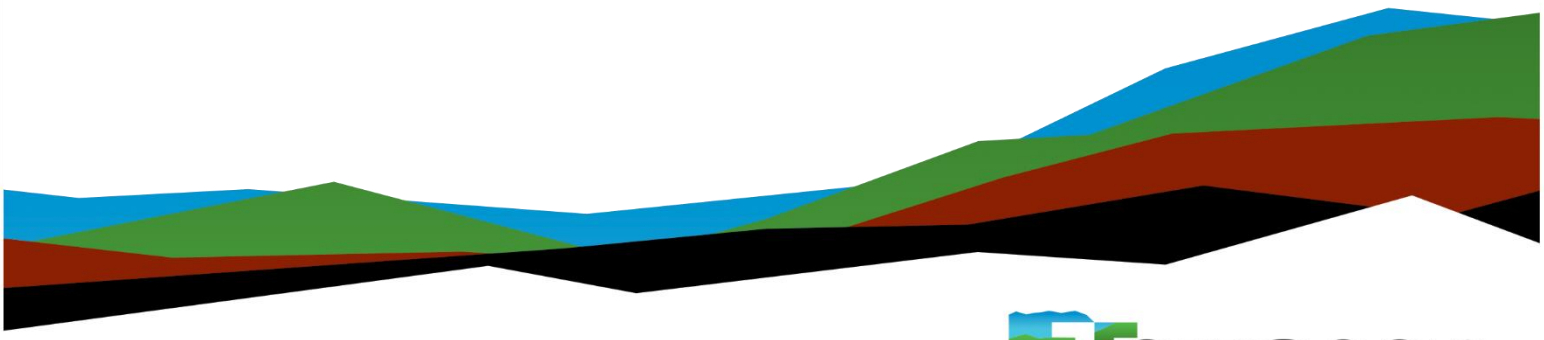
Structural Plate Pipe Replacements

Geotechnical Exploration Report

July 27, 2023 | Terracon Project No. M2225065

Prepared for:

Apex Engineering Group
600 S 2nd St, Suite 145
Bismarck, ND 58504



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Bismarck, ND 58504
P (701) 258-2833
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July 27, 2023

Apex Engineering Group
600 S 2nd St, Suite 145
Bismarck, ND 58504

Attn: Derek Anderson
P: (701) 323 3950
E: derek.anderson@apexenggroup.com

Re: Geotechnical Exploration Report
Structural Plate Pipe Replacements
IM-X-1-094(215)162, PCN 22958
Bismarck, ND
Terracon Project No. M2225065

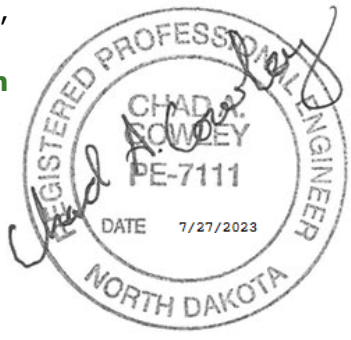
Dear Mr. Anderson:

We have completed the scope of Geotechnical Exploration services for the above referenced project in general accordance with Terracon Proposal No. PM2225065 dated February 14, 2023. This report presents the findings of the subsurface exploration for the proposed project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

Terracon



Chad A. Cowley, P.E.
Department Manager

Kate D. Staley, P.E.
Project Engineer

Attachments

Exploration and Testing Procedures

Field Exploration

Number of Borings	Approximate Boring Depth (feet)	Location
1	31	108” SPP Structure #094-162.739
1	16	84” SPP Structure #094-164.917
1	31	132” SPP Structure #094-167.314

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ±10 feet) and referencing existing site features. If elevations and a more precise boring layout are desired, we recommend borings be surveyed.

Subsurface Exploration Procedures: We advanced the borings with a track-mounted rotary drill rig using continuous flight augers. Samples were obtained at 5-foot intervals in each boring using thin-walled and split-barrel sampling procedures. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge was pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

We also observed the boreholes while drilling and at the completion of drilling for the presence of groundwater. Groundwater was not observed at these times during field exploration in the boreholes.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials observed during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following types of tests:

- Moisture Content
- Dry Unit Weight
- Atterberg Limits
- Grain Size Analysis
- Consolidated-Undrained (CU) Triaxial Testing

The laboratory testing program often included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we described and classified the soil samples in accordance with the Unified Soil Classification System.

Site Location and Exploration Plans

Contents:

Site Location Plan
Exploration Plan

Note: All attachments are one page unless noted above.

Site Location

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

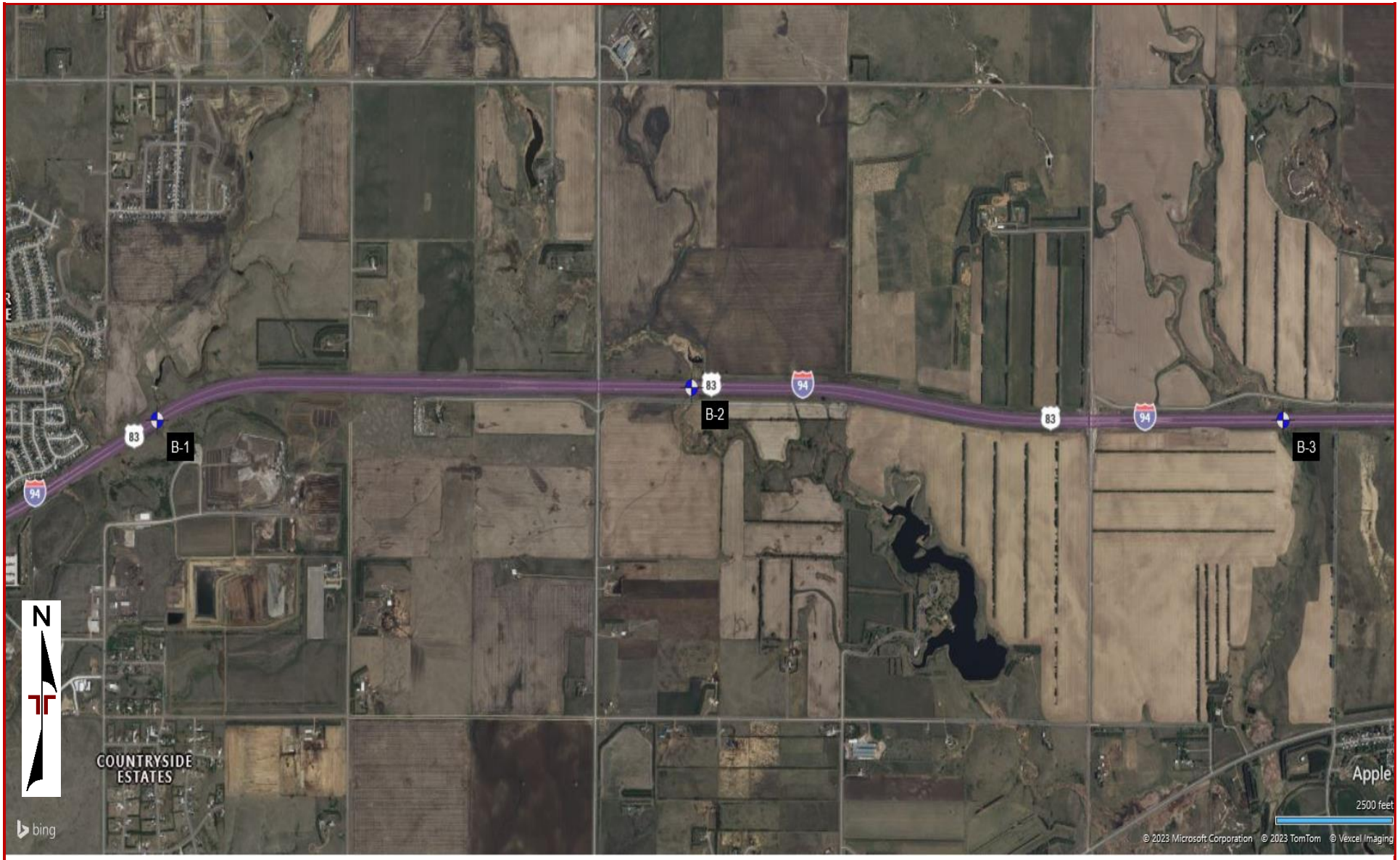


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Note: All attachments are one page unless noted above.

Structural Plate Pipe Replacements
IM-X-1-094(215)162, PCN 22958 | Bismarck, ND
Terracon Project No. M2225065

Terracon
1502 Grumman Lane, Suite 4
I PO Box 2084
Bismarck, ND

Boring Log No. B-1

Location: See Exploration Plan

Latitude: 46.8371° Longitude: -100.7052°

Graphic Log	Depth (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
	0.8	**TOPSOIL AND ROOTZONE**, dark brown							
		FILL - LEAN CLAY WITH SAND, brown, seams and layers of silty sand			4	2-3-3 N=6	12.7		
	4.0								
		SILTY SAND, fine to medium grained, brown			22		20.8	NP	24
	7.0								
		SANDY LEAN CLAY, brown, seams and layers of silty sand			18	3-6-8 N=14	26.0		
	14.0								
		SANDY LEAN CLAY (CL), brown, stiff			22			35-17-18	60
					15	4-7-5 N=12	19.2		
	24.0								
		COBBLES			0				
	26.0								
		SANDY LEAN CLAY (CL), brownish gray, very stiff, laminations of silt							
					18	4-6-10 N=16	30.0	42-14-28	54
	31.0								
		Boring Terminated at 31 Feet							

5 10 15 20 25 30

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None observed

Drill Rig
Mobile B-57

Hammer Type
Automatic

Driller
M. Roberts

Logged by
J. Hoeven

Boring Started
06-08-2023

Boring Completed
06-08-2023

Notes
Elevation Reference: Elevations not obtained
Structure #094-162.739

Advancement Method
3¼" HSA, 0-29½'

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Structural Plate Pipe Replacements
IM-X-1-094(215)162, PCN 22958 | Bismarck, ND
Terracon Project No. M2225065

Terracon
1502 Grumman Lane, Suite 4
I PO Box 2084
Bismarck, ND

Boring Log No. B-2

Location: See Exploration Plan

Latitude: 46.8385° Longitude: -100.6595°

Graphic Log	Depth (Ft.)	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
	0.8 **TOPSOIL AND ROOTZONE**, dark brown								
	FILL - SANDY LEAN CLAY (CL), brown, seams and layers of sand				8	3-3-3 N=6	17.0		
		5			5	5-8-8 N=16	17.6		
		10			26			35-14-21	54
	14.0								
	SANDY FAT CLAY (CH), brown, very stiff, laminations of silt	15			18	5-9-15 N=24	33.9	54-17-37	68
	16.0								
	Boring Terminated at 16 Feet								

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None observed

Drill Rig
Mobile B-57

Hammer Type
Automatic

Driller
M. Roberts

Logged by
J. Hoeven

Boring Started
06-08-2023

Boring Completed
06-08-2023

Notes
Elevation Reference: Elevations not obtained
Structure #094-164.917

Advancement Method
3¼" HSA, 0-14½'

Abandonment Method
Boring backfilled with auger cuttings upon completion.

Structural Plate Pipe Replacements
IM-X-1-094(215)162, PCN 22958 | Bismarck, ND
Terracon Project No. M2225065

Terracon
1502 Grumman Lane, Suite 4
I PO Box 2084
Bismarck, ND

Boring Log No. B-3

Location: See Exploration Plan

Latitude: 46.8371° Longitude: -100.6089°

Depth (Ft.)	Graphic Log	Material Description	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	Water Content (%)	Atterberg Limits LL-PL-PI	Percent Fines
0.8		**TOPSOIL AND ROOTZONE**, dark brown							
		FILL - LEAN CLAY WITH SAND, brown, mixture of clayey sand, fat clay, and lean clay							
0				X	16	2-2-2 N=4	17.6		
5				X	18	2-4-5 N=9	18.4	44-14-30	70
10				■	24				
15				X	18	14-1-3 N=4	24.8		
16.0		**LEAN CLAY WITH SAND (CL)**, brownish gray, stiff, laminations of silt and sand							
20				■	26			35-14-21	73
25				X	18	3-5-7 N=12	20.5		
29.0		**CLAYEY SAND (SC-SM)**, trace gravel, fine to coarse grained, brown							
30				■	20		16.8	31-13-18	35
31.0		***Boring Terminated at 31 Feet***							

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Water Level Observations
None observed

Drill Rig
Mobile B-57

Hammer Type
Automatic

Driller
M. Roberts

Logged by
J. Hoeven

Boring Started
06-08-2023

Boring Completed
06-08-2023

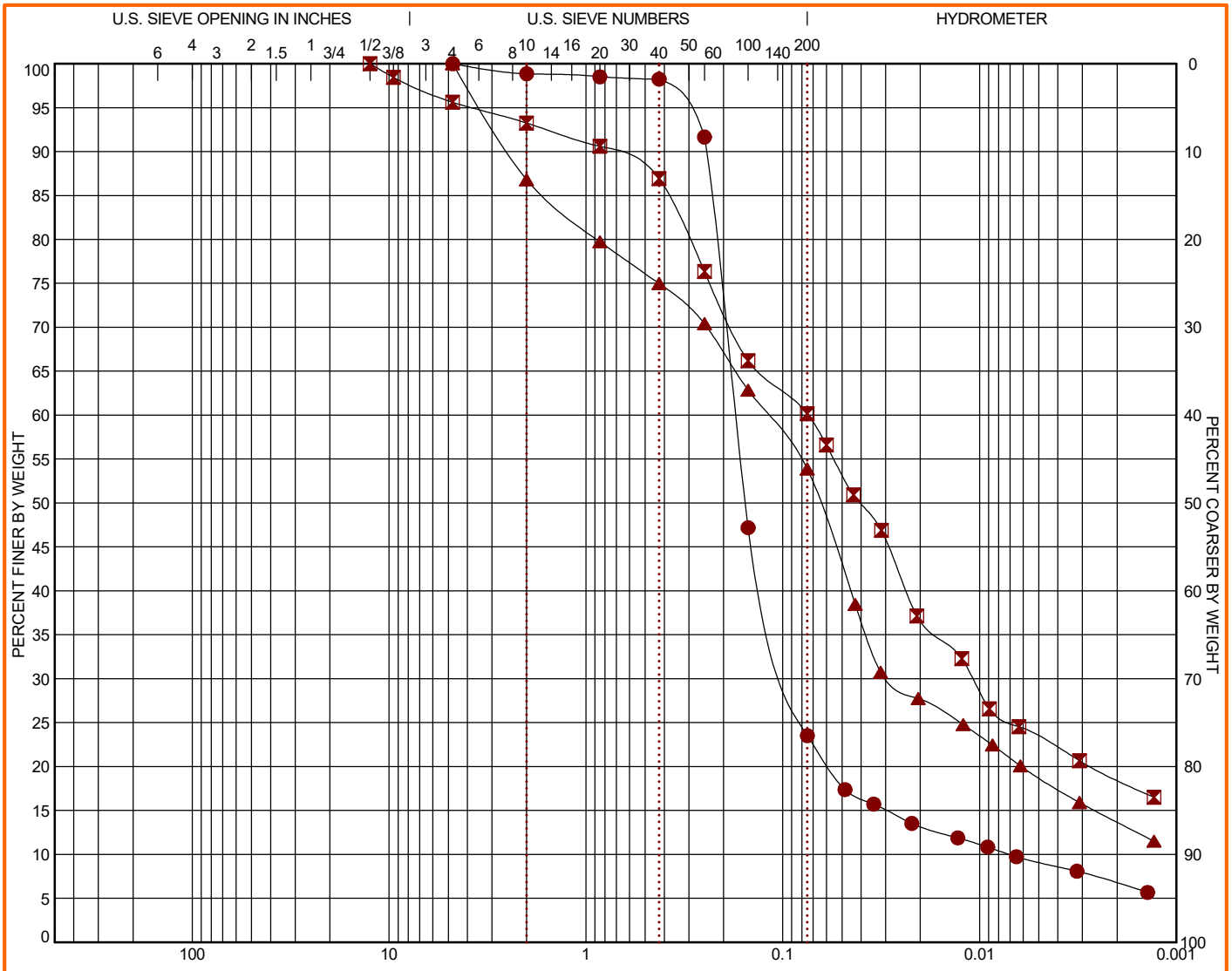
Notes
Elevation Reference: Elevations not obtained
Structure #094-167.314

Advancement Method
3¼" HSA, 0-29½'

Abandonment Method
Boring backfilled with auger cuttings upon completion.

GRAIN SIZE DISTRIBUTION

AASHTO T-88



COARSE MATERIAL	SAND		SILT OR CLAY
	coarse	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-1	4.5 - 6.5	0.0	1.1	75.3	16.8		6.7	SM
⊠	B-1	14.5 - 16.5	0.0	6.8	33.1	41.6		18.6	CL
▲	B-1	29.5 - 31	0.0	13.2	32.9	40.2		13.7	CL

GRAIN SIZE	●	⊠	▲
D_{60}	0.174	0.074	0.12
D_{30}	0.091	0.011	0.029
D_{10}	0.007		

COEFFICIENTS	●	⊠	▲
C_C	6.72		
C_U	24.68		

●		⊠		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
#4	100.0	1/2"	100.0	#4	100.0
#10	98.86	3/8"	98.44	#10	86.8
#20	98.5	#4	95.61	#20	79.73
#40	98.24	#10	93.24	#40	74.98
#60	91.65	#20	90.59	#60	70.41
#100	47.19	#40	86.93	#100	62.85
#200	23.52	#60	76.36	#200	53.88
		#100	66.2		
		#200	60.15		

SOIL DESCRIPTION	
●	A-2-4 (0)
⊠	A-6 (8)
▲	A-7-6 (11)

REMARKS	
●	
⊠	
▲	

PROJECT: Structural Plate Pipe Replacements

SITE: IM-X-1-094(215)162, PCN 22958
Bismarck, ND

Terracon
1502 Grumman Lane, Suite 4 I PO Box 2084
Bismarck, ND

PROJECT NUMBER: M2225065

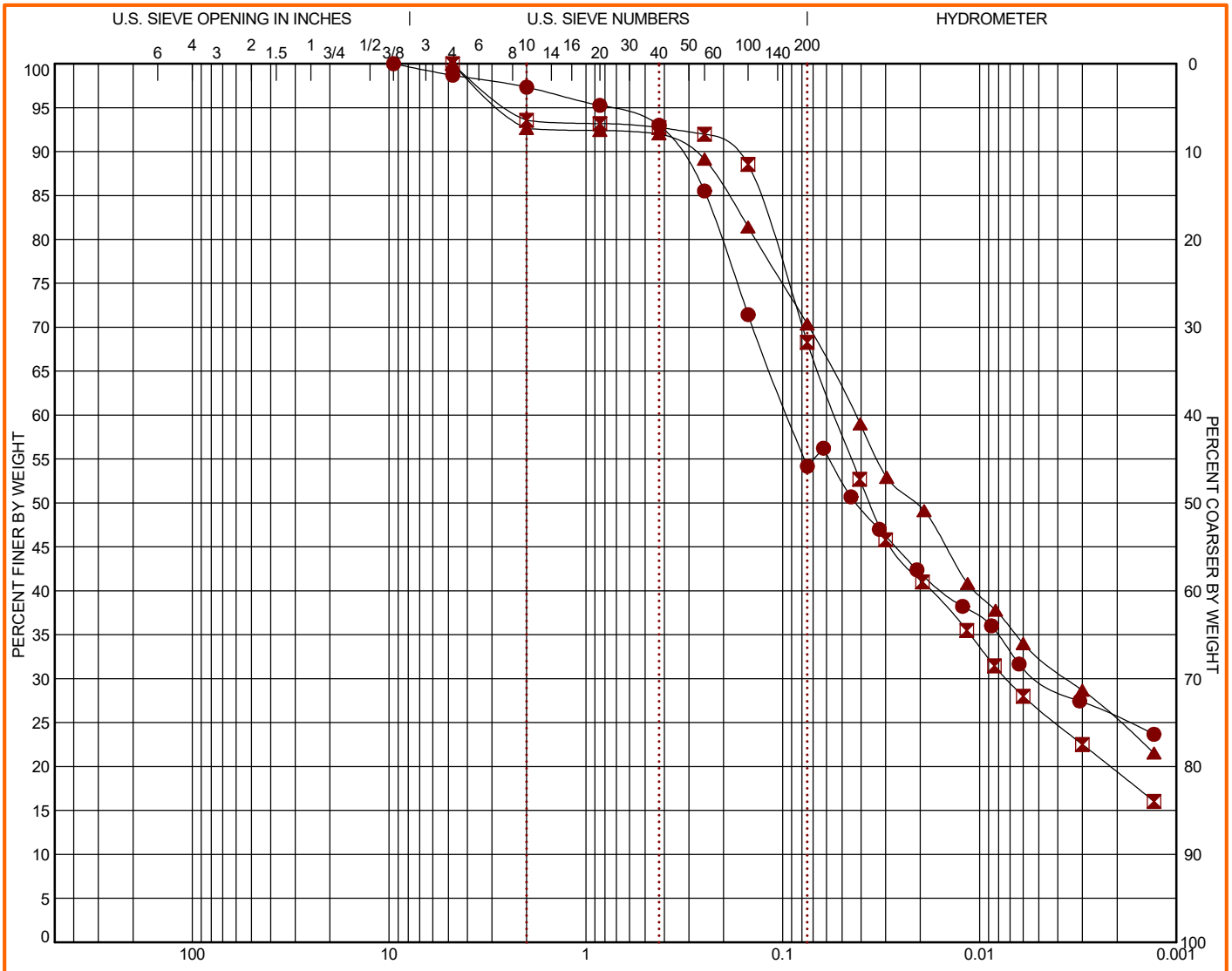
CLIENT: Apex Engineering Group
Bismarck, ND

GRAIN SIZE: AASHTO T-88 M2225065 STRUCTURAL PLATE .GPJ TERRACON_DATATEMPLATE.GDT 7/26/23

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT.

GRAIN SIZE DISTRIBUTION

AASHTO T-88



COARSE MATERIAL	SAND		SILT OR CLAY
	coarse	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-2	9.5 - 11.5	0.0	2.7	43.1	28.6		25.6	CL
⊠	B-2	14.5 - 16	0.0	6.4	25.3	48.9		19.4	CH
▲	B-3	4.5 - 6	0.0	7.4	22.3	45.1		25.2	CL

GRAIN SIZE	●	⊠	▲
D_{60}	0.077	0.054	0.043
D_{30}	0.005	0.007	0.004
D_{10}			

COEFFICIENTS	●	⊠	▲
C_C			
C_U			

●		⊠		▲	
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
3/8"	100.0	#4	100.0	#4	100.0
#4	98.69	#10	93.56	#10	92.62
#10	97.33	#20	93.17	#20	92.39
#20	95.26	#40	92.74	#40	92.01
#40	92.99	#60	91.97	#60	89.15
#60	85.51	#100	88.53	#100	81.41
#100	71.43	#200	68.29	#200	70.36
#200	54.18				

SOIL DESCRIPTION	
●	A-6 (8)
⊠	A-7-6 (23)
▲	A-7-6 (19)

REMARKS	
●	
⊠	
▲	

PROJECT: Structural Plate Pipe Replacements

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Bismarck, ND

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Bismarck, ND

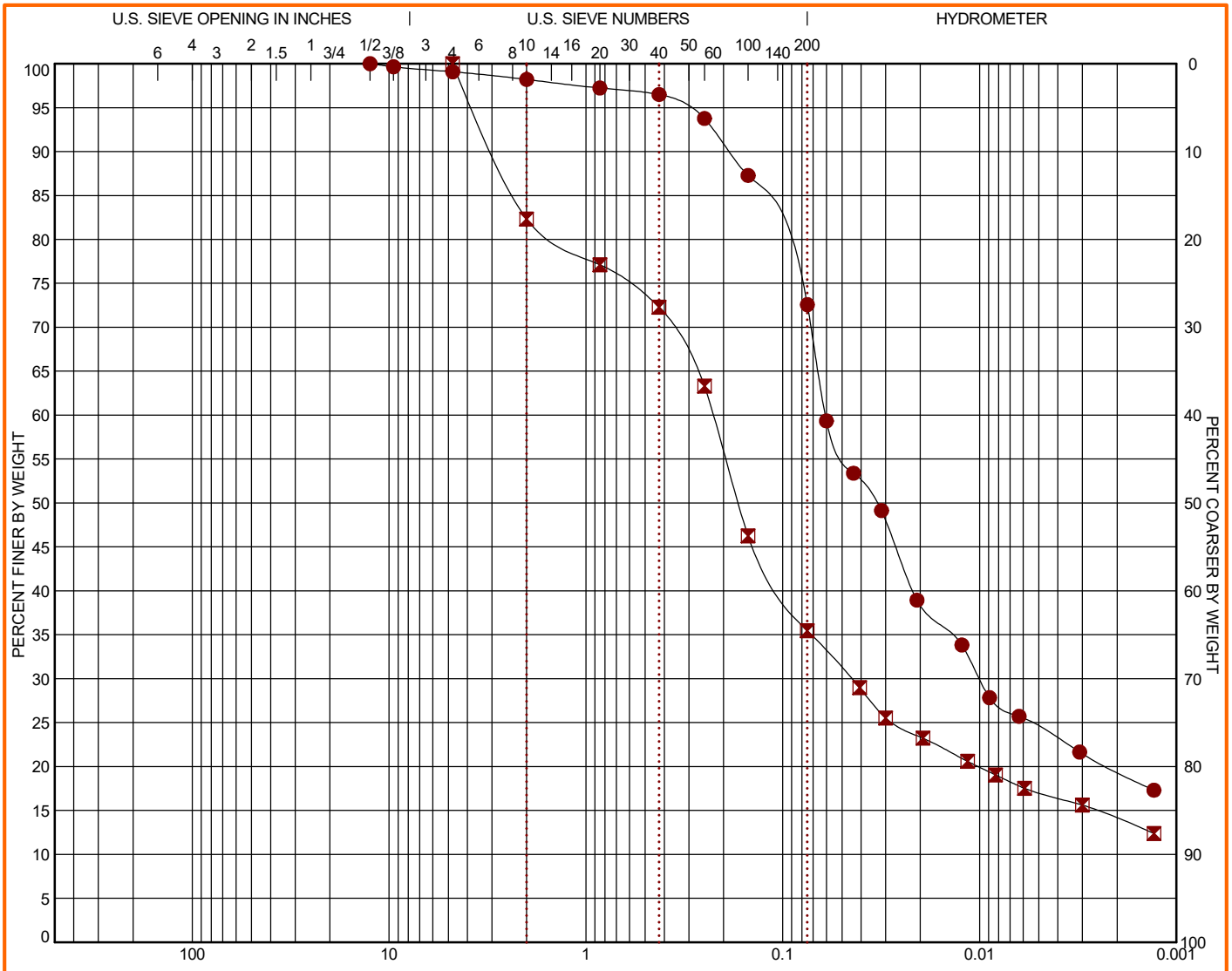
PROJECT NUMBER: M2225065

CLIENT: Apex Engineering Group
Bismarck, ND

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: AASHTO T-88 M2225065 STRUCTURAL PLATE .GPJ TERRACON_DATATEMPLATE.GDT 7/26/23

GRAIN SIZE DISTRIBUTION

AASHTO T-88



COARSE MATERIAL	SAND		SILT OR CLAY
	coarse	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	B-3	19.5 - 21.5	0.0	1.8	25.6	53.1		19.5	CL
⊠	B-3	29 - 31	0.0	17.7	46.9	21.4		14.0	SC

GRAIN SIZE	●	⊠	
D_{60}	0.061	0.226	
D_{30}	0.01	0.045	
D_{10}			

COEFFICIENTS	●	⊠	
C_C			
C_U			

●		⊠			
Sieve	% Finer	Sieve	% Finer	Sieve	% Finer
1/2"	100.0	#4	100.0		
3/8"	99.65	#10	82.31		
#4	99.08	#20	77.12		
#10	98.2	#40	72.28		
#20	97.23	#60	63.31		
#40	96.49	#100	46.26		
#60	93.77	#200	35.45		
#100	87.27				
#200	72.57				

SOIL DESCRIPTION	
●	A-6 (13)
⊠	A-2-6 (2)

REMARKS	
●	
⊠	

PROJECT: Structural Plate Pipe Replacements

SITE: IM-X-1-094(215)162, PCN 22958
Bismarck, ND

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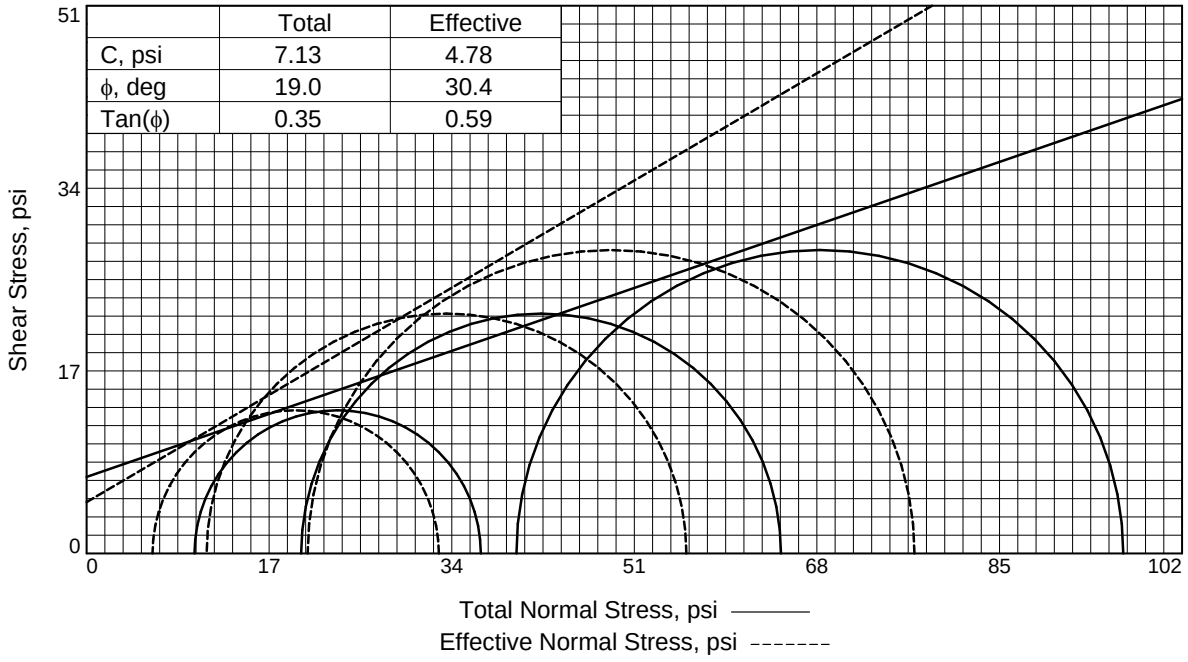
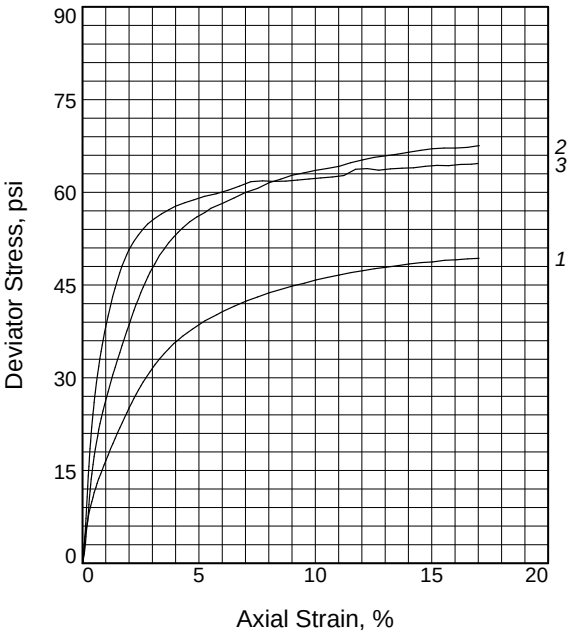
Bismarck, ND

PROJECT NUMBER: M2225065

CLIENT: Apex Engineering Group
Bismarck, ND



	Total	Effective
C, psi	7.13	4.78
ϕ, deg	19.0	30.4
Tan(ϕ)	0.35	0.59



Sample No.		1	2	3
Initial	Water Content, %	17.4	17.0	17.0
	Dry Density, pcf	109.7	110.5	109.8
	Saturation, %	87.6	87.5	85.6
	Void Ratio	0.5368	0.5253	0.5354
	Diameter, in.	1.377	1.377	1.377
	Height, in.	2.777	2.778	2.778
At Test	Water Content, %	19.8	18.7	18.4
	Dry Density, pcf	109.9	112.1	112.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5335	0.5039	0.4958
	Diameter, in.	1.376	1.371	1.365
	Height, in.	2.775	2.765	2.754
Strain rate, in./min.		0.001	0.001	0.001
Back Pressure, psi		50.0	51.0	50.0
Cell Pressure, psi		60.0	71.0	90.0
Fail. Stress, psi		26.7	44.7	56.5
Excess Pore Pr., psi		3.9	8.8	19.4
Ult. Stress, psi		48.7	67.0	64.4
Excess Pore Pr., psi		-7.6	-3.4	15.5
$\bar{\sigma}_1$ Failure, psi		32.8	55.8	77.1
$\bar{\sigma}_3$ Failure, psi		6.1	11.2	20.6

Type of Test:
CU with Pore Pressures

Sample Type: Shelby Tube

Description: CL, Dark Gray Brown Clay

Assumed Specific Gravity= 2.7

Remarks:

Figure _____

Client: Apex Engineering Group

Project: Structural Plate Pipe Replacements, IM-X-1-094(215)162, PCN 22958

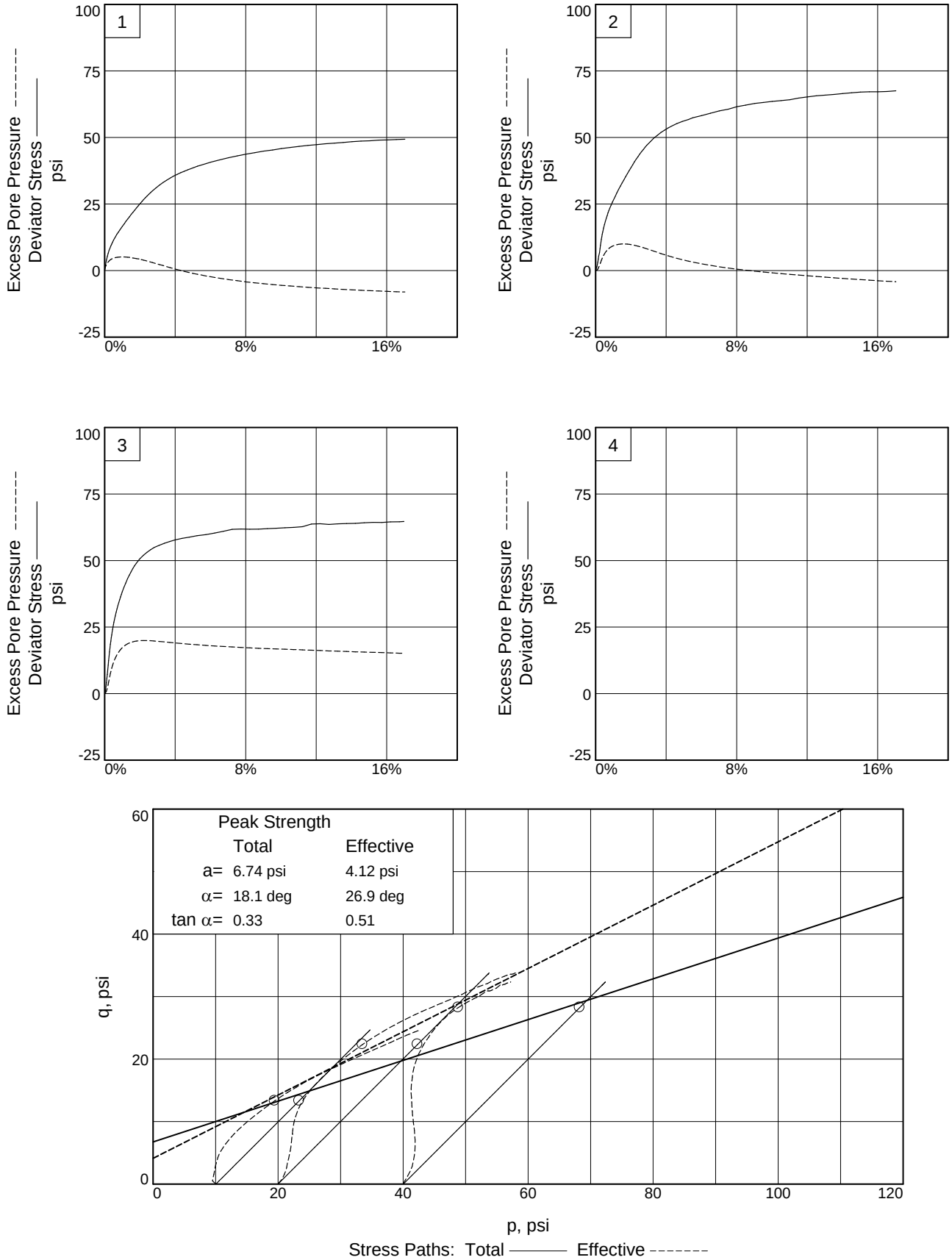
Source of Sample: B-1 **Depth:** 14.5-16.5'

Sample Number: 14

Proj. No.: M2225065 **Date Sampled:** 6/8/2023

TRIAXIAL SHEAR TEST REPORT

Terracon Consultants, Inc.
Chattanooga, TN



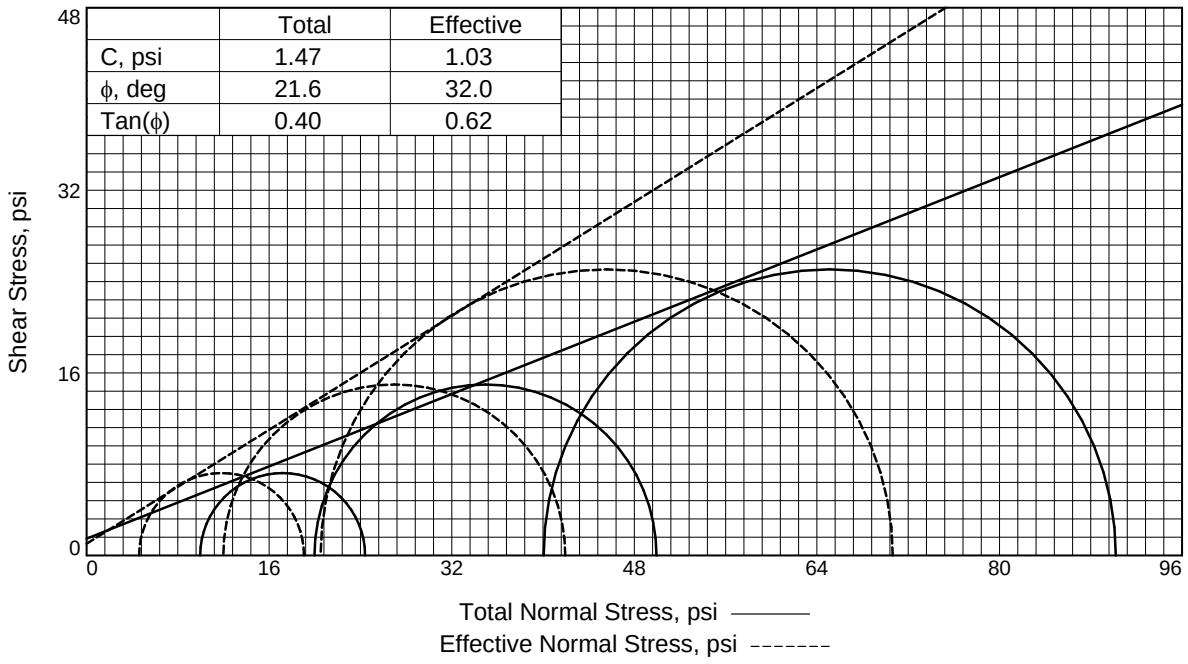
Client: Apex Engineering Group

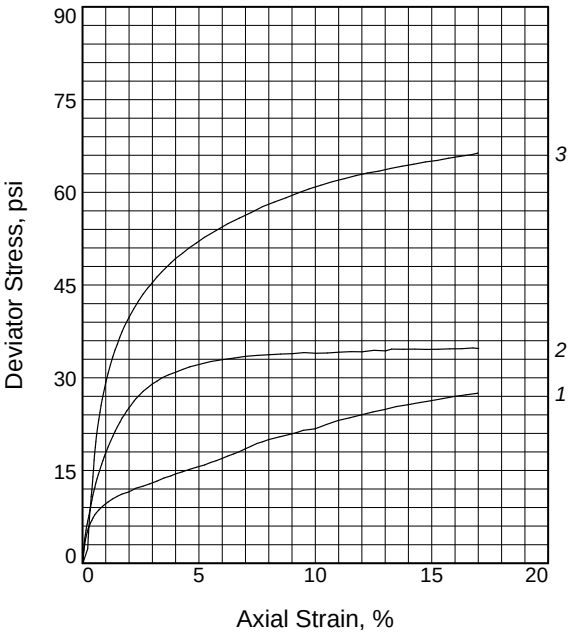
Project: Structural Plate Pipe Replacements, IM-X-1-094(215)162, PCN 22958

Source of Sample: B-1 **Depth:** 14.5-16.5' **Sample Number:** 14

Project No.: M2225065 **Figure** _____

Terracon Consultants, Inc.





Sample No.		1	2	3
Initial	Water Content, %	17.9	25.2	22.6
	Dry Density, pcf	108.9	97.8	102.6
	Saturation, %	88.2	94.0	95.2
	Void Ratio	0.5478	0.7232	0.6421
	Diameter, in.	1.368	1.375	1.413
	Height, in.	2.765	2.772	2.773
At Test	Water Content, %	19.6	26.4	21.9
	Dry Density, pcf	110.2	98.5	105.9
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5293	0.7120	0.5909
	Diameter, in.	1.363	1.372	1.398
	Height, in.	2.754	2.766	2.744
Strain rate, in./min.		0.001	0.001	0.001
Back Pressure, psi		50.0	45.0	48.0
Cell Pressure, psi		60.0	65.0	88.0
Fail. Stress, psi		14.4	30.0	50.1
Excess Pore Pr., psi		5.4	8.0	19.5
Ult. Stress, psi		26.3	34.6	65.2
Excess Pore Pr., psi		-0.3	2.8	8.9
$\bar{\sigma}_1$ Failure, psi		19.0	41.9	70.6
$\bar{\sigma}_3$ Failure, psi		4.6	12.0	20.5

Type of Test:
CU with Pore Pressures

Sample Type: Shelby Tube

Description: CL, Bluish Gray Green Black Clay with Sand and Trace of Gravel

Assumed Specific Gravity= 2.7

Remarks:

Figure _____

Client: Apex Engineering Group

Project: Structural Plate Pipe Replacements, IM-X-1-094(215)162, PCN 22958

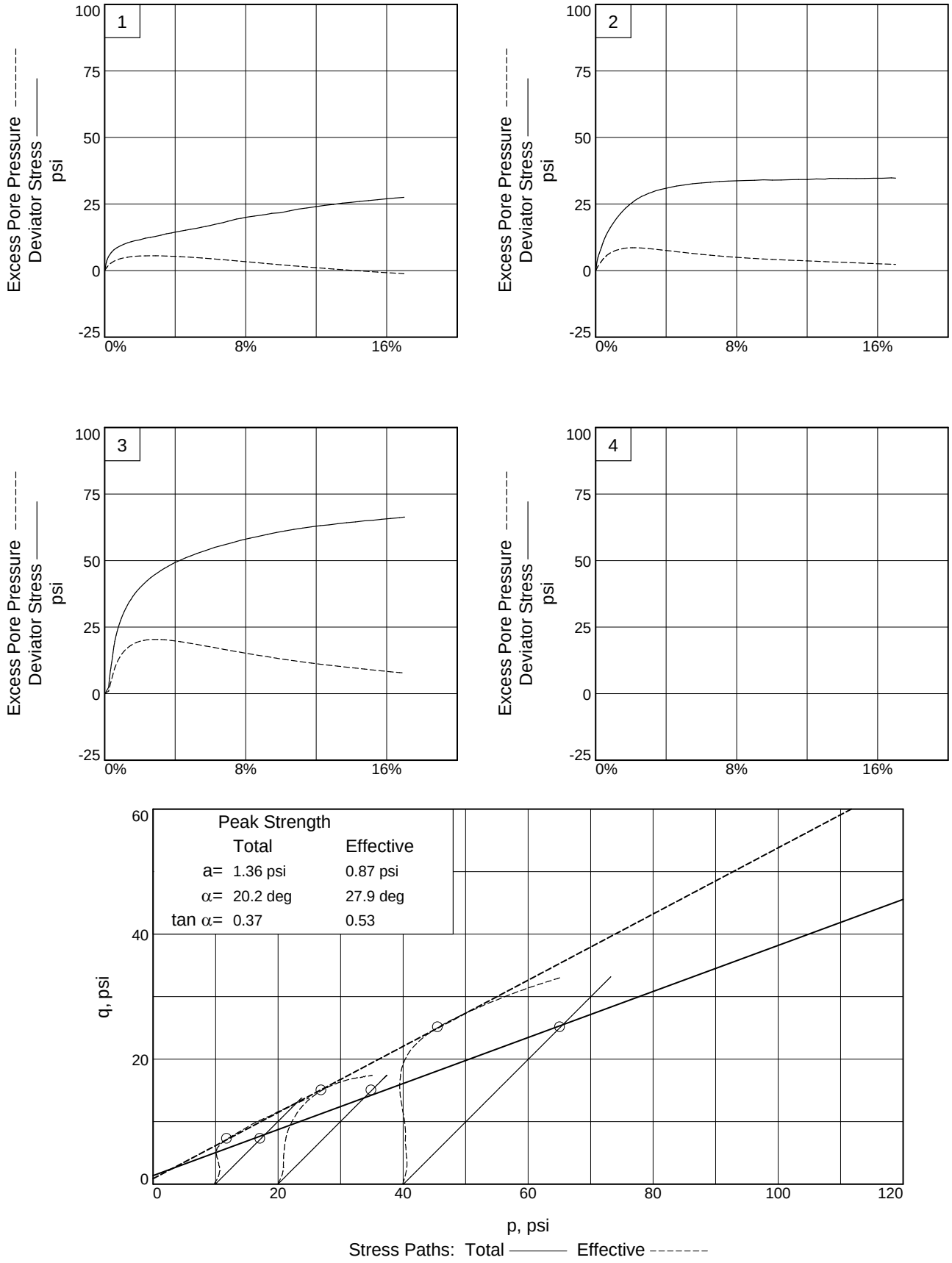
Source of Sample: B-2 **Depth:** 9.5-11.5'

Sample Number: 3

Proj. No.: M2225065 **Date Sampled:** 6/8/2023

TRIAXIAL SHEAR TEST REPORT

Terracon Consultants, Inc.
Chattanooga, TN



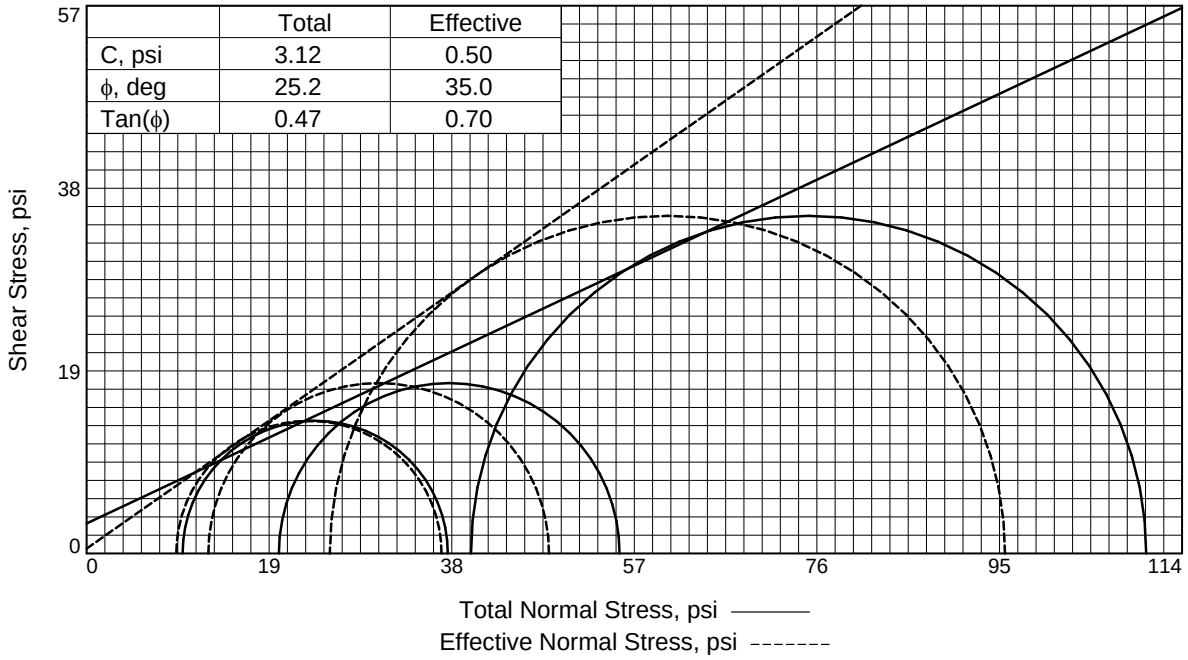
Client: Apex Engineering Group

Project: Structural Plate Pipe Replacements, IM-X-1-094(215)162, PCN 22958

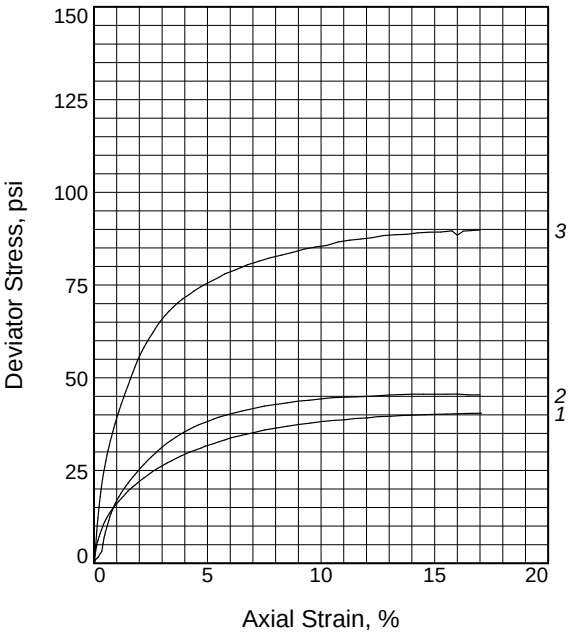
Source of Sample: B-2 **Depth:** 9.5-11.5' **Sample Number:** 3

Project No.: M2225065 **Figure** _____

Terracon Consultants, Inc.



	Total	Effective
C, psi	3.12	0.50
ϕ, deg	25.2	35.0
Tan(ϕ)	0.47	0.70



Sample No.		1	2	3
Initial	Water Content, %	21.5	20.5	17.9
	Dry Density, pcf	103.2	103.1	111.0
	Saturation, %	91.6	87.2	93.3
	Void Ratio	0.6330	0.6343	0.5179
	Diameter, in.	1.360	1.369	1.382
	Height, in.	2.776	2.778	2.774
At Test	Water Content, %	21.2	22.3	18.3
	Dry Density, pcf	107.1	105.2	112.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5735	0.6027	0.4950
	Diameter, in.	1.343	1.360	1.375
	Height, in.	2.742	2.760	2.760
Strain rate, in./min.		0.001	0.001	0.001
Back Pressure, psi		50.0	51.0	50.0
Cell Pressure, psi		60.0	71.0	90.0
Fail. Stress, psi		27.6	35.5	70.3
Excess Pore Pr., psi		0.7	7.3	14.7
Ult. Stress, psi		40.1	45.6	89.3
Excess Pore Pr., psi		-6.7	1.1	3.6
$\bar{\sigma}_1$ Failure, psi		36.9	48.1	95.6
$\bar{\sigma}_3$ Failure, psi		9.3	12.7	25.3

Type of Test:
CU with Pore Pressures

Sample Type: Shelby Tube

Description: CL, Brownish Gray Clay

Assumed Specific Gravity= 2.7

Remarks:

Figure _____

Client: Apex Engineering Group

Project: Structural Plate Pipe Replacements, IM-X-1-094(215)162, PCN 22958

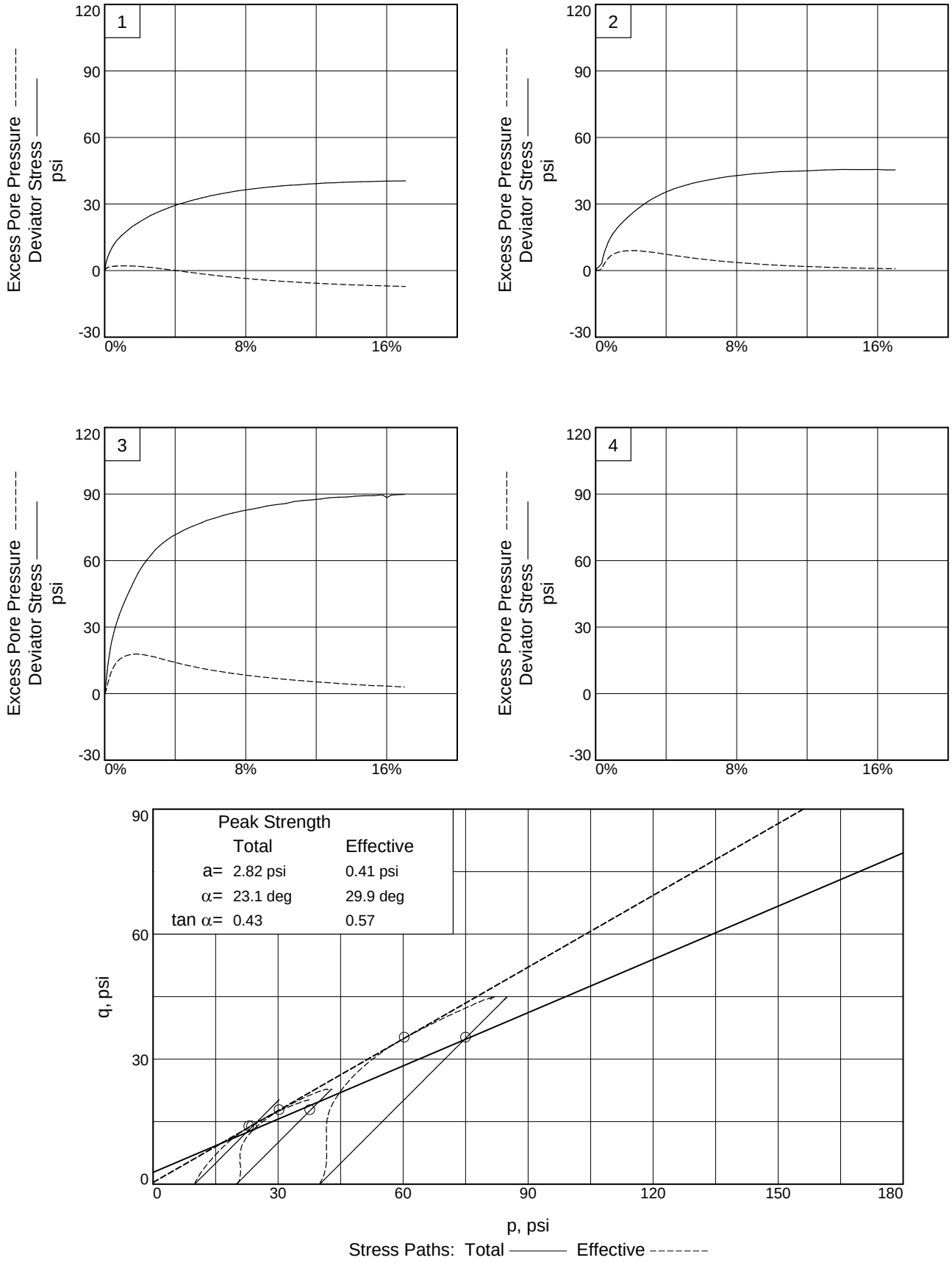
Source of Sample: B-3 **Depth:** 19.5-21.5'

Sample Number: 5

Proj. No.: M2225065 **Date Sampled:** 6/8/2023

TRIAXIAL SHEAR TEST REPORT

Terracon Consultants, Inc.
Chattanooga, TN



Client: Apex Engineering Group

Project: Structural Plate Pipe Replacements, IM-X-1-094(215)162, PCN 22958

Source of Sample: B-3 **Depth:** 19.5-21.5' **Sample Number:** 5

Project No.: M2225065 **Figure** _____

Terracon Consultants, Inc.

Supporting Information

Contents:

Note: All attachments are one page unless noted above.

Terracon
1502 Grumman Lane, Suite 4
I PO Box 2084
Bismarck, ND

General Notes

Sampling	Water Level	Field Tests
Shelby Tube Split Spoon	Water Initially Encountered Water Level After a Specified Period of Time Water Level After a Specified Period of Time Cave In Encountered Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	N Standard Penetration Test Resistance (Blows/Ft.) (HP) Hand Penetrometer (T) Torvane (DCP) Dynamic Cone Penetrometer UC Unconfined Compressive Strength (PID) Photo-Ionization Detector (OVA) Organic Vapor Analyzer

Descriptive Soil Classification

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

Location And Elevation Notes

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

Strength Terms

Relative Density of Coarse-Grained Soils (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		Consistency of Fine-Grained Soils (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Relative Density	**Standard Penetration or N-Value (Blows/Ft.)**	**Consistency**	**Unconfined Compressive Strength Qu (tsf)**	**Standard Penetration or N-Value (Blows/Ft.)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

Relevance of Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 4 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu≥4 and 1≤Cc≤3 [E]	GW	Well-graded gravel [F]
			Cu<4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu≥6 and 1≤Cc≤3 [E]	SW	Well-graded sand [I]
			Cu<6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.
[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.