GEOTECHNICAL EXPLORATION

COUNTY ROAD M BRIDGE
FOUNDATION ANALYSIS
HENRY COUNTY, OHIO

JULY 2009

PREPARED FOR:

HENRY COUNTY ENGINEER
660 NORTH PERRY STREET
NAPOLEON, OH 43445

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1.0 INTRODUCTION

The Mannik & Smith Group, Inc., (MSG) was retained by the Henry County Engineer to conduct a geotechnical exploration for a proposed replacement of the County Road M Bridge over South Turkeyfoot Creek in Henry County, Ohio. The bridge location is depicted in Figure 1 Site Location. This report describes the exploration, presents MSG's geotechnical engineering recommendations of foundation types best suited for this application, provides an assessment of the factored resistance, bearing elevation and discusses the foundation elements.

2.0 PURPOSE AND SCOPE

The purpose of the exploration was to establish the subsurface soil and groundwater conditions at the site and to provide geotechnical engineering recommendations for the design of the foundation for the proposed County Road M Bridge replacement. The proposed bridge replacement will be constructed in the location of the existing structure. Geotechnical soil borings were advanced adjacent to the existing abutments, as depicted in Figure 2 – Boring Locations.

The exploration was performed in accordance with the scope of work included in the MSG proposal dated April 13, 2009. The exploration included two geotechnical borings totaling 116 linear feet of drilling and sampling and 10 linear feet of bedrock coring. Representative soil samples were tested in the laboratory to develop parameters for use in geotechnical analyses and in the development of design recommendations.

3.0 SUBSURFACE EXPLORATION

Details regarding the exploration are summarized below. Results of field and laboratory testing conducted as part of the exploration are also summarized below.

3.1 Drilling Procedures

Two soil borings, identified as SB-1 and SB-2 were drilled on site for geotechnical exploration purposes, on May 8 and May 11, 2009. MSG subcontracted TTL Associates, Inc., (TTL) to supply personnel and equipment to complete the borings. The borings were drilled in the vicinity of the existing County Road M Bridge to a depth of approximately 63.0 feet below ground surface (bgs). A truck-mounted drill rig was used to advance the boring by mechanically turning 4.25-inch inner diameter hollow-stem augers into the soil material. An NX diamond bit drill was then used to core into the underlying bedrock. All drilling activities were performed in general accordance with ASTM D 1452 (auger borings) and ASTM D 2113 (rock core drilling).

A standard 2-inch outer diameter split-spoon sampler was driven 18 inches into the soil with blows of a 140-pound hammer falling 30 inches. The sum of the number of hammer blows required to drive the sampler the second and third six-inch intervals was recorded and designated the "standard penetration resistance", or blow count, in units of blows per foot (bpf). The standard penetration resistance or "N" value, when properly evaluated, is an index of the soil's strength and density and is a measure of the soil's ability to support foundations. Soil sampling was conducted using the Standard Penetration Test (SPT) in general accordance with ASTM D1586.

Split-spoon samples were generally collected at 2.5-foot intervals in the upper 30 feet and at 5-foot intervals thereafter. The results of the field exploration have been summarized on the boring logs provided in Appendix A.

Rock core samples were continuously collected from approximately 58 to 63 feet bgs in 5.0 foot intervals. Rock Quality Designation (RQD) was recorded for each interval. The results of the field explorations have been summarized on test boring logs provided in Appendix A.

A representative of MSG visually classified the split-spoon soil samples in the field (ASTM D2488), conducted pocket penetrometer tests, calculated RQD and logged the borings. Soil and rock core samples were delivered to MSG for further examination and the assignment of laboratory testing on selected samples.

3.2 Laboratory Testing

MSG conducted Geotechnical laboratory testing of select samples. All samples were visually classified in accordance with the Unified Soil Classification System (USCS) and tested for natural moisture content.

Atterberg Limits, Grain Size Distribution and Soil Classification tests were performed on soils taken from select split spoon samples. Unconfined Compressive tests were performed on an intact piece of each rock core sample.

Geotechnical testing was conducted in accordance with the test schedule and standard methods as summarized in Table 3.2.

Table 3.2
Geotechnical Testing Schedule

Boring/ Sample	ASTM D422 (Grain Size Distribution)	ASTM D4318 (Atterberg Limits)	ASTM D2166 (Unconfined Compression)
SB-01/SS-2	●	●	
SB-01/SS-5	●	●	
SB-01/SS-8	●		
SB-01/SS-11	●	●	
SB-01/SS-14	●	●	
SB-01/SS-17	●		
SB-01/RC-1			●
SB-02/SS-2	●	●	
SB-02/SS-5	●	●	
SB-02/SS-8	●	●	
SB-02/SS-11	●	●	
SB-02/SS-14	●	●	
SB-02/SS-17	●	●	
SB-02/RC-2			●

Results of the laboratory testing are included in Appendix B. Test results are generally discussed in the following sections.

4.0 SUBSURFACE CONDITIONS

The subsurface soil and groundwater conditions encountered in the borings drilled at the site are shown in detail on the Soil Boring Logs contained in Appendix A. Notes and charts illustrating the soil classification criteria, and terminology used in the boring logs are also included in Appendix A.

The following sections describe subsurface conditions in terms of major soil strata for the purposes of geotechnical exploration. The soil boundaries indicated are inferred from non-continuous sampling and observations of the drilling and/or sampling resistance. The subsurface conditions discussed in the following paragraphs and that shown on the boring log represent an estimate of the subsurface conditions based on interpretation of the field and laboratory data using normally accepted geotechnical engineering judgment. The subsurface conditions described herein may vary beyond the boring location.

4.1 Soil Profile

The site is located in the Maumee Lake Plains region of Ohio and the soil profile represents a lacustrine formation consisting of massive deposits of fine grained clay with sand material transitioning to glacial silty sand with gravel and hard pan at depth overlying limestone bedrock. Bedrock was encountered during this exploration at approximately 58 feet bgs.

4.1.1 Soil Unit 1 – Stiff to Very Stiff Lean Clay with Sand

Soil Unit 1 consisted of a stiff to very stiff brown and gray lean clay with sand (CL) extended to a depth of approximately 39 feet in the borings. SPT results ranged from 6 to 25 bpf averaging 13 indicating a stiff to very stiff material. Pocket penetrometer tests results ranged from 1.5 to 4.0 TSF.

4.1.2 Soil Unit 2 – Very Loose to Loose Clayey Sand Seam

Soil Unit 2 consisted of a very loose to loose clayey sand seams with silty clay in between at depths of about 18 and 24 feet. SPT "N" values ranged from 2 to 7 bpf averaging 4 indicating a very loose to loose material. No pocket penetrometer tests were conducted in this layer as it was granular and thus un-testable.

4.1.3 Soil Unit 3 – Stiff to Hard Sandy Lean Clay

Soil Unit 3 consisted of a stiff to hard sandy lean clay at depths of about 39 to 45 feet. SPT "N" values ranged from 10 to 39 bpf averaging 20 indicating a stiff to hard material. Pocket penetrometer tests results ranged from 3.75 to 4.5+ TSF.

4.1.4 Soil Unit 4 – Glacial Hard Pan

Soil Unit 4 consisted of a very hard glacial hard pan at depths of about 45 to 58 feet. SPT "N" values ranged from 72 to 100 bpf averaging 85 indicating a very hard material. Pocket penetrometer tests results were consistently above 4.5 TSF.

4.2 Bedrock Profile

The site is located on the middle section of the Findlay Arch bedrock region of Ohio. The upper bedrock profile represents chemical sedimentary rock formations consisting of massive deposits of limestone, dolomite and gypsum. Bedrock was encountered during this exploration at a depth of approximately 58 feet.

4.2.1 Bedrock Unit 1 – Limestone

Bedrock Unit 1 consisted of massive, slightly fractured, dry gray limestone.

The RQD ranged from 60% to 88% and average unconfined compressive strength for the rock core samples representative of this unit from the 60 foot depth interval was 14,200 psi.

4.3 Groundwater

Ground water was encountered within the boring during drilling activities in the confined sand seams. However, stabilized water levels did not occur during the course of the exploration. Also, a change in soil color, from brown to gray, was generally noted at a depth of approximately 5-7 feet bgs in the borings. Changes in soil color, from brown to gray, are generally indicative of the median water table. The ground water elevation fluctuates and is naturally at a seasonal high during the winter and spring and is usually lower in the summer and early fall.

5.0 GENERAL RECOMMENDATIONS

The following evaluations and conclusions are based on interpretations of field and laboratory data obtained during the geotechnical exploration and MSG experience with similar soils and subsurface conditions. Where comments are made with regard to construction or the proposed development, they are provided in order to highlight aspects of construction that could potentially affect the design of the project. Contractors bidding on or undertaking the work should make their own interpretations of the factual results of the investigation as it affects their construction methods, equipment capabilities, costs, schedule, sequencing and the like.

A qualified geotechnical consultant should be retained for this project to monitor subsurface conditions and foundation preparation activities to verify that suitable materials are in place.

This report and evaluation reflects only the geotechnical aspects of the subsurface conditions at the site. Review and evaluation of environmental aspects of subsurface conditions is beyond the scope of this report.

5.1 Design Parameters

This section presents a summary of soil and bedrock strength parameters for design considerations. These parameters have been developed from SPT N values and laboratory testing data and are consistent with similar soils encountered in other explorations within the vicinity of the project site. Soil properties for the major stratigraphic units are summarized in Table 5.1

The soil strength design parameters generally represent the lower bound of test results for conservative analyses. Strength parameters were developed from SPT values representing total stress. Total Stress parameters represent short-term, undrained conditions present immediately after a load is applied to the soil and until excess soil pore pressures have dissipated or when conditions change rapidly enough that equilibrium can not be maintained. Test results are contained in Appendix B. Table 5.1 presents a summary of the soil strength parameters used in the driven pile capacity analyses:

Table 5.1
Summary of Soil Strength Design Parameters (Major Units)

Soil Unit / Description	Unit Wt. γ (pcf)	Total Stress	
		c (psf)	ϕ (°)
Soil Unit 1 – Stiff to Very Stiff Lean Clay with Sand	130.0	1,600	0
Soil Unit 2 – Loose to Very Loose Clayey Sand	130.0	0	21
Soil Unit 3 – Stiff to Hard Sandy Lean Clay	132.0	2,500	0
Soil Unit 4 – Glacial Hard Pan	135.0	0	41

The bedrock mass shear strength design value generally represents the lower bound of test results for conservative analyses. The rock mass shear strength was calculated from RQD and the average unconfined compressive strength of rock core samples according to Section 10.4.6.4 of the AASHTO LRFD Code. Rock core test results are contained in Appendix B. A Rock Mass Rating (RMR) of the intact bedrock mass of 79 was assigned to the limestone bedrock according to table 10.4.6.4-1 of the AASHTO LRFD Code. The RMR was then used to establish constants m and s (m=2.0, s=0.068) which were used to calculate the rock mass shear strength. The rock mass shear strength for the limestone bedrock was calculated to be 478,000 psf. Rock mass shear strength calculations are included in Appendix C.

5.2 Foundations

Various foundation types have been considered for the transfer of loads to subsurface soils and/or bedrock. Subsurface conditions at the site are most conductive to the use of deep foundations due to the relatively softer compressible soils near the surface with underlying harder soils and the proximity of the bedrock to the ground surface.

Driven piles are preferred to other deep foundation types for the range of loads anticipated with the proposed structure. H pile sizes of 10x42 and 12x53 were evaluated. The number of piles, geometric arrangement of the piles and the minimum spacing requirements will be used to select the pile size utilized in the final design of the foundation. Design and construction recommendations are presented in the following sections.

5.2.1 Driven Pile Design Recommendations

The factored resistance for piles driven to refusal on bedrock is typically governed by structural resistance. The total factored load for any single pile shall not exceed the maximum factored structural resistance ($R_{R\ max}$). The pile sizes considered for this analysis and the maximum factored structural resistance allowed for each is listed below in Table 5.2.1.

Table 5.2.1
Maximum Factored Structural Resistance

H Pile Size	$R_{R\,max}$ (kips)
HP 10x42	310
HP 12x53	380

Pile lengths required to develop the maximum factored resistance were calculated using Tomlinson's general cohesive soil adhesion model contained in Driven 1.2. Piles must be driven to bedrock in order to achieve the maximum factored structural resistance values listed above. It was assumed that the piles would be completely end bearing on the bedrock surface, therefore skin friction values were not considered in the evaluation of total pile resistance. Table 5.2.2 summarizes the required lengths for the piles that may be considered for this project to support the LRFD design load.

Table 5.2.2
Driven Piles Resistance

H Pile Size	Required Length (feet)	Ultimate End Bearing (kips)	Ultimate Skin Friction (kips)	Total Resistance (kips)
HP 10x42	58	370	0	370
HP 12x53	58	463	0	463

It is typical for piles to be driven after the completion of any embankments that may be associated with the bridge replacement allowing the majority of the settlement to occur. If piles are driven before settlement has had time to occur, the effects of down-drag should be considered by the structural engineer when sizing the piles.

Finally, the piles will be installed in such a manner as to allow expansion and contraction of the bridge deck.

5.2.2 Driven Pile Construction Recommendations

Piles should be driven to achieve the required ultimate bearing value, using a hammer selected to be compatible with driving conditions and with sufficient rated energy to achieve capacity as determined by criteria identified in the State of Ohio Department of Transportation Construction and Material Specifications (CMS) Items 507.04 and 507.05.

The existence of cobbles of boulders within the glacial till sub-soils is not unusual for this region. These conditions, if encountered, could hamper pile driving operations and possibly damage some piles. In addition, smaller piles may not fully penetrate the hardpan layer overlying bedrock. If some piles are observed to meet refusal at depths markedly less than that indicated above, boulder obstruction or pre-mature "fetching" may

be indicated. If these conditions are indicated, a pile load test or dynamic load test should be performed to evaluate the capacity of the pile. Alternately, for a project of this size, one or more replacement piles could be driven, probably at less expense than the cost of a load test.

A geotechnical engineer or a qualified soil technician under supervision of a geotechnical engineer should monitor driven pile installations in order to confirm the installation process, driving criteria, and review the procedures and acceptance criteria if necessary.

Where piles are to be driven to refusal, refusal shall be considered to be attained after the pile has contacted hard bedrock and then received at least 20 blows. The provisions of Section 606.1 of the current edition of ODOT "Bridge Design Manual" should be followed.

In order to protect the tips of steel H-piles, steel pile points or shoes should be used as the piles are anticipated to be driven to refusal onto hard bedrock.

If fill is added to the embankments, the piles should be driven after consolidation of the subsurface soils in order to minimize negative skin friction loads on the piles.

5.2.3 Excavation Recommendations

Activities at the site such as the installation/relocation of utilities may require excavations at significant depths below the ground surface. Slope height, slope inclination, and excavation depth (including utility trench excavations) should in no case exceed those specified in local, state, or federal safety regulations (see especially *OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926 Subpart P*). Such regulations are strictly enforced and, if not followed, the contractor, earthwork subcontractor, or utility subcontractors could be liable for substantial penalties.

The native soils encountered during the investigation were brown and gray silty clay with sand and some gravel with possible interbedded sand seams. Based upon the data obtained, these soils would be classified as Type B, cohesive soils with unconfined compressive strength greater than 0.5 TSF but less than 1.5 TSF. Simple side slopes for open excavations in these materials must be no steeper than 1 horizontal to 1 vertical (1H:1V).

As an alternative to sloping, excavations may be properly braced against lateral movement. If any excavation, including a utility trench, is extended to a depth of more than 20 feet, OSHA requires that a Professional Engineer design the side slopes of such excavations.

5.3 Groundwater Control and Drainage

Seepage within any excavations can be removed by means of pumping. However, if the amount of seepage exceeds the anticipated volumes, or the walls of the excavations can become unstable, temporary bracings, as described above, may have to be utilized to properly maintain excavations in adverse groundwater infiltration situations. The groundwater seepage should be monitored during construction in order to evaluate the adequacy of the dewatering techniques in use and determine construction methods.

Proper management of surface water flows and excavations above the normal water level should also be implemented.

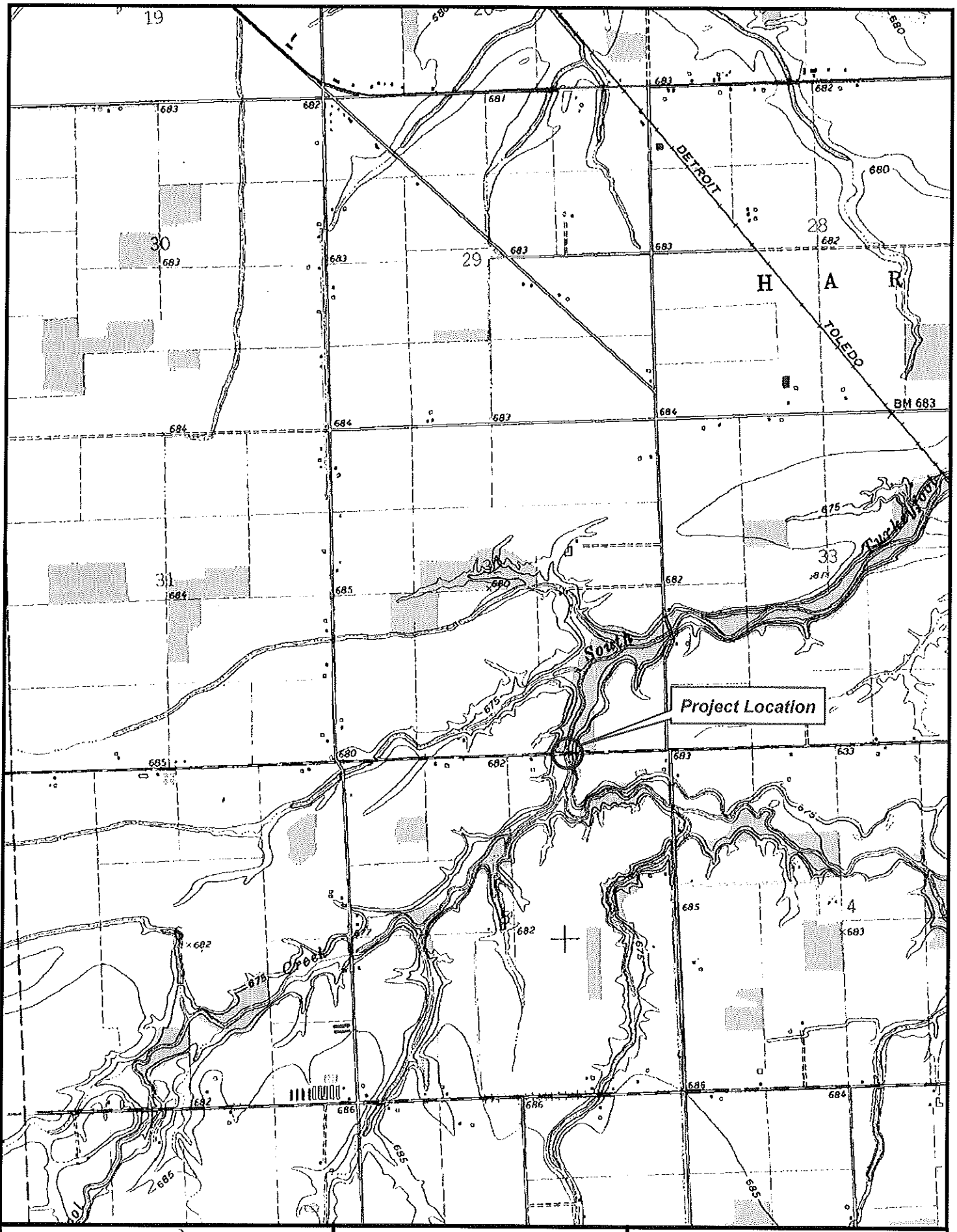
6.0 CONCLUSIONS

The evaluations, conclusions and recommendations in this report are based on our interpretation of the field and laboratory data obtained during the geotechnical exploration, our understanding of the project and our experience with similar sites and subsurface conditions. Data used during this exploration included:

- Two (2) exploratory borings performed during this study;
- Observations of the project site by MSG staff;
- Results of laboratory soil and rock core testing completed to date;
- Published soil and geologic data for the area; and
- Preliminary design loads.

The subsurface conditions discussed in this report and those shown on the boring log represents an estimate of the subsurface conditions based on interpretation of the boring data using normally accepted geotechnical engineering judgments. Although individual test borings are representative of the subsurface conditions at the boring locations on the dates shown, they are not necessarily indicative of subsurface conditions at other locations or at other times. As variations in the soil profile are encountered, additional subsurface sampling and testing may be necessary to provide data required to re-evaluate the recommendations of this report. MSG is not responsible for independent conclusions, opinions, or recommendations made by others based upon information presented in this report.

The project plans and specifications should be reviewed by the geotechnical engineer to confirm that the geotechnical aspects are generally consistent with the recommendations of this report. In addition, site subgrade preparation, structural fill (if required) compaction activities, and foundation installation activities should be monitored by the geotechnical engineer.



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Civil Engineering, Surveying and Environmental Consulting
MAUMEE ♦ CLEVELAND ♦ MONROE ♦ CANTON

Figure 1
Site Location
County Road M
Henry County, Ohio

Notes
USGS Quadrangles, 7.5' Series Topographic
Malinta, Henry Co., OH 1969
Photorevised 1971

Feet
0 1,000 2,000

N

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Figure 2
Soil Boring Locations
County Road M
Henry County, Ohio

Notes
The Henry county photography, dated April 2006, is provided by OGRIP, as part of the Ohio Statewide Imagery Program.

Feet
100 50 0 100

Project # HENC0016 July 2009. HENC0016_SB.mxd

APPENDIX A

Soil Boring Logs

The Mannik & Smith Group, Inc.

CLIENT Henry County, Ohio

PROJECT NAME Road M Over South Turkeyfoot Creek STS

PROJECT NUMBER HENC0016

PROJECT LOCATION Henry County, Ohio

LITHOLOGIC SYMBOLS
(Unified Soil Classification System)

- Topsoil
- USCS Well-graded Gravel
- Clay
- Silty Sand
- Limestone
- SILT

SAMPLER SYMBOLS

- Split Spoon
- Rock Core

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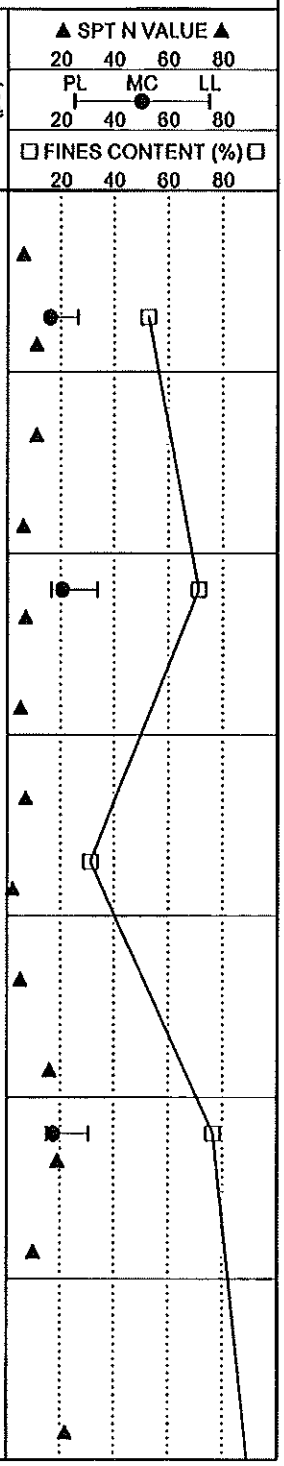
BORING NUMBER SB-1

The Mannik & Smith Group, Inc.
TOLEDO CANTON LANSING DETROIT MONROE CLEVELAND COLUMBUS
The Mannik & Smith Group, Inc.
2365 Haggerty Road South, Canton, MI 48188
ph: 734-397-3100 fax: 734-397-3131

CLIENT Henry County, Ohio
PROJECT NAME Road M Over South Turkeyfoot Creek STS
PROJECT NUMBER HENC0016
PROJECT LOCATION Henry County, Ohio
DATE STARTED 5/8/09 COMPLETED 5/8/09
GROUND ELEVATION 676.36 FEET BORING DIAMETER: 8.25"
DRILLING CONTRACTOR TTL
WELL SURVEY INFORMATION: 10020.56 Northing; 10958.04 Easting
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING: 18 FEET
LOGGED BY TAM CHECKED BY BDK
AT END OF DRILLING: N/A
NOTES
AFTER DRILLING: N/A

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION		SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
0		**Topsoil**	675.5					
		Crushed stone	674.2	SS 1		6-4-2 (6)		
		Medium stiff, brown Clay, damp						
5		-Stiff		SS 2		3-4-7 (11)	4.0	
			670.4					
		Stiff, mottled brown and gray Clay, trace sand, damp	668.9	SS 3		5-5-6 (11)	3.0	
		Medium stiff, gray Clay, damp						
10				SS 4		2-3-3 (6)	1.5	
				SS 5		2-3-4 (7)	1.25	
		-Trace sand	661.9	SS 6		2-2-3 (5)	1.0	
15		Gray Silty Sand organics, wet						
			659.9	SS 7		3-3-4 (7)	1.5	
		Medium stiff, gray Clay, trace sand, moist						
			657.9					
20		Very loose, gray Silty Sand wet		SS 8		1-1-1 (2)		
		-Loose		SS 9		1-1-4 (5)		
			652.4					
25		Very stiff, gray Clay, trace sand and gravel, moist		SS 10		4-7-9 (16)	3.5	
				SS 11		5-9-10 (19)	2.75	
30		-Stiff		SS 12		3-4-6 (10)	2.75	
35		-Very stiff		SS 13		6-10-12 (22)	3.75	



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BORING NUMBER SB-1

Mannik & Smith Group, Inc.
TOLEDO CANTON LANSING DETROIT MONROE CLEVELAND COLUMBUS

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2365 Haggerty Road South, Canton, MI 48188
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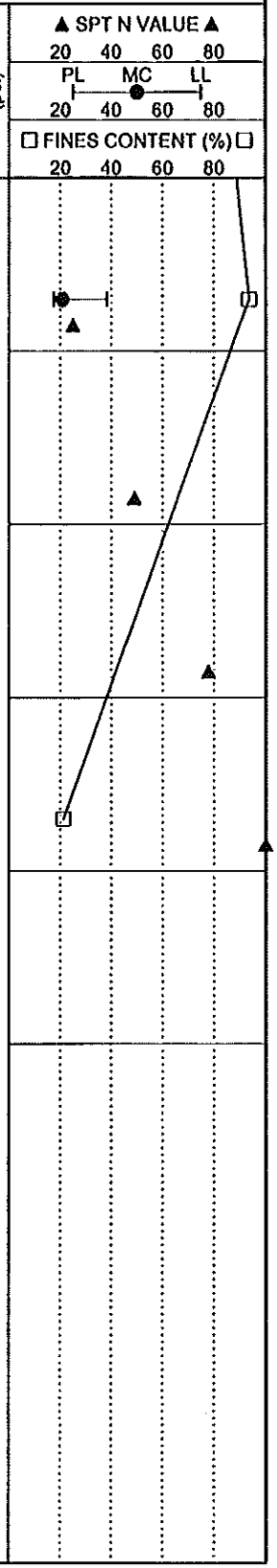
CLIENT Henry County, Ohio
PROJECT NAME Road M Over South Turkeyfoot Creek STS
PROJECT NUMBER HENC0016
PROJECT LOCATION Henry County, Ohio

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
35		Very stiff, gray Clay, trace sand and gravel, moist *(continued)*					
40		·Very stiff, trace sand	SS 14		7-10-15 (25)	3.75	
45		·Hard, trace sand	SS 15		15-17-32 (49)	4.5+	
		631.4 Very dense, gray Silty Sand, trace gravel, wet					
50			SS 16		24-34-44 (78)		
55			SS 17		37-50-50 (100)		
		617.9					
60		LIMESTONE, gray	RC 1	100			
		612.8					

Bottom of borehole at 63.6 feet.



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BORING NUMBER SB-2

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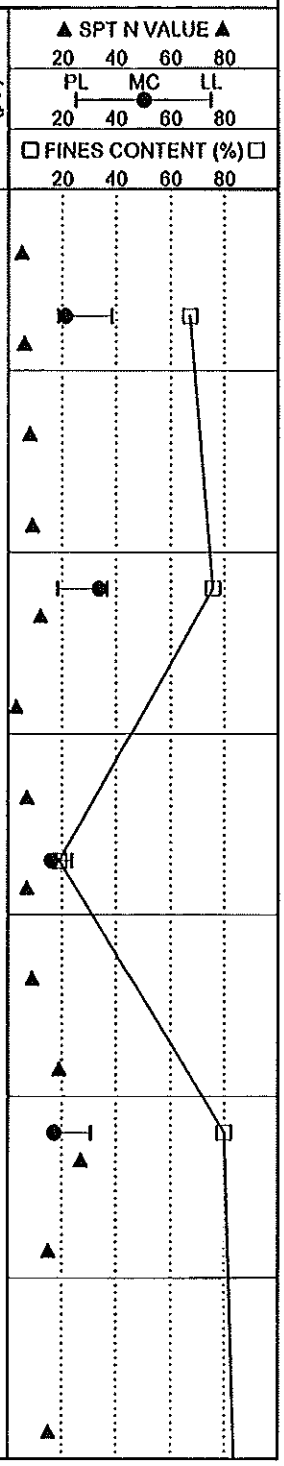
The Mannik & Smith Group, Inc.
2365 Haggerty Road South, Canton, MI 48188
ph: 734-397-3100 fax: 734-397-3131

CLIENT Henry County, Ohio
PROJECT NAME Road M Over South Turkeyfoot Creek STS
PROJECT NUMBER HENC0016
PROJECT LOCATION Henry County, Ohio
DATE STARTED 5/11/09 COMPLETED 5/11/09
GROUND ELEVATION 675.64 FEET BORING DIAMETER: 8.25"
DRILLING CONTRACTOR TTL
WELL SURVEY INFORMATION: 9983.24 Northing; 11101.81 Easting
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING: 14.2 FEET
LOGGED BY TAM CHECKED BY BDK
AT END OF DRILLING: N/A
NOTES
AFTER DRILLING: N/A

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
0		TOPSOIL 675.5					
		Crushed stone 673.6	SS 1	11	3-3-2 (5)		
		Medium stiff, brown CLAY, trace Sand, damp 672.1					
		Medium stiff, gray CLAY, trace Sand and Gravel, damp 670.6	SS 2	83	3-3-3 (6)	2.25	
5		Medium stiff, mottled brown and gray CLAY, trace Sand and Gravel, damp	SS 3	100	4-4-4 (8)	1.75	
		-Stiff, little Sand	SS 4	100	3-4-5 (9)	2.5	
10		663.6 Stiff, gray CLAY, damp	SS 5	100	5-6-6 (12)	2.75	
		661.7 Very loose, Silty SAND, wet 661.5	SS 6	83	0-0-3 (3)	0.75	
15		Soft, gray CLAY, little Sand, moist					
		-Medium stiff, trace Sand	SS 7	100	3-4-3 (7)	1.5	
		-Medium stiff, trace Sand 656.1	SS 8	78	1-3-4 (7)	1.25	
20		Loose, gray Silty SAND, some Gravel, wet					
		653.6 Very stiff, gray CLAY, trace Sand, moist	SS 9	100	3-4-5 (9)	2.25	
25			SS 10	100	3-8-11 (19)	3.25	
			SS 11	100	12-12-15 (27)	4.0	
30		-Stiff	SS 12	100	4-6-9 (15)	2.75	
35		-Stiff	SS 13	100	3-6-9 (15)	2.5	



(Continued Next Page)

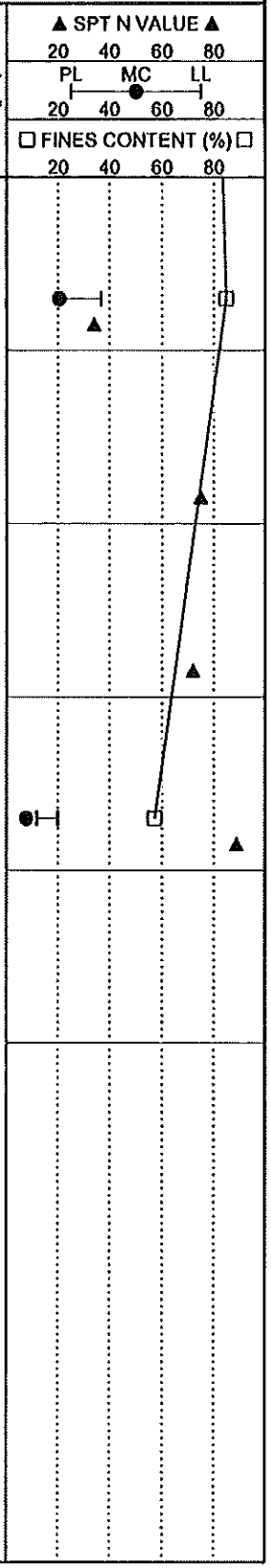
GEOTECH BH PLOTS - GINT STD US LAB.GDT - 7/10/09 09:36 - W:\PROJECTS\PROJECTS F-J\HENC0016\ADMINISTRATION\HENC0016.BORING LOGS.GPJ

BORING NUMBER SB-2

Mannik & Smith Group, Inc.
TOLEDO CANTON LANSING DETROIT MONROE CLEVELAND COLUMBUS
The Mannik & Smith Group, Inc.
2365 Haggerty Road South, Canton, MI 48188
ph: 734-397-3100 fax: 734-397-3131

CLIENT Henry County, Ohio
PROJECT NAME Road M Over South Turkeyfoot Creek STS
PROJECT NUMBER HENC0016
PROJECT LOCATION Henry County, Ohio

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)
35		Very stiff, gray CLAY, trace Sand, moist *(continued)*					
40		-Hard	SS 14	100	5-12-22 (34)	4.25	
45		-Hard	SS 15	100	18-25-50 (75)	4.5+	
		630.6 Hard, gray Clayey SILT, little Sand and Gravel, moist					
50			SS 16	100	16-28-44 (72)	4.5+	
55			SS 17	100	23-39-50 (89)	4.5+	
		Auger Refusal at 57' 10" 617.8					
60		LIMESTONE, gray	RC 2	96			
		613.1 Bottom of borehole at 62.6 feet.					



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APPENDIX B

Soil Laboratory Test Data

Mannik & Smith Group, Inc.

TOLEDO CANTON LANSING DETROIT MONROE CLEVELAND COLUMBUS

SUMMARY OF LABORATORY RESULTS

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CLIENT Henry County, Ohio

PROJECT NAME Road M Over South Turkeyfoot Creek STS

PROJECT NUMBER HENC0016

PROJECT LOCATION Henry County, Ohio

Borehole	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Maximum Size (mm)	%<#200 Sieve	Class-ification	Water Content (%)	Bulk Density (pcf)	Satur-ation (%)	Specific Gravity
SB-1	3.5	26	16	10	19	53	CL	16.0			
SB-1	11.0	34	17	17	2	71	CL	20.6			
SB-1	18.5				9.525	31		20.8			
SB-1	26.0	31	15	16	19	77	CL	17.3			
SB-1	38.5	38	17	21	2	94	CL	20.8			
SB-1	53.5				19	21		15.9			
SB-2	3.5	38	18	20	4.75	67	CL	21.0			
SB-2	11.0	37	18	19	4.75	76	CL	33.7			
SB-2	18.5	24	16	8	9.525	19	SC	16.0			
SB-2	26.0	31	16	15	4.75	80	CL	17.2			
SB-2	38.5	37	19	18	19	85	CL	20.5			
SB-2	53.5	20	12	8	9.525	57	CL	7.7			

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LAB SUMMARY - GINT STD US LAB.GDT - 6/10/09 09:55 - W:\PROJECTS\PROJECTS F-J\HENC0016\ADMINISTRATION\HENC0016.BORING LOGS.GPJ

ATTERBERG LIMITS' RESULTS

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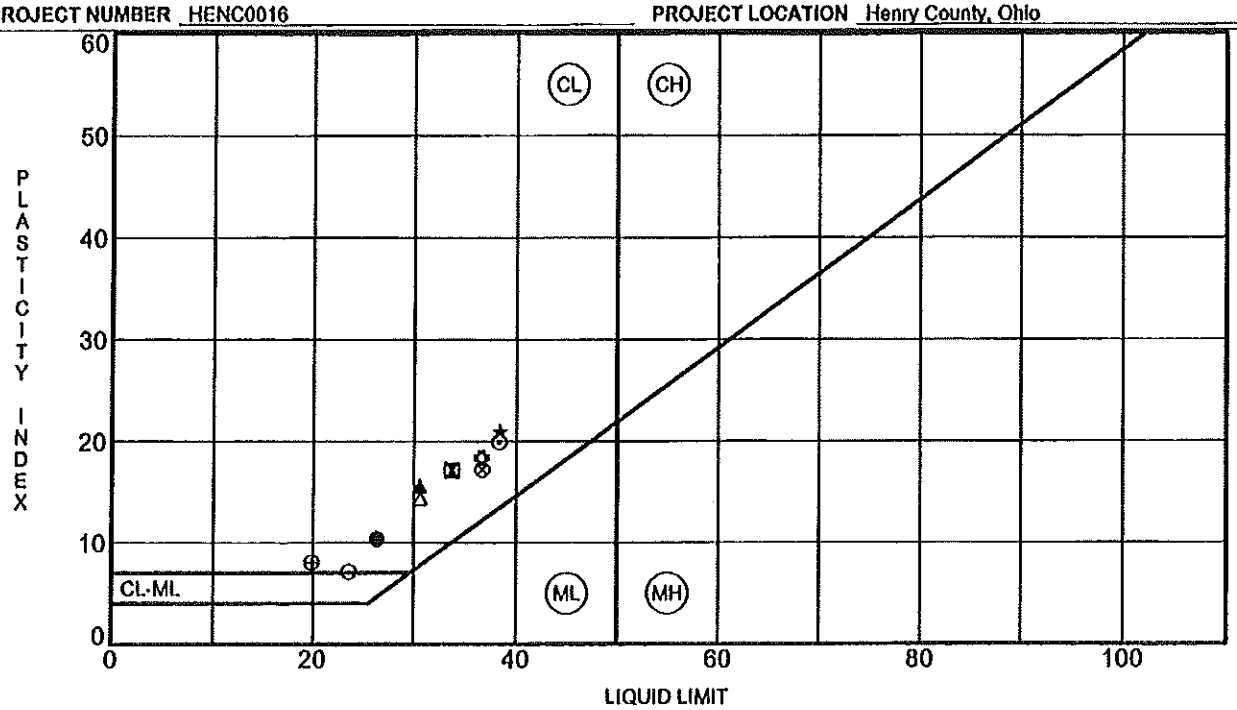
CLIENT Henry County, Ohio

PROJECT NAME Road M Over South Turkeyfoot Creek STS

PROJECT NUMBER HENC0016

PROJECT LOCATION Henry County, Ohio



	Specimen Identification		LL	PL	PI	Fines	Classification
●	SB-1	3.5	26	16	10	53	SANDY LEAN CLAY(CL)
⊠	SB-1	11.0	34	17	17	71	LEAN CLAY with SAND(CL)
▲	SB-1	26.0	31	15	16	77	LEAN CLAY with SAND(CL)
★	SB-1	38.5	38	17	21	94	LEAN CLAY(CL)
⊙	SB-2	3.5	38	18	20	67	SANDY LEAN CLAY(CL)
✿	SB-2	11.0	37	18	19	76	LEAN CLAY with SAND(CL)
○	SB-2	18.5	24	16	8	19	CLAYEY SAND(SC)
△	SB-2	26.0	31	16	15	80	LEAN CLAY with SAND(CL)
⊗	SB-2	38.5	37	19	18	85	LEAN CLAY with SAND(CL)
⊕	SB-2	53.5	20	12	8	57	SANDY LEAN CLAY(CL)

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ATTERBERG LIMITS - GINT STD US LAB.GDT - 6/10/09 09:54 - W:\PROJECTS\PROJECTS F-J\HENC0016\ADMINISTRATION\HENC0016 BORING LOGS.GPJ

GRAIN SIZE DISTRIBUTION

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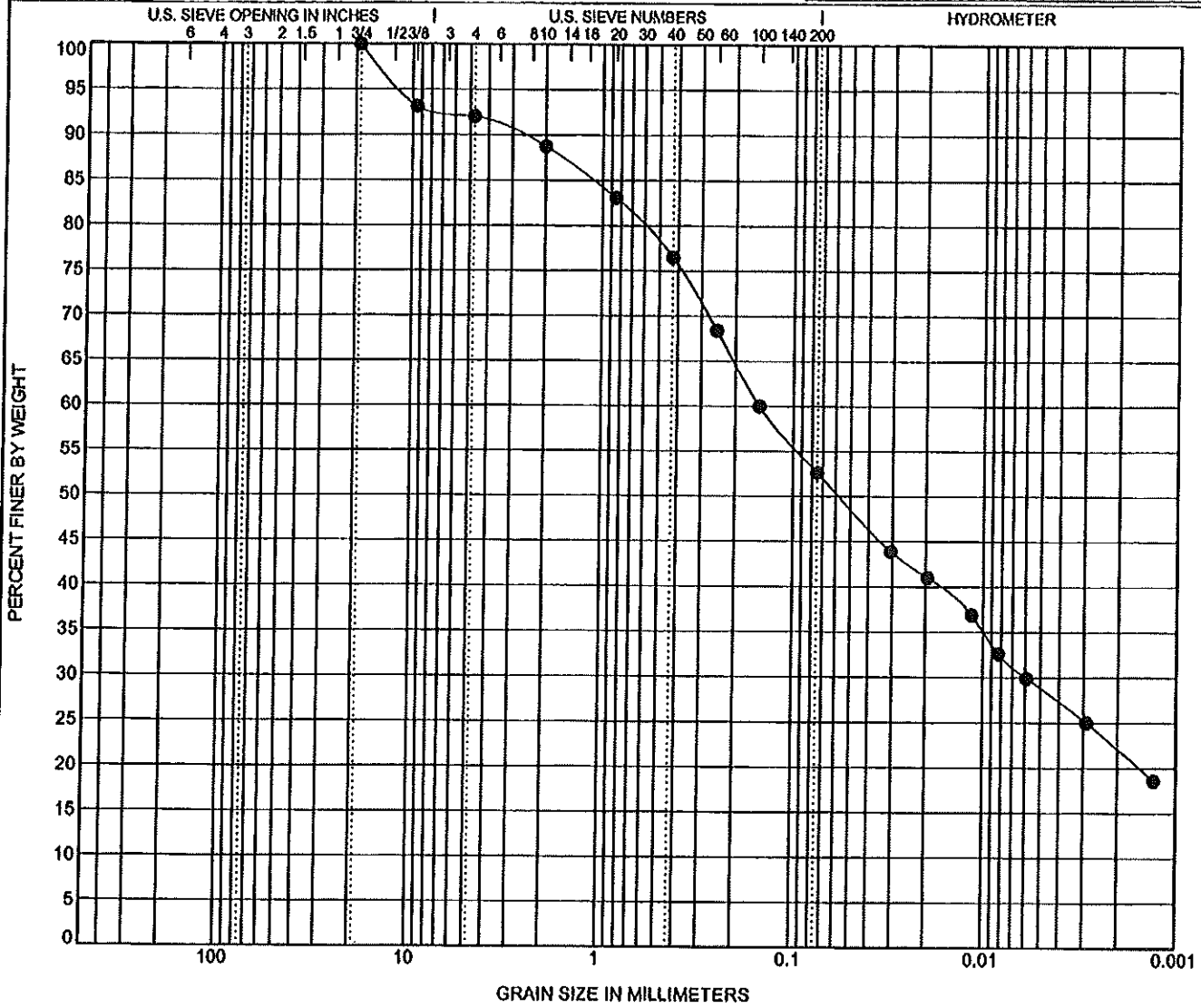
CLIENT Henry County, Ohio

PROJECT NAME Road M Over South Turkeyfoot Creek STS

PROJECT NUMBER HENC0016

PROJECT LOCATION Henry County, Ohio



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● SB-1	3.5	SANDY LEAN CLAY(CL)	26	16	10		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB-1	3.5	19	0.15	0.006		8.0	39.4	30.6	22.0

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GRAIN SIZE - GINT STD US LAB.GDT - 5/10/09 09:32 - W:\PROJECTS\PROJECTS F-J\HENC0016\ADMINISTRATION\HENC0016.BORING LOGS.GPJ

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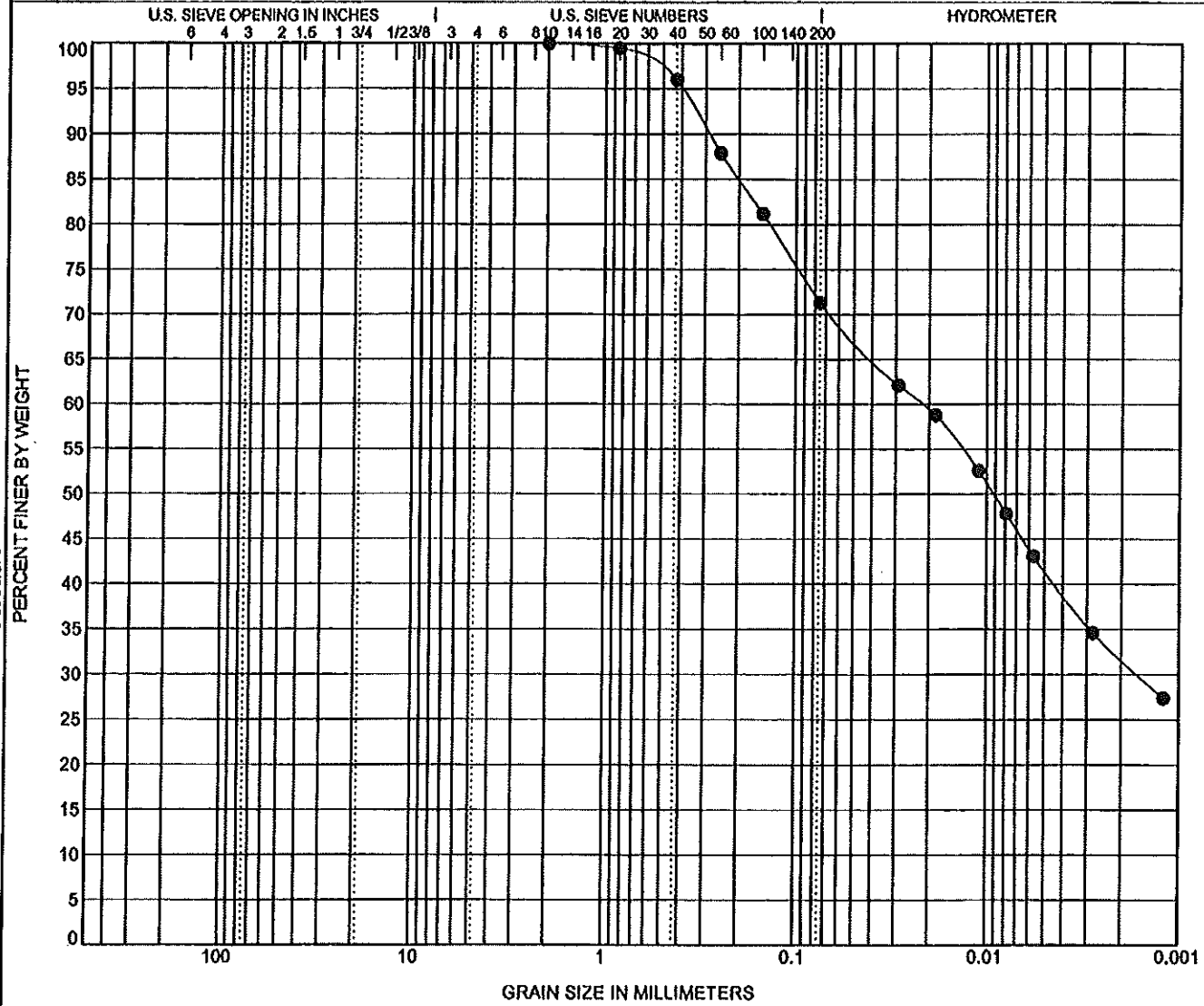
PROJECT NAME Road M Over South Turkeyfoot Creek STS

PROJECT NUMBER HENC0016

PROJECT LOCATION Henry County, Ohio



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	SB-1	11.0	LEAN CLAY with SAND(CL)	34	17	17		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SB-1	11.0	2	0.022	0.002		0.0	28.7	39.6	31.7

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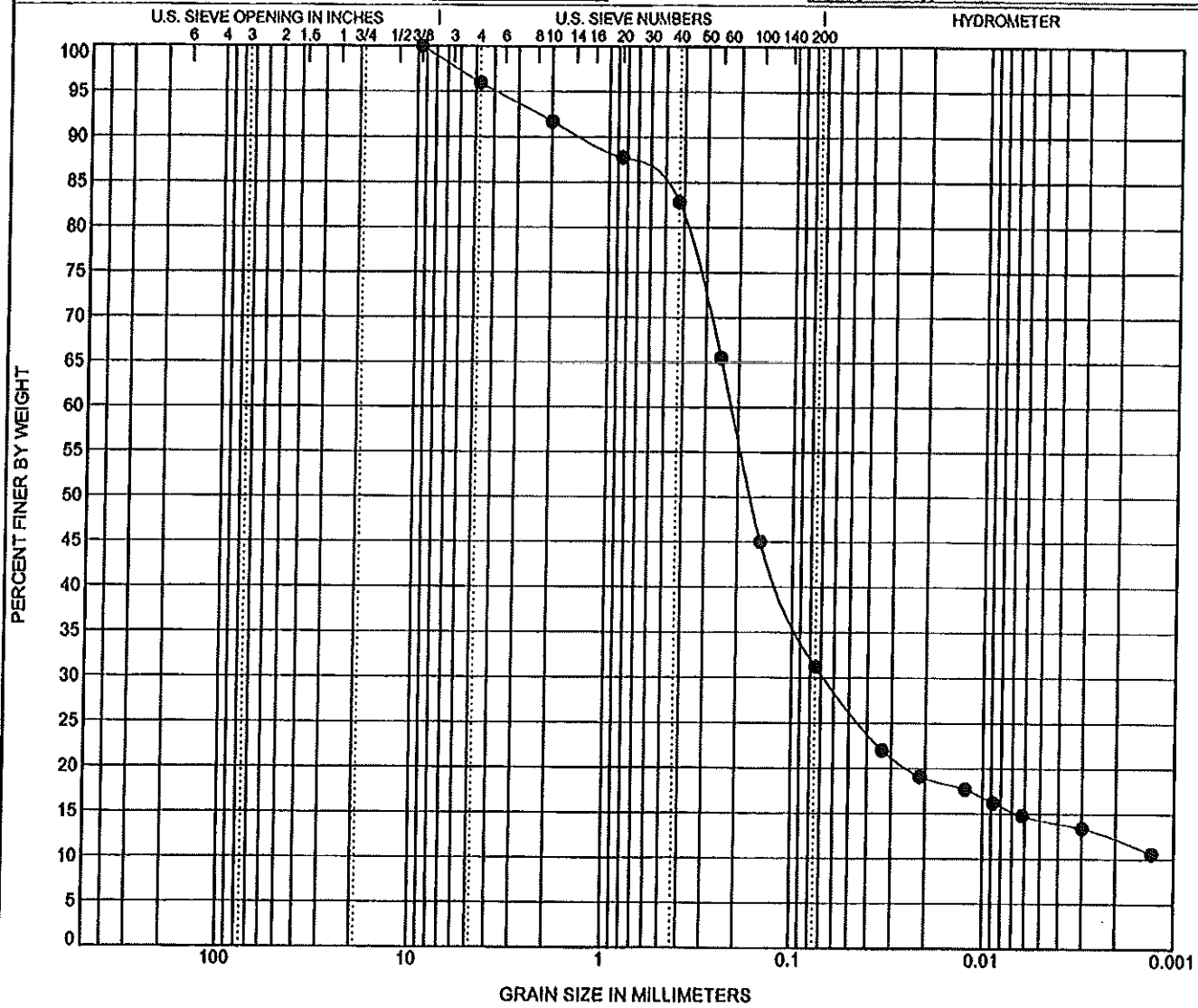
CLIENT Henry County, Ohio

PROJECT NAME Road M Over South Turkeyfoot Creek STS

PROJECT NUMBER HENC0016

PROJECT LOCATION Henry County, Ohio



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● SB-1	18.5	CLAYEY SAND(SC)					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB-1	18.5	9.525	0.218	0.067		4.0	64.8	19.2	12.0

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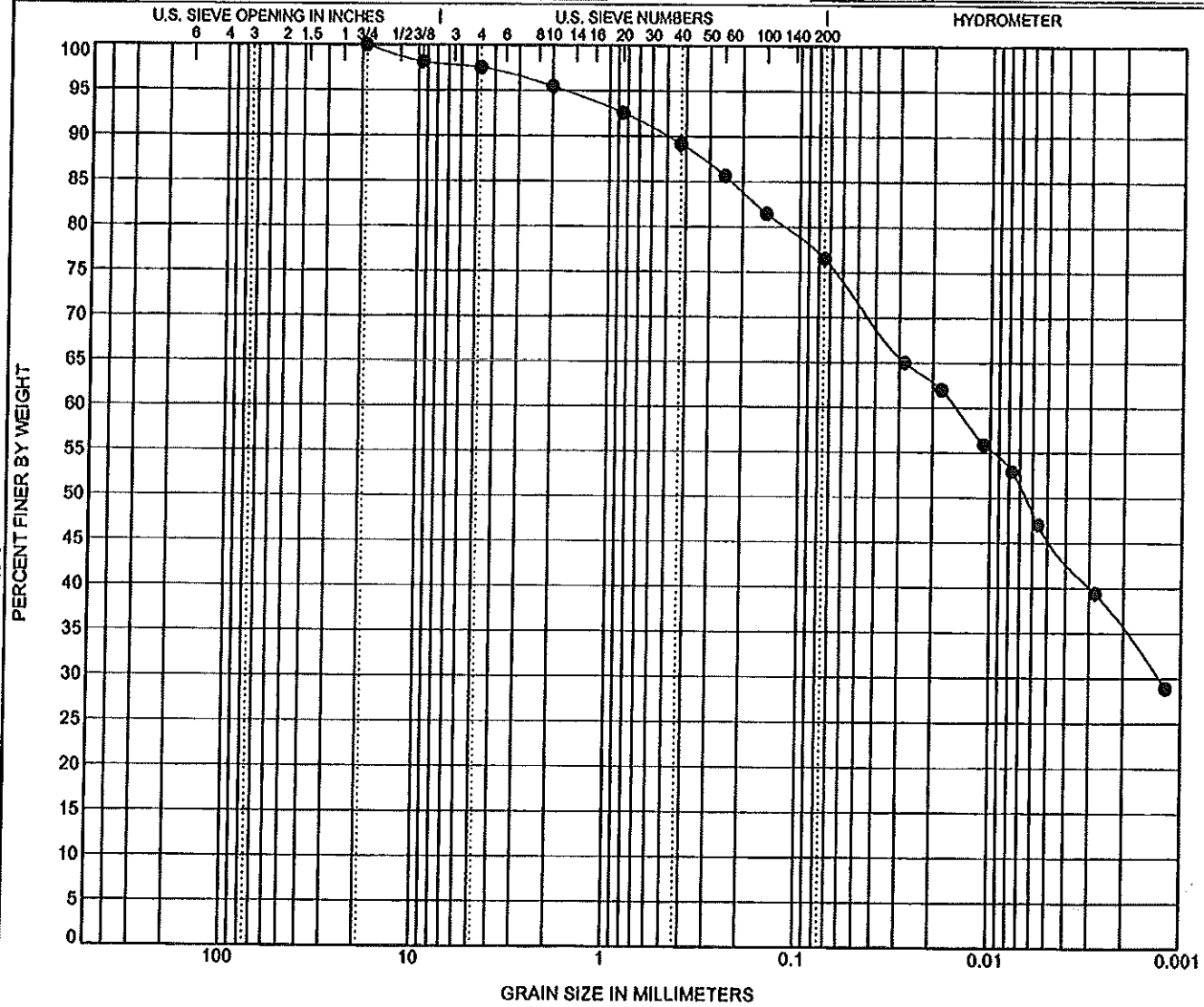
CLIENT Henry County, Ohio
PROJECT NAME Road M Over South Turkeyfoot Creek STS
PROJECT NUMBER HENC0016
PROJECT LOCATION Henry County, Ohio



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● SB-1	26.0	LEAN CLAY with SAND(CL)	31	15	16		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB-1	26.0	19	0.015	0.001		2.5	21.0	41.3	35.2

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GRAIN SIZE - GINT STD US LAB.GDT - 6/16/09 09:33 - W:\PROJECTS\PROJECTS F-J\HENC0016\ADMINISTRATION\HENC0016.BORING LOGS.GPJ

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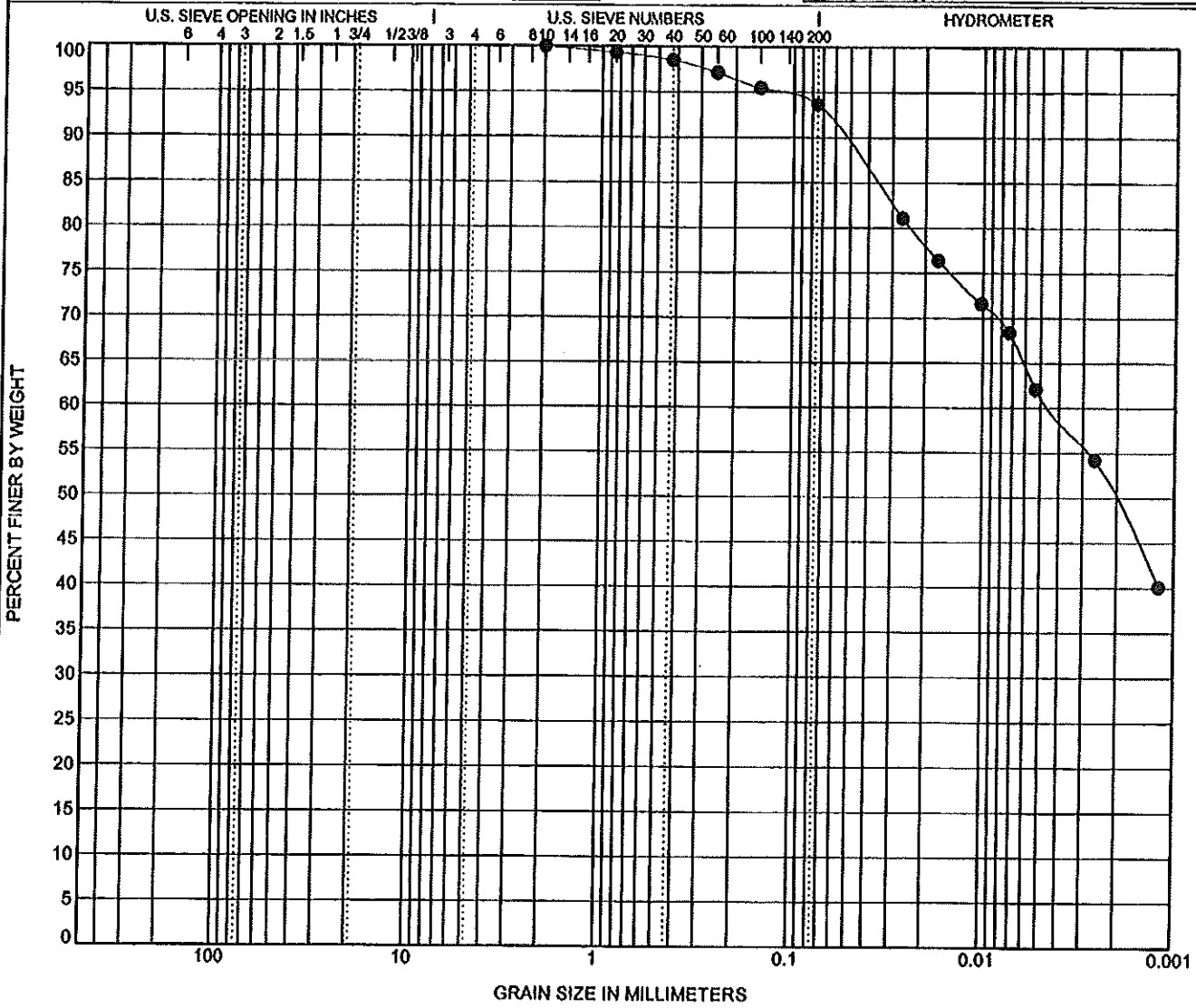
PROJECT NAME Road M Over South Turkeyfoot Creek STS

PROJECT NUMBER HENC0016

PROJECT LOCATION Henry County, Ohio



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	SB-1	38.5	LEAN CLAY(CL)	38	17	21		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SB-1	38.5	2	0.004			0.0	6.3	44.2	49.4

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GRAIN SIZE - GINT STD US LAB.GDT - 6/10/09 09:34 - W:\PROJECTS\PROJECTS F-J\HENC0016\ADMINISTRATION\HENC0016.BORING LOGS.GPJ

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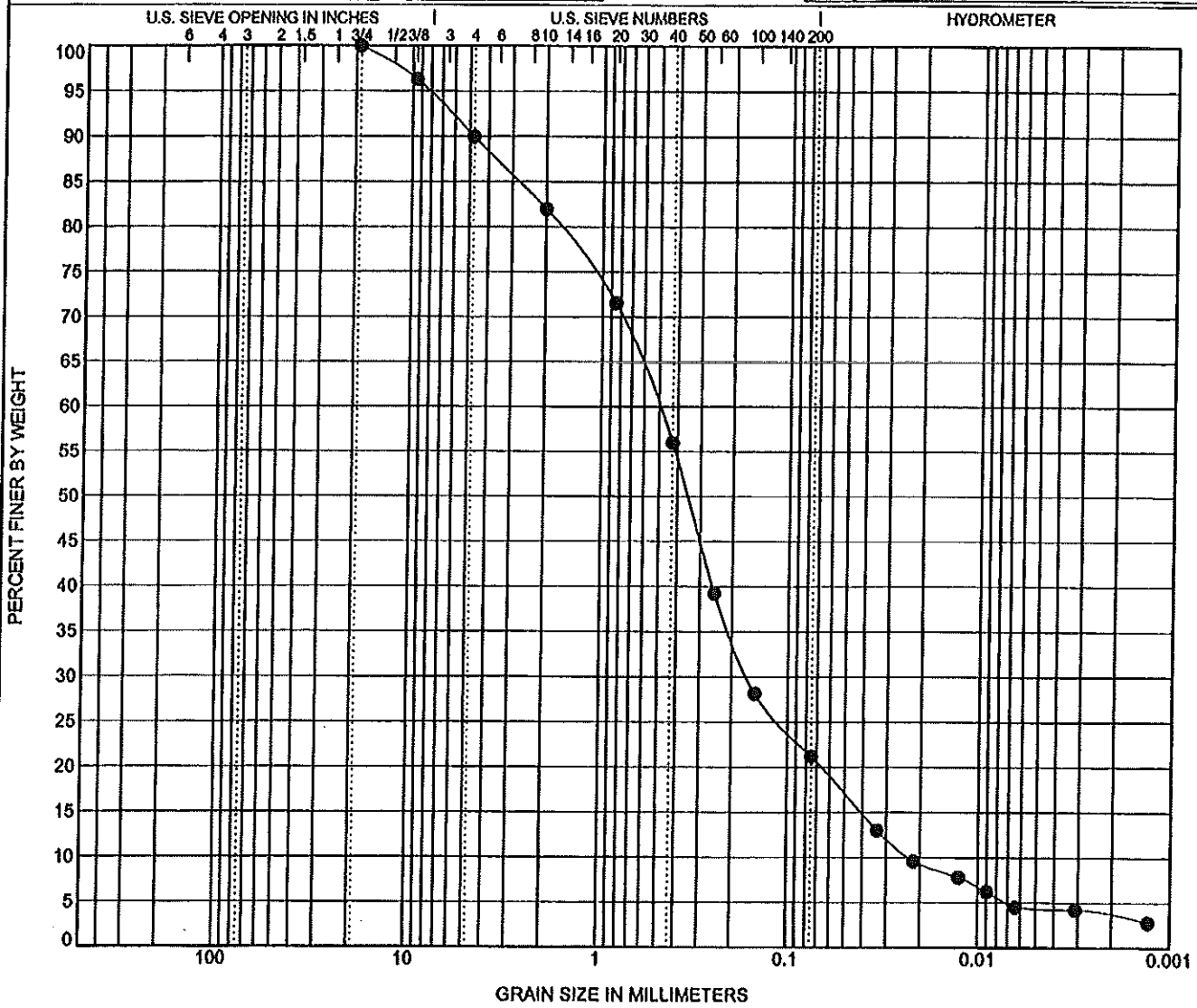
CLIENT Henry County, Ohio

PROJECT NAME Road M Over South Turkeyfoot Creek STS

PROJECT NUMBER HENC0016

PROJECT LOCATION Henry County, Ohio



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	SB-1	53.5	CLAYEY SAND(SC)				2.31	22.35

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SB-1	53.5	19	0.508	0.163	0.023	10.0	68.8	17.7	3.5

TAM
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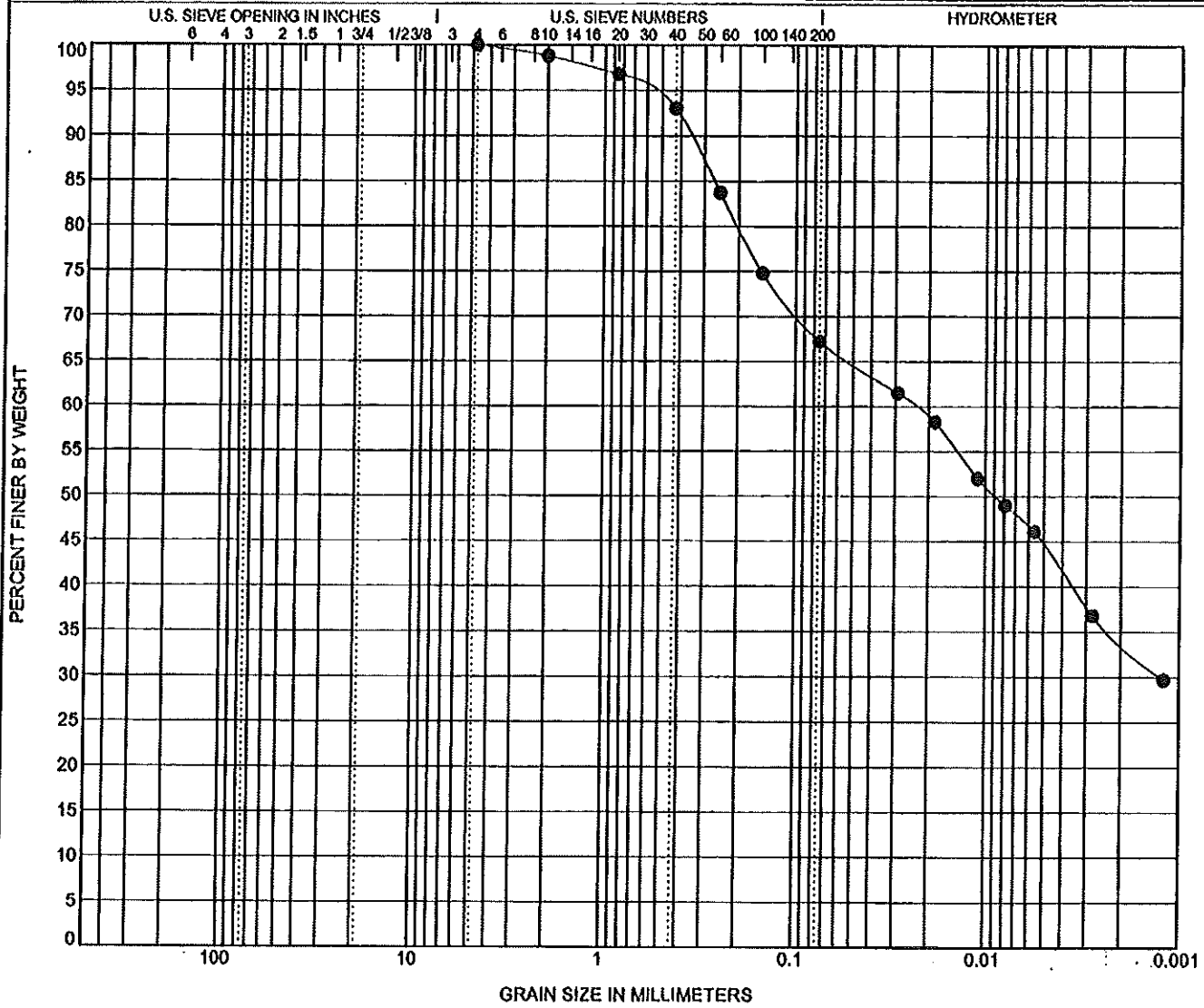
CLIENT Henry County, Ohio

PROJECT NAME Road M Over South Turkeyfoot Creek STS

PROJECT NUMBER HENC0016

PROJECT LOCATION Henry County, Ohio



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● SB-2	3.5	SANDY LEAN CLAY(CL)	38	18	20		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB-2	3.5	4.75	0.024	0.001		0.0	32.8	33.2	34.0

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GRAIN SIZE - GINT STD US LAB.GDT - 6/10/09 09:35 - W:\PROJECTS\PROJECTS F-J\HENC0016\ADMINISTRATION\HENC0016.BORING LOGS.GPJ

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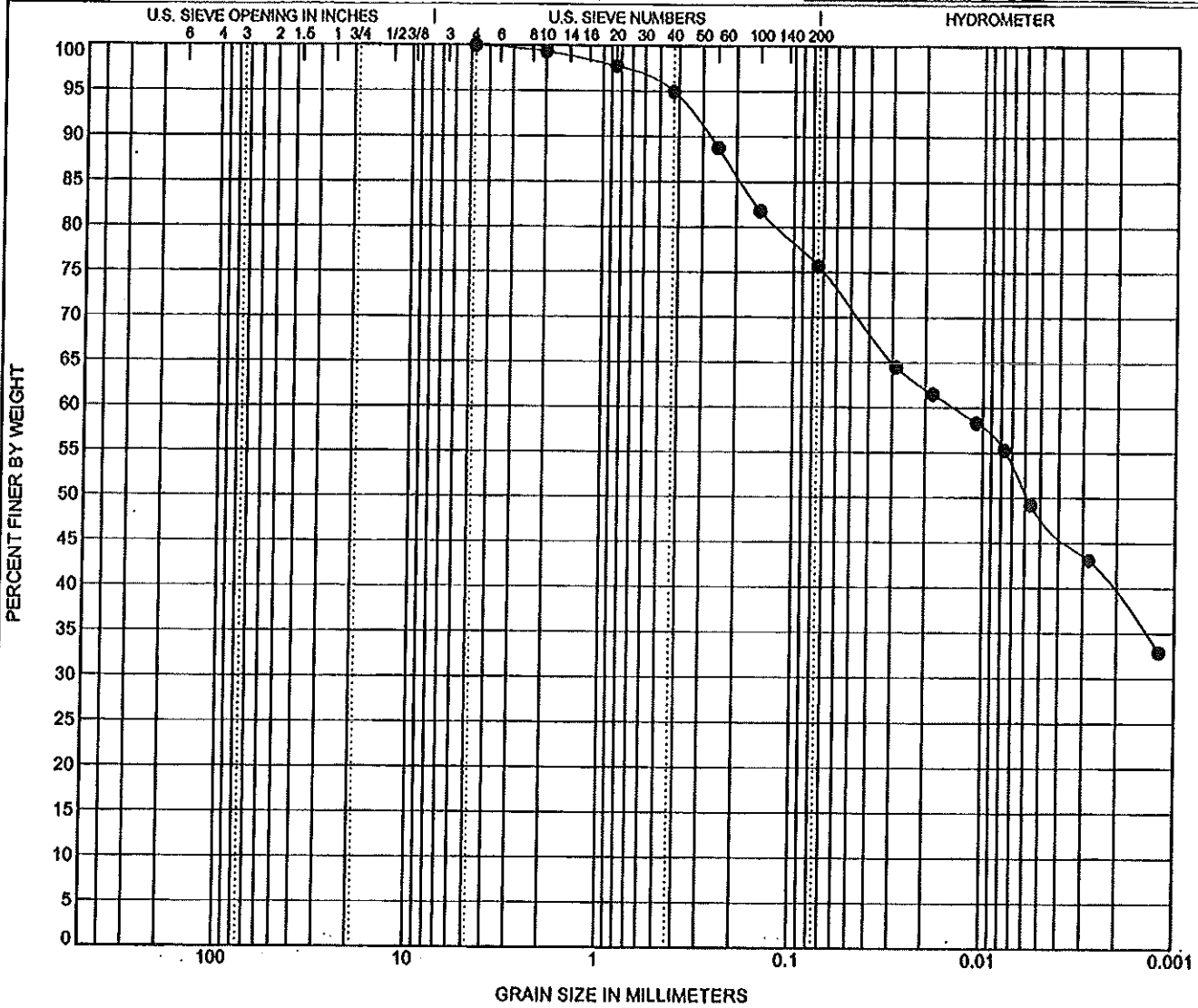
CLIENT Henry County, Ohio

PROJECT NAME Road M Over South Turkeyfoot Creek STS

PROJECT NUMBER HENC0016

PROJECT LOCATION Henry County, Ohio



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● SB-2	11.0	LEAN CLAY with SAND(CL)	37	18	19		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB-2	11.0	4.75	0.014			0.0	24.3	36.7	39.0

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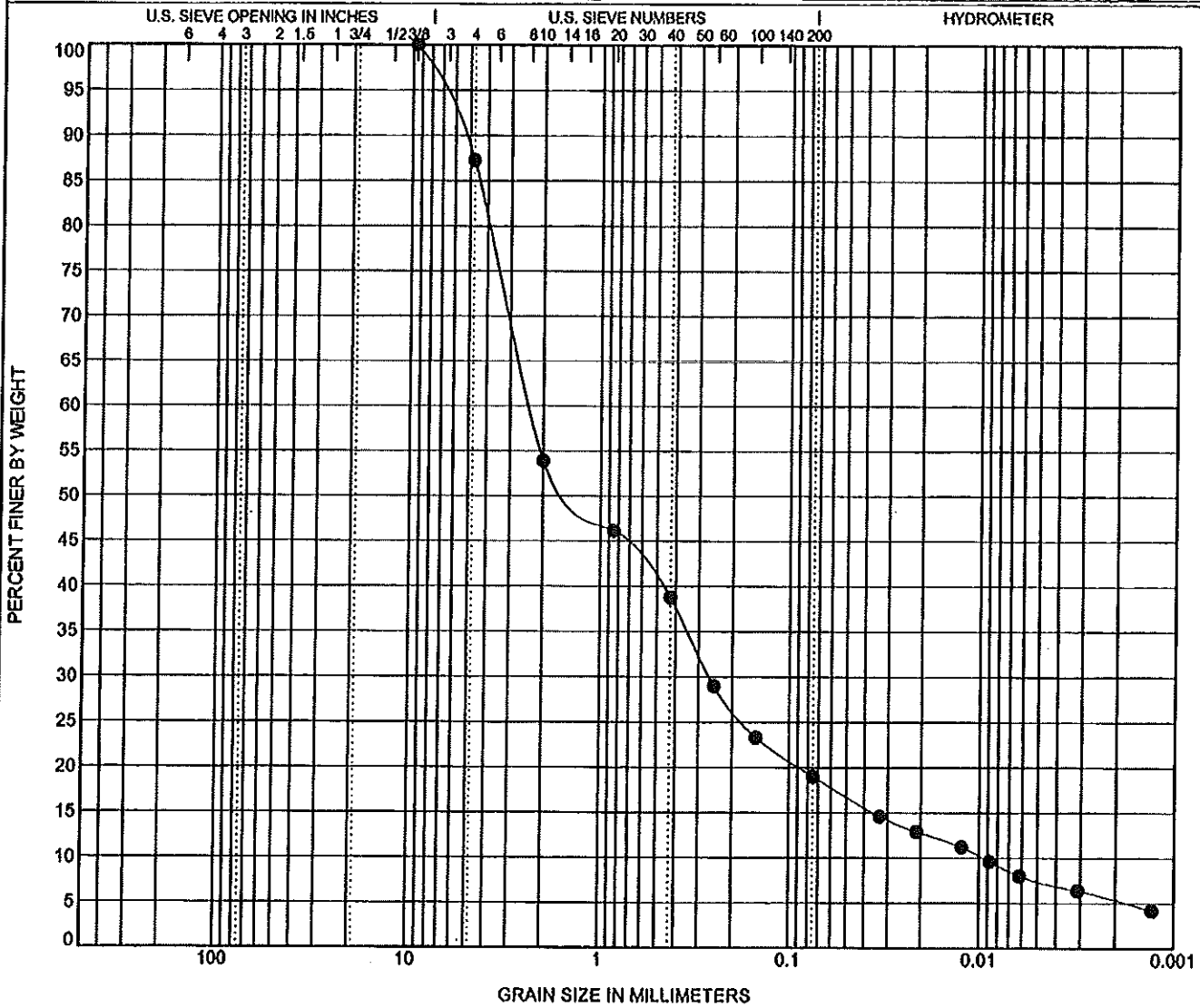
CLIENT Henry County, Ohio

PROJECT NAME Road M Over South Turkeyfoot Creek STS

PROJECT NUMBER HENC0016

PROJECT LOCATION Henry County, Ohio



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	SB-2	18.5	CLAYEY SAND(SC)	24	16	8	3.11	244.79

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SB-2	18.5	9.525	2.342	0.264	0.01	12.7	68.3	13.7	5.3

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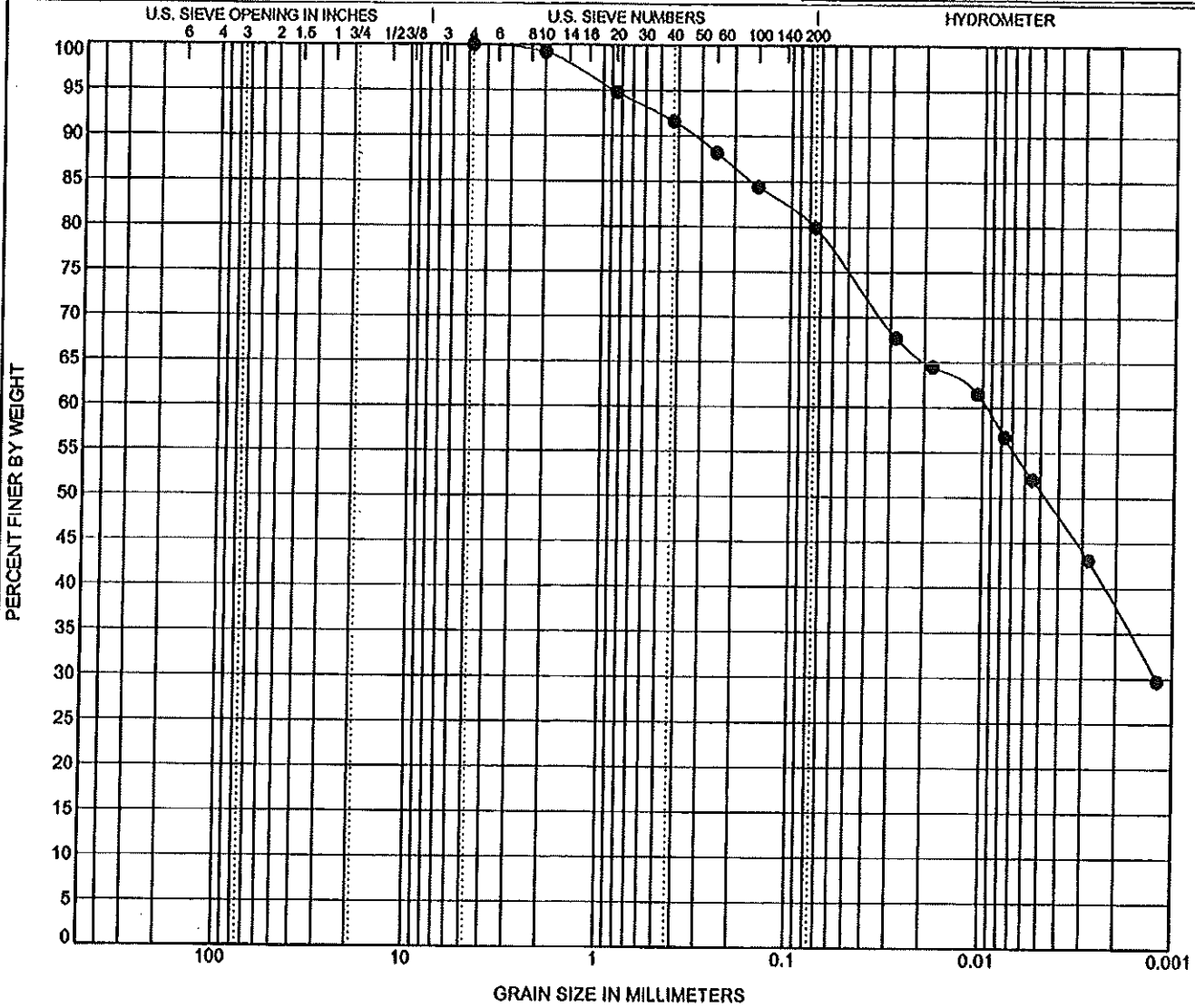

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	SB-2	26.0	LEAN CLAY with SAND(CL)	31	16	15		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SB-2	26.0	4.75	0.01	0.001		0.0	20.1	42.1	37.8

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GRAIN SIZE - GINT STD US LAB.GDT - 6/10/09 09:39 - W:\PROJECTS\PROJECTS F-J\HENC0016\ADMINISTRATION\HENC0016.BORING LOGS.GPJ

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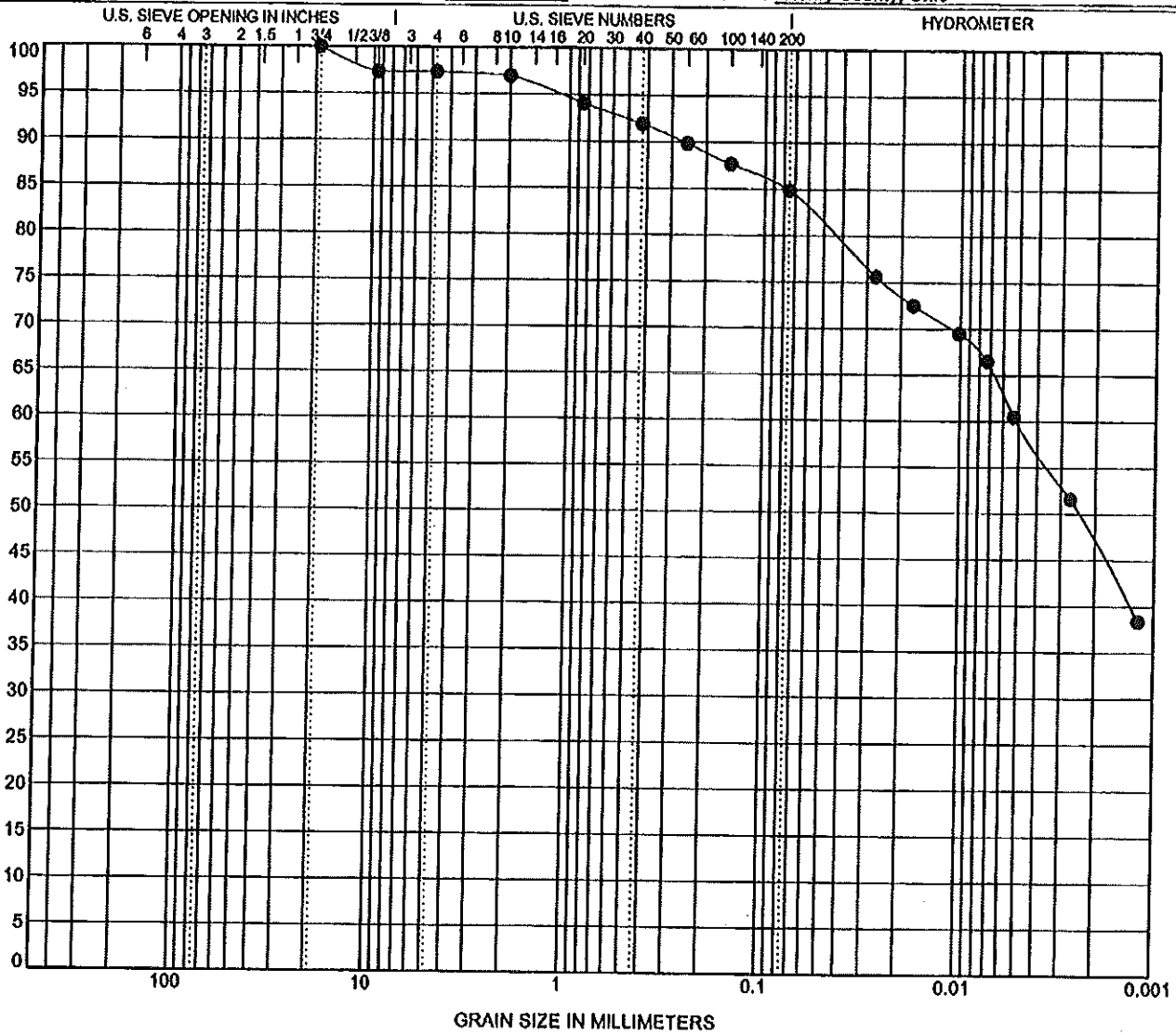
PROJECT NAME Road M Over South Turkeyfoot Creek STS
PROJECT NUMBER HENC0016
PROJECT LOCATION Henry County, Ohio



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	LL	PL	PI	Cc	Cu
● SB-2	38.5	LEAN CLAY with SAND(CL)	37	19	18		

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● SB-2	38.5	19	0.005			2.7	12.5	38.2	46.7

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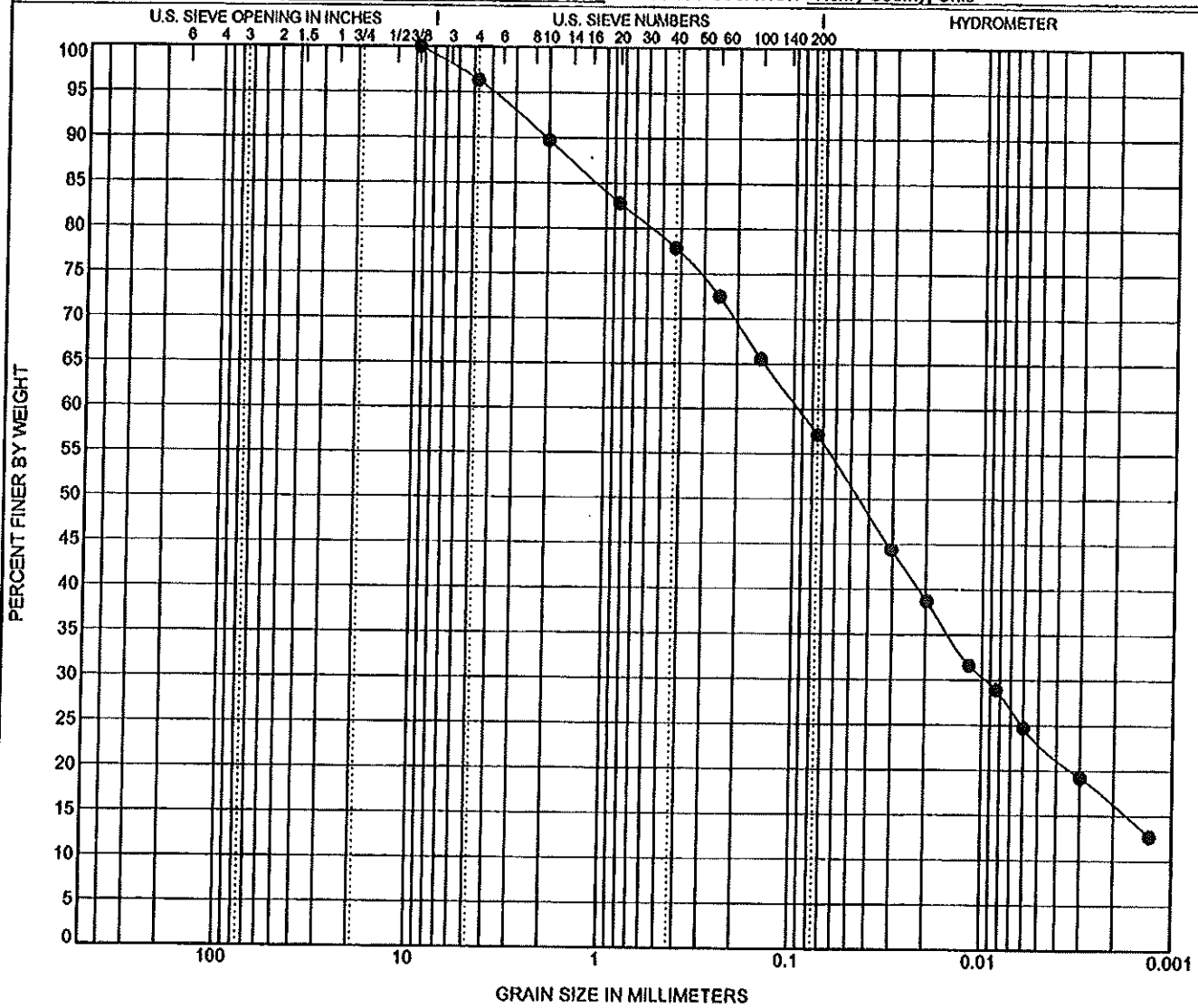
CLIENT Henry County, Ohio

PROJECT NAME Road M Over South Turkeyfoot Creek STS

PROJECT NUMBER HENC0016

PROJECT LOCATION Henry County, Ohio



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	LL	PL	PI	Cc	Cu
●	SB-2	53.5	SANDY LEAN CLAY(CL)	20	12	8		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	SB-2	53.5	9.525	0.095	0.01		3.7	39.2	41.1	16.0

TAM
6/11/09

GRAIN SIZE - GINT STD US LAB.GDT - 5/7/09 09:39 - W:\PROJECTS\PROJECTS F-J\HENC0016\ADMINISTRATION\HENC0016.BORING LOGS.GPJ

The Mannik & Smith Group, Inc.

Civil Engineering, Surveying and Environmental Consulting

TOLEDO CANTON LANSING DETROIT MONROE CLEVELAND COLUMBUS

ROCK QUALITY DESIGNATION (RQD)
D6032

Project Name: Road M Over South Turkeyfoot Creek STS

Project Number: HENC0016

Sample Number: SB-1 Rock Core

Depth: 58.5' - 63.5'

Sample Diameter: 2.04 (in)

Sample Length: 4.76 (in)

Sample ID	Length of Core (ft)	Total Segment > 4" (ft)	RQD (%)	UCS Sample Depth (ft)	Max Load (lbs)	Strength (psi)
SB-1 RC	5.00	3.01	60.20	58.5'	30,710	9,400

AVERAGE RQD 60.20

Tested By: CS

Checked By: TAM 6/11/09

The Mannik & Smith Group, Inc.

Civil Engineering, Surveying and Environmental Consulting

TOLEDO CANTON LANSING DETROIT MONROE CLEVELAND COLUMBUS

ROCK QUALITY DESIGNATION (RQD)
D6032

Project Name: Road M Over South Turkeyfoot Creek STS

Sample Number: SB-2 Rock Core

Sample Diameter: 2.04 (inch)

Sample Length: 4.69 (inch)

Project Number: HENC0016

Depth of Core: 57.83' - 62.58'

Sample ID	Length of Core (ft)	Total Segment > 4" (ft)	RQD (%)	UCS Sample Depth (ft)	Max Load (lbs)	Strength (psi)
SB-2 RC	4.75	4.20	88.42	58.0	61,840	18,930

AVERAGE RQD 88.42

Tested By: CS

Checked By: TAM 6/11/09

APPENDIX C

Calculations

CALCULATION OF ROCK MASS SHEAR STRENGTH

HENC0016

The following method is taken from Section 10.4.6.4 of the AASHTO LRFD Code.

Units and Definitions

$ksf := 1000 \frac{lbf}{ft^2}$ $\quad$ $psf := 1 \frac{lbf}{ft^2}$

Define Variables

$q_u := 14200psi$ $\quad$ $q_u = 2044.80\,ksf$ $\quad$ Average unconfined compressive strength of rock cores

Use Table 10.4.6.4-1 to determine RMR:

$i := 1..5$

$Class_1 := 7$

$Class_2 := 17$

$Class_3 := 25$

$Class_4 := 20$

$Class_5 := 10$

$RMR := \sum_{i=1}^{5} Class_i$ $\quad$ $RMR = 79$

$\sigma_n := 50psi$ $\quad$ $\sigma_n = 7.20\,ksf$ $\quad$ Effective normal stress

Use RMR above in Table 10.4.6.4-3 and 10.4.6.4-4 to obtain the following constants:

$m := 2.0$ $\quad$ Constant from Table 10.4.6.4-4

$s := 0.068$ $\quad$ Constant from Table 10.4.6.4-4

Constants calculated by GAB - 6/10/09

Calculate Shear Strength

$$h := 1 + \frac{16\cdot(m\cdot\sigma_n + s\cdot q_u)}{3\cdot(m^2)\cdot q_u}$$

$h = 1.10$

$$\phi_i := \operatorname{atan}\left[\left[4\cdot h\cdot\left[\cos\left[\left(30 + 0.33\cdot\operatorname{asin}\left(h^{-\frac{3}{2}}\right)\right)\cdot deg\right]^2\right]\right]^{-\frac{1}{2}}\right]$$

$\phi_i = 28.92\,deg$

$$\tau := \left(\cot(\phi_i) - \cos(\phi_i)\right)\cdot m\cdot\frac{q_u}{8}$$ *AASHTO 10.4.6.4-1*

$\tau = 477.94\,ksf$

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: W:\PROJECTS\PROJEC~2\HENC0016\ENGAPPS\HENC0016.DVN
Project Name: County Road M Geotech Project Date: 06/10/2009
Project Client: Henry County Engineer
Computed By: GAB
Project Manager: JJH

PILE INFORMATION

Pile Type: H Pile - HP10X42
Top of Pile: 0.00 ft
Perimeter Analysis: Box
Tip Analysis: Pile Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	0.00 ft
	- Driving/Restrike	0.00 ft
	- Ultimate:	0.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesive	18.00 ft	0.00%	130.00 pcf	1600.00 psf	T-79 Steel
2	Cohesionless	6.00 ft	0.00%	130.00 pcf	22.0/22.0	Nordlund
3	Cohesive	15.00 ft	0.00%	130.00 pcf	1600.00 psf	T-79 Steel
4	Cohesive	6.00 ft	0.00%	132.00 pcf	2500.00 psf	T-79 Steel
5	Cohesionless	13.00 ft	0.00%	135.00 pcf	41.0/41.0	Nordlund
6	Cohesive	7.00 ft	0.00%	140.00 pcf	478000.00 psf	T-79 Steel

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	1090.00 psf	0.04 Kips
9.01 ft	Cohesive	N/A	N/A	1096.34 psf	32.56 Kips
17.99 ft	Cohesive	N/A	N/A	1189.04 psf	70.50 Kips
18.01 ft	Cohesionless	1217.14 psf	16.13	N/A	70.55 Kips
23.99 ft	Cohesionless	1419.26 psf	16.13	N/A	75.68 Kips
24.01 ft	Cohesive	N/A	N/A	1251.18 psf	75.74 Kips
33.01 ft	Cohesive	N/A	N/A	1344.08 psf	115.61 Kips
38.99 ft	Cohesive	N/A	N/A	1350.00 psf	142.39 Kips
39.01 ft	Cohesive	N/A	N/A	1525.00 psf	142.49 Kips
44.99 ft	Cohesive	N/A	N/A	1525.00 psf	172.54 Kips
45.01 ft	Cohesionless	3054.36 psf	30.06	N/A	172.66 Kips
54.01 ft	Cohesionless	3381.06 psf	30.06	N/A	241.82 Kips
57.99 ft	Cohesionless	3525.54 psf	30.06	N/A	276.67 Kips
58.01 ft	Cohesive	N/A	N/A	1260.00 psf	276.80 Kips
64.99 ft	Cohesive	N/A	N/A	1260.00 psf	305.78 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
9.01 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
17.99 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
18.01 ft	Cohesionless	1217.48 psf	11.24	1.15 Kips	0.46 Kips
23.99 ft	Cohesionless	1621.72 psf	11.24	1.15 Kips	0.50 Kips
24.01 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
33.01 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
38.99 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
39.01 ft	Cohesive	N/A	N/A	N/A	1.94 Kips
44.99 ft	Cohesive	N/A	N/A	N/A	1.94 Kips
45.01 ft	Cohesionless	3054.73 psf	202.00	43.36 Kips	40.49 Kips
54.01 ft	Cohesionless	3708.13 psf	202.00	43.36 Kips	43.36 Kips
57.99 ft	Cohesionless	3997.07 psf	202.00	43.36 Kips	43.36 Kips
58.01 ft	Cohesive	N/A	N/A	N/A	370.45 Kips
64.99 ft	Cohesive	N/A	N/A	N/A	370.45 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.04 Kips	1.24 Kips	1.28 Kips
9.01 ft	32.56 Kips	1.24 Kips	33.80 Kips
17.99 ft	70.50 Kips	1.24 Kips	71.74 Kips
18.01 ft	70.55 Kips	0.46 Kips	71.01 Kips
23.99 ft	75.68 Kips	0.50 Kips	76.19 Kips
24.01 ft	75.74 Kips	1.24 Kips	76.98 Kips
33.01 ft	115.61 Kips	1.24 Kips	116.85 Kips
38.99 ft	142.39 Kips	1.24 Kips	143.63 Kips
39.01 ft	142.49 Kips	1.94 Kips	144.42 Kips
44.99 ft	172.54 Kips	1.94 Kips	174.48 Kips
45.01 ft	172.66 Kips	40.49 Kips	213.15 Kips
54.01 ft	241.82 Kips	43.36 Kips	285.18 Kips
57.99 ft	276.67 Kips	43.36 Kips	320.02 Kips
58.01 ft	276.80 Kips	370.45 Kips	647.25 Kips
64.99 ft	305.78 Kips	370.45 Kips	676.23 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	1090.00 psf	0.04 Kips
9.01 ft	Cohesive	N/A	N/A	1096.34 psf	32.56 Kips
17.99 ft	Cohesive	N/A	N/A	1189.04 psf	70.50 Kips
18.01 ft	Cohesionless	1217.14 psf	16.13	N/A	70.55 Kips
23.99 ft	Cohesionless	1419.26 psf	16.13	N/A	75.68 Kips
24.01 ft	Cohesive	N/A	N/A	1251.18 psf	75.74 Kips
33.01 ft	Cohesive	N/A	N/A	1344.08 psf	115.61 Kips
38.99 ft	Cohesive	N/A	N/A	1350.00 psf	142.39 Kips
39.01 ft	Cohesive	N/A	N/A	1525.00 psf	142.49 Kips
44.99 ft	Cohesive	N/A	N/A	1525.00 psf	172.54 Kips
45.01 ft	Cohesionless	3054.36 psf	30.06	N/A	172.66 Kips
54.01 ft	Cohesionless	3381.06 psf	30.06	N/A	241.82 Kips
57.99 ft	Cohesionless	3525.54 psf	30.06	N/A	276.67 Kips
58.01 ft	Cohesive	N/A	N/A	1260.00 psf	276.80 Kips
64.99 ft	Cohesive	N/A	N/A	1260.00 psf	305.78 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
9.01 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
17.99 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
18.01 ft	Cohesionless	1217.48 psf	11.24	1.15 Kips	0.46 Kips
23.99 ft	Cohesionless	1621.72 psf	11.24	1.15 Kips	0.50 Kips
24.01 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
33.01 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
38.99 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
39.01 ft	Cohesive	N/A	N/A	N/A	1.94 Kips
44.99 ft	Cohesive	N/A	N/A	N/A	1.94 Kips
45.01 ft	Cohesionless	3054.73 psf	202.00	43.36 Kips	40.49 Kips
54.01 ft	Cohesionless	3708.13 psf	202.00	43.36 Kips	43.36 Kips
57.99 ft	Cohesionless	3997.07 psf	202.00	43.36 Kips	43.36 Kips
58.01 ft	Cohesive	N/A	N/A	N/A	370.45 Kips
64.99 ft	Cohesive	N/A	N/A	N/A	370.45 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.04 Kips	1.24 Kips	1.28 Kips
9.01 ft	32.56 Kips	1.24 Kips	33.80 Kips
17.99 ft	70.50 Kips	1.24 Kips	71.74 Kips
18.01 ft	70.55 Kips	0.46 Kips	71.01 Kips
23.99 ft	75.68 Kips	0.50 Kips	76.19 Kips
24.01 ft	75.74 Kips	1.24 Kips	76.98 Kips
33.01 ft	115.61 Kips	1.24 Kips	116.85 Kips
38.99 ft	142.39 Kips	1.24 Kips	143.63 Kips
39.01 ft	142.49 Kips	1.94 Kips	144.42 Kips
44.99 ft	172.54 Kips	1.94 Kips	174.48 Kips
45.01 ft	172.66 Kips	40.49 Kips	213.15 Kips
54.01 ft	241.82 Kips	43.36 Kips	285.18 Kips
57.99 ft	276.67 Kips	43.36 Kips	320.02 Kips
58.01 ft	276.80 Kips	370.45 Kips	647.25 Kips
64.99 ft	305.78 Kips	370.45 Kips	676.23 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	1090.00 psf	0.04 Kips
9.01 ft	Cohesive	N/A	N/A	1096.34 psf	32.56 Kips
17.99 ft	Cohesive	N/A	N/A	1189.04 psf	70.50 Kips
18.01 ft	Cohesionless	1217.14 psf	16.13	N/A	70.55 Kips
23.99 ft	Cohesionless	1419.26 psf	16.13	N/A	75.68 Kips
24.01 ft	Cohesive	N/A	N/A	1251.18 psf	75.74 Kips
33.01 ft	Cohesive	N/A	N/A	1344.08 psf	115.61 Kips
38.99 ft	Cohesive	N/A	N/A	1350.00 psf	142.39 Kips
39.01 ft	Cohesive	N/A	N/A	1525.00 psf	142.49 Kips
44.99 ft	Cohesive	N/A	N/A	1525.00 psf	172.54 Kips
45.01 ft	Cohesionless	3054.36 psf	30.06	N/A	172.66 Kips
54.01 ft	Cohesionless	3381.06 psf	30.06	N/A	241.82 Kips
57.99 ft	Cohesionless	3525.54 psf	30.06	N/A	276.67 Kips
58.01 ft	Cohesive	N/A	N/A	1260.00 psf	276.80 Kips
64.99 ft	Cohesive	N/A	N/A	1260.00 psf	305.78 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
9.01 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
17.99 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
18.01 ft	Cohesionless	1217.48 psf	11.24	1.15 Kips	0.46 Kips
23.99 ft	Cohesionless	1621.72 psf	11.24	1.15 Kips	0.50 Kips
24.01 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
33.01 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
38.99 ft	Cohesive	N/A	N/A	N/A	1.24 Kips
39.01 ft	Cohesive	N/A	N/A	N/A	1.94 Kips
44.99 ft	Cohesive	N/A	N/A	N/A	1.94 Kips
45.01 ft	Cohesionless	3054.73 psf	202.00	43.36 Kips	40.49 Kips
54.01 ft	Cohesionless	3708.13 psf	202.00	43.36 Kips	43.36 Kips
57.99 ft	Cohesionless	3997.07 psf	202.00	43.36 Kips	43.36 Kips
58.01 ft	Cohesive	N/A	N/A	N/A	370.45 Kips
64.99 ft	Cohesive	N/A	N/A	N/A	370.45 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.04 Kips	1.24 Kips	1.28 Kips
9.01 ft	32.56 Kips	1.24 Kips	33.80 Kips
17.99 ft	70.50 Kips	1.24 Kips	71.74 Kips
18.01 ft	70.55 Kips	0.46 Kips	71.01 Kips
23.99 ft	75.68 Kips	0.50 Kips	76.19 Kips
24.01 ft	75.74 Kips	1.24 Kips	76.98 Kips
33.01 ft	115.61 Kips	1.24 Kips	116.85 Kips
38.99 ft	142.39 Kips	1.24 Kips	143.63 Kips
39.01 ft	142.49 Kips	1.94 Kips	144.42 Kips
44.99 ft	172.54 Kips	1.94 Kips	174.48 Kips
45.01 ft	172.66 Kips	40.49 Kips	213.15 Kips
54.01 ft	241.82 Kips	43.36 Kips	285.18 Kips
57.99 ft	276.67 Kips	43.36 Kips	320.02 Kips
58.01 ft	276.80 Kips	370.45 Kips	647.25 Kips
64.99 ft	305.78 Kips	370.45 Kips	676.23 Kips

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: W:\PROJECTS\PROJEC~2\HENC0016\ENGAPPS\HENC0016.DVN
Project Name: County Road M Geotech Project Date: 06/10/2009
Project Client: Henry County Engineer
Computed By: GAB
Project Manager: JJH

PILE INFORMATION

Pile Type: H Pile - HP12X53
Top of Pile: 0.00 ft
Perimeter Analysis: Box
Tip Analysis: Pile Area

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	0.00 ft
	- Driving/Restrike	0.00 ft
	- Ultimate:	0.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesive	18.00 ft	0.00%	130.00 pcf	1600.00 psf	T-79 Steel
2	Cohesionless	6.00 ft	0.00%	130.00 pcf	22.0/22.0	Nordlund
3	Cohesive	15.00 ft	0.00%	130.00 pcf	1600.00 psf	T-79 Steel
4	Cohesive	6.00 ft	0.00%	132.00 pcf	2500.00 psf	T-79 Steel
5	Cohesionless	13.00 ft	0.00%	135.00 pcf	41.0/41.0	Nordlund
6	Cohesive	7.00 ft	0.00%	140.00 pcf	478000.00 psf	T-79 Steel

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	1090.00 psf	0.04 Kips
9.01 ft	Cohesive	N/A	N/A	1090.00 psf	39.00 Kips
17.99 ft	Cohesive	N/A	N/A	1158.66 psf	82.77 Kips
18.01 ft	Cohesionless	1217.14 psf	16.57	N/A	82.83 Kips
23.99 ft	Cohesionless	1419.26 psf	16.57	N/A	89.28 Kips
24.01 ft	Cohesive	N/A	N/A	1210.64 psf	89.34 Kips
33.01 ft	Cohesive	N/A	N/A	1288.35 psf	135.38 Kips
38.99 ft	Cohesive	N/A	N/A	1339.98 psf	169.05 Kips
39.01 ft	Cohesive	N/A	N/A	1505.12 psf	169.17 Kips
44.99 ft	Cohesive	N/A	N/A	1525.00 psf	205.38 Kips
45.01 ft	Cohesionless	3054.36 psf	30.88	N/A	205.53 Kips
54.01 ft	Cohesionless	3381.06 psf	30.88	N/A	295.18 Kips
57.99 ft	Cohesionless	3525.54 psf	30.88	N/A	340.35 Kips
58.01 ft	Cohesive	N/A	N/A	1260.00 psf	340.51 Kips
64.99 ft	Cohesive	N/A	N/A	1260.00 psf	375.44 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
9.01 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
17.99 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
18.01 ft	Cohesionless	1217.48 psf	11.24	1.43 Kips	0.60 Kips
23.99 ft	Cohesionless	1621.72 psf	11.24	1.43 Kips	0.72 Kips
24.01 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
33.01 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
38.99 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
39.01 ft	Cohesive	N/A	N/A	N/A	2.42 Kips
44.99 ft	Cohesive	N/A	N/A	N/A	2.42 Kips
45.01 ft	Cohesionless	3054.73 psf	202.00	54.20 Kips	50.61 Kips
54.01 ft	Cohesionless	3708.13 psf	202.00	54.20 Kips	54.20 Kips
57.99 ft	Cohesionless	3997.07 psf	202.00	54.20 Kips	54.20 Kips
58.01 ft	Cohesive	N/A	N/A	N/A	463.06 Kips
64.99 ft	Cohesive	N/A	N/A	N/A	463.06 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.04 Kips	1.55 Kips	1.59 Kips
9.01 ft	39.00 Kips	1.55 Kips	40.55 Kips
17.99 ft	82.77 Kips	1.55 Kips	84.32 Kips
18.01 ft	82.83 Kips	0.60 Kips	83.43 Kips
23.99 ft	89.28 Kips	0.72 Kips	90.00 Kips
24.01 ft	89.34 Kips	1.55 Kips	90.89 Kips
33.01 ft	135.38 Kips	1.55 Kips	136.93 Kips
38.99 ft	169.05 Kips	1.55 Kips	170.60 Kips
39.01 ft	169.17 Kips	2.42 Kips	171.59 Kips
44.99 ft	205.38 Kips	2.42 Kips	207.80 Kips
45.01 ft	205.53 Kips	50.61 Kips	256.14 Kips
54.01 ft	295.18 Kips	54.20 Kips	349.38 Kips
57.99 ft	340.35 Kips	54.20 Kips	394.54 Kips
58.01 ft	340.51 Kips	463.06 Kips	803.58 Kips
64.99 ft	375.44 Kips	463.06 Kips	838.50 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	1090.00 psf	0.04 Kips
9.01 ft	Cohesive	N/A	N/A	1090.00 psf	39.00 Kips
17.99 ft	Cohesive	N/A	N/A	1158.66 psf	82.77 Kips
18.01 ft	Cohesionless	1217.14 psf	16.57	N/A	82.83 Kips
23.99 ft	Cohesionless	1419.26 psf	16.57	N/A	89.28 Kips
24.01 ft	Cohesive	N/A	N/A	1210.64 psf	89.34 Kips
33.01 ft	Cohesive	N/A	N/A	1288.35 psf	135.38 Kips
38.99 ft	Cohesive	N/A	N/A	1339.98 psf	169.05 Kips
39.01 ft	Cohesive	N/A	N/A	1505.12 psf	169.17 Kips
44.99 ft	Cohesive	N/A	N/A	1525.00 psf	205.38 Kips
45.01 ft	Cohesionless	3054.36 psf	30.88	N/A	205.53 Kips
54.01 ft	Cohesionless	3381.06 psf	30.88	N/A	295.18 Kips
57.99 ft	Cohesionless	3525.54 psf	30.88	N/A	340.35 Kips
58.01 ft	Cohesive	N/A	N/A	1260.00 psf	340.51 Kips
64.99 ft	Cohesive	N/A	N/A	1260.00 psf	375.44 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
9.01 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
17.99 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
18.01 ft	Cohesionless	1217.48 psf	11.24	1.43 Kips	0.60 Kips
23.99 ft	Cohesionless	1621.72 psf	11.24	1.43 Kips	0.72 Kips
24.01 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
33.01 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
38.99 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
39.01 ft	Cohesive	N/A	N/A	N/A	2.42 Kips
44.99 ft	Cohesive	N/A	N/A	N/A	2.42 Kips
45.01 ft	Cohesionless	3054.73 psf	202.00	54.20 Kips	50.61 Kips
54.01 ft	Cohesionless	3708.13 psf	202.00	54.20 Kips	54.20 Kips
57.99 ft	Cohesionless	3997.07 psf	202.00	54.20 Kips	54.20 Kips
58.01 ft	Cohesive	N/A	N/A	N/A	463.06 Kips
64.99 ft	Cohesive	N/A	N/A	N/A	463.06 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.04 Kips	1.55 Kips	1.59 Kips
9.01 ft	39.00 Kips	1.55 Kips	40.55 Kips
17.99 ft	82.77 Kips	1.55 Kips	84.32 Kips
18.01 ft	82.83 Kips	0.60 Kips	83.43 Kips
23.99 ft	89.28 Kips	0.72 Kips	90.00 Kips
24.01 ft	89.34 Kips	1.55 Kips	90.89 Kips
33.01 ft	135.38 Kips	1.55 Kips	136.93 Kips
38.99 ft	169.05 Kips	1.55 Kips	170.60 Kips
39.01 ft	169.17 Kips	2.42 Kips	171.59 Kips
44.99 ft	205.38 Kips	2.42 Kips	207.80 Kips
45.01 ft	205.53 Kips	50.61 Kips	256.14 Kips
54.01 ft	295.18 Kips	54.20 Kips	349.38 Kips
57.99 ft	340.35 Kips	54.20 Kips	394.54 Kips
58.01 ft	340.51 Kips	463.06 Kips	803.58 Kips
64.99 ft	375.44 Kips	463.06 Kips	838.50 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesive	N/A	N/A	1090.00 psf	0.04 Kips
9.01 ft	Cohesive	N/A	N/A	1090.00 psf	39.00 Kips
17.99 ft	Cohesive	N/A	N/A	1158.66 psf	82.77 Kips
18.01 ft	Cohesionless	1217.14 psf	16.57	N/A	82.83 Kips
23.99 ft	Cohesionless	1419.26 psf	16.57	N/A	89.28 Kips
24.01 ft	Cohesive	N/A	N/A	1210.64 psf	89.34 Kips
33.01 ft	Cohesive	N/A	N/A	1288.35 psf	135.38 Kips
38.99 ft	Cohesive	N/A	N/A	1339.98 psf	169.05 Kips
39.01 ft	Cohesive	N/A	N/A	1505.12 psf	169.17 Kips
44.99 ft	Cohesive	N/A	N/A	1525.00 psf	205.38 Kips
45.01 ft	Cohesionless	3054.36 psf	30.88	N/A	205.53 Kips
54.01 ft	Cohesionless	3381.06 psf	30.88	N/A	295.18 Kips
57.99 ft	Cohesionless	3525.54 psf	30.88	N/A	340.35 Kips
58.01 ft	Cohesive	N/A	N/A	1260.00 psf	340.51 Kips
64.99 ft	Cohesive	N/A	N/A	1260.00 psf	375.44 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
9.01 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
17.99 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
18.01 ft	Cohesionless	1217.48 psf	11.24	1.43 Kips	0.60 Kips
23.99 ft	Cohesionless	1621.72 psf	11.24	1.43 Kips	0.72 Kips
24.01 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
33.01 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
38.99 ft	Cohesive	N/A	N/A	N/A	1.55 Kips
39.01 ft	Cohesive	N/A	N/A	N/A	2.42 Kips
44.99 ft	Cohesive	N/A	N/A	N/A	2.42 Kips
45.01 ft	Cohesionless	3054.73 psf	202.00	54.20 Kips	50.61 Kips
54.01 ft	Cohesionless	3708.13 psf	202.00	54.20 Kips	54.20 Kips
57.99 ft	Cohesionless	3997.07 psf	202.00	54.20 Kips	54.20 Kips
58.01 ft	Cohesive	N/A	N/A	N/A	463.06 Kips
64.99 ft	Cohesive	N/A	N/A	N/A	463.06 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.04 Kips	1.55 Kips	1.59 Kips
9.01 ft	39.00 Kips	1.55 Kips	40.55 Kips
17.99 ft	82.77 Kips	1.55 Kips	84.32 Kips
18.01 ft	82.83 Kips	0.60 Kips	83.43 Kips
23.99 ft	89.28 Kips	0.72 Kips	90.00 Kips
24.01 ft	89.34 Kips	1.55 Kips	90.89 Kips
33.01 ft	135.38 Kips	1.55 Kips	136.93 Kips
38.99 ft	169.05 Kips	1.55 Kips	170.60 Kips
39.01 ft	169.17 Kips	2.42 Kips	171.59 Kips
44.99 ft	205.38 Kips	2.42 Kips	207.80 Kips
45.01 ft	205.53 Kips	50.61 Kips	256.14 Kips
54.01 ft	295.18 Kips	54.20 Kips	349.38 Kips
57.99 ft	340.35 Kips	54.20 Kips	394.54 Kips
58.01 ft	340.51 Kips	463.06 Kips	803.58 Kips
64.99 ft	375.44 Kips	463.06 Kips	838.50 Kips