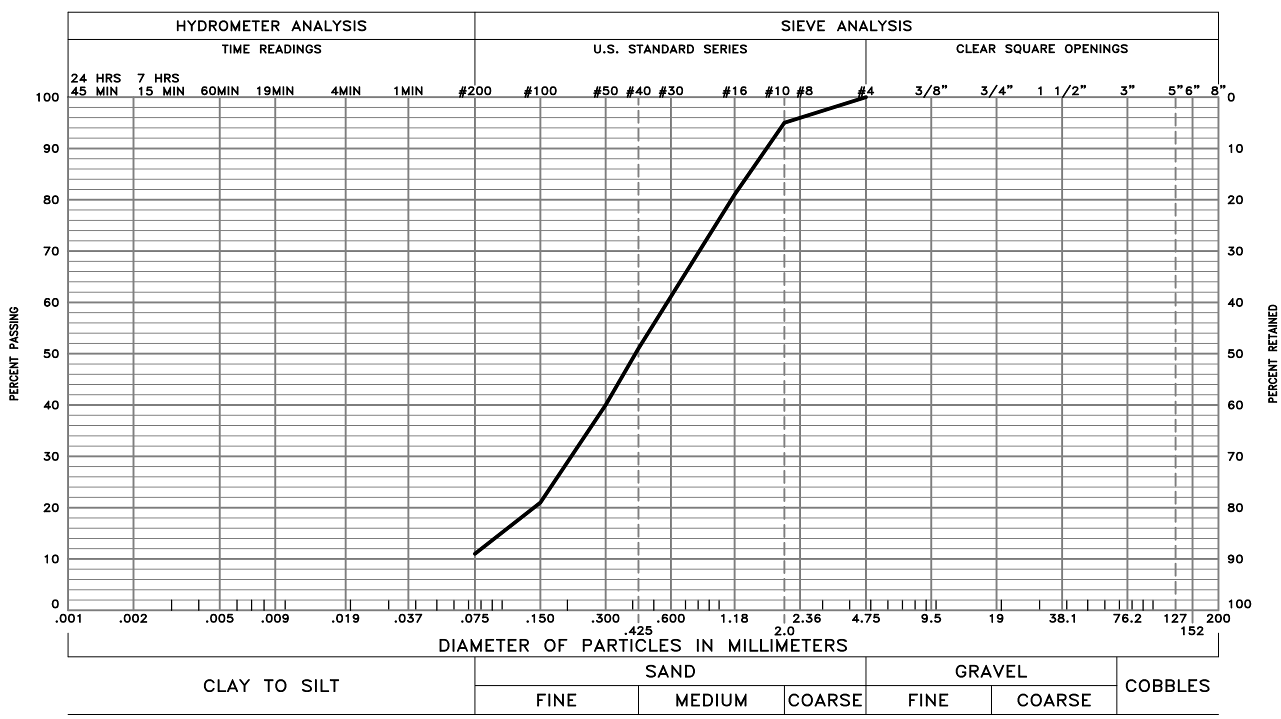
19–2–195	Kumar & Associates	GRADATION TEST RESULTS	Fig. 8



GRAVEL 1 % SAND 83 % SILT AND CLAY 16 %

LIQUID LIMIT PLASTICITY INDEX NP

SAMPLE OF: Silty Sand (SM) FROM: Boring 6 @ 2'

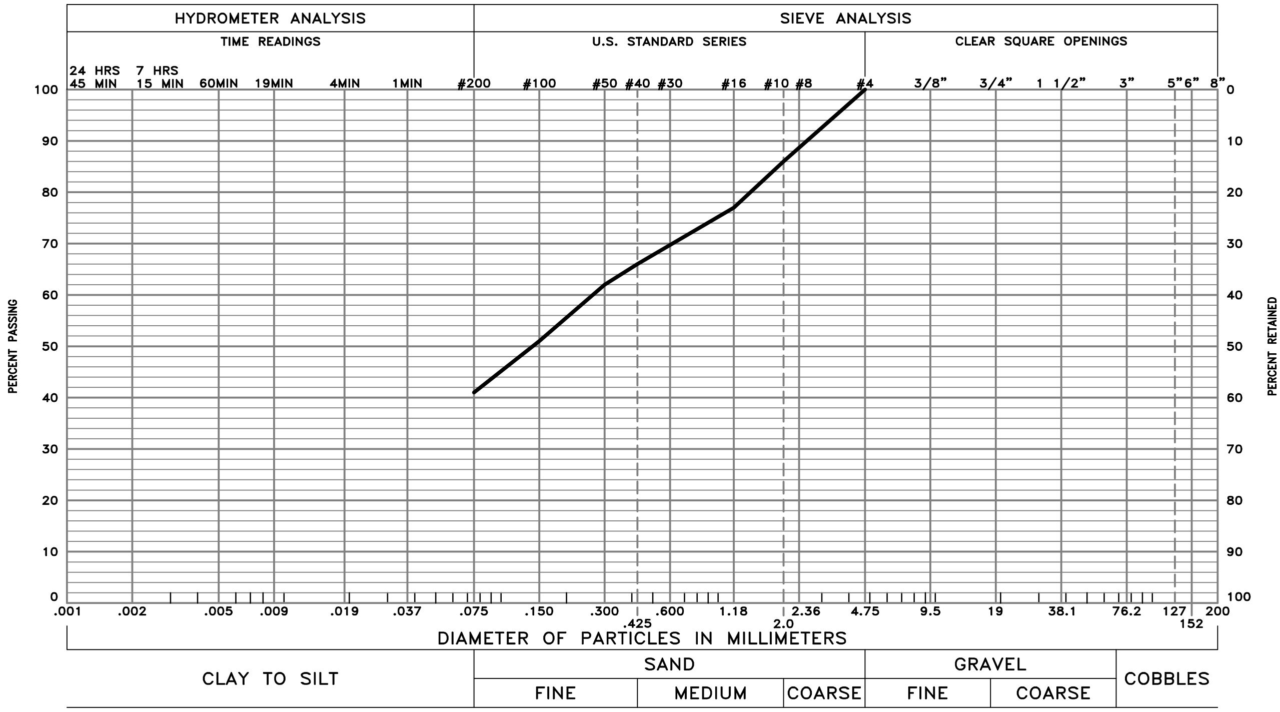


GRAVEL 0 % SAND 89 % SILT AND CLAY 11 %

LIQUID LIMIT PLASTICITY INDEX NP

SAMPLE OF: Well Graded Sand with Silt (SW–SM) FROM: Boring 7 @ 4'

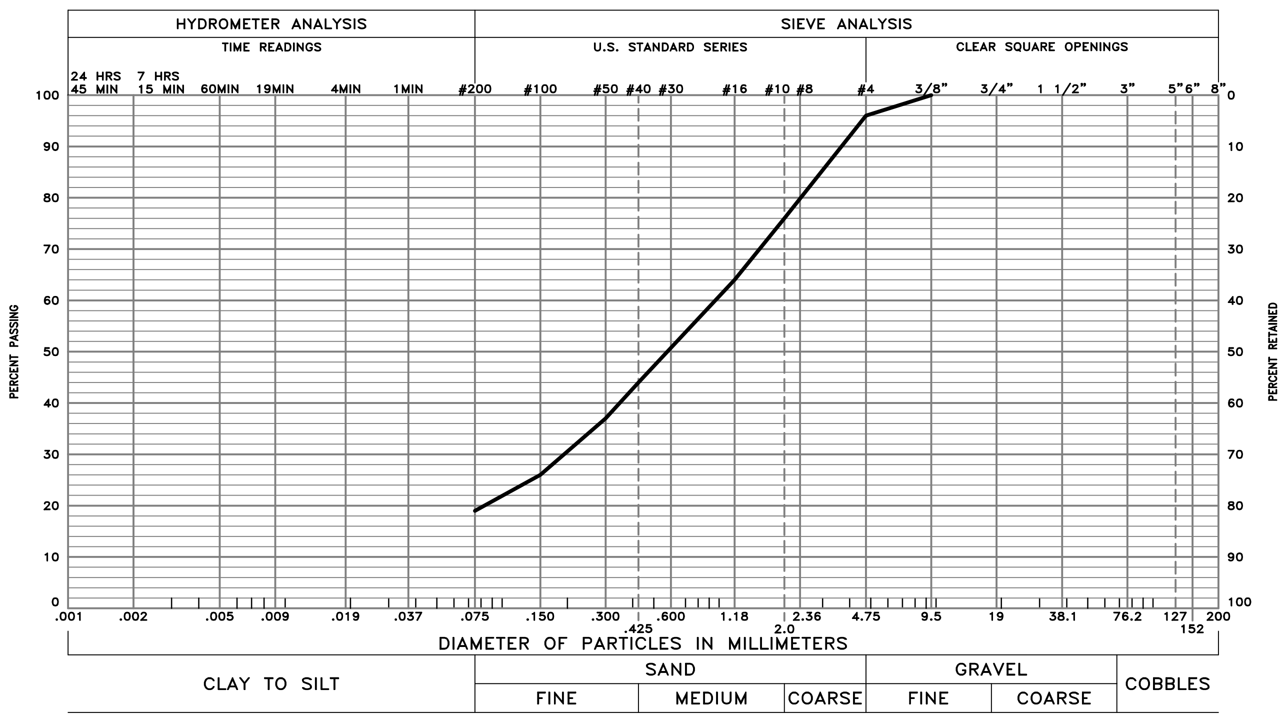
These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D6913, ASTM D7928, ASTM C136 and/or ASTM D1140.



GRAVEL 0 % SAND 59 % SILT AND CLAY 41 %

LIQUID LIMIT 35 PLASTICITY INDEX 16

SAMPLE OF: Clayey Sand (SC) FROM: Boring 8 @ 1"–5'



GRAVEL 4 % SAND 77 % SILT AND CLAY 19 %

LIQUID LIMIT 29 PLASTICITY INDEX 8

SAMPLE OF: Clayey Sandstone FROM: Boring 9 @ 2'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D6913, ASTM D7928, ASTM C136 and/or ASTM D1140.

August 29, 2019 – 02:47pm
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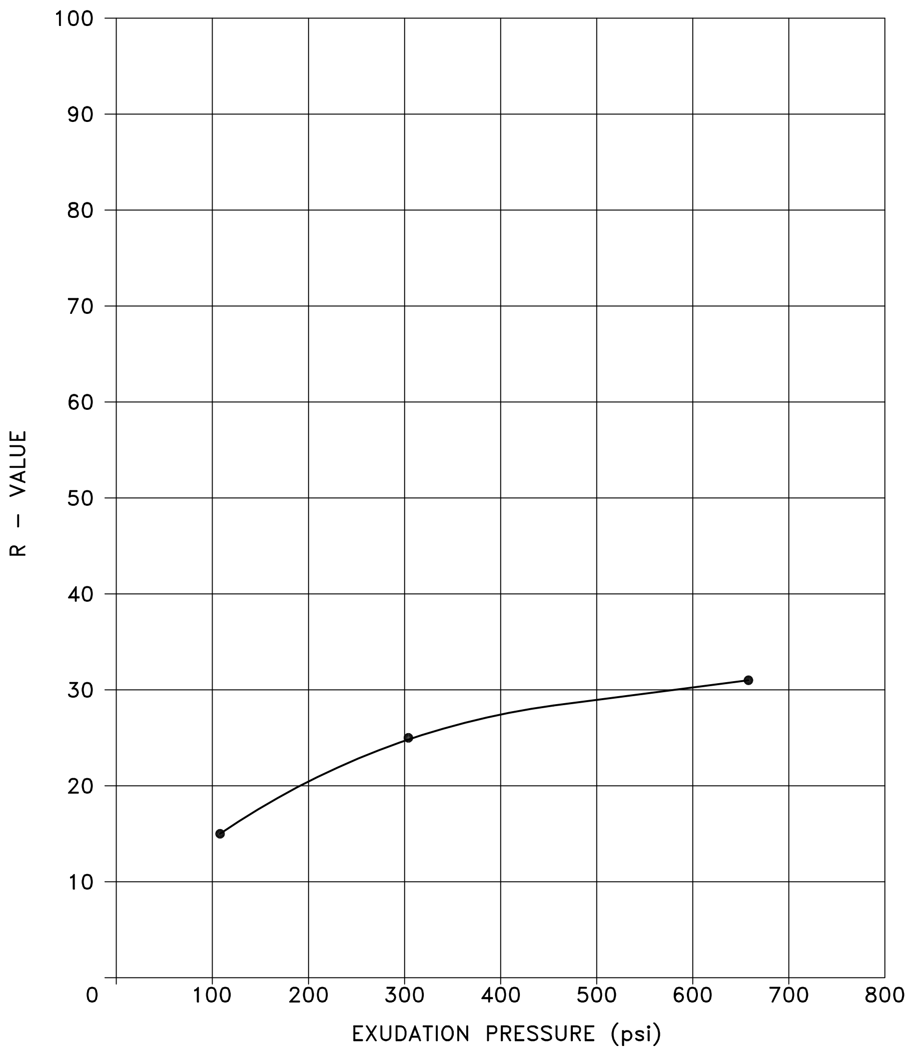
19–2–195	Kumar & Associates	GRADATION TEST RESULTS	Fig. 10

TEST SPECIMEN	1	2	3	4	R –VALUE (300 psi)
MOISTURE CONTENT (%)	11.0	9.2	8.3		
DENSITY (pcf)	122.1	126.3	127.5		
EXPANSION PRESSURE (psi)	0.000	0.000	0.000		
EXUDATION PRESSURE (psi)	108	304	658		
R VALUE	15	25	31		25



SOIL TYPE: Clayey Sand (SC), A–2–6 (0)

LOCATION: Deer Creek Road, Boring 1 @ 2"–5'

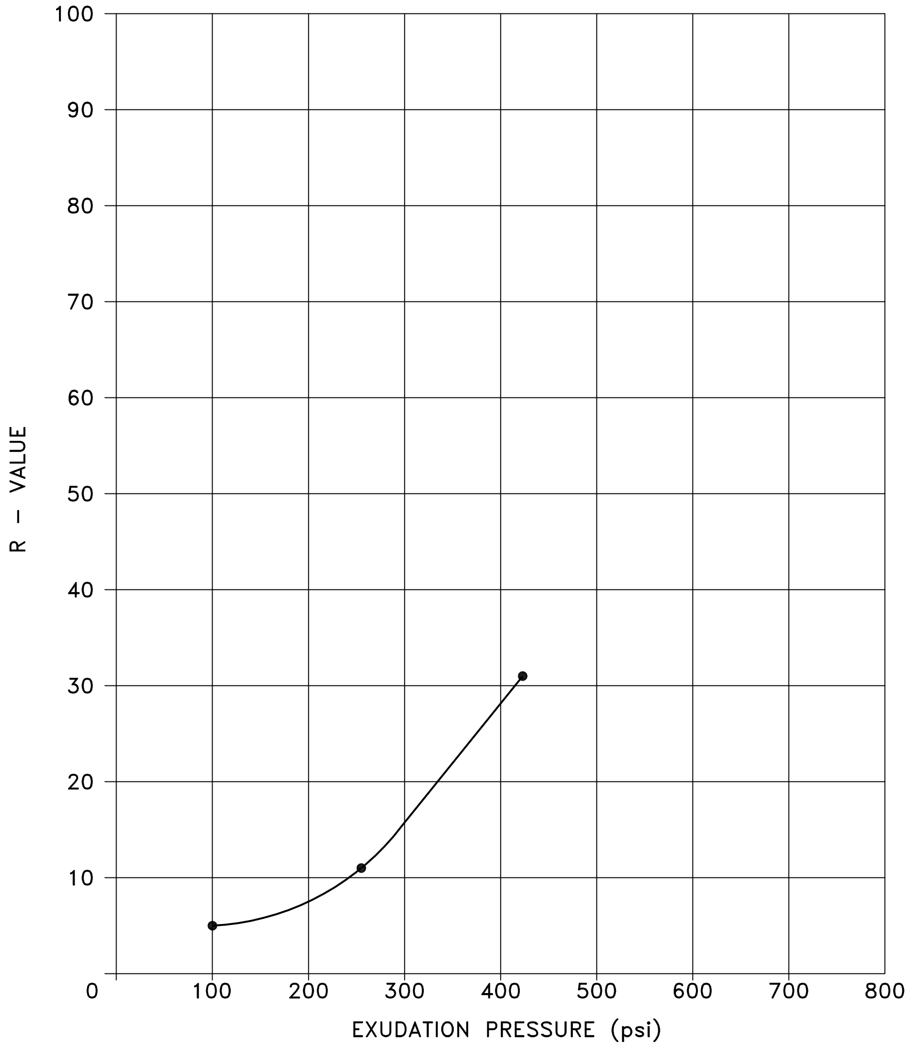
DATE SAMPLED: 8/12/19 DATE RECEIVED: 8/13/19 DATE TESTED: 8/22/19

GRAVEL: 2 % SAND: 71 % SILT AND CLAY: 27 %

LIQUID LIMIT: 31 PLASTICITY INDEX: 14

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. R–value performed in accordance with ASTM D2844. Atterberg limits performed in accordance with ASTM D4318. Sieve analyses performed in accordance with ASTM D422, D1140.

TEST SPECIMEN	1	2	3	4	R –VALUE (300 psi)
MOISTURE CONTENT (%)	14.6	12.8	11.5		
DENSITY (pcf)	114.9	119.5	120.5		
EXPANSION PRESSURE (psi)	0.000	0.240	0.480		
EXUDATION PRESSURE (psi)	100	255	423		
R VALUE	5	11	31		16



SOIL TYPE: Clayey Sand (SC), A–6 (5)

LOCATION: Deer Creek Road, Boring 4 @ 2.5"–5'

DATE SAMPLED: 8/13/19 DATE RECEIVED: 8/13/19 DATE TESTED: 8/22/19

GRAVEL: 1 % SAND: 53 % SILT AND CLAY: 46 %

LIQUID LIMIT: 40 PLASTICITY INDEX: 20

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. R–value performed in accordance with ASTM D2844. Atterberg limits performed in accordance with ASTM D4318. Sieve analyses performed in accordance with ASTM D422, D1140.

19–2–195	Kumar & Associates	GRADATION TEST RESULTS	Fig. 12

August 29, 2019 – 02:48pm
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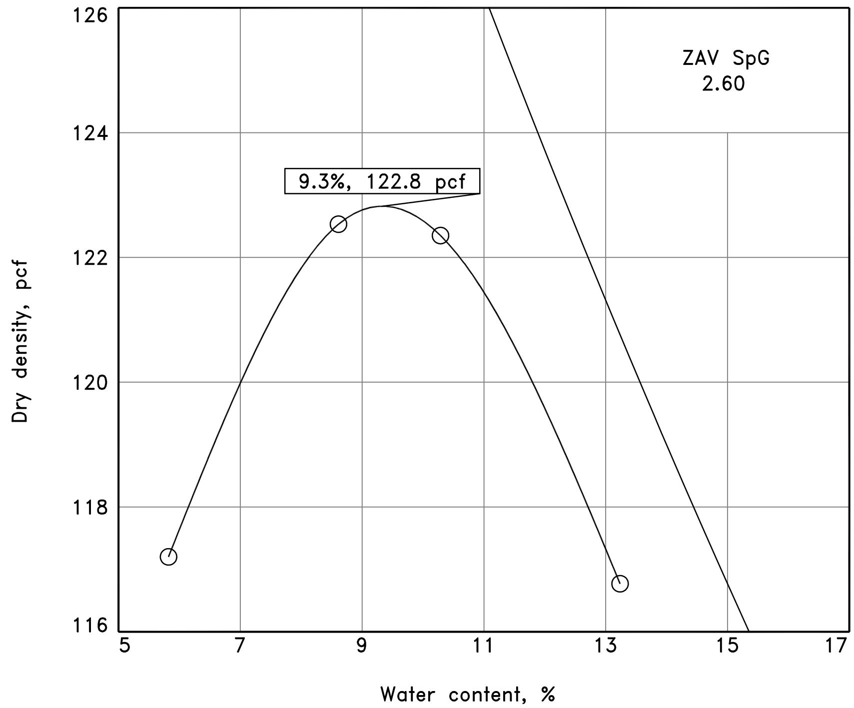
COMPACTION TEST REPORT

Curve No. 9783



Preparation Method	
Rammer: Wt.	5.5 lb.
Drop	12 in.
Type	Manual
Layers: No.	3
Blows per	25
Mold Size	0.03333 cu. ft.
Test Performed on Material Passing ___ Sieve	#4
%>#4	
%<No.200	
Atterberg (D 4318): LL	
PI	
NM (D 2216)	
Sp.G. (D 854)	2.6
USCS (D 2487)	
AASHTO (M 145)	
Date: Sampled	8-16-19
Received	8-16-19
Tested	8-22-19
Tested By	AS

COMPACTION TESTING DATA
ASTM D 698-12 Method A Standard

	1	2	3	4	5	6
WM + WS	4170.0	4198.0	4157.0	4033.0		
WM	2158.0	2158.0	2158.0	2158.0		
WW + T #1	386.4	437.8	489.2	383.5		
WD + T #1	366.8	412.0	456.8	370.7		
TARE #1	139.2	161.2	212.0	150.8		
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	8.6	10.3	13.2	5.8		
DRY DENS.	122.5	122.4	116.8	117.2		

SIEVE TEST RESULTS
ASTM D-422 ASTM D-1140

Opening Size	% Passing	Specs.

TEST RESULTS

Maximum dry density = 122.8 pcf

Optimum moisture = 9.3 %

Material Description

Clayey Sand (SC)

Remarks:

Project No. 19-2-195 Client: EPC

Project: Deer Creek Road

○ Location: Boring #1 Depth: 2"-5' Sample Number: 9783

Checked by: DS

Title: Lab Manager

19-2-195	Kumar & Associates	MOISTURE-DENSITY RELATIONSHIPS	Fig. 13

August 29, 2019 - 02:48pm
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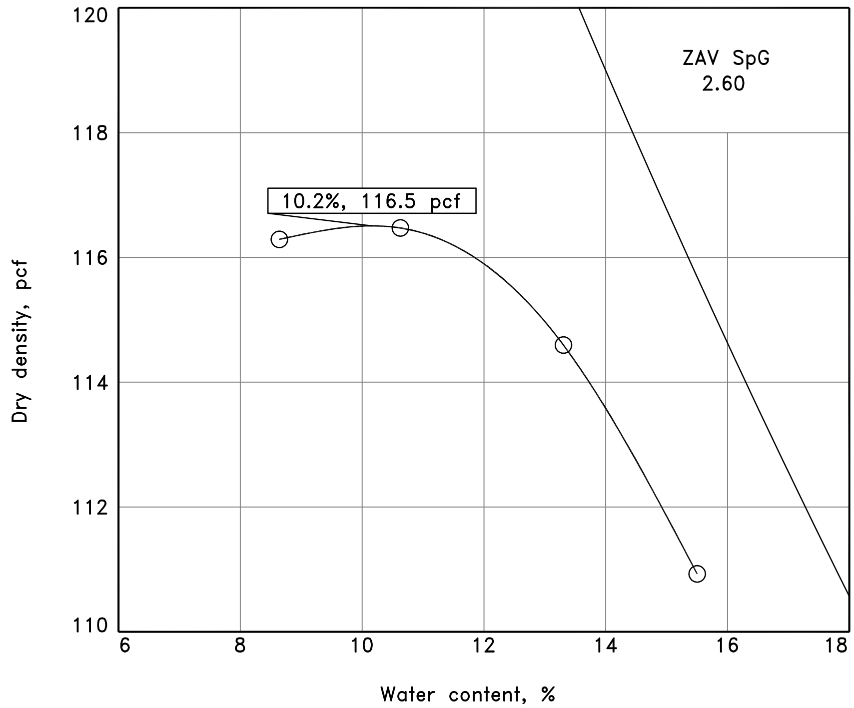
COMPACTION TEST REPORT

Curve No. 9784



Preparation Method			
Rammer: Wt.	5.5 lb.	Drop	12 in.
Type	Manual		
Layers: No.	3	Blows per	25
Mold Size	0.03333 cu. ft.		
Test Performed on Material Passing	#4	Sieve	
%>#4		%<No.200	
Atterberg (D 4318): LL		PI	
NM (D 2216)		Sp.G. (D 854)	2.6
USCS (D 2487)			
AASHTO (M 145)			
Date: Sampled	8-16-19		
Received	8-16-19		
Tested	8-22-19		
Tested By	AS		

COMPACTION TESTING DATA
ASTM D 698-12 Method A Standard

	1	2	3	4	5	6
WM + WS	4106.0	4121.0	4095.0	4068.0		
WM	2158.0	2158.0	2158.0	2158.0		
WW + T #1	429.6	395.2	378.4	426.2		
WD + T #1	403.2	366.3	346.9	406.3		
TARE #1	154.8	149.1	143.7	176.0		
WW + T #2						
WD + T #2						
TARE #2						
MOIST.	10.6	13.3	15.5	8.6		
DRY DENS.	116.5	114.6	110.9	116.3		

SIEVE TEST RESULTS
ASTM D-422 ASTM D-1140

Opening Size	% Passing	Specs.

TEST RESULTS

Maximum dry density = 116.5 pcf

Optimum moisture = 10.2 %

Material Description

Clayey Sand (SC)

Remarks:

Project No. 19-2-195 Client: EPC

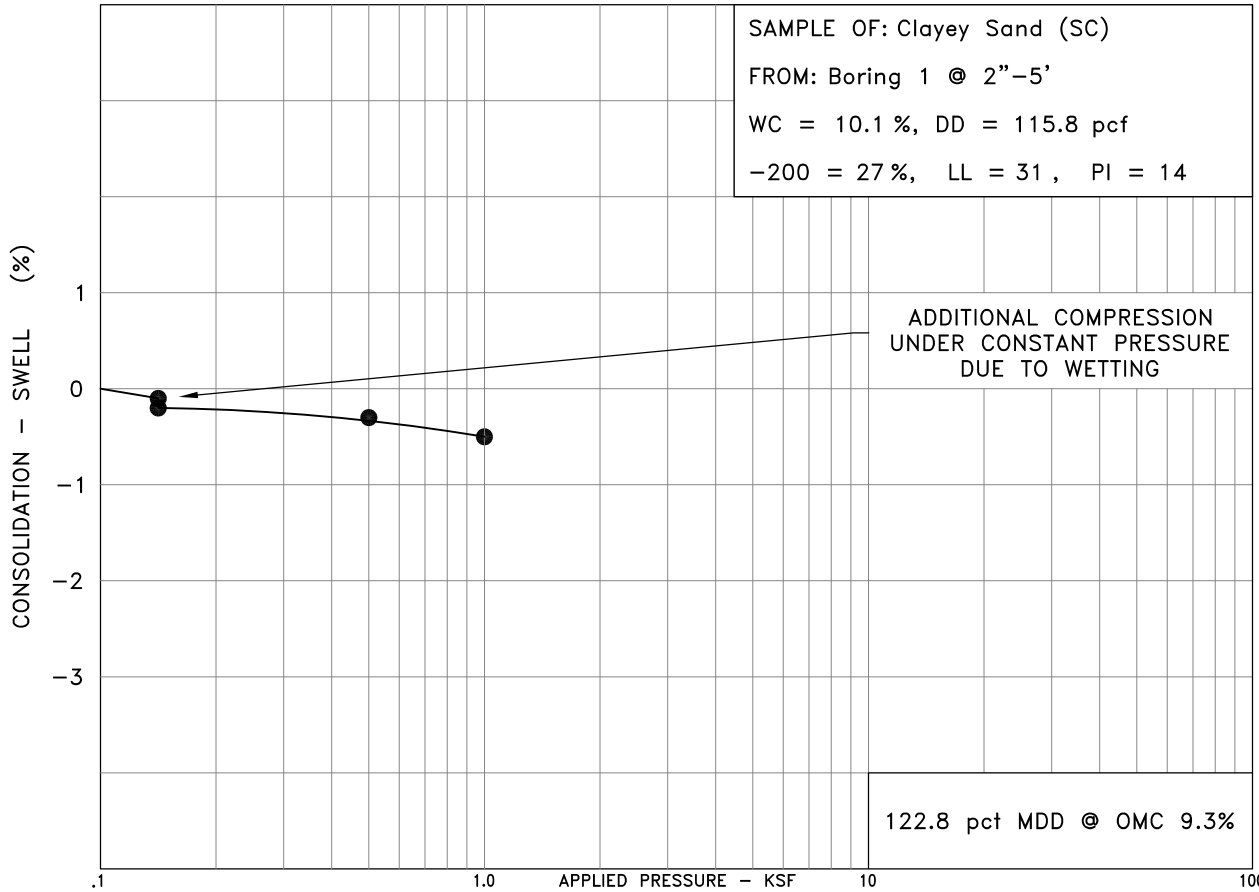
Project: Deer Creek Road

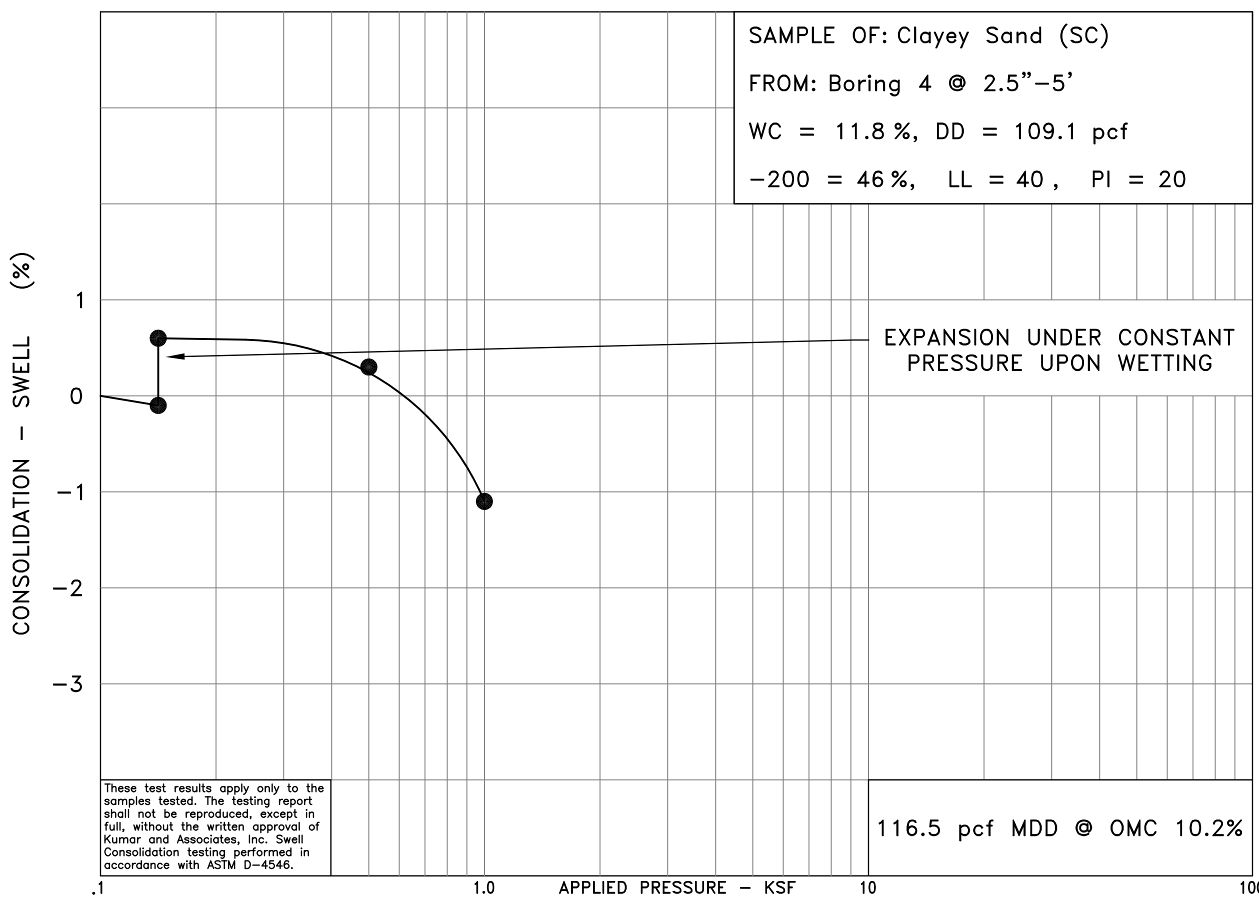
○ Location: Boring #4 Depth: 2.5"-5' Sample Number: 9784

Checked by: DS

Title: Lab Manager

19-2-195	Kumar & Associates	MOISTURE-DENSITY RELATIONSHIPS	Fig. 14





19–2–195	Kumar & Associates	REMOLDED SWELL–CONSOLIDATION TEST RESULTS	Fig. 15

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Kumar and Associates, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Project No.: 19-2-195
Project Name : Deer Creek Rd, Base Camp Rd, and Microscope Way
Date Sampled: 8/12/2019 and 8/13/2019
Date Received: 8/13/2019

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		WATER SOLUBLE SULFATES (%)	R-VALUE	STANDARD PROCTOR		AASHTO CLASSIFICATION (Group Index)	SOIL OR BEDROCK TYPE (Unified Soil Classification)
BORING	DEPTH (ft)				GRAVEL (%)	SAND (%)		LIQUID LIMIT	PLASTICITY INDEX			MAX DRY DENSITY (pcf)	OPTIMUM MOISTURE CONTENT (%)		
1	2" - 5'	8/20/19			2	71	27	31	14		25	122.8	9.3	A-2-6 (0)	Clayey Sand (SC)
1	2'	8/20/19	5.6	108.5											Clayey Sand (SC)
2	2'	8/20/19	7.9	125.9	5	75	20	31	12	0.02				A-2-6 (0)	Clayey Sandstone
3	2'	8/20/19	8.9	122.7	2	72	26	24	6					A-2-4 (0)	Fill: Silty Clayey Sand (SC-SM)
3	9'	8/20/19	34.0	81.0			68	63	31					A-7-5 (22)	Sandy Fat Clay (CH)
4	2.5" - 5'	8/20/19			1	53	46	40	20		16	116.5	10.2	A-6 (5)	Clayey Sand (SC)
4	4'	8/20/19	11.4	119.0											Clayey Sand (SC)
4	9'	8/20/19	10.4	127.5	4	81	15	35	11					A-2-6 (0)	Clayey Sandstone
5	2" - 5'	8/20/19			1	60	39	35	17					A-6 (2)	Clayey Sand (SC)
5	2'	8/20/19	10.6	118.3						<0.01					Clayey Sand (SC)
6	2'	8/20/19	5.4	108.6	1	83	16		NP					A-1-b (0)	Silty Sand (SM)
7	4'	8/20/19	7.0	103.6	0	89	11		NP					A-2-4 (0)	Well Graded Sand with Silt (SW-SM)
8	1" - 5'	8/20/19			0	59	41	35	16					A-6 (3)	Clayey Sand (SC)
8	2'	8/20/19	7.3	112.0											Clayey Sand (SC)
9	2'	8/20/19	10.1	121.2	4	77	19	29	8					A-2-4 (0)	Clayey Sandstone

APPENDIX

(Pavement Design Calculations)

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Kumar & Associates
6735 Kumar Heights
Colorado Springs, CO 80918
USA

Flexible Structural Design Module

19-2-195
Deer Creek Road
HMA/ABC, R=16

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	875,000
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	4,334 psi
Stage Construction	1
Calculated Design Structural Number	3.59 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	6	-	2.64
2	ABC	0.11	1	9	-	0.99
Total	-	-	-	15.00	-	3.63

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Kumar & Associates
6735 Kumar Heights
Colorado Springs, CO 80918
USA

Flexible Structural Design Module

19-2-195
Deer Creek Road
HMA/CTS, R=16

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	875,000
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Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	4,334 psi
Stage Construction	1
Calculated Design Structural Number	3.59 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	6	-	2.64
2	CTS	0.12	1	8	-	0.96
Total	-	-	-	14.00	-	3.60

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Kumar & Associates
6735 Kumar Heights
Colorado Springs, CO 80918
USA

Flexible Structural Design Module

19-2-195
Base Camp Road & Microscope Road
HMA/ABC, R=16

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	36,500
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	4,334 psi
Stage Construction	1
Calculated Design Structural Number	2.25 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	4	-	1.76
2	ABC	0.11	1	5	-	0.55
Total	-	-	-	9.00	-	2.31

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Kumar & Associates
6735 Kumar Heights
Colorado Springs, CO 80918
USA

Flexible Structural Design Module

19-2-195
Base Camp Road & Microscope Road
HMA/CTS, R=16

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	36,500
Initial Serviceability	4.5
Terminal Serviceability	2
Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	4,334 psi
Stage Construction	1
Calculated Design Structural Number	2.25 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.44	1	3.5 *	-	1.54
2	CTS	0.12	1	~~6~~	-	0.72
Total	-	-	-	9.50	-	2.26

Increase to rec. min 8"

2/9/2024

Geotechnical Evaluation Report

Proposed Deer Creek Road Roundabout

Intersection of Deer Creek Road and Woodmoor Drive

El Paso County, Colorado

VIVID Project No.: D23-2-711

February 9, 2024

Report prepared for:

Wes Suchsland, PE
AECOM
7595 Technology Way, Suite 200
Denver, Colorado 80237
Wes.Suchsland@aecom.com

GEOTECHNICAL EVALUATION REPORT
Proposed Deer Creek Road Roundabout
Intersection of Deer Creek Road and Woodmoor Drive
El Paso County, Colorado
VIVID Project No. D23-2-711

Prepared by:

Mary Beth Ray, E.I.
Staff Engineer

2/9/2024

William J. Barreire, P.E.
Senior Geotechnical Engineer

Vivid Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, CO 80907
(719) 896-4356 phone
(719) 896-4357 fax

Table of Contents

1.0 INTRODUCTION

1.1 GENERAL

This report presents the results of a geotechnical investigation performed for the proposed Deer Creek Road Roundabout project, located at the intersection of Deer Creek Road and Woodmoor Drive in El Paso County, Colorado. An attached Vicinity Map (Figure 1) shows the general location of the project. Our investigation was performed for AECOM and was authorized by Mr. Wes Suchsland, P.E.

This report includes our recommendations relating to the geotechnical aspects of project design and construction. The conclusions and recommendations stated in this report are based upon the subsurface conditions found at the locations of our exploratory borings at the time our exploration was performed. They are also subject to the provisions stated in the report section titled **Additional Services & Limitations**. Our findings, conclusions, and recommendations should not be extrapolated to other areas or used for other projects without our prior review. Furthermore, they should not be used if the site has been altered, or if a prolonged period has elapsed since the date of the report, without VIVID's prior review to determine if they remain valid.

1.2 PROJECT DESCRIPTION

We understand the project consists of the design and construction of a roundabout within the existing intersection of Deer Creek Road and Woodmoor Drive in El Paso County, Colorado. The improvements are anticipated to provide a free flow condition for all turning movements and will eliminate stop signs. Medians, concrete curb and gutter, as well as striping and appropriate signage will be installed on all four quadrants to delineate lanes and instruct drivers. Crosswalks, curb ramps, landscaping and other appurtenances will also be installed. We anticipate the pavement improvements will consist of complete removal of the existing pavement and construction of a new pavement section consisting of asphalt over aggregate base course or concrete over aggregate base course. No retaining walls or other structures are planned.

We anticipate the final grade of the proposed roundabout and improvements will be similar to the existing grade, with other minor drainage improvements. VIVID should be notified in order to review and revise our recommendations if the construction varies from that presented above.

1.3 PURPOSE AND SCOPE

The purpose of our investigation was to explore and evaluate subsurface conditions at various locations near the proposed project improvements and, based upon the conditions found, to develop recommendations relating to the geotechnical aspects of project design and construction. Our conclusions and recommendations in this report are based upon analysis of the data from our field exploration, laboratory tests, and our experience with similar soil and geologic conditions in the area.

VIVID's scope of services included:

- A visual reconnaissance to observe surface and geologic conditions at the project site and locating the exploratory borings;
- Obtaining a work in the right of way/excavation permit from El Paso County;
- Notification of the Utility Notification Center of Colorado (UNCC)/Colorado 811 to identify underground utility lines at the boring locations prior to our drilling;

- Providing traffic control services and the drilling of four exploratory borings within the area of the proposed roundabout and improvements, the locations of which were selected based upon the proposed construction plans, access, and the locations of existing utilities;
- Laboratory testing of selected samples obtained during the field exploration to evaluate relevant physical and engineering properties of the soil;
- Evaluation and engineering analysis of the field and laboratory data collected to develop our geotechnical conclusions and recommendations; and
- Preparation of this report, which includes a description of the proposed project, a description of the surface and subsurface site conditions found during our investigation, our conclusions and recommendations as to pavement section thickness design, other related geotechnical issues, and appendices which summarize our field and laboratory investigations.

2.0 FIELD EXPLORATION AND LABORATORY TESTING

2.1 FIELD EXPLORATION

A field exploration performed on January 18, 2024, included drilling four exploratory borings at the approximate locations indicated on the attached Field Exploration Plans shown on Figure 2. A summary of the explorations is presented below:

Table 1
Summary of Subsurface Exploration

Boring Designation / Location	Approximate Boring Depth [feet, below ground surface]	Approximate Depth to Groundwater at Time of Drilling [feet, below ground surface]	Approximate Existing Asphalt Thickness [inches]	Approximate Existing Granular Base Thickness [inches]
B-1 / Woodmoor Drive	14.5	None Encountered	8.5	None Encountered
B-2 / Deer Creek Road	2.5	None Encountered	1.5	None Encountered
B-3 / Deer Creek Road	3.0	None Encountered	8.0	None Encountered
B-4 / Woodmoor Drive	14.5	None Encountered	10.0	None Encountered

The borings on Deer Creek Road were drilled to a shallow depth due to unknown locations/depths of utilities at locations approved by Woodmoor Water and Sanitation District. The borings were advanced with a truck-mounted CME-55 drill rig equipped with 4-inch outside diameter, continuous-flight auger. Samples were taken with a 2.5-inch O.D./2.0-inch I.D. California-type sampler and by bulk methods. Penetration tests were obtained at the various sample depths as well.

Appendix A to this report includes logs describing the subsurface conditions. The lines defining boundaries between soil types on the logs are based upon drill behavior and interpolation between samples and are therefore approximate. Transition between soil types may be abrupt or may be gradual.

2.2 GEOTECHNICAL LABORATORY TESTING

Laboratory tests were performed on selected soil samples to estimate their relative engineering properties. Tests were performed in general accordance with the following methods of ASTM or other recognized standards-setting bodies, and local practice:

- Description and Identification of Soils (Visual-Manual Procedure)
- Classification of Soils for Engineering Purposes
- Moisture Content and Unit Weight
- Sieve Analysis of Fine and Coarse Aggregates
- Liquid Limit, Plastic Limit, and Plasticity Index
- R-value

Results of the geotechnical laboratory tests are included in Appendix B of this report. Selected test results are also shown on the boring logs in Appendix A.

2.3 ANALYTICAL LABORATORY TESTING

Analytical testing for soil corrosivity was performed on a selected sample and included the following tests:

- pH
- Resistivity
- Redox Potential
- Water-soluble Sulfates
- Water-soluble Chlorides
- Sulfides

Results of the analytical laboratory tests are included in Appendix C of this report.

3.0 SITE CONDITIONS

3.1 SURFACE

At the time of our investigation, the existing asphalt was in fair to good condition with occasional transverse cracking on Woodmoor Drive and Deer Creek, east of Woodmoor Drive. Deer Creek Road, west of Woodmoor Drive, was in poor condition with severe alligator cracking. Residential properties are present to the east of the intersection, commercial properties to the northwest and Lewis Palmer Middle School to the southwest. The site varies from flat to moderately sloping to the south.

3.2 GEOLOGY

Prior to drilling, the site geology was evaluated by reviewing geologic maps including the CGS Geologic Map of the Monument Quadrangle, El Paso County, Colorado (Thorson and Madole, 2004). Mapping indicates the surficial soils in the general area of the project site comprise predominantly of alluvium comprised of sand and gravel underlain by sandstone and claystone bedrock of the Dawson Formation. The mapping is generally consistent with the materials encountered in our explorations. However, existing fill was encountered in our borings. The fill is associated with the original grading of the intersection and installation of utilities.

3.3 SUBSURFACE

VIVID explored the subsurface conditions by drilling, logging, and sampling four exploratory borings within or as near as possible to the general area to be occupied by the proposed roundabout as shown approximately on Figure 2. These borings were drilled to depths of approximately 2.5 to 14.5 feet below the existing ground surface. The general profile encountered in our borings consisted of:

Asphalt

The asphalt was generally between 8 and 10 inches thick with the exception of Deer Creek Road, west of Woodmoor Drive where the asphalt was only 1.5 inches. Granular base materials were not encountered underlying the asphalt.

Existing Fill

A layer of silty, clayey sand fill was encountered below the pavement and extended to depths of approximately 3 feet or the terminal depth of the borings. The fill was reddish-brown and medium to dark brown in color, slightly moist to moist, and very dense based on field penetration resistance testing.

Sand

A layer of silty, clayey sand material was encountered underlying the existing fill at the Woodmoor Drive boring locations and extended to depths of approximately 8 and 9 feet below the ground surface. The sand materials were light to dark brown, slightly moist to moist, and loose to medium dense based on field penetration resistance testing.

Bedrock

Sandstone bedrock was encountered below the units described above in borings B-1 and B-4. A thin layer of siltstone was encountered in boring B-1. The bedrock was light brown in color, moist, and hard based on field penetration resistance testing.

The boring logs in Appendix A should be reviewed for more detailed descriptions of the subsurface conditions at each of the boring locations explored.

3.3.1 Groundwater

Groundwater was not encountered in any of the borings. For safety reasons, the borings were backfilled and patched immediately after drilling due to the roads being in active traffic area. We do not believe that groundwater will be a construction consideration since improvements will mainly be limited to shallow pavement section construction. However, groundwater levels commonly vary over time and space depending on seasonal precipitation, irrigation practices, land use, and runoff conditions. These conditions and the variations that they create often are not apparent at the time of field investigation. Accordingly, the soil moisture and groundwater data in this report pertain only to the locations and times at which exploration was performed. They can be extrapolated to other locations and times only with caution. It should also be noted that VIVID has not performed a hydrologic study to verify the seasonal high-water level.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 GENERAL

A pavement section is a layered system designed to distribute concentrated traffic loads to the subgrade. Performance of the pavement structure is directly related to the physical properties of the subgrade soils and traffic loadings. Soils are represented for pavement design purposes by means of a soil support value. Pavement design procedures are based on strength properties of the subgrade and pavement materials, along with the design traffic conditions.

Our pavement investigation and thickness calculations were performed in general accordance with the El Paso County Engineering Criteria Manual, which is based on the 1993 American Association of State and Highway Transportation Officials (AASHTO) Guide for Design of Pavement Structures. Included herein are options for pavement section thickness design that meet the El Paso County Engineering Criteria Manual requirements.

The following sections describe in more detail the pavement section thickness design recommendations for areas requiring new pavement section construction.

4.2 PAVEMENT RECOMMENDATIONS

4.2.1 Anticipated Pavement Subgrade Material and Preparation

The pavement subgrade materials are anticipated to consist of predominantly granular materials (A-2-4, and A-4 materials using AASHTO classification). Hveem stabilometer (R-Value) testing was performed on composite soil samples comprising the upper 4 feet of soil below the pavement section obtained in each boring. The resulting R-value was 41. Therefore, a resilient modulus (M_R) value of 9,812 psi was calculated and used in our pavement thickness calculations.

Due to the granular nature of the near-surface materials, the subgrade materials were judged to be non-expansive. Therefore, swell testing was not performed.

The pavement section thickness recommendations are described in more detail below.

4.2.2 Pavement Design Parameter Summary

Based upon information provided by AECOM, the above-referenced pavement design manual, and the composite R-value sample of the pavement subgrade from the borings, the following table presents the pavement design parameters that were utilized in our design calculations. The roadway classification used was based on ESALs calculated based on the traffic study provided by AECOM, performed in 2021. A growth rate of 2.57, provided within the traffic study report, was used in our ESAL calculations. The following parameters were utilized to calculate required thicknesses of new Hot Mix Asphalt (HMA), Portland Cement Concrete (PCC), and Aggregate Base Course (ABC) layers.

Table 2
Summary of Pavement Design Parameters - New Flexible/HMA Pavement Section Construction

Pavement Design Parameters	Deer Creek Road	Woodmoor Drive
Roadway Classification[1]	Rural - Collector	Rural - Collector
20 year, 18-kip ESAL[2]	123,965	235,010
Serviceability Index [1]	2.5	
Overall Standard Deviation[1]	0.45	
Reliability [%][1]	80	
R-Value	41	
Resilient Modulus (M_R) [psi]	9,812	
Strength Coefficients		
New Hot Mix Asphalt[1]	0.44	
New Aggregate Base Course[1]	0.11	

1) Indicates classification and pavement design parameter(s) obtained from the El Paso County Engineering Criteria Manual and based on the roadway classifications provided by AECOM.
2) ESALs calculated from traffic study performed in 2021, provided by AECOM. A 2.57 growth rate was applied based on the traffic study report.

Table 3
Summary of Pavement Design Parameters – Rigid/PCC Pavement Section Construction

Pavement Design Parameters	Deer Creek Road	Woodmoor Drive
Roadway Classification[1]	Rural - Collector	Rural - Collector
30 year, 18-kip ESAL[2]	328,090	615,105
Serviceability Index[1]	2.5	
Overall Standard Deviation[1]	0.35	
28-day Mean PCC Modulus of Rupture [psi] [1]	650	
28-day Mean Elastic Modulus of Slab [psi]	3,400,000	
Reliability [%][1]	80	
R-Value	41	
K-Value	35	
Resilient Modulus (M_R) [psi]	9,812	
Strength Coefficients		
New Aggregate Base Course[1]	0.11	

1) Indicates classification and pavement design parameter(s) obtained from the El Paso County Pavement Design Criteria and based on the roadway classification provided by AECOM.
2) ESALs calculated from Traffic Study performed in 2021, provided by AECOM

If it is determined that different roadway classifications, traffic loadings, or strength coefficients should be used, please notify our office to re-evaluate the appropriate pavement section.

4.2.3 Design Sections

Our recommended pavement sections below are for areas of new pavement based on a Collector roadway classification. Material requirements and compaction specifications for PCC, HMA, ABC, and subgrade materials are presented in Sections 4.3.1 and 4.3.4, respectively. The design is based on the Pavement Design Criteria for El Paso County. The pavement section for Woodmoor Drive should be applied to the roundabout pavement.

The following describes our recommended design section that includes the required thickness of HMA, PCC, and ABC layers.

Table 4
New Pavement Section Thickness Recommendations

Roadway	Flexible Composite Section Thickness (HMA / ABC)	Rigid PCC Section Thickness (PCC / ABC)
Deer Creek Road	4” HMA / 6” ABC *over* properly prepared subgrade	7” PCC / 6” ABC *over* properly prepared subgrade
Woodmoor Drive and New Roundabout	4” HMA / 6” ABC *over* properly prepared subgrade	7.5” PCC / 6” ABC *over* properly prepared subgrade

Notes:
1) Composite design assumes removal of existing pavement section.

Concrete pavements should be provided with adequate reinforcement based upon anticipated loads.

4.3 CONSTRUCTION CONSIDERATIONS

All site preparation, earthwork operations and construction materials should be performed in accordance with applicable codes, safety regulations and other local, State or Federal guidelines as applicable including, but not limited to:

- El Paso County Engineering Standard Specifications;
- El Paso County Pavement Design Criteria;
- Pikes Peak Region Asphalt Paving Specifications Manual, and;
- Colorado Department of Transportation (CDOT), as applicable, and included by reference.

Proper drainage is of paramount importance in enhancing pavement performance. To avoid distress to pavement from wet subgrade soils, we recommend the maintenance of good drainage away from all pavements. Possible water sources include storm runoff, irrigation of landscaping adjacent to the pavement and localized groundwater seepage, among others. Landscaping adjacent to the pavements should be avoided. Joints in the pavement or at asphalt/concrete interfaces should be sealed. Any cracks or openings in the finished pavement surface should be sealed and/or repaired as quickly as possible.

4.3.1 Pavement Materials

The asphalt pavement should consist of a bituminous plant mix composed of a mixture of aggregate and bituminous material that meets the requirements of a job-mix formula established by a qualified engineer. We recommend Grading SX (75 gyrations) with PG 64-22 mix be utilized. Hot Mix Asphalt (HMA) design and construction shall conform to the requirements of the current Pikes Peak Region Asphalt Paving Specifications Manual. The HMA pavement should be placed in lifts not to exceed 3 inches in thickness, unless otherwise accepted by the project engineer, and be compacted to between 92 percent and 96 percent of its maximum theoretical (Rice) density.

Portland Cement Concrete (PCC) shall conform to the requirements of the El Paso County Specifications.

Aggregate Base Course (ABC) materials should conform to CDOT Class 6 ABC specifications. The ABC material should be placed in a uniform layer without segregation of size to a compacted maximum lift thickness of 6 inches. ABC should be moisture conditioned and compacted as described in Section 4.3.4 of this report.

Use of blankets, soil cover, or heating may be required to help prevent the subgrade from freezing if construction occurs during cold weather.

4.3.2 Subgrade Preparation

Any obviously unsuitable materials present (e.g. existing pavement, debris, organic materials, waste) should be completely removed. Remove the stripped materials for offsite disposal in accordance with local laws and regulations.

Prior to placement of new pavement sections, processing of the subgrade should be performed. This should include scarifying the subgrade as necessary to a minimum depth of 6 inches, moisture conditioning, and compacting the subgrade soils as recommended in Table 5 in Section 4.3.4 of this report.

After processing of the subgrade and prior to placing the new pavement section for the roadway, including the aggregate base and pavement, the pavement subgrade should be proof-rolled with a heavily loaded pneumatic-tired vehicle (such as a fully-loaded water truck) after preparation. Areas that pump or deform significantly under heavy wheel loads are not stable and should be removed and replaced to achieve a stable subgrade prior to paving. Care should be taken to ensure areas around manholes or other utility protrusions are proof-rolled adequately.

Our investigation did not find obvious moisture content, soil types, or blow counts that would indicate unstable conditions are expected during construction. However isolated soft spots and adverse weather conditions during construction can result in challenges to creating a stable subgrade for paving. Any soft and/or wet areas of subgrade exposed during the excavation process may need to be stabilized prior to placement of new fill and pavement sections to create a stable, unyielding construction platform. The method and extent of stabilization will depend on the actual conditions encountered, and the more appropriate method of stabilization will likely be best determined in the field at the time of excavation, by VIVID representatives. A typical stabilization method includes utilizing geo-grid and Aggregate Base Course (ABC) or crowding rock to form a stable base on which to place the pavement section. Installation typically includes placement of the geo-grid directly on subgrade with on the order of 12 to 18 inches of ABC above the grid. If crowding rock size can vary widely depending on conditions but 3 to 6 inch or larger is common. Heavier weight/stiffer geo-grids can allow for thinner ABC sections but need to be analyzed on a case-by-case basis. Thicknesses will vary depending on actual conditions encountered and would require adjustment during construction.

4.3.3 Excavation Characteristics

Excavation into the overburden soil material can likely be accomplished utilizing conventional standard duty earth moving equipment. The majority of the surficial overburden soil consisted of sand soils. Sloughing/collapse of trench sidewalls in areas that have clean sand materials is likely. Based on this information, and depending on the depth of trenching, shoring is likely to be needed in these locations and where appropriate sloping cannot be achieved.

For trenches extending into bedrock, heavy duty excavation equipment will be required. Excavations that extend into the bedrock materials should anticipate variable conditions ranging from softer, severely weathered bedrock conditions to very hard rock and difficult excavation operations.

All excavations must comply with the applicable Local, State and Federal safety regulations, and particularly with the excavation standards of the Occupational Safety and Health Administration (OSHA). Construction site safety, including excavation safety, is the sole responsibility of the Contractor as part of its overall responsibility for the means, methods and sequencing of construction operations. VIVID's recommendations for excavation support are intended for the Client's use in planning the project, and in no way relieve the Contractor of its responsibility to construct, support and maintain safe slopes. Under no circumstances should the following recommendations be interpreted to mean that VIVID is assuming responsibility for either construction site safety or the Contractor's activities.

We believe that the soils on this site will classify as Type C materials using OSHA criteria. OSHA requires that unsupported cuts be laid back to ratios no steeper than 1½:1 (horizontal to vertical) in Type C materials. However, the hard and intact on-site bedrock may be classified as Type B material. OSHA requires that unsupported cuts up to 20 feet in height be laid back to ratios no steeper than 1H:1V (horizontal to vertical) for a Type B material. In general, we believe that these slope ratios will be temporarily stable under unsaturated conditions. Where groundwater seepage occurs, flatter slopes will be appropriate. Please note that the actual determination of soil type and allowable sloping must be made in the field by an OSHA-qualified "competent person."

4.3.4 Compaction Requirements

Soil and aggregate materials should be placed on a horizontal plane and placed in loose lifts not to exceed 8 inches in thickness, unless otherwise accepted by the geotechnical engineer. Materials should be moisture-conditioned and compacted according to following criteria:

Table 5
Fill Placement and Compaction Criteria

Fill Location	Material Type	Percent Compaction[1]	Moisture Content
Subgrade Preparation (after clearing, grubbing, excavation, and prior to placement of new fill and/or structural elements)	On-site Soils	95 minimum (ASTM D1557)	± 2 % of optimum
Embankment Fill	On-site Granular Soils or Imported Granular Fill (must meet minimum R-value of 41)	95 minimum (ASTM D1557)	± 2 % of optimum
Aggregate Base Course	See Section 4.3.1	95 minimum (ASTM D1557)	± 2 % of optimum
Utility Trench Backfill/ Flatwork Subgrade	On-site Soils or Imported Granular Fill	95 minimum (ASTM D1557)	± 2 % of optimum

1) In non-structural/landscaped areas, the compaction specification may be reduced to 90 percent. The higher compaction criteria should be utilized where two or more "fill locations" coincide.

4.3.5 Embankment Fill

If imported fill is required at this site for roadway embankment, it should consist of a non-expansive, granular material with a maximum particle size of 2 inches, a liquid limit of less than 30 percent, a plasticity index of less than 6 percent, and a minimum R-value of 41. The fill should have between about 10 and 30 percent passing the No. 200 sieve. A sample of any imported fill material should be submitted to our office for approval and testing at least 1 week prior to stockpiling at the site.

Embankment fill should be compacted according to the recommendations in Section 4.3.4 of this report. We recommend that a qualified representative of VIVID visit the site during excavation and during placement of the structural fill to verify the soils exposed in the excavations are consistent with those encountered during our subsurface exploration and that proper subgrade preparation and placement is performed.

4.3.6 Trench Backfill

Backfill material for trenches should be free of humus, vegetation, or other organic matter, frozen material, clods, sticks and debris. In addition, rock particles and hard earth "clods" larger than 3 inches will be removed. However, backfill material in the "pipe zone" (from the trench floor to 1 foot above the top of pipe) should not contain rock particles larger than 1 inch. Requirements specified by the utility agency for bedding and pipe-zone fill should be observed and take precedence where in conflict with the recommendations in this report. In general, backfill above the pipe zone in utility trenches should be placed in lifts of 6 to 8 inches, and compacted using power equipment designed for trench work to the specifications recommended in Section 4.3.4 of this report.

4.3.7 Construction in Wet or Cold Weather

During construction, grade the site such that surface water can drain readily away from the project area. Promptly pump out or otherwise remove any water that may accumulate in excavations or on subgrade surfaces and allow these areas to dry before resuming construction. Berms, ditches and similar means may be used to prevent stormwater from entering the work area and to convey any water off site efficiently.

If earthwork is performed during the winter months when freezing is a factor, no grading fill, structural fill or other fill should be placed on frosted or frozen ground, nor should frozen material be placed as fill. Frozen ground should be allowed to thaw or be completely removed prior to placement of fill. A good practice is to cover the compacted fill with a "blanket" of loose fill to help prevent the compacted fill from freezing.

If construction is initiated during cold weather, concrete elements should not be constructed on frozen soil. Frozen soil should be completely removed from beneath the concrete elements, or thawed, scarified and recompacted. The amount of time passing between excavation or subgrade preparation and placing concrete should be minimized during freezing conditions to prevent the prepared soils from freezing. Blankets, soil cover or heating as required may be utilized to prevent the subgrade from freezing.

4.3.8 Drainage

Proper drainage is of paramount importance in enhancing long-term pavement performance. To avoid distress to pavement from wet, soft subgrade soils, we recommend the maintenance of good drainage away from all pavements. Possible water sources include storm runoff, irrigation of landscaping adjacent to the pavement and localized groundwater seepage, among others. Joints in the pavement or at asphalt/concrete interfaces should be sealed. Any cracks or openings in the finished pavement surface should be sealed and/or repaired as quickly as possible.

4.3.9 Pavement Maintenance

Annual maintenance generally refers to crack filling and general surface sealers. We recommend implementation of an at least annual if not more frequent flatwork/pavement crack sealing program. This is very important to prevent surface water (especially from slow infiltration from sources such as snow melt and surface run-off) from entering cracks and wetting the subgrade. Due to temperature fluctuations in Colorado, significant separations can also occur at interfaces between the asphalt pavement and curbs, concrete flatwork, and other features. These areas generally result in a high rate of premature distress and failure that can propagate well beyond the original problem area. Any cracks or openings in the finished pavement surface should be sealed and/or repaired as quickly as possible.

4.4 METAL CORROSIVITY AND CONCRETE SULFATE DEGRADATION

Laboratory chloride concentration, sulfate concentration, sulfide concentration, pH, oxidation reduction potential, and electrical resistivity tests were performed on a sample of onsite materials obtained during our field investigation. The results of the tests are included in Appendix C to this report and are summarized below in Table 6.

Table 6
Summary of Laboratory Soil Corrosivity Testing

Boring No.	Sample Depth (ft)	Lithology	Water Soluble Chloride (%)	pH	Redox Potential (mV)	Resistivity (ohm-cm)	Water Soluble Sulfate (%)	Sulfide Content (ppm)
B-1	0-4	Silty, Clayey SAND	0.020	8.3	110.4	2300	<0.001	Negative
B-3	0-4	Existing Fill – Silty, Clayey SAND	0.015	8.6	71.2	2600	<0.001	Negative

4.4.1 Metal Corrosion

Laboratory testing was completed to provide data regarding corrosivity of onsite soils. Our scope of services does not include corrosion engineering and, therefore, a detailed analysis of the corrosion test results is not included. A qualified corrosion engineer should be retained to review the test results and design protective systems that may be required.

Metal and concrete elements in contact with soil, whether part of a foundation system or part of a supported structure, are subject to degradation due to corrosion or chemical attack. Therefore, buried metal and concrete elements should be designed to resist corrosion and degradation based on accepted practices.

Based on the "10-point" method developed by the American Water Works Association (AWWA) in standard AWWA C105/A21.5, the corrosivity test results indicate that the onsite soils have low corrosive potential. We recommend that a corrosion engineer be consulted to recommend appropriate protective measures, if required. CDOT provides guidance on pipe material selection based on soil corrosion test data as well.

4.4.2 Chemical Sulfate Susceptibility and Concrete Type

The degradation of concrete or cement grout can be caused by chemical agents in the soil or groundwater that react with concrete to either dissolve the cement paste or precipitate larger compounds within the concrete, causing cracking and flaking. The concentration of water-soluble sulfates in the soils is a good indicator of the potential for chemical attack of concrete or cement grout. The American Concrete Institute (ACI) in their publication Guide to Durable Concrete (ACI 201.2R-08) provides guidelines for this assessment.

The concentration of water-soluble sulfates measured on subsurface soil materials submitted for testing represents a Class 0 exposure of sulfate attack on concrete exposed to the soils per CDOT Standard Specifications for Road and Bridge Construction, 2023, Section 601.04.

5.0 ADDITIONAL SERVICES & LIMITATIONS

5.1 ADDITIONAL SERVICES

Attached to this report is a document by the Geoprofessional Business Association (GBA) that summarizes limitations of geotechnical reports as well as additional services that are required to further confirm subgrade materials are consistent with that encountered at the specific boring locations presented in this report. This document should be read in its entirety before implementing design or construction activities. Examples of other services beyond completion of a geotechnical report are necessary or desirable to complete a project satisfactorily include:

- Review of design plans and specifications to verify that our recommendations were properly interpreted and implemented.
- Attendance at pre-bid and pre-construction meetings to highlight important items and clear up misunderstandings, ambiguities, or conflicts with design plans and specifications.
- Performance of construction observation and testing which allows verification that existing materials at locations beyond our borings are consistent with that presented in our report, construction is compliant with the requirements/recommendations, evaluation of changed conditions.

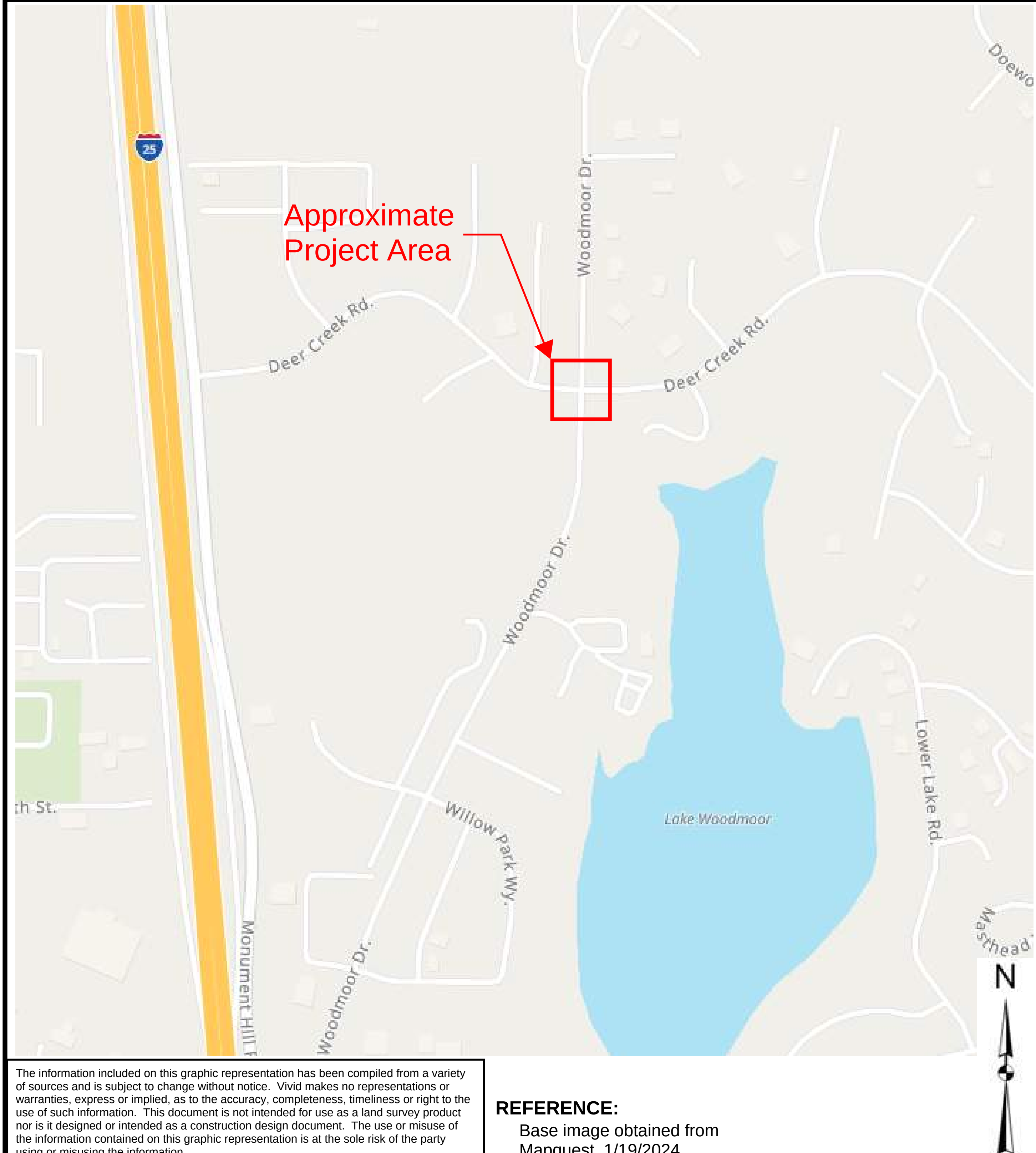
5.2 LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of VIVID's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. VIVID makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

This report may be used only by the Client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than two (2) years from the date of the report.

The work performed was based on project information provided by Client. If Client does not retain VIVID to review any plans and specifications, including any revisions or modifications to the plans and specifications, VIVID assumes no responsibility for the suitability of our recommendations. In addition, if there are any changes in the field to the plans and specifications, Client must obtain written approval from VIVID's engineer that such changes do not affect our recommendations. Failure to do so will vitiate VIVID's recommendations.

Figures



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REFERENCE:
Base image obtained from
Mapquest, 1/19/2024

VIVID Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, CO 80907
719-896-4356

Project No. D23-2-711	**VICINITY MAP**
Date: 1/19/2024	Proposed Deer Creek Road Roundabout Intersection of Deer Creek Road and Woodmoor Drive El Paso County, Colorado
Drawn by: DC	
Reviewed by: MBR	

FIGURE

1

Note: Not to Scale.

The information included on this graphic representation has been compiled from a variety of sources and is subject to change without notice. Vivid makes no representations or warranties, express or implied, as to the accuracy, completeness, timeliness or right to the use of such information. This document is not intended for use as a land survey product nor is it designed or intended as a construction design document. The use or misuse of the information contained on this graphic representation is at the sole risk of the party using or misusing the information.

REFERENCE

Base Image obtained from Google Earth Pro, 2023.

LEGEND

B-1 Approximate Boring Location

VIVID Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, CO 80907
719-896-4356

Project No. D23-2-711

Date: 1/19/2024

Drawn by: DC

Reviewed by: WJB

FIELD EXPLORATION PLAN
(AERIAL)

Proposed Deer Creek Road Roundabout
Intersection of Deer Creek Road and Woodmoor Drive
El Paso County, Colorado

FIGURE
2

Appendix A

Log of Exploratory Borings

Vivid Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

KEY TO SYMBOLS

CLIENT AECOM
PROJECT NAME Proposed Deer Creek Road Roundabout
PROJECT NUMBER D23-2-711
PROJECT LOCATION El Paso County, Colorado

LITHOLOGIC SYMBOLS (Unified Soil Classification System)

ASPHALT

FILL

SANDSTONE

SC-SM: USCS Clayey Sand

SILTSTONE

SAMPLER SYMBOLS

Grab Sample

2" I.D. Modified California Sampler (MC)

Standard Penetration Test (SPT)

ABBREVIATIONS

LL - LIQUID LIMIT (%)
PI - PLASTIC INDEX (%)
MC - MOISTURE CONTENT (%)
DD - DRY DENSITY (PCF)
NP - NON PLASTIC
FINES- PERCENT PASSING NO. 200 SIEVE

∇ Water Level at Time Drilling, or as Shown

Vivid Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

BORING NUMBER B-1

CLIENT AECOM

PROJECT NAME Proposed Deer Creek Road Roundabout

PROJECT NUMBER D23-2-711

PROJECT LOCATION El Paso County, Colorado

DATE STARTED 1/18/24 **COMPLETED** 1/18/24

GROUND ELEVATION **HOLE SIZE** 4 inches

DRILLING CONTRACTOR Custom Auger Drilling (CME-55)

GROUND WATER LEVELS:

DRILLING METHOD 4" Solid Stem Auger

AT TIME OF DRILLING ---

LOGGED BY J. Krebs **CHECKED BY** W. Barreire

AT END OF DRILLING ---

NOTES

AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0					**Asphalt - 8.5 inches**
0.7	SPT	50/5"			**Existing Fill** Silty, Clayey SAND, reddish-brown, moist, very dense
2.5	GB		MC = 8.5% LL = 23 PL = 16 Fines = 34.0% Chloride = 0.020%, pH = 8.3, Redox Potential = 110.4 mV, Resistivity = 2300 ohm-cm, Sulfate = <0.001%, Sulfide = Negative		
3.0					Silty, Clayey SAND, light brown, moist, medium dense
5.0	MC	12-10	MC = 10.7% DD = 116.4 pcf LL = 24 PL = 20 Fines = 19.0%		
7.5					
9.0	MC	32-50/3"	MC = 17.2% DD = 109.7 pcf LL = 38 PL = 25 Fines = 66.0%		**Dawson Formation** SILTSTONE, light brown, moist, hard
10.0					**Dawson Formation** SANDSTONE, light brown, moist, hard
12.5					
14.6	SPT	50/7"			

Bottom of borehole at 14.6 feet.

GENERAL BH / TP / WELL - MODIFIED - GINT STD US LAB.GDT - 2/5/24 12:12 - C:\USERS\MARY BETH RAY\VIVID ENGINEERING GROUP\GEO - DOCUMENTS\PROJECTS_2023\D23-2-711_AECOM_DEER CREEK ROUNDABOUT\6 - DRAFTING\D23-2-711.GPJ

Vivid Engineering Group, Inc.
1053 Elkton Drive
Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

BORING NUMBER B-2

CLIENT AECOM

PROJECT NAME Proposed Deer Creek Road Roundabout

PROJECT NUMBER D23-2-711

PROJECT LOCATION El Paso County, Colorado

DATE STARTED 1/18/24 **COMPLETED** 1/18/24

GROUND ELEVATION **HOLE SIZE** 4 inches

DRILLING CONTRACTOR Custom Auger Drilling (CME-55)

GROUND WATER LEVELS:

DRILLING METHOD 4" Solid Stem Auger

AT TIME OF DRILLING ---

LOGGED BY D. Crozier **CHECKED BY** W. Barreire

AT END OF DRILLING ---

NOTES

AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0			0.1	**Asphalt - 1.5 inches**
				Existing Fill Clayey SAND, dark brown, reddish-brown, slightly moist
1	GB	MC = 6.1% LL = 22 PL = 14 Fines = 39.0%		
2				*Boring was terminated shallow due to inability of utility locators to fully identify location/depth of a water line.
			2.5	

Bottom of borehole at 2.5 feet.

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Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

BORING NUMBER B-3

CLIENT AECOM
PROJECT NAME Proposed Deer Creek Road Roundabout
PROJECT NUMBER D23-2-711
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 1/18/24 **COMPLETED** 1/18/24
GROUND ELEVATION ______ **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-55)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY D. Crozier **CHECKED BY** W. Barreire
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0 – 0.7			(asphalt)	**Asphalt - 8 inches**
0.7 – 3.0	GB	MC = 5.7% LL = 22 PL = 15 Fines = 37.0% Chloride = 0.015%, pH = 8.6, Redox Potential = 71.2 mV, Resistivity = 2600 ohm-cm, Sulfate = <0.001%, Sulfide = Negative	(fill)	**Existing Fill** Silty, Clayey SAND, reddish-brown, slightly moist

*Boring was terminated shallow due to inability of utility locators to fully identify location/depth of a water line.

Bottom of borehole at 3.0 feet.

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1053 Elkton Drive
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Telephone: 719-896-4356
Fax: 719-896-4357

BORING NUMBER B-4

CLIENT AECOM
PROJECT NAME Proposed Deer Creek Road Roundabout
PROJECT NUMBER D23-2-711
PROJECT LOCATION El Paso County, Colorado
DATE STARTED 1/18/24 **COMPLETED** 1/18/24
GROUND ELEVATION **HOLE SIZE** 4 inches
DRILLING CONTRACTOR Custom Auger Drilling (CME-55)
GROUND WATER LEVELS:
DRILLING METHOD 4" Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY D. Crozier **CHECKED BY** W. Barreire
AT END OF DRILLING ---
NOTES
AFTER DRILLING ---

DEPTH (ft)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	TESTS	GRAPHIC LOG	MATERIAL DESCRIPTION
0.0					**Asphalt - 10 inches**
0.8					**Existing Fill** Silty, Clayey SAND, medium brown, reddish-brown, slightly moist, very dense
	SPT	50/4"			
2.5	GB		MC = 4.0% LL = 18 PL = 14 Fines = 29.0%		
3.0					Silty, Clayey SAND, medium brown, dark brown, moist, loose
5.0	SPT	4-4-3 (7)	MC = 11.5% LL = 26 PL = 19 Fines = 27.0%		
7.5					
8.0					**Dawson Formation** SANDSTONE, light brown, slightly moist, very hard
10.0	MC	44-38	MC = 8.5% DD = 124.8 pcf LL = NP PL = NP Fines = 18.0%		
12.5					
14.3	SPT	50/4"			

Bottom of borehole at 14.3 feet.

Appendix B

Geotechnical Laboratory Test Results

Vivid Engineering Group, Inc.
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Colorado Springs, Colorado 80907
Telephone: 719-896-4356
Fax: 719-896-4357

SUMMARY OF LABORATORY RESULTS

CLIENT AECOM
PROJECT NAME Proposed Deer Creek Road Roundabout
PROJECT NUMBER D23-2-711
PROJECT LOCATION El Paso County, Colorado

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Dry Density (pcf)		
B-1	1.4	23	16	7	9.5	34	A-2-4	8.5			
B-1	4.0	24	20	4	9.5	19	A-2-4	10.7	116.4		
B-1	9.0	38	25	13	0.6	66	A-6	17.2	109.7		
B-2	0.1	22	14	8	19	39	A-4	6.1			
B-3	0.7	22	15	7	9.5	37	A-4	5.7			
B-4	1.3	18	14	4	9.5	29	A-2-4	4.0			
B-4	4.0	26	19	7	9.5	27	A-2-4	11.5			
B-4	9.0	NP	NP	NP	9.5	18	A-1-b	8.5	124.8		

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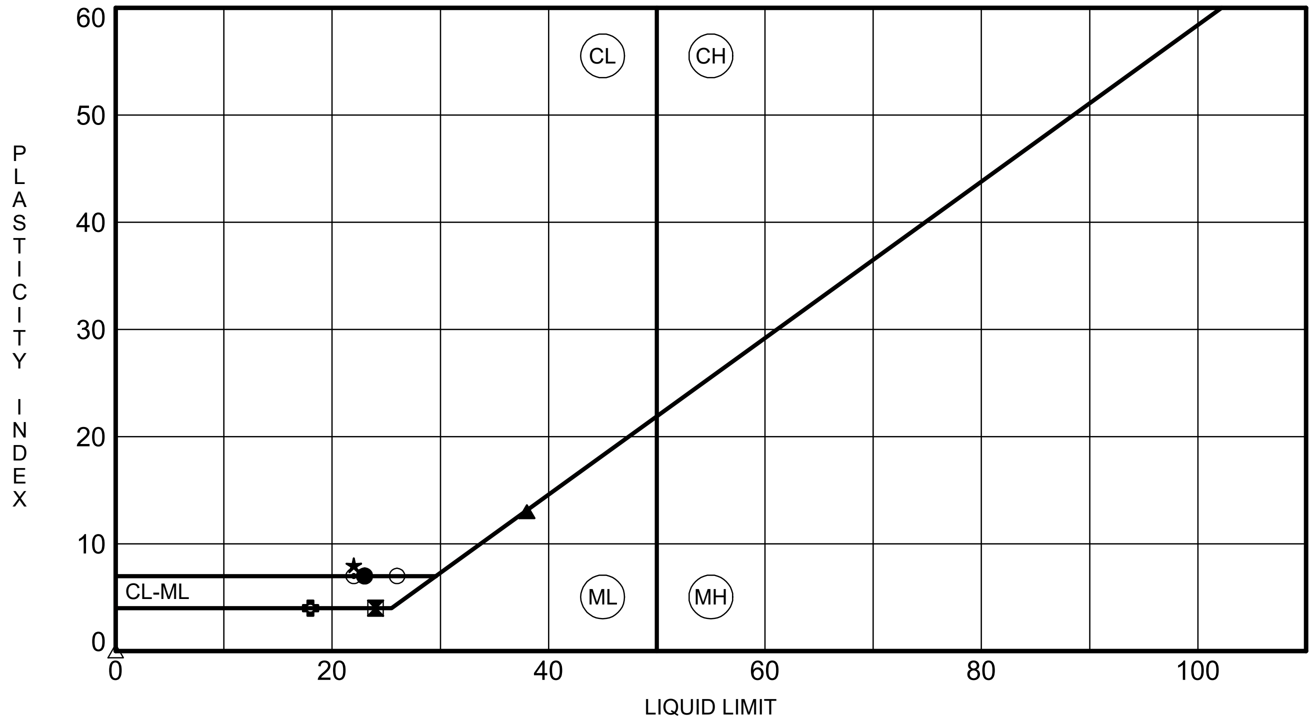
ATTERBERG LIMITS' RESULTS

CLIENT AECOM
PROJECT NAME Proposed Deer Creek Road Roundabout
PROJECT NUMBER D23-2-711
PROJECT LOCATION El Paso County, Colorado



	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**B-1**	**1.4**	**23**	**16**	**7**	**34**	**SILTY, CLAYEY SAND(SC-SM)**
⧗	**B-1**	**4.0**	**24**	**20**	**4**	**19**	**SILTY, CLAYEY SAND(SC-SM)**
▲	**B-1**	**9.0**	**38**	**25**	**13**	**66**	**SANDY SILT(ML)**
★	**B-2**	**0.1**	**22**	**14**	**8**	**39**	**CLAYEY SAND(SC)**
⊙	**B-3**	**0.7**	**22**	**15**	**7**	**37**	**SILTY, CLAYEY SAND(SC-SM)**
✪	**B-4**	**1.3**	**18**	**14**	**4**	**29**	**SILTY, CLAYEY SAND(SC-SM)**
○	**B-4**	**4.0**	**26**	**19**	**7**	**27**	**SILTY, CLAYEY SAND(SC-SM)**
△	**B-4**	**9.0**	**NP**	**NP**	**NP**	**18**	**SILTY SAND(SM)**

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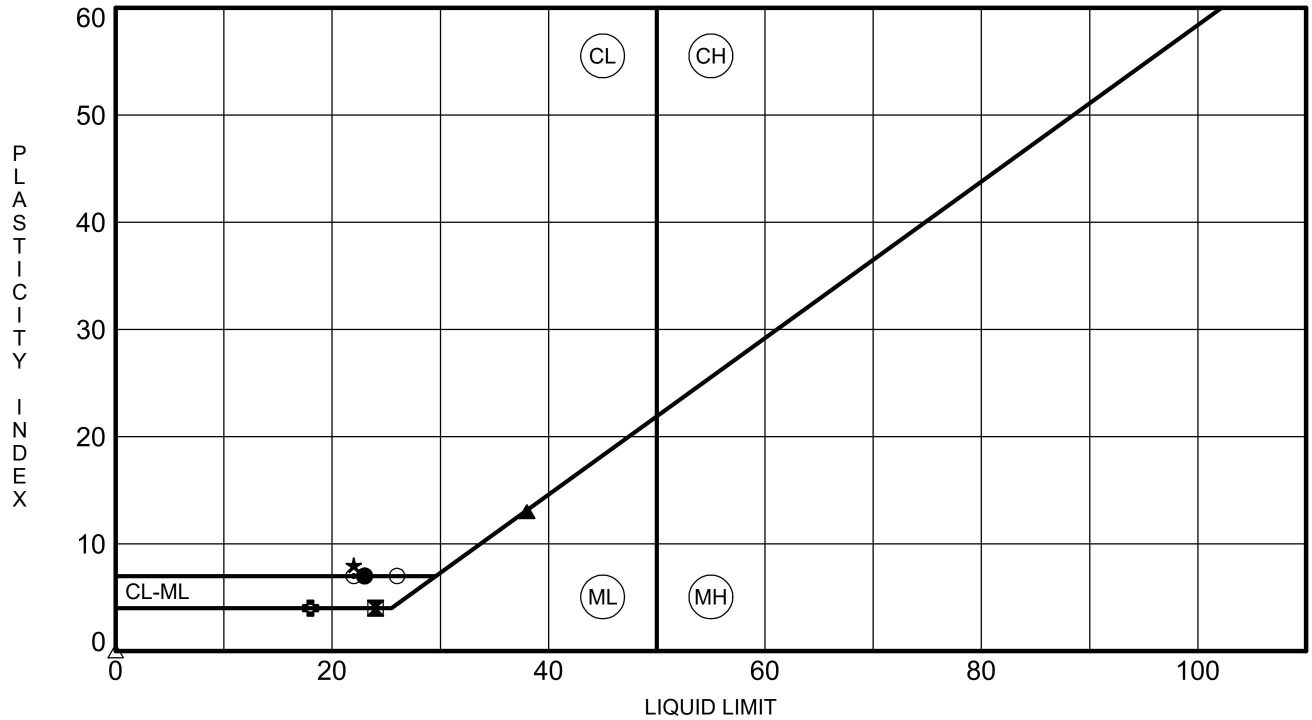
ATTERBERG LIMITS' RESULTS

CLIENT AECOM
PROJECT NAME Proposed Deer Creek Road Roundabout
PROJECT NUMBER D23-2-711
PROJECT LOCATION El Paso County, Colorado



	BOREHOLE	DEPTH	LL	PL	PI	Fines	Classification
●	**B-1**	**1.4**	**23**	**16**	**7**	**34**	**(A-2-4)**
⊠	**B-1**	**4.0**	**24**	**20**	**4**	**19**	**(A-2-4)**
▲	**B-1**	**9.0**	**38**	**25**	**13**	**66**	**(A-6)**
★	**B-2**	**0.1**	**22**	**14**	**8**	**39**	**(A-4)**
⊙	**B-3**	**0.7**	**22**	**15**	**7**	**37**	**(A-4)**
✿	**B-4**	**1.3**	**18**	**14**	**4**	**29**	**(A-2-4)**
○	**B-4**	**4.0**	**26**	**19**	**7**	**27**	**(A-2-4)**
△	**B-4**	**9.0**	**NP**	**NP**	**NP**	**18**	**(A-1-b)**

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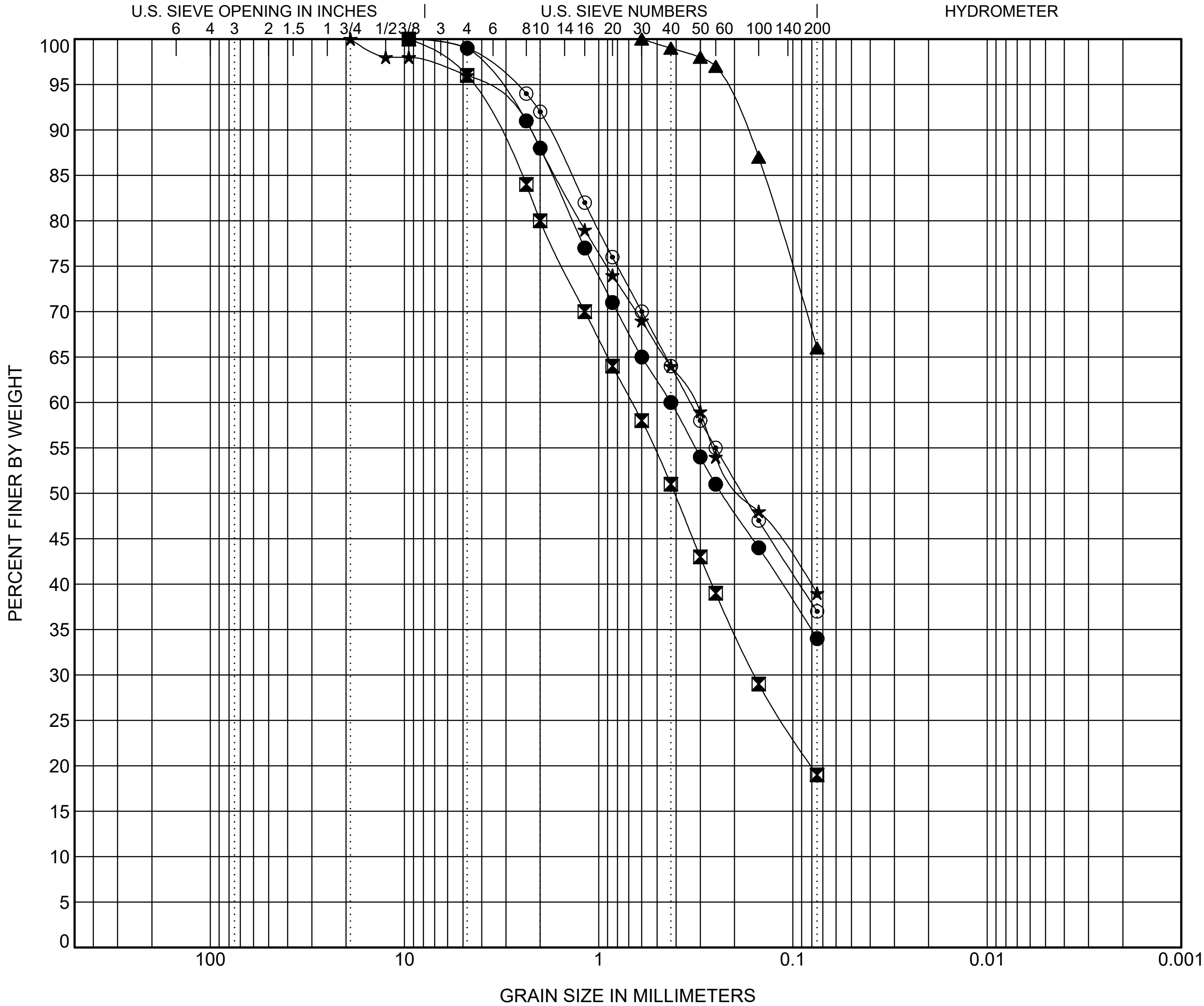
GRAIN SIZE DISTRIBUTION

CLIENT AECOM
PROJECT NAME Proposed Deer Creek Road Roundabout
PROJECT NUMBER D23-2-711
PROJECT LOCATION El Paso County, Colorado



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	**B-1**	**1.4**	**SILTY, CLAYEY SAND(SC-SM)**	**23**	**16**	**7**		
⊠	**B-1**	**4.0**	**SILTY, CLAYEY SAND(SC-SM)**	**24**	**20**	**4**		
▲	**B-1**	**9.0**	**SANDY SILT(ML)**	**38**	**25**	**13**		
★	**B-2**	**0.1**	**CLAYEY SAND(SC)**	**22**	**14**	**8**		
⊙	**B-3**	**0.7**	**SILTY, CLAYEY SAND(SC-SM)**	**22**	**15**	**7**		

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-1**	**1.4**	**9.5**	**0.425**			**1.0**	**65.0**	**34.0**	
⊠	**B-1**	**4.0**	**9.5**	**0.674**	**0.158**		**4.0**	**77.0**	**19.0**	
▲	**B-1**	**9.0**	**0.6**				**0.0**	**34.0**	**66.0**	
★	**B-2**	**0.1**	**19**	**0.322**			**4.0**	**57.0**	**39.0**	
⊙	**B-3**	**0.7**	**9.5**	**0.337**			**1.0**	**62.0**	**37.0**	

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GRAIN SIZE DISTRIBUTION

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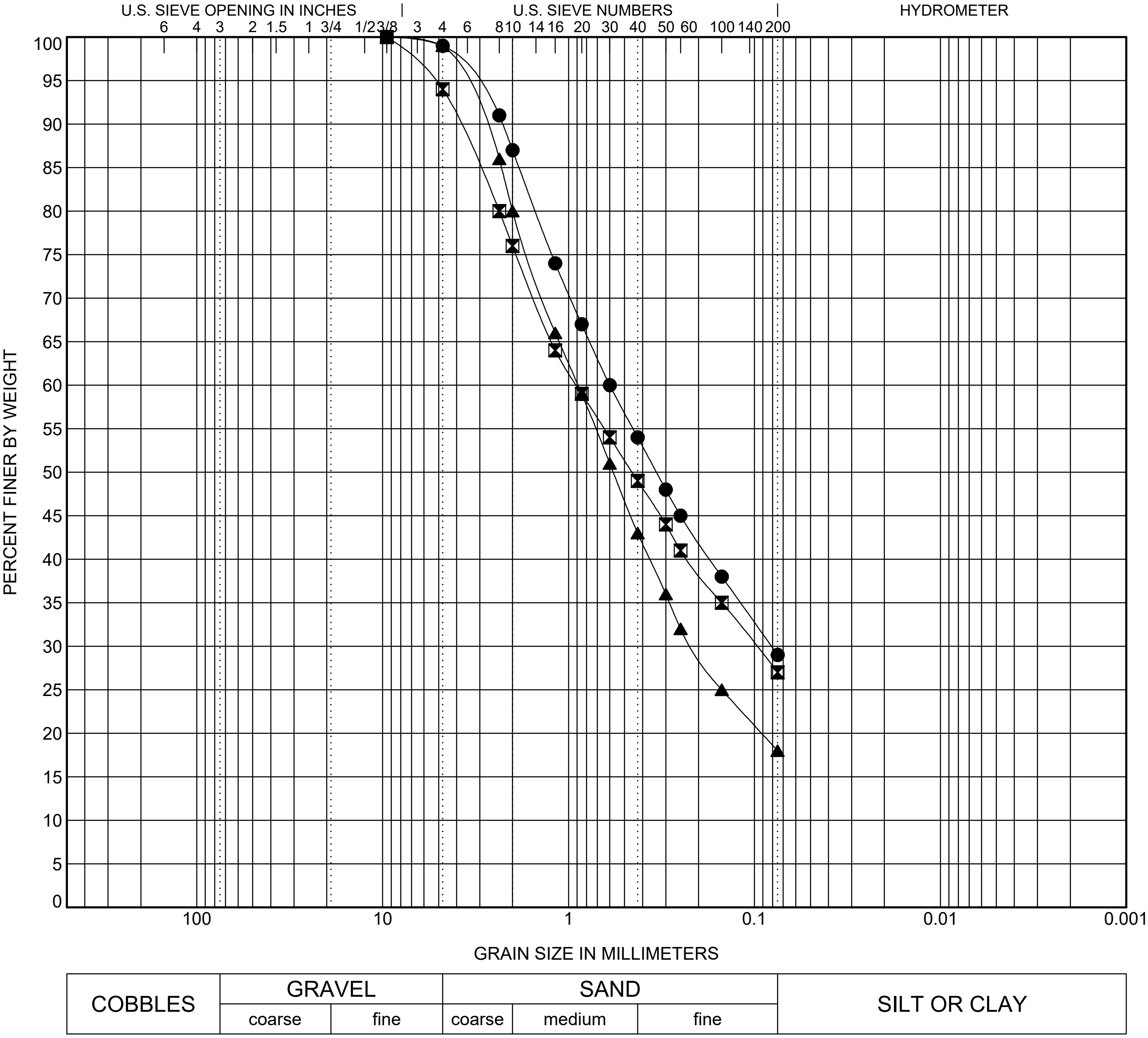
PROJECT NAME Proposed Deer Creek Road Roundabout
PROJECT NUMBER D23-2-711
PROJECT LOCATION El Paso County, Colorado



BOREHOLE		DEPTH	Classification	LL	PL	PI	Cc	Cu
●	B-4	1.3	SILTY, CLAYEY SAND(SC-SM)	18	14	4		
⊠	B-4	4.0	SILTY, CLAYEY SAND(SC-SM)	26	19	7		
▲	B-4	9.0	SILTY SAND(SM)	NP	NP	NP		

BOREHOLE		DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-4	1.3	9.5	0.6	0.081		1.0	70.0	29.0	
⊠	B-4	4.0	9.5	0.908	0.097		6.0	67.0	27.0	
▲	B-4	9.0	9.5	0.891	0.216		1.0	81.0	18.0	

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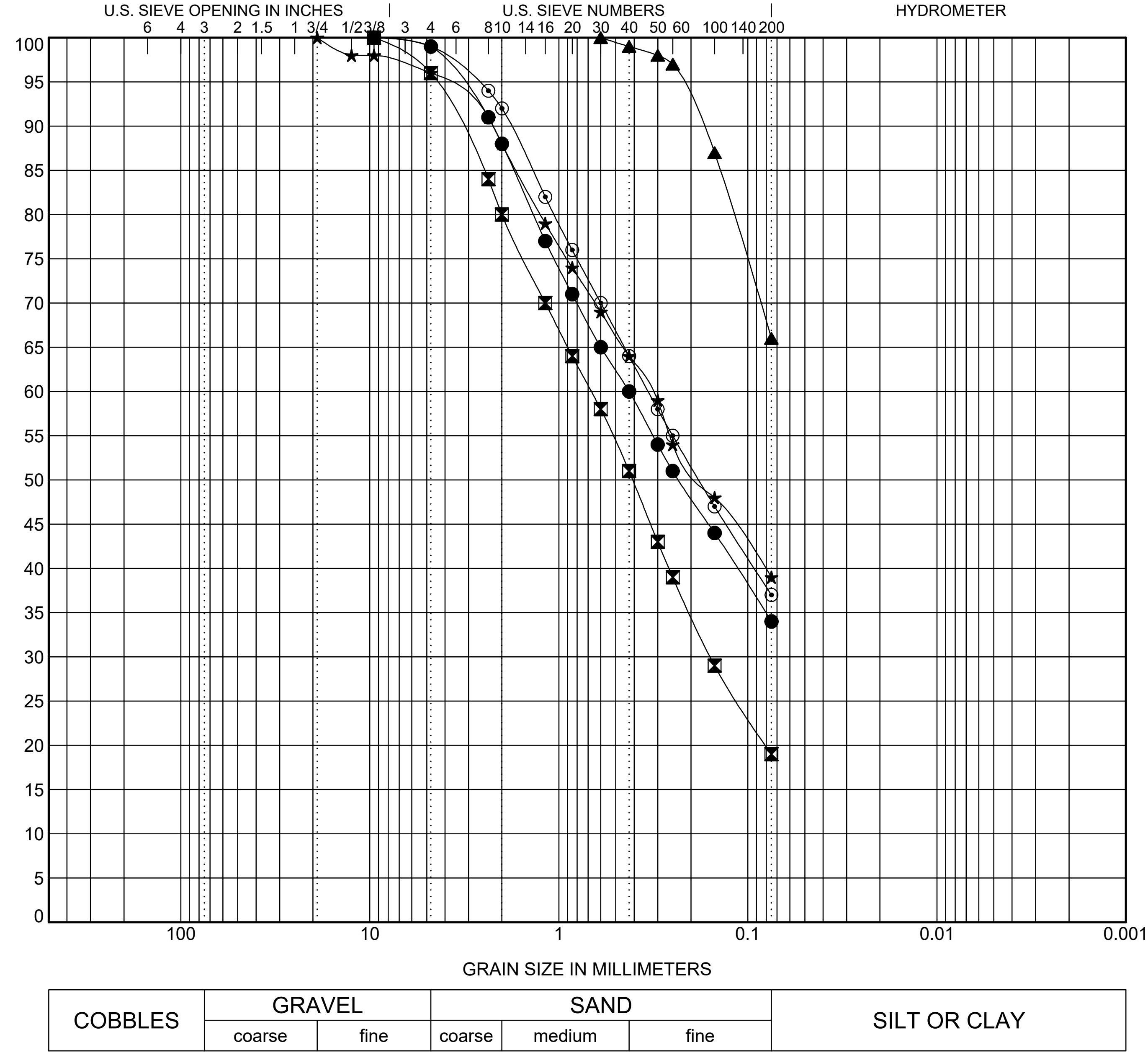
GRAIN SIZE DISTRIBUTION

CLIENT AECOM **PROJECT NAME** Proposed Deer Creek Road Roundabout

PROJECT NUMBER D23-2-711 **PROJECT LOCATION** El Paso County, Colorado



	BOREHOLE	DEPTH	Classification	LL	PL	PI	Cc	Cu
●	B-1	1.4	(A-2-4)	23	16	7		
⊠	B-1	4.0	(A-2-4)	24	20	4		
▲	B-1	9.0	(A-6)	38	25	13		
★	B-2	0.1	(A-4)	22	14	8		
⊙	B-3	0.7	(A-4)	22	15	7		

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt / %Clay
●	B-1	1.4	9.5	0.425			1.0	65.0	34.0
⊠	B-1	4.0	9.5	0.674	0.158		4.0	77.0	19.0
▲	B-1	9.0	0.6				0.0	34.0	66.0
★	B-2	0.1	19	0.322			4.0	57.0	39.0
⊙	B-3	0.7	9.5	0.337			1.0	62.0	37.0

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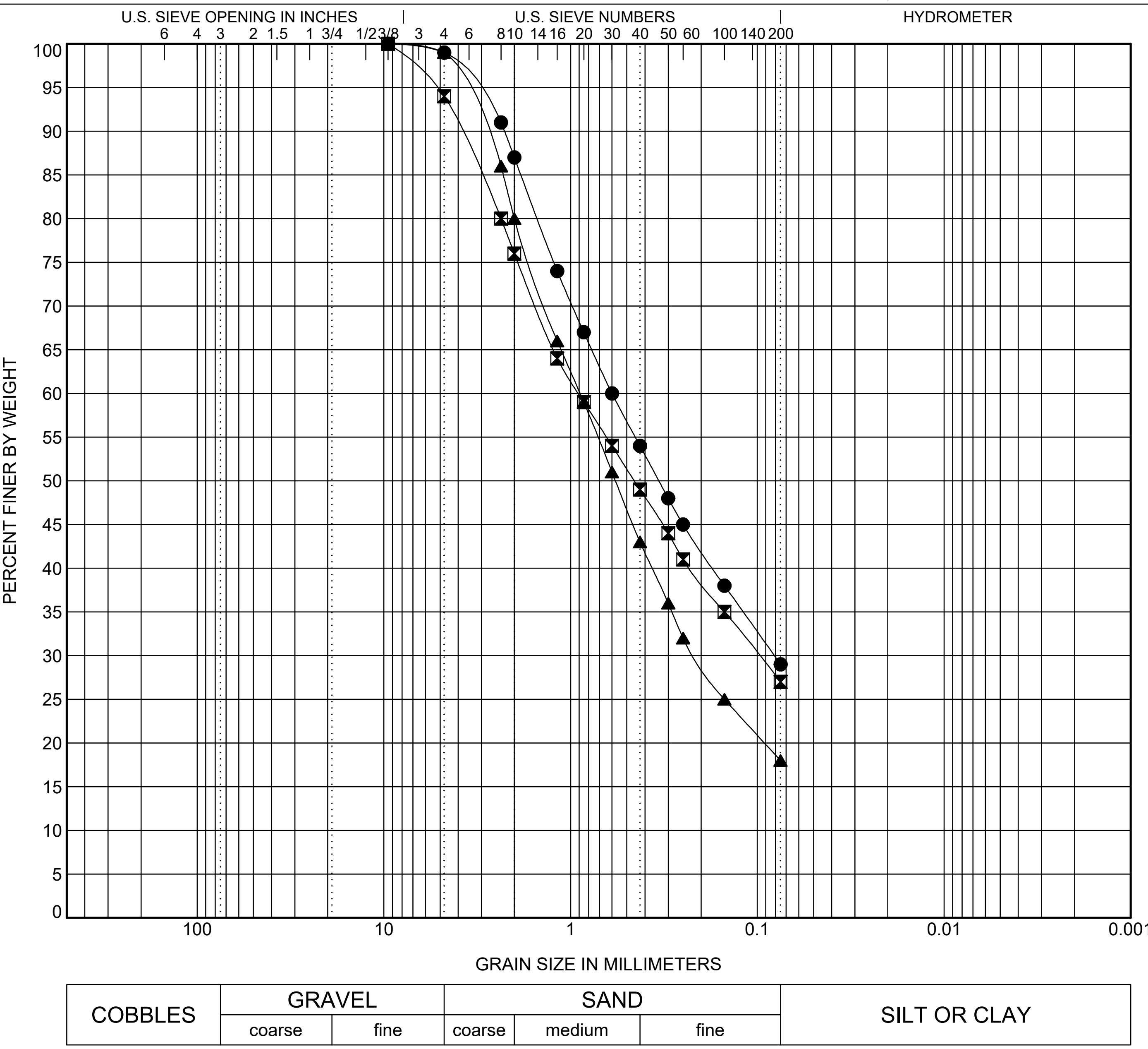
GRAIN SIZE DISTRIBUTION

CLIENT AECOM **PROJECT NAME** Proposed Deer Creek Road Roundabout

PROJECT NUMBER D23-2-711 **PROJECT LOCATION** El Paso County, Colorado



BOREHOLE		DEPTH	Classification	LL	PL	PI	Cc	Cu
●	B-4	1.3	(A-2-4)	18	14	4		
⊠	B-4	4.0	(A-2-4)	26	19	7		
▲	B-4	9.0	(A-1-b)	NP	NP	NP		

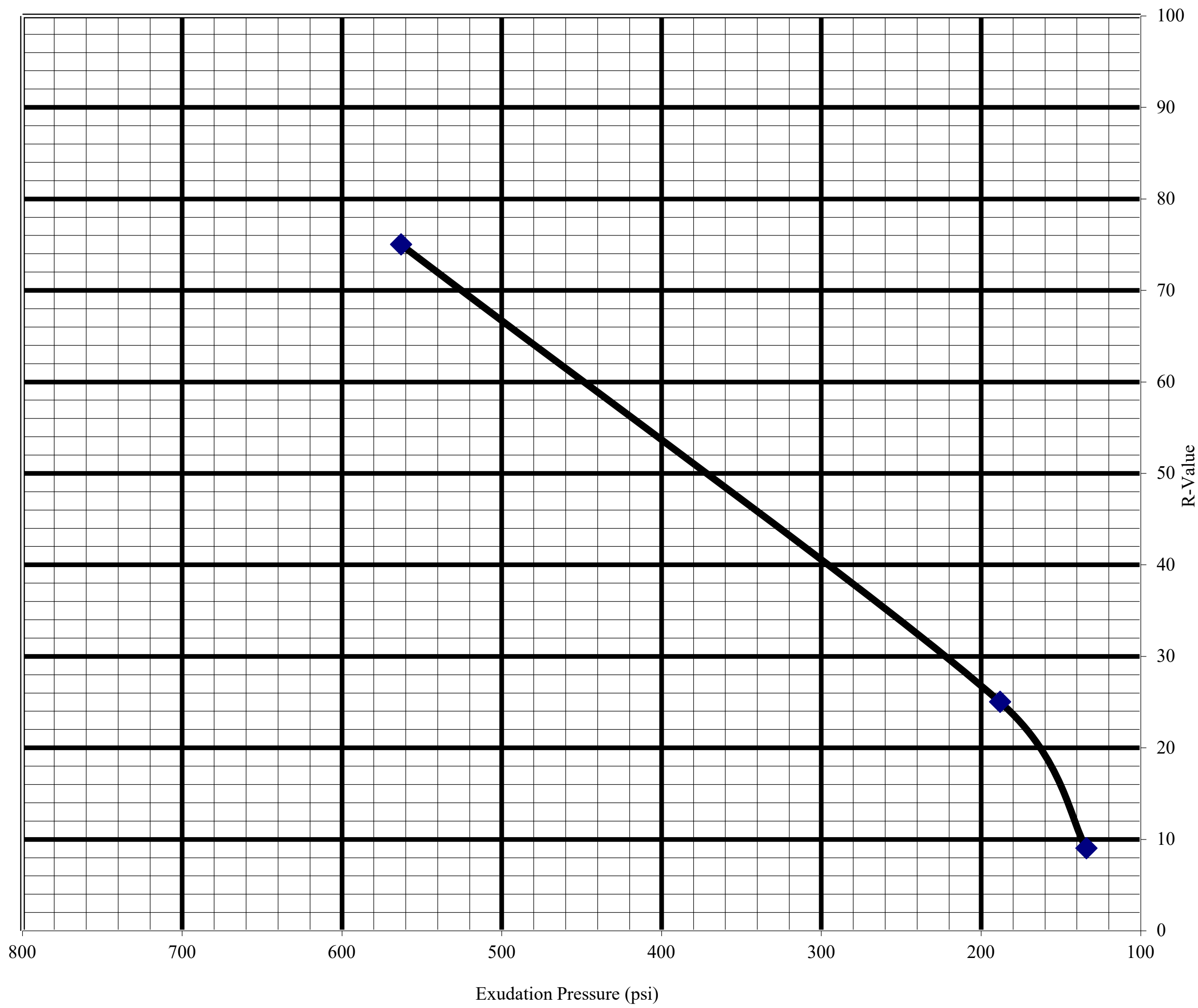
BOREHOLE		DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-4	1.3	9.5	0.6	0.081		1.0	70.0	29.0	
⊠	B-4	4.0	9.5	0.908	0.097		6.0	67.0	27.0	
▲	B-4	9.0	9.5	0.891	0.216		1.0	81.0	18.0	

3885 Forest Street
Denver, CO 80207

Vivid Engineering Group
R-Value Test Report

Project Numbe	D23-2-711	**Project Name:**	Proposed Deer Creek Road Roundabout
Sample Id:	B-1 -> B-4 Combined	**Depth (ft):**	0-4'
Location:	B-1 thru B-4	**Classification:**	Silty to Clayey SAND
Date Sampled:	1/18/2024	**Date Tested:**	1/23/2024

R-Value at 300 psi exudation pressure = 41



Test No.	Compact. Press. (psi)	Density (pcf)	Moist. (%)	Horizont. Pressure (psi)'@ 160 psi	Sample Height (in).	Exud. Pressure (psi)	R Value	R Value Correct.
1	350	122.4	7.1	31	2.35	563	76	75
2	150	119.6	8.4	100	2.49	188	25	25
3	100	122.3	9.3	138	2.56	134	8	9

Sampled by: DC **Tested by:** CV **Checked by:** WJB

Rev. 12-13-2022

Appendix C

Analytical Laboratory Test Results

Corrosion Test Results

Project Name: Proposed Deer Creek Roundabout
Project No. D23-2-711

Tested By: AL/TA
Date Sampled: 1/18/2024
Date Tested: 1/24/2024

Sample ID: **B-1 @ 0-4'** Matrix: Soil

Test	Results		Method
Chloride - Water Soluble	0.020	%	AASHTO T291-91/ASTM D4327
pH	8.3	units	AASHTO T289-91
Redox Potential	110.4	mv	ASTM D1498
Electrical Resistivity	2300	ohm-cm	AASHTO T288-91
Sulfate - Water Soluble	<0.001	%	CDOT CP-L 2103/ASTM D4327
Sulfide	Negative	-	AWWA C105

Sample ID: **B-3 @ 0-4'** Matrix: Soil

Test	Results		Method
Chloride - Water Soluble	0.015	%	AASHTO T291-91/ASTM D4327
pH	8.6	units	AASHTO T289-91
Redox Potential	71.2	mv	ASTM D1498
Electrical Resistivity	2600	ohm-cm	AASHTO T288-91
Sulfate - Water Soluble	<0.001	%	CDOT CP-L 2103/ASTM D4327
Sulfide	Negative	-	AWWA C105

Appendix D

Site Photos

LOCATION OF BORING B-1 - LOOKING WEST

LOCATION OF BORING B-2 - LOOKING SOUTH

VIVID Engineering Group	Project No: D23-2-711 Date: 2/5/2024 Drawn by: MBR Reviewed by: WJB	**SITE PHOTOS** Proposed Deer Creek Road Roundabout Intersection of Deer Creek Road and Woodmoor Drive El Paso County, Colorado	**FIGURE** **D-1**

LOCATION OF BORING B-3 - LOOKING WEST

VIVID Engineering Group	Project No: D23-2-711	**SITE PHOTOS**	**FIGURE**
	Date: 2/5/2024	Proposed Deer Creek Road Roundabout	**D-2**
	Drawn by: MBR	Intersection of Deer Creek Road and Woodmoor Drive	
	Reviewed by: WJB	El Paso County, Colorado	

Appendix E

Pavement Calculations

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

dbennett@vivideg.com

Flexible Structural Design Module

Woodmoor Drive
R = 41

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	235,010
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	9,812 psi
Stage Construction	1
Calculated Design Structural Number	2.26 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	4	-	1.76
2	New ABC	0.11	1	6	-	0.66
Total	-	-	-	10.00	-	2.42

-

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

dbennett@vivideg.com

Rigid Structural Design Module

Woodmoor Drive
R = 41

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	615,105
Initial Serviceability	4.5
Terminal Serviceability	2.5
28-day Mean PCC Modulus of Rupture	650 psi
28-day Mean Elastic Modulus of Slab	3,400,000 psi
Mean Effective k-value	35 psi/in
Reliability Level	80 %
Overall Standard Deviation	0.35
Load Transfer Coefficient, J	4.2
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	7.46 in

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

dbennett@vivideg.com

Flexible Structural Design Module

Deer Creek Road
R = 41

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	123,965
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	9,812 psi
Stage Construction	1
Calculated Design Structural Number	2.04 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	4	-	1.76
2	New ABC	0.11	1	6	-	0.66
Total	-	-	-	10.00	-	2.42

-

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

dbennett@vivideg.com

Rigid Structural Design Module

Deer Creek
R = 41

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	328,090
Initial Serviceability	4.5
Terminal Serviceability	2.5
28-day Mean PCC Modulus of Rupture	650 psi
28-day Mean Elastic Modulus of Slab	3,400,000 psi
Mean Effective k-value	35 psi/in
Reliability Level	80 %
Overall Standard Deviation	0.35
Load Transfer Coefficient, J	4.2
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	6.72 in

Appendix F

Important Information About This Geotechnical Engineering Report

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will <u>not</u> likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will <u>not</u> be adequate to develop geotechnical design recommendations for the project.

Do <u>not</u> rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do <u>not</u> rely on an executive summary. Do <u>not</u> read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept* *responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

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