Introduction

ARCADIS has completed the soil and geological investigation for the widening of State Route 29 (U.S. 27) from State Route 61 to State Route 328 near Harriman, Tennessee. The investigation included drilling 71 borings along the proposed route and performing field and laboratory tests on selected samples. This report includes the results of the drilling and testing program, information on the subsurface conditions, and stability analyses on the finished road cuts. Recommendations regarding final slope inclinations and acid runoff mitigation are also offered.

Project Description

The project consists of upgrading an approximate 5-mile section of State Route 29 from an existing two-lane highway to a divided four-lane highway. As shown in Figure 1, the project begins at Station 100+00 in Roane County and ends at Station 345+00 in Morgan County. The area topography includes rock cuts, rolling to steep hills, and low-lying areas adjacent to Bitter Creek and Little Emory River. The project includes 14 significant cut and fill sections as well as three bridges. In addition, a main gas line crosses the proposed alignment in four locations.

Site Geology

The project is located within the eastern escarpment of the Cumberland Plateau and the Valley and Ridge Province north of Harriman, Tennessee. Figure 2 presents an excerpt of the Geologic Map of Tennessee, 1966, for the subject area. A more detailed description of the geologic formations is included as part of the legend. The Cumberland Plateau marks the western limit of Alleghanian deformation in East Tennessee and is preserved as a result of Pennsylvanian sandstone caprock. At the southern limit of the project, thrusting and folding along the eastern escarpment has nearly exposed rocks as old as the Ordovician Chickamauga Group, and the northern limits of the proposed expansion approach the nearly undeformed Pennsylvanian strata of the Cumberland Plateau thrust sheet. The Cumberland Plateau overthrust, the Emory River Fault Complex, and the Rockwood Fault comprise the structural features within the project.

From Station 100+00 to approximately Station 150+00, the project falls within the Valley and Ridge Province and includes a significant cut in a limestone sequence of the Chickamauga Group. Due to folding and faulting, this slightly metamorphosed limestone proved to be extremely hard during the drilling operations. The Valley and Ridge portion of the project includes the upper portion of the Chickamauga Group.

This group includes formations of primarily limestone with alternating layers of shale and siltstones. The geologic exposures across the Little Emory River become more complicated as a result of the Emory River Fault Complex.

The rock outcrop visible at the road-cut between Station 155+00 and Station 175+00 illustrates such complexity. Structurally, the road-cut has exposed three fault surfaces within the Emory River Fault Complex. This fault complex is the northern limit of the Cumberland Plateau overthrust, and juxtaposes Ordovician-aged rocks with Pennsylvanian-aged rocks. This series of tear faults trend normal or perpendicular to the thrust sheet. The Emory River Fault Complex is a series of laterally moving strike-slip faults that generally dip 30 degrees to the southeast. One fault surface can be observed at the intersection of State Route 29 and Coal Hill Road near Station 172+00. At this exposure, folded and overturned beds of the Crab Orchard Mountain Group contact the near horizontally bedded sandstones of the Rockcastle Conglomerate.

The upper Rockcastle Conglomerate is composed of sandstone, some conglomeratic, gray to brown, fine- to coarse-grained, with thin coal-bearing shales near the middle of the sequence. The lower Pennsylvanian Crab Orchard Mountain group contains gray to brown, fine- to coarse-grained, conglomerate, sandstone, siltstone, shale and coal.

From Station 180+00 to Station 325+00, the exposed rock consists of the Rockcastle Conglomerate and the Crooked Fork Group. As a part of the Cumberland Plateau escarpment, these formations are folded as a result of the Emory River Fault Complex, which lies on the southwest side of the existing road surface. Another northeast to southwest trending fault surface is exposed near Station 328+00 at the intersection of State Route 29 and Hanging Rock Road. This fault is within the Rockcastle Conglomerate. Steeply dipping strata resulting from drag folding can be seen on the southeast side of the intersection.

Field Exploration and Sampling

For this investigation, 71 test borings designated B-1 through B-71 were drilled at the approximate locations shown on Figure 3. Boring locations were established in the field by referencing existing site features, and later surveyed by the Tennessee Department of Transportation (TDOT). Photographs showing prominent rock outcrops near selected boring locations are presented in Appendix A.

Drilling began on April 23, 2001, and was concluded on June 1, 2001. The borings were drilled to depths of 2 to 153 feet below the ground surface using conventional auger drilling and rock coring techniques.

Splitspoon samples were collected using the standard penetration test (SPT) test method in accordance with AASHTO T 206. This test is performed by mechanically driving a standard 2-inch outside diameter, 1.4-inch inside diameter splitspoon sampler 18 inches into the soil using a 140-pound hammer dropped from a height of 30 inches. The blows required to drive the sampler through each 6-inch interval were counted and recorded. The SPT N-value for each test is the sum of blow counts for the last two 6-inch intervals for that test. Samples were obtained at 2.5-foot intervals in the upper 10 feet of each boring and at 5-foot intervals for depths greater than 10 feet or at each change in strata.

Splitspoon samples were inspected and placed in plastic bags for subsequent laboratory testing. Using the procedures outlined in ASTM D-2488 "Description and Identification of Soils (Visual-Manual Procedure)," the soil samples obtained from each boring were classified and logged by an ARCADIS geotechnical engineer or geologist. Three composite bag samples were collected from the auger cuttings for Standard Proctor testing.

Auger refusal was encountered at 68 of the 71 borings, with refusal ranging from 0 to 39 feet below existing ground surface (BGS). Borings B-1, B-3, and B-5 were terminated at 25 feet BGS without encountering refusal. Rock coring was performed at borings B-7 through B-11, B-14 through B-22, B-24 through B-29, B-31, B-33, B-36, B-37, B-45 through B-64, B-66, and B-70 using N-sized diamond coring tools to determine composition and continuity of the refusal materials. For each run, the length of recovery and rock quality designation (RQD) were determined.

The subsurface conditions encountered at the boring locations are detailed in the boring logs located in Appendix B. The groundwater levels indicated on the logs were measured at the time of drilling. Occasionally, water level measurements were not possible due to collapse of the boreholes. If a collapse did occur, the cave-in depth was measured and reported on the boring log. It should be noted that the lines designating the interfaces between various strata represent approximate boundaries only, as transitions between materials may be gradual.

Soil Index Testing

Laboratory testing consisted of four Atterberg limits, four natural moisture contents, one Standard Proctor density test, and one California Bearing Ratio (CBR) test. These tests were performed on selected splitspoon and composite samples to verify the field classifications and to evaluate soil design parameters.

Table 1 summarizes the Atterberg limit and natural moisture content testing, as well as presents the results of the CBR and Standard Proctor density tests. These results indicate that the soils encountered vary from granular materials consisting of both sands and gravels to fine-grained silts and clays. The tests show natural moisture contents of 3.6 to 9.4 percent for the granular soil samples, and 35.7 to 41.6 percent for the fine-grained materials. The natural moisture contents of the fine-grained soils encountered on-site are all greater than the optimum moisture content of 18 percent as determined by the Standard Proctor Density Test. Detailed results of the laboratory tests performed are presented in Appendix C.

TABLE 1

Summary of Soil Index

Boring	Sample Depth, ft	Liquid Limit	Plastic Limit	Plasticity Index	USCS Class	AASHTO Class	Water Content
Index Test Results from Splitspoon Samples							
B-8	8.5-10.0	51	37	14	CL	A-7-6	42%
B-8	18.5-20.0	48	34	14	CL	A-7-6	35%
B-58	9.0-10.5	30	27	3	SM	A-2-4	9%
B-59	18.5-20.0	NP	NP	NP	GW	A-1-A	4%

Boring	Sample Depth, ft	Max. Dry Density, pcf	Optimum Water Content (%)	CBR	Description	USCS Class
Proctor and CBR Test Results from Bulk Samples						
B-64	6	109	18	12	Sandy Silt	ML

Acid-Base Testing

Several geologic formations of the Cumberland Plateau are known to contain pyrite and other acid-producing minerals. The mineral pyrite is commonly present in both coal seams and in sandstone and shale layers adjacent to these seams. Historically, water runoff in areas where excavated bedrock containing pyrite has been stockpiled or used as embankment material has been acidic. Acidic drainage results when the mineral pyrite (iron disulfide, FeS_2) is exposed to air and water, thus releasing acidic hydrogen ions into the water, which in turn forms sulfuric acid and the precipitate iron hydroxide.

The chemical equation for this reaction is:

$$4FeS_{2(s)} + 15O_{2(g)} + 14H_2O_{(l)} \rightarrow 4Fe(OH)_{3(s)} + 8SO_4^{2-}{}_{(aq)} + 16H^+{}_{(aq)}$$

or

$$FeS_2 + 3.75\ O_2 + 3.5\ H_2O \rightarrow Fe(OH)_3 + 2\ H_2SO_4$$

The amount of acid produced is a function of the amount of pyrite (pyritic sulfur) contained within the rock and available for reaction with air and water

Sandstones and shales such as those encountered from Station 150+00 to the end of the project have been known to produce acidic runoff. Accordingly, acid-base testing was performed to evaluate the potential for acid producing minerals from areas where significant rock cuts are expected. Table 2 presents the station number, the estimated area of excavated material, and the description of the core samples selected.

TABLE 2

Selected Rock Core Samples for Acid-Base Testing

Approximate Station	Boring Number	Depth (feet)	Area of Excavated Material (yards^2)	Description
160+77	B-16A	78	715	Light blue/gray fine-grained silty sandstone with thin shaly layers.
164+01	B-17	93	1000	Blue-gray fine to medium sandstone with thin coal seams.
185+00	B-28	21	280	Light gray shaly fine-grained sandstone with thin coal seams.
188+58	B-29	24	375	Gray to charcoal gray interbedded sandstone and shale.
260+17	B-45	10	240	Orange-tan sandstone fragments
268+99	B-48	39	265	Dark gray/black siltstone/shale
310+10	B-59	50	1685	Light gray fine-grained sandstone with thin coal seams.
324+97	B-64	38	540	Light gray fine-grained sandstone with two 2-inch shale layers.

The acid-base testing consisted of sulfur content determination and paste pH as well as acid and neutralization potentials. Paste pH is a measure of the rock's immediate acidity or alkalinity, and samples with a paste pH of 4.0 or less are generally classified as acid-producing. The neutralization potential measures the total sum of the carbonates, alkaline earth metals, and other base minerals available within the rock to neutralize acidity. The results of the acid-base testing are summarized in Table 3, with detailed results presented in Appendix C.

TABLE 3

Results of Acid-Base Testing

Boring Number	Percent Sulfur (%)	Paste pH	Neutralization Potential[1]	Acid Potential[1]	Net Neutralization Potential[2]
B-16A	0.147	6.0	2.14	4.6	-2.46
B-17	0.025	8.2	2.89	0.79	2.10
B-28	0.114	4.3	1.13	3.55	-2.42
B-29	0.290	5.8	10.68	9.07	1.61
B-45	0.063	6.5	3.89	1.97	1.92
B-48	0.803	6.0	6.28	25.09	-18.81
B-59	0.130	4.9	3.27	4.07	-0.80
B-64	0.255	6.3	2.64	7.97	-5.33

1 As tons $CaCO_3$, equivalent per 1,000 tons of material

2 Neutralization Potential minus Acid Potential

The pH values determined by paste pH testing ranged from 4.3 to 8.2 for the selected rock samples and are not classified as acidic. However, the paste pH results reflect only the current geochemical condition of the rock, and are by themselves unreliable for predicting future acid generation due to continued weathering of the rock material.

Calculations of the maximum potential acidity and the neutralization potential are structured to form a common basis of comparison. The test results are combined to obtain a net acid-producing or net neutralizing potential (NNP), a value which may be positive or negative. A negative result indicates a rock that can be expected to generate net acidity at some point in time. A positive result generally implies that the sample will not be a net acid generator. The test results indicate NNP values ranging from -18.81 to 2.1 tons of calcium carbonate per 1,000 tons of material. Comparison

of the results with the descriptions of the core samples shows a correlation between the amount of shale or coal present within the rock sample and the acid potential of the rock. Those samples with little or no interbedded shale/coal layers tended to have a positive NNP value. As the presence of shale or coal increased, the NNP value decreased, and typically was negative. Based on the NNP values obtained during testing and review of the boring logs, the excavated materials from Station 155+00 to Station 185+00, and Station 265+00 to Station 327+00 have, in general, the potential to produce acidic runoff.

Recommendations? p.15

Rock Slope Analysis

Analyses were performed at selected cross-sections to determine the overall stability of the proposed side slopes. Nine sections were selected based on the size of the cut or if the subsurface characteristics warranted analysis. Stratigraphy was based on borings at or near each selected cross-section, and each section was analyzed under static conditions assuming a recommended minimum factor of safety of 1.3. Conservative strength parameters for the soil and rock materials were selected based on published information and the rock description and quality.

The stability analyses were performed using the computer program WinStable, a windows version of PCSTABL6M. The program's capacity to analyze both circular and non-circular failure surfaces was used in the analyses of all slopes. The analysis of circular failure surfaces was performed using the Modified Bishops Method of Slices. This method divides the failure surface into vertical slices and evaluates the resultant shear resistance at the base of each slice. The moment forces are summed around the center of the circle, and the factor of safety is defined as the ratio of the resisting moments to the driving moments. For non-circular failure surfaces or wedge failures, the Janbu Method of Generalized Slices was used. In this method, the failure plane is manipulated to pass through a weak layer or zone. Active and passive wedges are generated to complete the failure surface. The factor of safety is defined as the ratio of the resisting forces to the driving forces.

Results of Stability Analysis

The minimum factor of safety calculated for both circular and non-circular failure surfaces are located in Table 4. The slope cross sections with the critical failure surfaces analyzed are presented in Appendix D, and the computer output files are presented in Appendix E. The analyses indicate that the proposed slopes will have adequate factors of safety against failure.

TABLE 4

Rock Slope Stability Analyses

Section Location	Circular Failure Factor of Safety Min: 1.30	Non-Circular Failure Factor of Safety Min: 1.30
STA 137+00	2.63	2.51
STA 155+00	1.59	1.32
STA 161+00	2.78	2.38
STA 169+00	5.64	5.53
STA 188+00	8.73	8.95
STA 225+00	4.59	4.13
STA 267+00	2.81	2.79
STA 295+00	27.77	15.90
STA 322+00	2.55	2.32

Rock Slope Wedge Analysis

The proposed roadway alignment will require a sizeable rock cut from Station 160+00 to Station 172+00. In order to evaluate the potential for intersecting discontinuities to form unstable wedges, a rock wedge analysis was performed for this area. The available large outcrop between these stations allowed detailed geologic mapping of discontinuities to be performed. Due to the steep and irregular nature of the rock slopes, safety considerations dictated that mapping measurements be restricted to the lower portions of the cut slope.

Rock wedge stability is generally governed by the shear strength properties of both the intact rock and the discontinuities within the rock mass, as well as the propensity for these discontinuities to intersect and form potential failure planes or wedges. Knowledge of the orientation and characterization of the discontinuities is essential in understanding if these planes of weakness may form an unstable wedge.

For organization of measurements, the outcrop was grouped into 100-foot increments beginning with Station 159+94 and terminating at Station 170+94. Strike and dip measurements were taken at each visible discontinuity in sequential order from south to north, and later converted to dip and dip direction for analysis. A total of 126 measurements were made on the outcrop, with each discontinuity categorized according to type (bedding planes, tectonic joints, or faults) and location. Mapping of

the outcrop resulted in 63 joint measurements, 61 bedding plane measurements, and two fault plane measurements. Photographs and a plan view showing stationing and each measured discontinuity are presented in Appendix F.

Analysis Methodology

Stereonets and rose diagrams were prepared from the field measurements to obtain the relative orientation of the measured discontinuities and allow for statistical comparison between the sets. Data was compiled using the computer program GEOrient, and the graphical output presented in Appendix F.

Analysis of the data produced generalized families of joints, bedding planes, and faults. Due to the large number of measurements collected and the hundreds of possible rock wedge combinations, the joint measurements were sorted into 10 sets of 36-degree intervals by dip direction based on the assumption that joints within +/-18 degrees will produce similar wedges upon analysis. A group of 16 mean measurements from 10 joint sets plus the bedding data and fault measurements was tabulated. Regardless of their location within the outcrop, each of the 16 data sets was analyzed for formation of critical wedges using a matrix format. Table 5 presents the 16 data sets and the mean measurement used in the analysis.

TABLE 5

Discontinuity Measurement Sets

Set Number	Interval (degrees)	Measurement Location	Dip, (degrees)	Dip Direction (degrees)	Average Dip and Dip Direction (degrees)
Joints					
J-1	0-36	62J3	88	020	63, 010
		65J3	87	008	
		68J4	51	001	
		69J8	24	010	
J-2	37-72	63J1	69	062	74, 057
		63J3	74	066	
		65J13	80	044	
J-3	73-108	68J1	83	098	64, 094
		68J2	79	095	
		69J3	60	103	
		69J7	74	100	
		69J11	22	073	
J-4	109-144	65J10	78	136	78, 136

TABLE 5

Discontinuity Measurement Sets

Set Number	Interval (degrees)	Measurement Location	Dip, (degrees)	Dip Direction (degrees)	Average Dip and Dip Direction (degrees)
J-5	145-180	63J5	87	179	80, 175
		65J6	85	175	
		65J11	62	176	
		65J16	87	169	
J-6	181-216	61J3	44	208	72, 194
		63J2	90	188	
		63J4	84	182	
		65J2	68	213	
		65J12	23	186	
		65J15	86	184	
		66J4	84	196	
		67J1	74	191	
		68J6	88	194	
		69J2	74	196	
		69J4		196	
J-7	217-252	61J1	78	225	76, 228
		62J2	53	219	
		65J4	68	230	
		5J5	83	229	
		65J	76	226	
		65J8	78	226	
		66J1	88	234	
		66J2	82	222	
		67J2	77	244	
J-8	253-288	65J14	13	284	15, 280
		69J6	23	282	
		69J9	9	275	
J-9	289-324	62J1	62	290	77, 298
		64J2	87	323	
		65J1	84	292	
		66J3	86	302	
		67J3	88	289	
		68J3	64	295	
		68J5	74	305	
		69J1	81	290	
		69J5	71	304	

TABLE 5

Discontinuity Measurement Sets

Set Number	Interval (degrees)	Measurement Location	Dip, (degrees)	Dip Direction (degrees)	Average Dip and Dip Direction (degrees)
J-10	325-360	61J2	58	351	65, 341
		61J4	83	331	
		62J4	81	350	
		62J5	73	335	
		62J6	71	345	
		62J7	84	335	
		62J8	75	348	
		64J1	89	345	
		64J3	84	356	
		65J2	30	325	
		65J9	87	348	
		67J4	19	350	
		68J8	48	326	
		69J6	65	345	
		69J10	21	328	
Bedding Planes					
BP-11	N/A	61B1	24	200	24, 206
		62B1	24	211	
BP-12	N/A	63B1	17	256	16, 252
		64B1	15	247	
BP-13	N/A	65B1	14	302	17, 296
		66B1	14	303	
		67B1	23	282	
BP-14	N/A	68B1	40	338	46, 338
BP-15	N/A	69B1	78	191	78, 191
Faults					
F-16	N/A	69F1	45	354	45, 009
		69F2	45	012	

The potential for sets of discontinuities to intersect and form failure wedges was evaluated using the computer program SWEDGE. If a failure wedge is produced, the program computes the factor of safety for transitional slip of the rock wedge. Input data for the SWEDGE program includes the orientation of two discontinuities, shear strength of the discontinuities, unit weight of the rock, the presence of groundwater, and the orientation and height of the rock face slope. Figure 4 presents a general schematic of a wedge failure.

Due to the complex geology within this area, and to set initial screening criteria, conservative shear strength parameters were assumed for the discontinuities. Regardless of the measured length, the discontinuities were assumed to be continuous, with a friction angle of 25 degrees and an initial cohesion value of zero. The unit weight of rock was assigned a value of 158 pounds per cubic feet (pcf), and additional assumptions included no groundwater or water pressure acting along the joints, no surcharge along the top of the slope, and no earthquake load. Three slope configurations were initially evaluated (Vertical, 0.25H:1V, 0.5H:1V) with a slope height of 140 feet. The average dip and dip direction measurements presented in Table 4 were used in the analyses.

Results of the Rock Wedge Analysis

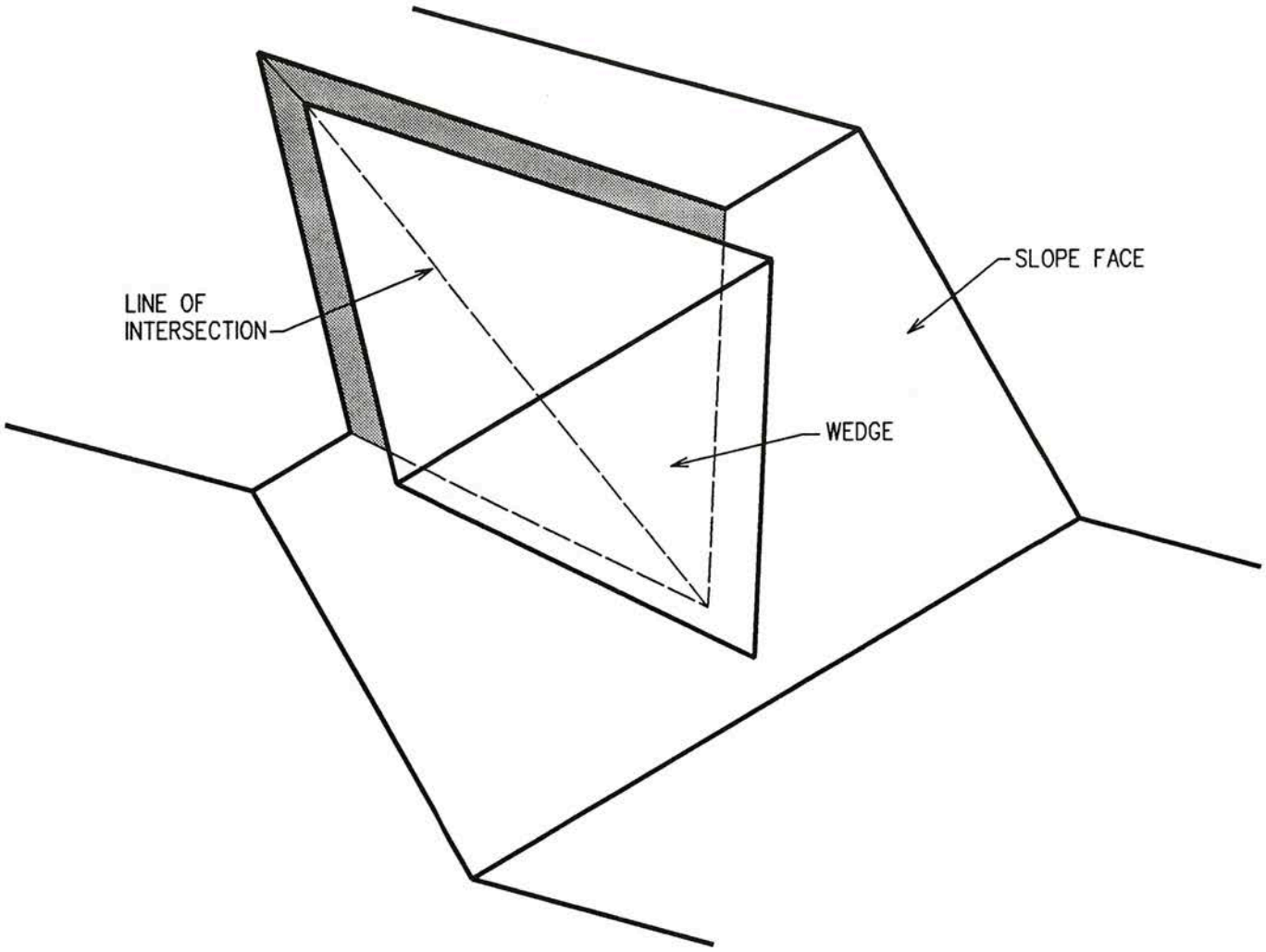
Analysis of the 16 sets of discontinuities produced 120 combinations of planes with a possible 59 wedge combinations within the outcrop. Using the conservative shear strength parameters outlined above and a slope inclination of 0.5H:1V, screening-level stability analyses indicated that 55 of the 59 wedge combinations produced a factor of safety (FS) greater than the recommended minimum allowable FS of 1.3. Table 6 presents those four sets of discontinuities that produced a calculated FS less than the recommended minimum, with the full results of the stability analyses shown in Appendix F.

TABLE 6

Joint Combinations with an FS < 1.3

Wedge	Joint Combination	Dip, Dip Direction (degrees)	Calculated Factor of Safety
1	J-1	63, 010	1.20
	BP-14	46, 338	
2	J-7	76, 228	0.71
	BP-14	46, 338	
3	J-4	78, 136	1.23
	BP-11	24, 206	
4	J-9	77, 298	1.10
	BP-11	24, 206	

As apparent cohesion along the joint surface was neglected during the screening-level stability analyses, the four wedges indicated in Table 6 were evaluated more closely by including cohesion in the analyses. The cohesion was estimated using a procedure



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VIEW OF WEDGE FAILURE
T.D.O.T - S.R. 29
HARRIMAN, TENNESSEE

PROJECT NUMBER
CT052497

FIGURE NUMBER
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presented in the revised third edition of "Rock Slope Engineering" (Hoek & Bray, 1991). The formula presented was derived from the Mohr-Coulomb equation ($\tau = C + \sigma_n \tan\phi_b$) and reflects changes in the shear strength of a discontinuity with an increasing normal stress.

$\tau = \sigma_n \tan\{\phi_b + JRC\log_{10}(JCS/\sigma_n)\}$ where:

JRC = Joint wall roughness coefficient

JCS = Joint wall compressive strength

σ_n = Normal stress acting on the discontinuity

ϕ_b = Friction angle of the failure plane = 25°

C = Cohesion

τ = Shear stress

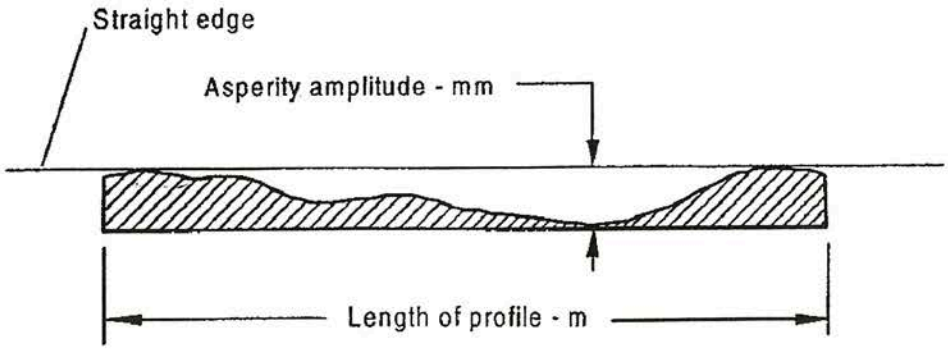
A JRC of 10 was established by comparing the actual joint surfaces with the standard profiles presented in Figure 5. A JCS of 1460 ksf (70 MPa) was estimated using published test data on sandstone similar to the rock outcrop. The normal stress was determined using the normal force acting upon the failure plane and the known surface area of the plane. These values were generated during the screening-level SWEDGE analyses. Upon solving, the calculated shear stress was substituted in the Mohr-Coulomb equation, and a cohesion of 51 psf was obtained.

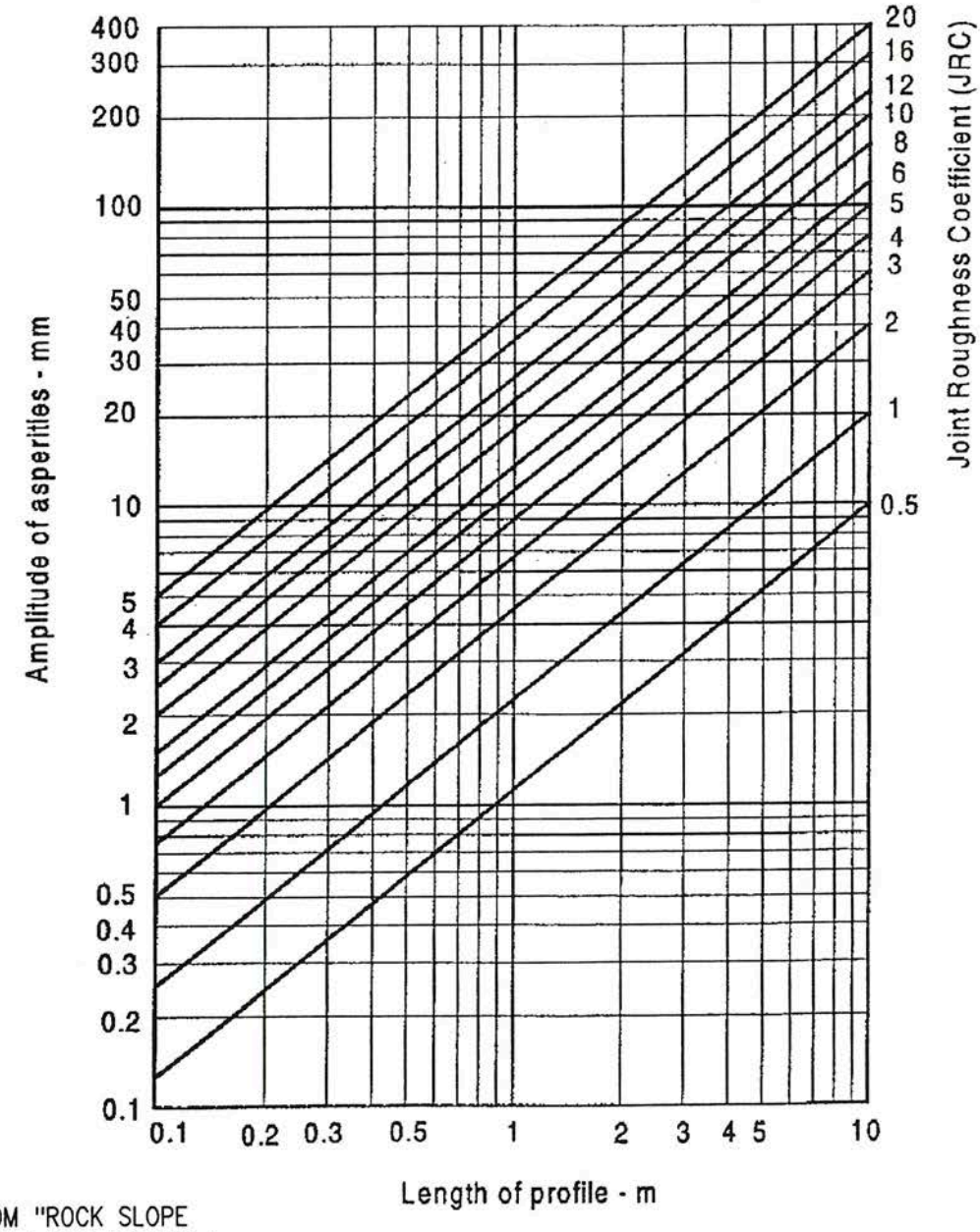
The updated factors of safety utilizing both cohesion and the friction angle are presented in Table 7.

TABLE 7

Factors of Safety for Joint Combinations, Considering Cohesion

Wedge	Joint Combination	Factor of Safety
1	J-1 & BP-14	1.45
2	J-7 & BP-14	0.80
3	J-4 & BP-11	1.27
4	J-9 & BP-11	1.14





NOTE: ADAPTED FROM "ROCK SLOPE ENGINEERING (REVISED THIRD EDITION)," HOEK & BRAY, PAGE 66

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ALTERNATE METHOD FOR ESTIMATING JRC
GEOTECHNICAL INVESTIGATION - TDOT S.R. 29/U.S. 27
HARRIMAN, TENNESSEE

PROJECT NUMBER
CT052497
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FIGURE NUMBER
5

Of the four reevaluated failure wedges, three wedges still indicate a calculated FS less than the recommended minimum.

For Wedge 3, a FS of 1.27 was calculated. This calculated FS is close enough to the recommended minimum to not be considered significant. As such, the 0.5H:1V slope is satisfactory.

A factor of safety of 1.14 was calculated for Wedge 4. The bedding planes used to develop the set BP-11 are found between Station 162+00 and Station 164+00, and only a single joint measurement (64J2) of the nine measurements comprising joint set J-9 is located within this same section. As a result, the likelihood of an actual wedge forming along these two discontinuities appears extremely low, and a 0.5H:1V slope is reasonable.

The low FS calculated for Wedge 2 indicates that without remedial treatment, a failure could occur in the assumed 0.5H:1V slope. Because of the folding and faulting in the area, rock bolting for stabilization does not appear to be a good alternative. As such, flattening the cut slope was evaluated. By reducing the slope to 0.75H:1V, Wedge 2 is actually removed and the stability issues resolved. Geologic mapping indicates that the bedding planes comprising BP-14 are located between Station 168+50 and 169+20. Study of the rock outcrop in this area also detected a series of faults, with a fault surface located near Station 169+00 and also at the intersection of SR 29 and Coal Hill Road near Station 172+00. To eliminate not only the potential for failure due to the formation of rock wedges, but also to address loose, broken rock around the two known faults, it is recommended that the rock slope be cut at 0.75H:1V from Station 168+00 to Station 172+00.

Design Recommendations

Based on our understanding of the proposed project, the drilling and testing data, and our engineering analyses, ARCADIS makes the following design recommendations.

General Recommendations

The majority of the site is covered with vegetation ranging from thick underbrush to heavy woods, with pasture areas located at the beginning of the project. As such, clearing and grubbing is required and should be performed in accordance with Sections 201.03 and 201.04 of the Standard Specifications. After clearing and grubbing, any topsoil should be stripped and stockpiled for later use in accordance with Section 203.06 of the Standard Specifications. Stripping depths are not expected to exceed

12 inches. Exposed subgrade soil materials should be inspected for any weak or unusual areas, particularly near borings B-7, B-8, and B-9. Undercutting of the soft or loose soils should be performed in accordance with Section 203.05 of the Standard Specifications.

Based on the boring logs and visual exploration of the proposed roadway alignment, significant rock cuts are expected. Both partially weathered rock and bedrock were encountered at numerous locations as shown on the soil profile sheets presented in Appendix D. The weathering process tends to be erratic, and variations within the partially weathered rock and rock profile can be expected at small lateral distances. The partially weathered rock encountered is generally unsuitable for use as structural fill and should be wasted. Excess or unsuitable materials that are excavated should be disposed of in accordance with Section 203.07 of the Standard Specifications.

Any existing ground surface with slopes that are steeper than 4H:1V and will have an embankment constructed upon it, will be benched in accordance with Section 205.03 of the Standard Specifications. Embankments that are composed of either non-degradable or degradable material should be constructed as presented in Section 205.04 of the Standard Specifications.

Surface water, as well as natural or perched groundwater, may be encountered during embankment construction adjacent to Forked Creek, Bitter Creek, Little Emory River, and an unnamed creek running between approximate Station 120+00 and Station 144+00. Erosion control measures should be implemented in accordance with Section 209.06 of the Standard Specifications due to the close proximity of these creeks and rivers. Low-lying areas receiving fill may require additional fill protection measures. A geotextile net or jute mesh to protect the finished embankment slopes from erosion and enhance vegetation growth is recommended.

Bitter Creek was relocated from the right side of State Route 29 during the previous major roadway improvement. Standing water is present in several sections of the relic streambed, most notably from approximately Station 192+00 to 198+00, Station 240+00 to 248+00, and Station 273+00 to 280+00. Durable rock should be used as embankment fill material within these and other low-lying areas.

Acid Drainage

Rock fills constructed of known acid-producing materials must incorporate design features to prevent or limit the generation of acidic drainage. Based on the results of the acid-base testing and review of the boring logs, excavated materials from Station

155+00 to Station 185+00, and Station 265+00 to Station 327+00 have, in general, the potential to produce acidic runoff. Several options are available to mitigate the potential for acidic drainage and to utilize the excavated materials within the proposed embankments. Detailed testing can further support which option or combination of options would cost-effectively reduce the impact of acid runoff using this material. As such, it is recommended that the rock cuttings generated from selected holes during blast-hole drilling be sampled at five-foot intervals and tested for acid potential. Test results can be generated within 24 hours and used to select the best alternative to mitigate or prevent acid runoff.

The recommended options to prevent or limit acid runoff in order of decreasing preference are presented as follows:

- Off-Site Disposal – The proposed alignment is expected to result in an excess of excavated material. Through careful selection during excavation, fill materials consisting mainly of sandstone with little siltstone or shale layering can be segregated and directed for placement. Those materials with a high potential to produce acidic runoff, mainly siltstones and shales, can be targeted for off-site disposal.

- Encapsulation – Typically, acid-producing materials with an NNP less than -5 are encapsulated within low-permeability soils to reduce the oxidation process. This alternative requires careful construction techniques and drainage controls to reduce storm water infiltration. Because very little clayey material was encountered on-site, soils of low permeability may need to be imported.

- Additives – Acid-producing materials with an NNP ranging from 0 to -5 are typically treated using processed lime, crushed limestone, or soda ash. These additives are incorporated into each lift to buffer the acid-generating chemical reaction and to raise the pH of the runoff. This option depends heavily on the availability and cost of the needed quantities of buffer material.

- Blending – Mixing the acid-producing rock materials with rock of sufficient neutralizing potential, such as limestone, can help maintain a neutral pH. The only naturally occurring limestone on site was encountered at borings B-7, B-8, and B-9. The volume of cut in this area is not likely to produce sufficient blending volumes; however, this alternative may be used in conjunction with additives to offset the purchase cost of materials if the cherty limestone is determined to have a positive NNP.

Design Slope Recommendations

Unless otherwise specified, all embankments constructed of soil or degradable material shall not have side slopes steeper than 3H:1V, and all cut slopes shall be constructed with slopes not steeper than 2H:1V. Table 8 summarizes those slopes that require special design and are denoted by station number. Typical cross-sections with representative slopes are presented in Appendix E.

TABLE 8

Recommended Cut and Fill Slope Inclinations

Section No.	Approx. Station Range	Slope Type	Slope Inclination and Comments
1	132+00 to 134+50	Embankment	2H:1V slope on left side (LS) of roadway as space between the roadway and the adjacent stream is limited. Use durable rock for fill material with an armored toe to resist eroding forces.*
2	134+50 to 138+50	Cut Slope	0.25H:1V slope for 20 vertical feet to a 15-foot-wide bench on right side (RS) of roadway. From the initial bench, a 2H:1V slope with a 15-foot-wide bench every 30 vertical feet until slope intersects with existing slope. Begin slope transition at approximate Station 132+50. End transition at Station 141+00.
3	158+00 to 168+00	Cut Slope	0.5H:1V slope for 30 vertical feet to a 15-foot wide bench on RS of roadway. From the initial bench, a 0.5H:1V slope with a 15-foot-wide bench every 50 vertical feet until slope intersects with existing slope. Begin slope transition at approximate Station 156+50.
4	168+00 to 172+00	Cut Slope	0.75H:1V slope for 30 vertical feet to a 15-foot wide bench on RS of roadway. From the initial bench, a 0.75H:1V slope with a 15-foot-wide bench every 50 vertical feet until slope intersects with existing slope.
5	175+00 to 178+50	Embankment	Space between the RS of the proposed roadway and Bitter Creek is extremely limited. As a bridge crossing the Little Emory River is located at one end of this section, and another bridge over Bitter Creek at the other end, the centerline of the roadway could not be shifted without losing either one or both of the existing bridges. Relocation of Bitter Creek does not appear to be economically feasible as the opposite stream bank is comprised of solid sandstone. Therefore, it is recommended that a retaining wall be constructed within this section. The wall should bear on the underlying sandstone bedrock located approximately 5 to 12 feet below the existing ground surface and tie into the bridge abutments to be located at each end of this section.

TABLE 8

Recommended Cut and Fill Slope Inclinations

Section No.	Approx. Station Range	Slope Type	Slope Inclination and Comments
6	185+00 to 190+50	Cut Slope	0.5H:1V slope until slope intersects with the existing slope. Begin slope transition at approximate Station 184+00. End transition at Station 191+50.
7	261+00 to 270+00	Cut Slope	1.5H:1V slope with a 15-foot wide bench every 50 vertical feet on RS of roadway. Begin slope transition at approximate Station 260+00. End transition at Station 271+00.
8	291+00 to 320+00	Cut Slope	0.5H:1V slope for 20 vertical feet to a 15-foot wide bench on RS of roadway. From the initial bench, a 1.5H:1V slope with a 15-foot-wide bench every 50 vertical feet until slope intersects with existing slope.
9	321+00 to 328+00	Cut Slope	1.5H:1V slope for 20 vertical feet to a 15-foot wide bench on RS of roadway. From the initial bench, a 1.5H:1V slope with a 15-foot wide bench every 50 vertical feet until slope intersects with existing slope. Begin slope transition at Station 320+00.
10	326+50 to 330+00	Embankment	2H:1V slope on LS of roadway as space between the roadway and Bitter Creek is limited. Use durable rock for fill material with an armored toe to resist eroding forces.*
11	332+50 to 333+00	Embankment	2H:1V slope on LS of roadway as space between the roadway and Bitter Creek is limited. Use durable rock for fill material with an armored toe to resist eroding forces.*

* Sizing of rock (riprap) for armored toe should be determined from hydraulic design.

APPENDIX II

FIELD TESTING PROCEDURES

TEST BORING RECORD LEGEND

TEST BORING RECORDS

ROCK CORE PHOTOGRAPHS

FIELD TESTING PROCEDURES

HOLLOW STEM AUGERING PROCEDURES WITH STANDARD PENETRATION RESISTANCE TESTING AASHTO T 206

The borings were advanced using auger drilling techniques. At regular intervals, soil samples were obtained with a standard 1.4-inch I.D., 2.0-inch O.D., split-tube sampler. The sampler was initially seated 6 inches to penetrate any loose cuttings and then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot is the standard penetration resistance. Standard penetration resistance, when properly evaluated, is an index to the soil's strength and density. The criteria used during this exploration are presented on the Test Boring Record Legend.

Representative portions of the soil samples, thus obtained, were placed in sealed containers and transported to the laboratory. The engineer selected samples for laboratory testing. The Test Boring Records in this Appendix provide the soil descriptions and penetration resistances.

Soil drilling and sampling equipment may not be capable of penetrating hard cemented soils, thin rock seams, large boulders, waste materials, weathered rock, or sound continuous rock. Refusal is the term applied to materials that cannot be penetrated with soil drilling equipment or where the standard penetration resistance exceeds 100 blows per foot. Core drilling is needed to determine the character and continuity of the refusal materials.

UNDISTURBED SAMPLING PROCEDURES AASHTO T 207

Relatively undisturbed samples were obtained for laboratory testing. A 3-inch O.D., 16-gauge, steel tube was slowly and uniformly pushed into the soil at the desired sampling level. The tube was then removed from the ground and the encased soil was sealed at the ends to prevent loss of moisture. The depth at which undisturbed samples were taken is indicated on the Test Boring Records.

ROCK CORING PROCEDURES ASTM D 2113

Refusal materials were explored using a diamond-studded bit fastened to a double tube core barrel. An NQ-size bit was used during this exploration, which obtains core samples approximately 2 inches in diameter. The materials recovered were placed in a sample box. Our engineer classified the type and hardness of the rock, core recovery, and Rock Quality Designation (RQD). Core recovery is the sample length recovered divided by the length drilled, and RQD is the sample length recovered in pieces 4 inches or longer divided by the length drilled. Both core recovery and RQD are expressed as percentages. Rock hardness was judged based on the following criteria:

Rock Hardness	Criteria
Very Soft	Rock disintegrates or easily compresses when touched; can be hard to very hard soil
Soft	Rock is coherent but breaks very easily with thumb pressure at sharp edges and crumbles with firm hand pressure.
Moderately Hard	Small pieces can be broken off along sharp edges by hard considerable thumb pressure; can be broken with light hammer blows.
Hard	Rock cannot be broken by thumb pressure, but can be broken by moderate hammer blows.
Very Hard	Rock can only be broken by heavy hammer blows.

TEST BORING/PIT RECORD LEGEND

FINE AND COARSE GRAINED SOIL INFORMATION

COARSE GRAINED SOILS (SANDS & GRAVELS)

N	Relative Density
0-4	Very Loose
5-10	Loose
11-20	Firm
21-30	Very Firm
31-50	Dense
Over 50	Very Dense

FINE GRAINED SOILS (SILTS & CLAYS)

N	Consistency	Qu, KSF Estimated
0-1	Very Soft	0-0.5
2-4	Soft	0.5-1
5-8	Firm	1-2
9-15	Stiff	2-4
16-30	Very Stiff	4-8
Over 31	Hard	8+

PARTICLE SIZE

Boulders	Greater than 300 mm (12 in)
Cobbles	75 mm to 300 mm (3 to 12 in)
Gravel	4.74 mm to 75 mm (3/16 to 3 in)
Coarse Sand	2 mm to 4.75 mm
Medium Sand	0.425 mm to 2 mm
Fine Sand	0.075 mm to 0.425 mm
Silts & Clays	Less than 0.075 mm

The **STANDARD PENETRATION TEST** as defined by ASTM D 1586 is a method to obtain a disturbed soil sample for examination and testing and to obtain relative density and consistency information. A standard 1.4-inch I.D./2-inch O.D. split-barrel sampler is driven three 6-inch increments with a 140 lb. hammer falling 30 inches. The hammer can either be of a trip, free-fall design, or actuated by a rope and cathead. The blow counts required to drive the sampler the final two increments are added together and designate the N-value defined in the above tables.

ROCK PROPERTIES

ROCK QUALITY DESIGNATION (RQD)

Percent RQD	Quality
0-25	Very Poor
25-50	Poor
50-75	Fair
75-90	Good
90-100	Excellent

ROCK HARDNESS

Very Hard:	Rock can be broken by heavy hammer blows
Hard:	Rock cannot be broken by thumb pressure, but can be broken by moderate hammer blows.
Moderately Hard:	Small pieces can be broken off along sharp edges by considerable hard thumb pressure; can be broken with light hammer blows.
Soft:	Rock is coherent but breaks very easily with thumb pressure at sharp edges and crumbles with firm hand pressure.
Very Soft:	Rock disintegrates or easily compresses when touched; can be hard to very hard soil.

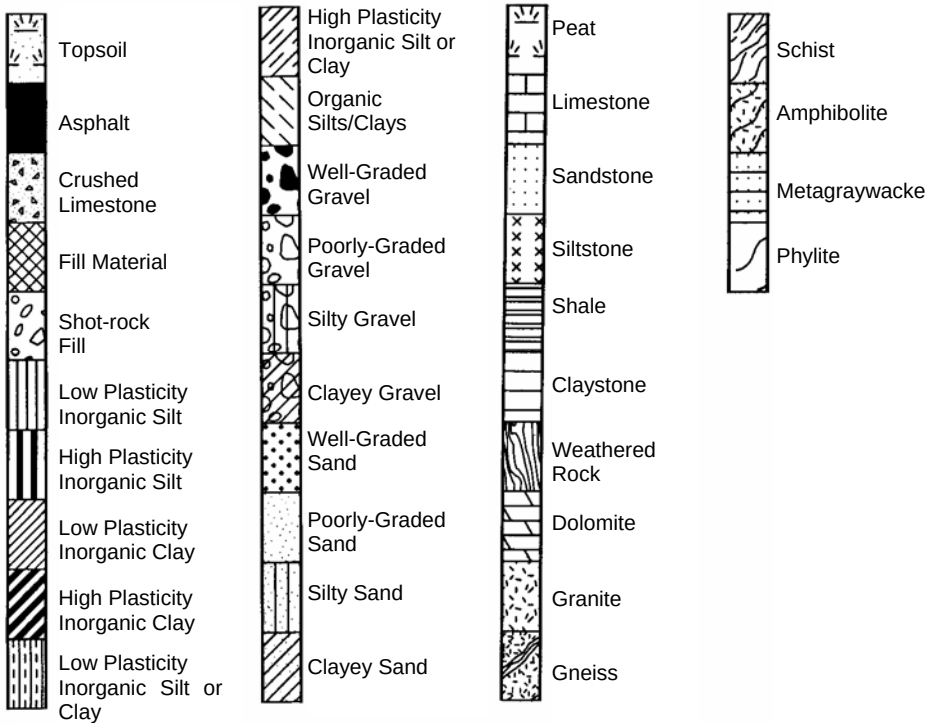
$$\text{RQD} = \frac{\text{Sum of 4 in. and longer Rock Pieces Recovered}}{\text{Length of Core Run}} \times 100 = \frac{43\ \text{RQD}}{\text{NQ}}$$

$$\text{Recovery} = \frac{\text{Length of Rock Core Recovered}}{\text{Length of Core Run}} \times 100 = \frac{\text{NQ}}{63\ \text{REC}}$$

Core Diameter	Inches
BQ	1-7/16
NQ	1-7/8
HQ	2-1/2

SYMBOLS

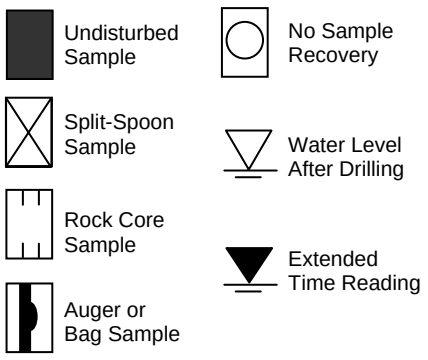
KEY TO MATERIAL TYPES



SOIL PROPERTY SYMBOLS

N:	Standard Penetration, BPF
M:	Moisture Content, %
LL:	Liquid Limit, %
PI:	Plasticity Index, %
Qp:	Pocket Penetrometer Value, TSF
Qu:	Unconfined Compressive Strength Estimated Qu, TSF
γ_D:	Dry Unit Weight, PCF
F:	Fines Content

SAMPLING SYMBOLS



STATION: 154+84 106'R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 785 feet ±	BORING STARTED: 2/15/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/15/2013	HAMMER: Automatic	
GROUNDWATER: Dry ATD	Remarks:		

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
	785.0	0	Auger boring to collect undisturbed sample		
	771.0	14'	Undisturbed sample attempt Recovered 0.9 foot		45%
	769.0	15	*Boring terminated at 16 feet*		

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F- 1B

Project Manager: J. Hudson, PE

STATION: 154+85 106'R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 785 feet ±	BORING STARTED: 2/15/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/15/2013	HAMMER: Automatic	
GROUNDWATER: Dry ATD	Remarks:		

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
	785.0	0	Auger boring to collect undisturbed samples		
	781.0	4'	Undisturbed sample attempt Recovered 0.9 foot		45%
	779.0	6'	Auger boring to collect undistubed samples		
	773.7	10	*Auger refusal at 11.3 feet, boring terminated*		
		15			
		20			
		25			
		30			
		35			
		40			
		45			
		50			

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F 1A

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 154+90 106' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 785 feet ±	BORING STARTED: 2/14/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/15/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD
▼ 13 feet on 2/22/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) 0 10 20 30 40 50 60 70 80 90 100	BLOWS/6"
	785.0	0								
	784.5	0.5'	TOPSOIL							
	782.0	3'	SILTY CLAY (CL) with organics, brown, moist, firm	RESIDUUM					6	1 - 2 - 4 **(6)**
			SANDY CLAY (CL) with rock fragments, yellow-brown and brown, firm to hard						5	1 - 2 - 3 **(5)**
		5							8	3 - 4 - 4 **(8)**
									15	3 - 6 - 9 **(15)**
		10							44	8 - 19 - 25 **(44)**
▼	773.0	12'	SANDY CLAY (CL) with rock fragments, yellow-brown and gray, very stiff to hard						22	6 - 8 - 14 **(22)**
		15								
		20							20	4 - 7 - 13 **(20)**
	760.3	24.7'	*Refusal at 24.7 feet, began NQ coring*						>>	50/1 **(50+)**
		25	SILTSTONE, dark gray and gray, rust colored staining at fractures, continuous, poor quality, fractured throughout, slight to moderately severe weathering, hard	BEDROCK						25.5' / 759.5' msl
	756.1	28.9'								
		30	SANDSTONE, dark gray to gray, minor rust colored staining at fractures, continuous, good quality with widely spaced fractures, slightly weathered, hard							30.5' / 754.5' msl
	749.5	35	*Coring terminated at 35.5 feet*							35.5' / 749.5' msl 35.5'
		40								
		45								
		50								

RUN 1 (NQ)
RUN - 0.8' - Depth from 24.7' to 25.5'
RQD - 0%
REC - 60%

RUN 2 (NQ)
RUN - 5.0' - Depth from 25.5' to 30.5'
RQD - 28%
REC - 98%

RUN 3 (NQ)
RUN - 5.0' - Depth from 30.5' to 35.5'
RQD - 68%
REC - 100%

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-1

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 156+28 95'R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 785 feet ±	BORING STARTED: 2/14/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/14/2013	HAMMER: Automatic	
GROUNDWATER: Dry ATD	Remarks:		

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
	785.0	0	Auger boring to obtain undisturbed sample		
	781.0	4'	Undisturbed sample attempt Tube crushed, no recovery		%0
	779.0	5	*Boring terminated at 6 feet*		
		10			
		15			
		20			
		25			
		30			
		35			
		40			
		45			
		50			

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F- 2A

Project Manager: J. Hudson, PE

STATION: 156+33 95' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 785 feet ±	BORING STARTED: 2/13/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/14/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD
1 feet on 2/22/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	785.0	0							
	783.5	1.5'	SILTY CLAY (CL) with sandstone fragments, brown, soft	RESIDUUM					5 - 2 - 2 **(4)**
	782.0	3'	CLAYEY SAND (SC) with sandstone fragments, yellow-brown and brown, loose						1 - 3 - 4 **(7)**
			CLAYEY SILT (ML), yellow-brown and gray, stiff and hard						5 - 5 - 9 **(14)**
	776.6	8.4'	*Refusal at 8.4 feet, began NQ coring*						6 - 21 - 20 **(41)**
			SANDY CLAY (CL) with floating sandstone boulders, gray and red-brown, sandy clay observed washing out in coring water during rock coring						
	762.7	22.3'	SHALE, dark gray, bedded at about 60 degrees, competent, poor quality with fractures throughout, broken up below about 27.7 feet during rock coring, slightly weathered, soft	BEDROCK					
	754.5	30	*Coring terminated at 30.5 feet*						

RUN 1 (NQ)
RUN - 2.1' - Depth from 8.4' to 10.5'
RQD - 0%
REC - 19%
10.5' / 774.5' msl

RUN 2 (NQ)
RUN - 5.0' - Depth from 10.5' to 15.5'
RQD - 16%
REC - 32%
15.5' / 769.5' msl

RUN 3 (NQ)
RUN - 5.0' - Depth from 15.5' to 20.5'
RQD - 0%
REC - 8%
20.5' / 764.5' msl

RUN 4 (NQ)
RUN - 5.0' - Depth from 20.5' to 25.5'
RQD - 0%
REC - 64%
25.5' / 759.5' msl

RUN 5 (NQ)
RUN - 5.0' - Depth from 25.5' to 30.5'
RQD - 8%
REC - 60%
30.5' / 754.5' msl
30.5'

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-2

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 160+00 150' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 873 feet ±	BORING STARTED: 10/24/2012	RIG TYPE:CME-550	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/31/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION		L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	873.0	0	CLAYEY SAND (SC) with rock fragments, brown, dense to very firm	RESIDUUM						13 - 19 - 21 **(40)**
		5								11 - 17 - 12 **(29)**
	866.5	6.5'	WEATHERED SANDSTONE, brown and yellow-brown, very dense							15 - 16 - 12 **(28)**
	863.7	9.3'	*Refusal at 9.3 feet, began NQ coring*							10 - 15 - 50/5 **(50+)**
		10	SANDSTONE, gray and tan, rust colored staining at fractures, very fractured from 9.3 to 10 feet and 15 to 16.8 feet, hard	BEDROCK						50/1 **(50+)**
		15								
	856.2	16.8'	SOIL SEAM - washed away during coring							
	853.8	19.2'	SANDSTONE with rust stained fractures, tan, void from 24.1 to 24.4 feet, hard							
		20								
		25								
		30								
		35								
		40								
	827.0	45								
		46'	SANDSTONE, fractured, rust staining below 51 feet, gray, hard							
		50								

RUN 1 (NQ) — 10' / 863' msl
RUN - 0.7' - Depth from 9.3' to 10'
RQD - 0%
REC - 100%

RUN 2 (NQ) — 15' / 858' msl
RUN - 5.0' - Depth from 10' to 15'
RQD - 66%
REC - 100%

RUN 3 (NQ) — 20' / 853' msl
RUN - 5.0' - Depth from 15' to 20'
RQD - 16%
REC - 52%

RUN 4 (NQ) — 25' / 848' msl
RUN - 5.0' - Depth from 20' to 25'
RQD - 74%
REC - 94%

RUN 5 (NQ) — 30' / 843' msl
RUN - 5.0' - Depth from 25' to 30'
RQD - 90%
REC - 100%

RUN 6 (NQ) — 35' / 838' msl
RUN - 5.0' - Depth from 30' to 35'
RQD - 60%
REC - 100%

RUN 7 (NQ) — 40' / 833' msl
RUN - 5.0' - Depth from 35' to 40'
RQD - 68%
REC - 100%

RUN 8 (NQ) — 45' / 828' msl
RUN - 5.0' - Depth from 40' to 45'
RQD - 54%
REC - 100%

Borehole ID: B-1

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Project Manager: J. Hudson, PE

STATION: 160+00 150' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 873 feet ±	BORING STARTED: 10/24/2012	RIG TYPE:CME-550	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/31/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks:

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
		50	SANDSTONE, fractured, rust staining below 51 feet, gray, hard *(Continued)*			**RUN 9** (NQ) RUN - 5.0' - Depth from 45' to 50' RQD - 32% REC - 84%
	820.0	53'	VERY WEATHERED SHALE, dark gray, soft			**RUN 10** (NQ) RUN - 5.0' - Depth from 50' to 55' RQD - 20% REC - 58%
	813.0	60'	INTERBEDDED SHALE AND SANDSTONE, steeply bedded, gray and dark gray, hard and moderately hard			**RUN 11** (NQ) RUN - 5.0' - Depth from 55' to 60' RQD - 66% REC - 100%
		65				**RUN 12** (NQ) RUN - 5.0' - Depth from 60' to 65' RQD - 72% REC - 100%
		70				**RUN 13** (NQ) RUN - 5.0' - Depth from 65' to 70' RQD - 42% REC - 90%
		75				**RUN 14** (NQ) RUN - 5.0' - Depth from 70' to 75' RQD - 80% REC - 100%
		80				**RUN 15** (NQ) RUN - 5.0' - Depth from 75' to 80' RQD - 60% REC - 100%
		85				**RUN 16** (NQ) RUN - 5.0' - Depth from 80' to 85' RQD - 52% REC - 100%
		90				**RUN 17** (NQ) RUN - 5.0' - Depth from 85' to 90' RQD - 70% REC - 92%
		95				**RUN 18** (NQ) RUN - 5.0' - Depth from 90' to 95' RQD - 60%
		100				

50' / 823' msl
55' / 818' msl
60' / 813' msl
65' / 808' msl
70' / 803' msl
75' / 798' msl
80' / 793' msl
85' / 788' msl
90' / 783' msl
95' / 778' msl

Borehole ID: B-1

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Project Manager: J. Hudson, PE

STATION: 160+00 150' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 3 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 873 feet ±	BORING STARTED: 10/24/2012	RIG TYPE:CME-550	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/31/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
		100	INTERBEDDED SHALE AND SANDSTONE, steeply bedded, gray and dark gray, hard and moderately hard *(Continued)*			REC - 100% 100' / 773' msl
		105				**RUN 19** (NQ) RUN - 5.0' - Depth from 95' to 100' RQD - 80% REC - 100% 105' / 768' msl
		110				**RUN 20** (NQ) RUN - 5.0' - Depth from 100' to 105' RQD - 46% REC - 100% 110' / 763' msl
		115				**RUN 21** (NQ) RUN - 5.0' - Depth from 105' to 110' RQD - 16% REC - 100% 115' / 758' msl
		120				**RUN 22** (NQ) RUN - 5.0' - Depth from 110' to 115' RQD - 40% REC - 92% 120' / 753' msl
		125				**RUN 23** (NQ) RUN - 5.0' - Depth from 115' to 120' RQD - 84% REC - 100% 125' / 748' msl
	743.0	130	*Coring terminated at 130 feet*			**RUN 24** (NQ) RUN - 5.0' - Depth from 120' to 125' RQD - 92% REC - 100% 130' / 743' msl 130'
		135				**RUN 25** (NQ) RUN - 5.0' - Depth from 125' to 130' RQD - 84% REC - 90%
		140				
		145				
		150				

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-1

Project Manager: J. Hudson, PE

STATION: 161+23 170' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 882 feet ±	BORING STARTED: 2/13/2013	RIG TYPE:CME-750	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/21/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD
▼ 7 feet on 2/25/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	882.0	0	CLAYEY SAND (SC) with sandstone fragments, orange brown, dense to very dense — FILL						4 - 17 - 15 **(32)**
		5							15 - 24 - 31 **(55)**
▼	876.0	6'	CLAYEY SAND (SC) with sandstone fragments, orange-brown, very dense to very firm — RESIDUUM						8 - 18 - 23 **(41)**
		10							50/4 **(50+)**
									9 - 20 - 32 **(52)**
		15							2 - 14 - 12 **(26)**
	862.6	19.4'	*Refusal at 19.4 feet, began NQ coring*						
		20	SANDSTONE and SANDY CLAY (CL), tan and orange-brown, clay observed washing away in coring water during rock coring, rust colored staining at joints, 45 degree bedding, competent, very poor quality, moderately to very severely weathered, hard and soft						
		25							
		30							
		35							
	841.0	40							
		41'	SILTY CLAY (CL) with shale fragments, brown, orange-brown and yellow-brown, material observed washing away in coring water during rock coring, relic structure of parent rock, incompetent, very poor quality, very severely weathered, soft						
		45							
		50							

RUN 1 (NQ)
RUN - 6.8' - Depth from 19.4' to 26.2'
RQD - 19%
REC - 72%

26.2' / 855.8' msl

RUN 2 (NQ)
RUN - 10.0' - Depth from 26.2' to 36.2'
RQD - 13%
REC - 50%

36.2' / 845.8' msl

RUN 3 (NQ)
RUN - 10.0' - Depth from 36.2' to 46.2'
RQD - 5%
REC - 28%

46.2' / 835.8' msl

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F- 3

Project Manager: J. Hudson, PE *Logged by: D. Reed, EI* *Checked by: J. Hudson, PE*

STATION: 161+23 170' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 882 feet ±	BORING STARTED: 2/13/2013	RIG TYPE:CME-750	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/21/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD
▼ 7 feet on 2/25/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
	827.0	55'	SILTY CLAY (CL) with shale fragments, dark gray, material observed washing away in coring water during rock coring, relic structure of parent rock, incompetent, very poor quality, very severely weathered, soft		
	812.0	70'	SHALE, dark gray, vertical rust colored stained fracture from about 74 to 76 feet, 45 degree bedding, continuous, very poor quality, moderately severe weathering, moderately soft	BEDROCK	
	803.5	78.5'	SHALE, olive, incompetent, very poor quality, very severely weathered, soft		
	800.3	81.7'	SILTSTONE, gray, 45 degree bedding, 2 inch clay seam at about 89.7 feet, 1 inch clay seam at about 100.9 feet, thin shale interbeds, continuous, good quality, very slightly weathered, hard		

RUN 4 (NQ)
RUN - 10.0' - Depth from 46.2' to 56.2'
RQD - 0%
REC - 27%*(Continued)*

56.2' / 825.8' msl

RUN 5 (NQ)
RUN - 10.0' - Depth from 56.2' to 66.2'
RQD - 0%
REC - 7%

66.2' / 815.8' msl

RUN 6 (NQ)
RUN - 10.0' - Depth from 66.2' to 76.2'
RQD - 0%
REC - 62%

76.2' / 805.8' msl

RUN 7 (NQ)
RUN - 10.0' - Depth from 76.2' to 86.2'
RQD - 18%
REC - 74%

86.2' / 795.8' msl

RUN 8 (NQ)
RUN - 10.0' - Depth from 86.2' to 96.2'
RQD - 78%
REC - 97%

96.2' / 785.8' msl

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-3

Project Manager: J. Hudson, PE *Logged by: D. Reed, EI* *Checked by: J. Hudson, PE*

STATION: 161+23 170' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 3 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 882 feet ±	BORING STARTED: 2/13/2013	RIG TYPE:CME-750	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/21/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD
▼ 7 feet on 2/25/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
	781.0	100				
		101'	SHALE, dark gray, 45 degree bedding, continuous, moderately soft			**RUN 9** (NQ) RUN - 10.0' - Depth from 96.2' to 106.2' RQD - 26% REC - 97%*(Continued)*
	779.1	102.9'	SILTY CLAY (CL) with shale fragments, dark gray, relic structure of parent rock, continuous, very poor quality, very severely weathered, soft			106.2' / 775.8' msl
	777.0	105				**RUN 10** (NQ) RUN - 10.0' - Depth from 106.2' to 116.2' RQD - 70% REC - 92%
		105'	SILTSTONE, dark gray, 45 degree bedding, occasional thin shale interbeds, 6 inch shale interbed from about 113.2 to 113.7 feet, good quality, slightly weathered, hard			
		110				
		115				116.2' / 765.8' msl
	762.0	120				**RUN 11** (NQ) RUN - 10.0' - Depth from 116.2' to 126.2' RQD - 94% REC - 100%
		120'	SILTSTONE, gray, 1/2 inch clay seam at about 121.3 feet, one inch shale seam at about 122.1 feet, three inch clay seam at about 123.7 feet, continuous, excellent quality, fresh, moderately severe weathering at joints, hard			
		125				126.2' / 755.8' msl
	752.0	130	*Coring terminated at 130 feet*			**RUN 12** (NQ) RUN - 3.8' - Depth from 126.2' to 130' RQD - 100% REC - 100%
		135				130' / 752' msl 130'
		140				
		145				
		150				

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F- 3

Project Manager: J. Hudson, PE *Logged by: D. Reed, EI* *Checked by: J. Hudson, PE*

STATION: 163+26 165' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 890 feet ±	BORING STARTED: 11/1/2012	RIG TYPE:CME-550	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 11/6/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION		L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	890.0	0	SANDY SILT (ML) with rock fragments and boulders, brown and red-brown, hard and very stiff	RESIDUUM						9 - 18 - 13 **(31)** 33 - 19 - 15 **(34)** 5 - 8 - 22 **(30)** 50/2 **(50+)**
	881.3	8.7'	*Refusal at 8.7 feet, began NQ coring*							
			SANDSTONE, tan and brown, hard	BEDROCK						
	877.8	12.2'								
	877.0	13'	SOIL SEAM							
	875.5	14.5'	SANDSTONE, tan, fractured, hard							
			SOIL SEAM							
	873.0	17'	SANDSTONE with rust stained fractures and seams, tan and gray, dark gray shale zone from about 29.5 to 30 feet, occasional thin coal seams, hard							

RUN 1 (NQ)
RUN - 4.8' - Depth from 8.7' to 13.5'
RQD - 48%
REC - 88%
13.5' / 876.5' msl

RUN 2 (NQ)
RUN - 5.0' - Depth from 13.5' to 18.5'
RQD - 32%
REC - 76%
18.5' / 871.5' msl

RUN 3 (NQ)
RUN - 5.0' - Depth from 18.5' to 23.5'
RQD - 78%
REC - 100%
23.5' / 866.5' msl

RUN 4 (NQ)
RUN - 5.0' - Depth from 23.5' to 28.5'
RQD - 96%
REC - 100%
28.5' / 861.5' msl

RUN 5 (NQ)
RUN - 5.0' - Depth from 28.5' to 33.5'
RQD - 56%
REC - 100%
33.5' / 856.5' msl

RUN 6 (NQ)
RUN - 5.0' - Depth from 33.5' to 38.5'
RQD - 66%
REC - 100%
38.5' / 851.5' msl

RUN 7 (NQ)
RUN - 5.0' - Depth from 38.5' to 43.5'
RQD - 82%
REC - 100%
43.5' / 846.5' msl

RUN 8 (NQ)
RUN - 5.0' - Depth from 43.5' to 48.5'
RQD - 94%
REC - 100%
48.5' / 841.5' msl

Borehole ID: B-2

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Project Manager: J. Hudson, PE

STATION: 163+26 165' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 890 feet ±	BORING STARTED: 11/1/2012	RIG TYPE:CME-550	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 11/6/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks:

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
		50	SANDSTONE with rust stained fractures and seams, tan and gray, dark gray shale zone from about 29.5 to 30 feet, occasional thin coal seams, hard *(Continued)*			**RUN 9** (NQ) RUN - 5.0' - Depth from 48.5' to 53.5' RQD - 76% REC - 100% *(Continued)* — 53.5' / 836.5' msl
		55				**RUN 10** (NQ) RUN - 5.0' - Depth from 53.5' to 58.5' RQD - 94% REC - 100% — 58.5' / 831.5' msl
		60				**RUN 11** (NQ) RUN - 5.0' - Depth from 58.5' to 63.5' RQD - 100% REC - 100% — 63.5' / 826.5' msl
		65				**RUN 12** (NQ) RUN - 5.0' - Depth from 63.5' to 68.5' RQD - 80% REC - 100% — 68.5' / 821.5' msl
		70				**RUN 13** (NQ) RUN - 5.0' - Depth from 68.5' to 73.5' RQD - 84% REC - 100% — 73.5' / 816.5' msl
		75				**RUN 14** (NQ) RUN - 5.0' - Depth from 73.5' to 78.5' RQD - 72% REC - 100% — 78.5' / 811.5' msl
	811.7	78.3'	SANDSTONE with thin shale and coal seams, tan and gray, some conglomeratic zones, hard			**RUN 15** (NQ) RUN - 5.0' - Depth from 78.5' to 83.5' RQD - 74% REC - 100% — 83.5' / 806.5' msl
		80				**RUN 16** (NQ) RUN - 5.0' - Depth from 83.5' to 88.5' RQD - 90% REC - 100% — 88.5' / 801.5' msl
		85				**RUN 17** (NQ) RUN - 5.0' - Depth from 88.5' to 93.5' RQD - 96% REC - 100% — 93.5' / 796.5' msl
		90				**RUN 18** (NQ) RUN - 5.0' - Depth from 93.5' to 98.5' RQD - 100% — 98.5' / 791.5' msl
		95				
		100				

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-2

Project Manager: J. Hudson, PE

STATION: 163+26 165' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 3 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 890 feet ±	BORING STARTED: 11/1/2012	RIG TYPE:CME-550	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 11/6/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks:

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
		100	SANDSTONE with thin shale and coal seams, tan and gray, some conglomeratic zones, hard *(Continued)*			REC - 100%
		105				**RUN 19** (NQ) RUN - 5.0' - Depth from 98.5' to 103.5' RQD - 100% REC - 100% *(Continued)* — 103.5' / 786.5' msl
		110				**RUN 20** (NQ) RUN - 5.0' - Depth from 103.5' to 108.5' RQD - 76% REC - 100% — 108.5' / 781.5' msl
		115				**RUN 21** (NQ) RUN - 5.0' - Depth from 108.5' to 113.5' RQD - 92% REC - 100% — 113.5' / 776.5' msl
		120				**RUN 22** (NQ) RUN - 5.0' - Depth from 113.5' to 118.5' RQD - 94% REC - 100% — 118.5' / 771.5' msl
		125				**RUN 23** (NQ) RUN - 5.0' - Depth from 118.5' to 123.5' RQD - 74% REC - 100% — 123.5' / 766.5' msl
		130				**RUN 24** (NQ) RUN - 5.0' - Depth from 123.5' to 128.5' RQD - 66% REC - 100% — 128.5' / 761.5' msl
		135				**RUN 25** (NQ) RUN - 5.0' - Depth from 128.5' to 133.5' RQD - 86% REC - 100% — 133.5' / 756.5' msl
	752.0	140	*Coring terminated at 138 feet*			**RUN 26** (NQ) RUN - 4.5' - Depth from 133.5' to 138' RQD - 91% REC - 100% — 138' / 752' msl 138'
		145				
		150				

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-2

Project Manager: J. Hudson, PE

STATION: 166+00 157' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 4
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 911 feet ±	BORING STARTED: 10/31/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 11/6/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Driller noted some broken rock and clay seams encountered from about 1.5 to 6.5 feet washed away during coring.

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION		L	S	
	911.0	0					
	909.5	1.5'	SANDY CLAY (CL), red-brown *Refusal at 1.5 feet, began NQ coring* SANDSTONE BOULDERS and SANDY CLAY (CL), tan and red-brown, moderately hard and soft	FILL			1.5' / 909.5' msl
	904.3	6.7'	SANDSTONE with rust stained fractures and seams, tan and gray, occasional quartz pebbles (conglomeratic zones), occasional thin shale and coal seams, hard	BEDROCK			**RUN 1** (NQ) RUN - 5.3' - Depth from 1.5' to 6.8' RQD - 9% REC - 53% 6.8' / 904.2' msl
		5					**RUN 2** (NQ) RUN - 5.0' - Depth from 6.8' to 11.8' RQD - 82% REC - 100% 11.8' / 899.2' msl
		10					**RUN 3** (NQ) RUN - 5.0' - Depth from 11.8' to 16.8' RQD - 88% REC - 100% 16.8' / 894.2' msl
		15					**RUN 4** (NQ) RUN - 5.0' - Depth from 16.8' to 21.8' RQD - 96% REC - 100% 21.8' / 889.2' msl
		20					**RUN 5** (NQ) RUN - 5.0' - Depth from 21.8' to 26.8' RQD - 94% REC - 100% 26.8' / 884.2' msl
		25					**RUN 6** (NQ) RUN - 5.0' - Depth from 26.8' to 31.8' RQD - 70% REC - 100% 31.8' / 879.2' msl
		30					**RUN 7** (NQ) RUN - 5.0' - Depth from 31.8' to 36.8' RQD - 100% REC - 100% 36.8' / 874.2' msl
		35					**RUN 8** (NQ) RUN - 5.0' - Depth from 36.8' to 41.8' RQD - 88% REC - 100% 41.8' / 869.2' msl
		40					**RUN 9** (NQ) RUN - 5.0' - Depth from 41.8' to 46.8' RQD - 100% REC - 100% 46.8' / 864.2' msl
		45					
		50					

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-3

Project Manager: J. Hudson, PE

STATION: 166+00 157' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 4
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 911 feet ±	BORING STARTED: 10/31/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 11/6/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Driller noted some broken rock and clay seams encountered from about 1.5 to 6.5 feet washed away during coring.

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
		50	SANDSTONE with rust stained fractures and seams, tan and gray, occasional quartz pebbles (conglomeratic zones), occasional thin shale and coal seams, hard*(Continued)*	BEDROCK		**RUN 10** (NQ) RUN - 5.0' - Depth from 46.8' to 51.8' RQD - 100% REC - 100%*(Continued)* — 51.8' / 859.2' msl
		55				**RUN 11** (NQ) RUN - 5.0' - Depth from 51.8' to 56.8' RQD - 82% REC - 100% — 56.8' / 854.2' msl
		60				**RUN 12** (NQ) RUN - 5.0' - Depth from 56.8' to 61.8' RQD - 94% REC - 100% — 61.8' / 849.2' msl
		65				**RUN 13** (NQ) RUN - 5.0' - Depth from 61.8' to 66.8' RQD - 100% REC - 100% — 66.8' / 844.2' msl
		70				**RUN 14** (NQ) RUN - 5.0' - Depth from 66.8' to 71.8' RQD - 100% REC - 100% — 71.8' / 839.2' msl
		75				**RUN 15** (NQ) RUN - 5.0' - Depth from 71.8' to 76.8' RQD - 92% REC - 100% — 76.8' / 834.2' msl
		80				**RUN 16** (NQ) RUN - 5.0' - Depth from 76.8' to 81.8' RQD - 100% REC - 100% — 81.8' / 829.2' msl
		85				**RUN 17** (NQ) RUN - 5.0' - Depth from 81.8' to 86.8' RQD - 98% REC - 100% — 86.8' / 824.2' msl
		90				**RUN 18** (NQ) RUN - 5.0' - Depth from 86.8' to 91.8' RQD - 78% REC - 100% — 91.8' / 819.2' msl
		95				**RUN 19** (NQ) RUN - 5.0' - Depth from 91.8' to 96.8' RQD - 100% — 96.8' / 814.2' msl
		100				

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-3

Project Manager: J. Hudson, PE

STATION: 166+00 157' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 3 OF 4
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 911 feet ±	BORING STARTED: 10/31/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 11/6/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Driller noted some broken rock and clay seams encountered from about 1.5 to 6.5 feet washed away during coring.

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
		100	SANDSTONE with rust stained fractures and seams, tan and gray, occasional quartz pebbles (conglomeratic zones), occasional thin shale and coal seams, hard *(Continued)*	BEDROCK		REC - 100%
		105				**RUN 20** (NQ) 101.8' / 809.2' msl RUN - 5.0' - Depth from 96.8' to 101.8' RQD - 94% REC - 100% *(Continued)*
		110				**RUN 21** (NQ) 106.8' / 804.2' msl RUN - 5.0' - Depth from 101.8' to 106.8' RQD - 86% REC - 100%
		115				**RUN 22** (NQ) 111.8' / 799.2' msl RUN - 5.0' - Depth from 106.8' to 111.8' RQD - 100% REC - 100%
		120				**RUN 23** (NQ) 116.8' / 794.2' msl RUN - 5.0' - Depth from 111.8' to 116.8' RQD - 98% REC - 100%
		125				**RUN 24** (NQ) 121.8' / 789.2' msl RUN - 5.0' - Depth from 116.8' to 121.8' RQD - 86% REC - 100%
		130				**RUN 25** (NQ) 126.8' / 784.2' msl RUN - 5.0' - Depth from 121.8' to 126.8' RQD - 96% REC - 100%
	778.1	132.9	SHALE with coal seams and some interbedded sandstone, dark gray and black, moderately hard and soft			**RUN 26** (NQ) 131.8' / 779.2' msl RUN - 5.0' - Depth from 126.8' to 131.8' RQD - 86% REC - 100%
	773.6	137.4	SANDSTONE with thin coal seams, gray, hard			**RUN 27** (NQ) 136.8' / 774.2' msl RUN - 5.0' - Depth from 131.8' to 136.8' RQD - 84% REC - 98%
		140				**RUN 28** (NQ) 141.8' / 769.2' msl RUN - 5.0' - Depth from 136.8' to 141.8' RQD - 86% REC - 94%
	765.5	145.5	COAL, black, moderately hard			
	764.3	146.7				
	763.5	147.5	SANDSTONE with thin coal seams, gray, hard			**RUN 29** (NQ) 146.8' / 764.2' msl RUN - 5.0' - Depth from 141.8' to 146.8'
		150				

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-3

Project Manager: J. Hudson, PE

STATION: 166+00 157' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 4 OF 4
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 911 feet ±	BORING STARTED: 10/31/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 11/6/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Driller noted some broken rock and clay seams encountered from about 1.5 to 6.5 feet washed away during coring.

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
	759.4	150				
		151.6	COAL, black, moderately hard *(Continued)*			RQD - 70% REC - 96%
			SHALE, dark gray, moderately hard			151.8' / 759.2' msl
	755.7	155	*Coring terminated at 155.3 feet*			**RUN 30** (NQ) RUN - 5.0' - Depth from 146.8' to 151.8' RQD - 10% REC - 48% *(Continued)*
						155.3' / 755.7' msl 155.3'
						RUN 31 (NQ) RUN - 3.5' - Depth from 151.8' to 155.3' RQD - 77% REC - 91%
		160				
		165				
		170				
		175				
		180				
		185				
		190				
		195				
		200				

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-3

Project Manager: J. Hudson, PE

STATION: 168+00 170' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 904 feet ±	BORING STARTED: 10/28/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/30/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Coal Hill Road Station 41+67, 26 feet right. Driller noted water loss at about 77.5 feet.

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION		L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	904.0	0	SANDY CLAY (CL) with rock fragments, brown, very stiff, firm, and stiff	RESIDUUM						5 - 12 - 6 **(18)** 5 - 3 - 3 **(6)** 3 - 5 - 6 **(11)**
	897.5	6.5'	*Refusal at 7.5 feet, began NQ coring*							
	896.5	7.5'	WEATHERED SANDSTONE, red and gray, very dense	BEDROCK						12 - 50/5 **(50+)** 50/0 **(50+)**
	895.0	9'	SANDSTONE, tan and brown, hard							
	893.4	10.6'	VERY WEATHERED SHALE, yellow-brown and brown, soft							
		15	SANDSTONE, gray and tan with occasional water and rust stained seams, thin coal seams at 92.7, 102.0, 108.0, and 111.8 feet, hard							
		20								
		25								
		30								
		35								
		40								
		45								
		50								

RUN 2 (NQ)
RUN - 2.5' - Depth from 7.5' to 10'
RQD - 56%
REC - 80%
10' / 894' msl

RUN 2 (NQ)
RUN - 5.0' - Depth from 10' to 15'
RQD - 66%
REC - 96%
15' / 889' msl

RUN 3 (NQ)
RUN - 5.0' - Depth from 15' to 20'
RQD - 98%
REC - 100%
20' / 884' msl

RUN 4 (NQ)
RUN - 5.0' - Depth from 20' to 25'
RQD - 66%
REC - 100%
25' / 879' msl

RUN 5 (NQ)
RUN - 5.0' - Depth from 25' to 30'
RQD - 100%
REC - 100%
30' / 874' msl

RUN 6 (NQ)
RUN - 5.0' - Depth from 30' to 35'
RQD - 98%
REC - 100%
35' / 869' msl

RUN 7 (NQ)
RUN - 5.0' - Depth from 35' to 40'
RQD - 96%
REC - 100%
40' / 864' msl

RUN 8 (NQ)
RUN - 5.0' - Depth from 40' to 45'
RQD - 96%
REC - 100%
45' / 859' msl

RUN 9 (NQ)

Borehole ID: B-4

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Project Manager: J. Hudson, PE

STATION: 168+00 170' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 904 feet ±	BORING STARTED: 10/28/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/30/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Coal Hill Road Station 41+67, 26 feet right. Driller noted water loss at about 77.5 feet.

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
		50	SANDSTONE, gray and tan with occasional water and rust stained seams, thin coal seams at 92.7, 102.0, 108.0, and 111.8 feet, hard *(Continued)*			RUN - 5.0' - Depth from 45' to 50' RQD - 94% REC - 100% — 50' / 854' msl
		55				**RUN 10** (NQ) RUN - 5.0' - Depth from 50' to 55' RQD - 92% REC - 100% — 55' / 849' msl
		60				**RUN 11** (NQ) RUN - 5.0' - Depth from 55' to 60' RQD - 90% REC - 100% — 60' / 844' msl
		65				**RUN 12** (NQ) RUN - 5.0' - Depth from 60' to 65' RQD - 90% REC - 100% — 65' / 839' msl
		70				**RUN 13** (NQ) RUN - 5.0' - Depth from 65' to 70' RQD - 96% REC - 100% — 70' / 834' msl
		75				**RUN 14** (NQ) RUN - 5.0' - Depth from 70' to 75' RQD - 94% REC - 100% — 75' / 829' msl
		80				**RUN 15** (NQ) RUN - 5.0' - Depth from 75' to 80' RQD - 86% REC - 100% — 80' / 824' msl
		85				**RUN 16** (NQ) RUN - 5.0' - Depth from 80' to 85' RQD - 84% REC - 100% — 85' / 819' msl
		90				**RUN 17** (NQ) RUN - 5.0' - Depth from 85' to 90' RQD - 96% REC - 100% — 90' / 814' msl
		95				**RUN 18** (NQ) RUN - 5.0' - Depth from 90' to 95' RQD - 84% REC - 100% — 95' / 809' msl
		100				

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-4

Project Manager: J. Hudson, PE

STATION: 168+00 170' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 3 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 904 feet ±	BORING STARTED: 10/28/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/30/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Coal Hill Road Station 41+67, 26 feet right. Driller noted water loss at about 77.5 feet.

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
		100	SANDSTONE, gray and tan with occasional water and rust stained seams, thin coal seams at 92.7, 102.0, 108.0, and 111.8 feet, hard *(Continued)*			**RUN 19** (NQ) RUN - 5.0' - Depth from 95' to 100' RQD - 88% REC - 100% — 100' / 804' msl
		105				**RUN 20** (NQ) RUN - 5.0' - Depth from 100' to 105' RQD - 98% REC - 100% — 105' / 799' msl
		110				**RUN 21** (NQ) RUN - 5.0' - Depth from 105' to 110' RQD - 100% REC - 100% — 110' / 794' msl
		115				**RUN 22** (NQ) RUN - 5.0' - Depth from 110' to 115' RQD - 88% REC - 100% — 115' / 789' msl
		120				**RUN 23** (NQ) RUN - 5.0' - Depth from 115' to 120' RQD - 80% REC - 100% — 120' / 784' msl
	779.0	125	125' SANDSTONE, gray, fractured throughout with white precipitate in joints, moderately hard to hard			**RUN 24** (NQ) RUN - 5.0' - Depth from 120' to 125' RQD - 86% REC - 100% — 125' / 779' msl
		130				**RUN 25** (NQ) RUN - 5.0' - Depth from 125' to 130' RQD - 56% REC - 100% — 130' / 774' msl
		135				**RUN 26** (NQ) RUN - 5.0' - Depth from 130' to 135' RQD - 62% REC - 100% — 135' / 769' msl
	764.0	140	*Coring terminated at 140 feet*			**RUN 27** (NQ) RUN - 5.0' - Depth from 135' to 140' RQD - 96% REC - 100% — 140' / 764' msl 140'
		145				
		150				

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-4

Project Manager: J. Hudson, PE

STATION: CHR 43+68 12' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 878 feet ±	BORING STARTED: 2/1/2013	RIG TYPE:CME-750	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/6/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
- ▽ 24 feet ATD
- ▼ 11.4 feet on 2/22/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	878.0	0							
	876.5	1.5'	SANDY CLAY (CL) with rock fragments, orange-brown, moist, soft	FILL					1 - 2 - 2 **(4)**
			SILTY CLAY (CL), brown, yellow-brown and orange-brown, relic structure of parent rock, weathered shale fragments in 4 to 5.5 foot sample, soft and very stiff	RESIDUUM					2 - 2 - 2 **(4)**
	872.0	6'	WEATHERED SHALE, brown and tan, hard	BEDROCK					2 - 8 - 12 **(20)**
▼	866.0	12'	WEATHERED SHALE, dark gray, hard Note: 24 to 25.5 foot sample was wet.						8 - 25 - 50/4 **(50+)** 12 - 50/2 **(50+)** 31 - 50/1 **(50+)** 30 - 50/1 **(50+)**
▽	852.4	25.6'	*Refusal at 25.6 feet, began NQ coring*						50/2 **(50+)**
	850.5	27.5'	SHALE, dark gray, about 30 degree bedding, continuous, poor quality, moderately severe weathering, soft and moderately hard						
			SHALE, dark gray, about 30 degree bedding, incompetent, very poor quality, moderately to very severely weathered, soft and moderately hard						
	832.2	45.8'	SANDY SILTSTONE with shale interbeds, dark gray and gray, 45 degree bedding, continuous, fair						
	830.8	47.2'							

RUN 1 (NQ)
RUN - 1.6' - Depth from 25.6' to 27.2'
RQD - 25%
REC - 94%
27.2' / 850.8' msl

RUN 2 (NQ)
RUN - 10.0' - Depth from 27.2' to 37.2'
RQD - 26%
REC - 69%
37.2' / 840.8' msl

RUN 3 (NQ)
RUN - 10.0' - Depth from 37.2' to 47.2'
RQD - 8%
REC - 54%
47.2' / 830.8' msl

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F- 4

Project Manager: J. Hudson, PE *Logged by: D. Reed, EI* *Checked by: J. Hudson, PE*

STATION: CHR 43+68 12' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 878 feet ±	BORING STARTED: 2/1/2013	RIG TYPE:CME-750	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/6/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
- 24 feet ATD
- 11.4 feet on 2/22/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
	825.2	52.8'	quality, moderately weathered, moderately hard SHALE, dark gray, about 30 degree bedding, incompetent, very poor quality, very severely weathered, soft and moderately hard *(Continued)*	BEDROCK	
	820.8	57.2'	INTERBEDDED SHALE and SILTSTONE, dark gray and gray, 70 to 90 degree bedding, continuous, fair quality, moderately weathered, moderately hard		
	817.9	60.1'	SHALE with siltstone interbeds, dark gray and gray, 1 inch clay seam at about 63.6 feet, 70 to 90 degree bedding, continuous, fair quality, moderately to severely weathered, moderately soft		
	792.6	85.4'	SHALE, dark gray, 45 to 60 degree bedding, fairly continuous, very poor quality, very severely weathered, moderately soft and soft		
	780.3 779.3	97.7' 98.7'	SILTSTONE, gray, 70 to 90 degree bedding, continuous, excellent quality,		

RUN 4 (NQ)
RUN - 10.0' - Depth from 47.2' to 57.2'
RQD - 13%
REC - 53%*(Continued)*

57.2' / 820.8' msl

RUN 5 (NQ)
RUN - 10.0' - Depth from 57.2' to 67.2'
RQD - 56%
REC - 90%

67.2' / 810.8' msl

RUN 6 (NQ)
RUN - 10.0' - Depth from 67.2' to 77.2'
RQD - 61%
REC - 97%

77.2' / 800.8' msl

RUN 7 (NQ)
RUN - 10.0' - Depth from 77.2' to 87.2'
RQD - 50%
REC - 100%

87.2' / 790.8' msl

RUN 8 (NQ)
RUN - 10.0' - Depth from 87.2' to 97.2'
RQD - 19%
REC - 85%

97.2' / 780.8' msl

Borehole ID: F- 4

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Project Manager: J. Hudson, PE *Logged by: D. Reed, EI* *Checked by: J. Hudson, PE*

STATION: CHR 43+68 12' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 3 OF 3
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 878 feet ±	BORING STARTED: 2/1/2013	RIG TYPE:CME-750	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/6/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
- 24 feet ATD
- 11.4 feet on 2/22/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
	777.7	100	100.3' very slightly weathered, hard SHALE, dark gray, 70 to 90 degree bedding, continuous, poor quality, severely weathered, moderately soft *(Continued)*		
	773.0	105	SILTSTONE, gray, no apparent bedding, continuous, excellent quality, fresh, hard		
		110	*Coring terminated at 105 feet*		
		115			
		120			
		125			
		130			
		135			
		140			
		145			
		150			

RUN 9 (NQ)
RUN - 7.8' - Depth from 97.2' to 105'
RQD - 51%
REC - 94% *(Continued)*

105' / 773' msl
105'

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F- 4

Project Manager: J. Hudson, PE

Logged by: D. Reed, EI *Checked by: J. Hudson, PE*

STATION: 172+00 100' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 823 feet ±	BORING STARTED: 10/26/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/27/2012	HAMMER: Automatic	CORE DIA.: NQ2=2.0 in NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Coal Hill Road
Station 45+74, 68 feet left

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	823.0	0							
	820.0	3'	SILTY SAND (SM) with rock fragments, brown and red-brown, very firm and very dense	RESID.					7 - 10 - 15 **(25)**
		5	WEATHERED SANDSTONE, tan and red-brown, very dense	BEDROCK					15 - 30 - 36 **(66)**
									50/3 **(50+)**
									50/3 **(50+)**
	812.5	10	*Refusal at 10.5 feet, began NQ coring*						50/4 **(50+)**
		10.5'	SANDSTONE with soil seams, tan and brown with rust staining at fractures, moderately hard and soft						50/0 **(50+)**
		15							**RUN 1** (NQ) RUN - 5.0' - Depth from 10.5' to 15.5' RQD - 30% REC - 82% — 15.5' / 807.5' msl
		20							**RUN 2** (NQ) RUN - 5.0' - Depth from 15.5' to 20.5' RQD - 22% REC - 80% — 20.5' / 802.5' msl
	797.7	25							**RUN 3** (NQ) RUN - 5.0' - Depth from 20.5' to 25.5' RQD - 0% REC - 68% — 25.5' / 797.5' msl
		25.3'	SANDSTONE with thin shale interbeds, gray and dark gray, weathered shale zone from 40 to 44 feet, hard and moderate hard						
		30							**RUN 4** (NQ) RUN - 5.0' - Depth from 25.5' to 30.5' RQD - 66% REC - 100% — 30.5' / 792.5' msl
		35							**RUN 5** (NQ) RUN - 5.0' - Depth from 30.5' to 35.5' RQD - 96% REC - 100% — 35.5' / 787.5' msl
		40							**RUN 6** (NQ) RUN - 5.0' - Depth from 35.5' to 40.5' RQD - 70% REC - 100% — 40.5' / 782.5' msl
		45							**RUN 7** (NQ) RUN - 5.0' - Depth from 40.5' to 45.5' RQD - 40% REC - 100% — 45.5' / 777.5' msl
	775.5	47.5'	SANDSTONE, light gray, hard						
		50							

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-5

Project Manager: J. Hudson, PE

STATION: 172+00 100' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 823 feet ±	BORING STARTED: 10/26/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/27/2012	HAMMER: Automatic	CORE DIA.: NQ2=2.0 in NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Coal Hill Road
Station 45+74, 68 feet left

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
		50	SANDSTONE, light gray, hard*(Continued)*			**RUN 8** (NQ) RUN - 5.0' - Depth from 45.5' to 50.5' RQD - 66% REC - 100%*(Continued)* — 50.5' / 772.5' msl
		55				**RUN 9** (NQ) RUN - 5.0' - Depth from 50.5' to 55.5' RQD - 96% REC - 100% — 55.5' / 767.5' msl
	762.5	60	*Coring terminated at 60.5 feet*			**RUN 10** (NQ) RUN - 5.0' - Depth from 55.5' to 60.5' RQD - 76% REC - 90% — 60.5' / 762.5' msl 60.5'
		65				
		70				
		75				
		80				
		85				
		90				
		95				
		100				

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-5

Project Manager: J. Hudson, PE

STATION: CHR 46+70 25' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 828 feet ±	BORING STARTED: 1/31/2013	RIG TYPE:CME-750	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 1/31/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	828.0	0							
	827.6		0.4' TOPSOIL	RESIDUUM					
			SANDY CLAY (CL) with roots and sandstone fragments, orange-brown and yellow-brown, firm to very stiff						
	824.5	3.5'							
		5	SILTY SAND (SM), orange-brown and pink, very dense						
	822.0	6'							
			SAND (SW) and SANDSTONE FRAGMENTS, light brown, very dense						
	818.6	9.4'	*Refusal at 9.4 feet, began NQ coring*	BEDROCK					
		10	SANDSTONE, gray, orange-brown, brown and dark gray, some weathered shale seams, some rust colored staining along weathered seams, 3 inch clay seam at about 14.9 feet, one inch clay seam at about 16.5 feet, incompetent, very poor quality, severely and very slightly weathered, soft, moderately hard and hard						
	809.3	18.7'							
	808.9	19.1'							
		20							
	807.0	21'							
	805.8	22.2'	SHALE, dark brown, incompetent, very poor quality, very severely weathered, soft						
		25	SANDY SILTSTONE, gray, rust colored staining at joints, continuous, excellent quality, fresh, hard						
	800.7	27.3'							
		30	SANDY SILTSTONE, gray and red-brown, rust colored staining along fractures, vertically fractured, competent, fair quality, slightly weathered, moderately hard						
		35	SANDY SILTSTONE, gray, some rust colored staining at joints, continuous, excellent quality, fresh, hard						
	790.2	37.8'							
		40	SANDY SILTSTONE with shale interbeds, gray and dark gray, one inch clay seams at about 31.5, 34.5 and 37.7 feet, continuous, excellent quality, very slightly weathered, hard						
		45	SANDY SILTSTONE, gray, 3 inch shale seam at about 54.6 feet, continuous, excellent quality, fresh, hard						
		50							

STANDARD PENETRATION RESISTANCE (N) BLOWS/6" — 0 10 20 30 40 50 60 70 80 90 100

1 - 2 - 3 **(5)**
3 - 6 - 12 **(18)**
10 - 25 - 50/4 **(50+)**
50/2 **(50+)**
50/2 **(50+)**

RUN 1 (NQ)
RUN - 6.7' - Depth from 9.4' to 16.1'
RQD - 24%
REC - 54%

16.1' / 811.9' msl

RUN 2 (NQ)
RUN - 10.0' - Depth from 16.1' to 26.1'
RQD - 81%
REC - 92%

26.1' / 801.9' msl

RUN 3 (NQ)
RUN - 10.0' - Depth from 26.1' to 36.1'
RQD - 88%
REC - 98%

36.1' / 791.9' msl

RUN 4 (NQ)
RUN - 10.0' - Depth from 36.1' to 46.1'
RQD - 76%
REC - 100%

46.1' / 781.9' msl

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F- 5

Project Manager: J. Hudson, PE *Logged by: D. Reed, EI* *Checked by: J. Hudson, PE*

STATION: CHR 46+70 25' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 828 feet ±	BORING STARTED: 1/31/2013	RIG TYPE:CME-750	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 1/31/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks:

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
		50	SANDY SILTSTONE, gray, 3 inch shale seam at about 54.6 feet, continuous, excellent quality, fresh, hard *(Continued)*			**RUN 5** (NQ) RUN - 10.0' - Depth from 46.1' to 56.1' RQD - 95% REC - 100% *(Continued)*
		55				56.1' / 771.9' msl
	769.8	58.2'				**RUN 6** (NQ) RUN - 4.0' - Depth from 56.1' to 60.1' RQD - 88% REC - 100%
	767.9	60	SANDY SILTSTONE with shale interbeds, gray and dark gray, continuous, excellent quality, fresh, hard			60.1' / 767.9' msl 60.1'
			Coring terminated at 60.1 feet			
		65				
		70				
		75				
		80				
		85				
		90				
		95				
		100				

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F- 5

Project Manager: J. Hudson, PE

Logged by: D. Reed, EI *Checked by: J. Hudson, PE*

STATION: 180+19 96' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 800 feet ±	BORING STARTED: 2/20/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/21/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD
▼ 3.5 feet on 2/22/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	800.0	0							0 10 20 30 40 50 60 70 80 90 100
▼	798.5	1.5'	SILTY CLAY (CL) with trace organics, brown, moist, soft	RESIDUUM					3 — 1 - 1 - 2 **(3)**
		5	SANDY CLAY-SANDY SILT (CL-ML) with rock fragments, brown and gray, stiff to hard						15 — 4 - 7 - 8 **(15)**
									>> — 10 - 50/4 **(50+)**
	792.1	7.9'	*Refusal at 7.9 feet, began NQ coring*						>> — 50/4 **(50+)**
		10	SANDSTONE, gray and brown, clay seams from about 10.5 to 10.7 feet and 12.2 to 12.5 feet, continuous, good to fair quality with widely spaced fractures, moderate to moderately severe weathering, moderately hard to hard	BEDROCK					
	784.5	15							
		15.5'	SANDSTONE, gray and light gray, continuous, fair to good quality with widely spaced horizontal fractures, slightly weathered, hard						
		20							
	775.1	24.9'							
		25	SANDSTONE with thin shale interbeds, gray to dark gray, continuous, good quality with widely spaced horizontal fractures, slightly weathered, hard						
		30							
	764.5	35	*Coring terminated at 35.5 feet*						
		40							
		45							
		50							

RUN 1 (NQ)
RUN - 2.6' - Depth from 7.9' to 10.5'
RQD - 73%
REC - 100%
10.5' / 789.5' msl

RUN 2 (NQ)
RUN - 5.0' - Depth from 10.5' to 15.5'
RQD - 68%
REC - 96%
15.5' / 784.5' msl

RUN 3 (NQ)
RUN - 5.0' - Depth from 15.5' to 20.5'
RQD - 74%
REC - 94%
20.5' / 779.5' msl

RUN 4 (NQ)
RUN - 5.0' - Depth from 20.5' to 25.5'
RQD - 88%
REC - 100%
25.5' / 774.5' msl

RUN 5 (NQ)
RUN - 5.0' - Depth from 25.5' to 30.5'
RQD - 80%
REC - 100%
30.5' / 769.5' msl

RUN 6 (NQ)
RUN - 5.0' - Depth from 30.5' to 35.5'
RQD - 80%
REC - 98%
35.5' / 764.5' msl
35.5'

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F- 6

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 180+24 96'R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 800 feet ±	BORING STARTED: 2/21/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/21/2013	HAMMER: Automatic	
GROUNDWATER: Dry ATD	Remarks:		

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
	800.0	0			
	798.0	2'	Auger boring to collect undisturbed sample		
	796.0	5	Undisturbed sample attempt Recovered 1.8 feet		%06
			Boring terminated at 4 feet		
		10			
		15			
		20			
		25			
		30			
		35			
		40			
		45			
		50			

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F- 6A

Project Manager: J. Hudson, PE

STATION: 181+72 87' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 800 feet ±	BORING STARTED: 2/20/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/20/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD
▼ 21.7 feet on 2/22/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	800.0	0	SILTY CLAY (CL) with rock fragments, brown and red-brown, firm to stiff	RESIDUUM					5 — 2 - 2 - 3 **(5)**
		5							8 — 2 - 3 - 5 **(8)**
	794.0	6'	Undisturbed sample attempt Recovered 1.4 feet		70%			24	13 — 4 - 6 - 7 **(13)**
	792.0	8'	SILTY CLAY (CL) with rock fragments, brown and red-brown, very stiff						
		10							18 — 3 - 7 - 11 **(18)**
	787.0	13'	SANDY CLAY (CL), brown, yellow-brown and gray, very stiff to hard						22 — 4 - 9 - 13 **(22)**
		15							
		20							31 — 7 - 17 - 14 **(31)**
▼	778.0	22'	WEATHERED SHALE, gray and black, hard						>> — 25 - 50/4 **(50+)**
		25							
	772.0	28'	*Refusal at 28 feet, began NQ coring*						
		30	SANDSTONE, gray and dark gray, clay seam at about 34 feet, continuous, fair to good quality with widely spaced fractures, slightly to moderately weathered, hard	BEDROCK					
		35							
	759.7	40	*Coring terminated at 40.3 feet*						
		45							
		50							

RUN 1 (NQ)
RUN - 2.3' - Depth from 28' to 30.3'
RQD - 89%
REC - 96%
30.3' / 769.7' msl

RUN 2 (NQ)
RUN - 5.0' - Depth from 30.3' to 35.3'
RQD - 54%
REC - 100%
35.3' / 764.7' msl

RUN 3 (NQ)
RUN - 5.0' - Depth from 35.3' to 40.3'
RQD - 80%
REC - 100%
40.3' / 759.7' msl
40.3'

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-7

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 183+05 89' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 786 feet ±	BORING STARTED: 2/19/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/19/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD
▼ 13.8 feet on 2/22/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	786.0	0	SANDY CLAY (CL) with rock fragments, brown and dark brown, moist near surface, soft, firm and hard	RESIDUUM					1 - 0 - 1 **(1)**
		5							2 - 2 - 3 **(5)**
	780.4	5.6'	*Refusal at 5.6 feet, began NQ coring*						16 - 50/4 **(50+)**
			SILTSTONE, gray and brown, clay seams from about 9.5 to 13.2 feet, fairly continuous to competent, very poor quality with fractures throughout, moderately to severely weathered, moderately soft	BEDROCK					
▼	772.8	13.2'	SILTSTONE with shale seams, gray to dark gray, competent, very poor quality with fractures throughout, slightly to very severely weathered, hard						
	760.8	25	*Coring terminated at 25.2 feet*						

RUN 1 (NQ)
RUN - 4.6' - Depth from 5.6' to 10.2'
RQD - 37%
REC - 87%
10.2' / 775.8' msl

RUN 2 (NQ)
RUN - 5.0' - Depth from 10.2' to 15.2'
RQD - 0%
REC - 48%
15.2' / 770.8' msl

RUN 3 (NQ)
RUN - 5.0' - Depth from 15.2' to 20.2'
RQD - 8%
REC - 60%
20.2' / 765.8' msl

RUN 4 (NQ)
RUN - 5.0' - Depth from 20.2' to 25.2'
RQD - 0%
REC - 40%
25.2' / 760.8' msl
25.2'

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-8

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 184+61 56' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 792 feet ±	BORING STARTED: 2/19/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/19/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: 2/22/2013: Caved in at 2 feet

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6" 0 10 20 30 40 50 60 70 80 90 100
	792.0	0							
	790.5	1.5'	SILTY CLAY (CL) with organics, brown, moist, firm						6 — 3 - 2 - 4 **(6)**
	789.0	3'	SANDY CLAY (CL) with rock fragments, red-brown and gray, hard *Refusal at 3 feet, began NQ coring*						>> — 9 - 50/4 **(50+)**
		5	SANDSTONE, gray, brown and red-brown, clay seam from about 8.8 to 9.4 feet, continuous, good to fair quality, multiple fractures from about 0 to 45 degrees, severely weathered, soft to moderately soft						
	782.3	9.7'							
		10							
	776.8	15.2'	SANDSTONE with thin shale interbeds, gray to dark gray, continuous, poor quality, fractured throughout, slightly weathered, moderately soft to moderately hard						
		15							
	771.8	20.2'	SANDSTONE with thin shale interbeds, gray to dark gray, fairly continuous, very poor quality, highly fractured, slightly weathered, moderately hard						
		20							
	767.8	24.2'	SANDSTONE, gray, continuous, good quality, slightly weathered, hard						
		25							
	761.8	30	SANDSTONE with thin shale interbeds, gray and dark gray, fairly continuous, poor quality, fractured throughout, slightly weathered, moderately hard and hard						
		35	*Coring terminated at 30.2 feet*						
		40							
		45							
		50							

RESID.

BEDROCK

RUN 1 (NQ)
RUN - 2.2' - Depth from 3' to 5.2'
RQD - 68%
REC - 91%
5.2' / 786.8' msl

RUN 2 (NQ)
RUN - 5.0' - Depth from 5.2' to 10.2'
RQD - 48%
REC - 90%
10.2' / 781.8' msl

RUN 3 (NQ)
RUN - 5.0' - Depth from 10.2' to 15.2'
RQD - 42%
REC - 100%
15.2' / 776.8' msl

RUN 4 (NQ)
RUN - 5.0' - Depth from 15.2' to 20.2'
RQD - 10%
REC - 80%
20.2' / 771.8' msl

RUN 5 (NQ)
RUN - 5.0' - Depth from 20.2' to 25.2'
RQD - 64%
REC - 86%
25.2' / 766.8' msl

RUN 6 (NQ)
RUN - 5.0' - Depth from 25.2' to 30.2'
RQD - 22%
REC - 86%
30.2' / 761.8' msl
30.2'

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-9

Project Manager: J. Hudson, PE

Logged by: D. Grass, PE *Checked by: J. Hudson, PE*

STATION: 186+00 60' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 808 feet ±	BORING STARTED: 10/29/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/30/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Driller noted fractured and broken rock in Run 6 washed away during coring process.

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	808.0	0							0 10 20 30 40 50 60 70 80 90 100
	807.0	1'	TOPSOIL SANDY SILT (ML) with rock fragments, brown, soft and stiff	RESID.					3 — 10 — >> 2 - 2 - 1 **(3)** 5 - 5 - 5 **(10)**
	804.0	4'	WEATHERED SANDSTONE, red-brown and orange, very dense *Refusal at 6.5 feet, began NQ coring*	BEDROCK					6 - 50/4 **(50+)**
	801.5	6.5'	SANDSTONE with rust stained seams and fractures, tan, gray, and red-brown, hard						**RUN 1** (NQ) RUN - 10.5' - Depth from 6.5' to 17' RQD - 65% REC - 95%
		10							
		15							17' / 791' msl
									RUN 2 (NQ) RUN - 5.0' - Depth from 17' to 22' RQD - 70% REC - 100%
	786.8	20 21.2'	INTERBEDDED SHALE AND SANDSTONE, gray and dark gray, thin bedded, moderately hard						22' / 786' msl
	783.0	25 25'	SANDSTONE with rust stained fractures, tan, gray, and red-brown, hard						**RUN 3** (NQ) RUN - 5.0' - Depth from 22' to 27' RQD - 12% REC - 100%
	780.8	27.2'	SHALE with thin sandstone interbeds and soft weathered zones, dark gray and gray, soft and moderately hard						27' / 781' msl
	775.5	30 32.5'	SANDSTONE with thin shale interbeds, gray and dark gray, hard and soft						**RUN 4** (NQ) RUN - 5.0' - Depth from 27' to 32' RQD - 0% REC - 80%
	771.0	35 37'							32' / 776' msl
	769.5	38.5'	SANDSTONE with rust stained fractures, tan and red-brown, hard						**RUN 5** (NQ) RUN - 5.0' - Depth from 32' to 37' RQD - 14% REC - 80%
		40	INTERBEDDED SANDSTONE AND SHALE, gray and dark gray, hard, moderately hard and soft						37' / 771' msl
									RUN 6 (NQ) RUN - 5.0' - Depth from 37' to 42' RQD - 16% REC - 100%
		45							42' / 766' msl
									RUN 7 (NQ) RUN - 5.0' - Depth from 42' to 47' RQD - 40% REC - 100%
	757.7	50							47' / 761' msl
									RUN 8 (NQ) RUN - 3.3' - Depth from 47' to 50.3'
			Coring terminated at 50.3 feet						50.3' / 757.7' msl

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-6

Project Manager: J. Hudson, PE

STATION: 186+00 60' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 808 feet ±	BORING STARTED: 10/29/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/30/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Driller noted fractured and broken rock in Run 6 washed away during coring process.

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
			RQD - 27% REC - 100%		
			50.3'		

55
60
65
70
75
80
85
90
95
100

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-6

Project Manager: J. Hudson, PE

STATION: 187+63 49' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 809 feet ±	BORING STARTED: 2/18/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/18/2013	HAMMER: Automatic	CORE DIA.: NQ2=2.0 in NQ=1-7/8 in

GROUNDWATER:
Dry ATD
▼ 3 feet on 2/22/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	809.0	0	SILTY CLAY (CL) with trace organics, brown, soft	RESIDUUM					3 3 — 2 - 1 - 2 **(3)**
▼	806.0	3'	SANDY CLAY (CL), red-brown, yellow-brown and gray, very stiff						1 - 2 - 1 **(3)**
	803.5	5.5'	Undisturbed sample attempt Tube crushed, no recovery		0%				27 — 5 - 10 - 17 **(27)**
	803.0	6'							
	801.5	7.5'	SANDY CLAY (CL), red-brown, yellow-brown and gray, hard *Refusal at 7.5 feet, began NQ coring*	BEDROCK					>> — 15 - 47 - 50/2 **(50+)**
	794.0	15'	SANDSTONE, gray, brown and red-brown, clay seams at fractures, continuous, poor to fair quality, fractured throughout, moderately weathered, hard						
	786.5	22.5'	SANDSTONE, light gray to brown, continuous, good quality with widely spaced fractures, slightly weathered, hard						
	779.0	30'	SANDSTONE, gray to dark gray, several clay seams between about 27.2 and 29.4 feet, fairly continuous, fair quality with evenly spaced fractures, slightly weathered, hard						
	774.0	35'	SANDSTONE, light gray and brown, clay seam from 34 to 35 feet, clay lenses at fractures, continuous, fair quality with fractures throughout, moderately weathered, hard						
	759.0	50	SANDSTONE with thin shale seams, clay seam at about 36.1 feet, gray to dark gray, continuous, good quality with widely spaced fractures, slightly weathered, hard						

RUN 1 (NQ) — 10' / 799' msl
RUN - 2.5' - Depth from 7.5' to 10'
RQD - 44%
REC - 96%

RUN 2 (NQ) — 15' / 794' msl
RUN - 5.0' - Depth from 10' to 15'
RQD - 74%
REC - 94%

RUN 3 (NQ) — 20' / 789' msl
RUN - 5.0' - Depth from 15' to 20'
RQD - 90%
REC - 100%

RUN 4 (NQ) — 25' / 784' msl
RUN - 5.0' - Depth from 20' to 25'
RQD - 28%
REC - 50%

RUN 5 (NQ) — 30' / 779' msl
RUN - 5.0' - Depth from 25' to 30'
RQD - 24%
REC - 92%

RUN 6 (NQ) — 35' / 774' msl
RUN - 5.0' - Depth from 30' to 35'
RQD - 34%
REC - 84%

RUN 7 (NQ) — 40' / 769' msl
RUN - 5.0' - Depth from 35' to 40'
RQD - 64%
REC - 100%

RUN 8 (NQ) — 45' / 764' msl
RUN - 5.0' - Depth from 40' to 45'
RQD - 40%
REC - 100%

RUN 9 (NQ) — 50' / 759' msl

Coring terminated at 50 feet

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-10

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 187+63 49' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 809 feet ±	BORING STARTED: 2/18/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/18/2013	HAMMER: Automatic	CORE DIA.: NQ2=2.0 in NQ=1-7/8 in

GROUNDWATER:
Dry ATD
▼ 3 feet on 2/22/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
		50'	RUN - 5.0' - Depth from 45' to 50' RQD - 64% REC - 100%		
		55			
		60			
		65			
		70			
		75			
		80			
		85			
		90			
		95			
		100			

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-10

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 189+00 80' R

S&ME

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 804 feet ±	BORING STARTED: 10/29/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/29/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Driller noted fractured and broken rock encountered in Run 6 washed away during coring process.

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6" 0 10 20 30 40 50 60 70 80 90 100
	804.0	0							
	803.0	1'	TOPSOIL						
			SANDY CLAY (CL) with organics, brown, soft to firm						1 - 2 - 1 **(3)**
	801.0	3'							3 - 4 - 3 **(7)**
	799.0	5	CLAYEY SAND (SC) with rock fragments, red-brown and gray, very dense						4 - 12 - 50/1 **(50+)**
		5'	*Refusal at 5 feet, began NQ coring*						
			SANDSTONE with rust stained weathered seams and occasional seams of soft, weathered shale, gray and dark gray, hard and moderately hard	RESIDUUM / BEDROCK					
	776.6	27.4'	WEATHERED SHALE, dark gray, soft						
	775.3	28.7'	SANDSTONE with thin shale interbeds, occasional rust stained fractures, gray and dark gray, hard						
	758.6	45	*Coring terminated at 45.4 feet*						

RUN 1 (NQ) RUN - 1.9' - Depth from 5' to 6.9' RQD - 79% REC - 100% — 6.9' / 797.1' msl

RUN 2 (NQ) RUN - 5.0' - Depth from 6.9' to 11.9' RQD - 66% REC - 100% — 11.9' / 792.1' msl

RUN 3 (NQ) RUN - 5.0' - Depth from 11.9' to 16.9' RQD - 94% REC - 100% — 16.9' / 787.1' msl

RUN 4 (NQ) RUN - 5.0' - Depth from 16.9' to 21.9' RQD - 90% REC - 98% — 21.9' / 782.1' msl

RUN 5 (NQ) RUN - 5.0' - Depth from 21.9' to 26.9' RQD - 76% REC - 100% — 26.9' / 777.1' msl

RUN 6 (NQ) RUN - 5.0' - Depth from 26.9' to 31.9' RQD - 26% REC - 86% — 31.9' / 772.1' msl

RUN 7 (NQ) RUN - 5.0' - Depth from 31.9' to 36.9' RQD - 54% REC - 100% — 36.9' / 767.1' msl

RUN 8 (NQ) RUN - 5.0' - Depth from 36.9' to 41.9' RQD - 46% REC - 100% — 41.9' / 762.1' msl

RUN 9 (NQ) RUN - 3.5' - Depth from 41.9' to 45.4' RQD - 77% — 45.4' / 758.6' msl 45.4'

Borehole ID: B-7

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Project Manager: J. Hudson, PE

STATION: 189+00 80' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 804 feet ±	BORING STARTED: 10/29/2012	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/29/2012	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Driller noted fractured and broken rock encountered in Run 6 washed away during coring process.

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
		50	REC - 100%		
		55			
		60			
		65			
		70			
		75			
		80			
		85			
		90			
		95			
		100			

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-7

Project Manager: J. Hudson, PE

STATION: 190+66 48' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 788 feet ±	BORING STARTED: 2/18/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/18/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: 2/22/2013: Caved in at 5 feet

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	788.0	0	SANDY CLAY (CL) with rock fragments, red-brown, yellow-brown and gray, very stiff	RESIDUUM					2 - 10 - 6 **(16)**
	785.0	3'	SANDY CLAY (CL), yellow-brown, hard						4 - 7 - 9 **(16)**
		5	*Refusal at 6.5 feet, began NQ coring*						10 - 24 - 28 **(52)**
	781.5	6.5'	SANDSTONE, light gray and gray, continuous, good to fair quality, horizontal fractures from about 6.5 to 12 feet, 60 degree fractures from about 12 to 16.5 feet, slightly to moderately weathered, moderately hard	BEDROCK					
		10							**RUN 1** (NQ) RUN - 3.9' - Depth from 6.5' to 10.4' RQD - 85% REC - 97% 10.4' / 777.6' msl
		15							**RUN 2** (NQ) RUN - 5.0' - Depth from 10.4' to 15.4' RQD - 60% REC - 100% 15.4' / 772.6' msl
	770.6	17.4'	SANDSTONE, dark gray and gray, continuous, poor quality with fractures throughout, slightly weathered, hard						
		20							**RUN 3** (NQ) RUN - 5.0' - Depth from 15.4' to 20.4' RQD - 52% REC - 84% 20.4' / 767.6' msl
	765.5	22.5'	SANDSTONE with thin shale interbeds, clay seam at about 24.9 feet, dark gray and gray, continuous, fair to poor quality with fractures along shale seams, slightly weathered, hard						
		25							**RUN 4** (NQ) RUN - 5.0' - Depth from 20.4' to 25.4' RQD - 52% REC - 100% 25.4' / 762.6' msl
	757.6	30	*Coring terminated at 30.4 feet*						**RUN 5** (NQ) RUN - 5.0' - Depth from 25.4' to 30.4' RQD - 30% REC - 100% 30.4' / 757.6' msl 30.4'
		35							
		40							
		45							
		50							

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-11

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 221+89 110' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 787 feet ±	BORING STARTED: 2/21/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/21/2013	HAMMER: Automatic	

GROUNDWATER:
Dry ATD
▼ 18 feet on 2/25/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	787.0	0							
	785.5	1.5'	SILTY CLAY (CL) with rock fragments, brown and black, stiff	RESIDUUM					10 — 4 - 5 - 5 **(10)**
			SANDY CLAY (CL) with rock fragments, brown and yellow-brown, stiff, firm and very stiff						11 — 6 - 5 - 6 **(11)**
		5							6 — 3 - 2 - 4 **(6)**
									16 — 4 - 8 - 8 **(16)**
		10							27 — 5 - 11 - 16 **(27)**
	774.0	13'	WEATHERED SHALE, brown, hard						>> 38 - 50/3 **(50+)**
	771.0	15							
▼		16'	WEATHERED SHALE, gray to dark gray, clay seam and wet shale at about 24 feet, hard						>> 16 - 50/3 **(50+)**
		20							
									>> 50/3 **(50+)**
		25							
									>> 50/2 **(50+)**
		30							
									>> 50/2 **(50+)**
	751.5	35	*Boring terminated at 35.5 feet*						
		40							
		45							
		50							

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 7/8/13

Borehole ID: F-12

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 221+89 115'R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 787 feet ±	BORING STARTED: 2/21/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/21/2013	HAMMER: Automatic	
GROUNDWATER: Dry ATD	Remarks:		

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
	787.0	0	Auger boring to collect undisturbed sample		
	780.0	5			
	778.9	7'	Undisturbed sample attempt Recovered 1.1 feet		55%
		10	*Boring terminated at 8.1 feet*		
		15			
		20			
		25			
		30			
		35			
		40			
		45			
		50			

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-12A

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 225+50 120' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 813 feet ±	BORING STARTED: 10/23/2012	RIG TYPE:CME-750	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/24/2012	HAMMER: Manual	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
▽ 35 feet ATD

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	813.0	0	CLAYEY SILT (ML) with roots and orange-black sandstone fragments, brown, dry, stiff to very stiff	RESIDUUM					5 - 7 - 8 **(15)**
	809.5	3.5'	CLAYEY SILT (ML) with orange-brown and black stained claystone fragments and sandstone fragments, yellow-brown, dry, very stiff to hard						11 - 10 - 9 **(19)**
		5							7 - 10 - 12 **(22)**
		10							16 - 20 - 16 **(36)**
	800.0	13'	CLAYEY SILT (ML)/WEATHERED SHALE with trace fine sand, light brown with black staining, orange and dark gray, damp, very stiff (relic bedding of parent rock)						10 - 20 - 27 **(47)**
	795.0	15							7 - 10 - 16 **(26)**
		18'	SILTY FINE SAND (SM) with sandstone fragments, yellow-brown and light gray, wet, firm to very firm						4 - 6 - 11 **(17)**
		20							
		25							3 - 5 - 25 **(30)**
	786.5	26.5'	WEATHERED SHALE with trace fine sand, dark gray, hard						>> 50/4 **(50+)**
		30							>> 50/0 **(50+)**
▽		35							
	774.2	38.8'	*Refusal at 38.8 feet, began NQ coring*						
		40	SILTSTONE with trace mica and fine sand, dark gray, clay seam from about 40.4 to 40.6 feet, pyrite inclusion at fracture at about 45.6 feet, trace pyrite at about 50.4 feet, thin veins of pyrite in fractures at about 52 feet, fractured at about 51.9, 52.1 and 54.2 feet, hard	BEDROCK					
		45							
		50							

RUN 1 (NQ) — 40.4' / 772.6' msl
RUN - 1.6' - Depth from 38.8' to 40.4'
RQD - 100%
REC - 100%

RUN 2 (NQ) — 45.4' / 767.6' msl
RUN - 5.0' - Depth from 40.4' to 45.4'
RQD - 93%
REC - 98%

Borehole ID: B-8

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Project Manager: J. Hudson, PE

STATION: 225+50 120' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 813 feet ±	BORING STARTED: 10/23/2012	RIG TYPE:CME-750	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/24/2012	HAMMER: Manual	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
▽ 35 feet ATD

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	
		50	SILTSTONE with trace mica and fine sand, dark gray, clay seam from about 40.4 to 40.6 feet, pyrite inclusion at fracture at about 45.6 feet, trace pyrite at about 50.4 feet, thin veins of pyrite in fractures at about 52 feet, fractured at about 51.9, 52.1 and 54.2 feet, hard*(Continued)*	BEDROCK		**RUN 3** (NQ) RUN - 5.0' - Depth from 45.4' to 50.4' RQD - 96% REC - 100%*(Continued)* — 50.4' / 762.6' msl
		55				**RUN 4** (NQ) RUN - 5.0' - Depth from 50.4' to 55.4' RQD - 80% REC - 96% — 55.4' / 757.6' msl
	752.6	60	*Coring terminated at 60.4 feet*			**RUN 5** (NQ) RUN - 5.0' - Depth from 55.4' to 60.4' RQD - 68% REC - 100% — 60.4' / 752.6' msl 60.4'
		65				
		70				
		75				
		80				
		85				
		90				
		95				
		100				

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-8

Project Manager: J. Hudson, PE

STATION: 226+60 67' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 791 feet ±	BORING STARTED: 2/22/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/22/2013	HAMMER: Automatic	

GROUNDWATER:
- ▽ 26 feet ATD
- ▼ 10 feet on 2/25/2013

Remarks:

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6"
	791.0	0	SANDY CLAY (CL) with rock fragments, yellow-brown and brown, firm to soft	RESIDUUM					5 / 4 / 4 / 4 — 2 - 3 - 2 (5) at 1.5' / 789.5' msl; 2 - 2 - 2 (4) at 3' / 788' msl; 2 - 2 - 2 (4) at 5.5' / 785.5' msl
▼	783.0	8'	WEATHERED SHALE, dark gray, hard						2 - 2 - 2 (4) at 8' / 783' msl; 50/4" (50+) at 9.2' / 781.8' msl
	778.0	13'	WEATHERED SHALE, brown and gray, hard						57 — 6 - 27 - 30 (57) at 15.5' / 775.5' msl; 50/4" (50+) at 19.4' / 771.6' msl
	769.0	22'	WEATHERED SHALE, gray, wet from about 26 to 35.5 feet, hard						50/3" (50+) at 24.2' / 766.8' msl; 50/3" (50+) at 29.2' / 761.8' msl; 50/2" (50+) at 34.2' / 756.8' msl; 35.5'
	755.5	35	*Boring terminated at 35.5 feet*						
		40							
		45							
		50							

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-13

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 226+55 67'R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 791 feet ±	BORING STARTED: 2/22/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/22/2013	HAMMER: Automatic	
GROUNDWATER: Dry ATD	Remarks:		

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
	791.0	0			
	789.0	2'	Auger boring to collect undisturbed samples		
	787.0	4'	Undisturbed sample attempt Recovered 2 feet		100%
	785.0	5	Undisturbed sample attempt Recovered 2 feet		100%
			Boring terminated at 6 feet		
		10			
		15			
		20			
		25			
		30			
		35			
		40			
		45			
		50			

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-13A

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 227+50 180' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 846 feet ±	BORING STARTED: 10/25/2012	RIG TYPE:CME-750	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/26/2012	HAMMER: Manual	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Driller noted water loss at a depth of about 12.2 feet, and fractured rock and weathered shale below a depth of about 31 feet that washed away during the coring process.

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) BLOWS/6" 0 10 20 30 40 50 60 70 80 90 100
	846.0	0							
	844.5	1.5'	SANDSTONE BOULDER						
			CLAYEY SILT (ML) with sandstone fragments, orange and red, moist, hard						>> 6 - 50/4 **(50+)**
	842.4	3.6'	*Refusal at 3.6 feet, began NQ coring*						
		5	WEATHERED SANDSTONE and sandy clay seams, gray with rust staining, very fractured, moderately hard and soft						
		10							
		15							
	827.0	19'	VERY WEATHERED SHALE with clay seams, brown, soft						
		20							
		25							
		30							
		35							
	809.5	36.5'	INTERBEDDED VERY WEATHERED SHALE AND SANDSTONE, gray and brown with rust staining, very fractured, soft and moderately hard						
		40							
		45							
		50							

RES BEDROCK

RUN 1 (NQ)
RUN - 2.3' - Depth from 3.6' to 5.9'
RQD - 43%
REC - 78%
5.9' / 840.1' msl

RUN 2 (NQ)
RUN - 5.0' - Depth from 5.9' to 10.9'
RQD - 10%
REC - 36%
10.9' / 835.1' msl

RUN 3 (NQ)
RUN - 5.0' - Depth from 10.9' to 15.9'
RQD - 20%
REC - 72%
15.9' / 830.1' msl

RUN 4 (NQ)
RUN - 5.0' - Depth from 15.9' to 20.9'
RQD - 44%
REC - 62%
20.9' / 825.1' msl

RUN 5 (NQ)
RUN - 5.0' - Depth from 20.9' to 25.9'
RQD - 0%
REC - 8%
25.9' / 820.1' msl

RUN 6 (NQ)
RUN - 5.0' - Depth from 25.9' to 30.9'
RQD - 0%
REC - 6%
30.9' / 815.1' msl

RUN 7 (NQ)
RUN - 5.0' - Depth from 30.9' to 35.9'
RQD - 0%
REC - 66%
35.9' / 810.1' msl

RUN 8 (NQ)
RUN - 5.0' - Depth from 35.9' to 40.9'
RQD - 16%
REC - 48%
40.9' / 805.1' msl

RUN 9 (NQ)
RUN - 5.0' - Depth from 40.9' to 45.9'
RQD - 0%
REC - 26%
45.9' / 800.1' msl

Borehole ID: B-9

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Project Manager: J. Hudson, PE

STATION: 227+50 180' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 2 OF 2
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 846 feet ±	BORING STARTED: 10/25/2012	RIG TYPE:CME-750	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow Stem Augers	BORING COMPLETED: 10/26/2012	HAMMER: Manual	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: Driller noted water loss at a depth of about 12.2 feet, and fractured rock and weathered shale below a depth of about 31 feet that washed away during the coring process.

Explanation of acid base testing color codes

- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
		50			
		55	INTERBEDDED VERY WEATHERED SHALE AND SANDSTONE, gray and brown with rust staining, very fractured, soft and moderately hard *(Continued)*		
	789.0	57'			
		60	INTERBEDDED SHALE AND SANDSTONE, gray and dark gray, slightly weathered, some mechanical fracturing, moderately hard		
	783.0	63'			
		65	SHALE, dark gray, very fractured, moderately hard		
		70			
		75			
		80			
	760.1	85	*Coring terminated at 85.9 feet*		
		90			
		95			
		100			

RUN 10 (NQ) — 50.9' / 795.1' msl
RUN - 5.0' - Depth from 45.9' to 50.9'
RQD - 0%
REC - 26% *(Continued)*

RUN 11 (NQ) — 55.9' / 790.1' msl
RUN - 5.0' - Depth from 50.9' to 55.9'
RQD - 0%
REC - 8%

RUN 12 (NQ) — 60.9' / 785.1' msl
RUN - 5.0' - Depth from 55.9' to 60.9'
RQD - 42%
REC - 74%

RUN 13 (NQ) — 65.9' / 780.1' msl
RUN - 5.0' - Depth from 60.9' to 65.9'
RQD - 16%
REC - 58%

RUN 14 (NQ) — 70.9' / 775.1' msl
RUN - 5.0' - Depth from 65.9' to 70.9'
RQD - 30%
REC - 86%

RUN 15 (NQ) — 75.9' / 770.1' msl
RUN - 5.0' - Depth from 70.9' to 75.9'
RQD - 18%
REC - 80%

RUN 16 (NQ) — 80.9' / 765.1' msl
RUN - 5.0' - Depth from 75.9' to 80.9'
RQD - 8%
REC - 60%

RUN 17 (NQ) — 85.9' / 760.1' msl
RUN - 5.0' - Depth from 80.9' to 85.9'
RQD - 46%
REC - 100%

85.9'

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: B-9

Project Manager: J. Hudson, PE

STATION: 228+99 68'R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 798 feet ±	BORING STARTED: 2/22/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/22/2013	HAMMER: Automatic	
GROUNDWATER: Dry ATD	Remarks:		

G	ELEV (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S
	798.0	0			
	796.0	2'	Auger boring to obtain undisturbed samples		
	794.0	4'	Undisturbed sample attempt Recovered 2 feet		100%
	792.0	5	Undisturbed sample attempt Recovered 2 feet		100%
			Boring terminated at 6 feet		
		10			
		15			
		20			
		25			
		30			
		35			
		40			
		45			
		50			

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/18/13

Borehole ID: F-14A

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION: 229+04 68' R

TEST BORING RECORD

PROJECT: TDOT State Route 29 (US 27)		JOB NO: 1811-12-177A	SHEET 1 OF 1
PROJECT LOCATION: Morgan & Roane Counties, Tennessee			
ELEVATION: 798 feet ±	BORING STARTED: 2/21/2013	RIG TYPE:Diedrich D-50	AUGER DIA. (IN): 6¼
DRILLING METHOD: Hollow-Stem Augers	BORING COMPLETED: 2/22/2013	HAMMER: Automatic	CORE DIA.: NQ=1-7/8 in

GROUNDWATER:
Dry ATD

Remarks: 2/25/2013: Caved in at 16 feet

Explanation of acid base testing color codes
- APR - encapsulation required
- APR - blending or partial encapsulation required
- Potential APR - blending required

G	ELEV. (FT.)	DEPTH (FT.)	MATERIAL DESCRIPTION	L	S	R	M	PI	STANDARD PENETRATION RESISTANCE (N) 0 10 20 30 40 50 60 70 80 90 100	BLOWS/6"
	798.0	0	SANDY SILT (ML) with rock fragments, brown and yellow-brown, firm	RESIDUUM					6, 7	2 - 3 - 3 **(6)**
										4 - 3 - 4 **(7)**
	794.0	4' 5	SANDY CLAY (CL), yellow-brown, red-brown and brown, stiff						10	2 - 5 - 5 **(10)**
		10							10	3 - 4 - 6 **(10)**
									9	3 - 4 - 5 **(9)**
	783.2	14.8' 15	*Refusal at 14.8 feet, began NQ coring* SANDY CLAY (CL) with sandstone boulders, clay is brown and yellow-brown, sandstone is light gray							
		20								
	771.0	27' 25	SILTSTONE with thin shale interbeds and several clay seams, gray and dark gray, fairly continuous, very poor quality with fractures throughout, moderately weathered, moderately hard	BEDROCK						
	767.1	30.9' 30	SILTSTONE, dark gray, clay seam at about 35 to 35.9 feet, competent to continuous, poor to fair quality, slightly weathered, moderately hard							
		35								
	757.1	40	*Coring terminated at 40.9 feet*							
		45								
		50								

RUN 1 (NQ) — 15.9' / 782.1' msl
RUN - 1.1' - Depth from 14.8' to 15.9'
RQD - 82%
REC - 91%

RUN 2 (NQ) — 20.9' / 777.1' msl
RUN - 5.0' - Depth from 15.9' to 20.9'
RQD - 8%
REC - 24%

RUN 3 (NQ) — 25.9' / 772.1' msl
RUN - 5.0' - Depth from 20.9' to 25.9'
RQD - 0%
REC - 26%

RUN 4 (NQ) — 30.9' / 767.1' msl
RUN - 5.0' - Depth from 25.9' to 30.9'
RQD - 20%
REC - 80%

RUN 5 (NQ) — 35.9' / 762.1' msl
RUN - 5.0' - Depth from 30.9' to 35.9'
RQD - 24%
REC - 42%

RUN 6 (NQ) — 40.9' / 757.1' msl 40.9'
RUN - 5.0' - Depth from 35.9' to 40.9'
RQD - 62%
REC - 100%

BORING RECORD S&ME 1811-12-177A COMBINED.GPJ S&ME 1-18-2012.GDT 4/10/13

Borehole ID: F-14

Project Manager: J. Hudson, PE *Logged by: D. Grass, PE* *Checked by: J. Hudson, PE*

STATION 154+90, 106 FEET RIGHT: BOX 1 OF 1				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	24.7-25.5	0	60	24.7'-28.9': Dark gray and gray siltstone, rust colored staining at fractures, fractured throughout, slight to moderately severe weathering, hard 28.9'-35.5': Dark gray to gray sandstone, minor rust colored staining at fractures, slightly weathered, hard
2	25.5-30.5	28	98	
3	30.5-35.5	68	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 156+33, 95 FEET RIGHT: BOX 1 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	8.4-10.5	0	19	Gray and red-brown sandy clay with floating sandstone boulders, sandy clay observed washing out in the coring water during rock coring
2	10.5-15.5	16	32	

STATION 156+33, 95 FEET RIGHT: BOX 2 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	15.5-20.5	0	8	15.5'-22.3': Gray and red-brown sandy clay with floating sandstone boulders, sandy clay observed washing away in the coring water during rock coring 22.3'-25.5': Dark gray shale, bedded at about 60 degrees, fractured throughout, slightly weathered, soft
4	20.5-25.5	0	64	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 156+33, 95 FEET RIGHT: BOX 3 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	25.5-30.5	8	60	Dark gray shale, bedded at about 60 degrees, fractured throughout, broken up below about 27.7 feet during rock coring, slightly weathered, soft

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 160+00, 150 FEET RIGHT: BOX 1 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	9.3-10	0	100	Gray and tan sandstone, rust colored staining at fractures, hard

STATION 160+00, 150 FEET RIGHT: BOX 2 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
2	10-15	66	100	10'-16.8': Gray and tan sandstone, rust colored staining at fractures, hard 16.8'-19.2': Soil seam (washed away during coring) 19.2'-20': Tan sandstone with rust stained fractures, hard
3	15-20	16	52	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 160+00, 150 FEET RIGHT: BOX 3 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
4	20-25	74	94	Tan sandstone with rust stained fractures, hard Void from about 24.1' to 24.4'
5	25-30	90	100	

STATION 160+00, 150 FEET RIGHT: BOX 4 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
6	30-35	60	100	Tan sandstone with rust stained fractures, hard
7	35-40	68	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 160+00, 150 FEET RIGHT: BOX 5 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
8	40-45	54	100	40'-46': Tan sandstone with rust stained fractures, hard 46'-50': Gray sandstone, fractured, hard
9	45-50	32	84	

STATION 160+00, 150 FEET RIGHT: BOX 6 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
10	50-55	20	58	50'-53': Gray sandstone, fractured, rust staining below 51', hard 53'-60': Very weathered shale, dark gray, soft
11	55-60	66	100	

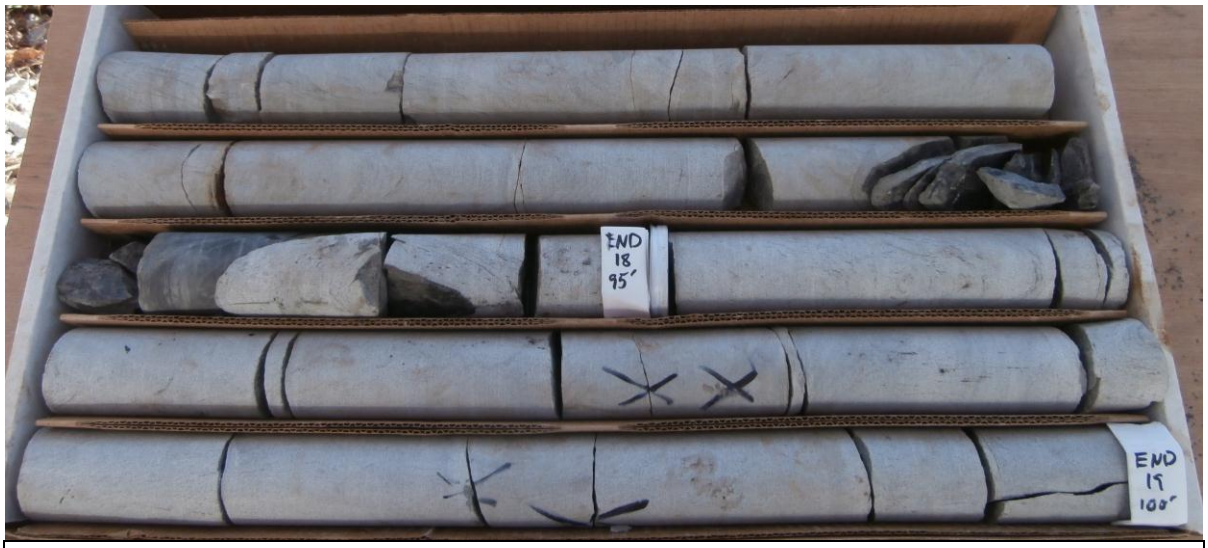
SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 160+00, 150 FEET RIGHT: BOX 7 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
12	60-65	72	100	Gray and dark gray interbedded shale and sandstone, steeply bedded, hard and moderately hard
13	65-70	42	90	

STATION 160+00, 150 FEET RIGHT: BOX 8 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
14	70-75	80	100	Gray and dark gray interbedded shale and sandstone, steeply bedded, hard and moderately hard
15	75-80	60	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 160+00, 150 FEET RIGHT: BOX 9 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
16	80-85	52	100	Gray and dark gray interbedded shale and sandstone, steeply bedded, hard and moderately hard
17	85-90	70	92	



STATION 160+00, 150 FEET RIGHT: BOX 10 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
18	90-95	60	100	Gray and dark gray interbedded shale and sandstone, steeply bedded, hard and moderately hard
19	95-100	80	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 160+00, 150 FEET RIGHT: BOX 11 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
20	100-105	46	100	Gray and dark gray interbedded shale and sandstone, steeply bedded, hard and moderately hard
21	105-110	16	100	

STATION 160+00, 150 FEET RIGHT: BOX 12 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
22	110-115	40	92	Gray and dark gray interbedded shale and sandstone, steeply bedded, hard and moderately hard
23	115-120	84	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 160+00, 150 FEET RIGHT: BOX 13 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
24	120-125	92	100	Gray and dark gray interbedded shale and sandstone, steeply bedded, hard and moderately hard
25	125-130	84	90	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 161+23, 170 FEET RIGHT: BOX 1 OF 12				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	19.4-26.2	19	72	Tan and orange-brown sandstone and sandy clay, clay observed washing away in coring water during rock coring, rust colored staining at joints, 45 degree bedding, moderately to very severely weathered, hard and soft

STATION 161+23, 170 FEET RIGHT: BOX 2 OF 12				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
2	26.2-36.2	13	50	Tan and orange-brown sandstone and sandy clay, clay observed washing away in coring water during rock coring, rust colored staining at joints, 45 degree bedding, moderately to very severely weathered, hard and soft

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 161+23, 170 FEET RIGHT: BOX 3 OF 12				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	36.2-46.2	5	28	36.2'-41': Tan and orange-brown sandstone and sandy clay, clay observed washing away in coring water during rock coring, rust colored staining at joints, 45 degree bedding, moderately to very severely weathered, hard and soft 41'-46.2': Brown, orange-brown and yellow-brown silty clay with shale fragments, material observed washing away in coring water during rock coring, very severely weathered, soft

STATION 161+23, 170 FEET RIGHT: BOX 4 OF 12				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
4	46.2-56.2	0	27	46.2'-55': Brown, orange-brown and yellow-brown silty clay with shale fragments, material observed washing away in coring water during rock coring, very severely weathered, soft 55'-56.2': Dark gray silty clay with shale fragments, very severely weathered, soft

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 161+23, 170 FEET RIGHT: BOX 5 OF 12				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	56.2-66.2	0	7	Dark gray silty clay with shale fragments, material observed washing away in coring water during rock coring, very severely weathered, soft

STATION 161+23, 170 FEET RIGHT: BOX 6 OF 12				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
6	66.2-76.2	0	62	66.2'-70': Dark gray silty clay with shale fragments, material observed washing away in coring water during rock coring, very severely weathered, soft 70'-76.2': Dark gray shale, vertical rust colored stained fracture from about 74 to 76 feet, 45 degree bedding, moderately severe weathering, moderately soft

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 161+23, 170 FEET RIGHT: BOX 7 OF 12				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
7	76.2-86.2	18	74	76.2'-78.5': Dark gray shale, 45 degree bedding, moderately severe weathering, moderately soft 78.5'-81.7': Olive shale, very severely weathered, soft 81.7'-86.2': Gray siltstone, 45 degree bedding, thin shale interbeds, very slightly weathered, hard

STATION 161+23, 170 FEET RIGHT: BOX 8 OF 12				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
8	86.2-96.2	78	97	Gray siltstone, 45 degree bedding, 2 inch clay seam at about 89.7 feet, thin shale interbeds, very slightly weathered, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 161+23, 170 FEET RIGHT: BOX 9 OF 12				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
9	96.2-106.2	26	97	96.2'-101': Gray siltstone, 45 degree bedding, one inch clay seam at about 100.9 feet, thin shale interbeds, very slightly weathered, hard 101'-102.9': Dark gray shale, 45 degree bedding, moderately soft 102.9'-105': Dark gray silty clay with shale fragments, relic structure of parent rock, very severely weathered, soft 105'-106.2': Dark gray siltstone, 45 degree bedding, occasional thin shale interbeds, slightly weathered, hard

STATION 161+23, 170 FEET RIGHT: BOX 10 OF 12				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
10	106.2-116.2	70	92	Dark gray siltstone, 45 degree bedding, occasional thin shale interbeds, 6 inch shale interbed from about 113.2 to 113.7 feet, slightly weathered, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 161+23, 170 FEET RIGHT: BOX 11 OF 12				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
11	116.2-126.2	94	100	116.2'-120': Dark gray siltstone, 45 degree bedding, occasional thin shale interbeds, slightly weathered, hard 120'-126.2': Gray siltstone, ½ inch clay seam at about 121.3 feet, one inch clay seam at about 122.1 feet, three inch clay seam at about 123.7 feet, moderately severe weathering at joints, hard

STATION 161+23, 170 FEET RIGHT: BOX 12 OF 12				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
12	126.2-130	100	100	Gray siltstone, moderately severe weathering at joints, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 163+26, 165 FEET RIGHT: BOX 1 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	8.7-13.5	48	88	8.7'-12.2': Tan and brown sandstone, hard 12.2'-13': Soil seam 13'-14.5': Tan sandstone, fractured, hard 14.5'-17': Soil seam 17'-18.5': Tan and gray sandstone with rust stained fractures and seams and occasional thin coal seams, hard
2	13.5-18.5	32	76	

STATION 163+26, 165 FEET RIGHT: BOX 2 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	18.5-23.5	78	100	Tan and gray sandstone with rust stained fractures and seams and occasional thin coal seams, hard
4	23.5-28.5	96	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 163+26, 165 FEET RIGHT: BOX 3 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	28.5-33.5	56	100	Tan and gray sandstone with rust stained fractures and seams and occasional thin coal seams, hard Dark gray shale zone from about 29.5 to 30 feet
6	33.5-38.5	66	100	

STATION 163+26, 165 FEET RIGHT: BOX 4 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
7	38.5-43.5	82	100	Tan and gray sandstone with rust stained fractures and seams and occasional thin coal seams, hard
8	43.5-48.5	94	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 163+26, 165 FEET RIGHT: BOX 5 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
9	48.5-53.5	76	100	Tan and gray sandstone with rust stained fractures and seams and occasional thin coal seams, hard
10	53.5-58.5	94	100	

STATION 163+26, 165 FEET RIGHT: BOX 6 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
11	58.5-63.5	100	100	Tan and gray sandstone with rust stained fractures and seams and occasional thin coal seams, hard
12	63.5-68.5	80	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 163+26, 165 FEET RIGHT: BOX 7 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
13	68.5-73.5	84	100	68.5'-78.3': Tan and gray sandstone with rust stained fractures and seams and occasional thin coal seams, hard 78.3'-78.5': Tan and gray sandstone with thin shale and coal seams, some conglomeratic zones, hard
14	73.5-78.5	72	100	

STATION 163+26, 165 FEET RIGHT: BOX 8 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
15	78.5-83.5	74	100	Tan and gray sandstone with thin shale and coal seams, some conglomeratic zones, hard
16	83.5-88.5	90	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 163+26, 165 FEET RIGHT: BOX 9 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
17	88.5-93.5	96	100	Tan and gray sandstone with thin shale and coal seams, some conglomeratic zones, hard
18	93.5-98.5	100	100	

STATION 163+26, 165 FEET RIGHT: BOX 10 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
19	98.5-103.5	100	100	Tan and gray sandstone with thin shale and coal seams, some conglomeratic zones, hard
20	103.5-108.5	76	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 163+26, 165 FEET RIGHT: BOX 11 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
21	108.5-113.5	92	100	Tan and gray sandstone with thin shale and coal seams, some conglomeratic zones, hard
22	113.5-118.5	94	100	

STATION 163+26, 165 FEET RIGHT: BOX 12 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
23	118.5-123.5	74	100	Tan and gray sandstone with thin shale and coal seams, some conglomeratic zones, hard
24	123.5-128.5	66	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 163+26, 165 FEET RIGHT: BOX 13 OF 13				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
25	128.5-133.5	86	100	Tan and gray sandstone with thin shale and coal seams, some conglomeratic zones, hard
26	133.5-138	91	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 166+00, 157 FEET RIGHT: BOX 1 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	1.5-6.8	9	53	1.5'-6.7': Tan and red-brown sandstone boulders and sandy clay, moderately hard and soft 6.7'-11.8' Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
2	6.8-11.8	82	100	

STATION 166+00, 157 FEET RIGHT: BOX 2 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	11.8-16.8	88	100	Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
4	16.8-21.8	96	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 166+00, 157 FEET RIGHT: BOX 3 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	21.8-26.8	94	100	Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
6	26.8-31.8	70	100	

STATION 166+00, 157 FEET RIGHT: BOX 4 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
7	31.8-36.8	100	100	Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
8	36.8-41.8	88	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 166+00, 157 FEET RIGHT: BOX 5 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
9	41.8-46.8	100	100	Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
10	46.8-51.8	100	100	

STATION 166+00, 157 FEET RIGHT: BOX 6 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
11	51.8-56.8	82	100	Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
12	56.8-61.8	94	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 166+00, 157 FEET RIGHT: BOX 7 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
13	61.8-66.8	100	100	Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
14	66.8-71.8	100	100	

STATION 166+00, 157 FEET RIGHT: BOX 8 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
15	71.8-76.8	92	100	Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
16	76.8-81.8	100	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 166+00, 157 FEET RIGHT: BOX 9 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
17	81.8-86.8	98	100	Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
18	86.8-91.8	78	100	

STATION 166+00, 157 FEET RIGHT: BOX 10 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
19	91.8-96.8	100	100	Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
20	96.8-101.8	94	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 166+00, 157 FEET RIGHT: BOX 11 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
21	101.8-106.8	86	100	Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
22	106.8-111.8	100	100	

STATION 166+00, 157 FEET RIGHT: BOX 12 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
23	111.8-116.8	98	100	Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
24	116.8-121.8	86	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 166+00, 157 FEET RIGHT: BOX 13 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
25	121.8-126.8	96	100	Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard
26	126.8-131.8	86	100	

STATION 166+00, 157 FEET RIGHT: BOX 14 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
27	131.8-136.8	84	98	131.8'-132.9': Tan and gray sandstone with rust stained fractures and seams, occasional quartz pebbles, and occasional thin shale and coal seams, hard 132.9'-137.4': Dark gray and black shale with coal seams and some interbedded sandstone, moderately hard and soft 137.4'-141.8': Gray sandstone with thin coal seams, hard
28	136.8-141.8	86	94	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 166+00, 157 FEET RIGHT: BOX 15 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
29	141.8-146.8	70	96	141.8'-145.5': Gray sandstone with thin coal seams, hard 145.5'-146.7': Black coal, moderately hard 146.7'-147.5': Gray sandstone with thin coal seams, hard 147.5'-151.6': Black coal, moderately hard 151.6'-151.8': Dark gray shale, moderately hard
30	146.8-151.8	10	48	

STATION 166+00, 157 FEET RIGHT: BOX 16 OF 16				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
31	151.8-155.3	77	91	Dark gray shale, moderately hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 1 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	7.5-10	56	80	7.5'-9': Tan and brown sandstone, hard 9'-10.6': Yellow-brown and brown very weathered shale, soft 10.6'-15': Gray and tan sandstone with occasional water and rust stained seams, hard
2	10-15	66	96	

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 2 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	15-20	98	100	Gray and tan sandstone with occasional water and rust stained seams, hard
4	20-25	66	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 3 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	25-30	100	100	Gray and tan sandstone with occasional water and rust stained seams, hard
6	30-35	98	100	

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 4 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
7	35-40	96	100	Gray and tan sandstone with occasional water and rust stained seams, hard
8	40-45	96	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 5 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
9	45-50	94	100	Gray and tan sandstone with occasional water and rust stained seams, hard
10	50-55	92	100	

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 6 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
11	55-60	90	100	Gray and tan sandstone with occasional water and rust stained seams, hard
12	60-65	90	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 7 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
13	65-70	96	100	Gray and tan sandstone with occasional water and rust stained seams, hard
14	70-75	94	100	

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 8 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
15	75-80	86	100	Gray and tan sandstone with occasional water and rust stained seams, hard
16	80-85	84	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 9 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
17	85-90	96	100	Gray and tan sandstone with occasional water and rust stained seams, hard
18	90-95	84	100	

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 10 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
19	95-100	88	100	Gray and tan sandstone with occasional water and rust stained seams, hard
20	100-105	98	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 11 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
21	105-110	100	100	Gray and tan sandstone with occasional water and rust stained seams, hard
22	110-115	88	100	

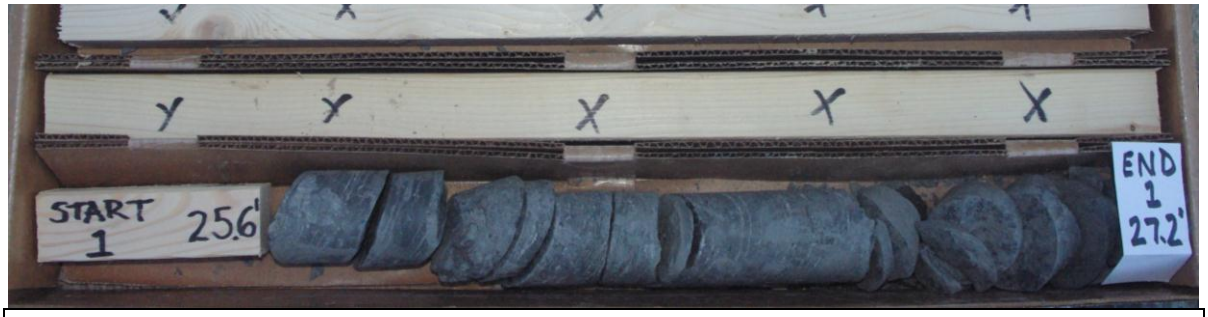
STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 12 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
23	115-120	80	100	Gray and tan sandstone with occasional water and rust stained seams, hard
24	120-125	86	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 13 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
25	125-130	56	100	Gray sandstone, fractured throughout with white precipitate in joints, moderately hard to hard
26	130-135	62	100	

STATION 168+00, 170 FEET RIGHT (CHR STATION 41+67, 26 FEET RIGHT): BOX 14 OF 14				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
27	135-140	96	100	Gray sandstone, fractured throughout with white precipitate in joints, moderately hard to hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE



COAL HILL ROAD STATION 43+68, 12 FEET RIGHT: BOX 1 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	25.6-27.2	25	94	Dark gray shale, about 30 degree bedding, moderately severe weathering, soft and moderately hard

COAL HILL ROAD STATION 43+68, 12 FEET RIGHT: BOX 2 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
2	27.2-37.2	26	69	Dark gray shale, about 30 degree bedding, moderately to very severely weathered, soft and moderately hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

COAL HILL ROAD STATION 43+68, 12 FEET RIGHT: BOX 3 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	37.2-47.2	8	54	37.2'-45.8': Dark gray shale, about 30 degree bedding, very severely weathered, soft and moderately hard 45.8'-47.2': Dark gray and gray sandy siltstone with shale interbeds, 45 degree bedding, moderately weathered, moderately hard

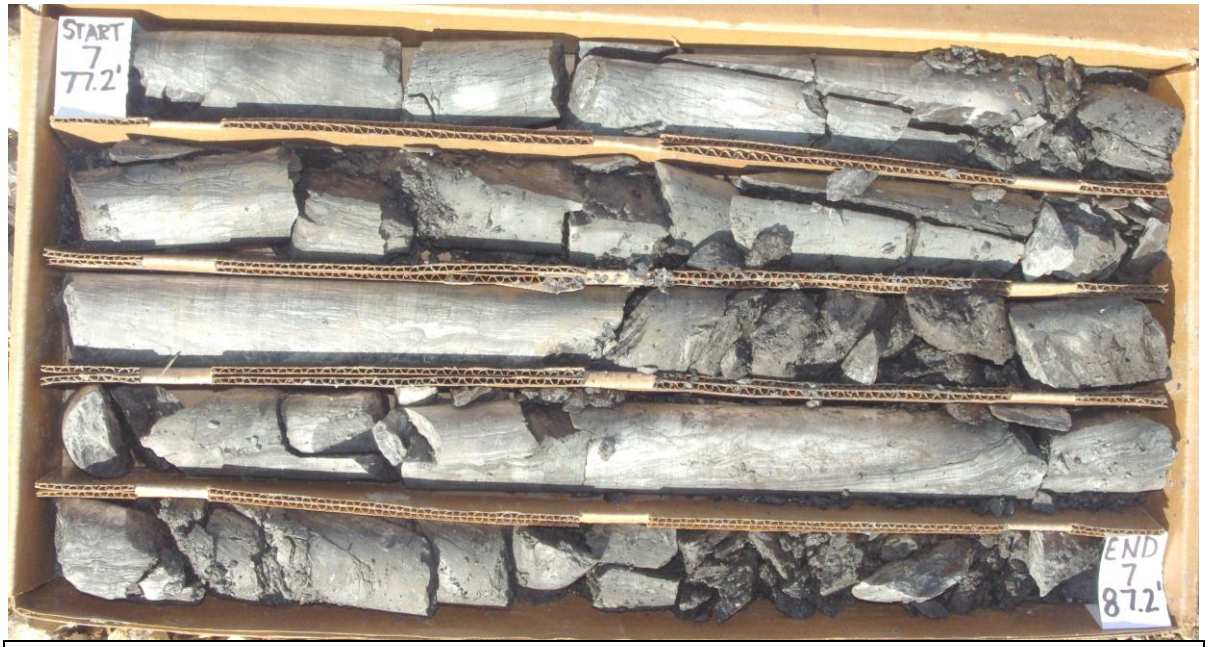
COAL HILL ROAD STATION 43+68, 12 FEET RIGHT: BOX 4 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
4	47.2-57.2	13	53	47.2'-52.8': Dark gray shale, about 30 degree bedding, very severely weathered, soft and moderately hard 52.8'-57.2': Dark gray and gray interbedded shale and siltstone, 70 to 90 degree bedding, moderately weathered, moderately hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

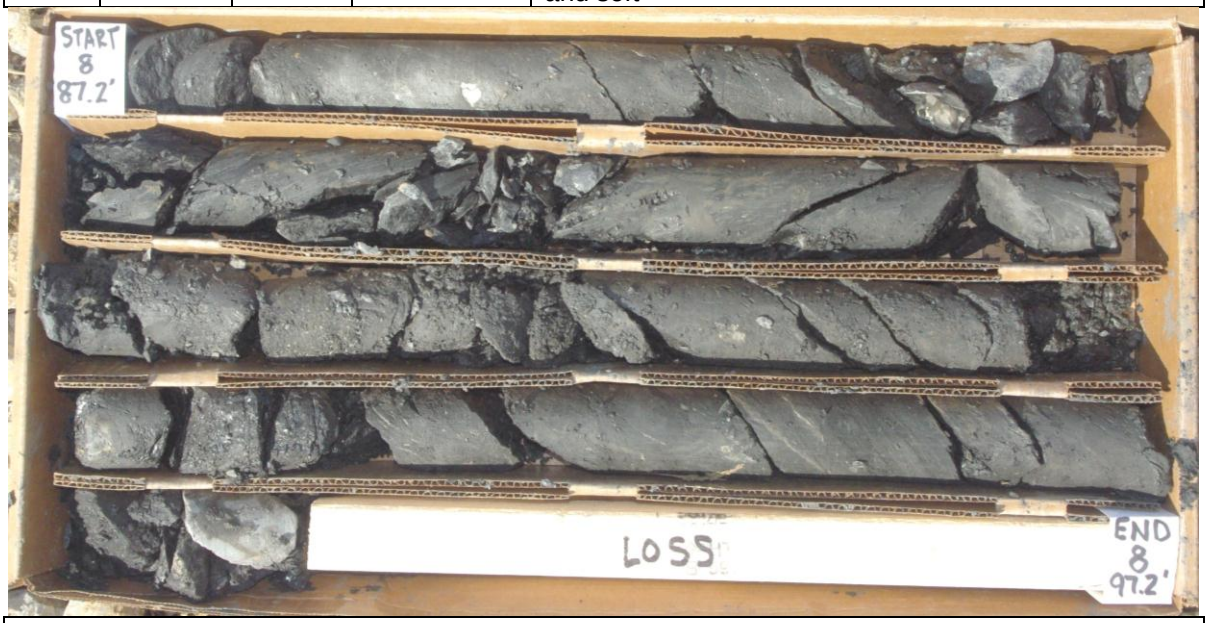
COAL HILL ROAD STATION 43+68, 12 FEET RIGHT: BOX 5 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	57.2-67.2	56	90	Dark gray and gray shale with siltstone interbeds, one inch clay seam at about 63.6 feet, 70 to 90 degree bedding, moderately weathered, moderately soft

COAL HILL ROAD STATION 43+68, 12 FEET RIGHT: BOX 6 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
6	67.2-77.2	61	97	Dark gray and gray shale with siltstone interbeds, 70 to 90 degree bedding, moderately weathered, moderately soft

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

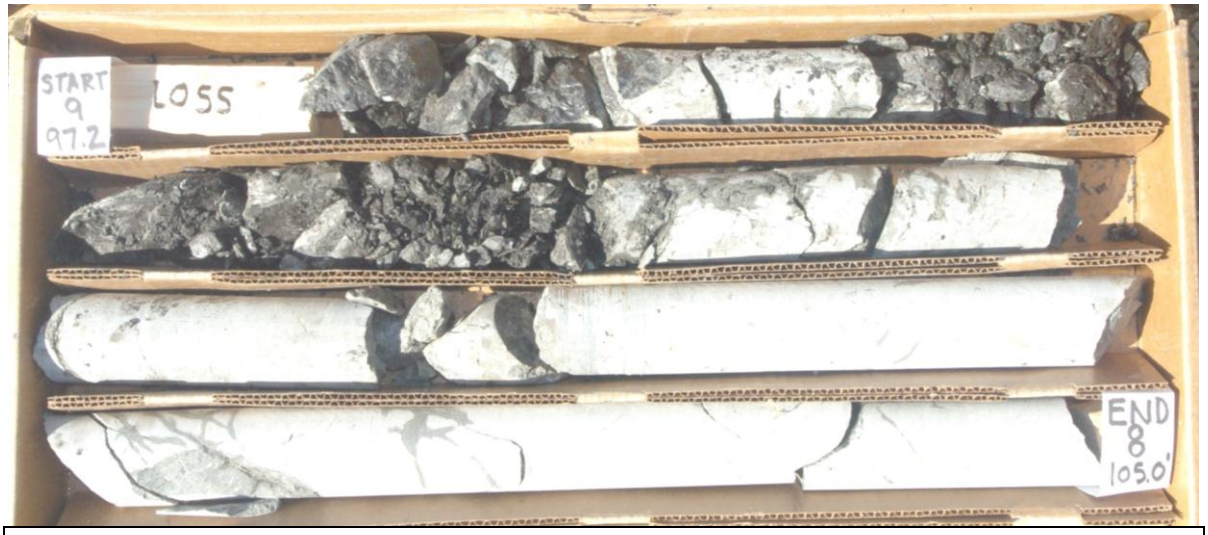


COAL HILL ROAD STATION 43+68, 12 FEET RIGHT: BOX 7 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
7	77.2-87.2	50	100	77.2'-85.4': Dark gray and gray shale with siltstone interbeds, 70 to 90 degree bedding, moderately to severely weathered, moderately soft 85.4'-87.2': Dark gray shale, 45 to 60 degree bedding, very severely weathered, moderately soft and soft



COAL HILL ROAD STATION 43+68, 12 FEET RIGHT: BOX 8 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
8	87.2-97.2	19	85	Dark gray shale, 45 to 60 degree bedding, very severely weathered, moderately soft and soft

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE



COAL HILL ROAD STATION 43+68, 12 FEET RIGHT: BOX 9 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
9	97.2-105	51	94	97.2'-97.7': Dark gray shale, 45 to 60 degree bedding, very severely weathered, moderately soft and soft 97.7'-98.7': Gray siltstone, 70 to 90 degree bedding, very slightly weathered, hard 98.7'-100.3': Dark gray shale, 70 to 90 degree bedding, severely weathered, moderately soft 100.3'-105': Gray siltstone, no apparent bedding, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 172+00, 100 FEET RIGHT (CHR STATION 45+74, 68 FEET LEFT): BOX 1 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	10.5-15.5	30	82	Tan and brown sandstone with soil seams, rust staining at fractures, moderately hard and soft
2	15.5-20.5	22	80	

STATION 172+00, 100 FEET RIGHT (CHR STATION 45+74, 68 FEET LEFT): BOX 2 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	20.5-25.5	0	68	20.5'-25.3': Tan and brown sandstone with soil seams, rust staining at fractures, moderately hard and soft 25.3'-30.5': Gray and dark gray sandstone with thin shale interbeds, hard and moderately hard
4	25.5-30.5	66	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 172+00, 100 FEET RIGHT (CHR STATION 45+74, 68 FEET LEFT): BOX 3 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	30.5-35.5	96	100	Gray and dark gray sandstone with thin shale interbeds, weathered shale zone from about 40 to 40.5 feet, hard and moderately hard
6	35.5-40.5	70	100	

STATION 172+00, 100 FEET RIGHT (CHR STATION 45+74, 68 FEET LEFT): BOX 4 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
7	40.5-45.5	40	100	40.5'-47.5': Gray and dark gray sandstone with thin shale interbeds, weathered shale zone from 40.5 to 44 feet, hard and moderately hard 47.5'-50.5': Light gray sandstone, hard
8	45.5-50.5	66	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 172+00, 100 FEET RIGHT (CHR STATION 45+74, 68 FEET LEFT): BOX 5 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
9	50.5-55.5	96	100	Light gray sandstone, hard
10	55.5-60.5	76	90	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

COAL HILL ROAD STATION 46+70, 25 FEET RIGHT: BOX 1 OF 6				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	9.4-16.1	24	54	Gray, orange-brown, brown and dark gray sandstone, some weathered shale seams, some rust colored staining along weathered seams, 3 inch clay seam at about 14.9 feet, severely and very slightly weathered, soft, moderately hard and hard

COAL HILL ROAD STATION 46+70, 25 FEET RIGHT: BOX 2 OF 6				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
2	16.1-26.1	81	92	16.1'-18.7': Gray, orange-brown, brown and dark gray sandstone, some weathered shale seams, some rust colored staining along weathered seams, one inch clay seam at about 16.5 feet, severely and very slightly weathered, soft, moderately hard and hard 18.7'-19.1': Dark brown shale, very severely weathered, soft 19.1'-21': Gray sandy siltstone, rust colored staining at joints, hard 21'-22.2': Gray and red-brown sandy siltstone, rust colored staining along fractures, slightly weathered, moderately hard 22.2'-26.1': Gray sandy siltstone, some rust colored staining at joints, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

COAL HILL ROAD STATION 46+70, 25 FEET RIGHT: BOX 3 OF 6				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	26.1-36.1	88	98	26.1'-27.3': Gray sandy siltstone, some rust colored staining at joints, hard 27.3'-36.1': Gray and dark gray sandy siltstone with shale interbeds, one inch clay seams at about 31.5 and 34.5 feet, very slightly weathered, hard

COAL HILL ROAD STATION 46+70, 25 FEET RIGHT: BOX 4 OF 6				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
4	36.1-46.1	76	100	36.1'-37.8': Gray and dark gray sandy siltstone with shale interbeds, one inch clay seam at about 37.7 feet, very slightly weathered, hard 37.8'-46.1': Gray sandy siltstone, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

COAL HILL ROAD STATION 46+70, 25 FEET RIGHT: BOX 5 OF 6				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	46.1-56.1	95	100	Gray sandy siltstone, 3 inch shale seam at about 54.6 feet, hard

COAL HILL ROAD STATION 46+70, 25 FEET RIGHT: BOX 6 OF 6				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
6	56.1-60.1	88	100	56.1'-58.2': Gray sandy siltstone, hard 58.2'-60.1': Gray and dark gray sandy siltstone with shale interbeds, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 180+19, 96 FEET RIGHT: BOX 1 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	7.9-10.5	73	100	Gray and brown sandstone, clay seams from about 10.5 to 10.7 feet and 12.2 to 12.5 feet, widely spaced fractures, moderate to moderately severe weathering, moderately hard to hard
2	10.5-15.5	68	96	

STATION 180+19, 96 FEET RIGHT: BOX 2 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	15.5-20.5	74	94	15.5'-24.9': Gray and light gray sandstone, widely spaced horizontal fractures, slightly weathered, hard 24.9'-25.5': Gray to dark gray sandstone with thin shale interbeds, widely spaced horizontal fractures, slightly weathered, hard
4	20.5-25.5	88	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 180+19, 96 FEET RIGHT: BOX 3 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	25.5-30.5	80	100	Gray to dark gray sandstone with thin shale interbeds, widely spaced horizontal fractures, slightly weathered, hard
6	30.5-35.5	80	98	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 181+72, 87 FEET RIGHT: BOX 1 OF 2				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	28-30.3	89	96	Gray and dark gray sandstone, clay seam at about 34 feet, widely spaced fractures, slightly to moderately weathered, hard
2	30.3-35.3	54	100	

STATION 181+72, 87 FEET RIGHT: BOX 2 OF 2				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	35.3-40.3	80	100	Gray and dark gray sandstone, widely spaced fractures, slightly to moderately weathered, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 183+05, 89 FEET RIGHT: BOX 1 OF 2				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	5.6-10.2	37	87	5.6'-13.2': Gray and brown siltstone, clay seams at about 9.5 and 13.2 feet, fractures throughout, moderately to severely weathered, moderately soft 13.2'-15.2': Gray to dark gray siltstone with shale seams, fractures throughout, moderately to slightly weathered, hard
2	10.2-15.2	0	48	

STATION 183+05, 89 FEET RIGHT: BOX 2 OF 2				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	15.2-20.2	8	60	Gray to dark gray siltstone with shale seams, fractured throughout, slightly to very severely weathered, hard
4	20.2-25.2	0	40	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 184+61, 56 FEET RIGHT: BOX 1 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	3-5.2	68	91	3'-9.7': Gray, brown and red-brown sandstone, clay seam from about 8.8 to 9.4 feet, multiple fractures from about 0 to 45 degrees, severely weathered, soft to moderately hard 9.7'-10.2': Gray to dark gray sandstone with thin shale interbeds, fractured throughout, slightly weathered, moderately soft to moderately hard
2	5.2-10.2	48	90	

STATION 184+61, 56 FEET RIGHT: BOX 2 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	10.2-15.2	42	100	10.2'-15.2': Gray to dark gray sandstone with thin shale interbeds, fractured throughout, slightly weathered, moderately soft to moderately hard 15.2'-20.2': Gray to dark gray sandstone with thin shale interbeds, highly fractured, slightly weathered, moderately hard
4	15.2-20.2	10	80	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 184+61, 56 FEET RIGHT: BOX 3 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	20.2-25.2	64	86	20.2'-24.2': Gray sandstone, slightly weathered, hard 24.2'-30.2': Gray and dark gray sandstone with thin shale interbeds, fractured throughout, slightly weathered, moderately hard and hard
6	25.2-30.2	22	86	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 186+00, 60 FEET RIGHT: BOX 1 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	6.5-17	65	95	Tan, gray and red-brown sandstone with rust stained seams and fractures, hard

STATION 186+00, 60 FEET RIGHT: BOX 2 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
2	17-22	70	100	17'-21.2': Tan, gray and red-brown sandstone with rust stained seams and fractures, hard 21.2'-25': Gray and dark gray interbedded shale and sandstone, thin bedded, moderately hard
3	22-27	12	100	25'-27': Tan, gray and red-brown sandstone with rust stained fractures, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 186+00, 60 FEET RIGHT: BOX 3 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
4	27-32	0	80	27'-27.2': Tan, gray and red-brown sandstone with rust stained fractures, hard 27.2'-32.5': Dark gray and gray shale with thin sandstone interbeds and soft weathered zones, soft and moderately hard 32.5'-37': Gray and dark gray sandstone with thin shale interbeds, hard and soft
5	32-37	14	80	

STATION 186+00, 60 FEET RIGHT: BOX 4 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
6	37-42	16	100	37'-38.5': Tan and red-brown sandstone with rust stained fractures, hard 38.5'-47': Gray and dark gray interbedded sandstone and shale, hard, moderately hard and soft
7	42-47	40	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 186+00, 60 FEET RIGHT: BOX 5 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
8	47-50.3	27	100	Gray and dark gray interbedded sandstone and shale, hard, moderately hard and soft

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 187+63, 49 FEET RIGHT: BOX 1 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	7.5-10	44	96	Gray, brown and red-brown sandstone, clay seams at fractures, fractured throughout, moderately weathered, hard
2	10-15	74	94	

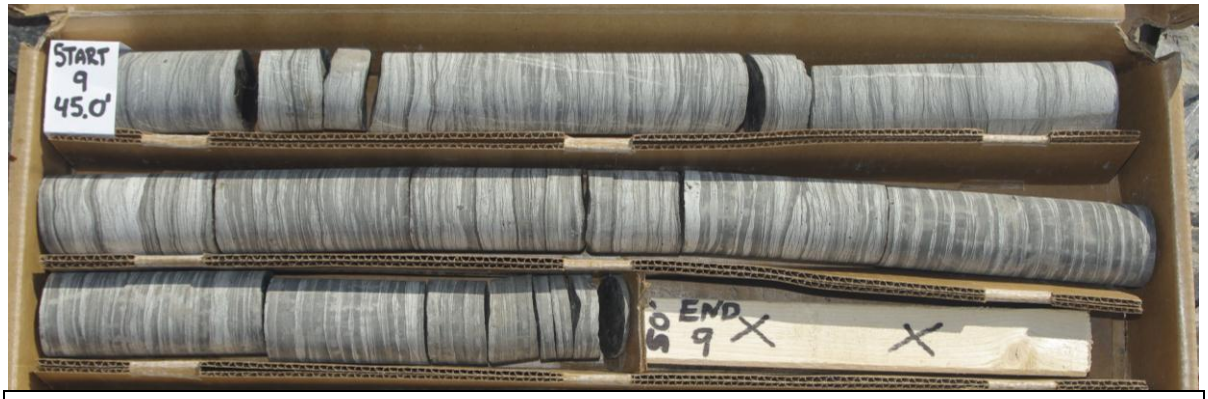
STATION 187+63, 49 FEET RIGHT: BOX 2 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	15-20	90	100	15'-22.5': Light gray to brown sandstone, widely spaced fractures, slightly weathered, hard 22.5'-25': Gray to dark gray sandstone, evenly spaced fractures, slightly weathered, hard
4	20-25	28	50	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 187+63, 49 FEET RIGHT: BOX 3 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	25-30	24	92	25'-30': Gray to dark gray sandstone, several clay seams between about 27.2 and 29.4 feet, evenly spaced fractures, slightly weathered, hard
6	30-35	34	84	30'-35': Light gray and brown sandstone, clay seam from about 34 to 35 feet, clay lenses at fractures, fractures throughout, moderately weathered, hard

STATION 187+63, 49 FEET RIGHT: BOX 4 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
7	35-40	64	100	Gray to dark gray sandstone with thin shale seams, clay seam at about 36.1 feet, widely spaced fractures, slightly weathered, hard
8	40-45	40	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE



STATION 187+63, 49 FEET RIGHT: BOX 5 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
9	45-50	64	100	Gray to dark gray sandstone with thin shale seams, widely spaced fractures, slightly weathered, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 189+00, 80 FEET RIGHT: BOX 1 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	5-6.9	79	100	Gray and dark gray sandstone with rust stained weathered seams and occasional seams of soft weathered shale, hard and moderately hard
2	6.9-11.9	66	100	

STATION 189+00, 80 FEET RIGHT: BOX 2 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	11.9-16.9	94	100	Gray and dark gray sandstone with rust stained weathered seams and occasional seams of soft weathered shale, hard and moderately hard
4	16.9-21.9	90	98	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 189+00, 80 FEET RIGHT: BOX 3 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	21.9-26.9	76	100	21.9'-27.4': Gray and dark gray sandstone with rust stained weathered seams and occasional seams of soft weathered shale, hard and moderately hard 27.4'-28.7': Dark gray weathered shale, soft 28.7'-31.9': Gray and dark gray sandstone with thin shale interbeds and occasional rust stained fractures, hard
6	26.9-31.9	26	86	

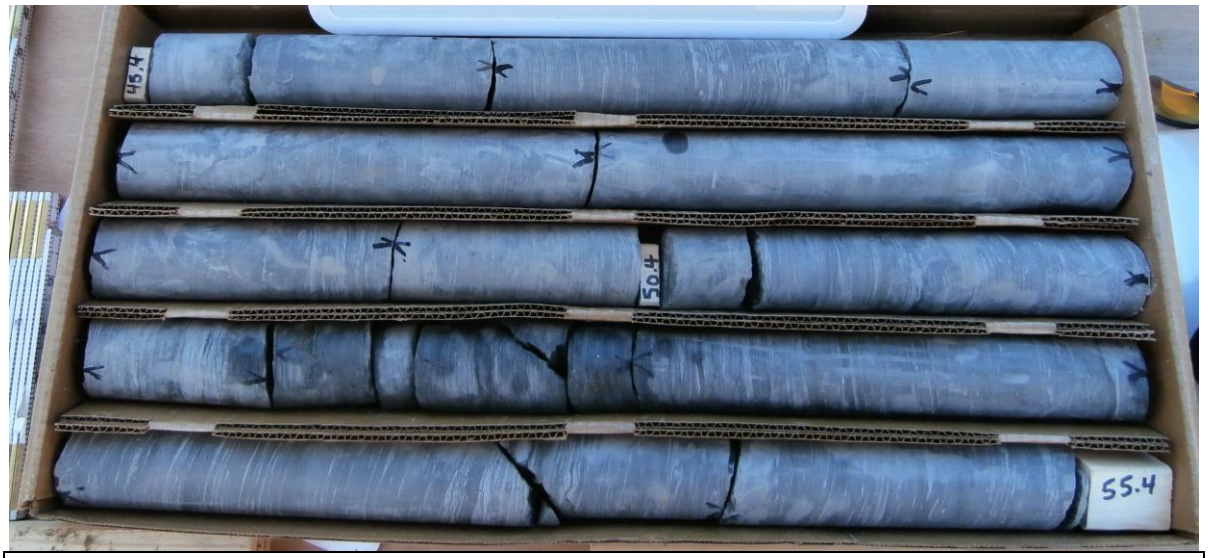
STATION 189+00, 80 FEET RIGHT: BOX 4 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
7	31.9-36.9	54	100	Gray and dark gray sandstone with thin shale interbeds and occasional rust stained fractures, hard
8	36.9-41.9	46	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 189+00, 80 FEET RIGHT: BOX 5 OF 5				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
9	41.9-45.4	77	100	Gray and dark gray sandstone with thin shale interbeds and occasional rust stained fractures, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 225+50, 120 FEET RIGHT: BOX 1 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	38.8-40.4	100	100	Dark gray siltstone with trace mica and fine sand, hard Clay seam from about 40.4' to 40.6'
2	40.4-45.4	93	98	



STATION 225+50, 120 FEET RIGHT: BOX 2 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	45.4-50.4	96	100	Dark gray siltstone with trace mica and fine sand, hard Fractured at about 51.9', 52.1', and 54.2'
4	50.4-55.4	80	96	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 190+66, 48 FEET RIGHT: BOX 1 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	6.5-10.4	85	97	Light gray and gray sandstone, horizontal fractures from about 6.5 to 12 feet, 60 degree fractures from about 12 to 16.5 feet, slightly to moderately weathered, moderately hard
2	10.4-15.4	60	100	

STATION 190+66, 48 FEET RIGHT: BOX 2 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	15.4-20.4	52	84	15.4'-19.6': Light gray and gray sandstone, 60 degree fractures from about 12 to 16.5 feet, slightly to moderately weathered, moderately hard 19.6'-20.7': Dark gray and gray sandstone, fractures throughout, severely weathered, soft 20.7'-25.4': Dark gray and gray sandstone with thin shale interbeds, clay seam at about 24.9 feet, fractures along shale seams, slightly weathered, hard
4	20.4-25.4	52	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

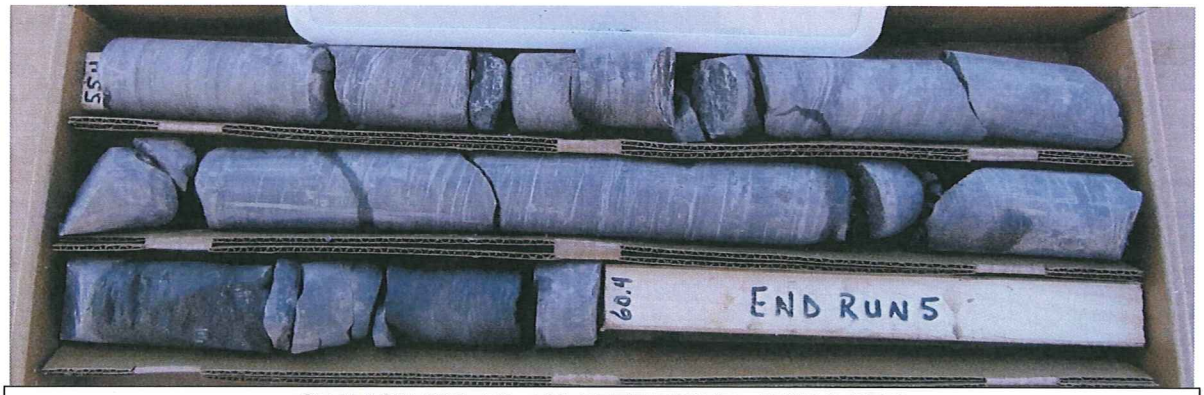
STATION 190+66, 48 FEET RIGHT: BOX 3 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	25.4-30.4	30	100	Dark gray and gray sandstone with thin shale interbeds, fractures along shale seams, slightly weathered, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 225+50, 120 FEET RIGHT: BOX 1 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	38.8-40.4	100	100	Dark gray siltstone with trace mica and fine sand, hard Clay seam from about 40.4' to 40.6'
2	40.4-45.4	93	98	

STATION 225+50, 120 FEET RIGHT: BOX 2 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	45.4-50.4	96	100	Dark gray siltstone with trace mica and fine sand, hard Fractured at about 51.9', 52.1', and 54.2'
4	50.4-55.4	80	96	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE



STATION 225+50, 120 FEET RIGHT: BOX 3 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	55.4-60.4	68	100	Dark gray siltstone with trace mica and fine sand, hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 227+50, 180 FEET RIGHT: BOX 1 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	3.6-5.9	43	78	Gray weathered sandstone and sandy clay seams with rust staining, very fractured, moderately hard and soft
2	5.9-10.9	10	36	

STATION 227+50, 180 FEET RIGHT: BOX 2 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	10.9-15.9	20	72	10.9'-19': Gray weathered sandstone and sandy clay seams with rust staining, very fractured, moderately hard and soft 19'-20.9': Brown very weathered shale with clay seams, soft
4	15.9-20.9	44	62	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 227+50, 180 FEET RIGHT: BOX 3 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	20.9-25.9	0	8	Brown very weathered shale with clay seams, soft
6	25.9-30.9	0	6	

STATION 227+50, 180 FEET RIGHT: BOX 4 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
7	30.9-35.9	0	66	30.9'-36.5': Brown very weathered shale with clay seams, soft 36.5'-40.9': Gray and brown interbedded very weathered shale and sandstone, rust staining, very fractured, soft and moderately hard
8	35.9-40.9	16	48	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 227+50, 180 FEET RIGHT: BOX 5 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
9	40.9-45.9	0	26	Gray and brown interbedded very weathered shale and sandstone, rust staining, very fractured, soft and moderately hard
10	45.9-50.9	0	26	

STATION 227+50, 180 FEET RIGHT: BOX 6 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
11	50.9-55.9	0	8	50.9'-57': Gray and brown interbedded very weathered shale and sandstone, rust staining, very fractured, soft and moderately hard 57'-60.9': Gray and dark gray interbedded shale and sandstone, slightly weathered, some mechanical fracturing, moderately hard
12	55.9-60.9	42	74	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 227+50, 180 FEET RIGHT: BOX 7 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
13	60.9-65.9	16	58	60.9'-63': Gray and dark gray interbedded shale and sandstone, slightly weathered, some mechanical fracturing, moderately hard 63'-70.9': Dark gray shale, very fractured, moderately hard
14	65.9-70.9	30	86	

STATION 227+50, 180 FEET RIGHT: BOX 8 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
15	70.9-75.9	18	80	Dark gray shale, very fractured, moderately hard
16	75.9-80.9	8	60	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 227+50, 180 FEET RIGHT: BOX 9 OF 9				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
17	80.9-85.9	46	100	Dark gray shale, very fractured, moderately hard

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 229+04, 68 FEET RIGHT: BOX 1 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
1	14.8-15.9	82	91	Brown and yellow-brown sandy clay with light gray sandstone boulders
2	15.9-20.9	8	24	

STATION 229+04, 68 FEET RIGHT: BOX 2 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
3	20.9-25.9	0	26	20.9'-27': Brown and yellow-brown sandy clay with light gray sandstone boulders 27'-30.9': Gray and dark gray siltstone with thin shale interbeds and several clay seams, fractures throughout, moderately weathered, moderately hard
4	25.9-30.9	20	80	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

STATION 229+04, 68 FEET RIGHT: BOX 3 OF 3				
RUN	**DEPTH (FT)**	**RQD (%)**	**RECOVERY (%)**	**ROCK DESCRIPTION**
5	30.9-35.9	24	42	Dark gray siltstone, clay seam at about 35 to 35.9 feet, slightly to severely weathered, moderately hard
6	35.9-40.9	62	100	

SEE TEST BORING RECORDS FOR FULL DESCRIPTION OF ROCK CORE

APPENDIX III

LABORATORY TEST PROCEDURES

GEOTECHNICAL LABORATORY TEST RESULTS SUMMARY

ACID BASE ACCOUNTING LABORATORY TEST RESULTS SUMMARY

LABORATORY TEST PROCEDURES

NATURAL MOISTURE
AASHTO T 265

The moisture content of soils is an indicator of various physical properties, including strength and compressibility. Selected samples obtained during exploratory drilling were taken from their sealed containers. Each sample was weighed and then placed in an oven heated to $110^{o}C \pm 5^{o}$. The sample remained in the oven until the free moisture had evaporated. The dried sample was removed from the oven, allowed to cool, and re-weighed. The moisture content was computed by dividing the weight of evaporated water by the weight of the dry sample. The results, expressed as a percent, are shown on the attached Geotechnical Laboratory Test Results Summary.

ATTERBERG LIMITS DETERMINATION
AASHTO T89/T90

Representative samples were subjected to Atterberg limits testing to determine the soil's plasticity characteristics. The plasticity index (PI) is the range of moisture content over which the soil deforms as a plastic material. The liquid limit (LL) marks the transition from the plastic state to the liquid state. The plastic limit (PL) marks the transition from the plastic state to the solid state.

To determine the liquid limit, a soil specimen is wetted until it is in a viscous fluid state. A portion of this soil is then placed in a brass cup of standardized dimensions, and a groove made through the middle of the soil specimen with a grooving tool of standardized dimensions. The cup is attached to a cam that lifts the cup 10 mm, and then allows the cup to fall and strike a rubber base of standardized hardness. The cam is rotated at about 2 drops per second until the two halves of the soil specimen come in contact at the bottom of the groove along a distance of 13 mm. The number of blows required to make this degree of contact is recorded, and a portion of the specimen is subjected to a moisture content determination. Additional water is added to the remainder of the specimen, and the grooving process and cam action process repeated. This testing sequence is repeated until the soil flows as a heavy viscous fluid. The number of blows vs. moisture content is then plotted on semi-logarithmic graph paper, and the moisture content corresponding to 25 blows is designated the liquid limit.

The plastic limit is the lowest moisture content at which the soil is sufficiently plastic to be manually rolled into threads 3 mm in diameter. It is determined by taking a pat of soil remaining from the liquid limit test, and repeatedly rolling, kneading, and air drying the specimen until the soil breaks into threads about 3 mm in diameter and 3 to 10 mm long. The moisture content of these soil threads is then determined, and is designated the plastic limit. The results of these tests are presented on the Geotechnical Laboratory Test Results Summary.

LABORATORY TEST PROCEDURES

GRAIN SIZE TEST PROCEDURES
AASHTO T 88

The grain size distribution of soil particles is an indicator of certain physical properties including permeability, compaction characteristics, consolidation, shrinkage and swelling, liquefaction, and other engineering properties. For this project, grain size testing was required to allow AASHTO classifications of the soil. Normally, the soil specimen is dried and then passed through a series of nested sieves. The portion of sample retained on each sieve is weighed and the percent of the total sample retained is computed. The percent passing the Number 200 sieve is provided on the Laboratory Test Results Summary. Hydrometer analyses were also performed and grain size distribution curves were developed. The Grain Size Distribution Test Reports are included in this Appendix.

UNCONFINED COMPRESSIVE STRENGTH OF SOIL
AASHTO T208-92

The unconfined compression test is an unconsolidated-undrained triaxial shear test with no lateral confining pressure. This test is used to determine the shear strength (cohesion) of clayey soils and rock. Undisturbed samples were prepared by cutting the ends perpendicular to the applied load. The sample was placed in a testing device and incrementally increasing vertical loads were applied until it failed. The test results are provided on the attached Unconfined Compressive Strength of Cohesive Soil test report and the Geotechnical Laboratory Test Results Summary.

UNCONFINED COMPRESSIVE STRENGTH OF ROCK CORE
ASTM D 2938

The unconfined compression test is a triaxial shear test with no lateral confining pressure. This test is used to determine the shear strength (cohesion) of rock. Select rock core samples were prepared by cutting the ends perpendicular to the applied load. The samples were placed in a testing device and incrementally increasing vertical loads were applied until it failed. The unconfined compressive strength of the rock core samples we tested are provided on the attached Geotechnical Laboratory Test Results Summary.

LABORATORY TEST PROCEDURES

ACID-BASE ACCOUNTING

Soil and rock core samples collected about every five feet in depth were selected for acid-base accounting laboratory testing. The samples were delivered to Galbraith Laboratories, Inc. in Knoxville, Tennessee by one of our engineers for testing.

Acid-base accounting is composed of the following four major components:

- Paste pH: The pH of a soil or rock sample is measured by a glass electrode by adding water to the sample to form a paste.

- Neutralization Potential: The amount of neutralization bases, including carbonates, in the overburden material is found by treating a sample with a known excess of standardized HCL. The calcium carbonate equivalent of the sample is obtained by determining the amount of unconsumed acid by titration with standardized sodium hydroxide.

- Total Sulfur Determination and Acid Potential: The total sulfur content in a sample in pyritic form, which corresponds with actual potential acidity from sulfur, is calculated as a percentage of the total mass tested.

- Net Acid Base: Calculated by subtracting the acid potential from the neutralization potential.

The acid base accounting test results were used to characterize the material's potential to produce acidic runoff based on TDOT's accepted criteria, Guideline for Acid Producing Rock Investigation, Testing and Monitoring, and Mitigation, prepared by Golder Associates, Inc. and dated October 2007. The test results and APR classifications are shown on the attached Acid Base Accounting Laboratory Test Results Summary.

				Atterberg Limits						
Station No.	Sample Type	Sample Depth (ft)	Natural Moisture Content (%)	LL	PL	PI	Percent Finer than No. 200 Sieve	USCS Classification	AASHTO Classification	Unconfined Compressive Strength (tsf)
154+85	UD	4-6		39	20	19	58.3	CL	A-6	
		14-16		27	16	11	55.6	CL	A-6	
161+23	RC	21.4-22								592
		109.2-109.9								535
		128.2-128.9								805
CHR 43+68	RC	30.4-30.9								247
CHR 46+70	RC	38.9-39.5								1,259
180+19	RC	12.8-13.4								345
		21.4-21.9								1,338
		28.1-29								728
180+24	UD	2-4		27	21	6	53.5	CL-ML	A-4	
181+72	UD	6-8	21.5	48	24	24	73.3	CL	A-7-6	2.66
	RC	32.3-33								715
		36.1-36.8								1,117
184+61	RC	14.2-14.8								628
187+63	RC	37.8-38.5								662
190+66	RC	24-24.8								102
221+89	UD	7-8.1		48	26	22	79.2	CL	A-7-6	
226+55	UD	4-6		38	23	15	23.2	CL	A-2-6	
228+99	UD	2-4		48	28	20	73.1	ML	A-7-6	
229+04	RC	38.9-39.8								548

UD - Undisturbed Shelby Tube Sample
RC - Rock Core Sample

GEOTECHNICAL LABORATORY TEST RESULTS SUMMARY
STATE ROUTE 29 PROPOSED RETAINING WALLS
MORGAN AND ROANE COUNTIES, TENNESSEE

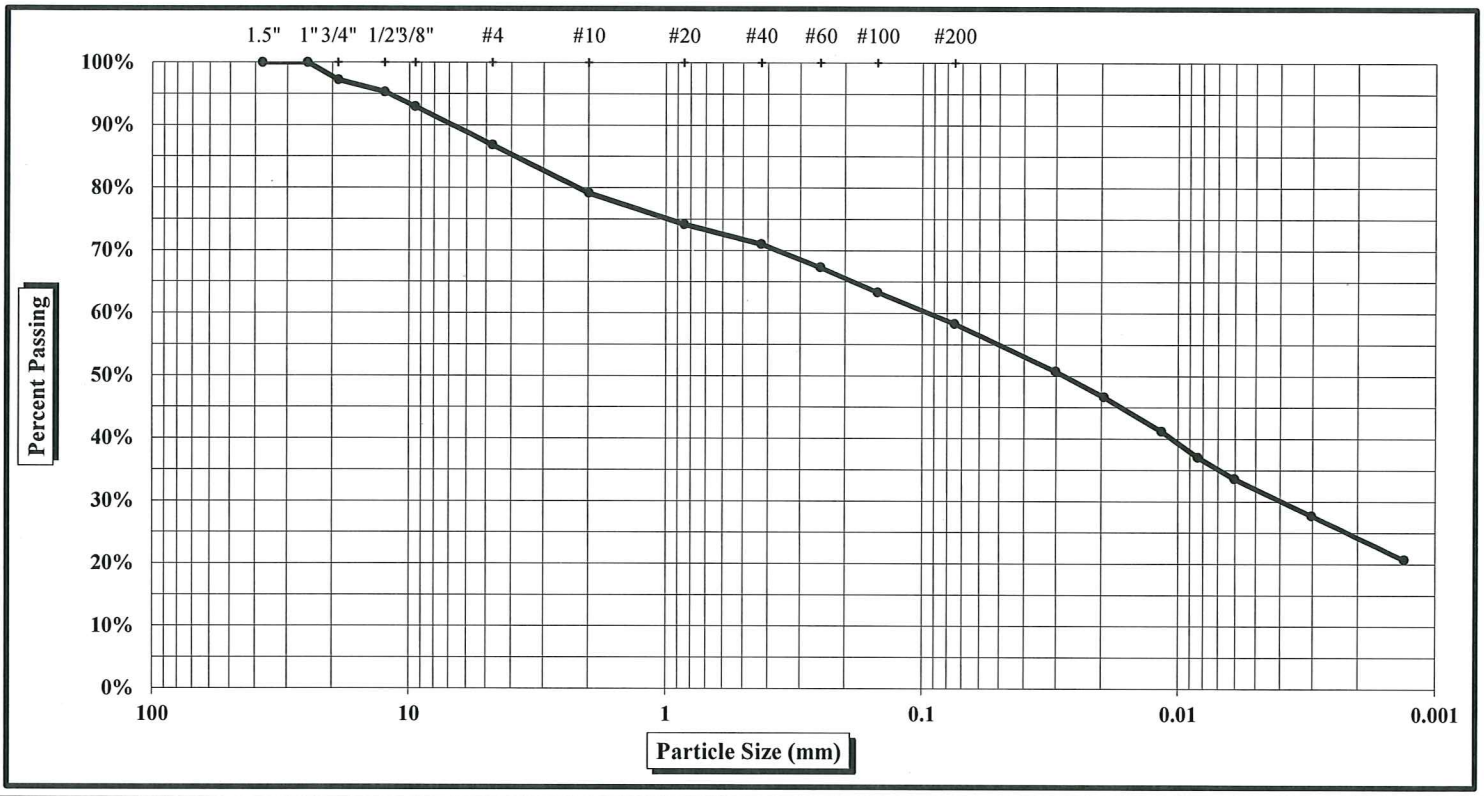
Laboratory Report Version 4.2

Particle Size Analysis of Soils

AASHTO T 88

S&ME Project #:	**1811-12-177A**	**Log#: 13-024**		Report Date:	3/22/2103
Project Name:	**State Route 29 Proposed Retaining Walls**			Test Date(s):	3/11-14/2013
Client Name:	Tennessee Department of Transportation				
Client Address:	6601 Centennial Boulevard, Nashville, TN 37243				

Boring #:	154+85	Sample #:	UD	Sample Date:	February 15, 2013
Location:	Station 154+85	Offset:	106 Feet Right	Depth:	4-6'
Sample Description:	Yellow-brown and brown sandy clay with rock fragments				



As Defined by AASHTO		Fine Sand	< 0.425 mm and > 0.075 mm
Gravel	< 75 mm and > 2.00 mm	Silt	< 0.075 and > 0.002 mm
Coarse Sand	< 2.00 mm and > 0.425 mm	Clay	< 0.002 mm

Gravel	20.8%	Coarse Sand	8.1%	Silt	34.1%
Maximum Particle Size	3/4"	Fine Sand	12.7%	Clay	24.2%
Apparent Relative Density	2.680	Moisture Content		Silt & Clay (% Passing #200)	58.3%
Liquid Limit	39	Plastic Limit	20	Plastic Index	19
AASHTO Classification	A-6	USCS Classification	CL		

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒ Hard & Durable ☒ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: AASHTO T88: Particle Size Analysis of Soils AASHTO T87: Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
AASHTO T89: Determining the Liquid Limit of Soils AASHTO T90: Determining the Plastic Limit & Plasticity Index of Soils
AASHTO M 145: The Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes ASTM D 854: Specific Gravity of Soils
AASHTO T265: Laboratory Determination of Moisture Content of Soils

Technical Responsibility: Jamie M. Hudson, PE *Signature* Senior Engineer *Signature*

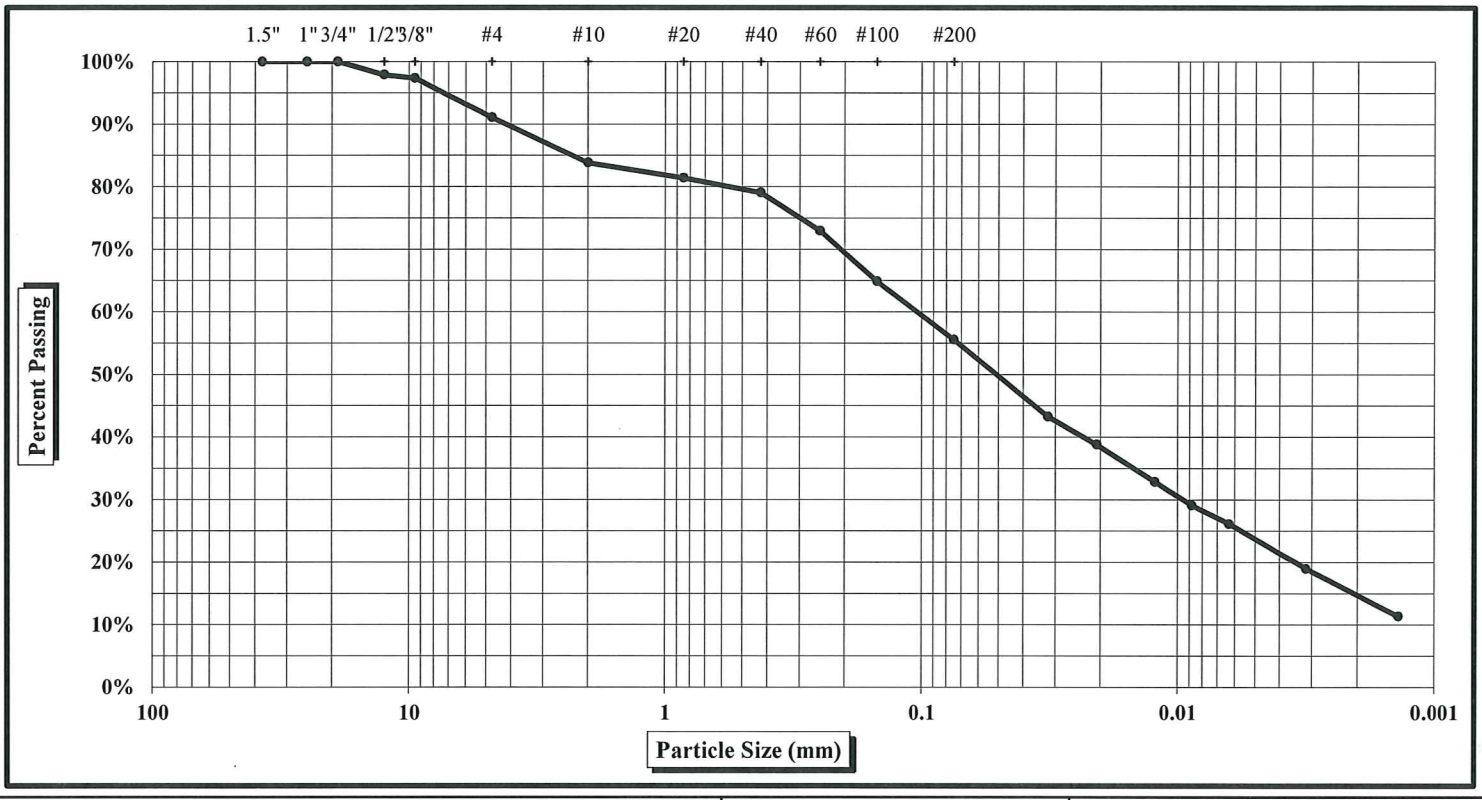
Laboratory Report Version 4.2

Particle Size Analysis of Soils

AASHTO T 88

S&ME Project #:	**1811-12-177A**	**Log#: 13-024**	Report Date: 3/22/2103
Project Name:	**State Route 29 Proposed Retaining Walls**		Test Date(s): 3/11-14/2013
Client Name:	Tennessee Department of Transportation		
Client Address:	6601 Centennial Boulevard, Nashville, TN 37243		

Boring #:	154+85	Sample #:	UD	Sample Date:	February 15, 2013
Location:	Station 154+85	Offset:	106 Feet Right	Depth:	14-16'
Sample Description:	Yellow-brown and gray sandy clay with rock fragments				



As Defined by AASHTO		Fine Sand	< 0.425 mm and > 0.075 mm
Gravel	< 75 mm and > 2.00 mm	Silt	< 0.075 and > 0.002 mm
Coarse Sand	< 2.00 mm and > 0.425 mm	Clay	< 0.002 mm

Gravel	16.2%	Coarse Sand	4.7%	Silt	40.9%
Maximum Particle Size	1/2"	Fine Sand	23.5%	Clay	14.7%
Apparent Relative Density	2.680	Moisture Content		Silt & Clay (% Passing #200)	55.6%
Liquid Limit	27	Plastic Limit	16	Plastic Index	11
AASHTO Classification	A-6	USCS Classification	CL		

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒ Hard & Durable ☒ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: AASHTO T88: Particle Size Analysis of Soils AASHTO T87: Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
AASHTO T89: Determining the Liquid Limit of Soils AASHTO T90: Determining the Plastic Limit & Plasticity Index of Soils
AASHTO M 145: The Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes ASTM D 854: Specific Gravity of Soils
AASHTO T265: Laboratory Determination of Moisture Content of Soils

Technical Responsibility: Jamie M. Hudson, PE *Signature* Senior Engineer *Signature*

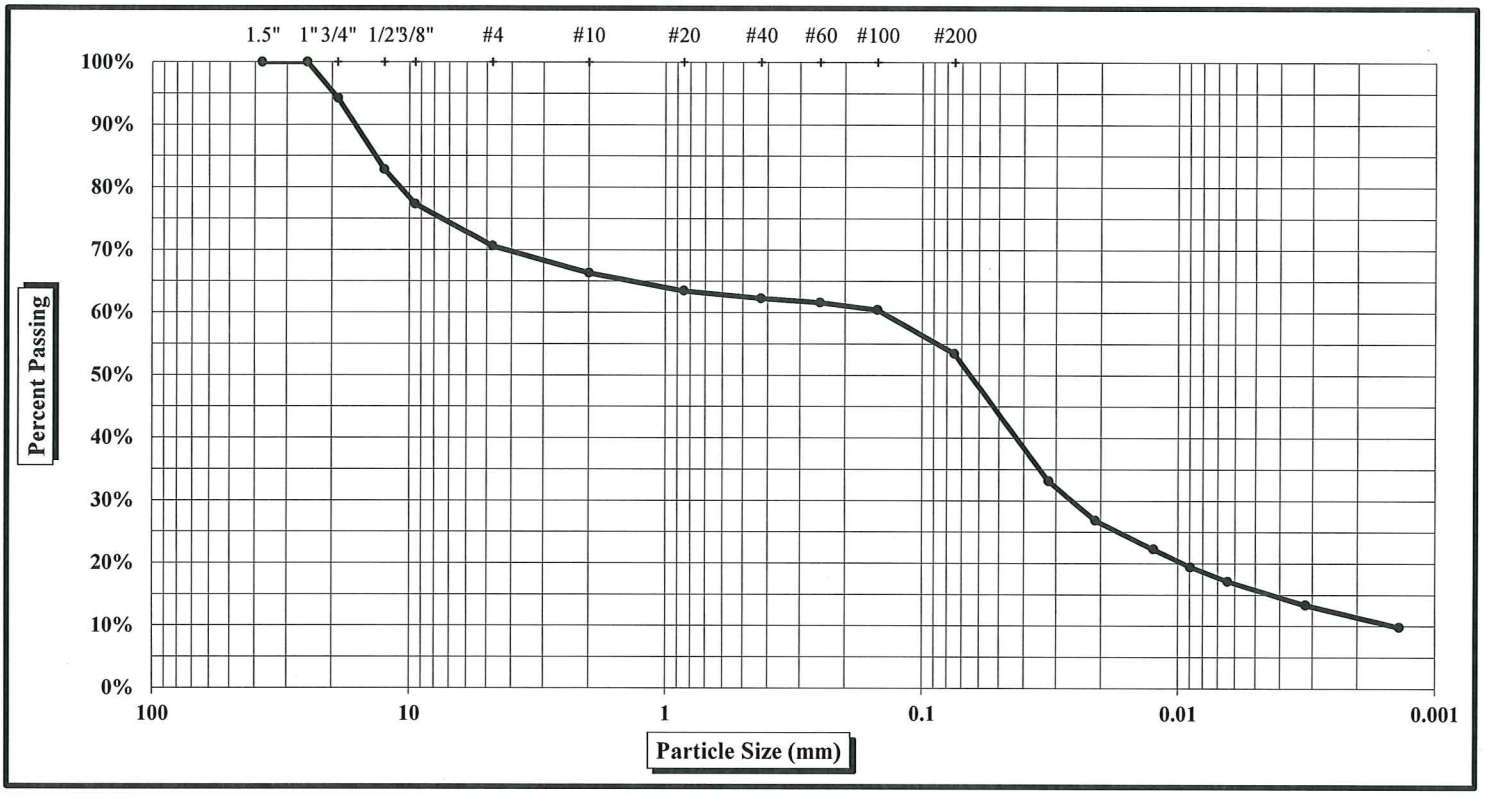
Laboratory Report Version 4.2

Particle Size Analysis of Soils

AASHTO T 88

S&ME Project #:	**1811-12-177A**	**Log#: 13-024**	Report Date: 3/22/2103
Project Name:	**State Route 29 Proposed Retaining Walls**		Test Date(s): 3/11-14/2013
Client Name:	Tennessee Department of Transportation		
Client Address:	6601 Centennial Boulevard, Nashville, TN 37243		

Boring #:	180+24	Sample #:	UD	Sample Date:	February 21, 2013
Location:	Station 180+24	Offset:	96 Feet Right	Depth:	2-4'
Sample Description:	Brown and gray sandy clay-sandy silt with rock fragments				



As Defined by AASHTO		Fine Sand	< 0.425 mm and > 0.075 mm
Gravel	< 75 mm and > 2.00 mm	Silt	< 0.075 and > 0.002 mm
Coarse Sand	< 2.00 mm and > 0.425 mm	Clay	< 0.002 mm

Gravel	33.7%	Coarse Sand	4.1%	Silt	42.1%
Maximum Particle Size	3/4"	Fine Sand	8.8%	Clay	11.4%
Apparent Relative Density	2.680	Moisture Content		Silt & Clay (% Passing #200)	53.5%
Liquid Limit	27	Plastic Limit	21	Plastic Index	6
AASHTO Classification	A-4	USCS Classification	CL-ML		

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒ Hard & Durable ☒ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: AASHTO T88: Particle Size Analysis of Soils AASHTO T87: Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
AASHTO T89: Determining the Liquid Limit of Soils AASHTO T90: Determining the Plastic Limit & Plasticity Index of Soils
AASHTO M 145: The Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes ASTM D 854: Specific Gravity of Soils
AASHTO T265: Laboratory Determination of Moisture Content of Soils

Technical Responsibility: Jamie M. Hudson, PE *Signature* Senior Engineer *Signature*

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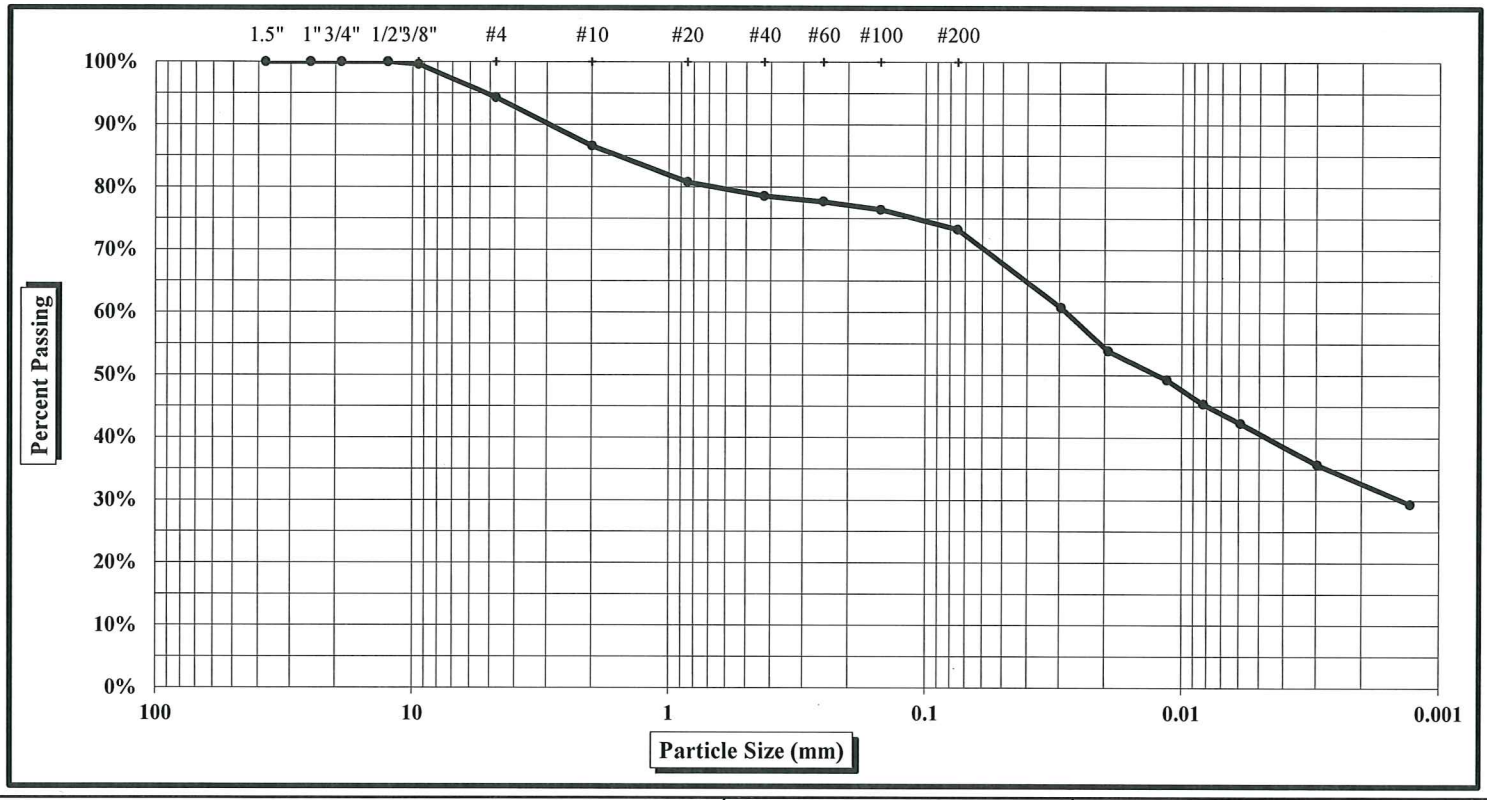
Laboratory Report Version 4.2

Particle Size Analysis of Soils

AASHTO T 88

S&ME Project #:	**1811-12-177A**	**Log#: 13-024**	Report Date: 3/22/2103
Project Name:	**State Route 29 Proposed Retaining Walls**		Test Date(s): 3/11-14/2013
Client Name:	Tennessee Department of Transportation		
Client Address:	6601 Centennial Boulevard, Nashville, TN 37243		

Boring #:	181+72	Sample #:	UD	Sample Date:	February 20, 2013
Location:	Station 181+72	Offset:	87 Feet Right	Depth:	6-8'
Sample Description:	Brown and red-brown silty clay with rock fragments				



As Defined by AASHTO		Fine Sand	< 0.425 mm and > 0.075 mm
Gravel	< 75 mm and > 2.00 mm	Silt	< 0.075 and > 0.002 mm
Coarse Sand	< 2.00 mm and > 0.425 mm	Clay	< 0.002 mm

Gravel	13.4%	Coarse Sand	8.0%	Silt	40.6%
Maximum Particle Size	3/8"	Fine Sand	5.3%	Clay	32.7%
Apparent Relative Density	2.680	Moisture Content	21.5%	Silt & Clay (% Passing #200)	73.3%
Liquid Limit	48	Plastic Limit	24	Plastic Index	24
AASHTO Classification	A-7-6	USCS Classification	CL		

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒ Hard & Durable ☒ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: AASHTO T88: Particle Size Analysis of Soils AASHTO T87: Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
AASHTO T89: Determining the Liquid Limit of Soils AASHTO T90: Determining the Plastic Limit & Plasticity Index of Soils
AASHTO M 145: The Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes ASTM D 854: Specific Gravity of Soils
AASHTO T265: Laboratory Determination of Moisture Content of Soils

Technical Responsibility: Jamie M. Hudson, PE *Signature* Senior Engineer *Signature*

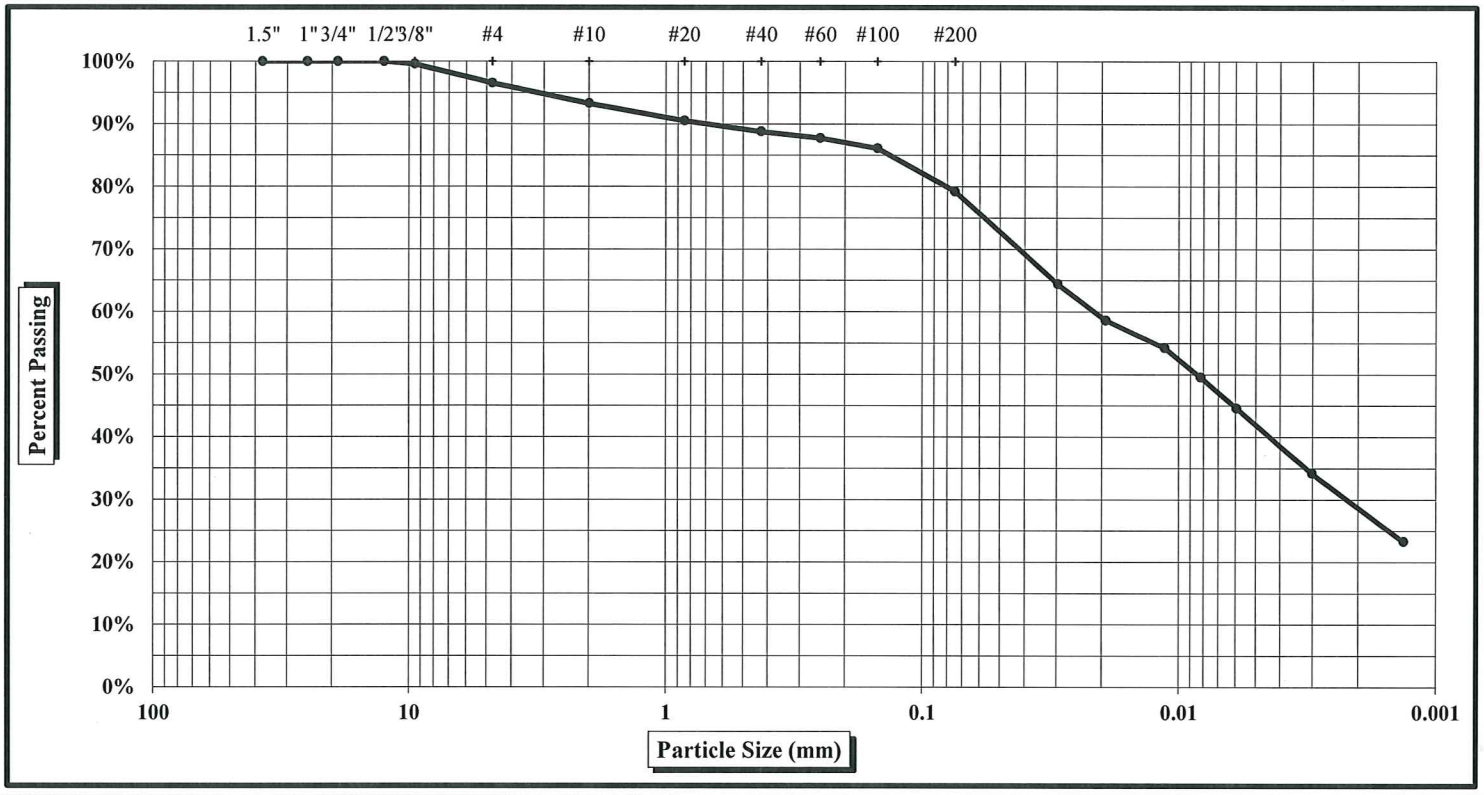
Laboratory Report Version 4.2

Particle Size Analysis of Soils

AASHTO T 88

S&ME Project #:	**1811-12-177A**	**Log#: 13-024**	Report Date: 3/22/2103
Project Name:	**State Route 29 Proposed Retaining Walls**		Test Date(s): 3/11-14/2013
Client Name:	Tennessee Department of Transportation		
Client Address:	6601 Centennial Boulevard, Nashville, TN 37243		

Boring #:	221+89	Sample #:	UD	Sample Date:	February 21, 2013
Location:	Station 221+89	Offset:	115 Feet Right	Depth:	7-8.1'
Sample Description:	Brown and yellow-brown sandy clay with rock fragments				



As Defined by AASHTO		Fine Sand	< 0.425 mm and > 0.075 mm
Gravel	< 75 mm and > 2.00 mm	Silt	< 0.075 and > 0.002 mm
Coarse Sand	< 2.00 mm and > 0.425 mm	Clay	< 0.002 mm

Gravel	6.7%	Coarse Sand	4.5%	Silt	50.5%
Maximum Particle Size	3/8"	Fine Sand	9.6%	Clay	28.7%
Apparent Relative Density	2.680	Moisture Content		Silt & Clay (% Passing #200)	79.2%
Liquid Limit	48	Plastic Limit	26	Plastic Index	22
AASHTO Classification	A-7-6	USCS Classification	CL		

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒ Hard & Durable ☒ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: AASHTO T88: Particle Size Analysis of Soils AASHTO T87: Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
AASHTO T89: Determining the Liquid Limit of Soils AASHTO T90: Determining the Plastic Limit & Plasticity Index of Soils
AASHTO M 145: The Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes ASTM D 854: Specific Gravity of Soils
AASHTO T265: Laboratory Determination of Moisture Content of Soils

Technical Responsibility: Jamie M. Hudson, PE *Signature* Senior Engineer *Signature*

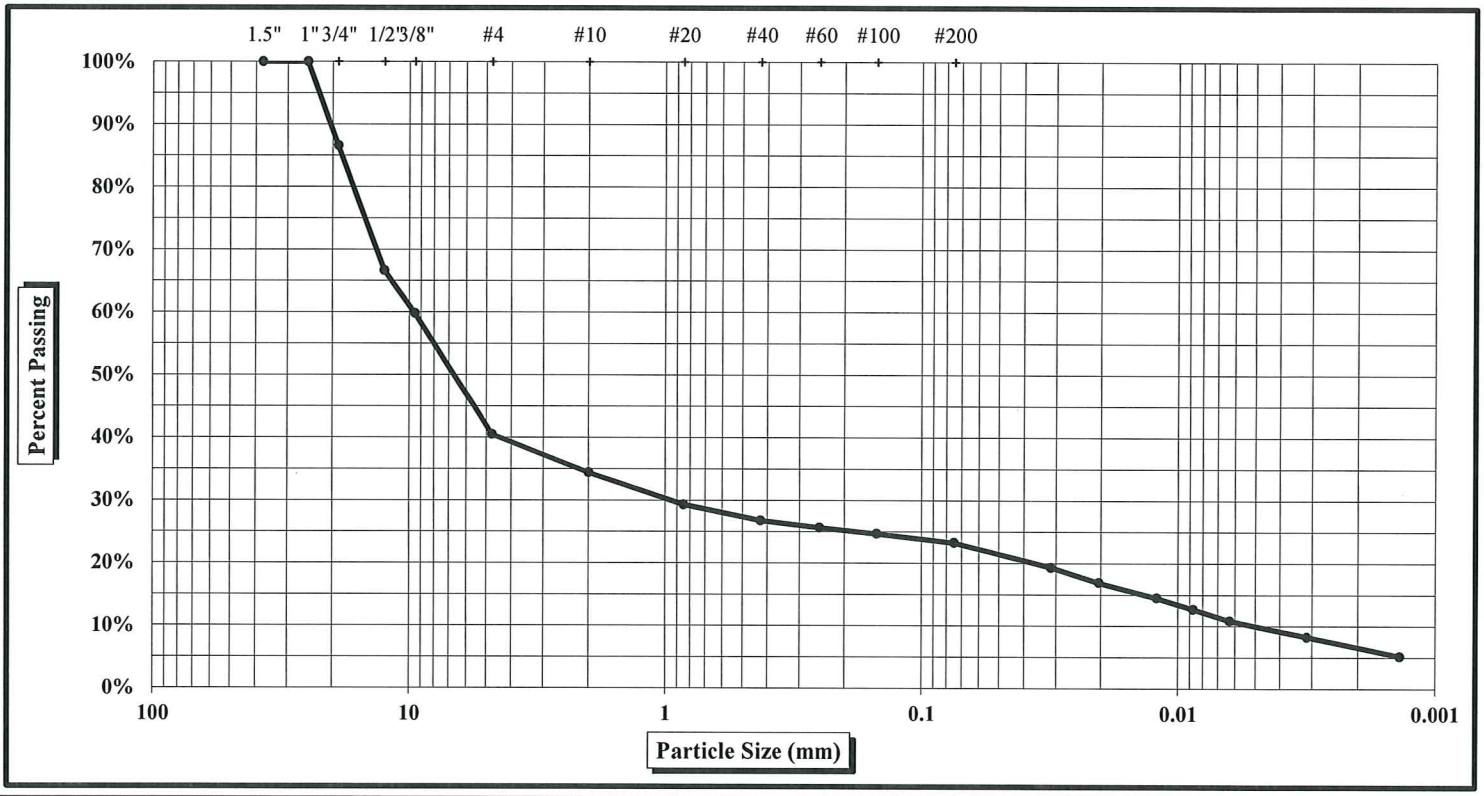
Laboratory Report Version 4.2

Particle Size Analysis of Soils

AASHTO T 88

S&ME Project #:	**1811-12-177A**	**Log#: 13-024**		Report Date:	3/22/2103
Project Name:	**State Route 29 Proposed Retaining Walls**			Test Date(s):	3/11-14/2013
Client Name:	Tennessee Department of Transportation				
Client Address:	6601 Centennial Boulevard, Nashville, TN 37243				

Boring #:	226+55	Sample #:	UD	Sample Date:	February 22, 2013
Location:	Station 226+55	Offset:	67 Feet Right	Depth:	4-6'
Sample Description:	Yellow-brown and brown sandy clay with rock fragments				



As Defined by AASHTO		Fine Sand	< 0.425 mm and > 0.075 mm
Gravel	< 75 mm and > 2.00 mm	Silt	< 0.075 and > 0.002 mm
Coarse Sand	< 2.00 mm and > 0.425 mm	Clay	< 0.002 mm

Gravel	65.6%	Coarse Sand	7.6%	Silt	16.6%
Maximum Particle Size	3/4"	Fine Sand	3.5%	Clay	6.6%
Apparent Relative Density	2.680	Moisture Content		Silt & Clay (% Passing #200)	23.2%
Liquid Limit	38	Plastic Limit	23	Plastic Index	15
AASHTO Classification	A-2-6	USCS Classification	CL		

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒ Hard & Durable ☐ Soft ☒ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: AASHTO T88: Particle Size Analysis of Soils AASHTO T87: Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
AASHTO T89: Determining the Liquid Limit of Soils AASHTO T90: Determining the Plastic Limit & Plasticity Index of Soils
AASHTO M 145: The Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes ASTM D 854: Specific Gravity of Soils
AASHTO T265: Laboratory Determination of Moisture Content of Soils

Technical Responsibility: Jamie M. Hudson, PE *Signature* Senior Engineer *Signature*

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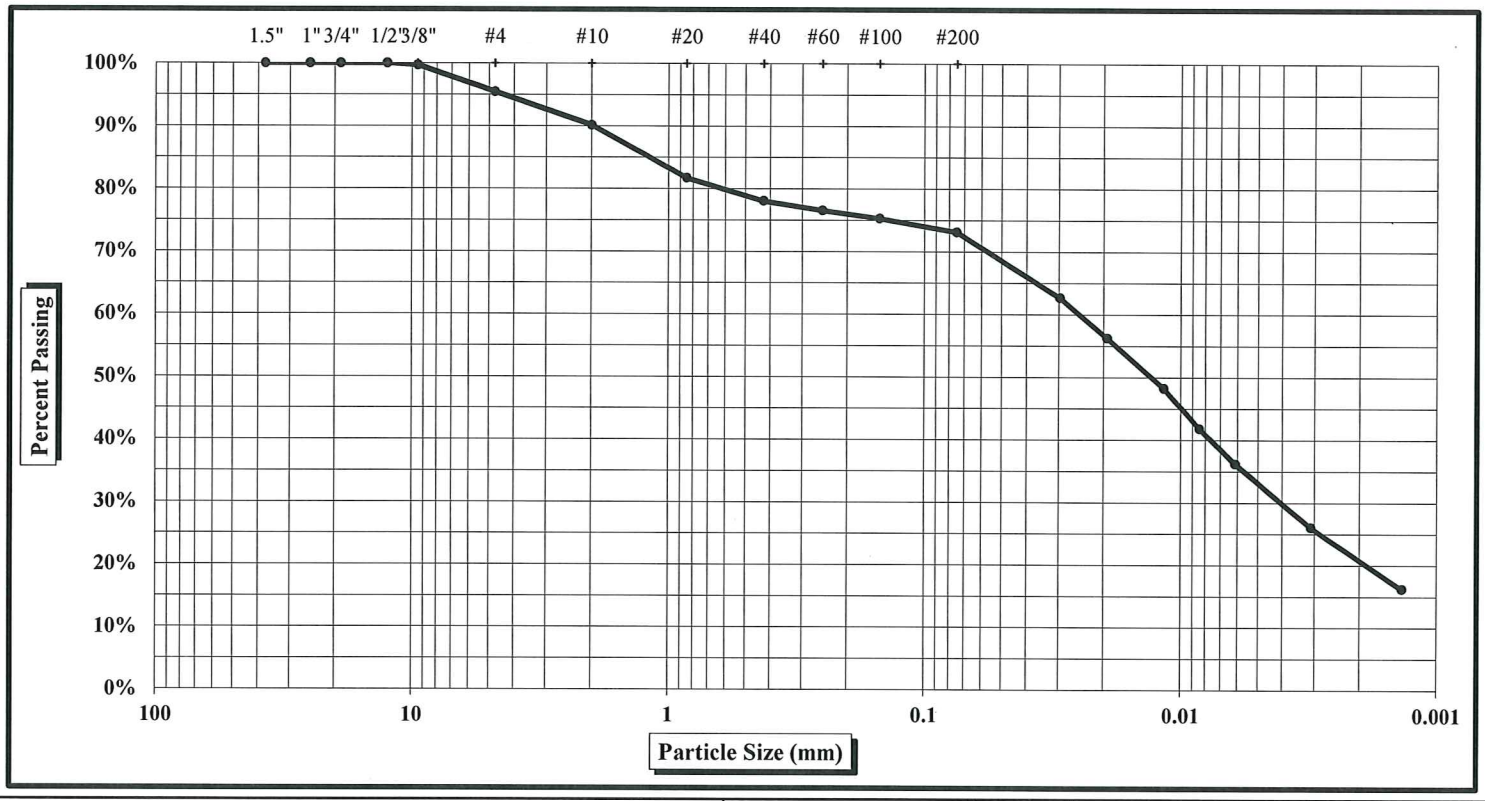
Laboratory Report Version 4.2

Particle Size Analysis of Soils

AASHTO T 88

S&ME Project #:	**1811-12-177A**	**Log#: 13-024**	Report Date: 3/22/2103
Project Name:	**State Route 29 Proposed Retaining Walls**		Test Date(s): 3/11-14/2013
Client Name:	Tennessee Department of Transportation		
Client Address:	6601 Centennial Boulevard, Nashville, TN 37243		

Boring #:	228+99	Sample #:	UD	Sample Date:	February 22, 2013
Location:	Station 228+99	Offset:	68 Feet Right	Depth:	2-4'
Sample Description:	Brown and yellow-brown sandy silt with rock fragments				



As Defined by AASHTO		Fine Sand	< 0.425 mm and > 0.075 mm
Gravel	< 75 mm and > 2.00 mm	Silt	< 0.075 and > 0.002 mm
Coarse Sand	< 2.00 mm and > 0.425 mm	Clay	< 0.002 mm

Gravel	9.9%	Coarse Sand	12.1%	Silt	52.3%
Maximum Particle Size	3/8"	Fine Sand	4.9%	Clay	20.8%
Apparent Relative Density	2.680	Moisture Content		Silt & Clay (% Passing #200)	73.1%
Liquid Limit	48	Plastic Limit	28	Plastic Index	20
AASHTO Classification	A-7-6	USCS Classification	ML		

Description of Sand & Gravel Particles: Rounded ☐ Angular ☒ Hard & Durable ☒ Soft ☐ Weathered & Friable ☐

Mechanical Stirring Apparatus (A) Length of Dispersion Period: 1 min. Dispersing Agent: Sodium Hexametaphosphate: 40 g./ Liter

References: AASHTO T88: Particle Size Analysis of Soils AASHTO T87: Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
AASHTO T89: Determining the Liquid Limit of Soils AASHTO T90: Determining the Plastic Limit & Plasticity Index of Soils
AASHTO M 145: The Classification of Soils and Soil Aggregate Mixtures for Highway Construction Purposes ASTM D 854: Specific Gravity of Soils
AASHTO T265: Laboratory Determination of Moisture Content of Soils

Technical Responsibility: Jamie M. Hudson, PE *Signature* Senior Engineer *Signature*

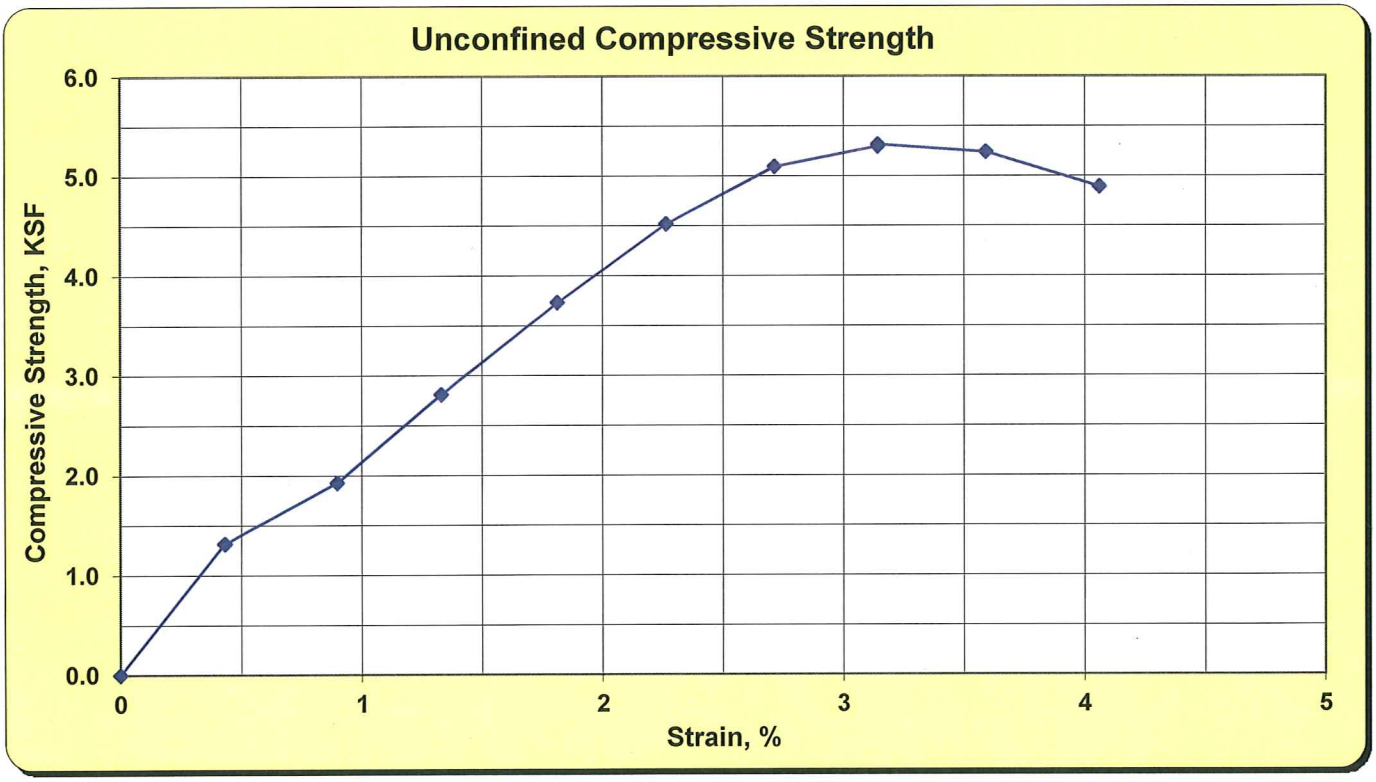
Unconfined Compressive Strength of Cohesive Soil

ASTM D2166-06

S&ME

S&ME, Inc. - Chattanooga 4291 Hwy 58, Suite 101 Chattanooga, TN 37416

Project No.:	1811-12-177A	**Log #: 13-024**		Report Date:	3/11/2013
Project Name:	State Route 29 Proposed Retaining Walls			Test Date(s):	3/8/2013
Client Name:	Tennessee Department of Transportation				
Client Address:	6601 Centennial Boulevard, Nashville, TN 37243				
Boring #:	Station 181+72, 87' R	Sample #:	UD	Sample Date:	2/20/2013
Location:	On-Site Boring	Offset:	-	Depth:	6-8'
Sample Description:	Brown and red-brown silty clay with rock fragments				



Wet Unit Weight, lbs/ft^3	**128.1**
Dry Unit Weight, lbs/ft^3	**105.4**
Moisture Content of sample, %	**21.5**
Unconfined Compressive Strenth, q_u, KSF	**5.32**
Undrained Shear Strength, s_u, KSF	**2.66**
Height to Diameter Ratio	**1.9**
Rate of Strain, in/min.	**0.05**
Strain at Failure, %	**3.13**
Liquid Limit	**48**
Plastic Limit	**24**
Plasticity Index	**24**
USCS Classification	**CL**

References / Comments / Deviations:

Jamie M. Hudson, PE		Senior Engineer	3/11/2013
Technical Responsibility	*Signature*	*Position*	*Date*

State Route 29 Improvements

Acid Base Accounting Laboratory Test Results Summary

APR - encapsulation required

APR - blending or partial encapsulation required

Potential APR - blending required

Station Number with Offset	Sample Depth/Approximate Elevation (feet/feet msl)	Sample Type	Paste pH	Neutralization Potential*	Potential Acidity*	CaCO3 (Def)/Sur*	Fizz	Total Sulfur (%)	Pyritic Sulfur (%)	NNP	NPR	Classification
State Route 29 Station 154+90, 106 feet right	1.5-3 / 783.5	Soil	5.09	3.56	0.4	3.2	None	0.013	0.039	3.16	8.90	
	6.5-8 / 778.5	Soil	4.87	0.00	0.4	-0.4	None	0.013	0.029	-0.4	0.00	APR
	14-15.5 / 771	Soil	5.35	1.58	0.14	1.4	None	0.005	0.039	1.44	11.29	
	19-20.5 / 766	Soil	6.38	3.42	0.19	3.2	None	0.006	0.087	3.23	18.00	
	24-24.5 / 761	Soil	7.80	11.27	0.38	10.9	Slight	0.012	0.037	10.89	29.66	
	26.5-27 / 758.5	Rock	7.52	4.73	0.13	4.6	None	0.004	0.025	4.6	36.38	
	33.5-34 / 751.5	Rock	8.44	3.08	0.24	2.8	None	0.008	0.018	2.84	12.83	
State Route 29 Station 156+33, 95 feet right	4-4.5 / 781	Soil	4.67	1.29	0.42	0.9	None	0.013	0.022	0.87	3.07	APR
	6.5-7 / 778.5	Soil	5.57	0.72	0.08	0.6	None	0.002	0.007	0.64	9.00	
	11-11.5 / 774	Rock	5.63	32.94	0.08	32.9	None	0.002	0.008	32.86	411.75	
	15.5-15.9 / 769.5	Rock	7.22	23.85	1.29	22.56	None	0.041	0.069	22.56	18.49	
	23.5-24 / 761.5	Rock	7.84	22.86	4.81	18.1	None	0.154	0.177	18.05	4.75	
	26-26.5 / 759	Rock	8.14	26.77	3.24	23.5	None	0.104	0.140	23.53	8.26	

*Tons of $CaCO_3$ per 1,000 tons of material

State Route 29 Improvements

Acid Base Accounting Laboratory Test Results Summary

APR - encapsulation required

APR - blending or partial encapsulation required

Potential APR - blending required

Station Number with Offset	Sample Depth/Approximate Elevation (feet/feet msl)	Sample Type	Paste pH	Neutralization Potential*	Potential Acidity*	CaCO3 (Def)/Sur*	Fizz	Total Sulfur (%)	Pyritic Sulfur (%)	NNP	NPR	Classification
State Route 29 Station 160+00, 150 feet right	0-1.5 / 873-871.5	Soil	5.08	0.24	0.22	0	None	0.007	0.009	0.02	1.09	
	6.5-8 / 866.5-865	Soil	5.23	0.19	0.19	0	None	0.006	0.005	0.00	1.00	
	11.8-12.3 / 861.2-860.7	Rock	5.51	0.23	0.16	0.1	None	0.005	0.005	0.07	1.44	
	19.2-19.7 / 853.8-853.3	Rock	5.64	0.16	0.09	0.1	None	0.003	0.003	0.07	1.78	
	21.5-22 / 851.5-851	Rock	5.88	0.38	0.03	0.3	None	0.001	0.003	0.35	12.67	
	28-28.5 / 845-844.5	Rock	6.34	0.43	0.06	0.37	None	0.002	0.004	0.37	7.17	
	32.5-33 / 840.5-840	Rock	5.89	0.55	0.09	0.5	None	0.003	0.007	0.46	6.11	
	38-38.5 / 835-834.5	Rock	6.51	0.44	0.44	0	None	0.014	0.014	0.00	1.00	
	43.5-44 / 829.5-829	Rock	6.60	0.45	0.06	0.4	None	0.002	0.006	0.39	7.50	
	48.5-49 / 824.5-824	Rock	6.79	0.00	0.94	-0.9	None	0.030	0.000	-0.94	0.00	
	51-51.5 / 822-821.5	Rock	6.39	0.00	0.81	-0.8	None	0.026	0.028	-0.81	0.00	
	56-56.5 / 817-816.5	Rock	6.02	2.86	3.94	-1.1	None	0.126	0.134	-1.08	0.73	APR
	61.1-61.6 / 811.9-811.4	Rock	6.62	1.18	2.13	-0.9	None	0.068	0.070	-0.95	0.55	
	66.5-67 / 806.5-806	Rock	7.12	0.49	0.15	0.3	None	0.005	0.005	0.34	3.27	
	72.9-73.4 / 800.1-799.6	Rock	7.47	1.10	0.25	0.9	None	0.008	0.011	0.85	4.40	
	78.3-78.8 / 794.7-794.2	Rock	7.26	0.66	0.16	0.5	None	0.005	0.004	0.50	4.13	
	80.8-81.3 / 792.2-791.7	Rock	7.33	0.65	0.16	0.5	None	0.005	0.005	0.49	4.06	
	86.5-87 / 796.5-786	Rock	6.92	1.01	0.28	0.7	None	0.009	0.011	0.73	3.61	
	93.4-93.9 / 779.6-779.1	Rock	7.43	1.55	0.44	1.1	None	0.014	0.017	1.11	3.52	
	96.5-97 / 776.5-776	Rock	7.04	0.46	0.09	0.4	None	0.003	0.004	0.37	5.11	
	102.7-103.2 / 770.3-769.8	Rock	7.39	1.92	0.59	1.3	None	0.019	0.031	1.33	3.25	
	108.3-108.8 / 764.7-764.2	Rock	7.08	0.85	0.16	0.7	None	0.005	0.007	0.69	5.31	
	110-110.5 / 763-762.5	Rock	6.41	3.38	0.81	2.6	None	0.026	0.056	2.57	4.17	
	115-115.5 / 758-757.5	Rock	6.16	1.02	1.59	-0.6	None	0.051	0.040	-0.57	0.64	
	121.5-122 / 751.5-751	Rock	6.37	1.27	0.38	0.9	None	0.012	0.024	0.89	3.34	
	127.5-128 / 745.5-745	Rock	6.50	1.65	0.16	1.5	None	0.005	0.019	1.49	10.31	

*Tons of $CaCO_3$ per 1,000 tons of material

State Route 29 Improvements

Acid Base Accounting Laboratory Test Results Summary

APR - encapsulation required

APR - blending or partial encapsulation required

Potential APR - blending required

Station Number with Offset	Sample Depth/Approximate Elevation (feet/feet msl)	Sample Type	Paste pH	Neutralization Potential*	Potential Acidity*	CaCO3 (Def)/Sur*	Fizz	Total Sulfur (%)	Pyritic Sulfur (%)	NNP	NPR	Classification
State Route 29 Station 161+23, 170 feet right	4-5.5 / 878	Soil	5.19	0.47	0.12	0.3	None	0.004	0.014	0.35	3.92	
	9-10.5 / 873	Soil	5.23	0.44	0.08	0.4	None	0.003	0.014	0.36	5.50	
	14-15.5 / 868	Soil	5.46	1.66	0.09	1.6	None	0.003	0.013	1.57	18.44	
	20.9-21.4 / 861.1	Rock	6.13	0.68	0.08	0.6	None	0.003	0.008	0.60	8.50	
	23.7-24.2 / 858.3	Rock	6.17	0.72	0.07	0.6	None	0.002	0.012	0.65	10.29	
	27.7-28.2 / 854.3	Rock	6.14	0.87	0.09	0.8	None	0.003	0.008	0.78	9.67	
	30.2-30.7 / 851.8	Rock	6.33	0.85	0.08	0.8	None	0.003	0.005	0.77	10.63	
	36.2-36.7 / 845.8	Rock	6.40	0.89	0.08	0.8	None	0.003	0.006	0.81	11.13	
	45.5-46 / 836.5	Soil and Rock	6.11	3.42	0.09	3.3	None	0.003	0.013	3.33	38.00	
	46.7-47.2 / 835.3	Soil and Rock	6.34	3.47	0.11	3.36	None	0.004	0.014	3.36	31.55	
	55.5-56 / 826.5	Soil and Rock	6.69	6.11	1.36	4.8	None	0.043	0.062	4.75	4.49	
	56.2-56.7 / 825.8	Soil and Rock	7.25	5.14	4.67	0.5	None	0.149	0.197	0.47	1.10	Potential APR
	70.2-70.7 / 811.8	Rock	6.99	5.12	7.99	-2.9	None	0.256	0.253	-2.87	0.64	APR
	74.9-75.4 / 807.1	Rock	5.89	2.62	7.02	-4.4	None	0.225	0.181	-4.40	0.37	APR
	77.7-78.2 / 804.3	Rock	6.47	3.48	2.01	1.5	None	0.064	0.076	1.47	1.73	
	83.1-83.6 / 798.9	Rock	6.99	3.55	0.53	3	None	0.017	0.027	3.02	6.70	
	89-89.5 / 793	Rock	7.04	1.19	0.72	0.5	None	0.023	0.023	0.47	1.65	
	94.2-94.7 / 787.8	Rock	6.32	0.79	1.32	-0.5	None	0.042	0.020	-0.53	0.60	
	96.9-97.4 / 785.1	Rock	7.19	1.56	4.79	-3.2	None	0.153	0.144	-3.23	0.33	APR
	103.7-104.2 / 778.3	Soil and Rock	7.24	8.75	2.5	6.3	None	0.080	0.123	6.25	3.50	Potential APR
	106.2-106.7 / 775.8	Rock	7.85	6.07	1.02	5	None	0.033	0.062	5.05	5.95	
	112.2-112.7 / 769.8	Rock	8.22	3.40	1.32	2.1	None	0.042	0.112	2.08	2.58	Potential APR
	117.5-118 / 764.5	Rock	8.31	3.08	2.39	0.7	None	0.076	0.064	0.69	1.29	
	122.2-122.7 / 759.8	Rock	8.25	1.75	0.25	1.5	None	0.008	0.020	1.50	7.00	
	129-129.5 / 753	Rock	8.36	1.57	0.12	1.5	None	0.004	0.008	1.45	13.08	

*Tons of $CaCO_3$ per 1,000 tons of material

State Route 29 Improvements

Acid Base Accounting Laboratory Test Results Summary

APR - encapsulation required

APR - blending or partial encapsulation required

Potential APR - blending required

Station Number with Offset	Sample Depth/Approximate Elevation (feet/feet msl)	Sample Type	Paste pH	Neutralization Potential*	Potential Acidity*	CaCO3 (Def)/Sur*	Fizz	Total Sulfur (%)	Pyritic Sulfur (%)	NNP	NPR	Classification
State Route 29 Station 163+26, 165 feet right	0-1.5 / 890-888.5	Soil	5.24	0.74	0.28	0.5	None	0.009	0.020	0.46	2.64	
	9.9-10.4 / 880.1-879.6	Rock	6.06	0.24	0.06	0.2	None	0.002	0.010	0.18	4.00	
	16.8-17.3 / 873.2-872.7	Rock	5.89	0.34	0.06	0.3	None	0.002	0.004	0.28	5.67	
	21.5-22.0 / 868.5-868	Rock	5.52	2.20	0.09	2.1	None	0.003	0.020	2.11	24.44	
	25.5-26.0 / 864.5-864	Rock	6.77	0.77	0.02	0.75	None	0.001	0.001	0.75	38.50	
	29-29.5 / 861-860.5	Rock	6.41	1.78	0.09	1.7	None	0.003	0.009	1.69	19.78	
	38-38.5 / 852-851.5	Rock	6.98	1.31	1.66	-0.3	None	0.053	0.022	-0.35	0.79	
	41-41.5 / 849-848.5	Rock	7.18	1.03	0.34	0.7	None	0.011	0.011	0.69	3.03	
	46.5-47 / 843.5-843	Rock	7.33	0.54	0.5	0	None	0.016	0.011	0.04	1.08	
	52-52.5 / 838-837.5	Rock	7.45	1.16	0.34	0.8	None	0.011	0.012	0.82	3.41	
	56.5-57 / 833.5-833	Rock	7.33	0.67	0.03	0.6	None	0.001	0.002	0.64	22.33	
	60-60.5 / 830-829.5	Rock	6.55	0.87	0.34	0.5	None	0.011	0.010	0.53	2.56	
	66-66.5 / 824-823.5	Rock	7.22	0.72	0.09	0.6	None	0.003	0.002	0.63	8.00	
	72-72.5 / 818-817.5	Rock	7.43	0.95	0.03	0.9	None	0.001	0.001	0.92	31.67	
	74.5-75 / 815.5-815	Rock	7.37	0.80	0.06	0.7	None	0.002	0.003	0.74	13.33	
	81.4-81.9 / 808.6-808.1	Rock	5.95	0.85	12.59	-11.7	None	0.403	0.360	-11.74	0.07	APR
	84.7-85.2 / 805.3-804.8	Rock	7.16	0.73	0.22	0.5	None	0.007	0.006	0.51	3.32	
	92-92.5 / 798-797.5	Rock	7.42	1.13	0.25	0.9	None	0.008	0.008	0.88	4.52	
	96-96.5 / 794-793.5	Rock	6.67	0.72	9.69	-8.97	None	0.310	0.178	-8.97	0.07	APR
	99.5-100 / 790.5-790	Rock	7.11	0.93	0.19	0.7	None	0.006	0.007	0.74	4.89	
	106.5-107 / 783.5-783	Rock	6.74	0.60	3.28	-2.7	None	0.105	0.095	-2.68	0.18	
	110-110.5 / 780-779.5	Rock	6.81	0.55	0.66	-0.1	None	0.021	0.014	-0.11	0.83	
	114.5-115 / 775.5-775	Rock	6.87	0.81	2	-1.2	None	0.064	0.066	-1.19	0.41	
	121.6-122.1 / 768.4-767.9	Rock	7.18	1.26	0.97	0.3	None	0.031	0.034	0.29	1.30	
	128-128.5 / 762-761.5	Rock	7.37	0.76	0.19	0.6	None	0.006	0.004	0.57	4.00	
	131.9-132.4 / 758.1-757.6	Rock	7.22	1.29	0.47	0.8	None	0.015	0.020	0.82	2.74	

*Tons of $CaCO_3$ per 1,000 tons of material

State Route 29 Improvements

Acid Base Accounting Laboratory Test Results Summary

APR - encapsulation required

APR - blending or partial encapsulation required

Potential APR - blending required

Station Number with Offset	Sample Depth/Approximate Elevation (feet/feet msl)	Sample Type	Paste pH	Neutralization Potential*	Potential Acidity*	CaCO3 (Def)/Sur*	Fizz	Total Sulfur (%)	Pyritic Sulfur (%)	NNP	NPR	Classification
State Route 29 Station 166+00 157 feet right	2.5-3 / 908.5-908	Soil and Rock	5.40	0.35	0.19	0.2	None	0.006	0.010	0.16	1.84	
	7.8-8.3 / 903.2-902.7	Rock	5.43	0.15	0.06	0.1	None	0.002	0.003	0.09	2.50	
	15.1-15.6 / 895.9-895.4	Rock	6.32	0.76	0.06	0.7	None	0.002	0.002	0.70	12.67	
	19-19.5 / 892-891.5	Rock	6.69	1.02	0.06	0.96	None	0.002	0.003	0.96	17.00	
	24.4-24.9 / 886.6-886.1	Rock	6.77	1.43	0.06	1.4	None	0.002	0.007	1.37	23.83	
	29.3-29.8 / 881.7-881.2	Rock	6.89	0.99	0.06	0.9	None	0.002	0.004	0.93	16.50	
	33.8-34.3 / 877.2-876.7	Rock	6.76	0.70	0.06	0.6	None	0.002	0.002	0.64	11.67	
	39.3-39.8 / 871.7-871.2	Rock	7.27	0.69	0.06	0.6	None	0.002	0.001	0.63	11.50	
	44.5-45 / 866.5-866	Rock	7.07	0.52	0.06	0.5	None	0.002	0.003	0.46	8.67	
	49.3-49.8 / 861.7-861.2	Rock	7.15	0.71	0.06	0.6	None	0.002	0.003	0.65	11.83	
	53-53.5 / 858-857.5	Rock	7.19	1.25	0.13	1.1	None	0.004	0.004	1.12	9.62	
	57-57.5 / 854-853.5	Rock	7.08	1.32	0.03	1.3	None	0.001	0.003	1.29	44.00	
	64.4-64.9 / 846.6-846.1	Rock	7.27	1.42	0.06	1.4	None	0.002	0.004	1.36	23.67	
	69.8-70.3 / 841.2-840.7	Rock	7.25	0.82	0.06	0.8	None	0.002	0.002	0.76	13.67	
	75.3-75.8 / 835.7-835.2	Rock	7.15	0.64	0.06	0.6	None	0.002	0.001	0.58	10.67	
	80-80.5 / 831-830.5	Rock	6.99	0.63	0.69	-0.1	None	0.022	0.014	-0.06	0.91	
	83.3-83.8 / 827.7-827.2	Rock	7.52	0.53	0.19	0.3	None	0.006	0.004	0.34	2.83	
	87.8-88.3 / 823.2-822.7	Rock	7.45	0.83	0.22	0.6	None	0.007	0.010	0.61	3.79	
	95.3-95.8 / 815.7-815.2	Rock	7.57	0.96	0.34	0.6	None	0.011	0.009	0.62	2.79	
	99.8-100.3 / 811.2-810.7	Rock	7.23	0.77	0.06	0.71	None	0.002	0.002	0.71	12.32	
	103.3-103.8 / 807.7-807.2	Rock	7.32	0.89	1.31	-0.4	None	0.042	0.032	-0.42	0.68	
	109.3-109.8 / 801.7-801.2	Rock	7.50	0.80	0.44	0.4	None	0.014	0.010	0.36	1.83	
	113.3-113.8 / 797.7-797.2	Rock	7.47	0.45	0.06	0.4	None	0.002	0.003	0.39	7.20	
	117.8-118.3 / 793.2-792.7	Rock	7.16	0.48	0.06	0.4	None	0.002	0.001	0.42	7.68	
	123.3-123.8 / 787.7-787.2	Rock	7.06	0.54	0.03	0.5	None	0.001	0.002	0.51	17.28	
	129.3-129.8 / 781.7-781.2	Rock	7.17	0.21	0.53	-0.3	None	0.017	0.018	-0.32	0.40	
	133.8-134.3 / 777.2-776.7	Rock	7.33	1.94	10.97	-9.0	None	0.351	0.140	-9.03	0.18	APR
	140.7-141.2 / 770.3-769.8	Rock	7.34	0.29	8.00	-7.7	None	0.256	0.024	-7.71	0.04	
	143.5-144 / 767.5-767	Rock	6.76	0.57	7.16	-6.6	None	0.229	0.144	-6.59	0.08	APR
	148.5-149 / 762.5-762	Rock	8.26	1.92	66.25	-64.3	None	2.120	1.660	-64.33	0.03	APR
	152.5-153 / 758.5-758	Rock	8.12	2.43	0.47	2.0	None	0.015	0.015	1.96	5.18	

*Tons of $CaCO_3$ per 1,000 tons of material

State Route 29 Improvements

Acid Base Accounting Laboratory Test Results Summary

APR - encapsulation required

APR - blending or partial encapsulation required

Potential APR - blending required

Station Number with Offset	Sample Depth/Approximate Elevation (feet/feet msl)	Sample Type	Paste pH	Neutralization Potential*	Potential Acidity*	CaCO3 (Def)/Sur*	Fizz	Total Sulfur (%)	Pyritic Sulfur (%)	NNP	NPR	Classification
State Route 29 Station 168+00, 170 feet right/Coal Hill Road Station 41+67, 26 feet right	1.5-3 / 902.5-901	Soil	5.38	0.14	0.5	-0.4	None	0.016	0.014	-0.36	0.28	
	9.5-10 / 894.5-893	Rock	5.17	0.47	1.84	-1.37	None	0.059	0.035	-1.37	0.26	
	12.5-13 / 891.5-891	Rock	5.84	0.90	0.09	0.8	None	0.003	0.007	0.81	10.00	
	18.5-19 / 885.5-885	Rock	7.01	1.15	0.53	0.6	None	0.017	0.016	0.62	2.17	
	21.3-21.8 / 882.7-882.2	Rock	7.11	1.37	0.06	1.3	None	0.002	0.004	1.31	22.83	
	28.5-29 / 875.5-875	Rock	7.25	1.60	0.63	1	None	0.020	0.023	0.97	2.54	
	34.5-35 / 869.5-869	Rock	7.09	1.14	0.13	1	None	0.004	0.002	1.01	8.77	
	39-39.5 / 865-864.5	Rock	6.76	0.80	0.09	0.7	None	0.003	0.004	0.71	8.89	
	42.5-43 / 861.5-861	Rock	7.16	1.12	0.06	1.1	None	0.002	0.003	1.06	18.67	
	46.8-47.4 / 857.2-856.7	Rock	6.65	1.79	0.09	1.7	None	0.003	0.006	1.70	19.89	
	52.1-52.6 / 851.9-851.4	Rock	5.92	0.80	0.09	0.7	None	0.003	0.002	0.71	8.89	
	66.5-67 / 837.5-837	Rock	6.94	0.86	0.06	0.8	None	0.002	0.002	0.80	14.33	
	71-71.5 / 833-832.5	Rock	7.71	0.77	0.06	0.7	None	0.002	0.003	0.71	12.83	
	57.5-58 / 846.5-846	Rock	7.64	1.73	0.06	1.7	None	0.002	0.011	1.67	28.83	
	63.9-64.4 / 840.1-839.6	Rock	7.35	0.89	0.06	0.8	None	0.002	0.007	0.83	14.83	
	77-77.5 / 827-826.5	Rock	7.36	0.82	0.06	0.8	None	0.002	0.004	0.76	13.67	
	82.3-82.8 / 821.7-821.2	Rock	7.52	0.72	0.09	0.6	None	0.003	0.016	0.63	8.00	
	86.5-87 / 817.5-817	Rock	7.53	0.94	0.03	0.91	None	0.001	0.006	0.91	31.33	
	94.5-95 / 809.5-809	Rock	6.71	0.63	0.25	0.4	None	0.008	0.006	0.38	2.52	
	96.5-97 / 807.5-807	Rock	6.86	0.61	0.41	0.2	None	0.013	0.009	0.20	1.49	
	101-101.5 / 803-802.5	Rock	7.15	0.58	0.44	0.1	None	0.014	0.010	0.14	1.32	
	107.5-108 / 796.5-796	Rock	6.81	0.96	2.13	-1.2	None	0.068	0.055	-1.17	0.45	
	111-111.5 / 793-792.5	Rock	7.41	0.60	0.34	0.3	None	0.011	0.008	0.26	1.76	
	118.5-119 / 785.5-785	Rock	7.27	0.65	0.22	0.4	None	0.007	0.004	0.43	2.95	
	124.5-125 / 779.5-779	Rock	7.55	0.75	0.25	0.5	None	0.008	0.008	0.50	3.00	
	127.8-128.3 / 776.2-775.7	Rock	7.27	0.71	0.25	0.5	None	0.008	0.007	0.46	2.84	
	134.5-135 / 769.5-769	Rock	6.97	0.64	0.25	0.4	None	0.008	0.005	0.39	2.56	
	137.3-137.8 / 766.7-766.2	Rock	6.68	0.59	0.44	0.2	None	0.014	0.007	0.15	1.34	

*Tons of $CaCO_3$ per 1,000 tons of material

State Route 29 Improvements

Acid Base Accounting Laboratory Test Results Summary

APR - encapsulation required

APR - blending or partial encapsulation required

Potential APR - blending required

Station Number with Offset	Sample Depth/Approximate Elevation (feet/feet msl)	Sample Type	Paste pH	Neutralization Potential*	Potential Acidity*	CaCO3 (Def)/Sur*	Fizz	Total Sulfur (%)	Pyritic Sulfur (%)	NNP	NPR	Classification
Coal Hill Road Station 43+68, 12 feet right	4-5.5 / 874	Soil	4.96	0.48	0.28	0.2	None	0.009	0.061	0.2	1.71	APR
	9-10.5 / 869	Soil	5.01	0.69	4	-3.3	None	0.128	0.121	-3.31	0.17	APR
	14-15.5 / 864	Soil and Rock	5.20	1.99	7.88	-5.9	None	0.252	0.272	-5.89	0.25	APR
	19-20.5 / 859	Soil and Rock	6.24	5.44	17.56	-12.1	None	0.562	0.526	-12.12	0.31	APR
	25.6-26.1 / 852.4	Rock	6.56	6.40	9.94	-3.5	None	0.318	0.328	-3.54	0.64	APR
	29.9-30.4 / 848.1	Rock	6.39	5.41	12.19	-6.8	None	0.390	0.397	-6.78	0.44	APR
	33.5-34 / 844.5	Rock	6.37	4.31	10.34	-6	None	0.331	0.392	-6.03	0.42	APR
	39.2-39.7 / 838.8	Rock	5.68	3.58	17.38	-13.8	None	0.556	0.527	-13.8	0.21	APR
	46.1-46.6 / 831.9	Rock	6.64	1.71	2.31	-0.6	None	0.074	0.091	-0.6	0.74	
	47.2-47.7 / 830.8	Rock	6.35	2.37	4.5	-2.1	None	0.144	0.171	-2.13	0.53	APR
	53.6-54.1 / 824.4	Rock	6.37	2.14	3.13	-1	None	0.100	0.109	-0.99	0.68	APR
	60-60.5 / 818	Rock	6.33	2.16	2.38	-0.2	None	0.076	0.093	-0.22	0.91	
	65.9-66.4 / 812.1	Rock	6.41	2.80	2.63	0.2	None	0.084	0.097	0.17	1.06	
	69.9-70.4 / 808.1	Rock	6.72	2.12	3.81	-1.7	None	0.122	0.137	-1.69	0.56	APR
	75.2-75.7 / 802.8	Rock	6.15	2.21	12.41	-10.2	None	0.397	0.444	-10.2	0.18	APR
	79.2-79.7 / 798.8	Rock	6.63	2.12	0.91	1.2	None	0.029	0.060	1.21	2.33	
	83.2-83.7 / 794.8	Rock	7.07	2.33	4.25	-1.9	None	0.136	0.168	-1.92	0.55	APR
	88.7-89.2 / 789.3	Rock	6.05	5.74	12.59	-6.9	None	0.403	0.426	-6.85	0.46	APR
	93.2-93.7 / 784.8	Rock	6.22	6.21	22.13	-15.9	None	0.708	0.601	-15.92	0.28	APR
	97.7-98.2 / 780.3	Rock	6.93	3.44	1.69	1.7	None	0.054	0.083	1.75	2.04	
	103.2-103.7 / 774.8	Rock	7.42	1.38	0.75	0.6	None	0.024	0.030	0.63	1.84	
State Route 29 Station 172+00, 100 feet right/Coal Hill Road Station 45+74, 68 feet left	0-1.5 / 823-821.5	Soil	5.06	0.00	0.06	-0.1	None	0.002	0.013	-0.06	0.00	
	6.5-7 / 816.5-816	Soil and Rock	5.66	0.02	0.16	-0.1	None	0.005	0.008	-0.14	0.13	
	11-11.5 / 812-811.5	Rock	6.02	0.04	0.06	0	None	0.002	0.006	-0.02	0.67	
	16.5-17 / 806.5-806	Rock	6.04	0.22	0.06	0.16	None	0.002	0.004	0.16	3.67	
	21-21.5 / 802-801.5	Rock	7.20	1.40	1.09	0.3	None	0.035	0.042	0.31	1.28	
	26-26.5 / 797-796.5	Rock	6.53	1.29	0.34	0.9	None	0.011	0.015	0.95	3.79	
	30.7-31.2 / 792.3-791.8	Rock	6.84	1.56	0.28	1.3	None	0.009	0.018	1.28	5.57	
	36-36.5 / 787-786.5	Rock	6.86	2.27	0.69	1.6	None	0.022	0.021	1.58	3.29	
	42.5-43 / 780.5-780	Rock	6.41	3.03	2.25	0.8	None	0.072	0.078	0.78	1.35	
	48.5-49 / 774.5-774	Rock	6.63	1.89	0.81	1.1	None	0.026	0.026	1.08	2.33	
	53.2-53.7 / 769.8-769.3	Rock	6.65	1.20	0.38	0.8	None	0.012	0.017	0.82	3.16	
	58.5-59 / 764.5-764	Rock	6.81	1.40	0.34	1.1	None	0.011	0.012	1.06	4.12	

*Tons of $CaCO_3$ per 1,000 tons of material

State Route 29 Improvements

Acid Base Accounting Laboratory Test Results Summary

APR - encapsulation required

APR - blending or partial encapsulation required

Potential APR - blending required

Station Number with Offset	Sample Depth/Approximate Elevation (feet/feet msl)	Sample Type	Paste pH	Neutralization Potential*	Potential Acidity*	CaCO3 (Def)/Sur*	Fizz	Total Sulfur (%)	Pyritic Sulfur (%)	NNP	NPR	Classification
Coal Hill Road Station 46+70, 25 feet right	1.5-3 / 826.5	Soil	4.93	0.04	0.53	-0.5	None	0.017	0.029	-0.49	0.08	APR
	6.5-8 / 821.5	Soil	5.44	0.87	2.09	-1.2	None	0.067	0.077	-1.22	0.42	
	15.5-16 / 812.5	Rock	6.71	1.40	0.22	1.2	None	0.007	0.015	1.18	6.36	
	18.6-19.1 / 809.4	Rock	6.47	1.19	0.16	1.04	None	0.005	0.017	1.03	7.44	
	22.1-22.6 / 805.9	Rock	6.23	1.19	1.56	-0.4	None	0.050	0.047	-0.37	0.76	
	29.1-29.6 / 798.9	Rock	7.96	1.73	0.31	1.4	None	0.010	0.013	1.42	5.58	
	34.1-34.6 / 793.9	Rock	7.49	1.56	0.59	1	None	0.019	0.014	0.97	2.64	
	37.6-38.1 / 790.4	Rock	7.37	1.55	1.43	0.1	None	0.046	0.042	0.12	1.08	
	41-41.5 / 787	Rock	8.52	1.90	0.38	1.5	None	0.012	0.014	1.52	5.00	
	48.5-49 / 779.5	Rock	8.72	3.39	0.56	2.8	None	0.018	0.022	2.83	6.05	
	55.4-55.9 / 772.6	Rock	8.59	6.58	0.81	5.8	None	0.026	0.032	5.77	8.12	
	59.6-60.1 / 768.4	Rock	8.63	3.86	0.88	3	None	0.028	0.035	2.98	4.39	
State Route 29 Station 180+19, 96 feet right	1.5-3 / 798.5	Soil	5.41	0.20	0.1	0.1	None	0.003	0.008	0.10	2.00	
	6.5-8 / 793.5	Soil	5.02	0.14	0.18	0	None	0.006	0.031	-0.04	0.78	
	10.9-11.4 / 789.1	Rock	4.70	0.00	0.43	-0.4	None	0.014	0.037	-0.43	0.00	APR
	17-17.5 / 783	Rock	7.39	1.00	0.2	0.8	None	0.007	0.007	0.80	5.00	
	24.4-24.9 / 775.6	Rock	6.08	0.68	0.16	0.5	None	0.005	0.010	0.52	4.25	
	29-29.5 / 771	Rock	6.73	1.19	0.72	0.5	None	0.023	0.052	0.47	1.65	
	34.8-35.3 / 765.2	Rock	5.73	0.77	0.74	0	None	0.024	0.022	0.03	1.04	
State Route 29 Station 181+72, 87 feet right	1.5-3 / 798.5	Soil	4.89	0.48	0.55	-0.1	None	0.017	0.030	-0.07	0.87	APR
	9-10.5 / 791	Soil	5.03	0.71	0.35	0.4	None	0.011	0.053	0.36	2.03	
	14-15.5 / 786	Soil	5.28	0.80	0.23	0.6	None	0.008	0.041	0.57	3.48	
	19-20.5 / 781	Soil	5.55	3.15	0.24	2.9	None	0.008	0.036	2.91	13.13	
	24-25 / 776	Soil	5.81	3.57	9.98	-6.4	None	0.319	0.278	-6.41	0.36	APR
	29.8-30.3 / 770.2	Rock	6.78	2.22	0.64	1.6	None	0.021	0.034	1.58	3.47	
	34.2-34.7 / 765.8	Rock	6.35	1.37	0.15	1.2	None	0.005	0.008	1.22	9.13	
	39.3-39.8 / 760.7	Rock	7.45	2.35	0.32	2	None	0.010	0.019	2.03	7.34	
State Route 29 Station 183+05, 89 feet right	1.5-3 / 784.5	Soil	4.91	0.70	0.36	0.3	None	0.011	0.021	0.34	1.94	APR
	6.7-7.2 / 779.3	Rock	6.02	1.52	0.06	1.5	None	0.002	0.007	1.46	25.33	
	13.2-13.7 / 772.8	Rock	6.94	3.29	1.25	2	None	0.040	0.045	2.04	2.63	
	16-16.5 / 770	Rock	8.03	2.85	2.92	-0.1	None	0.093	0.101	-0.07	0.98	APR
	21.2-21.7 / 764.8	Rock	8.15	1.89	4.1	-2.21	None	0.131	0.117	-2.21	0.46	APR

*Tons of $CaCO_3$ per 1,000 tons of material

State Route 29 Improvements

Acid Base Accounting Laboratory Test Results Summary

APR - encapsulation required

APR - blending or partial encapsulation required

Potential APR - blending required

Station Number with Offset	Sample Depth/Approximate Elevation (feet/feet msl)	Sample Type	Paste pH	Neutralization Potential*	Potential Acidity*	CaCO3 (Def)/Sur*	Fizz	Total Sulfur (%)	Pyritic Sulfur (%)	NNP	NPR	Classification
State Route 29 Station 184+61, 56 feet right	1.5-3 / 790.5	Soil	4.81	0.49	0.17	0.3	None	0.005	0.010	0.32	2.88	APR
	6.7-7.2 / 785.3	Rock	5.65	0.89	0.11	0.8	None	0.004	0.006	0.78	8.09	
	11.7-12.2 / 780.3	Rock	5.03	1.36	7.97	-6.6	Slight	0.255	0.209	-6.61	0.17	APR
	18.2-18.7 / 773.8	Rock	6.86	7.40	0.64	6.76	None	0.021	0.050	6.76	11.56	
	22.2-22.7 / 769.8	Rock	6.62	5.96	0.57	5.4	None	0.018	0.033	5.39	10.46	
	29.5-30 / 762.5	Rock	7.15	2.43	1.49	0.9	None	0.048	0.060	0.94	1.63	
State Route 29 Station 186+00, 60 feet right	1.5-3 / 806.5-805	Soil	4.78	0.17	0.69	-0.5	None	0.022	0.020	-0.52	0.25	APR
	8-8.5 / 800-799.5	Rock	5.86	0.32	0.09	0.2	None	0.003	0.009	0.23	3.56	
	11-11.5 / 797-796.5	Rock	5.81	0.52	0.06	0.5	None	0.002	0.009	0.46	8.67	
	19.5-20 / 788.5-788	Rock	6.12	0.94	0.53	0.41	None	0.017	0.013	0.41	1.77	
	23.5-24 / 784.5-784	Rock	5.29	4.72	7.72	-3	None	0.247	0.254	-3.00	0.61	APR
	27.7-28.2 / 780.3-779.8	Rock	5.35	1.27	10.38	-9.1	None	0.332	0.232	-9.11	0.12	APR
	33-33.5 / 775-774.5	Rock	5.96	10.99	1.72	9.3	None	0.055	0.036	9.27	6.39	
	37.7-38.2 / 770.3-769.8	Rock	5.79	0.90	0.22	0.7	None	0.007	0.008	0.68	4.09	
	44.2-44.7 / 763.8-763.3	Rock	6.99	2.55	0.47	2.1	None	0.015	0.013	2.08	5.43	
	48.5-49 / 759.5-759	Rock	6.19	2.01	1.03	1	None	0.033	0.034	0.98	1.95	
State Route 29 Station 187+63, 49 feet right	1.5-3 / 807.5	Soil	4.76	0.40	0.35	0	None	0.011	0.023	0.05	1.14	APR
	8.5-9 / 800.5	Soil	5.24	0.62	0.08	0.5	None	0.003	0.010	0.54	7.75	
	12-12.5 / 797	Soil	5.78	0.54	0.14	0.4	None	0.004	0.006	0.40	3.86	
	16-16.5 / 793	Rock	5.86	1.23	0.07	1.2	None	0.002	0.007	1.16	17.57	
	21.5-22 / 787.5	Rock	5.58	0.83	0.28	0.6	None	0.009	0.017	0.55	2.96	
	29.5-30 / 779.5	Rock	6.08	0.82	0.07	0.7	None	0.002	0.007	0.75	11.71	
	33.2-33.7 / 775.8	Rock	6.10	0.88	0.08	0.8	None	0.003	0.010	0.80	11.00	
	35.5-36 / 773.5	Rock	5.38	0.83	0.76	0.1	None	0.024	0.035	0.07	1.09	
	43.3-43.8 / 765.7	Rock	6.72	2.60	10.35	-7.8	None	0.331	0.315	-7.75	0.25	APR
	49.5-50 / 759.5	Rock	7.05	3.09	9.84	-6.8	None	0.315	0.279	-6.75	0.31	APR
State Route 29 Station 189+00, 80 feet right	4-5 / 800-799	Soil	5.00	0.08	0.75	-0.7	None	0.024	0.032	-0.67	0.11	
	6.1-6.6 / 797.9-797.4	Rock	5.02	0.40	8.34	-7.9	None	0.267	0.089	-7.94	0.05	
	9.9-10.4 / 794.1-793.6	Rock	4.53	0.72	16.03	-15.3	None	0.513	0.484	-15.31	0.04	APR
	11.9-12.4 / 792.1-791.6	Rock	5.36	0.78	14.38	-13.6	None	0.460	0.376	-13.60	0.05	APR
	18.7-19.2 / 785.3-784.8	Rock	5.40	0.85	1.63	-0.8	None	0.052	0.130	-0.78	0.52	APR
	22.6-23.1 / 781.4-780.9	Rock	6.19	3.01	4.06	-1.1	None	0.130	0.117	-1.05	0.74	APR
	30.2-30.7 / 773.8-773.3	Rock	6.65	2.44	1.25	1.2	None	0.040	0.041	1.19	1.95	
	36.4-36.9 / 767.6-767.1	Rock	6.76	1.05	4.81	-3.8	None	0.154	0.136	-3.76	0.22	APR
	39.2-39.7 / 764.8-764.3	Rock	6.88	1.07	12.16	-11.1	None	0.389	0.213	-11.09	0.09	APR
	44.9-45.4 / 759.1-758.6	Rock	7.98	2.72	5.44	-2.7	None	0.174	0.171	-2.72	0.50	APR

*Tons of $CaCO_3$ per 1,000 tons of material

State Route 29 Improvements

Acid Base Accounting Laboratory Test Results Summary

APR - encapsulation required

APR - blending or partial encapsulation required

Potential APR - blending required

Station Number with Offset	Sample Depth/Approximate Elevation (feet/feet msl)	Sample Type	Paste pH	Neutralization Potential*	Potential Acidity*	CaCO3 (Def)/Sur*	Fizz	Total Sulfur (%)	Pyritic Sulfur (%)	NNP	NPR	Classification
State Route 29 Station 190+66, 48 feet right	1.5-3 / 786.5	Soil	4.53	0.12	0.27	-0.1	None	0.009	0.028	-0.15	0.44	APR
	8.4-8.9 / 779.6	Rock	5.57	0.24	0.14	0.1	None	0.004	0.004	0.10	1.71	
	13.1-13.6 / 774.9	Rock	4.63	0.40	6.11	-5.7	None	0.196	0.174	-5.71	0.07	APR
	17.5-18 / 770.5	Rock	4.75	0.64	10.54	-9.9	Slight	0.337	0.283	-9.90	0.06	APR
	24.9-25.4 / 763.1	Rock	6.42	1.18	2.19	-1	None	0.070	0.064	-1.01	0.54	
	26.9-27.4 / 761.1	Rock	5.50	2.24	4.73	-2.5	None	0.151	0.161	-2.49	0.47	APR
State Route 29 Station 221+89, 110 feet right	0-1.5 / 787	Soil	5.43	11.20	0.71	10.5	None	0.023	0.019	10.49	15.77	
	6.5-8 / 780.5	Soil	4.90	0.24	0.61	-0.4	None	0.019	0.031	-0.37	0.39	APR
	9-10.5 / 778	Soil	4.99	0.00	0.17	-0.2	None	0.005	0.023	-0.17	0.00	APR
	14-15.5 / 773	Soil	5.72	2.71	0.2	2.5	None	0.006	0.052	2.51	13.55	
	19-20.5 / 768	Soil	6.58	3.67	6.73	-3.1	None	0.216	0.287	-3.06	0.55	APR
	24-25.5 / 763	Soil	6.24	10.68	1.68	9	None	0.054	0.052	9.00	6.36	
	29-30.5 / 758	Soil	8.20	6.92	3.53	3.4	None	0.113	0.144	3.39	1.96	Potential APR
State Route 29 Station 225+50, 120 feet right	4-5.5 / 809-807.5	Soil	5.27	1.27	0.19	1.1	None	0.006	0.035	1.08	6.68	
	9-10.5 / 804-802.5	Soil	4.29	1.84	0.45	1.4	None	0.015	0.006	1.39	4.09	APR
	14-15.5 / 799-797.5	Soil	4.71	1.43	0.13	1.3	None	0.004	0.022	1.30	11.00	APR
	19-20.5 / 794-792.5	Soil	5.44	1.86	0.19	1.67	None	0.006	0.019	1.67	9.79	
	24-25.5 / 789-787.5	Soil	5.97	1.50	0.34	1.2	None	0.011	0.021	1.16	4.41	
	29-30.5 / 784-782.5	Soil	6.53	5.20	2	3.2	None	0.064	0.064	3.20	2.60	
	34-35.5 / 779-777.5	Soil	6.38	5.35	2.03	3.3	Slight	0.065	0.078	3.32	2.64	
	36-38 / 777-775	Soil	6.39	4.54	4.13	0.4	None	0.132	0.145	0.41	1.10	Potential APR
	42.5-43 / 770.5-770	Rock	8.05	4.23	1.78	2.4	None	0.057	0.087	2.45	2.38	
	45.6-46.1 / 767.4-766.9	Rock	8.07	6.26	5.16	1.1	None	0.165	0.131	1.10	1.21	Potential APR
	49.9-50.4 / 763.1-762.6	Rock	7.84	5.11	3.58	1.5	None	0.115	0.113	1.53	1.43	Potential APR
	51.7-52.2 / 761.3-760.8	Rock	7.81	3.21	3.25	0	None	0.104	0.128	-0.04	0.99	APR
	59.4-59.8 / 753.6-753.2	Rock	7.67	7.67	2.25	5.4	None	0.072	0.117	5.42	3.41	Potential APR
State Route 29 Station 226+60, 67 feet right	1.5-3 / 789.5	Soil	5.80	2.93	0.14	2.8	None	0.004	0.031	2.79	20.93	
	6.5-8 / 784.5	Soil	5.82	3.36	0.18	3.19	None	0.006	0.034	3.18	18.67	
	14-15.5 / 777	Soil	6.34	3.00	0.21	2.8	None	0.007	0.024	2.79	14.29	
	19-20.5 / 772	Soil	6.57	4.83	1.14	3.7	None	0.036	0.056	3.69	4.24	
	24-25.5 / 767	Soil	7.25	5.44	2.74	2.7	None	0.088	0.111	2.70	1.99	Potential APR
	29-30.5 / 762	Soil	7.66	7.58	2.06	5.5	None	0.066	0.097	5.52	3.68	
	34-35.5 / 757	Soil	7.94	8.38	4.29	4.1	None	0.137	0.093	4.09	1.95	

*Tons of $CaCO_3$ per 1,000 tons of material

State Route 29 Improvements

Acid Base Accounting Laboratory Test Results Summary

APR - encapsulation required

APR - blending or partial encapsulation required

Potential APR - blending required

Station Number with Offset	Sample Depth/Approximate Elevation (feet/feet msl)	Sample Type	Paste pH	Neutralization Potential*	Potential Acidity*	CaCO3 (Def)/Sur*	Fizz	Total Sulfur (%)	Pyritic Sulfur (%)	NNP	NPR	Classification
State Route 29 Station 227+50, 180 feet right	1.5-3 / 844.5-843	Soil and Rock	4.64	0.77	0.28	0.5	None	0.009	0.015	0.49	2.75	APR
	6-6.5 / 840-839.5	Rock	6.00	0.22	0.06	0.2	None	0.002	0.007	0.16	3.67	
	11.5-12 / 834.5-834	Rock	6.25	0.61	0.16	0.5	None	0.005	0.017	0.45	3.81	
	18-18.5 / 828-827.5	Rock	5.17	0.21	0.06	0.1	None	0.002	0.005	0.15	3.50	
	30.9-31.4 / 815.1-814.6	Soil and Rock	5.63	2.42	0.19	2.23	None	0.006	0.047	2.23	12.74	
	38-38.5 / 808-807.5	Soil and Rock	6.26	0.81	0.09	0.7	None	0.003	0.008	0.72	9.00	
	41-41.5 / 805-804.5	Rock	6.89	0.76	0.03	0.7	None	0.001	0.004	0.73	25.33	
	46-46.5 / 800-799.5	Rock	6.13	0.66	0.03	0.6	None	0.001	0.004	0.63	22.00	
	56.5-57 / 789.5-789	Rock	6.19	3.97	1.56	2.4	None	0.050	0.072	2.41	2.54	
	59.5-60 / 786.5-786	Rock	6.82	2.32	0.63	1.7	None	0.020	0.015	1.69	3.68	
	60.9-61.4 / 785.1-784.6	Rock	7.06	3.12	0.63	2.5	None	0.020	0.018	2.49	4.95	
	65.9-66.4 / 780.1-779.6	Rock	7.26	6.15	1.25	4.9	None	0.040	0.062	4.90	4.92	
	70.9-71.4 / 775.1-774.6	Rock	8.06	7.98	1.78	6.2	None	0.057	0.066	6.20	4.48	
	75.9-76.4 / 770.1-769.6	Rock	8.05	6.22	1.44	4.8	None	0.046	0.062	4.78	4.32	
	85.4-85.9 / 760.6-760.1	Rock	8.05	2.67	2.06	0.6	None	0.066	0.077	0.61	1.30	
State Route 29 Station 229+04, 68 feet right	1.5-3 / 796.5	Soil	4.76	0.27	0.39	-0.12	None	0.013	0.028	-0.12	0.69	APR
	6.5-8 / 791.5	Soil	6.19	2.22	0.13	2.1	None	0.004	0.033	2.09	17.08	
	14.9-15.4 / 783.1	Rock	6.17	0.82	0.06	0.8	None	0.002	0.005	0.76	13.67	
	16.4-16.9 / 781.6	Rock	5.99	0.68	0.07	0.6	None	0.002	0.008	0.61	9.71	
	20.9-21.4 / 777.1	Rock	6.52	3.51	4.40	-0.9	None	0.141	0.155	-0.89	0.80	APR
	28.4-28.9 / 769.6	Rock	7.33	4.18	1.21	3.0	None	0.039	0.037	2.97	3.45	
	32.4-32.9 / 765.6	Rock	7.44	13.58	1.77	11.8	Slight	0.057	0.069	11.81	7.67	
	40.4-40.9 / 757.6	Rock	7.68	2.98	0.76	2.2	None	0.024	0.032	2.22	3.92	

*Tons of $CaCO_3$ per 1,000 tons of material

APPENDIX IV

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPORT

Important Information About Your Geotechnical Engineering Report

Variations in subsurface conditions can be a principal cause of construction delays, cost overruns and claims. The following information is provided to assist you in understanding and managing the risk of these variations.

Geotechnical Findings Are Professional Opinions

Geotechnical engineers cannot specify material properties as other design engineers do. Geotechnical material properties have a far broader range on a given site than any manufactured construction material, and some geotechnical material properties may change over time because of exposure to air and water, or human activity.

Site exploration identifies subsurface conditions at the time of exploration and only at the points where subsurface tests are performed or samples obtained. Geotechnical engineers review field and laboratory data and then apply their judgment to render professional opinions about site subsurface conditions. Their recommendations rely upon these professional opinions. Variations in the vertical and lateral extent of subsurface materials may be encountered during construction that significantly impact construction schedules, methods and material volumes. While higher levels of subsurface exploration can mitigate the risk of encountering unanticipated subsurface conditions, no level of subsurface exploration can eliminate this risk.

Scope of Geotechnical Services

Professional geotechnical engineering judgment is required to develop a geotechnical exploration scope to obtain information necessary to support design and construction. A number of unique project factors are considered in developing the scope of geotechnical services, such as the exploration objective; the location, type, size and weight of the proposed structure; proposed site grades and improvements; the construction schedule and sequence; and the site geology.

Geotechnical engineers apply their experience with construction methods, subsurface conditions and exploration methods to develop the exploration scope. The scope of each exploration is unique based on available project and site information. Incomplete project information or constraints on the scope of exploration increases the risk of variations in subsurface conditions not being identified and addressed in the geotechnical report.

Services Are Performed for Specific Projects

Because the scope of each geotechnical exploration is unique, each geotechnical report is unique. Subsurface conditions are explored and recommendations are made for a specific project. Subsurface information and recommendations may not be adequate for other uses. Changes in a proposed structure location, foundation loads, grades, schedule, etc. may require additional geotechnical exploration, analyses, and consultation. The geotechnical engineer should be consulted to determine if additional services are required in response to changes in proposed construction, location, loads, grades, schedule, etc.

Geo-Environmental Issues

The equipment, techniques, and personnel used to perform a geo-environmental study differ significantly from those used for a geotechnical exploration. Indications of environmental contamination may be encountered incidental to performance of a geotechnical exploration but go unrecognized. Determination of the presence, type or extent of environmental contamination is beyond the scope of a geotechnical exploration.

Geotechnical Recommendations Are Not Final

Recommendations are developed based on the geotechnical engineer's understanding of the proposed construction and professional opinion of site subsurface conditions. Observations and tests must be performed during construction to confirm subsurface conditions exposed by construction excavations are consistent with those assumed in development of recommendations. It is advisable to retain the geotechnical engineer that performed the exploration and developed the geotechnical recommendations to conduct tests and observations during construction. This may reduce the risk that variations in subsurface conditions will not be addressed as recommended in the geotechnical report.

RETAINING WALL AND
ACID PRODUCING ROCK EVALUATION REPORT
STATE ROUTE 29 WIDENING FROM STATE ROUTE 61
TO 0.6 MILE SOUTH OF WHETSTONE ROAD
MORGAN AND ROANE COUNTIES, TENNESSEE
TDOT PE No. 65001-1256-14
GES File No. 6520300
PIN 101411.01
ARCADIS Project No. CT052497.0009.00SME
S&ME Project No. 1811-12-177A

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June 19, 2013

S&ME

June 19, 2013

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Subject: Retaining Wall and Acid Producing Rock Evaluation Report
State Route 29 Widening From State Route 61
To 0.6 Mile South of Whetstone Road
Morgan and Roane Counties, Tennessee
TDOT PE No. 65001-1256-14
GES File No. 6520300
PIN 101411.01
Arcadis Project No. CT052497.0009.00SME
S&ME Project No. 1811-12-177A

Dear Mr. Butler:

S&ME, Inc. has completed the subsurface exploration for the above referenced project site in Morgan and Roane Counties, Tennessee. We conducted this exploration in general accordance with our Proposal No. 1113020 dated January 22, 2013.

This report presents our understanding of the project, documents our findings, and presents our recommendations for the planned retaining walls on State Route 29 between Stations 154+66 and 230+75, and along the east side of the portion of Coal Hill Road where a realignment is planned. Each of the retaining walls will be constructed right of the centerline. After you have reviewed our report, we recommend either a meeting or a telephone conference to discuss our recommendations.

S&ME, Inc. appreciates the opportunity to be of service to Arcadis, U.S., Inc. and the Tennessee Department of Transportation, and we look forward to helping you through project completion. Please contact us if you have any questions.

Respectfully submitted,

S&ME, Inc.

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Enclosures

FORTY YEARS OF ENGINEERING INTEGRITY

RETAINING WALL AND ACID PRODUCING ROCK EVALUATION REPORT
State Route 29 From State Route 61
To 0.6 Mile South of Whetstone Road
Morgan and Roane Counties, Tennessee
TDOT PE No. 65001-1256-14
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1.0 EXECUTIVE SUMMARY

This report presents the results of two subsurface explorations performed to evaluate the presence of acid producing rock and to provide subsurface information for the planned retaining walls on State Route 29 in Morgan and Roane Counties, Tennessee. Laboratory acid base accounting tests were performed by others on samples of the soil and rock encountered at depths of about every 5 feet in the test borings. The laboratory test results indicate the presence of acid producing rock (APR) and soil in the planned cut areas. To decrease the amount of excavation that will be required to construct the planned roadway widening project (and therefore decrease the amount of APR that will require disposal), five retaining walls will be constructed. Each of the walls will be a cut wall that will support a predominantly rock cut, although soil was encountered the full boring depth at a few of the boring locations.

Based on the test boring results, the provided project information, and TDOT Special Provision 624, the acceptable wall type for this project is an anchor wall. Additional wall design and construction recommendations are presented in this report. Attached to this report are the Retaining Wall Sheets, Test Boring Records, rock core photographs, and the geotechnical and acid base accounting laboratory test results.

This summary cannot be used by itself for planning, design, or construction. The necessary information is included within the body of this report.

2.0 INTRODUCTION

The project will consist of the widening of State Route 29 from two to four lanes starting at State Route 61 and extending to 0.6 mile south of Whetstone Road. The widening project will extend a total distance of about three miles. To widen the road, cuts on the east side (right of the centerline) of existing State Route 29 will be required. The results of acid base accounting laboratory testing performed on soil and rock core samples collected in conjunction with our Report of Acid Producing Rock for this project dated January 4, 2013 indicate acid producing rock (APR) is present in planned cut areas. To decrease the amount of excavation that will be required to construct the planned roadway widening project (and therefore decrease the amount of APR that will require disposal), retaining walls will be constructed in five areas. The retaining

walls will be constructed between State Route 29 Stations 154+66 and 230+75 and along the planned realignment of the west end of Coal Hill Road, right of the centerline. The approximate beginning and ending Station Numbers for the walls are as follows:

- State Route 29 Station 154+66 to 167+10
- Coal Hill Road Station 40+60 to 48+17
- State Route 29 Station 180+00 to 183+25
- State Route 29 Station 184+10 to 191+43
- State Route 29 Station 222+37 to 230+75

The provided drawings indicate the State Route 29 Station 154+66 to 167+10 wall will consist of two tiers about 15 feet apart. The lower tier wall will extend from about Station 154+66 to about Station 167+10 and will have a maximum above grade height of about 50 feet. The maximum top of wall elevation will be about 821.8 feet at about Station 167+10. Current site grades in the planned lower wall tier construction area range from about 770 feet near Station 156+00 to about 858 feet at Station 166+00. The upper tier wall will extend from about Station 158+17 to 167+10 and will have a maximum above grade height of about 50 feet. The maximum top of wall elevation for the upper tier will be about 873 feet near Station 167+10. Current site grades in the upper wall tier construction area range from about 825 feet near Station 160+50 to about 865 feet at Station 166+00.

The Coal Hill Road Station 40+60 to 48+17 wall will have three tiers that will be constructed about 15 feet apart. The lower tier wall will extend from about Coal Hill Road Station 40+60 to 48+17 and will have a maximum above grade height of about 50 feet. The maximum top of wall elevation will be about 838 feet at Station 44+50. Current site grades in the lower tier wall construction area range from about 775 feet at Station 48+17 to about 902 feet at Station 41+63. The middle tier wall will extend from about Station 40+75 to 46+32 and will have a maximum above grade height of about 50 feet. The maximum top of wall elevation will be about 886 feet at Station 43+50. Current site grades in the middle tier wall construction area range from about 833 feet at Station 46+32 to about 906 feet at Station 42+00 The upper tier wall will extend from about Station 40+84 to 44+00 and will have a maximum above grade height of about 43 feet. The maximum top of wall elevation will be about 922 feet at Station 42+00. Current site grades in the upper tier wall construction area range from about 875 feet at Station 40+84 to about 915 feet at Station 42+00.

The State Route 29 Station 180+00 to 183+25 wall will be a single wall with a maximum above grade height of about 19 ½ feet. The maximum top of wall elevation will be about 796 feet at Station 181+00. Current site grades in the planned wall construction area range from about 775 feet at Station 183+25 to about 792 feet at Station 181+50.

The State Route 29 Station 184+10 to 191+43 wall will be a single wall with a maximum above grade height of about 37 feet. The maximum top of wall elevation will be about 813 feet at Station 187+50. Current site grades in the planned wall area range from about 776 feet at Station 191+43 to about 811 feet at Station 187+50.

The State Route 29 Station 222+37 to 230+75 wall will be a single wall with a maximum above grade height of about 31 feet. The maximum top of wall elevation will be about 804 feet at Station 228+50. Current site grades in the wall area range from about 766 feet at Station 222+37 to about 798 feet at Station 228+50.

The current project included drilling test borings with rock coring in the planned retaining wall areas and performing acid base accounting laboratory testing on soil and rock core samples recovered from the test borings. The results of the exploration and testing performed for the current project and for the January 4, 2013 Report of Acid Producing Rock for this site are presented in this report.

3.0 GEOLOGY AND SITE CONDITIONS

3.1 RETAINING WALL SITE GEOLOGY

The southernmost portion of the project site is located in the Valley and Ridge Physiographic Province. Elongated ridges that trend in a northeast-southwest direction characterize this province. The ridges are typically formed on highly resistant sandstones and shales, while the valleys and rolling hills are formed on less resistant limestone, dolomite, and shales.

Based on our review of the Geologic Map of Tennessee, East Central Sheet, dated 1966, geologic formations found in the Valley and Ridge Physiographic Province extend from the beginning of the project north to about Station 165+00 of State Route 29. This portion of the site is underlain by undifferentiated formations of the Chickamauga Group. In the northwest part of the Valley and Ridge, the bedrock of this group is predominantly limestone about 2,000 feet thick, and produces a thin residuum typically less than 15 feet thick.

The remainder of the project site is located in the Cumberland Plateau Physiographic Province. The Cumberland Plateau is a highland area extending across Tennessee east of the Highland Rim and west of the Valley and Ridge Physiographic Province. The 30 to 60 mile wide area is dissected by streams extending from prominent mountains into valleys.

The East Central Sheet of the Geologic Map of Tennessee indicates two geologic formations are present in the planned retaining wall construction areas north of about Station 165+00. From south to north, these formations include the Crab Orchard Mountains and Gizzard Group, which extends from about Station 165+00 to about Station 170+45, and the Rockcastle Conglomerate, which underlies the retaining wall construction areas north of about Station 170+45.

The Crab Orchard Mountains Group includes the Rockcastle Conglomerate, Vandever Formation, Newton Sandstone, and Whitwell Shale and Sewanee Conglomerate formations. The Gizzard Group includes the Signal Point Shale, Warren Point Sandstone, and Raccoon Mountain formations. These formations consist of sandstone, conglomerate, siltstone, shale and thin coal beds. The thicknesses of these formations range from about 1,200 to 1,400 feet.

The Rockcastle Conglomerate, which is included in the Crab Orchard Mountains and is also mapped individually in the project area, is composed of conglomeratic sandstone and sandstone that is gray to brown and fine- to coarse-grained. Thin coal-bearing shale is locally present near the middle of the formation. The formation ranges from about 150 to 220 feet in thickness.

3.2 EXISTING SITE CONDITIONS IN PLANNED RETAINING WALL AREAS

In general, the planned retaining wall construction areas are rugged, steeply sloping and wooded. Rock outcrops are visible in several areas. The ground elevation slopes down from the east toward existing State Route 29, and varies in the retaining wall construction areas from about 770 feet near State Route 29 Station 156+00 to about 915 feet at Coal Hill Road Station 42+00.

4.0 SUBSURFACE EXPLORATION AND CONDITIONS

4.1 SUBSURFACE EXPLORATION PROCEDURES

The procedures used by S&ME for field and laboratory sampling and testing are in general accordance with AASHTO and ASTM procedures and established engineering practice in the State of Tennessee. The approximate boring locations are shown on the Retaining Wall Conceptual Drawings presented in Appendix I of this report. The field testing procedures, Test Boring Records, and photographs of the rock core recovered from the test borings are presented in Appendix II, and the laboratory test procedures and test results are presented in Appendix III.

Subsurface conditions in the vicinity of the proposed retaining walls were explored with 23 soil test borings. The locations where the borings were drilled were restricted to areas that could be accessed by all terrain and track mounted drilling equipment. A bulldozer was also necessary to clear access to and perform limited grading at the boring locations.

An ARCADIS survey crew staked the field locations of borings drilled in association with our January 4, 2013 report for this site. The borings were drilled right of the planned roadway centerline at the following approximate State Route 29 Station Numbers: 160+00, 163+26, 166+00, 168+00, 172+00, 186+00, 189+00, 225+50, and 227+50. The elevations of these borings were provided to us by Arcadis. The remaining 14 boring locations were drilled in association with the current project and were located in the field by one our engineers using a hand held GPS device referenced to the Tennessee state plane coordinate system. The locations of these 14 borings were superimposed onto the provided topographic drawing which was used to

estimate the ground surface elevation at the boring locations. The boring locations are depicted on the attached Retaining Wall Conceptual Drawings in Appendix I, and the elevations are shown on the Test Boring Records in Appendix II.

The drillers took soil samples from the borings using a split-barrel sampler according to AASHTO T 206 on a maximum 2 ½ foot interval in the upper 10 feet and on 5 foot intervals thereafter. An engineer logged the results of the Standard Penetration Tests (SPTs). After the borings were completed, or upon encountering auger refusal and prior to coring rock in 21 of the borings, we checked the boreholes for the presence of groundwater. The borings were backfilled with auger cuttings and a borehole plugging device before leaving the site.

Our field engineer logged the soil and rock core samples and photographed the rock core, selected soil and rock core samples from each boring on an about five foot interval for acid base accounting laboratory testing, packaged the samples in sealed containers, and labeled them for identification. We visually classified the soil samples according to the Unified Soil Classification System (ASTM D 2488) and measured the rock core recovery and the Rock Quality Designation (RQD). The rock core recovery is a measure of the length of core drilled to that recovered expressed as a percentage. The RQD is a measure of rock quality based on the percent of the core run containing pieces at least 4 inches long. The resulting soil and rock descriptions are shown on the Test Boring Records in Appendix II. A general description of the subsurface conditions encountered at the boring locations is provided below in Section 4.2.

The samples selected for acid base accounting laboratory testing were transported to Galbraith Laboratories, Inc.'s Knoxville office. The remaining samples were transported to the TDOT Region 1 office in Knoxville for storage.

4.2 SUBSURFACE CONDITIONS

General: The results of our field testing program and the moisture content and plasticity index laboratory test results are shown on the Test Boring Records in Appendix II. These records present our interpretation of the subsurface conditions at specific boring locations at the time of our exploration. The stratification lines represent the approximate boundary between soil types. The actual transitions may be more gradual than implied.

State Route 29 Station 154+66 to 167+10 Wall

Six test borings were drilled in the vicinity of this wall. The borings were drilled at the following approximate Station Numbers:

- Station 154+90, 106 feet right
- Station 156+33, 95 feet right
- Station 160+00, 150 feet right
- Station 161+23, 170 feet right
- Station 163+26, 165 feet right
- Station 166+00, 157 feet right

In addition to the test borings, three auger borings were drilled to depths ranging from about 6 to 16 feet in an effort to obtain undisturbed Shelby tube samples suitable for laboratory testing.

The Station 154+90 boring initially encountered about ½ foot of topsoil. Ground cover was not encountered in the remaining borings drilled for this wall.

At Stations 161+23 and 166+00, the borings initially encountered fill to depths of about 6 and 6 ½ feet, respectively. The fill encountered at Station 161+23 was composed of clayey sand with sandstone fragments. Standard Penetration Test (SPT) N values in the fill ranged from 32 to 55 blows per foot, indicating a dense to very dense granular soil consistency.

At Station 166+00, auger refusal was encountered at a depth of about 1 ½ feet in fill consisting of sandy clay. Rock coring was begun, and fill consisting of sandstone boulders and sandy clay was encountered to a depth of about 6 ½ feet. Our field engineer visually evaluated the sandstone boulders as moderately hard and the sandy clay as soft in consistency.

Below the topsoil at Station 154+90, below the fill at Station 161+23, and from the ground surface at the remaining boring locations except for Station 166+00, residual soils were encountered to auger refusal. The residual soils typically consisted of silty or sandy clay, sandy silt and clayey sand with rock and sandstone fragments. SPT N values in the residuum ranged from 4 to greater than 50 blows per foot, indicating a soft to hard soil consistency for the predominantly clay and silt soils, and a loose to very dense soil consistency for the predominantly sand soils.

In the borings drilled at Stations 156+33 and 161+23, auger refusal was encountered at depths of about 8 ½ feet and 19 ½ feet, respectively. Rock coring was begun, and residual materials were encountered. In the Station 156+33 boring, the residual materials consisted of sandy clay with floating sandstone boulders to a depth of about 22 feet. In the Station 161+23 boring, the residual materials consisted of sandstone and sandy clay to a depth of about 41 feet, and silty clay with shale fragments from about 41 to 70 feet. In both of the borings, the sandy and silty clay was observed washing out in the coring water during rock coring.

Auger refusal was encountered in the test borings at depths ranging from about 1 ½ feet to 25 ½ feet below the existing ground surface. Rock coring was performed in each of the borings to depths ranging from about 30 ½ to 155 feet. As previously discussed, the rock core samples were logged by one of our field engineers, who measured the recovery and RQD and also photographed the rock core.

Below the previously described fill and residuum encountered below auger refusal in the Station 156+33, 161+23 and 166+00 borings, and below auger refusal at the remaining boring locations, bedrock consisting of siltstone, sandstone, and shale was encountered to boring termination. Soil and coal seams were observed in some of the recovered core. The rock core recovery ranged from 0 to 100 percent. Of the 102 core runs, 82 (about 53 percent) of the core runs had recoveries of 90 percent or greater. The RQD for the rock core ranged from 0 to 100

percent, with about 53 percent of the RQD values ranging from 75 to 100 percent, indicating a predominantly good to excellent rock quality.

Coal Hill Road Station 40+60 to 48+17 Wall

The Coal Hill Road wall area was explored with four test borings drilled at the following approximate Station Numbers:

- SR 29 Station 168+00, 170 feet right (Coal Hill Road Station 41+67, 26 feet right)
- Coal Hill Road Station 43+68, 12 feet right
- SR 29 Station 172+00, 100 feet right (Coal Hill Road Station 45+74. 68 feet left)
- Coal Hill Road Station 46+70, 25 feet right

Ground cover consisting of less than ½ foot of topsoil was encountered at the Station 46+70 boring. Below the ground surface, the Station 43+68 boring encountered about 1 ½ feet of fill consisting of soft consistency sandy clay with rock fragments. Below the topsoil at Station 46+70, below the fill at Station 43+68, and below the ground surface at the other two boring locations, residual materials were encountered to auger refusal. The residual materials consisted of sandy clay, silt clay, silty sand, and weathered shale or sandstone. SPT N values in the residuum ranged from 4 to greater than 50 blows per foot, indicating a soft to hard consistency for the predominantly clay, silt and shale materials, and a very firm to very dense consistency for the predominantly sand and sandstone materials.

Auger refusal was encountered in the test borings at depths ranging from about 7 ½ feet to 25 ½ feet below the existing ground surface. Rock coring was performed in each of the borings to depths ranging from about 60 to 140 feet. The bedrock consisted of weathered sandstone, sandstone, weathered shale, shale, sandy siltstone, and siltstone. Clay, shale and coal seams were observed in some of the recovered rock core. The rock core recovery ranged from 53 to 100 percent. Of the 52 core runs, 43 (about 83 percent) of the core runs had recoveries of 90 percent or greater. The RQD for the rock core ranged from 0 to 100 percent, with about 58 percent of the RQD values ranging from 75 to 100 percent, indicating a predominantly good to excellent rock quality.

State Route 29 Station 180+00 to 183+25 Wall

Three test borings were drilled in this wall area at the following approximate locations:

- SR 29 Station 180+19, 96 feet right
- SR 29 Station 181+72, 87 feet right
- SR 29 Station 183+05, 89 feet right

In addition to the test borings, one auger boring was drilled near the Station 180+19 test boring to a depth of about 4 feet in an effort to obtain undisturbed Shelby tube samples suitable for laboratory testing. Also, an attempt was made to collect an undisturbed sample in the boring drilled near Station 181+72.

Below the ground surface, residual materials were encountered to auger refusal. The residual materials were composed of silty clay, sandy clay, rock fragments and weathered shale. SPT N values in the residuum ranged from 1 to greater than 50 blows per foot, indicating very soft to hard material consistencies.

Auger refusal was encountered in the test borings at depths ranging from about 5 ½ to 28 feet below the existing ground surface. Rock coring was performed in each of the borings to depths ranging from about 25 to 40 feet. The recovered rock core consisted of sandstone and siltstone. Clay and shale seams were observed in some of the recovered core. Recovery ranged from 40 to 100 percent, with nine (about 69 percent) of the recovery values for the 13 core runs drilled in these borings ranging from 90 to 100 percent. RQD values ranged from 0 to 89 percent, with only five (about 38 percent) of the values falling in the good to excellent rock quality ranges.

State Route 29 Station 184+10 to 191+43 Wall

Five test borings were drilled in this wall area at the following approximate locations:

- SR 29 Station 184+61, 56 feet right
- SR 29 Station 186+00, 60 feet right
- SR 29 Station 187+63, 49 feet right
- SR 29 Station 189+00, 80 feet right
- SR 29 Station 190+66, 48 feet right

About one foot of topsoil was encountered at the Station 186+00 and 189+00 borings. Below the topsoil in these two borings, and from the ground surface in the other three borings, residual materials were encountered to auger refusal. The residual materials consisted of silty and sandy clay, sandy silt, clayey sand, rock fragments, and weathered sandstone. SPT N values in the residual materials ranged from 3 to greater than 50 blows per foot, indicating soft to hard consistencies for the clays and silts, and a very dense consistency for the clayey sand and weathered sandstone.

Auger refusal was encountered in each of the borings at depths ranging from about 3 to 7 ½ feet. Rock coring was performed in each of the borings to depths of about 30 to 50 feet below the existing ground surface. The recovered rock core consisted of sandstone, shale and weathered shale. Clay seams were present in some of the recovered core samples. Rock core recovery ranged from 50 to 100 percent for the 37 core runs drilled in these borings. Twenty one (about 57 percent) of the recovery values were greater than 90 percent. RQDs ranged from 0 to 94 percent, with seven (about 19 percent) falling in the good to excellent rock quality ranges.

State Route 29 Station 222+37 to 230+75 Wall

Five test borings were drilled in the vicinity of this wall at the following approximate locations.

- SR 29 Station 221+89, 110 feet right

- SR 29 Station 225+50, 120 feet right
- SR 29 Station 226+60, 67 feet right
- SR 29 Station 227+50, 180 feet right
- SR 29 Station 229+04, 68 feet right

In addition to the test borings, three auger borings were drilled to depths of about 6 and 8 feet in an effort to obtain undisturbed Shelby tube samples suitable for laboratory testing.

Below the ground surface, residual materials were encountered to boring termination or auger refusal. The residual materials consisted of silty and sandy clay, clayey and sandy silt, weathered shale, silty sand, and rock and sandstone fragments. A sandstone boulder was encountered from the ground surface to a depth of about 1 ½ feet in the Station 227+50 boring. SPT N values ranged from 4 to greater than 50 blows per foot, indicating a soft to hard material consistency for the clays, silts, and weathered shale, and a firm to very firm consistency for the sand.

The borings drilled near Stations 221+89 and 226+60 were terminated in weathered shale at a depth of about 35 ½ feet. The remaining three borings encountered auger refusal at depths ranging from about 3 ½ to 39 feet. Rock was cored in these borings to depths ranging from about 41 to 86 feet. In the Station 229+04 boring, sandy clay mixed with sandstone boulders was encountered from auger refusal at a depth of about 15 feet to a depth of about 27 feet. Below this material, and below auger refusal in the Station 225+50 and 227+50 borings, bedrock composed of siltstone, weathered sandstone and weathered shale was encountered. Fine sand, clay seams and pyrite was observed in some of the recovered core. Rock core recovery for the 28 core runs drilled in these borings ranged from 6 to 100 percent, and eight (about 29 percent) of these values were greater than 90 percent. RQD values ranged from 0 to 100 percent. Five (about 18 percent) of the RQD values were in the good to excellent rock quality range.

4.3 GROUNDWATER

Groundwater was encountered in the following three test borings at the time of drilling and prior to coring rock:

- Coal Hill Road Station 43+68, 12 feet right: 24 feet
- State Route 29 Station 225+50, 120 feet right: 35 feet
- State Route 29 Station 226+60, 67 feet right: 26 feet

Delayed groundwater level measurements are shown on some of the test borings. However, the introduction of water into the borings during the rock coring process and rainfall during the time our field services were performed likely influenced the delayed measurements. It should be noted that groundwater levels can fluctuate with seasonal, climatic, and environmental changes. Further, groundwater may be encountered at additional locations where we drilled test borings at some future time.

5.0 ACID PRODUCING ROCK EVALUATION

5.1 ACID BASE ACCOUNTING LABORATORY TEST RESULTS

Soil and rock core samples were selected from each boring on an about five foot interval and were delivered to Galbraith Laboratories, Inc.'s Knoxville office for acid base accounting laboratory testing. The test results were used to characterize the material's potential to produce acidic runoff based on TDOT's accepted criteria, Guideline for Acid Producing Rock Investigation, Testing and Monitoring, and Mitigation, prepared by Golder Associates, Inc. and dated October 2007. The test results indicated 236 of the 306 tested samples were non Acid Producing Rock (APR), 9 were potential APR and 61 were APR. A tabulation of the laboratory test results is presented in Appendix III. The Retaining Wall Conceptual Drawings in Appendix I include boring profiles that show the APR and potential APR as do the Test Boring Records included in Appendix II. A summary of the test results in each wall area is presented in the following paragraphs.

State Route 29 Station 154+66 to 167+10 Wall

Of the 121 soil and rock core samples tested from the borings drilled in this wall area, the test results indicated three samples met the criteria for potential APR and 11 samples met the criteria for APR. Four of the samples were soil or a mix of soil and rock consisting of sandy clay with rock fragments, clayey silt, and silty clay with shale fragments. The remaining 10 samples were rock including weathered shale, shale, siltstone with occasional shale seams, shale with coal seams and some interbedded sandstone, and sandstone with thin shale and coal seams. One coal sample was tested.

Two shale rock samples tested from the Station 156+33 boring had greater than 0.1 percent pyritic sulfur, but the net neutralization potentials were about 18 and 23.5 percent, which are greater than the limit of 12 set for potential APR and less than zero set for APR in the Golder document.

Coal Hill Road Station 40+60 to 48+17 Wall

Of the 73 soil and rock core samples tested from the four borings drilled in this wall area, 16 met the criteria for APR, with 15 of them being from the Station 43+68 boring where all but six of the 21 tested samples met the criteria for APR. One soil sample collected from the Station 46+70 boring met the criteria for APR out of 12 samples tested from this boring. The APR samples included silty clay with weathered shale, shale and sandy siltstone with shale interbeds.

None of the samples tested from the Station 168+00 (CHR Station 41+67) and Station 172+00 (CHR Station 45+74) borings met the criteria for potential APR or APR. However, coal seams and shale interbeds were present in some of the untested rock core recovered from these borings.

State Route 29 Station 180+00 to 183+25 Wall

Twenty soil and rock core samples were tested from the borings drilled in this wall area. Six of the samples met the criteria for APR. In the boring drilled at Station 183+05, three out of five tested samples were classified as APR. Of the six samples that met the criteria for APR in this wall area, three were soil and three were rock core. The soil included silty and sandy clay with rock fragments and weathered shale. The rock included sandstone and siltstone with shale seams.

State Route 29 Station 184+10 to 191+43 Wall

Of the 42 samples tested from the borings drilled in this wall area, 19 met the criteria for APR, including 4 soil and 15 rock core samples. In the Station 189+00 boring, seven of the 10 tested samples were APR, and in the Station 190+66 boring, four of the six tested samples were APR. The soil consisted of sandy clay and sandy silt with rock fragments. The rock consisted of sandstone with thin shale seams, interbedded shale and sandstone, and sandstone.

State Route 29 Station 222+37 to 230+75 Wall

Fifty samples were tested from the borings drilled in this wall area. Six of the samples met the criteria for potential APR and nine for APR. In the boring drilled at Station 221+89, three of the seven tested samples met the criteria for APR and one sample met the criteria for potential APR. Of the 15 samples that met the criteria for potential APR and APR, nine were soil, one was a mix of soil and rock, and five were rock core. The soil consisted of sandy clay with rock fragments and sandstone boulders, weathered shale, and clayey and sandy silt with claystone, sandstone and weathered shale fragments. The rock was composed of siltstone with thin pyrite veins and pyrite inclusions.

5.2 APR CONCLUSIONS AND RECOMMENDATIONS

Based on the laboratory test results, it appears that the presence of shale in the bedrock as well as the obvious APR producers coal and pyrite will likely result in potential APR and APR materials that will require special handling during construction. Since the pyrite may not be visible in the bedrock during blasting and removal from the site (it was not observed in most of the samples with positive APR test results), and the coal seams may be relatively thin, we recommend field testing be performed at the time of construction to identify additional APR materials at this site. We recommend test samples be collected from blast boreholes and soil excavated from cut areas, and the samples be collected and tested as described in Section 3.3.1.2 of the Golder document. Based on our experience with this project, S&ME should be retained to provide sample collection during the excavation process.

On cut slopes where APR and potential APR materials will be exposed after design grades are met, The Best Management Practices (BMPs) described in Section 5.2 of the Golder document should be incorporated into the design and construction documents. These include steepening slopes as much as possible without compromising geotechnical stability or overall public safety to reduce the surface area of exposed APR materials, the placement of an interval of non-acidic

material in direct contact with the APR followed by an application of soil/plant material, and intermediate benches that are designed to be free-draining.

5.3 APR QUANTITY ESTIMATIONS

The acid base accounting test results were used to estimate the quantities of potential APR and APR in the planned retaining wall and cut areas. The test results were interpolated between the widely spaced borings, and the quantities were estimated using the average end area method. Employing these methods resulted in the following material quantity estimates:

- Estimated APR requiring encapsulation: 218,000 cubic yards
- Estimated APR requiring blending or encapsulation: 14,000 cubic yards
- Estimated Potential APR: 9,000 cubic yards

6.0 RECOMMENDATIONS

Unless specifically stated otherwise in the contract plans, the bidding for, the design of and the construction of retaining walls shown in the plans shall be governed by the Tennessee Department of Transportation Special Provision 624 regarding retaining walls. This special provision shall be considered as one of those documents which the bidder/contractor has examined and made himself familiar with as described in Section 102.04 – Examination of the Site, the Work, the Plans and the Specifications in the TDOT Standard Specifications for Road and Bridge Construction.

Excavation for the walls and/or their footings shall not be accomplished until the contractor has submitted wall designs and calculations and has been issued an approved set of wall plans and has labor and material resources available to begin and continue wall construction immediately after excavation.

These walls shall be designed in accordance with LRFD design procedures and requirements as described in AASHTO LRFD Bridge Design Specifications, 2012 and Interims.

For proprietary wall systems that have been approved as shown in Special Provision 624, the wall designer shall be responsible for providing wall designs incorporating materials and component as was originally submitted and approved by TDOT. If a material and/or component of the wall system have been modified from the originally approved system, a wall design and set of plans and calculations for this wall system cannot be submitted for review and approval until the wall system designer who originally submitted the wall system for approval by TDOT submits a request for re-approval utilizing the modified elements of the wall. This submittal does not guarantee approval of the modified system. If this re-approval process does not meet the contractor’s schedule or if the modified system is not approved, the contractor/wall designer shall provide a wall design for one of the approved systems at no change in contract price for the retaining wall and no change in project schedule requirements will be allowed.

The wall designer shall provide retaining wall plans, details and calculations as required by Special Provision 624 and as required herein.

- The wall designer shall utilize the geotechnical parameters and resistance factors as provided for each project retaining wall on the wall concept sheet and related retaining wall sheets to prepare and submit design calculations. Load factors and other pertinent design requirements provided in AASHTO LRFD Bridge Design Specifications, 2012 and Interims shall be used.

- Calculations for both internal (bearing capacity, sliding, settlement) and external (global) stability shall be provided for each critical wall section which demonstrates the required capacity to demand ratio of 1.0 is met utilizing the design parameters provided. The wall designer/contractor plans must include any foundation improvements as required herein on the wall designer/contractor's wall elevation views and any cross-sectional detail drawings.

- Load combinations as given in AASHTO LRFD Bridge Design Specifications, 2012 and Interims, shall be evaluated for each wall.

NOTE REGARDING CONSTRUCTION SLOPES

The contractor shall be responsible for making the excavation in accordance with OSHA and other applicable state and local regulations regarding construction slopes and trenches, in addition to the following applicable regulatory requirements: as a minimum requirement, all temporary construction slopes required for site access shall not exceed three (3) vertical feet. The contractor building the wall shall ensure that these temporary back slopes are not and do not become unstable. If the slope is unstable, becomes unstable, is cut steeper than a 1:1 slope or is unacceptable for another reason, then temporary shoring shall be used. Any unusual soil conditions other than those estimated should be reported to the project engineer.

ACCEPTABLE WALL TYPES

The retaining walls shall be the wall type listed below. The specific wall system supplier/installer shall be one of those listed as pre-approved in Special Provision 624.

- Anchor Wall

TABLE 1 – DESIGN REQUIREMENTS AND PARAMETERS

DESCRIPTION	VALUE – ANCHOR WALLS	NOTE *
Design Life	75 years	
Seismic Acceleration Coefficient (A_s)	0.15	
Pullout Resistance of Anchors		
Cohesionless (granular) soils	0.65	1
Cohesive soils	0.70	1
Rock	0.50	1
Where proof tests are conducted	1.0	2
Tensile Resistance of Anchor Tendon		
Mild steel (e.g., ASTM A615 bars)	0.90	3
High strength steel (e.g., ASTM A722 bars)	0.80	3
Flexural Capacity of Vertical Elements	0.90	
Resistance Factors of a Single Driven Pile Static Analyses Methods		
Side resistance and end bearing: clay and mixed soils		
α-Method (Tomlinson, 1987; Skempton, 1951)	0.35	
β-Method (Esrig & Kirby, 1997; Skempton, 1951)	0.25	
λ-Method (Vijayvergiya & Focht, 1972; Skempton, 1951)	0.40	
Side resistance and end bearing: sand		
Nordlund/Thurman Method (Hannigan et al, 2005)	0.45	
SPT-Method (Meyerhof)	0.30	
CPT-Method (Schmertmann)	0.50	
End bearing in rock (Canadian Geotech Society, 1985)	0.45	
Lateral geotechnical resistance of a single pile		
All soils and rock	1.0	
Resistance Factors of a Single Drilled Pile/Shaft		
Side resistance in clay		
α-Method (O'Neill and Reese, 1999)	0.45	
Tip resistance in clay		
Total stress (O'Neill and Reese, 1999)	0.40	
Side resistance in sand		
β-Method (O'Neill and Reese, 1999)	0.55	
Tip resistance in sand		
O'Neill and Reese, 1999	0.50	
Side resistance in intermediate geomaterials (IGMs)		
O'Neill and Reese, 1999	0.60	
Tip resistance in intermediate geomaterials (IGMs)		
O'Neill and Reese, 1999	0.55	
Side resistance in rock		
Horvath and Kenney (1979), O'Neill and Reese, 1999	0.55	
Carter and Kulhawy (1988)	0.50	
Tip resistance in rock		
Canadian Geotech Society (1985), O'Neill and Reese, 1999	0.50	
Lateral geotechnical resistance of a single pile/shaft		
All materials	1.0	
*Refer to Table 1.1 for notes.		

TABLE 1.1	
NOTES FOR TABLE 1	
NO.	**NOTE**
1	Apply to presumptive ultimate unit bond stresses for preliminary design only.
2	Apply where proof test(s) are conducted on every production anchor to a load of 1.0 or greater times the factored load on the anchor.
3	Apply to maximum proof test for anchors.
	Unless otherwise specified, all resistance factors shall be taken as 1.0 when investigating an extreme event limit state.

OTHER DESIGN REQUIREMENTS

Soldier pile/tie back walls shall have permanent structural concrete wall facing capable of resisting all design loads exerted on the wall components by the retained material. The mechanism connecting the soldier piles to the structural concrete facing shall have adequate capacity to transmit all loads from the facing, including self-weight, to the supporting soldier piles. Concrete lagging can be designed/used without application of permanent cast in place facing.

Timber lagging shall only be used to temporarily support material to allow for top down construction. Timber lagging is neither an acceptable permanent wall facing nor an acceptable permanent structural wall element.

The wall shall have a concrete drainage ditch at the top designed to carry surface runoff to either or both ends of walls. See Sheets 2Q and 2R of the Roadway Construction Plans for details on this concrete drainage ditch.

The wall designer/contractor's wall design plans shall include details for drainage behind the wall facing. Weep holes shall be constructed near the toe of walls 4-2, 5-2 and 5-3 to allow water to drain. See Roadway Construction Plans Sheet 2R for more information on weep hole outlet drainage. Weep holes shall not be allowed for walls 4-1, 5-1, 6, 7 and 8.

CONSTRUCTION NOTES

Assume drilling through in-place rock or colluvium required for installation of soldier piles.

Due to the site geology and the potential corrosive environment at the anchor area, it is recommended that the tendon bond length be encapsulated to provide additional corrosion protection (double corrosion protection). The encapsulation shall be fabricated from one of the following:

I. High density corrugated polyethylene tubing conforming to the requirements of AASHTO M 252 and having a minimum wall thickness of 0.06 inch except pregrouted tendons, which may have a minimum wall thickness of 0.04 inch.

II. Corrugated polyvinyl chloride tubes manufactured from rigid PVC compounds conforming to ASTM D 1784, Class 13646-B.

TABLE 2 – DESIGN PARAMETERS FOR ANCHOR WALL

STATION LIMITS	ELEVATION INTERVAL	MATERIAL	FRICTION ANGLE	COHESION	UNIT WEIGHT
WALL 4-1					
154+66.02 to 159+00	Top of wall to top of ground	ASTM D448 No. 57 stone	40°	0 psf	100 pcf
	Top of ground to base of wall	Soil	25°	200 psf	125 pcf
159+00 to 162+25	Top of wall to top of ground	ASTM D 448 No. 57 stone	40°	0 psf	100 pcf
	Top of ground to base of wall	Weathered shale, interbedded shale and sandstone	16°	4,300 psf	150 pcf
162+25 to 164+50	Top of wall to base of wall	Sandstone	47°	65,000 psf	160 pcf
164+50 to 167+09.99	Top of wall to elevation 780	Sandstone	47°	65,000 psf	160 pcf
	Elevation 780 to base of wall	Interbedded shale, sandstone and coal	27°	14,400 psf	155 pcf
WALL 4-2					
158+17 to 160+75	Top of wall to top of ground	ASTM D448 No. 57 stone	40°	0 psf	100 pcf
	Top of ground to base of wall	Sandstone and weathered shale	16°	4,300 psf	150 pcf
160+75 to 162+25	Top of wall to top of ground	ASTM D448 No. 57 stone	40°	0 psf	100 pcf
	Top of ground to base of wall	Soil	25°	200 psf	125 pcf
162+25 to 167+09.99	Top of wall to top of ground	ASTM D448 No. 57 stone	40°	0 psf	100 pcf
	Top of ground to base of wall	Sandstone	47°	65,000 psf	160 pcf

STATION LIMITS	ELEVATION INTERVAL	MATERIAL	FRICTION ANGLE	COHESION	UNIT WEIGHT
WALL 5-1					
40+59.65 to 42+50	Top of wall to base of wall	Sandstone	47^{o}	65,000 psf	160 pcf
42+50 to 48+17	Top of wall to top of ground	ASTM D448 No. 57 stone	40^{o}	0 psf	100 pcf
	Top of ground to base of wall	Weathered interbedded shale and siltstone, sandstone with interbedded shale	16^{o}	4,300 psf	150 pcf
WALL 5-2					
40+75.47 to 42+50	Top of wall to base of wall	Sandstone	47^{o}	65,000 psf	160 pcf
42+50 to 44+75	Top of wall to top of ground	ASTM D448 No. 57 stone	40^{o}	0 psf	100 pcf
	Top of ground to elevation 850	Soil	25^{o}	200 psf	125 pcf
	Elevation 850 to base of wall	Weathered interbedded shale and siltstone	16^{o}	4,300 psf	150 pcf
44+75 to 46+31.94	Top of wall to top of ground	ASTM D448 No. 57 stone	40^{o}	0 psf	100 pcf
	Top of ground to base of wall	Soil	25^{o}	200 psf	125 pcf
WALL 5-3					
40+84.23 to 44+00	Top of wall to top of ground	ASTM D448 No. 57 stone	40^{o}	0 psf	100 pcf
	Top of ground to elevation 890	Soil	25^{o}	200 psf	125 pcf
	Elevation 890 to base of wall	Sandstone	47^{o}	65,000 psf	160 pcf

STATION LIMITS	ELEVATION INTERVAL	MATERIAL	FRICTION ANGLE	COHESION	UNIT WEIGHT
WALL 6					
180+00 to 181+00	Top of wall to top of ground	ASTM D448 No. 57 stone	40^{o}	0 psf	100 pcf
	Top of ground to elevation 782	Soil	25^{o}	200 psf	125 pcf
	Elevation 782 to base of wall	Weathered sandstone	27^{o}	14,400 psf	155 pcf
181+00 to 183+25	Top of wall to top of ground	ASTM D448 No. 57 stone	40^{o}	0 psf	100 pcf
	Top of ground to base of wall	Soil	25^{o}	200 psf	125 pcf

STATION LIMITS	ELEVATION INTERVAL	MATERIAL	FRICTION ANGLE	COHESION	UNIT WEIGHT
WALL 7					
184+10 to 185+25	Top of wall to top of ground	ASTM D448 No. 57 stone	40°	0 psf	100 pcf
	Top of ground to elevation 789	Soil	25°	200 psf	125 pcf
	Elevation 789 to base of wall	Sandstone with interbedded shale	27°	14,400 psf	155 pcf
185+25 to 188+25	Top of wall to top of ground	ASTM D448 No. 57 stone	40°	0 psf	100 pcf
	Top of ground to elevation 801	Soil	25°	200 psf	125 pcf
	Elevation 801 to base of wall	Sandstone with interbedded shale	27°	14,400 psf	155 pcf
188+25 to 189+75	Top of wall to top of ground	ASTM D448 No. 57 stone	40°	0 psf	100 pcf
	Top of ground to elevation 799	Soil	25°	200 psf	125 pcf
	Elevation 799 to base of wall	Sandstone with interbedded shale	27°	14,400 psf	155 pcf
189+75 to 191+43.06	Top of wall to top of ground	ASTM D448 No. 57 stone	40°	0 psf	100 pcf
	Top of ground to elevation 781	Soil	25°	200 psf	125 pcf
	Elevation 781 to base of wall	Sandstone with interbedded shale	27°	14,400 psf	155 pcf
WALL 8					
222+37 to 230+75	Top of wall to top of ground	ASTM D448 No. 57 stone	40°	0 psf	100 pcf
	Top of ground to base of wall	Soil	25°	200 psf	125 pcf

TABLE 3 – RESISTANCE PARAMETERS

STATION LIMITS	ELEVATION INTERVAL	MATERIAL	NOMINAL ANCHOR BOND STRESS, τ_n	UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT
WALL 4-1					
154+66.02 to 159+00	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to base of wall	Soil	0.7 ksf	400 psf	125 pcf
159+00 to 162+25	Top of wall to top of ground	ASTM D 448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to base of wall	Weathered shale, interbedded shale and sandstone	10 ksf	8,600 psf	150 pcf
162+25 to 164+50	Top of wall to base of wall	Sandstone	20 ksf	130,000 psf	160 pcf
164+50 to 167+09.99	Top of wall to elevation 780	Sandstone	20 ksf	130,000 psf	160 pcf
	Elevation 780 to base of wall	Interbedded shale, sandstone and coal	15 ksf	28,800 psf	155 pcf
WALL 4-2					
158+17 to 160+75	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to base of wall	Sandstone and weathered shale	10 ksf	8,600 psf	150 pcf
160+75 to 162+25	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to base of wall	Soil	0.7 ksf	400 psf	125 pcf
162+25 to 167+09.99	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to base of wall	Sandstone	20 ksf	130,000 psf	160 pcf

STATION LIMITS	ELEVATION INTERVAL	MATERIAL	NOMINAL ANCHOR BOND STRESS, τ_n	UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT
WALL 5-1					
40+59.65 to 42+50	Top of wall to base of wall	Sandstone	20 ksf	130,000 psf	160 pcf
42+50 to 48+17	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to base of wall	Weathered interbedded shale and siltstone, sandstone with interbedded shale	10 ksf	8,600 psf	150 pcf
WALL 5-2					
40+75.47 to 42+50	Top of wall to base of wall	Sandstone	20 ksf	130,000 psf	160 pcf
42+50 to 44+75	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to elevation 850	Soil	0.7 ksf	400 psf	125 pcf
	Elevation 850 to base of wall	Weathered interbedded shale and siltstone	10 ksf	8,600 psf	150 pcf
44+75 to 46+31.94	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to base of wall	Soil	0.7 ksf	400 psf	125 pcf
WALL 5-3					
40+84.23 to 44+00	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to elevation 890	Soil	0.7 ksf	400 psf	125 pcf
	Elevation 890 to base of wall	Sandstone	20 ksf	130,000 psf	160 pcf

STATION LIMITS	ELEVATION INTERVAL	MATERIAL	NOMINAL ANCHOR BOND STRESS, τ_n	UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT
WALL 6					
180+00 to 181+00	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to elevation 782	Soil	0.7 ksf	400 psf	125 pcf
	Elevation 782 to base of wall	Weathered sandstone	15 ksf	28,800 psf	155 pcf
181+00 to 183+25	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to base of wall	Soil	0.7 ksf	400 psf	125 pcf

STATION LIMITS	ELEVATION INTERVAL	MATERIAL	NOMINAL ANCHOR BOND STRESS, τ_n	UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT
WALL 7					
184+10 to 185+25	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to elevation 789	Soil	0.7 ksf	400 psf	125 pcf
	Elevation 789 to base of wall	Sandstone with interbedded shale	15 ksf	28,800 psf	155 pcf
185+25 to 188+25	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to elevation 801	Soil	0.7 ksf	400 psf	125 pcf
	Elevation 801 to base of wall	Sandstone with interbedded shale	15 ksf	28,800 psf	155 pcf
188+25 to 189+75	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to elevation 799	Soil	0.7 ksf	400 psf	125 pcf
	Elevation 799 to base of wall	Sandstone with interbedded shale	15 ksf	28,800 psf	155 pcf
189+75 to 191+43.06	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to elevation 781	Soil	0.7 ksf	400 psf	125 pcf
	Elevation 781 to base of wall	Sandstone with interbedded shale	15 ksf	28,800 psf	155 pcf

STATION LIMITS	ELEVATION INTERVAL	MATERIAL	NOMINAL ANCHOR BOND STRESS, τ_n	UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT
WALL 8					
222+37 to 230+75	Top of wall to top of ground	ASTM D448 No. 57 stone	Not applicable	0 psf	100 pcf
	Top of ground to base of wall	Soil	0.7 ksf	400 psf	125 pcf

8.0 LIMITATIONS OF REPORT

This report has been prepared for the exclusive use of Arcadis, U.S., Inc. and the Tennessee Department of Transportation and their designers for specific application to the project referenced in this report. Our conclusions and recommendations have been prepared using generally accepted standards of geotechnical engineering practice in the State of Tennessee. No other warranty is expressed or implied. S&ME, Inc. is not responsible for the conclusions, opinions, or recommendations of others based on this data.

Our conclusions and recommendations are based on the design information furnished to us, the data obtained during the geotechnical exploration, the laboratory test results, and our past experience. They do not reflect variations in the subsurface conditions that are likely to exist between our borings and in unexplored areas of the site due to the inherent variability of the subsurface conditions in this geologic region and past land use. If such variations are found during construction, re-evaluating our conclusions and recommendations will be necessary.

If changes are made in the locations or elevations of the planned retaining walls, the recommendations contained in this report will not be considered valid unless our firm has reviewed the changes and modified or verified our recommendations in writing. You should give us the opportunity to review the final design plans and the applicable portions of the project specifications when the designers complete the design. This review will allow us to check whether these documents are consistent with the intent of our recommendations.

For more information on the use and limitations of this report, please read the ASFE document included in Appendix V.