Geotechnical Engineering Services Data Report

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

for
Audubon Engineering Company, LP

February 8, 2023

GeoEngineers

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Chester and Montgomery Counties, Pennsylvania

File No. 15556-032-00

February 8, 2023

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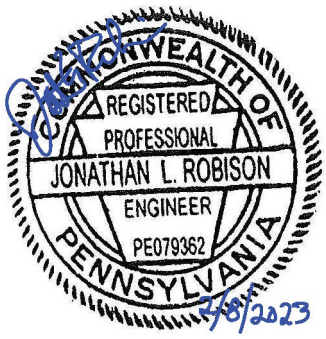

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1.0 INTRODUCTION

At the request of Audubon Engineering Company (Audubon) and in general accordance with our purchase order dated October 14, 2022, GeoEngineers, Inc. (GeoEngineers) is pleased to submit this geotechnical data report for the Schuylkill River Pipe Replacement Project in Chester and Montgomery Counties, Pennsylvania. The project is located approximately 1 mile south of Royersford, Pennsylvania as shown on the attached Vicinity Map, Figure 1. GeoEngineers conducted a subsurface exploration program by drilling two borings at locations on the east and west sides of the Schuylkill River, as shown on the attached Boring Location Map, Figure 2.

According to information provided by Audubon, we understand this report may be used by Audubon or others to design a horizontal direction drill (HDD) installation at the project site. Our geotechnical services included completing a subsurface soil exploration program by drilling two borings to depths of 103 and 114 feet below ground surface (bgs), respectively, adjacent to the proposed HDD site and preparing this geotechnical data report. HDD design engineering is not included in our scope.

2.0 SCOPE OF SERVICES

The purpose of our services is to perform a geotechnical exploration program and laboratory testing program. The services provided by GeoEngineers consisted of the following:

2.1. Phase 2. Geotechnical Exploration and Laboratory Testing

1. Obtained the Project specific safety training and Operator Qualification (OQ) prior to commencing our field exploration services.
2. Contacted the Pennsylvania 811 “One Call” number to notify them of our intent to perform soil borings at the site and to clear the boring locations of potential underground utilities. Audubon staked the proposed boring locations prior to our mobilization.
3. Explored the subsurface conditions at the project site by completing two geotechnical borings to depths of approximately 103 and 114 feet bgs, respectively, using a Truck-mounted geotechnical drilling rig.
4. Obtained soil samples on 2.5-foot-centers in the upper 10 feet bgs and 5-foot intervals below 10 feet bgs using a combination of standard penetration test (SPT) split spoon sampling in general accordance with ASTM International (ASTM) D1586 in soil and continuous core samples in bedrock. A GeoEngineers field representative managed the drilling operations, logged the borings, recorded the groundwater table depth, and obtained samples of the soils and rock encountered at various depths. Our field representative provided a daily field report of the project progress. Upon completion, we backfilled the borings with cement-bentonite grout.
5. Completed a laboratory testing program on selected samples (approximately 90 percent of the collected samples) obtained from the borings to evaluate pertinent engineering properties. The tests included the following:
    a. Standard Classification of Soils in general accordance with ASTM D2488,
    b. Atterberg Limits determination in general accordance with ASTM D4318,
    c. Grain size distribution (sieve) analyses (ASTM D422, D1140 and D6913),

d. Moisture content determination in general accordance with ASTM D2216,

e. Rock Quality Designation (RQD) in general accordance with ASTM D6032,

f. Unconfined compressive strength of Intact Rock Core Specimens in accordance with ASTM D2938, and

g. Mohs Scratch Hardness in general accordance with ASTM-C1895.

h. Cerchar Abrasivity Index (CAI) testing in general accordance with ASTM D7625.

i. Splitting Tensile Strength of Intact Rock Core Specimens in general accordance with ASTM D3967.

2.2. Phase 3. Geotechnical Data Report

1. Prepared logs of the borings, including:
    a. SPT values in soils as an indication of in-situ soil strength and density,
    b. RQD and recovery values for rock core samples.
    c. Shear strength properties of soil and rock,
    d. Moisture content and unit weight as applicable, and
    e. Index and classification properties of soils and rock.
2. Provided a draft Geotechnical Data Report with the information obtained from the subsurface explorations and laboratory testing.
3. Provided this final Geotechnical Data Report with the information obtained from the subsurface explorations and laboratory testing. The report includes the following:
    a. A general description of the site, including geology along with surface and subsurface conditions.
    b. Boring location map indicating the location of the borings.
    c. Logs of the borings showing the index, strength, and classification properties of the soil and rock samples and other pertinent soil and rock parameters.
    d. Description of in-situ and laboratory tests and their results.

3.0 SITE DESCRIPTION

3.1 Geology

3.1.1. Regional Geologic Setting

The proposed Schuylkill River Pipe Replacement Project is located within the Gettysburg-Newark Lowland Section of the Piedmont physiographic province in southeastern Pennsylvania. The Gettysburg-Newark Lowland is composed of Upper Triassic and Lower Jurassic sedimentary rocks and Lower Jurassic age diabase (Low, et al, 2002). The sedimentary rocks lie unconformably on strongly folded and deeply eroded Paleozoic and Precambrian Rocks. The sediments were deposited principally by streams and rivers that originated in nearby uplands and discharged into lakes or swamps in a down-warping basin formed as

eastern North America rifted from western Africa. The sedimentary rocks can be divided into four principal lithofacies: (1) alluvial-fan, (2) fluvial, (3) lacustrine and (4) lake margin clastic. Detrital cycles have been mapped and identified in the Lockatong and Brunswick Formations; chemical cycles are common in the Lockatong Formation. The intrusion of diabase dikes and sills occurred during the late stages of sedimentary deposition and at the completion of deposition. Following deposition, the basins were simultaneously faulted and folded to form a northwestward dipping homocline. The Newark Basin border faults dip 25 to 35 degrees to the southeast and it appears that reactivation of Paleozoic thrusts controlled the formation of the border faults in eastern Pennsylvania.

3.1.2. Bedrock Geology

As shown on the attached Geologic Map, Figure 3, geologic mapping indicates the Triassic Age (251 to 200 million years ago) Brunswick Formation is the predominant bedrock present at the Schuylkill River Pipe Replacement site (Berg, et al, 1980). The Brunswick Formation generally consists of reddish-brown mudstone, siltstone and shale, containing a few green and brown shale interbeds and red and dark-gray, interbedded argillites near the base. The youngest beds in the Brunswick Formation may be Jurassic in age (200 to 146 million years ago). The thickness of the Brunswick Formation is estimated to be 16,000 feet near Pottstown (Low, et al, 2002).

3.1.3. Surficial Geology

Surficial mapping indicates Holocene to Middle Pleistocene Age (1 million years ago to present) silty sand to silty clay decomposition residuum is the predominant surficial material present at the Schuylkill River Pipe Replacement site (Fullerton, et al, 1992). The residuum is typically purplish red, red, brownish yellow, yellow, reddish brown, grayish brown, brown, reddish gray, olive gray, gray, or mottled silty sand, sandy loam, loam, silt loam, silty clay loam, clay loam and silty clay. Colors, textures and clast lithology and abundance reflect composition of the underlying bedrock (as described above). The residuum is typically calcareous or acid, non-sorted and non-stratified. The residuum typically includes colluvium 3 to 10 feet thick on steep to moderate slopes. Clasts in colluvium are chiefly shale, sandstone and argillite. The residuum may also include widespread solifluction deposits 1 to 3 feet thick on slopes, composed chiefly of shale rubble and alluvium in valleys. The thickness is generally less than 3 feet, overlying the bedrock described above.

3.2. Surface Conditions

We observed the surface conditions in the vicinity of the site during our subsurface exploration program from December 8 through 15, 2022. The subject site is located just due west of Highway 4015. The geotechnical borings were completed within flat grass-covered areas on either side of the Schuylkill River.

3.3. Subsurface Conditions

GeoEngineers and our subcontracted driller (Double J Drilling [Double J]) explored the subsurface conditions at the site from December 8 through 15, 2022 by drilling two geotechnical borings (SR-1 and SR-2) along the proposed trenchless alignment, to depths of approximately 103 and 114 feet bgs, respectively, using truck-mounted drilling equipment. The locations of the borings are shown on Figure 2.

GeoEngineers' staff obtained soil samples from the borings at 2.5-foot-centers in the upper 10 feet bgs and 5-foot intervals below 10 feet using 1.5-inch inside-diameter (I.D.) SPT samplers. Below the bedrock

contact, rock was cored continuously using a 2-inch I.D. NQ core barrel. GeoEngineers' representative visually classified and collected the soil samples and documented other pertinent drilling information. Laboratory tests, including sieve analyses, moisture content determinations, Atterberg limit determinations, materials passing the U.S. No. 200 sieve, unconfined compression strength tests, Mohs scratch hardness tests, Cerchar Abrasiveness Index tests, and Splitting Tensile Strength tests were completed on selected samples from the borings. A description of the field exploration activities, logs of the borings (Figures A-3 through A-4), photos of the rock samples (Figures A-7 through A-16), along with graphs, tables and summaries of the lab testing are presented in Appendix A.

3.3.1. Summary of Subsurface Conditions

In general, the subsurface conditions encountered in the borings were consistent with published geology and are described within the boring descriptions below. Please refer to the attached boring logs for details.

3.3.1.1. Boring SR-1

Drilling operations were conducted at boring SR-1 from December 8 through 10, 2022 utilizing a truck-mounted drill rig. During drilling at boring SR-1, stiff silty clay and clayey silt with sand and medium dense to dense poorly graded gravel with varying amounts of silt, sand and clay was encountered to a depth of about 20 feet bgs, overlying bedrock. Bedrock, encountered from 20 feet bgs to the termination depth of approximately 103 feet bgs, generally consisted of slightly to moderately weathered, very poor to excellent quality claystone, shale and sandy siltstone with unconfined compressive strengths ranging from 4,517 to 7,390 pounds per square inch (psi), Mohs hardness ranging from 2.5 to 8, and Cerchar Abrasivity Index (CAI) values ranging from 2.14 to 3.53.

3.3.2.2 Boring SR-2

Drilling operations were conducted at boring SR-2 from December 13 through 15, 2022 utilizing a truck-mounted drill rig. During drilling at boring SR-2, medium stiff to stiff silt with varying amounts of clay and organic matter and medium dense to dense sand with varying amounts of silt and gravel was encountered to a depth of about 20 feet bgs, overlying bedrock. Bedrock, encountered from 20 feet bgs to the termination depth of approximately 114 feet bgs, generally consisted of fresh to moderately weathered, poor to excellent quality shale, sandy siltstone and sandstone with unconfined compressive strengths ranging from 4,238 to 23,220 psi, Mohs hardness ranging from 2.5 to 7, and CAI values ranging from 4.08 to 4.66.

3.3.2. Groundwater Conditions

Groundwater was noted in boring SR-1 at approximately 11 feet bgs and in boring SR-2 at approximately 9 feet bgs at the time of drilling. The groundwater level likely fluctuates seasonally with precipitation and the level of the nearby Schuylkill River.

4.0 LIMITATIONS

We have prepared this geotechnical data report for use by Audubon, their authorized agents and other approved members of the design team involved with this project. The data report is not intended for use by others, and the information contained herein is not applicable to other sites. The data and report should be provided to prospective contractors, but our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Variations in subsurface conditions are possible between the explorations. Subsurface conditions may also vary with time. A contingency for unanticipated conditions should be included in the project budget and schedule for such an occurrence. We recommend that sufficient monitoring, testing and consultation be provided by GeoEngineers during construction to evaluate that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork and pipeline installation activities comply with contract plans and specifications.

The scope of our services does not include services related to construction safety precautions. Our recommendations are not intended to direct the contractor's methods, techniques, sequences or procedures.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time the report was prepared. The conclusions, recommendations and opinions presented in this report are based on our professional knowledge, judgment and experience. No warranty or other conditions, express, written or implied, should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, and will serve as the official document of record.

Please refer to Appendix B, Report Limitations and Guidelines for Use, for additional information pertaining to use of this report.

5.0 REFERENCES

Berg, T.M., Edmunds, W.E., Geyer, A.R., Glover, A.D., Hoskins, D.M., MacLachlan, D.B., Root, S.I., Sevon, W.D., and Socolow, A.A., 1980, Geologic map of Pennsylvania (2nd ed.), Pennsylvania Geological Survey, Map 1, Scale 1:250,000.

Fullerton, D.S., Sevon, W.D., Muller, E.H., Judson, Sheldon, Black, R.F., Wagner, P.W., Hartshorn, J.H., Chapman, W.F., and Cowan, W.D., 1992, Quaternary geologic map of the Hudson River 4 degrees x 6 degrees quadrangle, United States and Canada, U.S. Geological Survey, Miscellaneous Investigations Series Map I-1420(NK-18), Scale 1:1,000,000.

FIGURES

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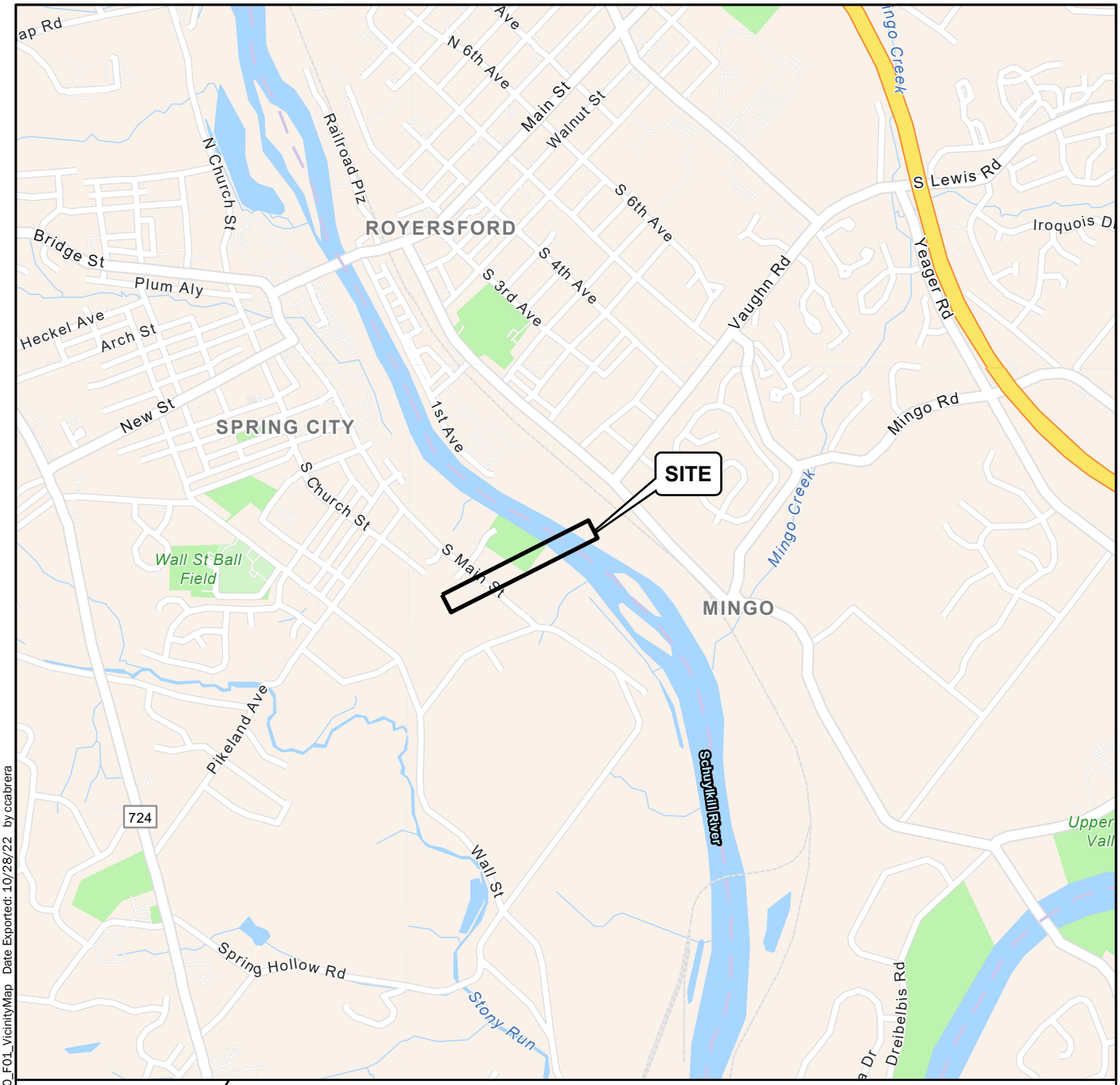

Source(s):
- ESRI

Coordinate System: NAD 1983 UTM Zone 18N

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VICINITY MAP

SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT
CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA

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Figure 1

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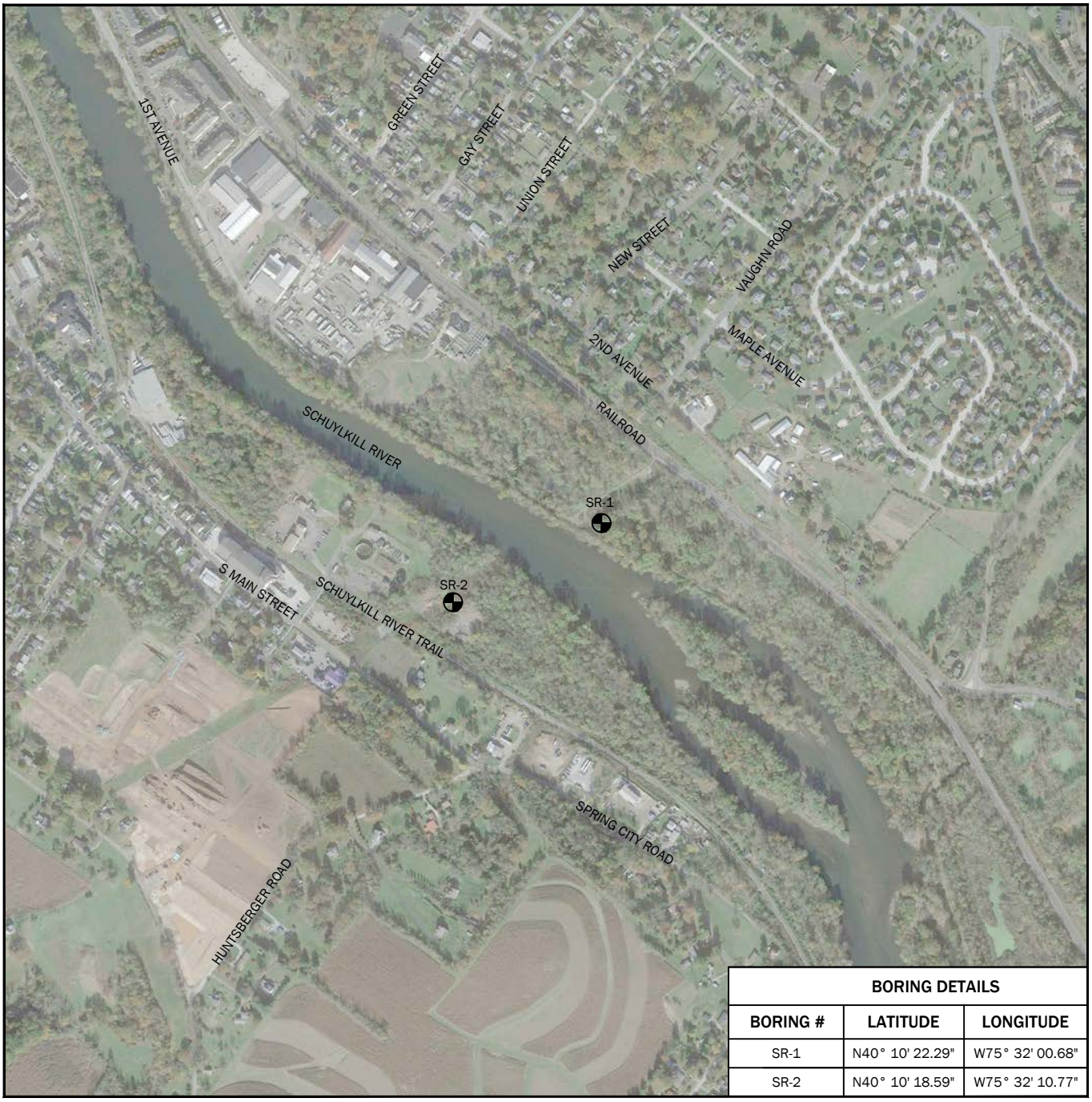

BORING DETAILS		
BORING #	LATITUDE	LONGITUDE
SR-1	N40° 10' 22.29"	W75° 32' 00.68"
SR-2	N40° 10' 18.59"	W75° 32' 10.77"

LEGEND

BORING LOCATION

N
W E
S

800 0 800

SCALE IN FEET

NOTES:

1. THE LOCATIONS OF ALL FEATURES SHOWN ARE APPROXIMATE.
2. THIS DRAWING IS FOR INFORMATION PURPOSES. IT IS INTENDED TO ASSIST IN SHOWING FEATURES DISCUSSED IN AN ATTACHED DOCUMENT. GEOENGINEERS, INC. CANNOT GUARANTEE THE ACCURACY AND CONTENT OF ELECTRONIC FILES. THE MASTER FILE IS STORED BY GEOENGINEERS, INC. AND WILL SERVE AS THE OFFICIAL RECORD OF THIS COMMUNICATION.

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BORING LOCATION MAP

SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT
CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA

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FIGURE 2

SMC : SWV

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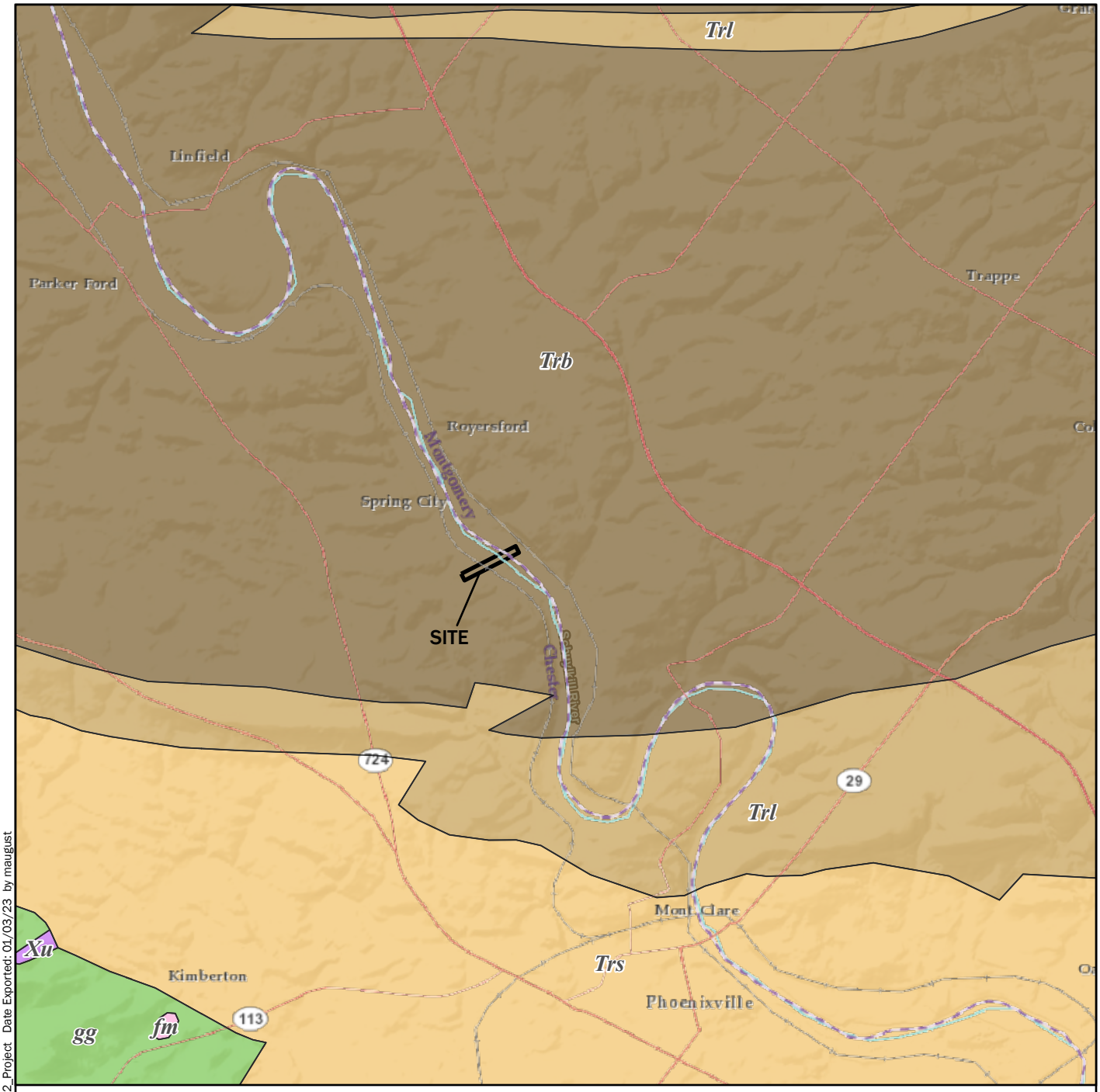

Legend

- Trb - Brunswick Formation
- Trl - Lockatong Formation
- Trs - Stockton Formation
- Xu - Ultramafic rocks
- fm - Franklin Marble
- gg - Graphitic felsic gneiss

0 1 Miles

N

Source(s): State Geologic Map Compilation (SGMC) geodatabase of the conterminous United States, accessed 2022.

Coordinate System: NAD 1983 UTM Zone 18N

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Geologic Map

SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT
CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA

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Figure 3

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APPENDICES

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APPENDIX A
Field Explorations and Laboratory Testing

APPENDIX A
FIELD EXPLORATIONS AND LABORATORY TESTING

Field Explorations

We explored subsurface conditions at the site from December 8 through 15, 2022 by drilling two geotechnical borings using truck-mounted drilling equipment. The Pennsylvania State "One-Call" utility locating agency was contacted to locate utilities in the project area prior to the start of the exploratory borings.

The drilling operations were monitored by GeoEngineers' field personnel who examined and classified the soil encountered, obtained representative samples, observed groundwater conditions where possible and prepared detailed logs of the borings. The soils encountered were classified visually in general accordance with American Society for Testing and Materials International (ASTM) D2488, which is described in Figure A-1. The locations of the drilled explorations are shown on the attached Boring Location Map, Figure 2.

In general, soil samples were obtained from the borings at 2.5-foot-depth intervals from the ground surface to approximately 10 feet below ground surface (bgs) and at 5-foot-depth intervals from 10 feet bgs to the termination depths in each boring using 1.5-inch inside-diameter (I.D.) split-spoon samplers. The split-spoon samplers were driven 18 inches during SPT, using a 140-pound hammer with a 30-inch drop. The number of hammer blows required to drive the sampler the final 12 inches was recorded on field logs. Bedrock was continuously cored using NQ rock coring techniques. Each boring was backfilled upon completion with cement-bentonite grout.

The relative density of the standard penetration test (SPT) samples recovered at each interval was evaluated based on correlations with lab and field observations in general accordance with the values outlined in Table A-1 below.

TABLE A-1 CORRELATION BETWEEN BLOW COUNTS AND RELATIVE DENSITY[1]

Cohesive Soils (Clay/Silt)						
Parameter	Very Soft	Soft	Medium Stiff	Stiff	Very Stiff	Hard
Blows, N	< 2	2 to 4	4 to 8	8 to 16	16 to 32	> 32
Cohesionless Soils[2] (Gravel/Sand/Silty Sand)						
Parameter	Very Loose	Loose	Medium Dense	Dense	Very Dense	
Blows, N	0 to 4	4 to 10	10 to 30	30 to 50	> 50	

Notes:

[1] After Terzaghi, K and Peck, R.B., "Soil Mechanics in Engineering Practice," John Wiley & Sons, Inc., 1962.

[2] Classification applies to soils containing additional constituents; that is, organic clay, silty or clayey sand, etc.

The exploration logs are presented in Figures A-3 and A-4. The logs are based on our interpretation of the field data and indicate the various types of soils encountered while indicating the approximate depths at which the subsurface conditions change. Unless noted on the boring logs, the lines between soil units represent approximate boundaries. The transition between materials may be gradual or may occur between recovered samples. Additionally, the boring logs represent conditions observed at the time of drilling and have been edited to incorporate results of the laboratory tests performed as appropriate.

Laboratory Testing

Soil samples obtained from the borings were transported to our laboratory and examined to confirm or modify field classifications. Representative samples were selected for laboratory testing consisting of moisture content determinations, Atterberg limits determinations, sieve analyses, percent passing the U.S. No. 200 sieve, unconfined compressive strength testing, and Mohs Hardness testing. After identifying depth ranges of harder, more abrasive rock, additional representative samples were shipped to Advanced Terra Testing's laboratory to perform Cerchar Abrasiveness Index tests and Brazilian Splitting Tensile Strength tests. The laboratory testing procedures are discussed in more detail below.

Moisture Content Testing

Moisture content tests were completed for representative soil samples obtained from the borings in general accordance with ASTM D2216. The results of these tests are presented on the boring logs in Figures A-3 and A-4 at the depths at which the samples were obtained.

Percent Passing U.S. No. 200 Sieve

Percent passing the U.S. No. 200 sieve were performed on selected coarse-grained samples in general accordance with ASTM D1140. The results of the analyses were plotted and classified in general accordance with the Unified Soil Classification System (USCS) and are presented in our Test Results and Summary. The percentage passing the U.S. No. 200 sieve is shown on the boring logs in Figures A-3 and A-4 at the respective sample depths.

Sieve Analysis

Sieve analyses were performed on selected samples in general accordance with ASTM D6913. The results of the sieve analyses were plotted and classified in general accordance with the USCS. The results of the tests are shown in our laboratory test results on Figure A-5.

Atterberg Limits Testing

Atterberg Limits were performed on selected fine-grained soil samples in general accordance with ASTM D4318. The tests were used to classify the soils as well as to evaluate their index properties. The results of the Atterberg Limits testing are shown on the boring logs in Figures A-3 and A-4 at the depth at which the samples were obtained and on Figure A-6.

Unconfined Compression Testing

Unconfined compressive strength tests were performed on selected rock soil samples obtained from the borings. The tests were completed in general accordance with ASTM D7012. The results of these tests are presented on the boring logs in Figures A-3 and A-4 at the depths at which the samples were obtained and in the attached Laboratory Test Results. Before and after test result photos can be seen in Figures A-17 through A-29.

Cerchar Abrasiveness Index Testing

Cerchar Abrasiveness Index (CAI) tests were performed on selected rock core samples obtained from the borings that exhibited high Mohs abrasivity test results. The CAI tests were completed in general accordance with ASTM D7625. The results of these tests are presented on the boring logs in Figures A-3 and A-4 at the depths at which the samples were obtained and in Advanced Terra Testing's Laboratory Test Results.

Brazilian Splitting Tensile Strength Testing

Brazilian Splitting Tensile Strength (BSTS) tests were performed on selected rock core samples obtained from the borings that exhibited high Mohs abrasivity test results. The BSTS tests were completed in general accordance with ASTM D3967. The results of these tests are presented on the boring logs in Figures A-3 and A-4 at the depths at which the samples were obtained and in Advanced Terra Testing's Laboratory Test Results.

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
MORE THAN 50% RETAINED ON NO. 200 SIEVE	SAND AND SANDY SOILS	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS
				SP	POORLY-GRADED SANDS, GRAVELLY SAND
	MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/ Quarry Spalls
	SOD	Sod/Forest Duff
	TS	Topsoil

Groundwater Contact

Measured groundwater level in exploration, well, or piezometer

Measured free product in well or piezometer

Graphic Log Contact

Distinct contact between soil strata

Approximate contact between soil strata

Material Description Contact

Contact between geologic units

Contact between soil of the same geologic unit

Sampler Symbol Descriptions

2.4-inch I.D. split barrel / Dames & Moore (D&M)

Standard Penetration Test (SPT)

Shelby tube

Piston

Direct-Push

Bulk or grab

Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

"P" indicates sampler pushed using the weight of the drill rig.

"WOH" indicates sampler pushed using the weight of the hammer.

Laboratory / Field Tests

%F	Percent fines
%G	Percent gravel
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DD	Dry density
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
Mohs	Mohs hardness scale
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PL	Point load test
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
UU	Unconsolidated undrained triaxial compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

Key to Exploration Logs

GeoEngineers

Figure A-1

Explanation of Bedrock Terms

Scale of Relative Rock Weathering[1]

Designation	Field Identification
Fresh	Crystals are bright. Discontinuities may show some minor surface staining. No discoloration in rock fabric.
Slightly Weathered	Rock mass is generally fresh. Discontinuities are stained and may contain clay. Some discoloration in rock fabric. Decomposition extends up to 1 inch into rock.
Moderately Weathered	Rock mass is decomposed 50% or less. Significant portions of rock show discoloration and weathering effects. Crystals are dull and show visible chemical alteration. Discontinuities are stained and may contain secondary mineral deposits.
Predominantly Decomposed	Rock mass is more than 50% decomposed. Rock can be excavated with geologist's pick. All discontinuities exhibit secondary mineralization. Complete discoloration of rock fabric. Surface of core is friable and usually pitted due to washing out of highly altered minerals by drilling water.
Decomposed	Rock mass is completely decomposed. Original rock "fabric" may be evident. May be reduced to soil with hand pressure.

Scale of Relative Rock Hardness[1]

Term	Hardness Designation	Field Identification	Approximate Unconfined Compressive Strength
Extremely Soft	R0	Can be indented with difficulty by thumbnail. May be moldable or friable with finger pressure.	< 100 psi
Very Soft	R1	Crumbles under firm blows with point of a geology pick. Can be peeled by a pocket knife. Scratched with fingernail.	100-1000 psi
Soft	R2	Can be peeled by a pocket knife with difficulty. Cannot be scratched with fingernail. Shallow indentation made by firm blow of geology pick.	1000-4000 psi
Medium Hard	R3	Can be scratched by knife or pick. Specimen can be fractured with a single firm blow of hammer/geology pick.	4000-8000 psi
Hard	R4	Can be scratched with knife or pick only with difficulty. Several hard hammer blows required to fracture specimen.	8000-16000 psi
Very Hard	R5	Cannot be scratched by knife or sharp pick. Specimen requires many blows of hammer to fracture or chip. Hammer rebounds after impact.	> 16000 psi

Discontinuity Spacing[1]

Description for Bedding, Foliation, or Flow Banding	Spacing	Description of Joints, Faults, or Other Fractures
Very Thick	>10 ft	Very Widely Spaced
Thick	3 ft – 10 ft	Widely Spaced
Medium	1 ft – 3 ft	Moderately Spaced
Thin	2 in – 1 ft	Closely Spaced
Very Thin	<2 in	Very Closely Spaced

Rock Quality Designation (RQD)[1, 2]

RQD (Percent)	Description of Rock Quality
0 – 25	Very Poor
25 – 50	Poor
50 – 75	Fair
75 – 90	Good
90 – 100	Excellent

Notes:

1. Based on ASCE Manual on Engineering Practice No. 56,1976.
2. RQD is a modified core recovery measurement which expresses the number of hard and sound rock pieces of 4" or more in size as a percentage of the total length of core run.

Explanation of Bedrock Terms

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-2

Drilled: Start 12/8/2022 End 12/10/2022	Total Depth (ft) 103	Logged By CWH / Checked By JWR	Driller Double J Drilling	Drilling Method Mud Rotary	
Surface Elevation (ft) 97.8 / Vertical Datum NAVD88		Hammer Data Autohammer 140 (lbs) / 30 (in) Drop		Drilling Equipment CME 55	
Latitude 40.17288 / Longitude -75.53352		System Datum Decimal Degrees WGS84		See "Remarks" section for groundwater observed	

Notes: Borehole backfilled full depth with cement bentonite grout.

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered Soil (in)/Rock (%)	Blows/foot	Sample/Run Testing	RQD %	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
95	0	15	9	SS-1			TS	Dark brown topsoil with organic matter (medium dense, moist)			
	5	15	4	SS-2 AL			CL	Brown silty clay (stiff, moist)	22		AL (LL = 34, PI = 13)
90		16	2	SS-3							
	10	12	14	SS-4 AL			CL-ML	Brown clayey silt with sand (stiff, moist)	23		AL (LL = 24, PI = 6)
85											Groundwater observed at approximately 11 feet below ground surface during drilling
	15	10	21	SS-5 SA			GP	Brown poorly graded gravel with silt and sand (medium dense, moist)	10	8	
80		5	50/4"	SS-6 %F				Becomes very dense, with clay	14	21	
	20	100		R1 Mohs	0		Claystone	Claystone, maroon, moderately weathered, very intensely fractured, soft, very thinly bedded			RQD very poor Mohs = 2.5
75											
	25	100		R2 Mohs	0						RQD very poor Mohs = 2.5
70											
	30	100		R3 Mohs	50			Becomes moderately hard, medium bedded			RQD fair Mohs = 3.5
65				UC							UC = 4,517 psi
	35										

Note: See Figure A-1 for explanation of symbols; Figure A-2 for explanation of bedrock terms.
Coordinates Data Source: Horizontal approximated based on Topographic Survey. Vertical approximated based on Topographic Survey.

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Log of Boring SR-1

GeoEngineers

Project: Schuylkill River Pipe Replacement Project
Project Location: Chester and Montgomery Counties, Pennsylvania
Project Number: 15556-032-00

Figure A-3
Sheet 1 of 3

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered Soil (in)/Rock (%)	FIELD DATA: Blows/foot	FIELD DATA: Sample/Run Testing	FIELD DATA: RQD %	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
60	35	100		R4 Mohs	25						RQD poor Mohs = 2.5
	40	100		R5 Mohs UC	52		Shale	Shale, reddish brown, moderately weathered, medium hard, medium bedded			RQD fair Mohs = 2.5 UC = 6,925 psi
55	45	100		R6 Mohs	40			Becomes slightly weathered, thinly bedded			RQD poor Mohs = 2.5
50	50	100		R7 Mohs	50						RQD fair Mohs = 3.5
45	55	100		R8 Mohs	68			Becomes medium hard			RQD fair Mohs = 4.5
40	60	100		R9 Mohs UC	70						RQD fair Mohs = 2.5 UC = 6,772 psi
35	65	100		R10 Mohs	9						RQD very poor Mohs = 2.5
30	70	97		R11 Mohs	57						RQD fair Mohs = 3.5
25	75	100		R12 Mohs UC	95			Becomes medium bedded, hard			RQD excellent Mohs = 3.5 UC = 12,833 psi

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Log of Boring SR-1 (continued)

GeoEngineers

Project: Schuylkill River Pipe Replacement Project
Project Location: Chester and Montgomery Counties, Pennsylvania
Project Number: 15556-032-00

Figure A-3
Sheet 2 of 3

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered Soil (in)/Rock (%)	FIELD DATA: Blows/foot	FIELD DATA: Sample/Run Testing	FIELD DATA: RQD %	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
20											
	80	100		R13 Mohs	90						Mohs = 2.5
15											
	85	100		R14 Mohs UC	64			Becomes thinly bedded			RQD fair Mohs = 2.5 UC = 7,390 psi
10											
	90	100		R15 Mohs	47		Sandy Siltstone	Sandy siltstone, brown, fresh, medium hard, thinly bedded			RQD poor Mohs = 8 Cerchar Abrasiveness Index (CAI) = 3.53 Splitting Tensile Strength = 3,745 psi
5											
	95	96		R16 Mohs UC	70						RQD fair Mohs = 8 UC = 6,505 psi CAI = 2.14 Splitting Tensile Strength = 1,067 psi
0											
	100	100		R17 Mohs	91		Shale	Shale, maroon, moderately weathered, soft, thinly bedded			RQD excellent Mohs = 2.5
-5											

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Log of Boring SR-1 (continued)

GeoEngineers

Project: Schuylkill River Pipe Replacement Project
Project Location: Chester and Montgomery Counties, Pennsylvania
Project Number: 15556-032-00

Figure A-3
Sheet 3 of 3

Drilled Start 12/13/2022 End 12/15/2022	Total Depth (ft) 114	Logged By CWH Checked By JWR	Driller Double J Drilling	Drilling Method Mud Rotary	
Surface Elevation (ft) 105.69 Vertical Datum NAVD88		Hammer Data Autohammer 140 (lbs) / 30 (in) Drop		Drilling Equipment CME 55	
Latitude 40.17183 Longitude -75.53632		System Datum Decimal Degrees WGS84		See "Remarks" section for groundwater observed	

Notes: Borehole backfilled full depth with cement bentonite grout.

Elevation (feet)	Depth (feet)	Interval Recovered Soil (in)/Rock (%)	Blows/foot	Sample/Run Testing	RQD %	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
105	0	1	10	SS-1			ML	Brown silt (stiff, dry)			
		2	5	SS-2				Becomes medium stiff, moist, with organic matter			
100	5	11	8	SS-3 AL			CL-ML	Reddish brown clayey silt (stiff, moist)	22		AL (LL = 27, PI = 7)
		12	16	SS-4 %F			SM	Dark brown silty sand (medium dense, moist)	11	15	Groundwater observed at approximately 9 feet below ground surface during drilling
95	10										
		15	30	SS-5 SA			SW-SM	Reddish brown well-graded sand with silt and gravel (dense, moist)	22	10	
90	15										
		6	50/5"	SS-6			CL	Red sandy lean clay (hard, moist)			
		100		R1 Mohs	0		Shale	Shale, reddish brown, moderately weathered, medium hard, very thinly bedded			RQD very poor Mohs = 4
85	20										
		100		R2 Mohs	9			Becomes soft			RQD very poor Mohs = 2.5
80	25										
		100		R3	5						RQD very poor
75	30			Mohs UC				Becomes hard			Mohs = 3.5 UC = 8,940 psi
		100		R4 Mohs	49						RQD poor Mohs = 3
	35										

Note: See Figure A-1 for explanation of symbols; Figure A-2 for explanation of bedrock terms.
Coordinates Data Source: Horizontal approximated based on Topographic Survey. Vertical approximated based on Topographic Survey.

Log of Boring SR-2

GeoEngineers

Project: Schuylkill River Pipe Replacement Project
Project Location: Chester and Montgomery Counties, Pennsylvania
Project Number: 15556-032-00

Elevation (feet)	Depth (feet)	Interval Recovered Soil (in)/Rock (%)	Blows/foot	Sample/Run Testing	RQD %	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35										
70		100		R5 Mohs UC	67			Becomes medium hard			RQD fair Mohs = 2.5 UC = 6,576 psi
	40										
65		90		R6 Mohs	48						RQD poor Mohs = 2.5
	45										
60		100		R7 Mohs UC	73						RQD poor Mohs = 3.5 UC = 7,512 psi
	50										
55		100		R8 Mohs	32		Sandy Siltstone	Sandy siltstone, reddish brown, moderately to slightly weathered, hard, thinly bedded			RQD poor Mohs = 7
50	55	85		R9 Mohs	34		Shale	Shale, reddish brown, moderately weathered, soft, thin bedded			RQD poor Mohs = 2.5
	60						Sandstone	Sandstone, gray, fresh, hard, thinly bedded			
45		100		R10 Mohs	60						RQD fair Mohs = 7 CAI = 4.08 Splitting Tensile Strength = 752 psi
	65										
40		100		R11 Mohs UC	66		Sandy Siltstone	Sandy siltstone, grayish brown, slightly weathered, very hard, thinly bedded			RQD fair Mohs = 7 UC = 23, 220 psi CAI = 4.66 Splitting Tensile Strength = 2,733 psi
35	70										
		100		R12 Mohs	60						RQD fair Mohs = 7
30	75						Shale				

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Log of Boring SR-2 (continued)

GeoEngineers

Project: Schuylkill River Pipe Replacement Project
Project Location: Chester and Montgomery Counties, Pennsylvania
Project Number: 15556-032-00

Figure A-4
Sheet 2 of 3

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered Soil (in)/Rock (%)	FIELD DATA: Blows/foot	FIELD DATA: Sample/Run Testing	FIELD DATA: RQD %	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
								Shale, reddish brown, slightly weathered, medium hard, thinly bedded			
25	80	100		R13 Mohs UC	100						RQD excellent Mohs = 3 UC = 6,600 psi
20	85	97		R14 Mohs	87						RQD good Mohs = 4.5
15	90	100		R15 Mohs	90						RQD excellent Mohs = 3.5
10	95	100		R16 Mohs UC	81						RQD good Mohs = 2.5 UC = 5,115 psi
5	100	100		R17 Mohs	57			Becomes very thinly bedded			RQD fair Mohs = 2.5
0	105	100		R18 Mohs UC	88			Becomes thinly bedded			RQD good Mohs = 2.5 UC = 4,238 psi
5	110	100		R19 Mohs	78						RQD good Mohs = 3.5

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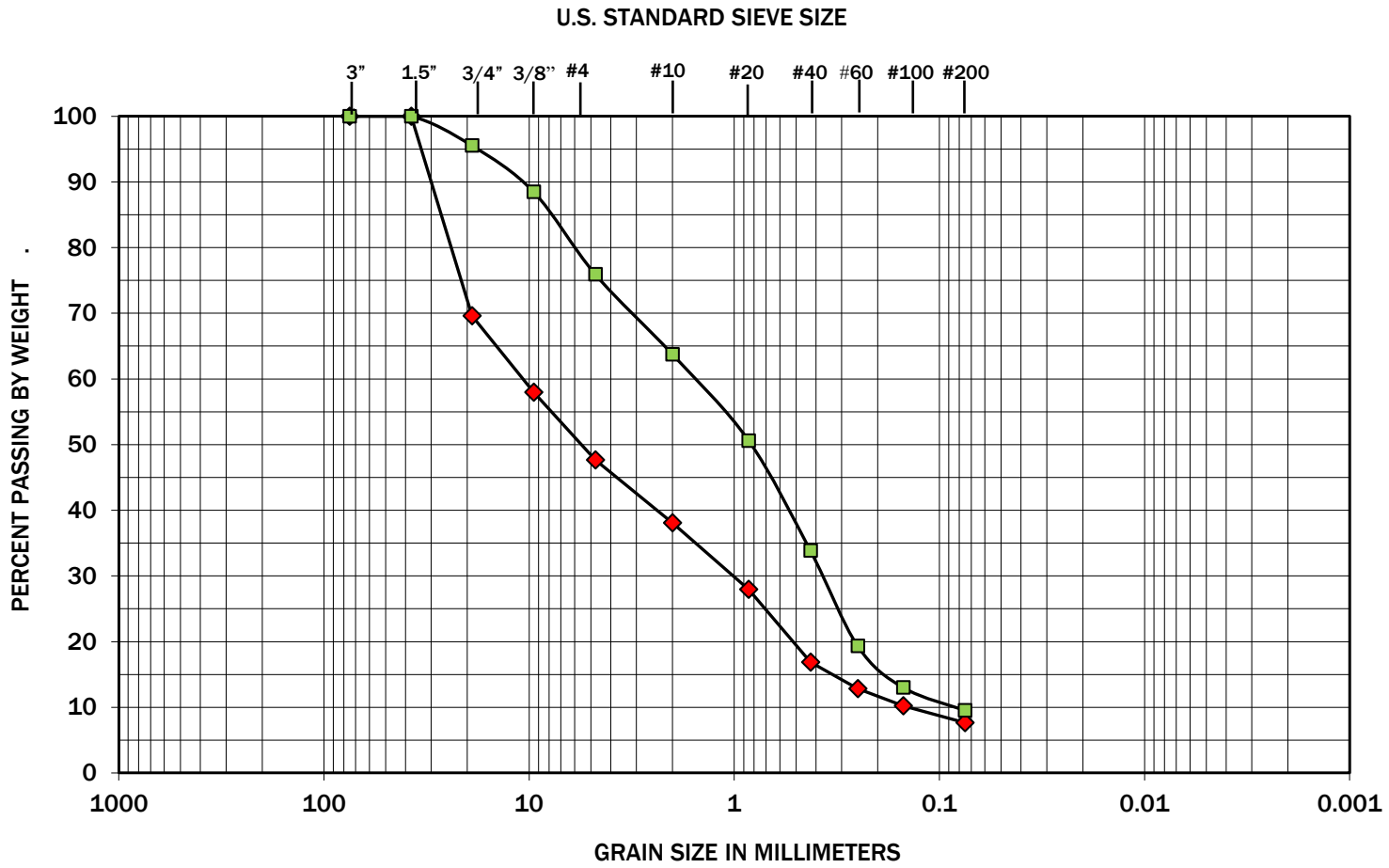
Log of Boring SR-2 (continued)

GeoEngineers

Project: Schuylkill River Pipe Replacement Project
Project Location: Chester and Montgomery Counties, Pennsylvania
Project Number: 15556-032-00

Figure A-4
Sheet 3 of 3



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	Boring Number	Sample Depth (feet)	Moisture Content (%)	Gravel (%)	Sand (%)	Fines (%)	Soil Description (USCS)
◆	SR-1	15	10.1	52.3	40	7.7	Brown poorly graded gravel with silt and sand (GP-GM)
■	SR-2	15	15.0	24.1	66.4	9.5	Reddish brown well-graded sand with silt and gravel (SW-SM)

Sieve Analysis Results

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

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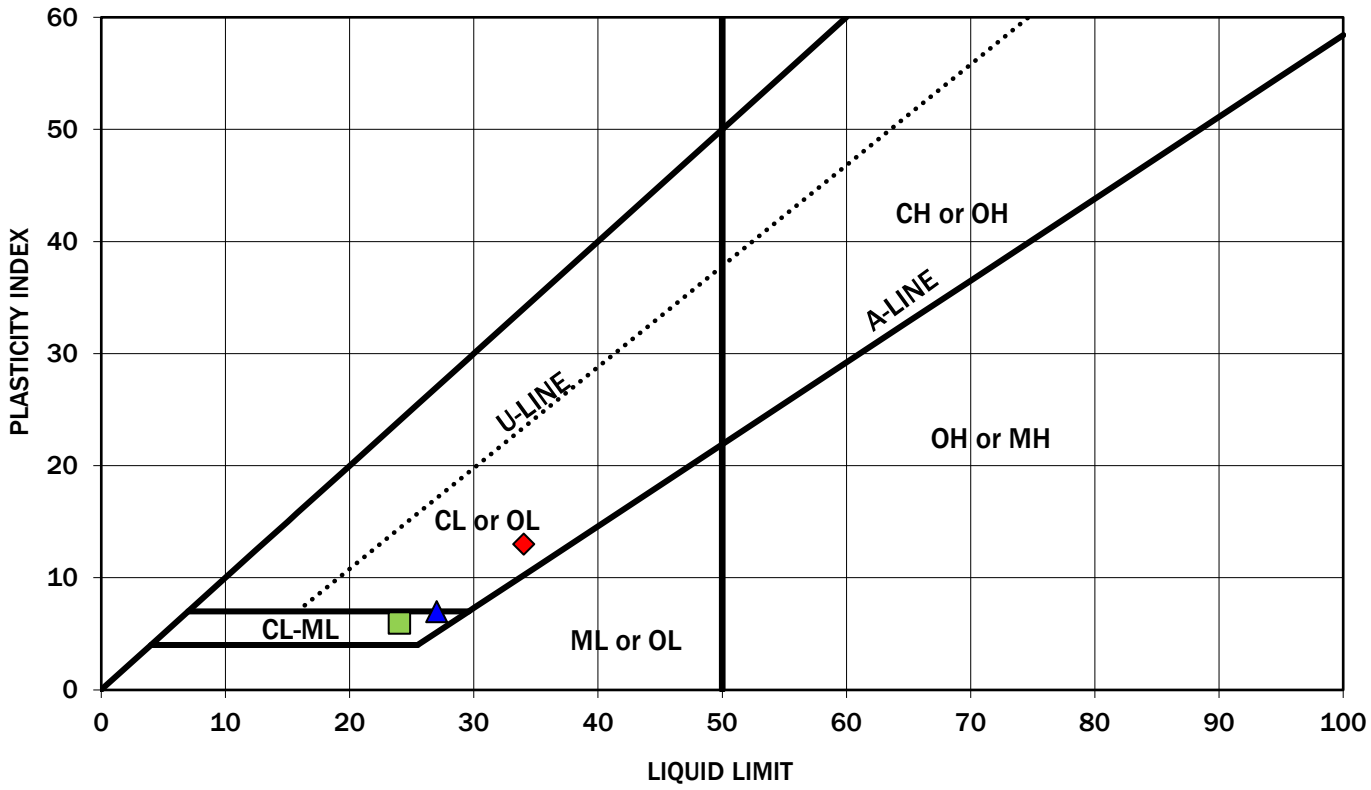
Figure A-5

15556-032-00 Date Exported: 01/05/23

PLASTICITY CHART



Symbol	Boring Number	Depth (feet)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Soil Description
◆	SR-1	5	22.2	34	13	Brown Silty Clay (CL)
■	SR-1	10	23.1	24	6	Brown Clayey Silt with Sand (CL-ML)
▲	SR-2	7.5	22.2	27	7	Reddish brown Clayey Silt (CL-ML)

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc. Test results are applicable only to the specific sample on which they were performed and should not be interpreted as representative of any other samples obtained at other times, depths or locations, or generated by separate operations or processes.

The liquid limit and plasticity index were obtained in general accordance with ASTM D 4318.

Atterberg Limits Test Results

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

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Figure A-6

15556-032-00 Date Exported: 01/05/23

SR-1: 20.0' to 30.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

SR-1: 30.0' to 40.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

Rock Core Photographs	
SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA	
GeoEngineers	Figure A-7

SR-1: 40.0' to 50.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

SR-1: 50.0' to 60.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

Rock Core Photographs

SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT
CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA

GeoEngineers

Figure A-8

SR-1: 60.0' to 70.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

SR-1: 70.0' to 80.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

Rock Core Photographs

SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT
CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA

GeoEngineers

Figure A-9

SR-1: 80.0' to 90.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

SR-1: 90.0' to 100.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

Rock Core Photographs

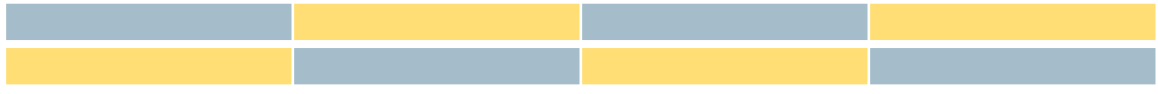
SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT
CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA

GeoEngineers

Figure A-10

SR-1: 100.0' to 103.0'

SR-2: 19.0' to 29.0'



Rock Core Photographs

SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT
CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA

GeoEngineers

Figure A-11

SR-2: 29.0' to 39.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

SR-2: 39.0' to 49.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

Rock Core Photographs

SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT
CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA

GeoEngineers

Figure A-12

SR-2: 49.0' to 59.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

SR-2: 59.0' to 69.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

Rock Core Photographs

SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT
CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA

GeoEngineers

Figure A-13

SR-2: 69.0’ to 79.0’

0 0.5 1.0 Scale In Feet 1.5 2.0

SR-2: 79.0’ to 89.0’

0 0.5 1.0 Scale In Feet 1.5 2.0

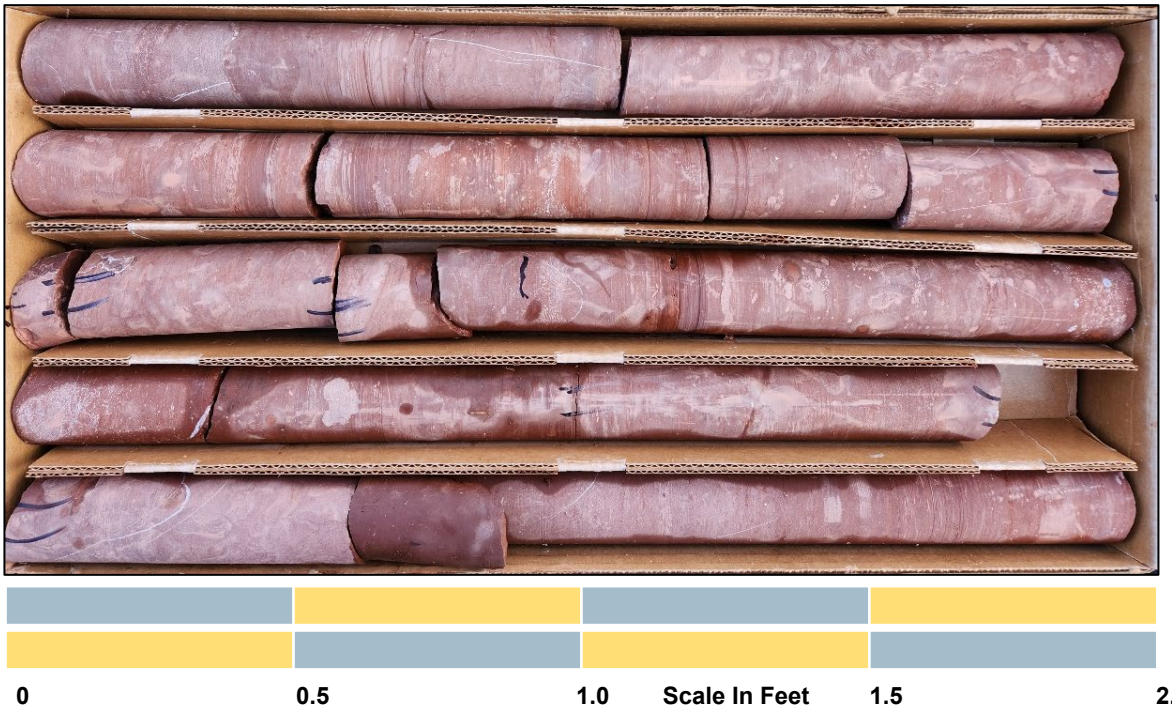
Rock Core Photographs

SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT
CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA

GeoEngineers

Figure A-14

SR-2: 89.0' to 99.0'



0 0.5 1.0 Scale In Feet 1.5 2.0

SR-2: 99.0' to 109.0'

0 0.5 1.0 Scale In Feet 1.5 2.0

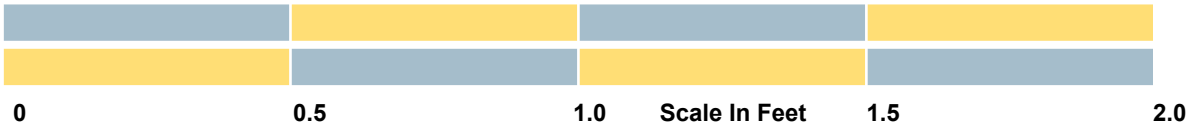
Rock Core Photographs

SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT
CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA

GeoEngineers

Figure A-15

SR-2: 109.0’ to 113.0’



Rock Core Photographs

SCHUYLKILL RIVER PIPE REPLACEMENT PROJECT
CHESTER AND MONTGOMERY COUNTIES, PENNSYLVANIA

GeoEngineers

Figure A-16

SR-1: 34.5' to 35.0', before break

SR-1: 34.5' to 35.0', after break

Avg. Diameter, in.	1.968
Avg. Length, in.	4.506
Area, in2	3.04
Load at failure, lbs.	13,740
Unc. Comp. Strength, psi	4,517
Dry Unit Weight, pcf	169.8

Unconfined Compressive Rock Photographs

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-17

SR-1: 41.5' to 42', before break

SR-1: 41.5' to 42', after break

Avg. Diameter, in.	1.965
Avg. Length, in.	4.225
Area, in2	3.03
Load at failure, lbs.	21,000
Unc. Comp. Strength, psi	6,925
Dry Unit Weight, pcf	172.0

Unconfined Compressive Rock Photographs

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-18

SR-1: 62.5' to 63', before break

SR-1: 62.5' to 63', after break

Avg. Diameter, in.	1.995
Avg. Length, in.	4.518
Area, in2	3.12
Load at failure, lbs.	21,160
Unc. Comp. Strength, psi	6,772
Dry Unit Weight, pcf	164.2

Unconfined Compressive Rock Photographs

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-19

SR-1: 76.5' to 77.0', before break

SR-1: 76.5' to 77.0', after break

Avg. Diameter, in.	1.977
Avg. Length, in.	4.569
Area, in2	3.07
Load at failure, lbs.	39,380
Unc. Comp. Strength, psi	12,833
Dry Unit Weight, pcf	171.1

Unconfined Compressive Rock Photographs

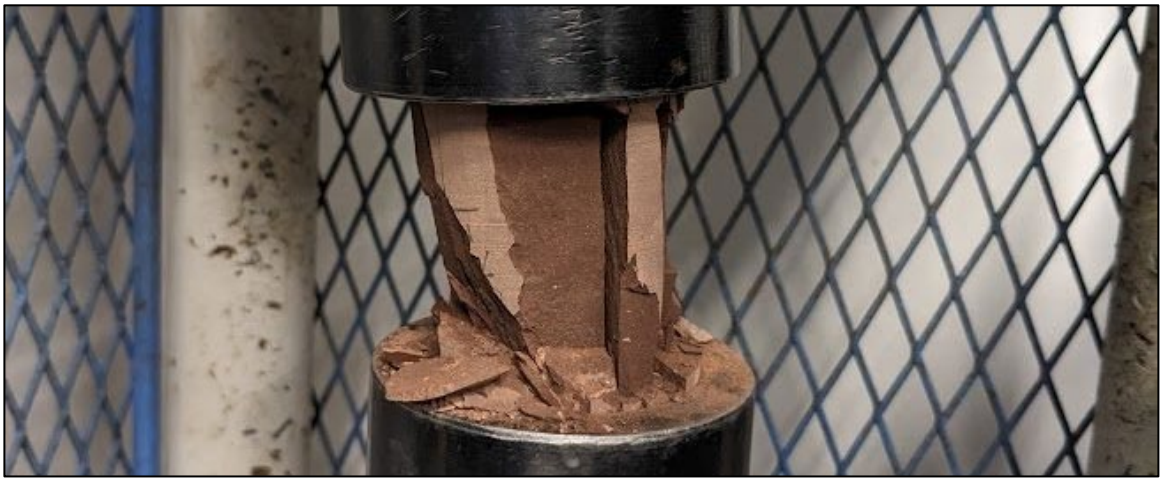
Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-20

SR-1: 85.5' to 86', before break

SR-1: 85.5' to 86', after break



Avg. Diameter, in.	1.968
Avg. Length, in.	4.499
Area, in2	3.04
Load at failure, lbs.	22,480
Unc. Comp. Strength, psi	7,390
Dry Unit Weight, pcf	169.6

Unconfined Compressive Rock Photographs

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-21

SR-1: 95' to 95.5', before break

SR-1: 95' to 95.5', after break

Avg. Diameter, in.	1.985
Avg. Length, in.	4.749
Area, in2	3.09
Load at failure, lbs.	20,130
Unc. Comp. Strength, psi	6,505
Dry Unit Weight, pcf	165.2

Unconfined Compressive Rock Photographs

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-22

SR-2: 31.5' to 32', before break

SR-2: 31.5' to 32', after break

Avg. Diameter, in.	1.979
Avg. Length, in.	4.485
Area, in2	3.07
Load at failure, lbs.	27,490
Unc. Comp. Strength, psi	8,940
Dry Unit Weight, pcf	167.5

Unconfined Compressive Rock Photographs

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-23

SR-2: 41.5' to 42', before break

SR-2: 41.5' to 42', after break

Avg. Diameter, in.	1.976
Avg. Length, in.	4.355
Area, in2	3.07
Load at failure, lbs.	20,160
Unc. Comp. Strength, psi	6,576
Dry Unit Weight, pcf	170.8

Unconfined Compressive Rock Photographs

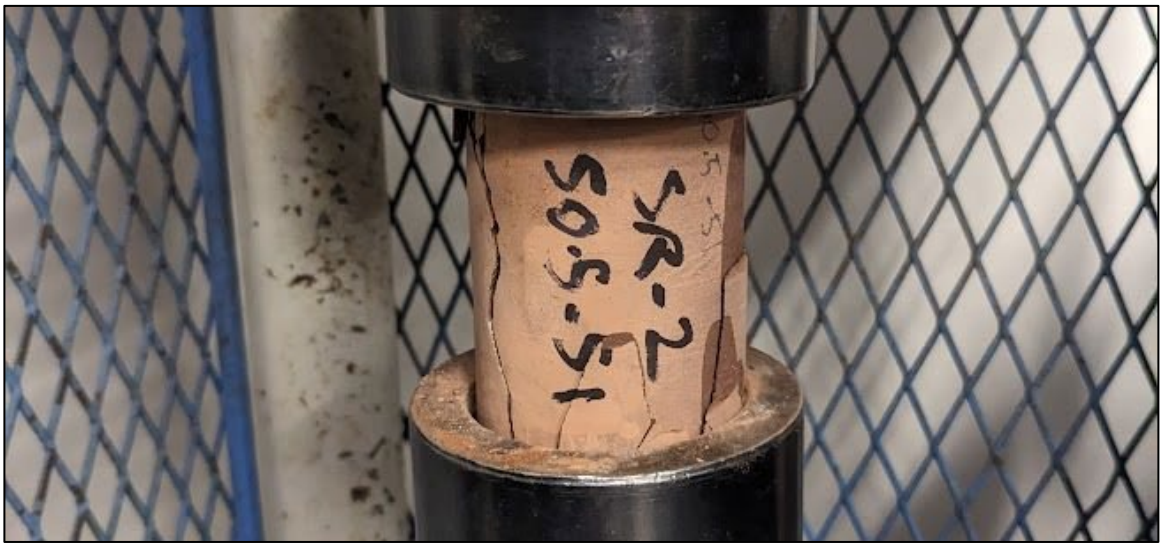
Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-24

SR-2: 50.5' to 51', before break

SR-2: 50.5' to 51', after break



Avg. Diameter, in.	1.992
Avg. Length, in.	4.400
Area, in2	3.12
Load at failure, lbs.	23,420
Unc. Comp. Strength, psi	7,512
Dry Unit Weight, pcf	165.6

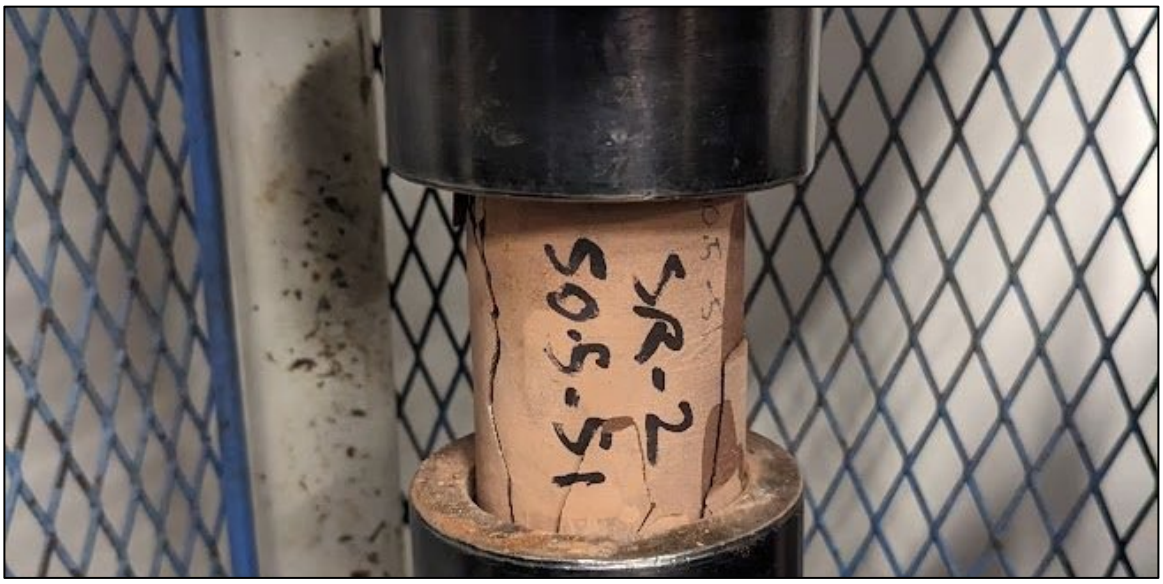
Unconfined Compressive Rock Photographs

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-25

SR-2: 71' to 71.5', before break



SR-2: 71' to 71.5', after break

Avg. Diameter, in.	1.983
Avg. Length, in.	4.502
Area, in2	3.09
Load at failure, lbs.	71,690
Unc. Comp. Strength, psi	23,220
Dry Unit Weight, pcf	164.4

Unconfined Compressive Rock Photographs

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-26

SR-2: 80' to 80.5', before break

SR-2: 80' to 80.5', after break

Avg. Diameter, in.	1.962
Avg. Length, in.	4.480
Area, in2	3.02
Load at failure, lbs.	19,960
Unc. Comp. Strength, psi	6,600
Dry Unit Weight, pcf	172.5

Unconfined Compressive Rock Photographs

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-27

SR-2: 95' to 95.5', before break

SR-2: 95' to 95.5', after break

Avg. Diameter, in.	1.982
Avg. Length, in.	4.513
Area, in2	3.09
Load at failure, lbs.	15,780
Unc. Comp. Strength, psi	5,115
Dry Unit Weight, pcf	171.2

Unconfined Compressive Rock Photographs

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-28

SR-2: 105' to 105.5', before break

SR-2: 105' to 105.5', after break

Avg. Diameter, in.	1.977
Avg. Length, in.	4.692
Area, in2	3.07
Load at failure, lbs.	13,010
Unc. Comp. Strength, psi	4,238
Dry Unit Weight, pcf	170.9

Unconfined Compressive Rock Photographs

Schuylkill River Pipe Replacement Project
Chester and Montgomery Counties, Pennsylvania

GeoEngineers

Figure A-29

Advanced Terra Testing's Laboratory Results

ADVANCED TERRA TESTING

CERCHAR Abrasiveness
ASTM D7625

CLIENT	GeoEngineers	JOB NO.	3170-001
PROJECT	Schuylkill River Pipe Crossing	LOCATION	Montgomery Counties, PA
PROJECT NO.	15556-032-00		

BORING NO.	SR-1	SR-1	SR-2	SR-2
DEPTH	90.0-91.5	94.0-94.5	65.0-65.75	71.5-72.0
SAMPLE NO.				
DATE SAMPLED				
DATE TESTED	02/03/23	02/03/23	02/03/23	02/03/23
TECHNICIAN	HN	HN	HN	HN
ROCK TYPE				
Surface Type:	Saw Cut	Saw Cut	Saw Cut	Saw Cut
Moisture Condition	As Received	As Received	As Received	As Received
Reading A.1 (in):	0.01040	0.00540	0.01720	0.01670
Reading A.2 (in):	0.01160	0.00970	0.00720	0.01670
Reading A.3 (in):	0.01330	0.00740	0.01680	0.01670
Reading A.4 (in):	0.01070	0.00640	0.01570	0.01700
Reading A.5 (in):	0.01360	0.00850	0.01340	0.01730
Reading B.1 (in):	0.01220	0.00690	0.01820	0.01500
Reading B.2 (in):	0.01100	0.01010	0.00810	0.01660
Reading B.3 (in):	0.01360	0.00610	0.01360	0.01660
Reading B.4 (in):	0.01260	0.00780	0.01540	0.01690
Reading B.5 (in):	0.01300	0.00560	0.01540	0.01670
Average Reading (in):	0.01220	0.00739	0.01410	0.01662
Average Reading (mm):	0.3099	0.1877	0.3581	0.4221
Uncorrected CAI or CAI_s:	**3.10**	**1.88**	**3.58**	**4.22**
Corrected CAI:	**3.53**	**2.14**	**4.08**	**4.66**

NOTES

CAI_s is the CAI calculated for saw cut specimens.

Corrected CAI for saw cut specimens based on ASTM suggested formula for CAIs<4.0; CAI = 1.14 *CAIs and for CAIs>4.0; 0.99*CAIs +0.48

Applied pins had a Rockwell Hardness of 54-56.

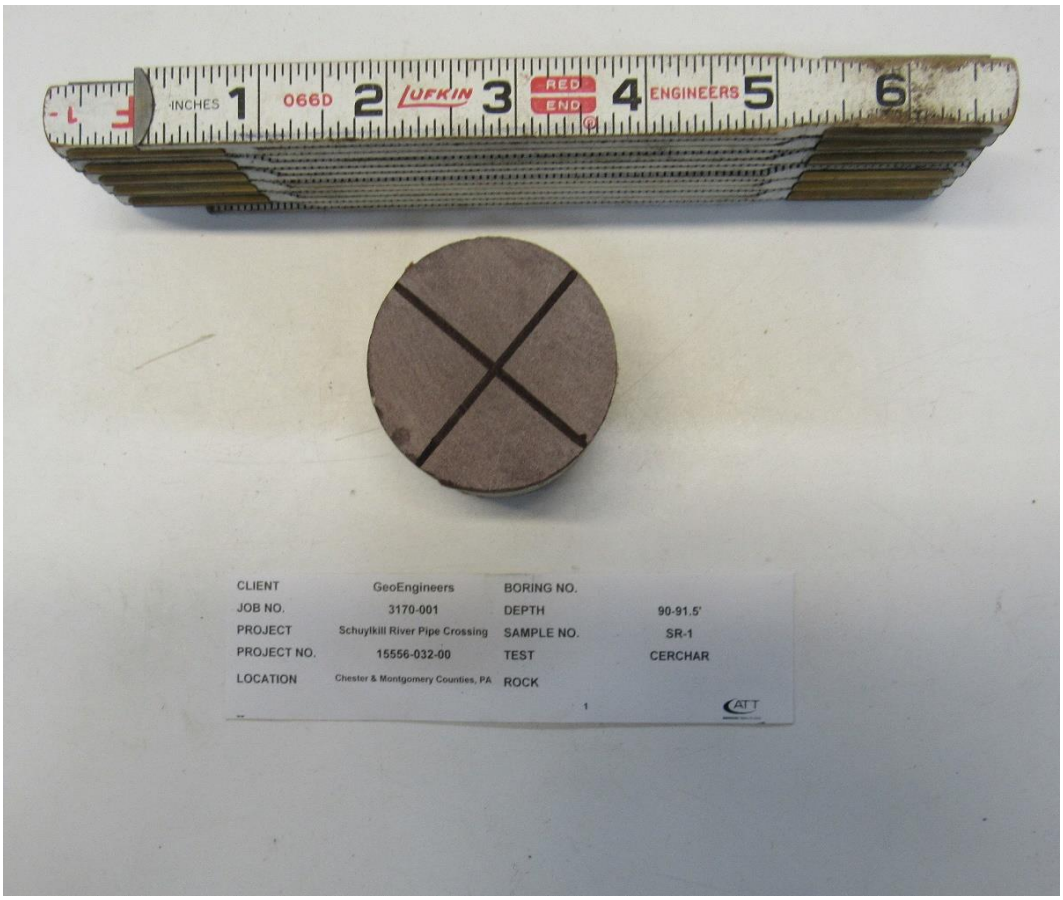
Data entry by:	HN	Date:	02/03/23
Checked by:	DL	Date:	02/03/23
File name:	3170001__CHERCHAR ASTM D7625_0.xlsm		

ADVANCED TERRA TESTING

CHERCHAR Abrasiveness
ASTM D7625

CLIENT	GeoEngineers	BORING NO.	SR-1
JOB NO.	3170-001	DEPTH	90.0-91.5
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	--
PROJECT NO.	15556-032-00	DATE SAMPLED	--
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/03/23
		TECHNICIAN	HN
		ROCK TYPE	--

Before Picture



NOTES

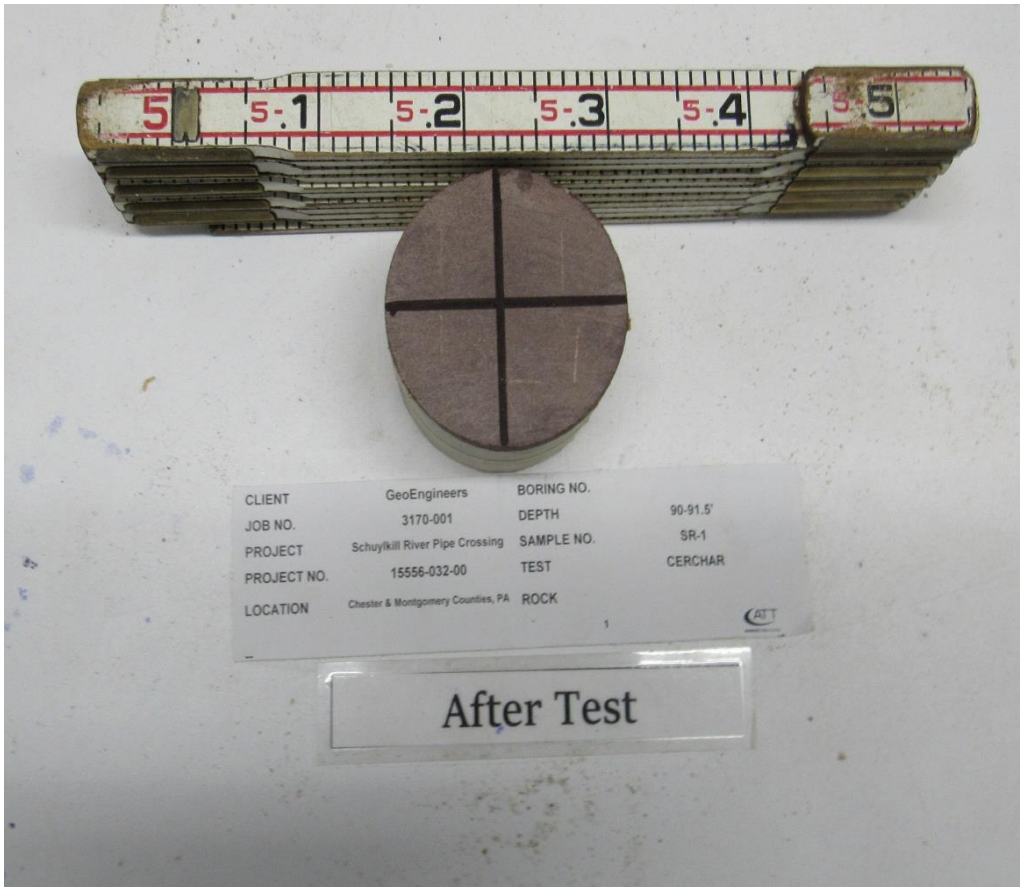
Picture File: 1.JPG
File name: 3170001__CHERCHAR ASTM D7625_0.xlsm

ADVANCED TERRA TESTING

CHERCHAR Abrasiveness
ASTM D7625

CLIENT	GeoEngineers	BORING NO.	SR-1
JOB NO.	3170-001	DEPTH	90.0-91.5
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	--
PROJECT NO.	15556-032-00	DATE SAMPLED	--
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/03/23
		TECHNICIAN	HN
		ROCK TYPE	--

After Picture



NOTES

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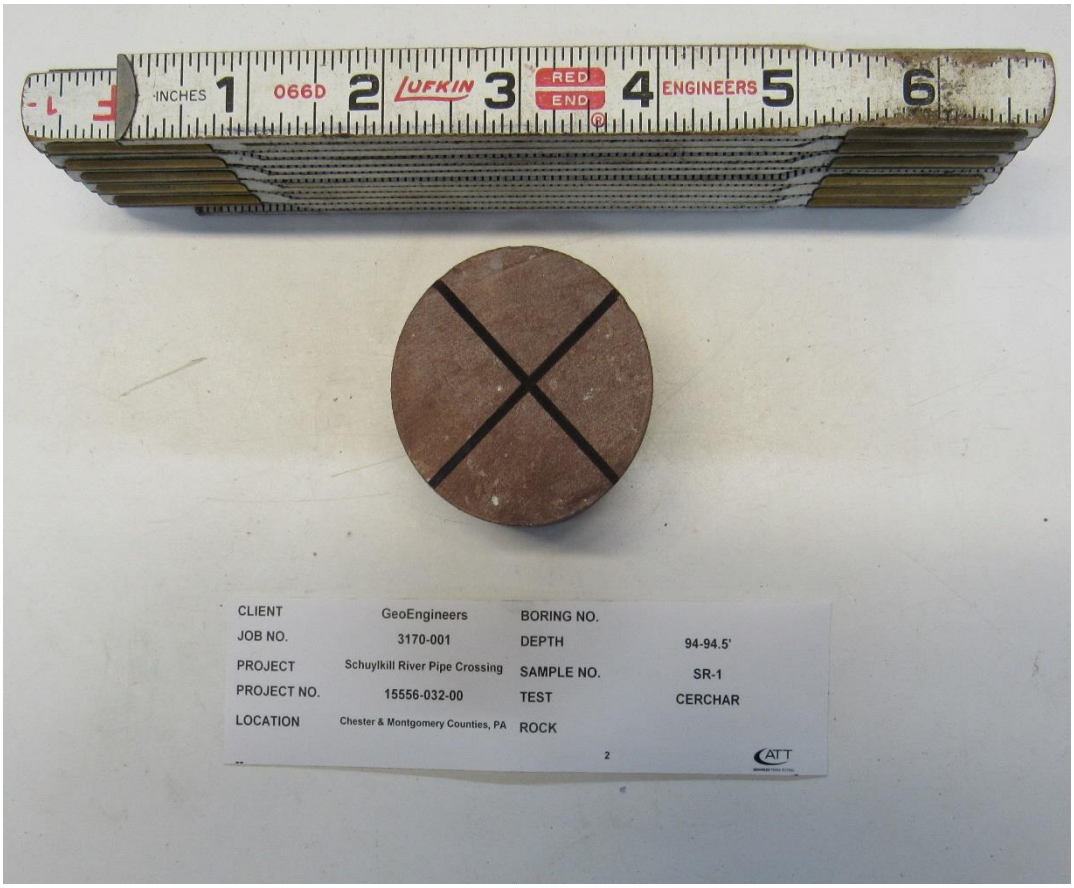
ADVANCED TERRA TESTING

CHERCHAR Abrasiveness
ASTM D7625

CLIENT	GeoEngineers	BORING NO.	SR-1
JOB NO.	3170-001	DEPTH	94.0-94.5
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	--
PROJECT NO.	15556-032-00	DATE SAMPLED	--
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/03/23
		TECHNICIAN	HN
		ROCK TYPE	--

Before Picture



NOTES

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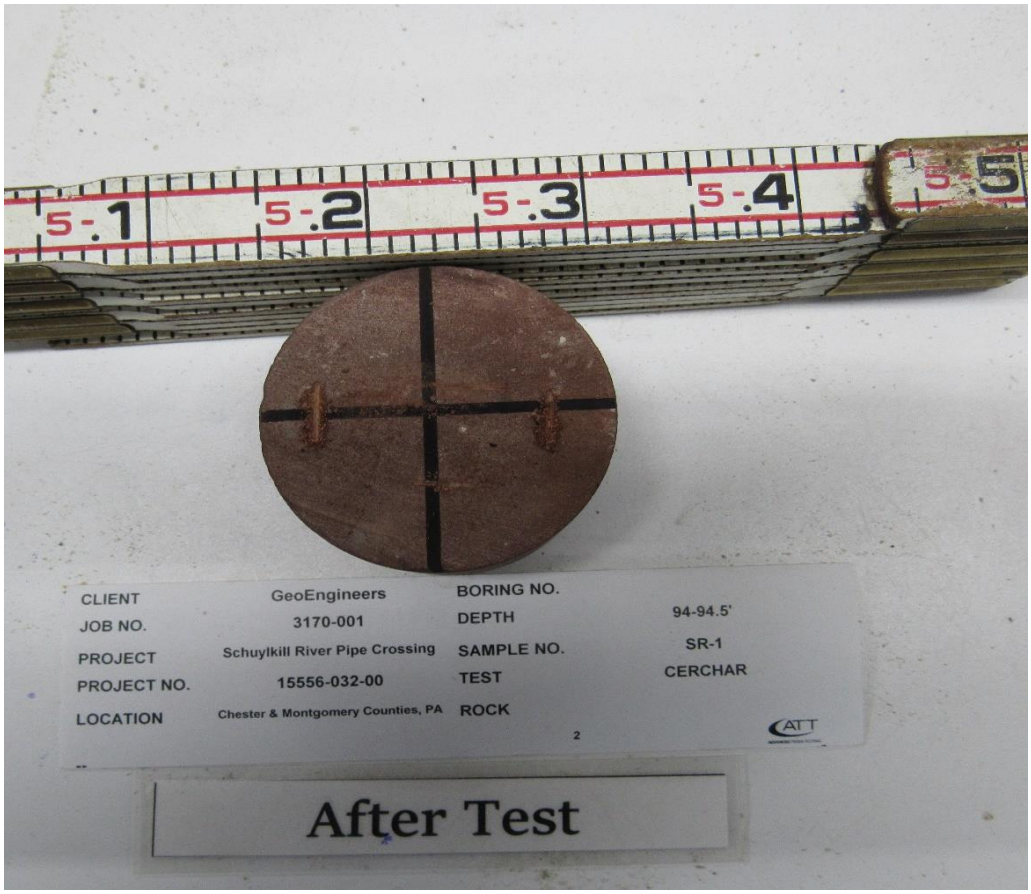
ADVANCED TERRA TESTING

CHERCHAR Abrasiveness
ASTM D7625

CLIENT	GeoEngineers	BORING NO.	SR-1
JOB NO.	3170-001	DEPTH	94.0-94.5
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	--
PROJECT NO.	15556-032-00	DATE SAMPLED	--
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/03/23
		TECHNICIAN	HN
		ROCK TYPE	--

After Picture



NOTES

Picture File: 2a.JPG
File name: 3170001__CHERCHAR ASTM D7625_0.xlsm

ADVANCED TERRA TESTING

CHERCHAR Abrasiveness
ASTM D7625

CLIENT	GeoEngineers	BORING NO.	SR-2
JOB NO.	3170-001	DEPTH	65.0-65.75
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	--
PROJECT NO.	15556-032-00	DATE SAMPLED	--
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/03/23
		TECHNICIAN	HN
		ROCK TYPE	--

Before Picture

NOTES

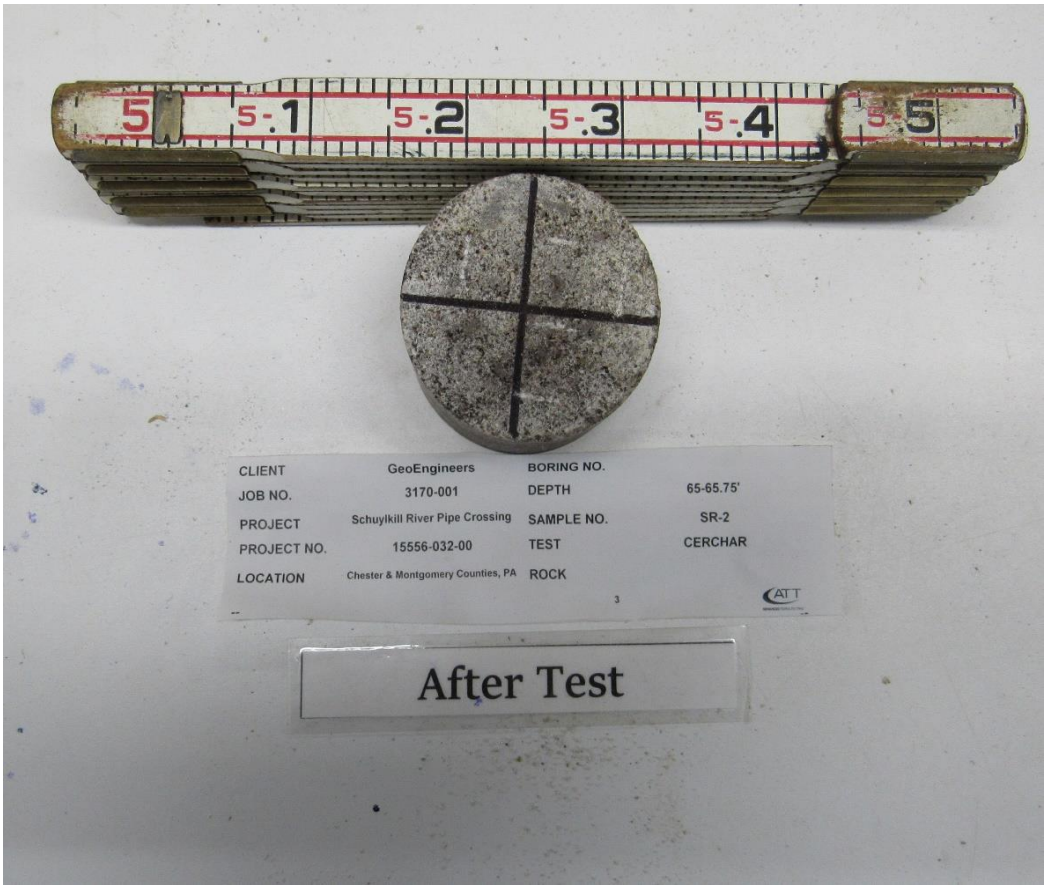
Picture File: 3.JPG
File name: 3170001__CHERCHAR ASTM D7625_0.xlsm

ADVANCED TERRA TESTING

CHERCHAR Abrasiveness
ASTM D7625

CLIENT	GeoEngineers	BORING NO.	SR-2
JOB NO.	3170-001	DEPTH	65.0-65.75
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	--
PROJECT NO.	15556-032-00	DATE SAMPLED	--
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/03/23
		TECHNICIAN	HN
		ROCK TYPE	--

After Picture



NOTES

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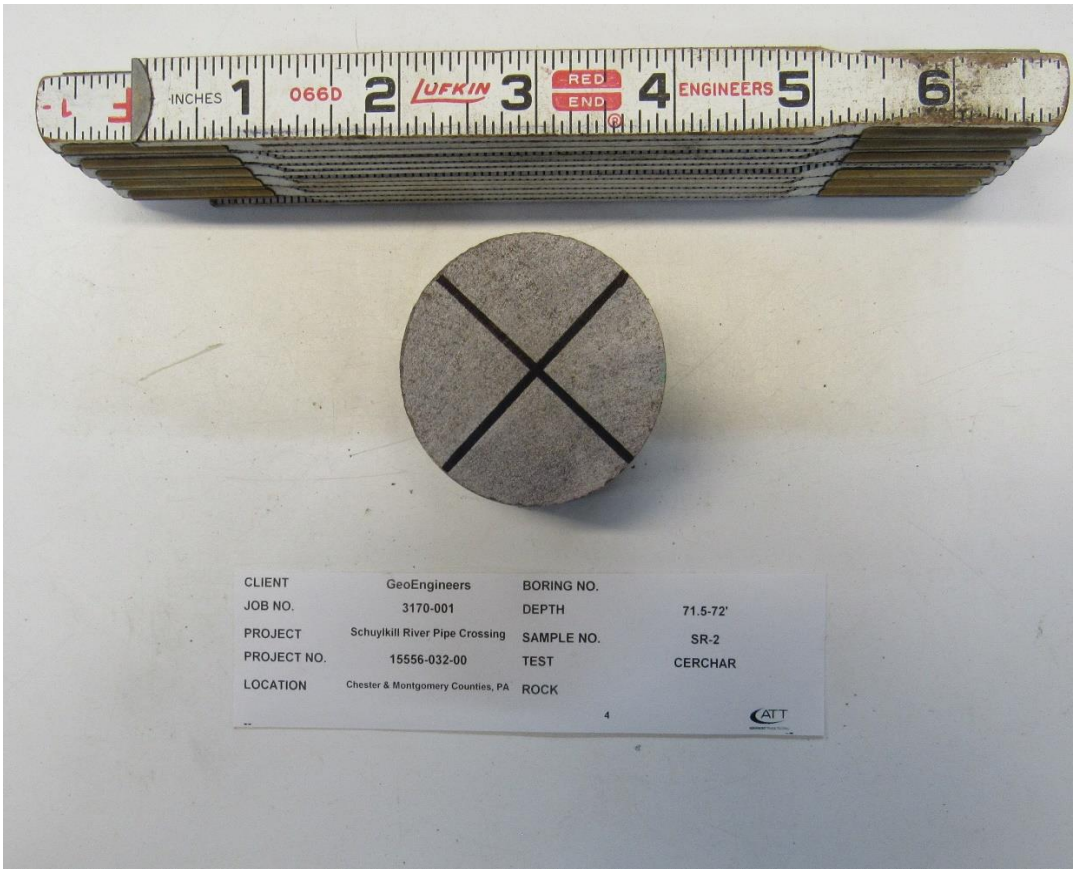
ADVANCED TERRA TESTING

CHERCHAR Abrasiveness
ASTM D7625

CLIENT	GeoEngineers	BORING NO.	SR-2
JOB NO.	3170-001	DEPTH	71.5-72.0
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	--
PROJECT NO.	15556-032-00	DATE SAMPLED	--
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/03/23
		TECHNICIAN	HN
		ROCK TYPE	--

Before Picture



NOTES

Picture File: 4.JPG
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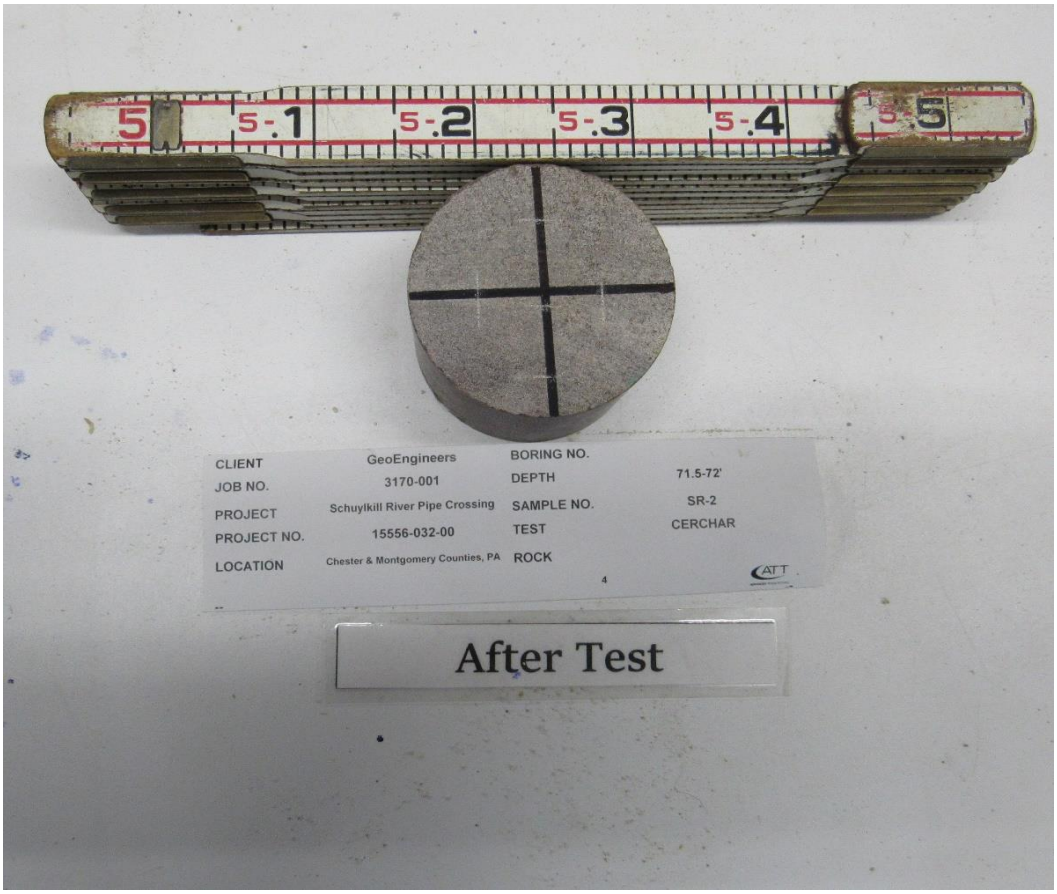
ADVANCED TERRA TESTING

CHERCHAR Abrasiveness
ASTM D7625

CLIENT	GeoEngineers	BORING NO.	SR-2
JOB NO.	3170-001	DEPTH	71.5-72.0
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	--
PROJECT NO.	15556-032-00	DATE SAMPLED	--
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/03/23
		TECHNICIAN	HN
		ROCK TYPE	--

After Picture



NOTES

Picture File: 4a.JPG
File name: 3170001__CHERCHAR ASTM D7625_0.xlsm

ADVANCED TERRA TESTING

Splitting Tensile Strength
ASTM D3967

CLIENT	GeoEngineers	JOB NO.	3170-001
PROJECT	Schuylkill River Pipe Crossing	LOCATION	Chester & Montgomery Counties
PROJECT NO.	15556-032-00		

BORING NO.				
DEPTH	90-91.5'	94-94.5'	65-65.75'	71.5-72'
SAMPLE NO.	SR-1	SR-1	SR-2	SR-2
DATE SAMPLED				
DATE TESTED	02/02/23	02/02/23	02/02/23	02/02/23
TECHNICIAN	DL	DL	DL	DL
ROCK TYPE				
Diameter (in):	1.982	1.981	1.988	1.991
Height (in):	1.064	1.086	1.037	1.044
Mass of Wet Rock (g):	144.50	147.30	118.20	132.40
Wet Density (lbs/ft³):	167.7	167.6	139.9	155.2
Wet Density (g/cm³):	2.686	2.685	2.241	2.486
Peak Load (lbs):	12405	3606	2437	8922
Splitting Tensile Strength (psi):	3745	1067	752	2733
Splitting Tensile Strength (kPa):	25820	7358	5188	18841
Failure Type:	Multiple Plane	Single Plane	Single Plane	Multiple Plane

BORING NO.	
DEPTH	
SAMPLE NO.	
DATE SAMPLED	
DATE TESTED	
TECHNICIAN	
ROCK TYPE	
Diameter (in):	
Height (in):	
Mass of Wet Rock (g):	
Wet Density (lbs/ft³):	
Wet Density (g/cm³):	
Peak Load (lbs):	
Splitting Tensile Strength (psi):	
Splitting Tensile Strength (kPa):	
Failure Type:	
NOTES	

Data entry by:	DL	Date: 02/02/23
Checked by:	HN	Date: 02/03/23
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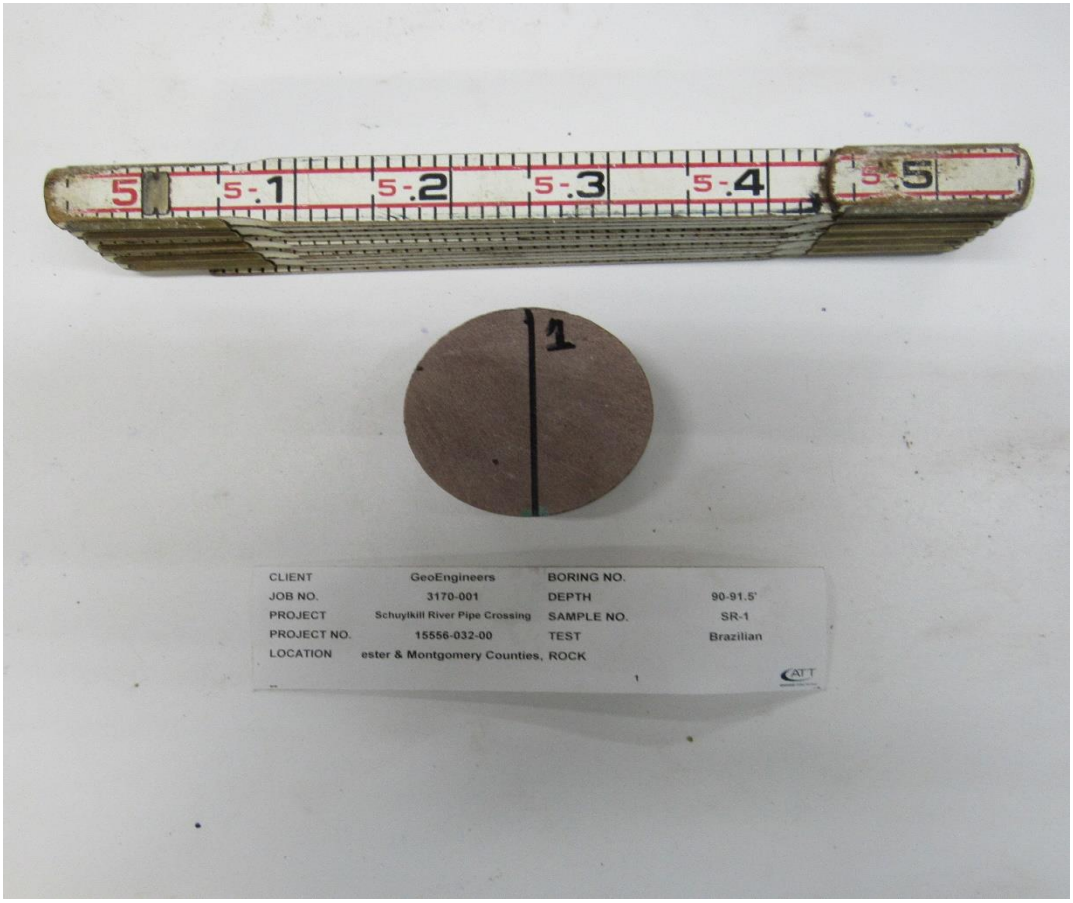
ADVANCED TERRA TESTING

Splitting Tensile
ASTM D3967

CLIENT	GeoEngineers	BORING NO.	
JOB NO.	3170-001	DEPTH	90-91.5'
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	SR-1
PROJECT NO.	15556-032-00	DATE SAMPLED	
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/02/23
		TECHNICIAN	DL
		ROCK TYPE	

Before Picture



NOTES

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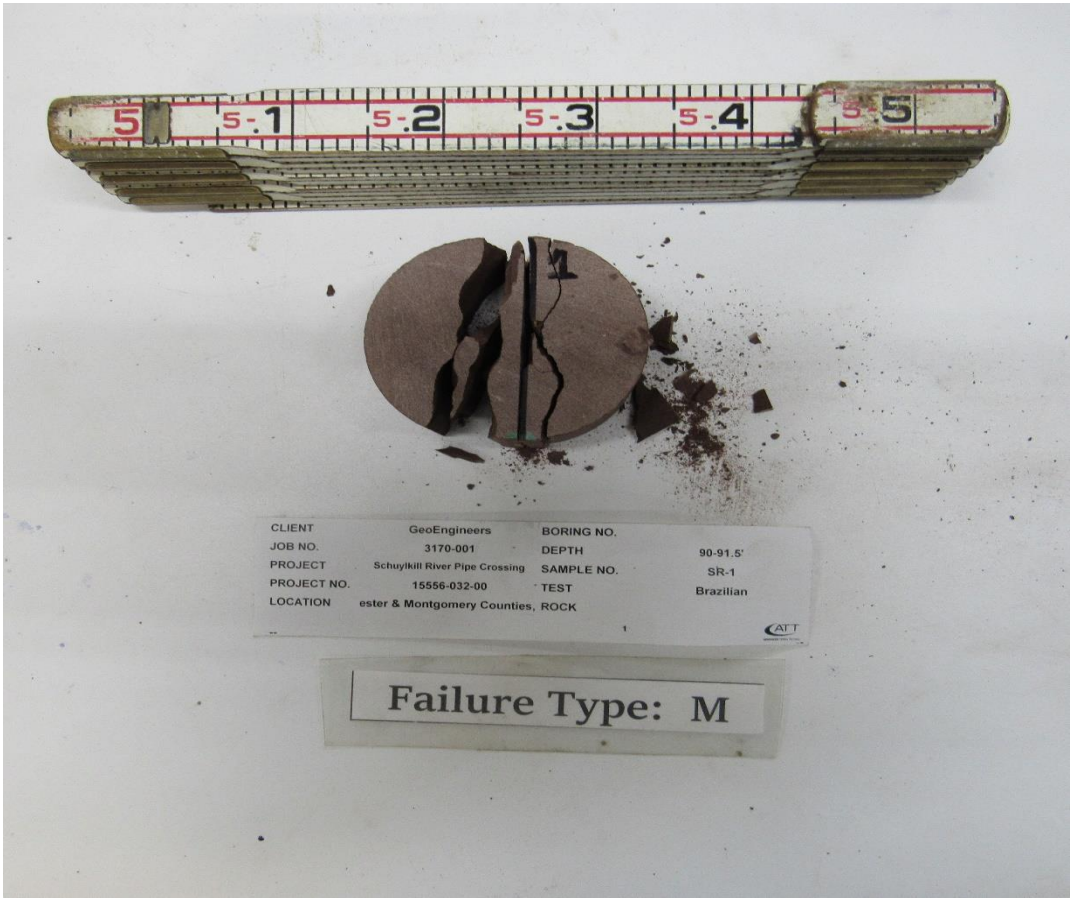
ADVANCED TERRA TESTING

Splitting Tensile
ASTM D3967

CLIENT	GeoEngineers	BORING NO.	
JOB NO.	3170-001	DEPTH	90-91.5'
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	SR-1
PROJECT NO.	15556-032-00	DATE SAMPLED	
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/02/23
		TECHNICIAN	DL
		ROCK TYPE	

After Picture



NOTES

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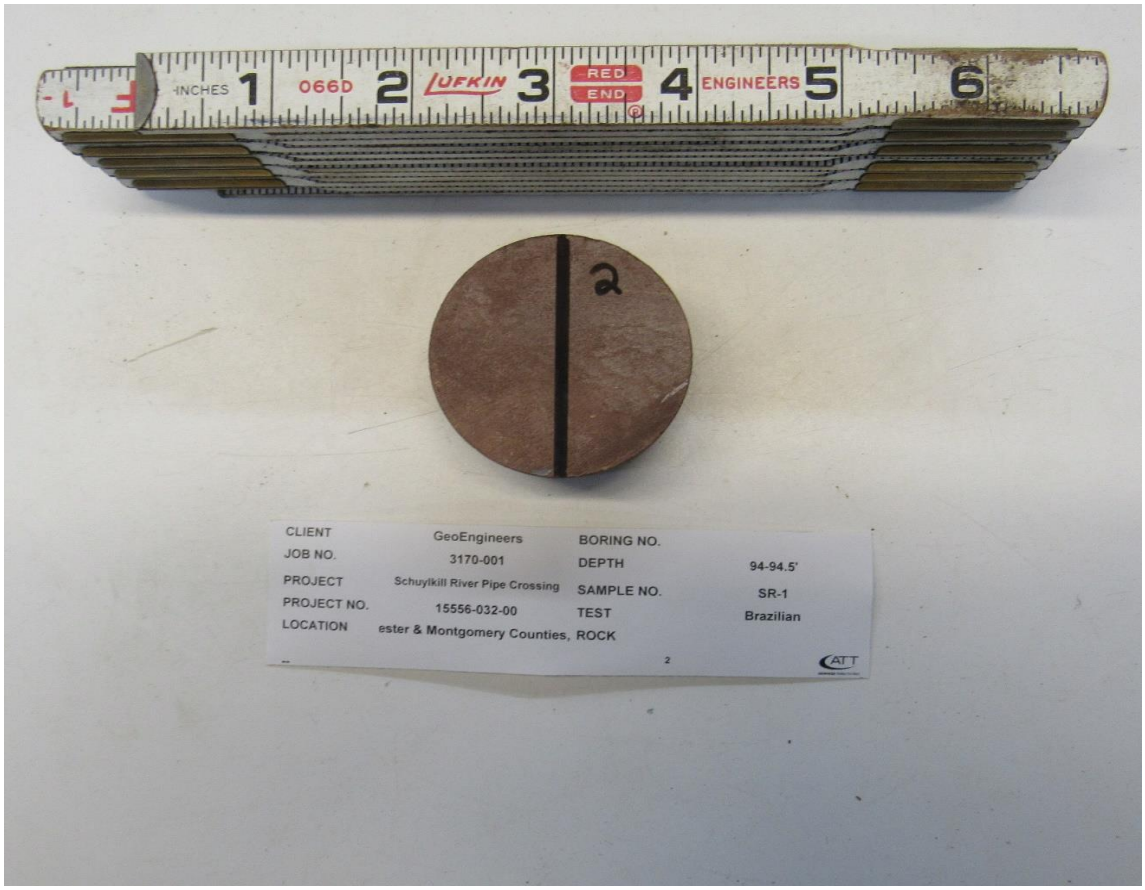
ADVANCED TERRA TESTING

Splitting Tensile
ASTM D3967

CLIENT	GeoEngineers	BORING NO.	
JOB NO.	3170-001	DEPTH	94-94.5'
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	SR-1
PROJECT NO.	15556-032-00	DATE SAMPLED	
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/02/23
		TECHNICIAN	DL
		ROCK TYPE	

Before Picture



NOTES

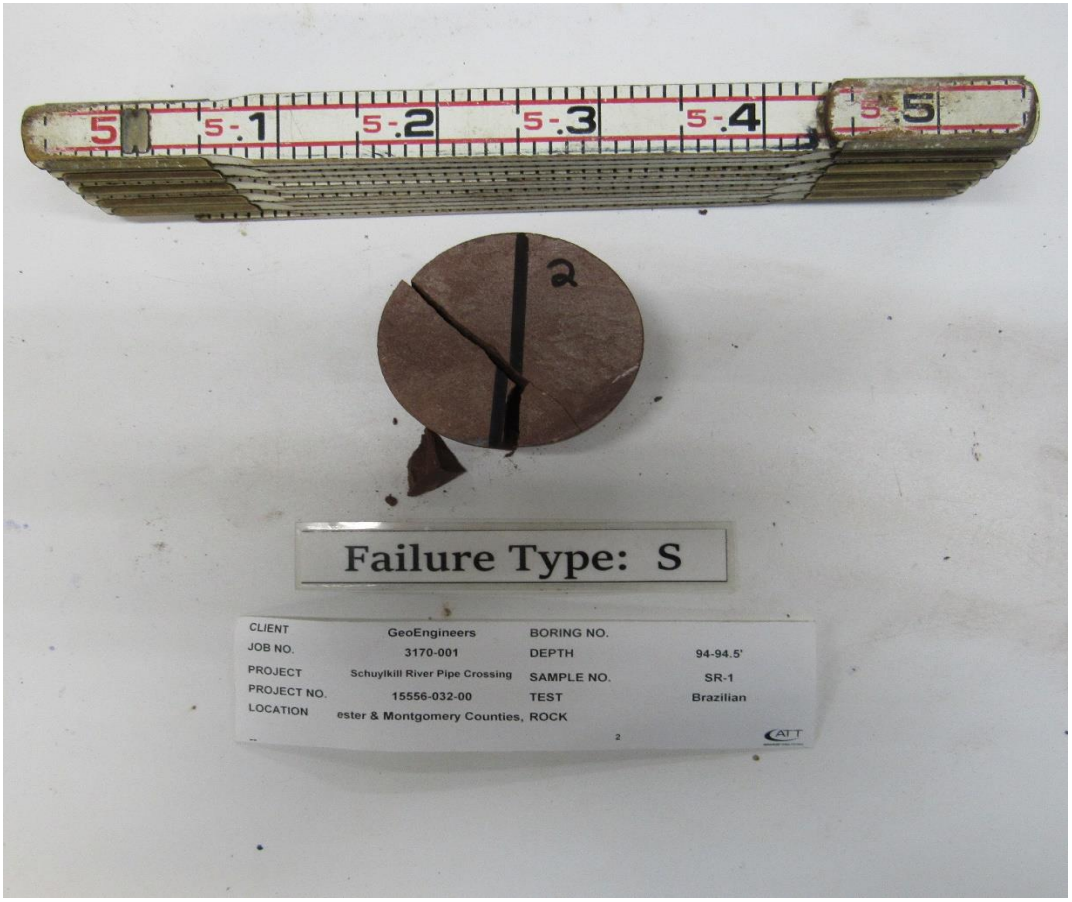
Picture File: 2.JPG
File name: 3170001__Brazilian ASTM D3967_0.xlsm

ADVANCED TERRA TESTING

Splitting Tensile
ASTM D3967

CLIENT	GeoEngineers	BORING NO.	
JOB NO.	3170-001	DEPTH	94-94.5'
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	SR-1
PROJECT NO.	15556-032-00	DATE SAMPLED	
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/02/23
		TECHNICIAN	DL
		ROCK TYPE	

After Picture



NOTES

Picture File: 2a.JPG
File name: 3170001__Brazilian ASTM D3967_0.xlsm

ADVANCED TERRA TESTING

Splitting Tensile
ASTM D3967

CLIENT	GeoEngineers	BORING NO.	
JOB NO.	3170-001	DEPTH	65-65.75'
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	SR-2
PROJECT NO.	15556-032-00	DATE SAMPLED	
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/02/23
		TECHNICIAN	DL
		ROCK TYPE	

Before Picture

NOTES

Picture File: 3.JPG
File name: 3170001__Brazilian ASTM D3967_0.xlsm

ADVANCED TERRA TESTING

Splitting Tensile
ASTM D3967

CLIENT	GeoEngineers	BORING NO.	
JOB NO.	3170-001	DEPTH	65-65.75'
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	SR-2
PROJECT NO.	15556-032-00	DATE SAMPLED	
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/02/23
		TECHNICIAN	DL
		ROCK TYPE	

After Picture

NOTES

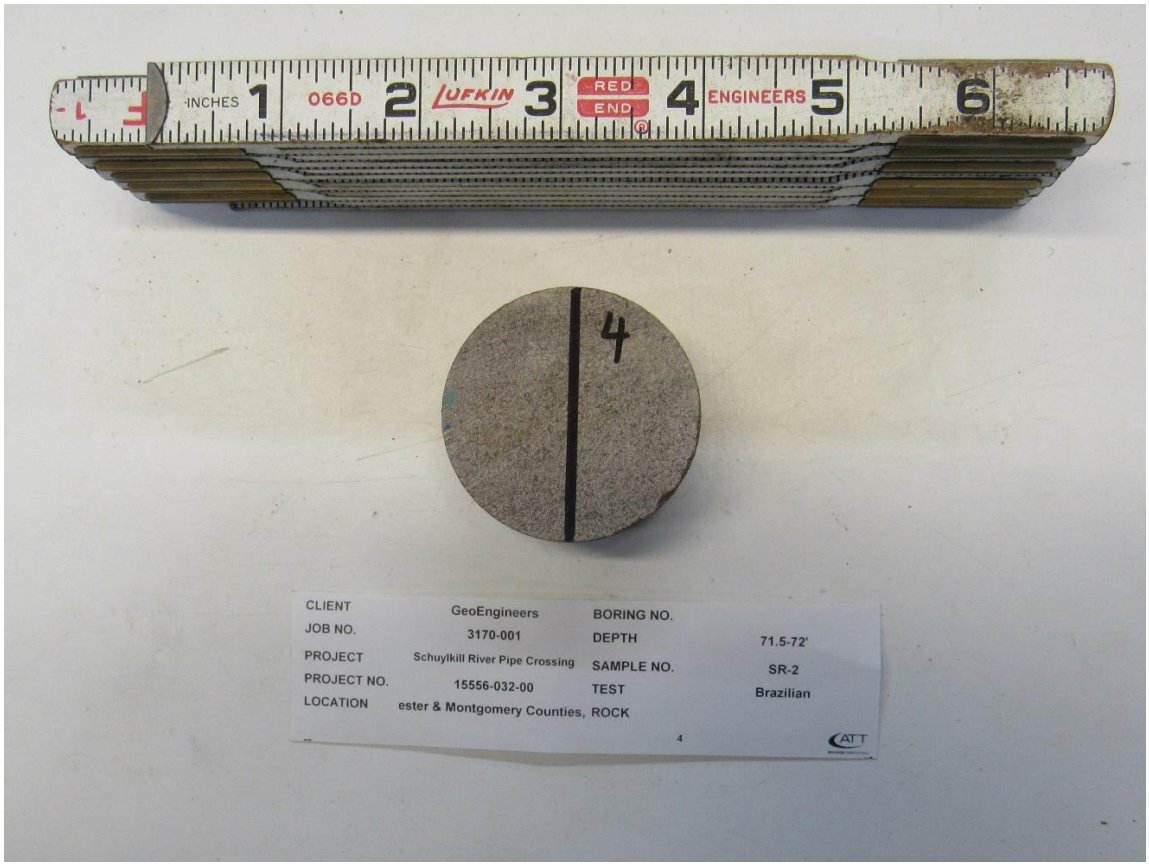
Picture File: 3a.JPG
File name: 3170001__Brazilian ASTM D3967_0.xlsm

ADVANCED TERRA TESTING

Splitting Tensile
ASTM D3967

CLIENT	GeoEngineers	BORING NO.	
JOB NO.	3170-001	DEPTH	71.5-72'
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	SR-2
PROJECT NO.	15556-032-00	DATE SAMPLED	
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/02/23
		TECHNICIAN	DL
		ROCK TYPE	

Before Picture



NOTES

Picture File: 4.JPG
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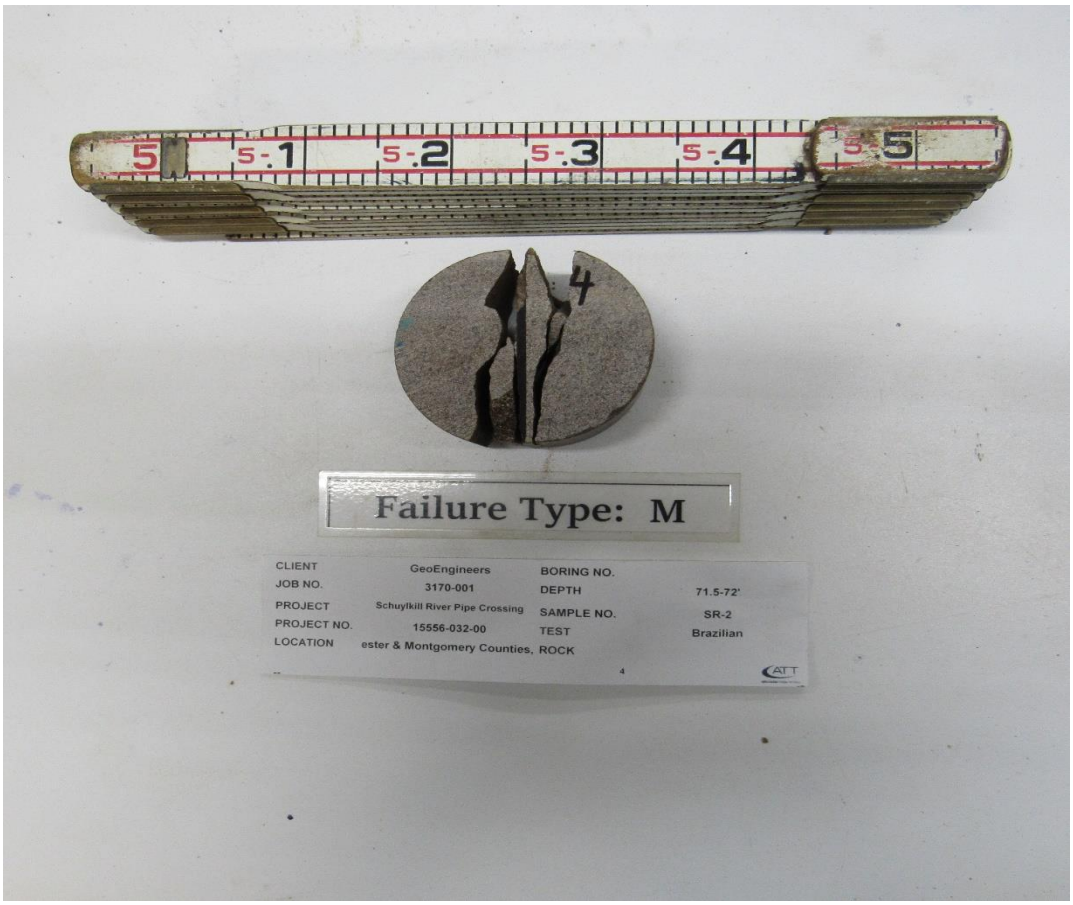
ADVANCED TERRA TESTING

Splitting Tensile
ASTM D3967

CLIENT	GeoEngineers	BORING NO.	
JOB NO.	3170-001	DEPTH	71.5-72'
PROJECT	Schuylkill River Pipe Crossing	SAMPLE NO.	SR-2
PROJECT NO.	15556-032-00	DATE SAMPLED	
LOCATION	Chester & Montgomery Counties, PA	DATE TESTED	02/02/23
		TECHNICIAN	DL
		ROCK TYPE	

After Picture



NOTES

Picture File: 4a.JPG
File name: 3170001__Brazilian ASTM D3967_0.xlsm

APPENDIX B
Report Limitations and Guidelines for Use

APPENDIX B
REPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Read These Provisions Closely

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) rely on professional judgment and opinion to a greater extent than other engineering and natural science disciplines, where more precise and/or readily observable data may exist. To help clients better understand how this difference pertains to our services, GeoEngineers, Inc. (GeoEngineers) includes the following explanatory "limitations" provisions in its reports. Please confer with GeoEngineers if you need to know more how these "Report Limitations and Guidelines for Use" apply to your project or site.

Geotechnical Services Are Performed for Specific Purposes, Persons and Projects

This report has been prepared for Audubon Engineering Company, LP and the design team for the Project specifically identified in the report. The information contained herein is not applicable to other sites or projects.

GeoEngineers structures its services to meet the specific needs of its clients. No party other than the party to whom this report is addressed may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project, and its schedule and budget, our services have been executed in accordance with terms and conditions in our work order No. 02486001-WO-GE0003-002, dated October 17, 2022 and generally accepted geotechnical practices in this area at the time this report was prepared. We do not authorize, and will not be responsible for, the use of this report for any purposes or projects other than those identified in the report.

A Geotechnical Engineering or Geologic Report is Based on a Unique Set of Project-Specific Factors

This report has been prepared for the Schuylkill River Pipe Replacement Project located in Chester and Montgomery Counties, Pennsylvania. GeoEngineers considered several unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- Not prepared for you,
- Not prepared for your project,
- Not prepared for the specific site explored, or
- Completed before important project changes were made.

[1] Developed based on material provided by ASFE/The Best People on Earth, Professional Firms Practicing in the Geosciences; www.asfe.org.

For example, changes that can affect the applicability of this report include those that affect:

- The function of the proposed structure;
- Elevation, configuration, location, orientation or weight of the proposed structure;
- Composition of the design team; or
- Project ownership.

If changes occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

Environmental Concerns are Not Covered

Unless environmental services were specifically included in our scope of services, this report does not provide any environmental findings, conclusions, or recommendations, including but not limited to, the likelihood of encountering underground storage tanks or regulated contaminants.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, new information or technology that becomes available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Geotechnical and Geologic Findings are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied its professional judgment to render an informed opinion about subsurface conditions at other locations. Actual subsurface conditions may differ, sometimes significantly, from the opinions presented in this report. Our report, conclusions and interpretations are not a warranty of the actual subsurface conditions.

Geotechnical Engineering Report Recommendations are Not Final

We have developed the following recommendations based on data gathered from subsurface investigation(s). These investigations sample just a small percentage of a site to create a snapshot of the subsurface conditions elsewhere on the site. Such sampling on its own cannot provide a complete and accurate view of subsurface conditions for the entire site. Therefore, the recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers

cannot assume responsibility or liability for the recommendations in this report if we do not perform construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective means of managing the risks associated with unanticipated conditions. If another party performs field observation and confirms our expectations, the other party must take full responsibility for both the observations and recommendations. Please note, however, that another party would lack our project-specific knowledge and resources.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable but separating logs from the report can create a risk of misinterpretation.

Give Contractors a Complete Report and Guidance

To help reduce the risk of problems associated with unanticipated subsurface conditions, GeoEngineers recommends giving contractors the complete geotechnical engineering or geologic report, including these "Report Limitations and Guidelines for Use." When providing the report, you should preface it with a clearly written letter of transmittal that:

- Advises contractors that the report was not prepared for purposes of bid development and that its accuracy is limited; and
- Encourages contractors to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

Contractors are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

Biological Pollutants

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.

Information Provided by Others

GeoEngineers has relied upon certain data or information provided or compiled by others in the performance of our services. Although we use sources that we reasonably believe to be trustworthy, GeoEngineers cannot warrant or guarantee the accuracy or completeness of information provided or compiled by others.

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