FOUNDATION ANALYSIS AND DESIGN REPORT

TO: Mark Bishop, PE, Kimley-Horn and Associates, Inc.

FROM: Jeffery K. Voyen, PE, American Engineering Testing, Inc.

DATE: June 25, 2014

SUBJECT: Bridges/Walls at Glenwood Avenue and over BNSF
Southwest Light Rail Transit Project
Minneapolis, Minnesota
AET No. 01-05697.05

1.0 PROJECT INFORMATION

This report provides foundation analysis and recommendations for the east and west Glenwood Avenue bridges which will abut the bridge deck-grade light rail transit (LRT) tracks, the bridge which will carry the LRT tracks over the existing BNSF tracks to the northeast of Glenwood Avenue, and the structurally retained LRT track approaches associated with these bridges.

The Glenwood Avenue bridges will be pre-stressed concrete beam structures each having a single span. The BNSF flyover will be a post-tensioned slab bridge also having a single span. Current substructure data is presented in Table 1.0.

Table 1.0 – Bridge Substructure Data

Bridge	Substructure	Approximate Station	Bottom of Foundation Elevation
Glenwood West	West Abutment	Glenwood 7+13	812.0
	East Abutment	Glenwood 8+02	812.0
Glenwood East	West Abutment	Glenwood 8+42	812.0
	East Abutment	Glenwood 9+36	812.0
BNSF Flyover	South Abutment	LRT 2938+58	813.5
	North Abutment	LRT 2939+50	813.5

The plan and profile sheets from the preliminary bridge plans are attached to this report.

The west LRT approach to Glenwood will begin at LRT Station 2925+71. The approach will rise to meet the Glenwood deck at elevation 850.68 feet (a height of about 29 feet). The retained tracks will then continue to the BNSF flyover bridge at approximate elevation 851.4 feet. Shorter wing walls will extend off the north side of the BNSF bridge, as grade substantially rises to Royalston Avenue. The approaches are planned to remain as retained embankments rather than a continuing bridge structure for crash wall need reasons. The approaches will be contained within parallel retaining walls, which will have a face-to-face width of about 30 feet. Bottom of foundations are assumed to be 4.5 feet deeper than current grade for frost cover.

Wing walls will extend off of the Glenwood Avenue bridges for approach roadway support. The placement of the new abutments is such that new fill loads will not be imposed on the approach soils supporting the Glenwood Avenue roadway.

2.0 SUBSURFACE EXPLORATION SUMMARY

2.1 Field Exploration Scope

The exploratory test program performed and included in this report consisted of the following:

- Glenwood Bridges: Borings 1021 SB, 1158 SB, 1159 SB, with 1136 SW a little to the west (LRT approach area).
- BNSF Bridge: Borings 1008 SB, 1204 SB.
- West LRT Approach: Borings 1134 SW to 1136 SW and CPTs 1160 CW to 1164 CW.

The locations of the above listed borings and CPTs appear on attached Figure 1.

2.2 Laboratory Scope

During laboratory classification logging, water content tests were conducted on cohesive soil samples. In addition, the following tests were performed:

- two consolidation tests
- thirty-one unconfined compression tests with density
- seven Atterberg Limits tests
- one density test with water content
- two organic content tests

The consolidation test results appear on the data sheets following the boring logs. The remaining tests appear on the individual boring logs, opposite the samples upon which they were performed.

2.3 Methods

2.3.1 Standard Penetration Test Borings

Logs of the above noted borings are attached. The SPT borings were drilled with 3.25 inch diameter hollow stem augers and mud rotary drilling methods. Standard penetration test samples were taken with split-barrel samplers per ASTM: D1586, with the exception that the hammers were calibrated to near N_{60} values, consistent with MnDOT requirements. Additional details of the methods used appear on the attached sheet entitled *Exploration/Classification Methods*.

The soils were classified per the Unified Soil Classification System, although the Soil Group category per the AASHTO Soil Classification System is also noted. The attached boring logs contain information concerning soil layering, soil classification, geologic description, and moisture condition. Relative density or consistency is also noted for the natural soils, which is based on the standard penetration resistance (N-value).

2.3.2 Piezocone Penetration Test Soundings

CPT_u testing was conducted in general accordance with ASTM:D5778; with the user notes, abbreviations, and definitions appearing on the attachment *Cone Penetration Test Index Sheet.*

Field and laboratory testing is done in general conformance with the described procedures. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

2.4 Conditions Present

2.4.1 Bedrock Type and Depth

The top of bedrock elevation varies significantly across the area of the two bridges. The greatest elevation range lies across the Glenwood bridge where top of bedrock ranges from a low of 730.8 feet at Boring 1158 SB (west abutment area) to 800.9 feet at Boring 1021 SB (east abutment area). From Boring 1021 SB, the top of bedrock again lowers to the north towards Royalston Avenue, defined by Boring 1008 SB to the north of the BNSF Flyover north abutment. The bedrock continues to lower to the west in the west retained LRT approach area, as Boring B1135 extended to elevation 695.6 feet (126 feet deep) without encountering bedrock.

The bedrock profile in the area consists of dolostone (dolomitic limestone) of the Platteville Formation over a relatively thin layer of shale of the Glenwood Formation over sandstone of the St. Peter Formation. As seen by Boring 1159 SB, the contact elevation between the shale and sandstone is about 795½ feet. The top of rock in most of the area is below elevation 795½ feet such that the dolostone and shale formations are absent. The dolostone only remained at Boring 1021 SB (top at about elevation 801 feet).

2.4.2 Overburden Soils

The site is geologically in the vicinity of the Bassett Creek valley which includes deep deposits of alluvial fat to lean clays. In much of the geologic valley, the clays are normally consolidated (i.e., have not been over-consolidated and are therefore soft). In some (mainly lower) areas of the valley, upper zones of the clay can be stiffer; in this case appearing to be due to desiccation. However, in most of this area of the Bassett Creek valley, the clays are consistently stiff to full depth, based on N-values on the order of 9 to 15. This is consistent with the higher ground to the north along Royalston, where stiff clays are again present to even greater depths. The clays in this area appear to be stiff and overconsolidated due to past overburden loads (whether soil or glacial ice).

In the western end of the west retained wall approach, the clays do become considerably softer, as evidenced by the soft clay conditions portrayed by Boring 1134 SW and CPT 1160 CW. These clay conditions represent the normally consolidated case (i.e., didn't experience the

overburden loads that the clays further east experienced). In addition, several feet of organic clay/boglime swamp deposits appear over the soft clays in this area.

Soils beneath the Bassett Creek clays include alluvial sands to silty sands and glacially-deposited tills (mainly clayey sands and sandy lean clays). These soils include varying amounts of gravel and have the potential to include cobbles/boulders. Alluvial clays and silts also appear beneath the sands and tills, which are overconsolidated. In areas, colluvium may be present above the bedrock which exhibit high gravel content and possible cobbles/boulders.

Fill is present above the natural soils, with thicknesses in the range of 8 feet to 29 feet. Thicker fills are associated with the raised Glenwood Avenue roadway embankment. The fill is predominantly granular, with some clayey sands and sandy lean clays. The fill occasionally includes debris and appears to have some cobbles. The N-values suggest moderate to high levels of compaction.

2.5 Ground Water

Ground-water levels were encountered at varying levels during drilling operations. The levels shown at most locations do not appear to represent the true hydrostatic ground-water case. Shallower levels appear caused by water perching above slow draining layers. Others were short term measurements which were not provided sufficient time to rise and stabilize. Boring 1158 SB does provide a reasonable indication of the apparent steady-state level, not at the level measured before penetrating the clay layer, but by the moisture condition of the sand samples below. The sands were moist to a depth of about 48 feet, then they became waterbearing, corresponding to an elevation of around 800 feet. This is generally consistent with levels present at the Interchange project (also in the Bassett Creek valley). It is also anticipated that the levels may rise to the north. Water levels are expected to fluctuate both seasonally and annually.

3.0 FOUNDATION ANALYSIS

3.1 Foundation Analysis

3.1.1 Foundation Type

Due to the varying depth to bedrock, both CIP steel pipe pile and H-pile are appropriate for consideration and use in this area.

Bedrock is quite deep in the retained wall west approach area. Where bedrock is deep, it is preferred to gain pile capacity through a combination of end bearing and side skin friction. The use of 12-inch diameter CIP steel pipe pile is commonly used and was the pile type analyzed. Per normal MnDOT limits, this pile can be designed for a Factored Pile Bearing Resistance value (φR_n) of up to 100 tons, assuming a pile wall thickness of 0.250 inches.

In the two bridge areas, including the raised retained wall between the bridges and the small wing/retaining walls to the north and east, the bedrock is sufficiently shallow, such that H-pile is

more appropriate. This report analyzed HP12x53, although alternate H-piles sizes can also be considered. Per normal MnDOT limits, HP12x53 can be designed for a Factored Pile Bearing Resistance value (φR_n) of up to 140 tons.

Bedrock is relatively shallow near the east abutment for the East Glenwood Avenue bridge. Based on the bottom of abutment footing elevation at 811 feet, the pile lengths would be on the order of 12 feet to 16 feet deep if Boring 1021 SB was representative of the conditions at the abutment location. However, the borings needed to be drilled away from the abutment (in the retained approach area) such that deeper bedrock is expected at the abutment. Piles are normally required to be driven at least 10 feet. It may be possible to consider using spread foundations for the east approach retaining walls, although some soil correction would be required to remove the alluvial fat clays where present below foundation grade and replace them with granular engineered fill. At this time, this report only addresses pile support of all bridge and wall foundations.

3.1.2 Pile Foundation Analysis Methods

Pile bearing resistance versus pile length where SPT borings were performed was analyzed using *DRIVEN* software (FHWA). This program uses the Nordlund method for granular soils and the Tomlinson method for cohesive soils. The granular soil internal friction angle used was based on its relationship to standard penetration test values as presented by Peck, Hanson, and Thorburn (1974), with the N-values being corrected for the influence of the effective overburden pressure. For cohesive soils, we estimated undrained shear strength based on correlations with the SPT data. The "ultimate capacity" determined from this *DRIVEN* analysis is considered the Nominal Resistance of Single Pile in Axial Compression (R_n) using LRFD terminology.

Pile bearing resistance versus pile length for the west approach area where CPT_u soundings were performed was analyzed using direct input of the CPT data. The data was analyzed using the computer program *UniPile5.0* (UniSoft), following the Eslami and Fellenius pile resistance method.

3.1.3 Analysis Results

The nominal resistance (ultimate capacity) needed to be demonstrated in the field depends on the Resistance Factor allowed by the "Condition/Resistance Determination Method" used. A Resistance Factor (φ) of 0.65 can be used when dynamic analysis is employed. Differing Resistance Factors are used for differing pile types when the field evaluation is based on the MPF12 driving formula (MnDOT's new formula), as follows:

- For H-pile, use a Resistance Factor (φ) of 0.60
- For steel pipe pile, use a Resistance Factor (φ) of 0.50

Where steel pipe pile is used, we recommend using dynamic analysis for pile evaluation. In the case of 12-inch diameter steel pipe pile designed for φR_n of 100 tons, a nominal resistance of 308

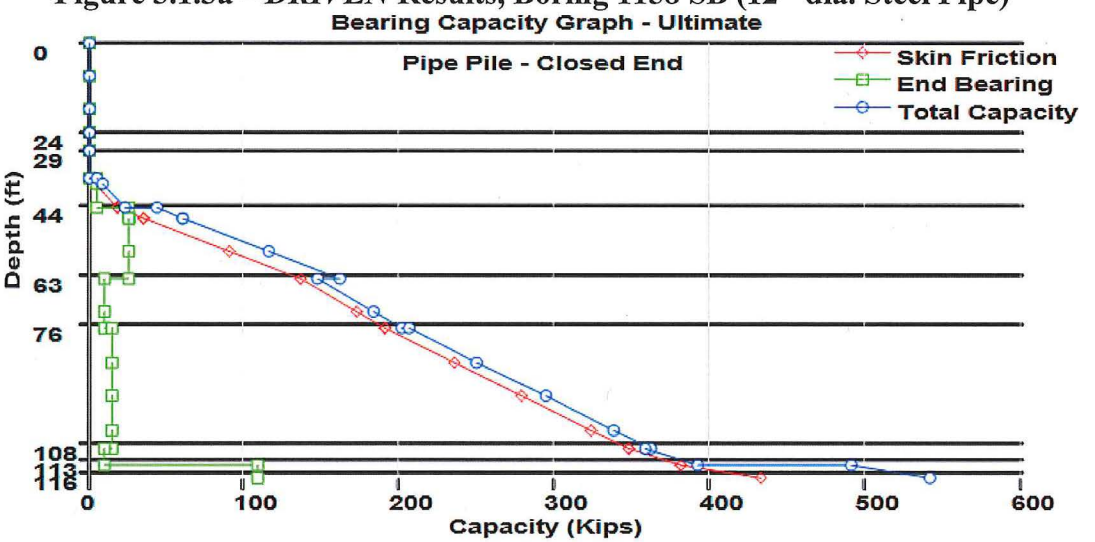
kips would then need to be demonstrated.

Where H-pile is used, either the MPF12 driving formula or dynamic analysis could be used; although dynamic analysis allows for better evaluation of whether or not pile damage is occurring. In the case of HP12x53 pile designed for φR_n of 140 tons, a nominal resistance of 431 kips (PDA verification) or 467 kips (MPF12 verification) would then need to be demonstrated.

The *DRIVEN* results indicate the stated nominal resistance values will not be achieved until reaching bedrock for most of the borings in the bridge area (1008 SB and 1204 SB at BNSF flyover and 1021 SB, 1159 SB, and 1136 SW at Glenwood). At Boring 1158 SB located at the Glenwood west abutment, the H-pile was shown to achieve resistance very close to the bedrock (and in reality will likely need to be driven to bedrock). If 12-inch diameter CIP steel pipe pile were to be used at 1158 SB, the analysis shows resistance would be met about 20 feet above the bedrock (elevation 750 feet).

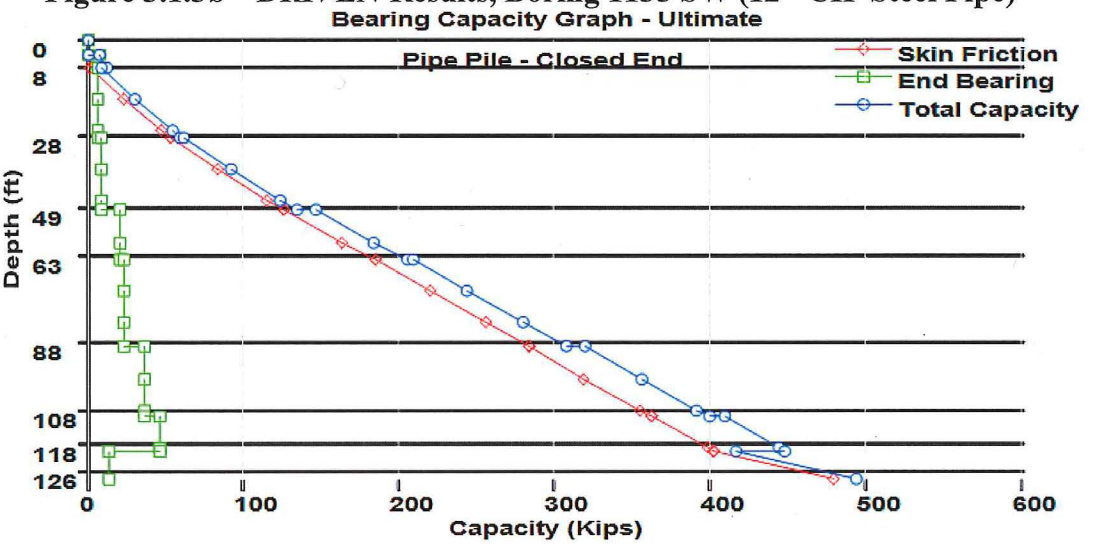
The *DRIVEN* results for 12-inch diameter CIP steel pipe pile at the Glenwood West west abutment, based on Boring 1158 SB is shown on the following figure:

Figure 3.1.3a – *DRIVEN* Results, Boring 1158 SB (12" dia. Steel Pipe)



Boring 1135 SW located in the retained wall LRT west approach to Glenwood Avenue was also analyzed for 12-inch diameter CIP steel pipe pile using *DRIVEN*. This analysis indicates a pile length (below a 4.5-foot deep footing) to be about 84 feet for a nominal resistance of 308 kips (tip elevation of about 733 feet).

Figure 3.1.3b – *DRIVEN* Results, Boring 1135 SW (12" CIP Steel Pipe)



The results of the *UniPile 5.0* analysis conducted using the CPT data in the LRT retained wall west approach area is shown on Figures 2 to 6 (included as attachments). As shown, a few of the CPT_u soundings did not extend deep enough to fully evaluate required pile lengths. However, CPT_u Nos. 1161 CW, 1163 CW, and 1164 CW did extend to depths allowing length evaluation, and show tip elevations in the vicinity of 735 feet, generally consistent with that demonstrated at Boring 1135 SW using *DRIVEN*. CPT 1165 CW terminated in highly resistant material around elevation 750 feet, which is likely the sandstone bedrock (or close to the bedrock), considering the shallower bedrock found at Boring 1136 SW (at about 760 feet).

3.1.4 Estimated Pile Lengths

The 12-inch diameter steel pipe pile lengths predicted by the computer analyses in order to attain a nominal resistance of 308 kips is shown in Table 3.1.4a. This assumes a design φR_n = 100 tons and the use of dynamic analysis for the field evaluation method (allowing φ = 0.65).

Table 3.1.4a – Estimated Pile Lengths, 12" dia. Steel Pipe

Bridge/Wall	Boring/CPT No.	Assumed Bottom of Footing Elevation, ft	Estimated Tip Elevation, ft	Estimated Pile Length, ft
Glenwood West, West Abutment	1158 SB	812	733	79
LRT Retained Wall West Approach	1161 CW	816	735	81
	1135 SW	816	733	83
	1163 CW	816	735	81
	1164 CW	816	735	81
	1165 CW	816	749	67
	1136 SW	816	759	57

The HP 12x53 pile lengths estimated based on depth to bedrock in order to attain a nominal resistance of 467 kips is shown in Table 3.1.4b. This assumes a design φR_n = 140 tons and the use of the MnDOT MPF12 formula for the field evaluation method (allowing φ = 0.60). However, it is anticipated that other H-pile sizes and nominal resistance needs would terminate at a similar depth since resistance is substantially gained from tip resistance on the bedrock.

Table 3.1.4b – Estimated Pile Lengths, HP12x53 Pile

Bridge/Wall	Substructure	Boring/CPT No.	Proposed Bottom of Footing Elevation, ft	Estimated Tip Elevation, ft	Estimated Pile Length, ft
BNSF Flyover	North Abutment	1008 SB	813.5	744½	69
	South Abutment	1204 SB	813.5	763	51
Glenwood - West	West Abutment	1158 SB	812.0	731	81
	East Abutment	*1136 SW	812.0	759	53
Glenwood - East	West Abutment	*1136 SW	812.0	759	53
	East Abutment	1021 SB	812.0	800	12
		1159 SB	812.0	796	16

*located to southwest of foundation

3.2 Retained Approach Embankment Settlement Review

The proposed west approach to Glenwood Avenue will raise grade by a maximum of about 29 feet, and it will be about 30 feet wide. The high approach will continue from the Glenwood Avenue bridges to the BNSF flyover bridge. Our analysis shows that settlements on the order of 6 inches to 8 inches would occur if the embankments were not supported on piles. Surcharging will not be possible due to space limitations, and even is space were available, the time rate of settlement would be very slow.

Even if the wall foundations were supported on piles and the interior fill were allowed to be supported on-grade, excessive settlements would be expected and downdrag (DD) loads would develop on the piles. It would be possible to use geofoam as the interior fill to control settlement and avoid DD loads, although a significant amount of geofoam would be needed. Although this could be analyzed further during advanced design (if desired), we are recommending that a continuous footing be placed below and between the walls, such that the walls and interior fill would be completely supported on the pile supported continuous foundation. Geofoam could still be used to reduce the loads that the piles would need to carry, although it will likely be more cost effective to support mineral fill with additional piles than using geofoam.

4.0 FOUNDATION RECOMMENDATIONS

The bridge structures should be supported on H-piles which are driven to the bedrock. Because the bedrock significantly lowers in the area of west abutment for the West Glenwood Avenue bridge, 12-inch diameter steel pipe pile could be considered for this particular substructure.

We recommend the use of the 12-inch diameter steel pipe pile for the west retained wall approach to Glenwood Avenue. The remaining retaining walls should be supported on the H-pile. In those areas where new retained fill load is imposed in areas which have not experienced those higher fill loads in the past, we recommend the new fill be supported upon a pile supported foundation.

4.1 H-Pile Foundation Support

Although HP12x53 was analyzed, it should be possible to support the bridge on alternate H-pile sizes as well. H-piles should meet ASTM A572, Grade 50 (f_y = 50 ksi). The piles should be equipped with rock points. The piles can be designed based on the following maximum Factored Pile Bearing Resistance (φR_n) values:

- HP10x42: 110 tons
- HP12x53: 140 tons
- HP14x73: 190 tons
- HP14x89: 225 tons.

The nominal resistance of the piles can be evaluated using either high strain dynamic (PDA) testing or the MnDOT MPF12 driving formula. The dynamic testing should meet the minimum requirements listed in Section 10.5.5 of the *AASHTO LRFD Bridge Design Specifications, 2012.* This approach includes Quality Control of non-tested pile by calibrated wave equation analyses. Resistance Factors of 0.65 or 0.60 should be employed for PDA or MPF12 field analysis methods, respectively. It is anticipated that all H-piles sizes would establish required resistance with "refusal" upon the bedrock. Estimated tip elevations are shown in Table 3.1.4b.

With the qualification that any new approach fill is supported on a pile supported foundation, it is our opinion that down drag (DD) loads do not need to be considered in the design.

A reduction factor for group effects does not need to be applied provided the pile arrangement maintains a center-to-center spacing of 3 times the flange length.

All foundations should have five or more piles for redundancy purposes. With five or more piles, a reduction factor for a lack of redundancy does not need to be applied.

Boulders or rock slabs may potentially be present within the profile. If pile penetration appears to be obstructed at abnormally variable depths (due to apparent boulders/slabs), additional pile and foundation review may be needed.

4.1 12-inch Diameter CIP Steel Pipe Pile

The west approach retained wall foundations can be supported with 12-inch diameter CIP steel pipe piles. This pile type could also be used for the west abutment for the West Glenwood Avenue bridge (in lieu of H-pile). The piles can be designed based on a Factored Pile Bearing Resistance (φR_n) value of up to 100 tons. The pipe piles should have a minimum yield strength (f_y) of 45 ksi and a minimum wall thickness of 0.250 inches. The pipe should be driven with a flat plate welded to the pile tip (closed end). The plate should have a minimum thickness of 0.75 inches and a diameter no greater than the pile diameter. The pipe piles should be inspected and concrete filled in accordance with MnDOT Specification 2452.D6. The minimum compressive strength of the concrete should be 3000 psi at 28-days.

The nominal resistance of the piles should be evaluated using high strain dynamic (PDA) testing, which will allow the Resistance Factor of 0.65. The dynamic testing should meet the minimum requirements listed in Section 10.5.5 of the *AASHTO LRFD Bridge Design Specifications, 2012.* This approach includes Quality Control of non-tested pile by calibrated wave equation analyses.

We refer you to previous Table 3.1.4a for the pile lengths predicted to achieve a nominal resistance of 308 kips. The pile lengths shown are based on the varying analysis methods discussed with assumed soil parameters, and the soil layer variations make accurate pile length predictions difficult. It is common for actual pile resistance to differ from the theoretical

resistance. The actual pile lengths must be confirmed at the time of driving, and lengths may be more or less than that shown.

If piles do not achieve the required resistance at desired depths, pile driving can be stopped and time can be given to allow pile "set-up" to occur. The increase in resistance can then be rechecked with a re-strike on the following day.

With the qualification that any new approach fill is supported on a pile supported foundation, it is our opinion that down drag (DD) loads do not need to be considered in the design.

A reduction factor for group effects does not need to be applied provided the pile arrangement maintains a center-to-center spacing of 3 times the diameter.

All foundations should have five or more piles for redundancy purposes. With five or more piles, a reduction factor for a lack of redundancy does not need to be applied.

Boulders or rock slabs may potentially be present within the profile. If pile penetration appears to be obstructed at abnormally variable depths (due to apparent boulders/slabs), additional pile and foundation review may be needed.

4.2 Abutment/Wingwall Backfilling

The imbalanced abutment walls and retaining walls must be designed to resist the lateral pressures exerted. Where lightweight fill is not used, the backfill material should consist of Select Granular Borrow (MnDOT 3149.2B2), which is modified to containing less than 10% by weight passing the #200 sieve. Typical "Select Granular Borrow 10% Modified" geometry is shown on attached MnDOT *Diagram F-1*. However, all excavation backsloping must also meet OSHA requirements. For proper track and roadway approach performance, frost tapering of the Select Granular Borrow over frost susceptible soils should be maintained at no steeper than 1V:20H within the frost zone (assume a frost zone of 4.5 feet). The backfill should be compacted per the Specified Density Method (MnDOT 2105.3F1).

The use of lightweight fill can significantly reduce lateral loads on the wall. These loads can be provided as the design develops.

4.3 Approach Fill

Approach fill, including sideslope fill, shall be placed and compacted per MnDOT Standard Specification 2105, using the Specified Density Method. Frost zone sand tapering shall be applied per Section 4.2.

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under Minnesota Statute Section 326.02 to 326.15

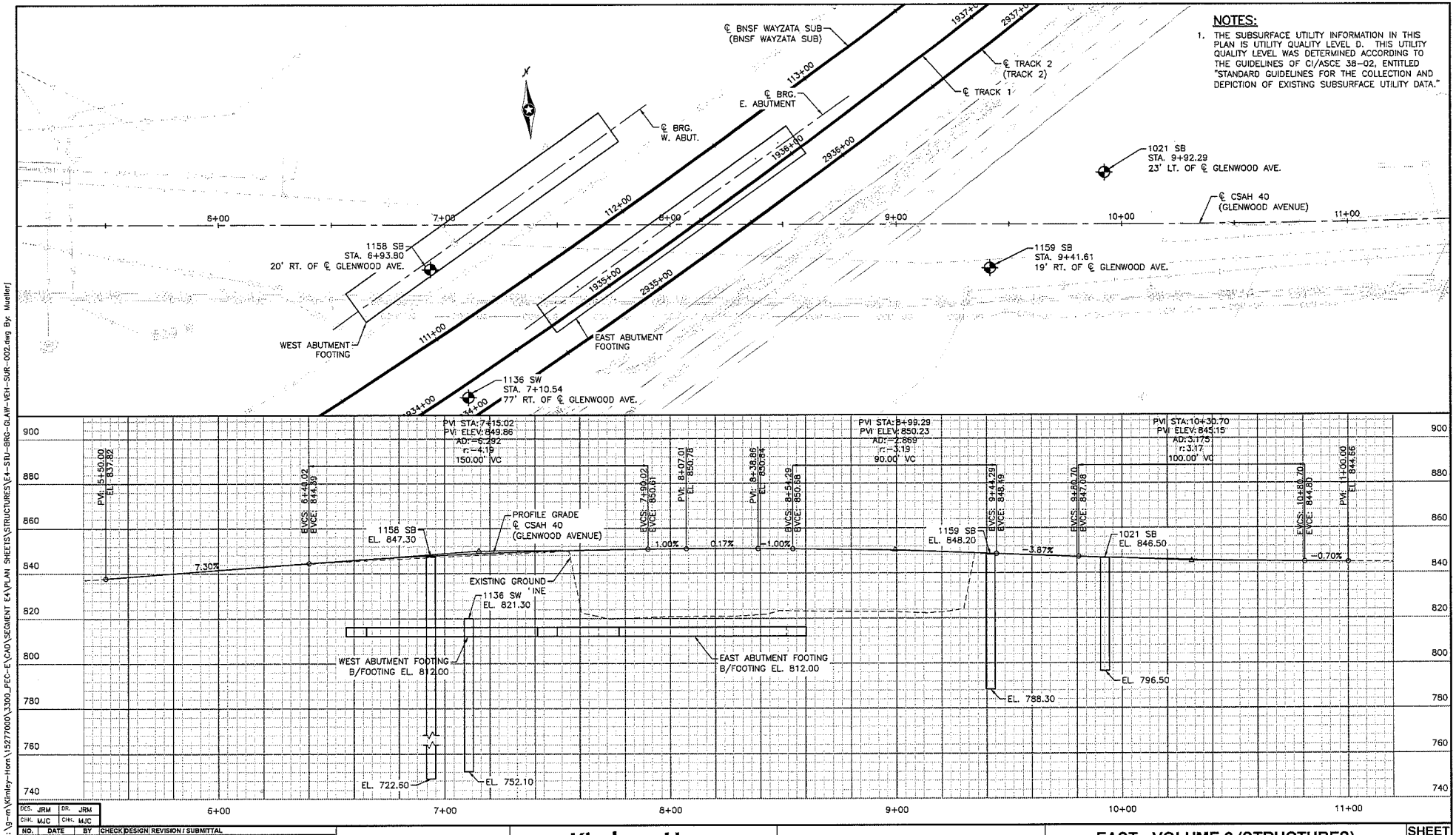
Name: Jeffery K. Voyen
Jeffery K. Voyen

Date: 6/25/14 **License #: 15928**

Report Reviewed By: Joseph G. Bentler
Joseph G. Bentler, PE, Senior Geotechnical Engineer

Attachments:

- Preliminary Bridge Plan-Profile Sheets
- Figure 1 – Boring/CPT Locations
- Subsurface Boring Logs
- Cone Penetration Test Logs
- Consolidation Test Results
- Figure 2 to 6 – UniPile 5.0 Analyses, CPTs 1160 CW to 1164 CW
- Exploration/Classification Methods
- Boring Log Notes
- Unified Soil Classification System
- AASHTO Soil Classification System
- Cone Penetration Test Index Sheet
- MnDOT Diagram F-1



NOTES:

1. THE SUBSURFACE UTILITY INFORMATION IN THIS PLAN IS UTILITY QUALITY LEVEL D. THIS UTILITY QUALITY LEVEL WAS DETERMINED ACCORDING TO THE GUIDELINES OF CI/ASCE 38-02, ENTITLED "STANDARD GUIDELINES FOR THE COLLECTION AND DEPICTION OF EXISTING SUBSURFACE UTILITY DATA."

DES.	JRM	DR.	JRM
CHK.	MJC	CHK.	MJC

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

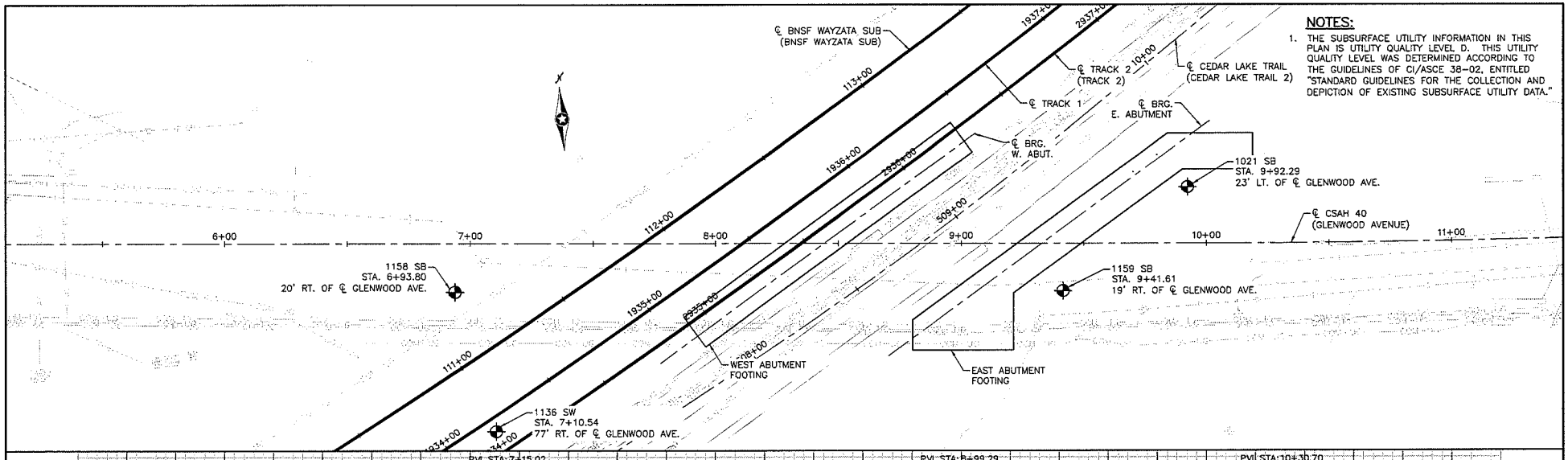
Kimley»Horn
TKDA
PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL
SOUTHWEST Green Line LRT Extension

EAST - VOLUME 2 (STRUCTURES)
CSAH 40 (GLENWOOD AVENUE) - WEST
BRIDGE XXXXX (VEH)
BORINGS (1 OF 3)

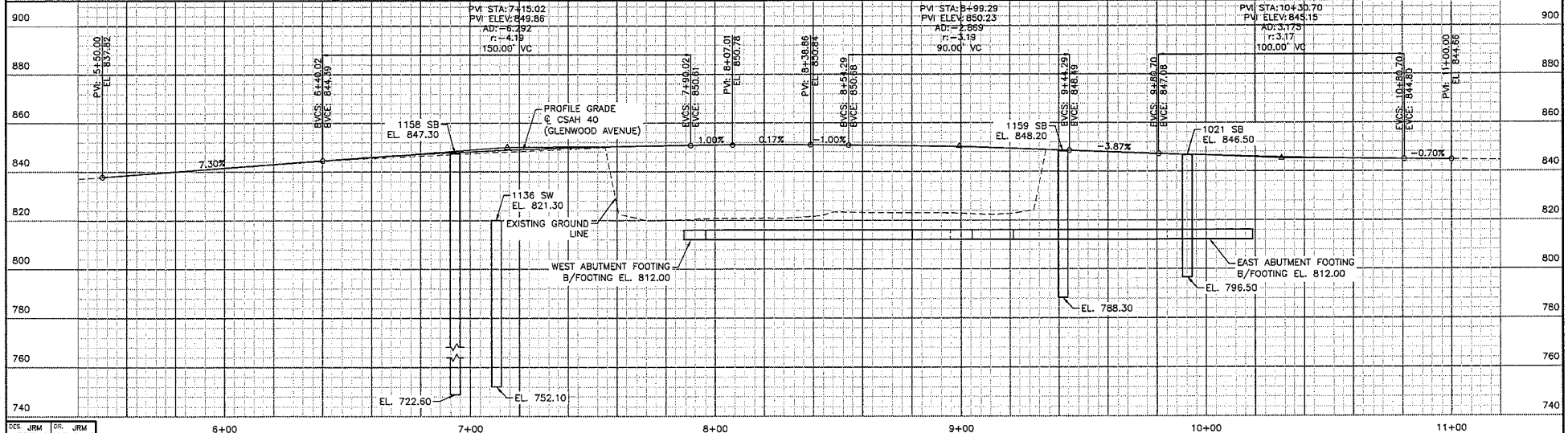
DISCIPLINE: STRUCTURES
SHEET NAME: E4-STU-BRG-GLAW-VEH-SUR-002

SHEET 158 OF 277



NOTES:

1. THE SUBSURFACE UTILITY INFORMATION IN THIS PLAN IS UTILITY QUALITY LEVEL D. THIS UTILITY QUALITY LEVEL WAS DETERMINED ACCORDING TO THE GUIDELINES OF CI/ASCE 38-02, ENTITLED "STANDARD GUIDELINES FOR THE COLLECTION AND DEPICTION OF EXISTING SUBSURFACE UTILITY DATA."



DES.	JRM	DR.	JRM
CHK.	MJC	CHK.	MJC

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

Kimley»Horn

TKDA

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

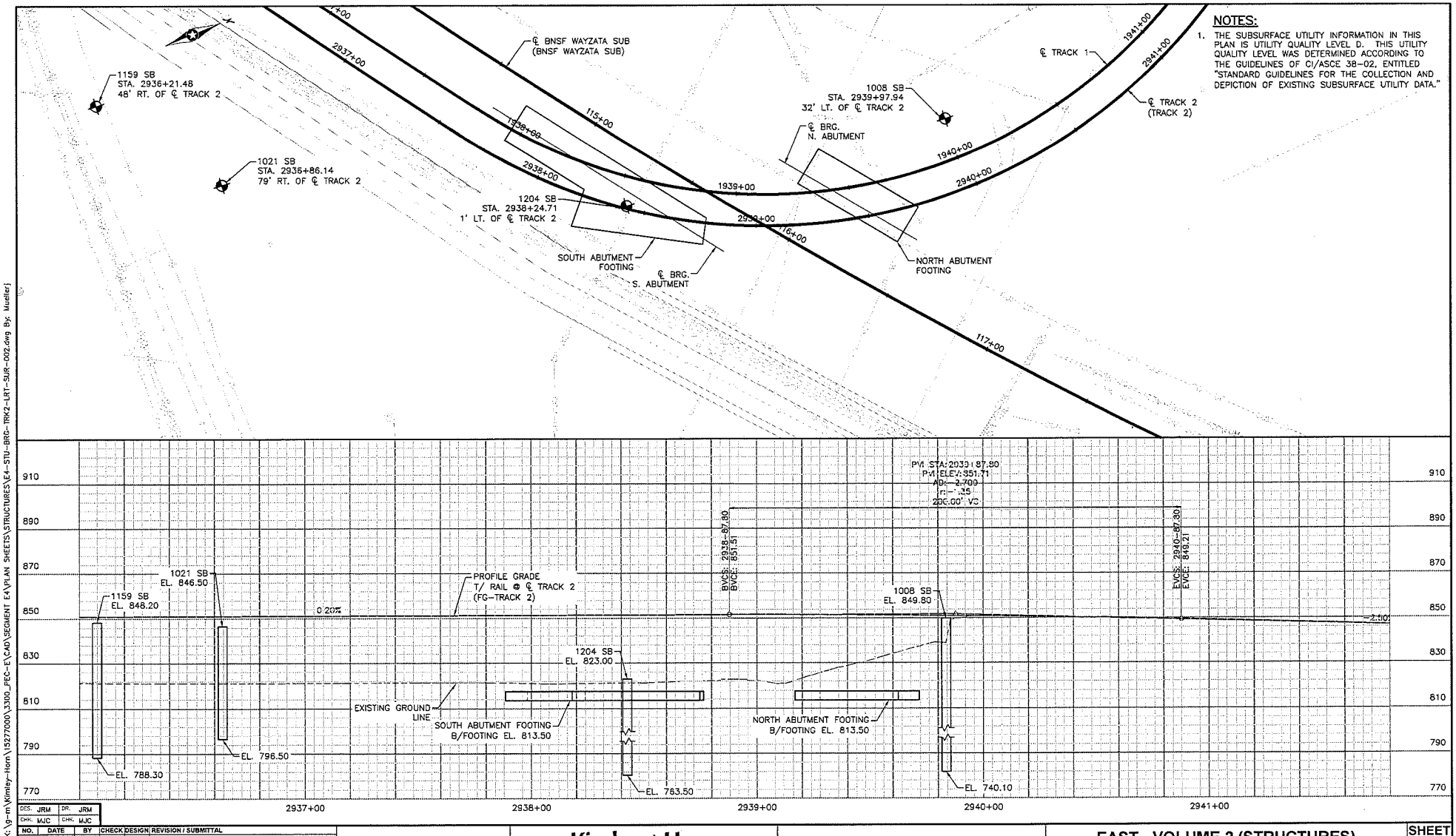
EAST - VOLUME 2 (STRUCTURES)
CSAH 40 (GLENWOOD AVENUE) - EAST
BRIDGE XXXXX (VEH)
BORINGS (1 OF 3)

DISCIPLINE: STRUCTURES

SHEET NAME: E4-STU-BRG-GLAE-VEH-SUR-002

SHEET 165 OF 277

Jun. 20 2014 11:52 am K:\g-m\Kimley-Horn\152770001\3300_PEC-E\CAD\SEGMENT E4\PLAN SHEETS\STRUCTURES\E4-STU-BRG-GLAE-VEH-SUR-002.dwg By: Mueller



NOTES:

1. THE SUBSURFACE UTILITY INFORMATION IN THIS PLAN IS UTILITY QUALITY LEVEL D. THIS UTILITY QUALITY LEVEL WAS DETERMINED ACCORDING TO THE GUIDELINES OF CI/ASCE 38-02, ENTITLED "STANDARD GUIDELINES FOR THE COLLECTION AND DEPICTION OF EXISTING SUBSURFACE UTILITY DATA."

DES. JRM | DR. JRM
CHK. MJC | CHK. MJC

NO.	DATE	BY	CHECK	DESIGN	REVISION / SUBMITTAL

Kimley»Horn
TKDA

PRELIMINARY ENGINEERING

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

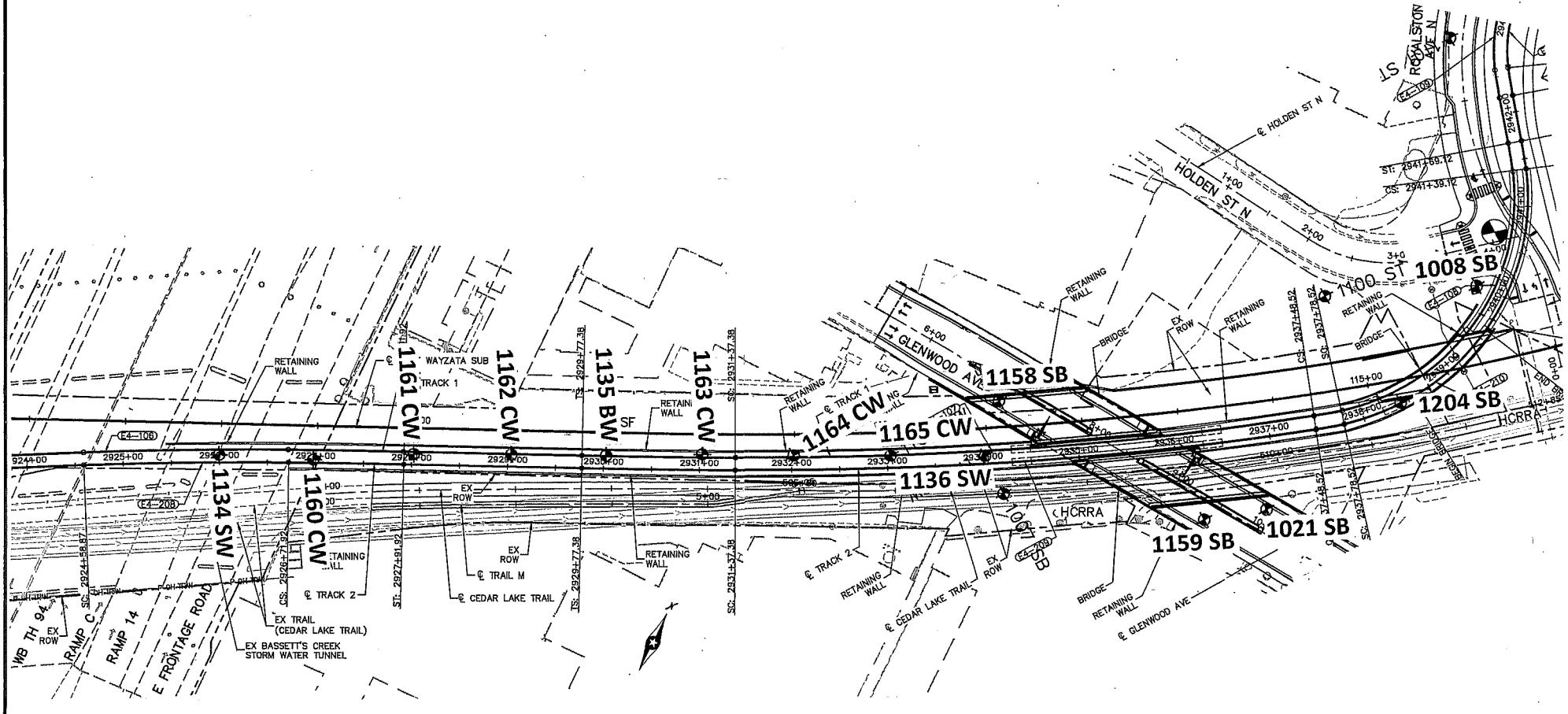
EAST - VOLUME 2 (STRUCTURES)
LRT OVER BNSF TRACK
BRIDGE XXXXX (LRT)
BORINGS (1 OF 3)

DISCIPLINE: STRUCTURES

SHEET NAME: E4-STU-BRG-TRK2-LRT-SUR-002

SHEET 172 OF 277

Jun. 20 2014 12:00 pm K:\g-rm\Kimley-Horn\152770001\3300_PEC-E\CAD\SEGMENT E4\PLAN SHEETS\STRUCTURES\E4-STU-BRG-TRK2-LRT-SUR-002.dwg By: Mueller



AMERICAN ENGINEERING TESTING, INC.	**PROJECT** LRT Glenwood Ave/BNSF Flyover Bridges		**AET NO.** 01-05697.05
	SUBJECT Boring/CPT Locations		**DATE** June 17, 2014
	SCALE 1" = 160'±	**PREPARED BY** KHA/JV	**FIGURE 1**

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Glenwood Avenue	**Southwest LRT, PEC East**	**1008 SB**	**849.8** *(Surveyed)*

Location **, , ft. LT**

Co. Coordinate: X=526064 Y=168850 (ft.)

Latitude (North)=44.9798966 Longitude (West)=-93.2826164

Drill Machine **91C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed **4/5/13**

DEPTH / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
0		Clayey sand, a little gravel, sandy lean clay, silty sand and sand, pieces of concrete, brick, bituminous and mortar, trace roots, dark brown, a little black, brown and light gray (A-6) fill		5	14				Hammer Calibration: 68% efficiency with 110 lb. hammer, 5/27/14
				9	8				
5				21	12				
				13	12				
10				14	12				
11.5 / 838.3		Mixture of sand with silt and sand, a little gravel, brown and grayish brown (A-3, A-1-b) fill		16					
15				9					
				7					
19.0 / 830.8		SAND WITH SILT, fine to medium grained, grayish brown, a little brown, moist, loose (SP-SM) (A-3) alluvium or fill		8					
20									
21.5 / 828.3		SAND, a little gravel, medium to fine grained, light brown, a little brown, moist, medium dense (SP) (A-1-b) alluvium or fill		15					
24.0 / 825.8									
25		LEAN CLAY, brownish gray, a little grayish brown and gray, stiff (CL) (A-7-6) alluvium		11	23				LL=42%, PL=17%, PI=25%
				12	24				
30					25	1670	129		
				11	24				LL=44%, PL=17%, PI=27%
34.0 / 815.8		LEAN CLAY, brownish gray, lenses and laminations of silty sand (CL) (A-7-6) alluvium			24	1950	129		
35				10	24				
37.0 / 812.8		LEAN CLAY, dark brownish gray, a little brownish gray and brown, stiff, laminations of silt and silty sand (CL) (A-7-6) alluvium			23	1840	129		
40				12	23				
44.0 / 805.8		FAT CLAY, brownish gray, a little light brown (CH/CL) (A-7-6) alluvium			25	2560	126		
45				15					
48.0 / 801.8									No recovery
50									

Index Sheet Code

(Continued Next Page)

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Glenwood Avenue	**Southwest LRT, PEC East**	**1008 SB**	**849.8** *(Surveyed)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
55			FAT CLAY, dark brownish gray to dark grayish brown, a little light tan and gray, stiff, laminations of silt (CH) (A-7-6) alluvium *(continued)*		14	31 33	1200	121		LL=71%, PL=22%, PI=49%
60					13	25				
	63.0 786.8									
65			SANDY LEAN CLAY, a little gravel, brownish gray, stiff (CL) (A-6) till		15	19				
	67.5 782.3									
70			LEAN CLAY WITH SAND, brownish gray, very stiff (CL) (A-6) till		18	22				
	73.0 776.8									
75			CLAYEY SAND WITH GRAVEL, grayish brown, very stiff (SC) (A-6) till		19	14				
▼	78.0 771.8									Water level measured at 77.2' deep with HSA to 79.5' deep (rose from 78.7' deep 10 minutes earlier)
80			SANDY LEAN CLAY, grayish brown, very stiff (CL) (A-6) till		23	21				
	83.0 766.8									
85			LEAN CLAY, grayish brown, stiff to very stiff (CL) (A-6) alluvium		14	23				
90				PD	16	21				
	93.0 756.8			PD						
95			SILTY SAND, possible cobbles, fine to medium grained, grayish brown, wet, dense (SM) (A-2-4) alluvium		44					
	98.0 751.8			PD						
100	100.0		GRAVEL WITH SAND, gray, waterbearing (GP) (A-1-b) till or colluvium							

(Continued Next Page)

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

SHEET 3 of 3

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Glenwood Avenue	**Southwest LRT, PEC East**	**1008 SB**	**849.8** (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
	749.8		CLAYEY SAND, a little gravel, apparent cobbles, grayish brown, very stiff (SC) (A-6) till and colluvium		25	17				
105	105.0 744.8		Top of Bedrock	PD						ST. PETER FORMATION
110			SANDSTONE, weathered to fresh, light gray		50/.4					
115				PD						
	119.6 730.2		END OF BORING		60/.1					

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Glenwood Avenue	**Southwest LRT, PEC East**	**1021 SB**	**846.5** *(Surveyed)*

Location **, , ft. LT**

Co. Coordinate: X=525969 Y=168543 (ft.)

Latitude (North)=44.9790550 *Longitude (West)=-93.2829849*

Drill Machine **41C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 1

Drilling Completed **10/2/13**

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
	1.0		11.5" Bituminous pavement							Hammer Calibration: 68% efficiency with 101 lb. hammer, 9/27/13
	845.5		Sand with silt and gravel, pieces of concrete and wood (A-1-b) fill		*					*10/.5 + 13/.5
	4.0				27					
5	842.5		Sand with silt, a little gravel, pieces of concrete, brown (A-1-b) fill		35					
	6.5									
	840.0		Sand with silt, a little gravel and clayey sand, a piece of wood around 15', brown, a little black (A-1-b) fill		26					
10					25					
					18					
15					25					
					25					
	19.0									
	827.5		Sand with gravel, light brown (A-1-b) fill		9					
20										
▼					8					Water level measured at 22.8' deep with SS to 23.5' deep
	24.0									
	822.5		Mixture of organic clay and clayey sand, pieces of brick and glass, trace roots, black and brown (A-6) fill		6	31				
25	26.5									
	820.0		LEAN CLAY, brown and gray mottled, a little brown, firm, laminations of sand (CL) (A-7-6) alluvium		5	33				
	29.0									
	817.5		FAT CLAY, dark grayish brown, a little light grayish brown, laminations of silt (CH) (A-7-6) alluvium			40	760	113		
30	32.0									
	814.5		FAT CLAY, gray to grayish brown, a little light grayish brown, stiff to very stiff, laminations of silt (CH) (A-7-6) alluvium		10					LL=87%, PL=24%, PI=63%
35						37	1140	116		
	38.0									
	808.5		SAND WITH SILT, a little gravel, brown, a little grayish brown, moist, medium dense, lenses of clayey sand (SM) (A-2-4) alluvium		19	41				
	39.0									
40	807.5		SILTY SAND WITH GRAVEL, fine to medium grained, brown, a little light brown, moist, medium dense, a lens of sand (SM) (A-2-4) alluvium		15					
	42.0									
	804.5				53					
	44.0		GRAVELLY SAND WITH SILT, fine to medium grained, brown, moist, very dense (SP-SM) (A-1-b) alluvium							
45	802.5				**					**4/.5 + 75/.5 + 50/.1
	45.6		SAND WITH SILT AND GRAVEL, fine to medium grained, light brown, moist, very dense (SP-SM) (A-1-b) alluvium							PLATTEVILLE FORMATION
	800.9		Top of Bedrock		70					
	50.0		DOLOSTONE, weathered, light brown		100/.1					
50	796.5		**END OF BORING - HSA Obstructed**							

Index Sheet Code

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Retaining Wall	**Southwest LRT, PEC East**	**1134 SW**	**821.8** (Surveyed)

Location , , **ft. LT**

Co. Coordinate: X=524955 Y=168125 (ft.)

Latitude (North)=44.9779120 Longitude (West)=-93.2869051

Drill Machine **1C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 1

Drilling Completed **11/22/13**

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
5	6.5 815.3		Silty sand with organic fines, a little gravel, sand with silt and clayey sand, pieces of rubber, concrete and coal, black and brown (A-2-4) fill		16 10 16					Hammer Calibration: 66% efficiency with 105-lb. hammer, 9/18/13
	9.0 812.8		Lean clay, a little sand and organic clay, light brownish gray, a little brown and black (A-6) fill		8	29				
10	10.0 811.8		ORGANIC CLAY, trace shells, dark brown, a little light gray, soft, laminations of silt (OH) (A-6) swamp deposits BOGLIME, light gray (OH) (A-4) swamp deposits		3	50 56				Organic Content = 6.6% Organic Content = 1.3%
	11.5 810.3		FAT CLAY, trace roots, brownish gray, a little brown, very soft, laminations of silt (CH) (A-7-6) alluvium		WH	56				
15	16.5 805.3					50	165	107		
					WH	43				LL=77%, PL=21%, PI=56%
20						68	300	102		
					WH	70				
25			FAT CLAY, brownish gray and grayish brown, a little light grayish brown, very soft, laminations of silt (CH) (A-7-6) alluvium			75		96		
					WH	90				LL=91%, PL=25%, PI=66%
30						79	405	98		
	34.0				WH	74				
35	787.8 37.0		FAT CLAY, dark brownish gray, a little gray, a lens of sand below 36' (CH) (A-7-6) alluvium			70	350	99		
	784.8 39.0		SILTY SAND, fine grained, dark brownish gray, wet, very loose (SM) (A-2-4) alluvium		WH					
40	782.8 41.5		SAND WITH SILT, fine grained, brownish gray, a little dark gray, waterbearing, very loose (SP-SM) (A-3) alluvium		4					
	780.3 44.0		SAND, fine to medium grained, light brown and gray, waterbearing, medium dense (SP) (A-3) alluvium		11					
45	777.8				19					
			SAND, a little gravel, medium to fine grained, light brown, waterbearing, medium dense to dense (SP) (A-1-b) alluvium		30					
50	51.0				40					
	770.8		END OF BORING							

Index Sheet Code

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Retaining Wall	**Southwest LRT, PEC East**	**1135 SW**	**821.6** *(Surveyed)*

Location **, , ft. LT**
Co. Coordinate: X=525320 Y=168296 (ft.)
Latitude (North)=44.9783797 Longitude (West)=-93.2854939

Drill Machine **85C**
Hammer **CME Automatic Calibrated**

SHEET 1 of 3
Drilling Completed **11/25/13**

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60}	MC (%)	COH (psf)	γ (pcf)	Soil / Rock	Other Tests Or Remarks / Formation or Member
					REC (%)	RQD (%)	ACL (ft)	Core Breaks		
	2.0 / 819.6		Clayey sand, a little gravel and ash/cinders, trace roots, black (A-6) fill		53					Hammer Calibration: 66% efficiency with 105 lb hammer, 10/31/12
					16					
5			Mixture of sand with silt and sand with gravel, a little clayey sand and lean clay, light brown and brown, a little brownish gray (A-3, A-6) fill		23					
	8.0 / 813.6				13					
10			FAT CLAY, brownish gray mottled to gray to dark brownish gray, stiff (CH) (A-7-6) alluvium		9	35				
						38	1080	117		
15					10	55				
	16.5 / 805.1									
						36	960	117		
20			FAT CLAY, gray to grayish brown, a little light gray, firm, laminations of silt (CH) (A-7-6) alluvium		8	37				
						52	560	112		
25					8	31				
	28.0 / 793.6									
			LEAN CLAY WITH SAND, a little gravel, possible cobble at 29', grayish brown, laminations of silty sand (CL) (A-6) till			23	1345	128		
30	29.5 / 792.1				10	15				
						15	1250	139		
35					12	15				
			CLAYEY SAND, a little gravel, grayish brown and gray to brown and gray mottled, stiff to very stiff, laminations of waterbearing sand from 47½' to 48½' and below 54' (A-6) till			13	890	142		
40					9	15				
						14	1270	141		
▼45					12	13				Water level measured at 45.0' deep with HSA to 47' deep (rose from 47.9' deep 10 minutes earlier)
					14	15				
50										

Index Sheet Code

(Continued Next Page)

Soil Class: Rock Class: Edit: Date: 8/25/14
X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Retaining Wall	**Southwest LRT, PEC East**	**1135 SW**	**821.6** *(Surveyed)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
					21					No recovery
55					28	14				
				PD						
60					21	16				
			CLAYEY SAND, a little gravel, grayish brown and gray to brown and gray mottled, stiff to very stiff, laminations of waterbearing sand from 47½' to 48½' and below 54' (A-6) till *(continued)*	PD						
65					26	17				
				PD						
70					25	15				
				PD						
75					26	16				
	78.0 743.6			PD						
80					30	16				
				PD						
85					29	14				
			CLAYEY SAND WITH GRAVEL, possible cobbles around 90' and 102½', brownish gray, very stiff to hard, laminations of waterbearing sand around 80' (SC) (A-6) till	PD						
90					55					1" recovery
				PD						
95					43	13				
				PD						
100										

(Continued Next Page)

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Retaining Wall	**Southwest LRT, PEC East**	**1135 SW**	**821.6** *(Surveyed)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60}	MC (%)	COH (psf)	γ (pcf)	Soil / Rock	Other Tests Or Remarks / Formation or Member
					REC (%)	RQD (%)	ACL (ft)	Core Breaks		
			CLAYEY SAND WITH GRAVEL, possible cobbles around 90' and 102½', brownish gray, very stiff to hard, laminations of waterbearing sand around 80' (SC) (A-6) till *(continued)*	X	47	13				
				PD						
105				X	37	13				
	108.0			PD						
	713.6		CLAYEY SAND, a little gravel, possible cobbles, brown and gray mottled, hard (SC) (A-6) till							
110				X	67	14				
	113.0			PD						
	708.6		CLAYEY SAND, a little gravel, brownish gray, hard, laminations of waterbearing sand (SC) (A-6) till							
115				X	52	14				
	118.0			PD						
	703.6		SAND WITH SILT, a little gravel, fine to medium grained, brownish gray, waterbearing, medium dense (SP-SM) (A-1-b) alluvium							
120				X	28					
	123.0			PD						
	698.6		SILTY SAND, a little gravel, fine to medium grained, brownish gray, wet, medium dense (SM) (A-2-4) alluvium							
125	126.0			X	22					
	695.6		**END OF BORING**							

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Retaining Wall	**Southwest LRT, PEC East**	**1136 SW**	**821.3** *(Surveyed)*

Location **, , ft. LT**
Co. Coordinate: X=525680 Y=168467 (ft.)
Latitude (North)=44.9788475 Longitude (West)=-93.2841020

Drill Machine **85C**
Hammer **CME Automatic Calibrated**

SHEET 1 of 2
Drilling Completed **11/22/13**

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60}	MC (%)	COH (psf)	γ (pcf)	Soil / Rock	Other Tests Or Remarks / Formation or Member
					REC (%)	RQD (%)	ACL (ft)	Core Breaks		
0	4.0 / 817.3		Gravelly sand with silt, a little fat clay brown (A-1-b, A-7-6) fill		17					Hammer Calibration: 66% efficiency with 105 lb hammer, 10/31/12
					9					
5					16					
					17					
10			Sand, a little gravel, light brown and light grayish brown (A-1-b, A-3) fill		16					
					24					
15					17					
	16.5 / 804.8				9	31	1080	123		
20						29				
			FAT CLAY, brownish gray to brown, a little dark brownish gray, stiff, laminations of silt (CH) (A-7-6) alluvium		18	31				LL=61%, PL=20%, PI=41%
25						34	1615	119		
▼					16	34				Water level measured at 27.9' deep with HSA to 49.5' deep
	29.0 / 792.3				14	15				
30			SANDY LEAN CLAY, a little gravel, brown and gray mottled to brown to brownish gray, stiff to hard (CL) (A-6) till			15	1395	141		
35					34	12				
	36.5 / 784.8					12	1790	147		
40			CLAYEY SAND, a little gravel, brown to brown and gray mottled, very stiff (SC) (A-6) till		16	13				
						13	1705	142		
	44.5 / 776.8				12	19				
45			SANDY LEAN CLAY, a little gravel, dark gray, stiff (CL) (A-6) till							
	48.0 / 773.3									
50			SAND WITH SILT, fine grained, brown and light gray, waterbearing, medium dense (SP-SM) (A-3) alluvium							No recovery

Index Sheet Code

(Continued Next Page)

Soil Class: Rock Class: Edit: Date: 8/25/14
X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Retaining Wall	**Southwest LRT, PEC East**	**1136 SW**	**821.3** *(Surveyed)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
	53.0 768.3		SAND WITH SILT, fine grained, brown and light gray, waterbearing, medium dense (SP-SM) (A-3) alluvium *(continued)*		23					
55	57.5 763.8		SAND, fine grained, light gray, waterbearing, dense (SP) (A-3) alluvium		35					
60	61.8 759.5		SAND WITH SILT, a little gravel, fine to medium grained, grayish brown, waterbearing, very dense (SP-SM) (A-3) alluvium Top of Bedrock		62					ST. PETER FORMATION
65	69.2 752.1		*59/.5 + 90/.5 + 10/.1 SANDSTONE, weathered to fresh, light gray **END OF BORING**	PD PD	* 100/.2					

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Glenwood Ave.	**Southwest LRT, PEC East**	**1158 SB**	**847.3** *(Surveyed)*

Location **, , ft. LT**

Co. Coordinate: X=525668 Y=168525 (ft.)

Latitude (North)=44.9790066 *Longitude (West)=-93.2841481*

Drill Machine **41C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed **10/3/13**

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
	1.0 846.3		11.5" Bituminous pavement							Hammer Calibration: 68% efficiency with 101 lb. hammer, 9/27/13 *8/.5 + 13/.5
5			Sand with silt and gravel, apparent cobbles, pieces of brick around 20', brown, a little dark brown (A-1-b) fill		* 27 38 21 27 33 29 50/.4 27 20 7 8					
	29.0 818.3									
30 ▼	31.5 815.8		LEAN CLAY, gray and brown mottled, a little brown, soft (CL/CH) (A-7-6) alluvium		3	37				Water level measured at 30.7' deep with HSA to 34.5' deep (rose from 32.1' deep 5 minutes earlier)
			FAT CLAY, brownish gray, a little gray and brown mottled, lenses of waterbearing sand below 33½', laminations of silt (CH) (A-7-6) alluvium			41	1375	113		
35	35.0 812.3				7	47 61				
40			FAT CLAY, grayish brown to dark brownish gray, a little light brownish gray, firm to soft, laminations of silt (CH) (A-7-6) alluvium		3 2	58 82 67	580	103		
	44.0 803.3									
45			SAND WITH SILT, fine grained, brown to brownish gray, moist, medium dense, a lens of clayey sand (SP-SM) (A-3) alluvium		24 17					
	49.0 798.3									
50										

Index Sheet Code

(Continued Next Page)

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Glenwood Ave.	**Southwest LRT, PEC East**	**1158 SB**	**847.3** (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
			SAND, medium to fine grained, brown, waterbearing, dense (SP) (A-1-b) alluvium *(continued)*	PD	33					
	53.0 / 794.3									
55			SAND, a little gravel, medium grained, brown, waterbearing, dense (SP) (A-1-b) alluvium	PD	33					
	58.0 / 789.3									
60			SAND WITH GRAVEL, medium grained, brown, waterbearing, medium dense (SP) (A-1-b) alluvium	PD	22					
	63.0 / 784.3									
65			FAT CLAY, dark gray and brownish gray mottled, stiff (CH) (A-7-6) alluvium	PD	14					
70				PD	11					
75				PD	11					
	76.5 / 770.8									
80			SANDY LEAN CLAY, a little gravel, brown, very stiff (CL) (A-6) till	PD	18					
85	85.0 / 762.3			PD	11					
90			CLAYEY SAND, a little gravel, brown, stiff to very stiff (SC) (A-6) till	PD	19					
95				PD	23					
100				PD						

(Continued Next Page)

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Glenwood Ave.	**Southwest LRT, PEC East**	**1158 SB**	**847.3** *(Surveyed)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 (%) REC	MC (%) RQD	COH (psf) ACL (ft)	γ (pcf) Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
			CLAYEY SAND, a little gravel, brown, stiff to very stiff (SC) (A-6) till *(continued)*		17					
	103.0 / 744.3			PD						
105			SANDY LEAN CLAY, a little gravel, dark brownish gray, stiff, a lamination of waterbearing fine grained sand (CL) (A-6) till		13					
	108.5 / 738.8			PD						
110			SAND WITH SILT, a little gravel, fine to medium grained, brown, waterbearing, medium dense (SP-SM) (A-1-b) alluvium		15					
	113.0 / 734.3			PD						
115			GRAVEL WITH SILT AND SAND, possible cobbles/ boulders around 112½', brown, waterbearing, very dense (GP-GM) alluvium or colluvium		60					
	116.5 / 730.8		Top of Bedrock							ST. PETER FORMATION
				PD						
120			SANDSTONE, fresh, light gray and gray		100/.3					
				PD						
	124.7 / 722.6		END OF BORING		100/.2					

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Glenwood Ave.	**Southwest LRT, PEC East**	**1159 SB**	**848.2** *(Surveyed)*

Location **, , ft. LT**
Co. Coordinate: X=525915 Y=168505 (ft.)
Latitude (North)=44.9789510 Longitude (West)=-93.2831938

Drill Machine **41C**
Hammer **CME Automatic Calibrated**

SHEET 1 of 2
Drilling Completed **10/8/13**

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} (%)	REC (%)	MC (%)	RQD (%)	COH (psf)	ACL (ft)	γ (pcf)	Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
	1.0 847.2		12" Bituminous pavement											Hammer Calibration: 68% efficiency with 101 lb. hammer, 9/27/13
	1.3 847.0		Silty sand with gravel, dark brown (A-1-b) fill		*									
5			*13/.5 + 30/.5		24 41									
10			Mixture of sand with silt and silty sand, with gravel, possible cobbles from 3' to 4½', pieces of brick around 18', brown and dark brown (A-1-b) fill		33 38 18									
15					27 24									
20	19.0 829.2		Mixture of sand with silt, clayey sand and sand, with gravel, dark brown and light brown, a little brownish gray (A-1-b) fill		15 9									
25	26.5 821.7		FAT CLAY, gray and dark brownish gray mottled, firm to stiff (CH) (A-7-6) alluvium		6 5 13									
30	33.5 814.7		GRAVEL WITH SILT AND SAND, brown, moist, dense (GP-GM) (A-1-b) alluvium											
35	36.5 811.7		SILT, brown, a little light grayish brown, moist, dense, lenses and laminations of sand (ML) (A-4) alluvium		43 36									
	39.0 809.2		GRAVELLY SAND, medium to coarse grained, brown, moist, medium dense (SP) (A-1-b) alluvium		25									
40	41.5 806.7		SILT WITH SAND, brown, a little gray, moist, very dense, lenses of sand with silt, laminations of fat clay (ML) (A-4) alluvium		55									
	43.5 804.7		GRAVELLY SAND, possible cobbles, medium grained, brown, moist, very dense (SP) (A-1-b) alluvium		**									** 11/.5 + 71/.5 + 100/.4
45	46.5 801.7		SILTY SAND WITH GRAVEL, fine to medium grained, brown, moist, very dense (SP) (A-1-b) alluvium or till		146									
50	49.0 799.2													

Index Sheet Code

(Continued Next Page)

Soil Class: Rock Class: Edit: Date: 8/25/14
X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Glenwood Ave.	**Southwest LRT, PEC East**	**1159 SB**	**848.2** *(Surveyed)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
	50.5 797.7		SAND WITH SILT AND GRAVEL, fine grained, brown, a little dark brown, light brown and gray, moist, very dense, laminations of sandy lean clay and lean clay (SP-SM)		59					GLENWOOD FORMATION
	52.5 795.7		(A-1-b) alluvium *(continued)*							ST. PETER FORMATION
			SANDY SHALE, weathered, light brown and gray							
55			SANDSTONE, weathered to fresh, light gray, a little brown to light tan, a little brown		***					*** 72/.5 + 100/.25
	59.9 788.3		**END OF BORING**		100/.4					

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Glenwood Ave.	**Southwest LRT, PEC East**	**1204 SB**	**821.5** *(Surveyed)*

Location **, , ft. LT** — SHEET 1 of 2

Co. Coordinate: X=526046 Y=168705 (ft.) — *Drill Machine* **85C** — *Drilling Completed* **12/2/13**

Latitude (North)=44.9830593 *Longitude (West)=-93.2831055* — *Hammer* **CME Automatic Calibrated**

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
0	2.0 819.5		Gravel with clay and sand, dark brown (A-1-b) fill		21 9	27				Hammer Calibration: 66% efficiency with 105 lb hammer, 10/31/12
5					11	28				
					11	28				
10						39	980	115		
					9	35				
15						30	1830	125		
					13	30				
20			FAT CLAY, grayish brown, a little light grayish brown, brown and gray mottled and brownish gray, stiff, laminations of silt (CH) (A-7-6) alluvium			30	1295	122		
					9	36				
25						33	1730	120		
					11	37				
30						24				
					14	31				
▼35						33	1380	118		
					15	30				
40						33	1850	121		
	41.5 780.0		LEAN CLAY, grayish brown, a little brown and light grayish brown, very stiff, laminations of sand and silt (CL/CH) (A-7-6) alluvium		16	21 20				
45	43.0 778.5		CLAYEY SAND, grayish brown, very stiff (SC) (A-2-6) alluvium		20					
	44.0 777.5		GRAVELLY SAND, medium to coarse grained, brown, waterbearing, medium dense (SP) (A-1-b) alluvium							
	46.5 775.0		SAND WITH GRAVEL, medium to fine grained, brown, waterbearing, medium dense (SP) (A-1-b) alluvium		25					
50										

Index Sheet Code (Continued Next Page)

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing

UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Glenwood Ave.	**Southwest LRT, PEC East**	**1204 SB**	**821.5** (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} / REC (%)	MC (%) / RQD (%)	COH (psf) / ACL (ft)	γ (pcf) / Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
	53.0 768.5		SAND WITH GRAVEL, medium to fine grained, brown, waterbearing, medium dense (SP) (A-1-b) alluvium *(continued)*	PD	24					
55	55.5 766.0		SANDY LEAN CLAY, a little gravel, brownish gray, hard (CL) (A-6) till		89	16				
	58.0 763.5		GRAVELLY SAND, medium to fine grained, brown, waterbearing, very dense, lenses of clayey sand (SP) (A-1-b) alluvium Top of Bedrock	PD						
60					100					ST. PETER FORMATION
			SANDSTONE, weathered to fresh, light gray to light brown	PD						
	64.9 756.6		**END OF BORING**		100/.4					

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697 MNDOT TEMPLATE.GPJ

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing.

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

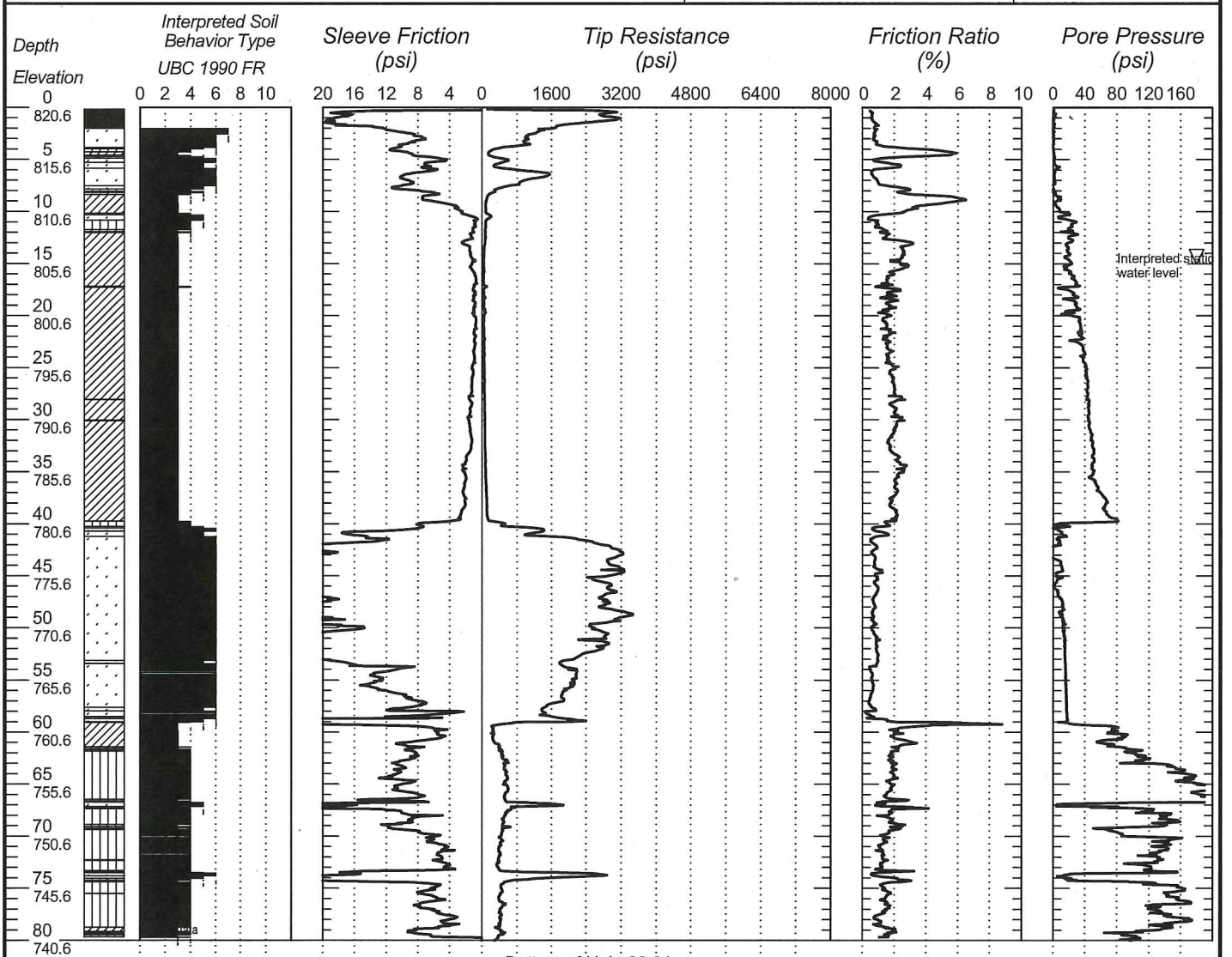
U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
AET 01-05697	**Glenwood Ave**	**Southwest LRT, PEC East**	**1160CW**	**820.6** *(Surveyed)*

Location	CPT Machine	SHEET 1 of 1
Hennepin Co. Coordinate: X=525046 Y=168162 (ft.)	CPT Operator **Adams**	
Latitude (North)= *Longitude (West)=*		*Date Completed*
No Station-Offset Information Available	*Hole Type* **CPT-SEISMIC**	**11/20/13**



Index Sheet Code 2020N1301C.ECP *Soil Class: Rock Class: Edit: Date: 8/25/14*

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697_RAPID CPT.GPJ

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing.

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

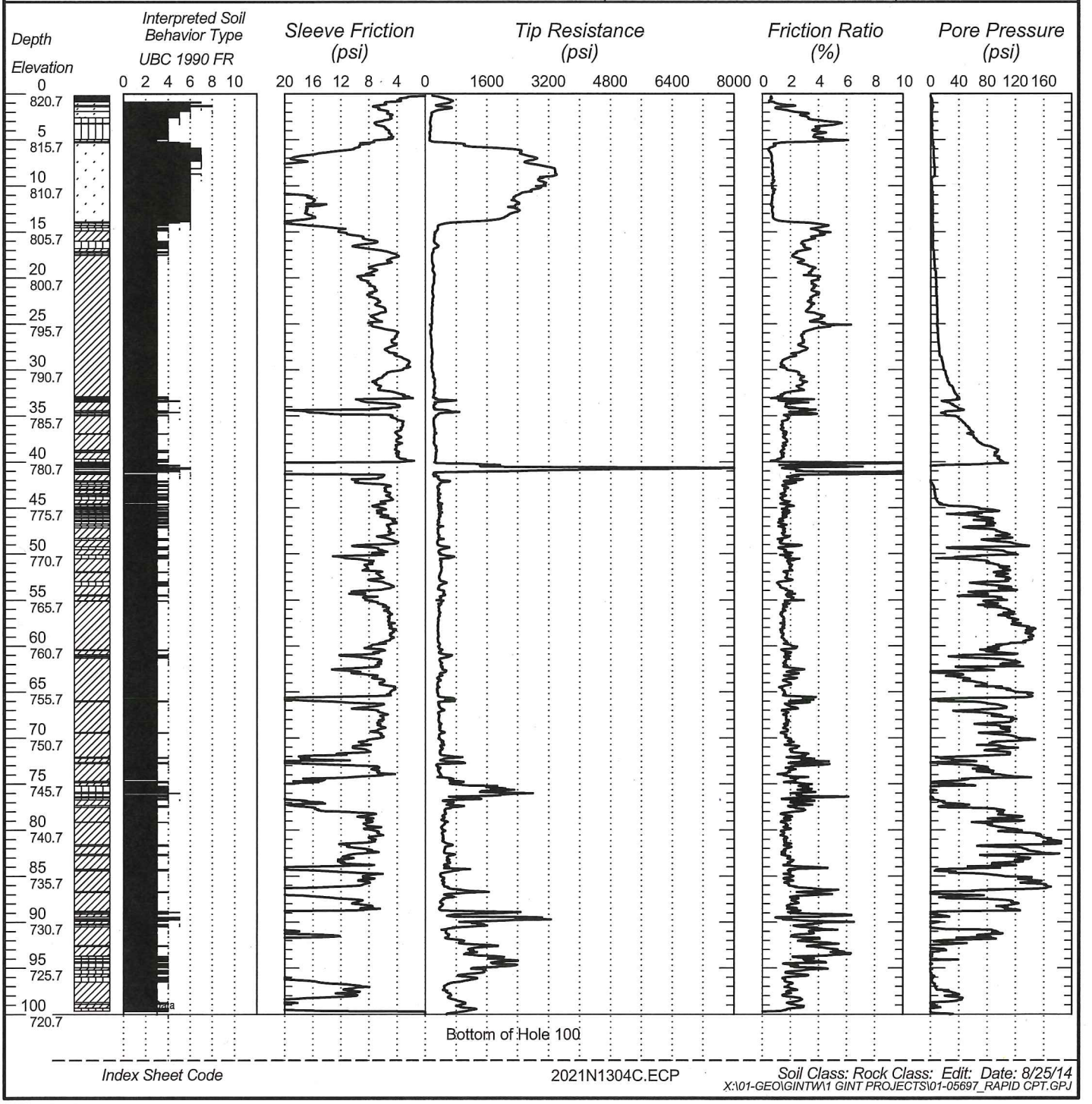
U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
AET 01-05697	Glenwood Ave	Southwest LRT, PEC East	1161CW	820.7 (Surveyed)

Location	CPT Machine	
Hennepin Co. Coordinate: X=525138 Y=168212 (ft.)	20	SHEET 1 of 1
Latitude (North)= Longitude (West)=	CPT Operator Adams	Date Completed
No Station-Offset Information Available	Hole Type CPT-SEISMIC	11/21/13



Index Sheet Code 2021N1304C.ECP

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697_RAPID CPT.GPJ

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing.

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

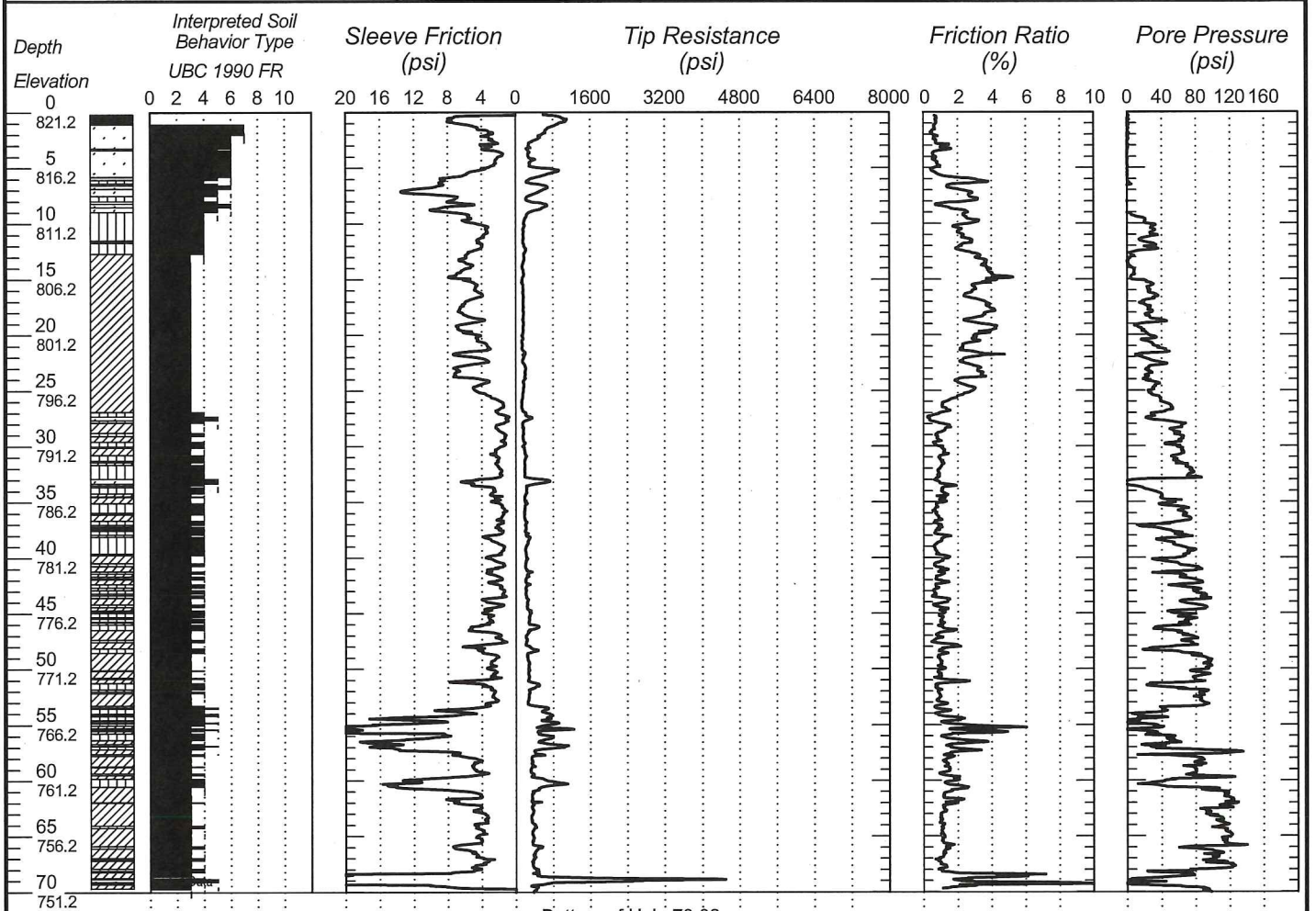
U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
AET 01-05697	Glenwood Ave	Southwest LRT, PEC East	1162CW	821.2 (Surveyed)

Location	CPT Machine	SHEET 1 of 1
Hennepin Co. Coordinate: X=525230 Y=168255 (ft.)	CPT Operator Adams	Date Completed
Latitude (North)= Longitude (West)=	Hole Type CPT-SEISMIC	11/22/13
No Station-Offset Information Available		



Bottom of Hole 70.02

Index Sheet Code

2022N1301C.ECP

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697_RAPID CPT.GPJ

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing.

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

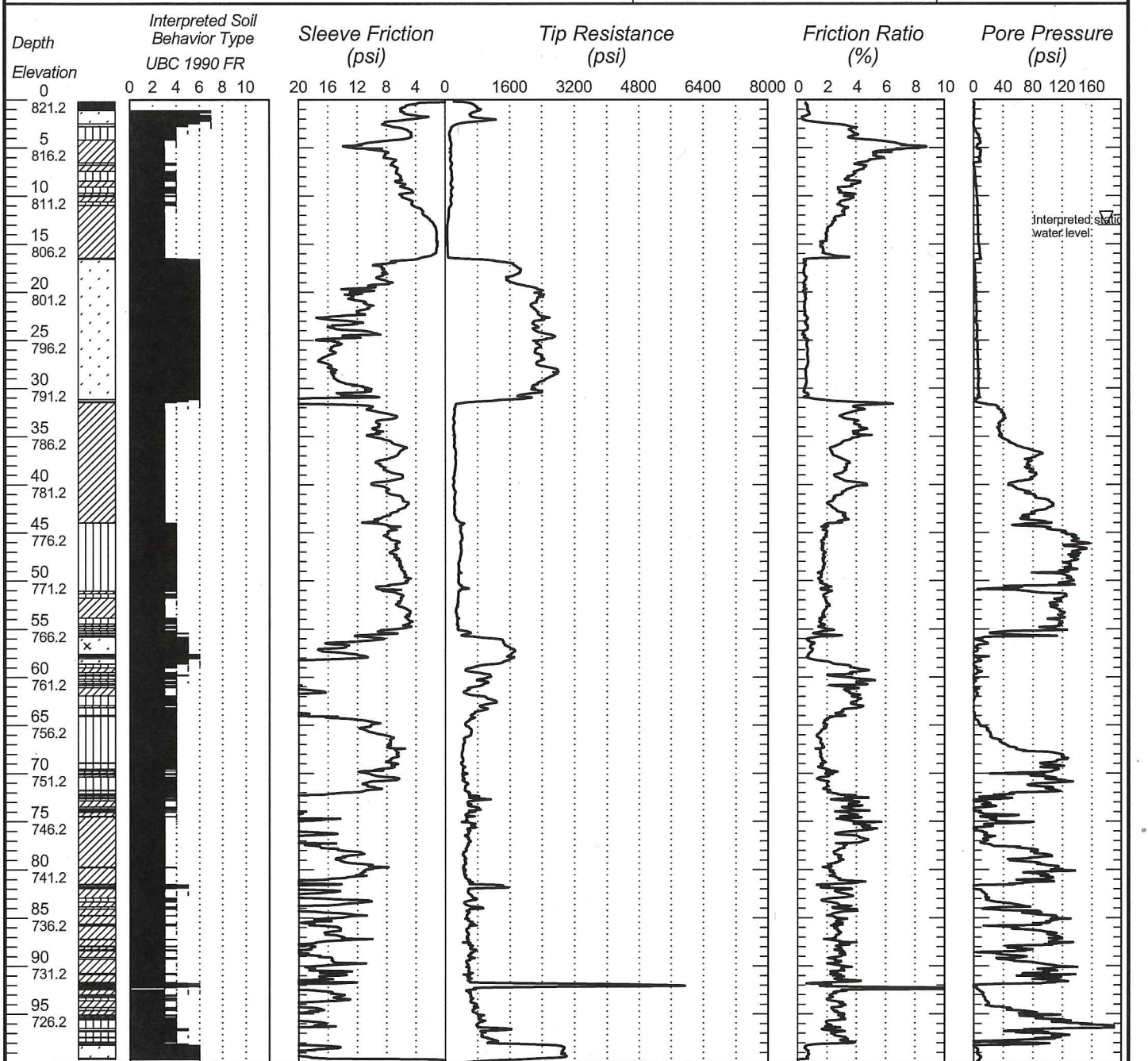
U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
AET 01-05697	Glenwood Ave	Southwest LRT, PEC East	1163CW	821.2 (Surveyed)

Location	CPT Machine	
Hennepin Co. Coordinate: X=525410 Y=168340 (ft.)	20	SHEET 1 of 1
Latitude (North)= Longitude (West)=	CPT Operator Adams	Date Completed
No Station-Offset Information Available	Hole Type CPT-SEISMIC	11/21/13



Index Sheet Code 2021N1303C.ECP

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697_RAPID CPT.GPJ

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing.

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

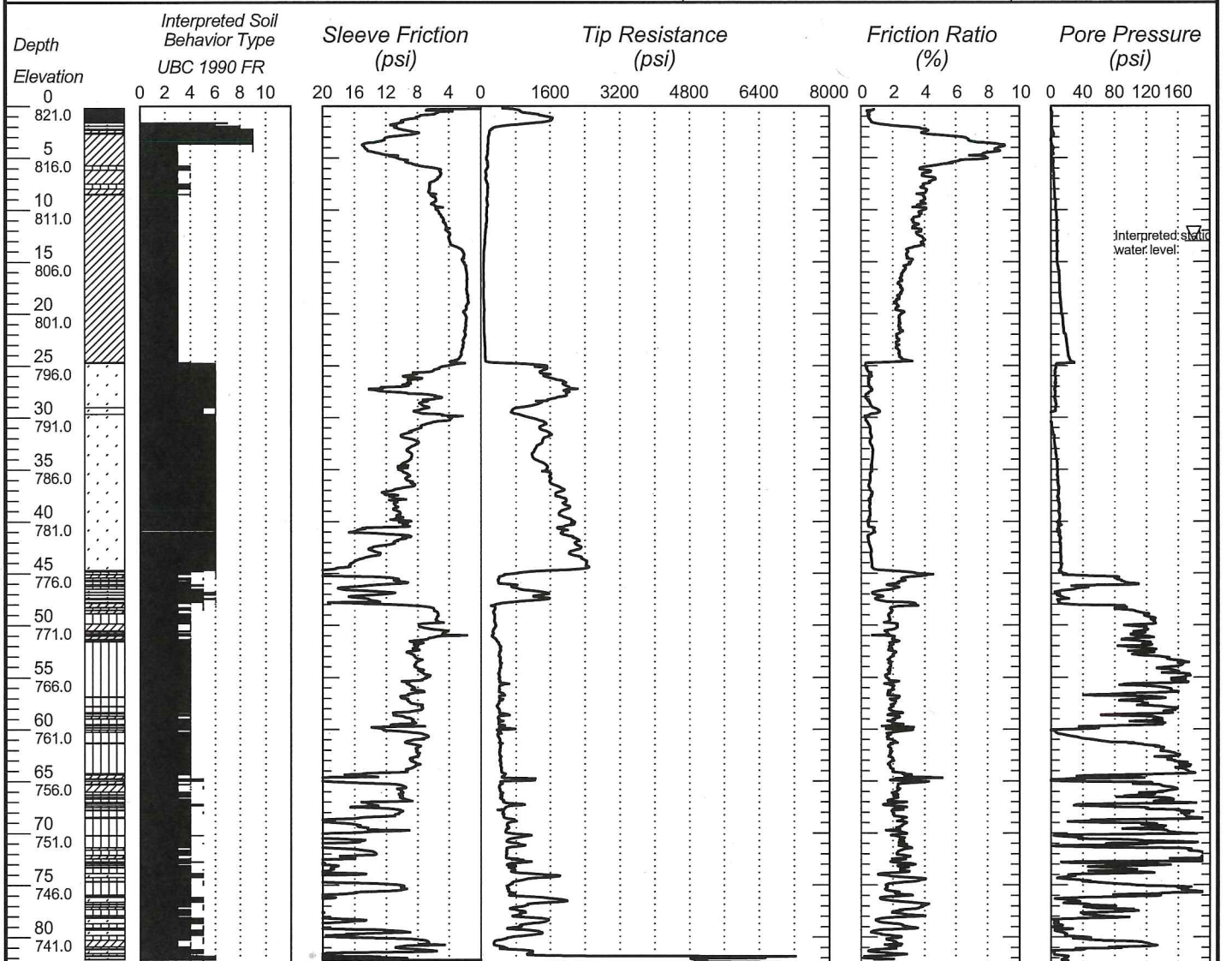
U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
AET 01-05697	Glenwood Ave	Southwest LRT, PEC East	1164CW	821.0 (Surveyed)

Location	CPT Machine	SHEET 1 of 1
Hennepin Co. Coordinate: X=525500 Y=168381 (ft.)	CPT Operator Adams	
Latitude (North)= Longitude (West)=		Date Completed
No Station-Offset Information Available	Hole Type CPT-SEISMIC	11/21/13



Index Sheet Code 2021N1302C.ECP

Soil Class: Rock Class: Edit: Date: 8/25/14

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697_RAPID CPT.GPJ

AMERICAN ENGINEERING TESTING, INC.

This boring was taken by American Engineering Testing.

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER

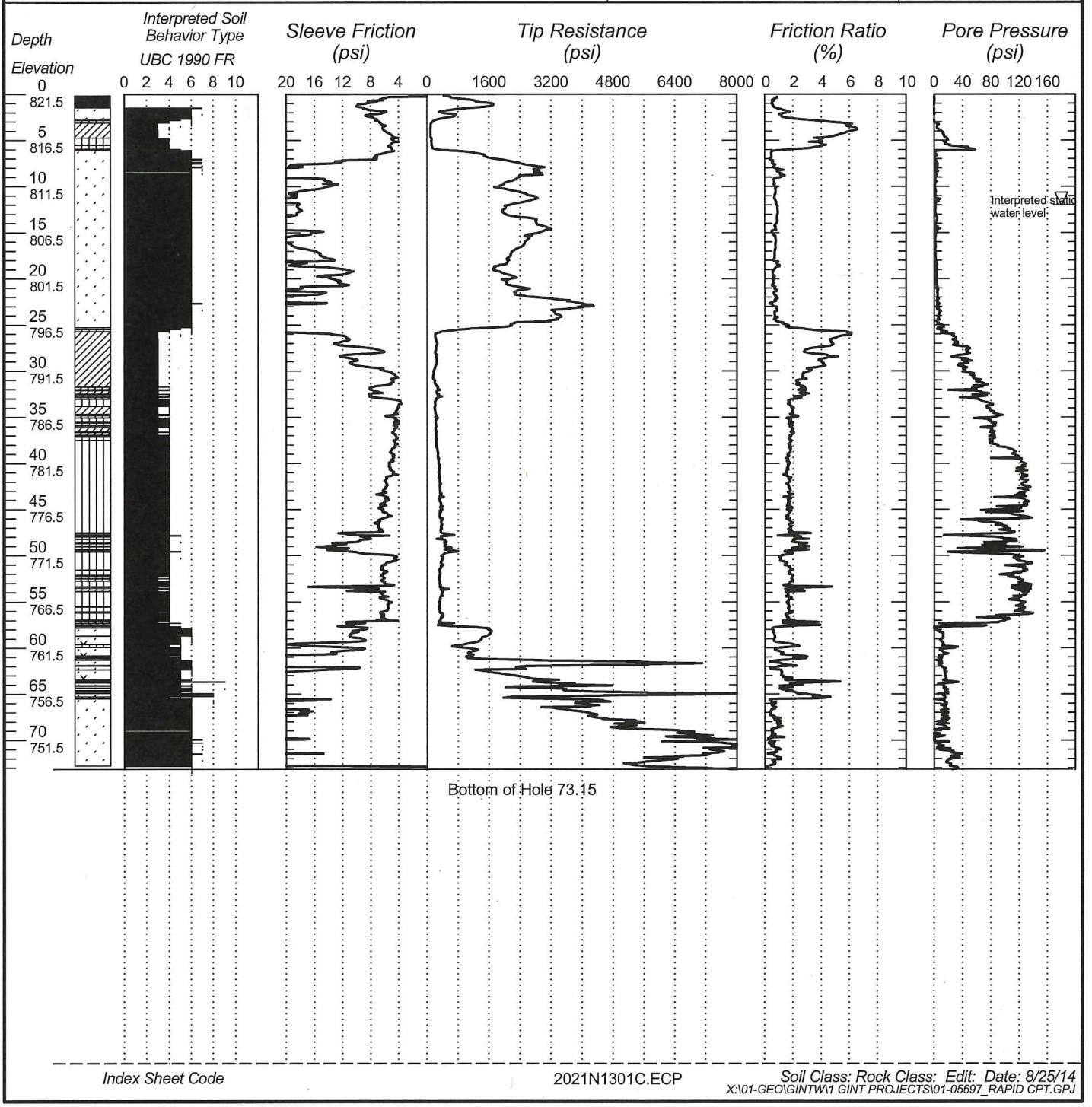
U.S. Customary Units

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
AET 01-05697	**Glenwood Ave**	**Southwest LRT, PEC East**	**1165CW**	**821.5** *(Surveyed)*

Location	CPT Machine	SHEET 1 of 1
Hennepin Co. Coordinate: X=525591 Y=168425 (ft.)	CPT Operator **Adams**	Date Completed
Latitude (North)= *Longitude (West)=*	Hole Type **CPT-SEISMIC**	**11/21/13**
No Station-Offset Information Available		



Index Sheet Code 2021N1301C.ECP *Soil Class: Rock Class: Edit: Date: 8/25/14*

X:\01-GEO\GINTW\1 GINT PROJECTS\01-05697_RAPID CPT.GPJ

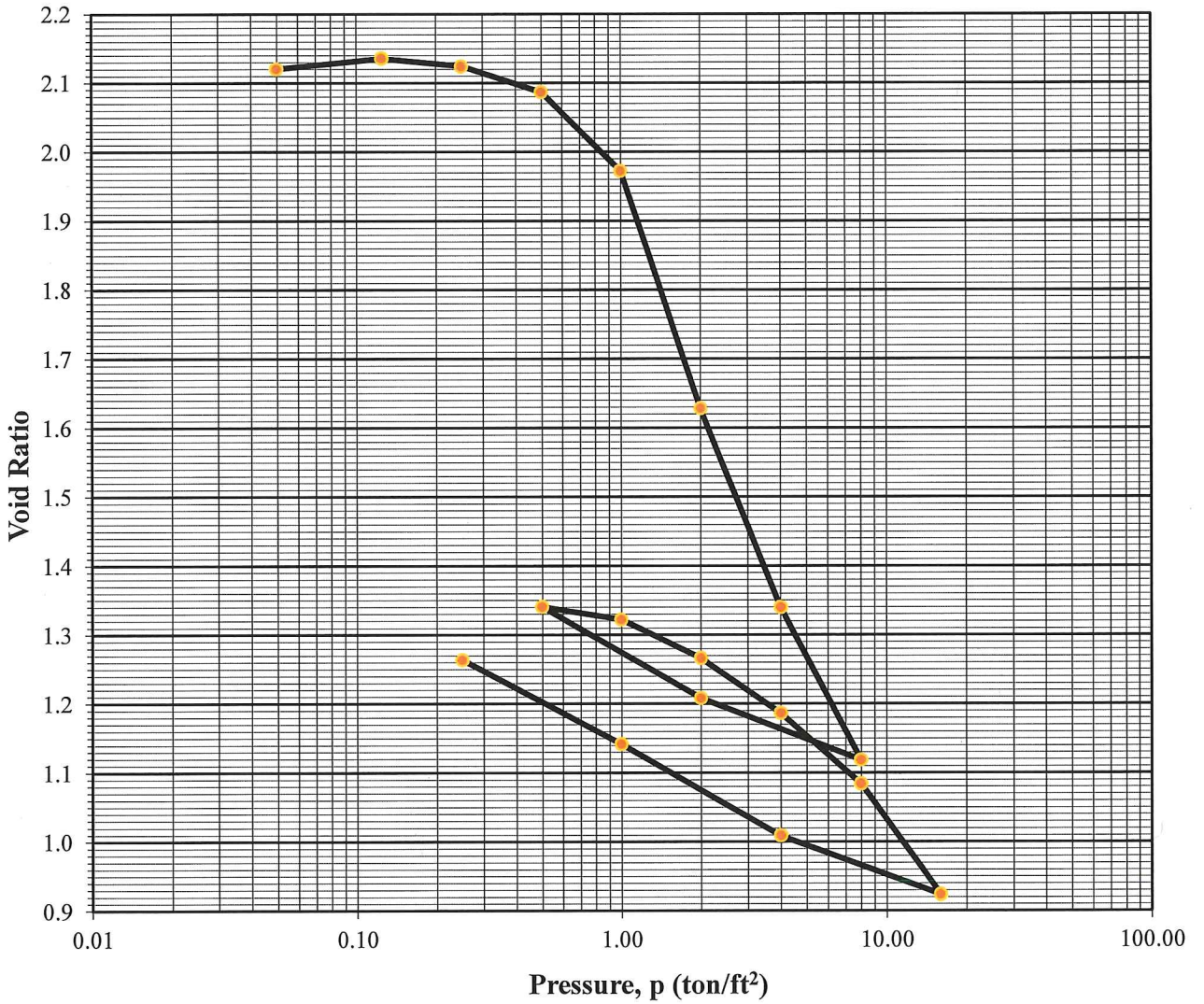
AMERICAN ENGINEERING TESTING, INC.

Consolidation Test Results: Void Ratio vs. Pressure

Project: SW Light Rail Transit
Minneapolis to Hopkins, MN

AET No.: 01-05697

Date: 1/2/2014



	Before	After	Liquid Limit (%):		Test Date: 12/11/2013
Water Content (%):	75.18	49.41	Plastic Limit (%):		
Dry Density (pcf):	54.84	73.20	Plasticity Index (%):		
Saturation (%):	97.19	101.24			
Void Ratio:	2.1157	1.2643	Specific Gravity:	2.741	Measured

Sample Description:	Gray Fat Clay (CH)		
Boring Number:	1134 SW	**Depth:** 24.5'-26.5'	**Soil Parameters:**
Remarks:	Test conducted in general accordance with ASTM D2435		Preconsolidation Pressure (Pc): 0.95 tsf Compression Index (Cc): 1.130 Recompression Index (Cr): 0.190

Tested By: Benjamin Pomroy	**Reviewed By:** Jeff Voyen

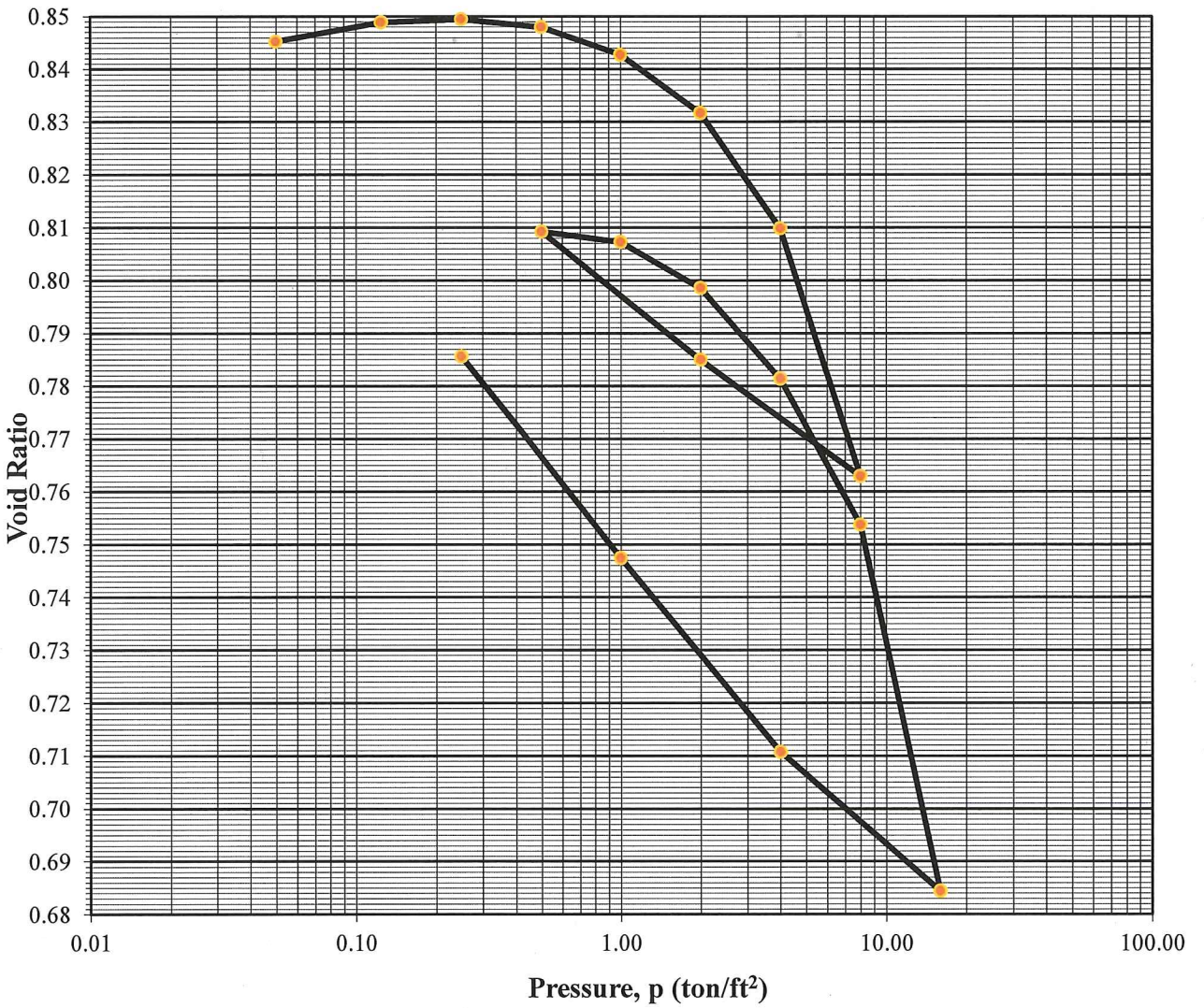
AMERICAN ENGINEERING TESTING, INC.

Consolidation Test Results: Void Ratio vs. Pressure

Project: SW Light Rail Transit
Minneapolis to Hopkins, MN

AET No.: 01-05697

Date: 1/27/2014



	Before	After	Liquid Limit (%):		Test Date: 1/3/13
Water Content (%):	30.00	31.79	Plastic Limit (%):		
Dry Density (pcf):	92.12	91.64	Plasticity Index (%):		
Saturation (%):	96.22	100.81			
Void Ratio:	0.8457	0.7827	Specific Gravity:	2.733	Measured

Sample Description:	Fat Clay, gray (CH)		
Boring Number:	1204 SB	**Depth:** 19.5-21.5	**Soil Parameters:**
Remarks:	Test conducted in general accordance with ASTM D2435		Preconsolidation Pressure (Pc): 3.2 tsf Compression Index (Cc): 0.212 Recompression Index (Cr): 0.039

Tested By: Benjamin Pomroy	**Reviewed By:** Jeff Voyen

Embedment Analysis
1160 CW 12" CIP at Final Condition

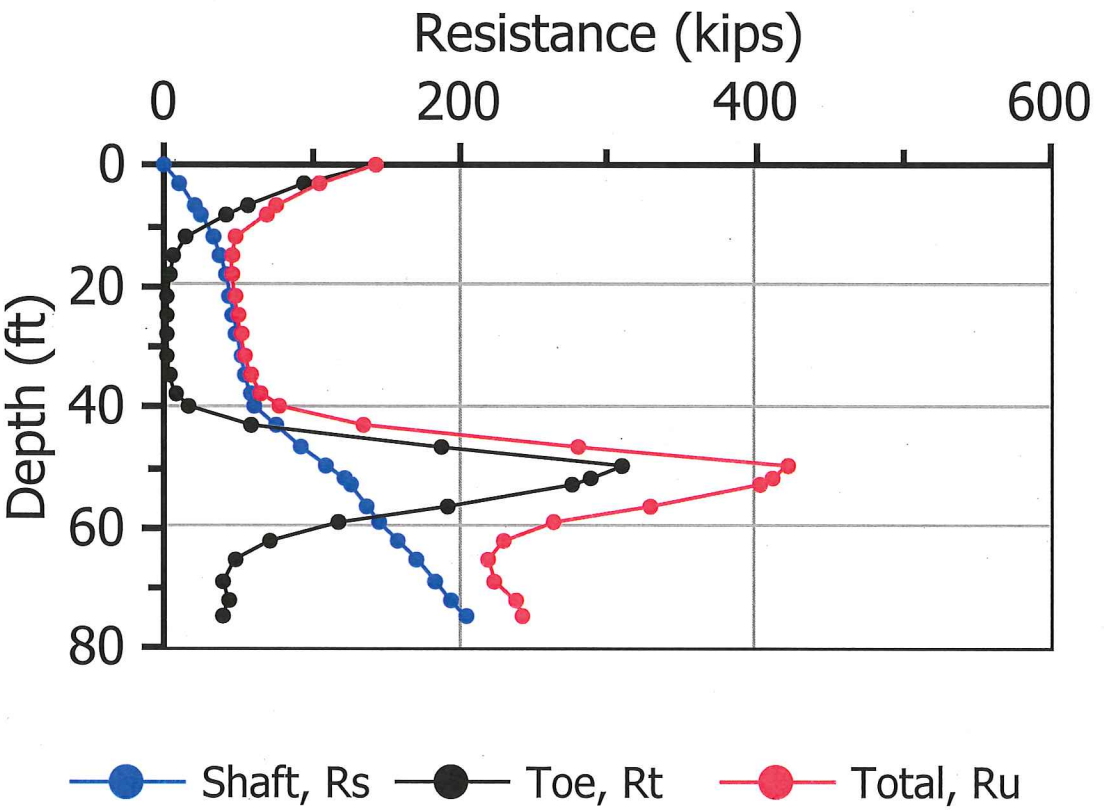


Figure 2 – UniPile 5.0 Analysis
AET No. 01-05697

Embedment Analysis
1161 CW 12" CIP at Final Condition

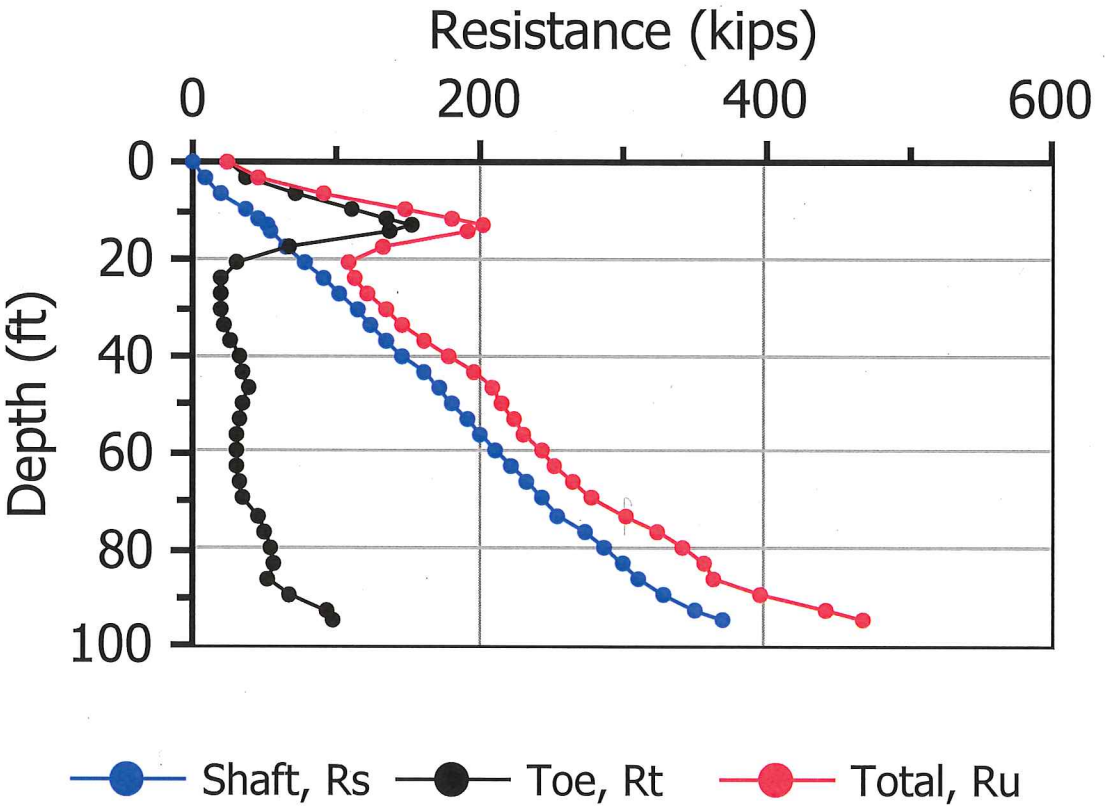


Figure 3 – UniPile 5.0 Analysis
AET No. 01-05697

Embedment Analysis
1162 CW 12" CIP at Final Condition

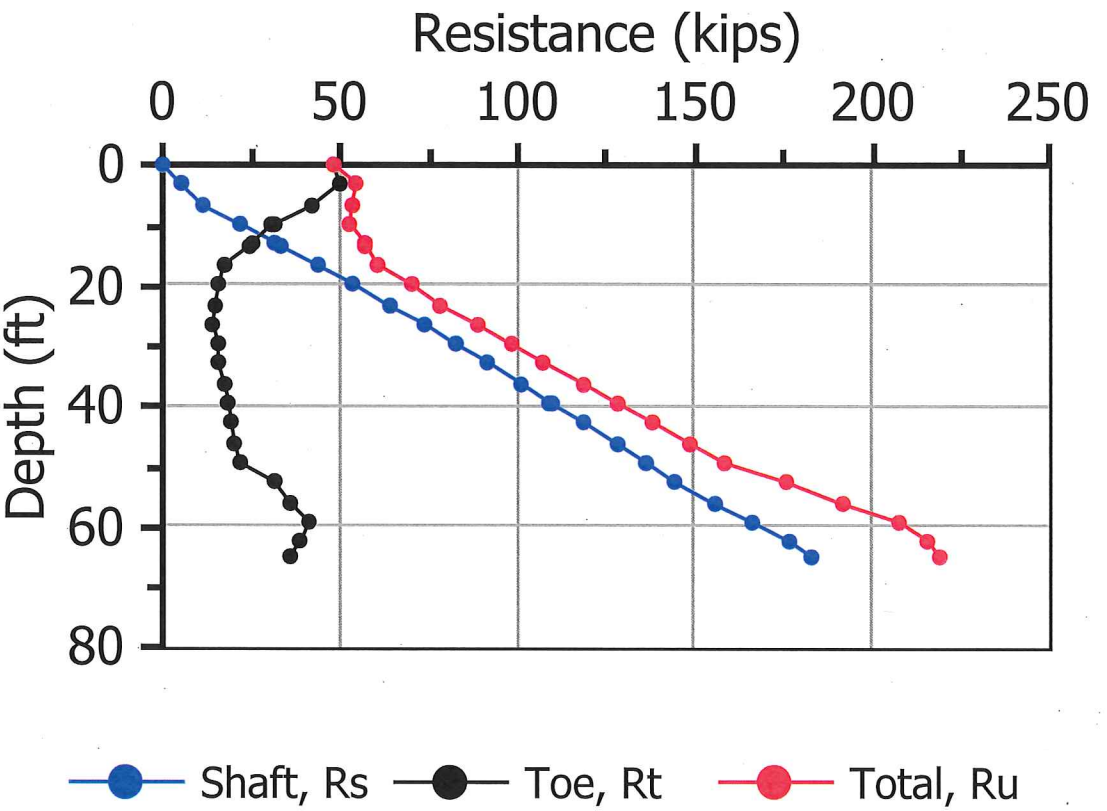


Figure 4 – UniPile 5.0 Analysis
AET No. 01-05697

Embedment Analysis
1163 CW 12" CIP at Final Condition

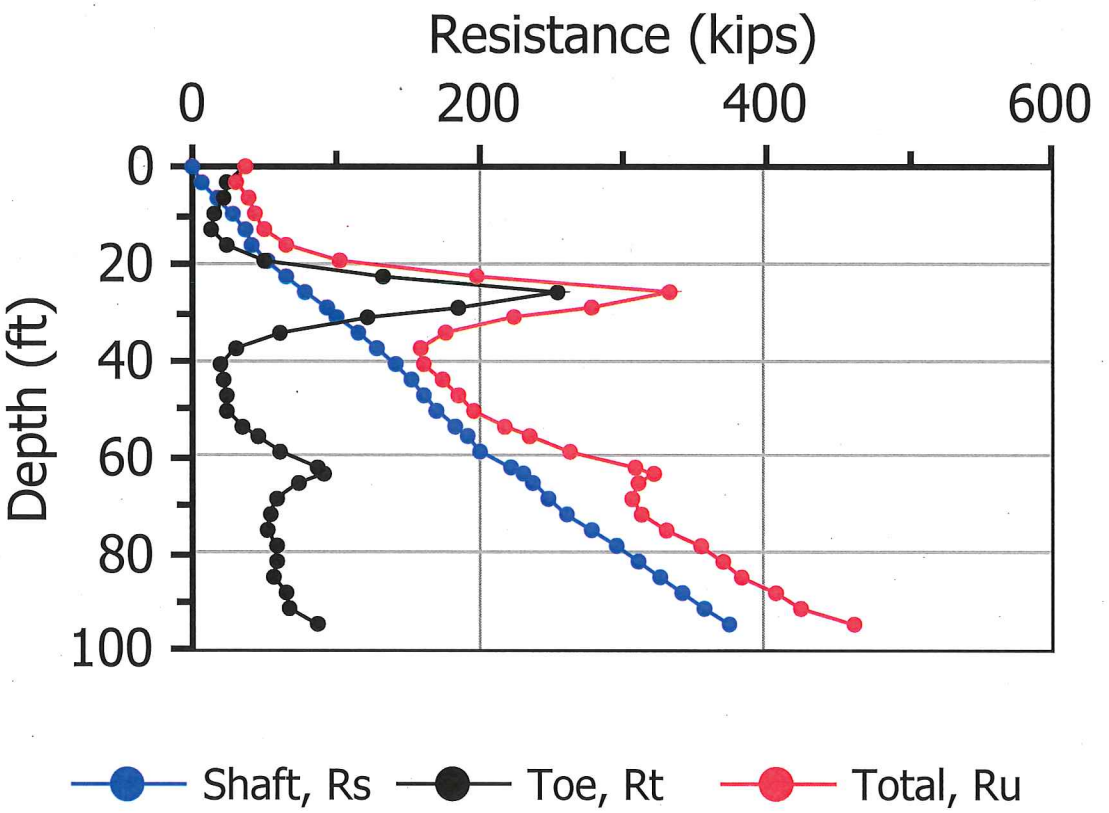


Figure 5 – UniPile 5.0 Analysis
AET No. 01-05697

Embedment Analysis
1164 CW 12" CIP at Final Condition

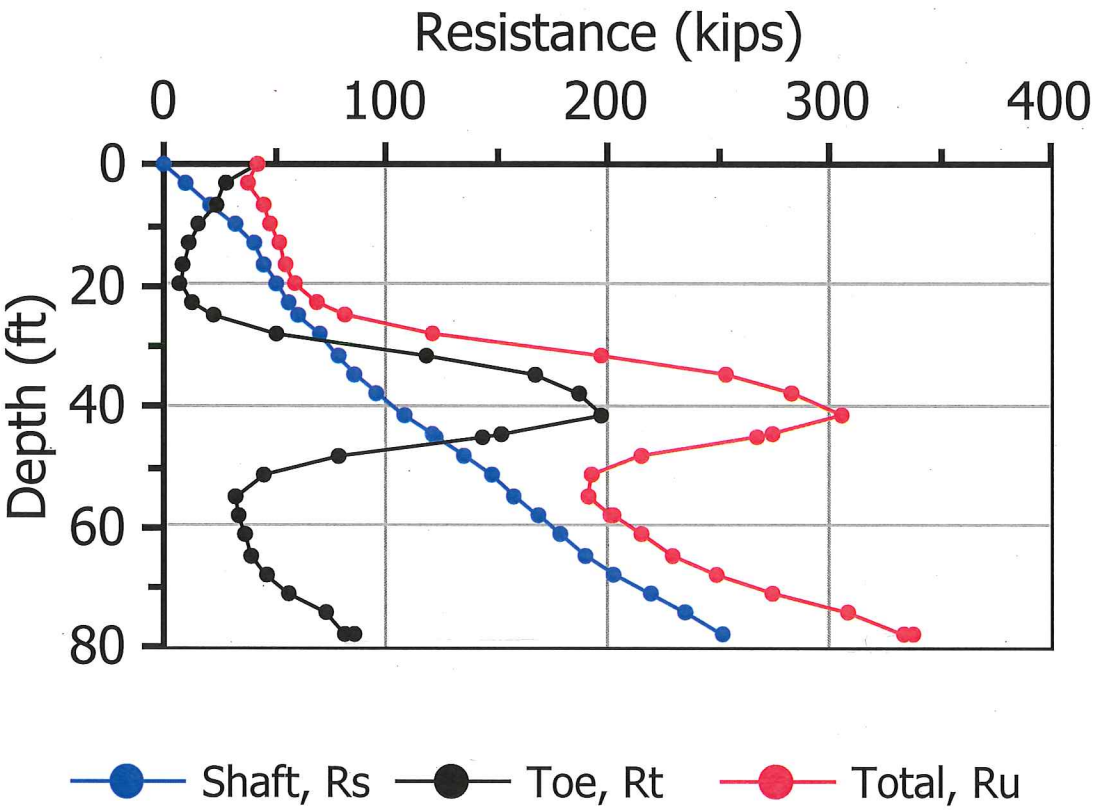


Figure 6 – UniPile 5.0 Analysis
AET No. 01-05697

SAMPLING METHODS

Split-Spoon Samples (SS) - Calibrated to N_{60} Values

Standard penetration (split-spoon) samples were collected in general accordance with ASTM: D1586 with one primary modification. The ASTM test method consists of driving a 2" O.D. split-barrel sampler into the in-situ soil with a 140-pound hammer dropped from a height of 30". The sampler is driven a total of 18" into the soil. After an initial set of 6", the number of hammer blows to drive the sampler the final 12" is known as the standard penetration resistance or N-value. Our method uses a modified hammer weight, which is determined by measuring the system energy using a Pile Driving Analyzer (PDA) and an instrumented rod.

In the past, standard penetration N-value tests were performed using a rope and cathead for the lift and drop system. The energy transferred to the split-spoon sampler was typically limited to about 60% of its potential energy due to the friction inherent in this system. This converted energy then provides what is known as an N_{60} blow count.

Most of today's drill rigs incorporate an automatic hammer lift and drop system, which has higher energy efficiency and subsequently results in lower N-values than the traditional N_{60} values. By using the PDA energy measurement equipment, we are able to determine actual energy generated by the drop hammer. With the various hammer systems available, we have found highly variable energies ranging from 55% to over 100%. Therefore, the intent of AET's hammer calibrations is to vary the hammer weight such that hammer energies lie within about 60% to 65% of the theoretical energy of a 140-pound weight falling 30". The current ASTM procedure acknowledges the wide variation in N-values, stating that N-values of 100% or more have been observed. Although we have not yet determined the statistical measurement uncertainty of our calibrated method to date, we can state that the accuracy deviations of the N-values using this method are significantly better than the standard ASTM Method.

Sampling Limitations

Unless actually observed in a sample, contacts between soil layers are estimated based on the spacing of samples and the action of drilling tools. Cobbles, boulders, and other large objects generally cannot be recovered from test borings, and they may be present in the ground even if they are not noted on the boring logs.

CLASSIFICATION METHODS

Soil classifications shown on the boring logs are based on the Unified Soil Classification (USC) system. The USC system is described in ASTM: D2487 and D2488. Where laboratory classification tests (sieve analysis or Atterberg Limits) have been performed, accurate classifications per ASTM: D2487 are possible. Otherwise, soil classifications shown on the boring logs are visual-manual judgments. Charts are attached which provide information on the USC system, the descriptive terminology, and the symbols used on the boring logs.

Visual-manual judgment of the AASHTO Soil Group is also noted as a part of the soil description. A chart presenting details of the AASHTO Soil Classification System is also attached.

The boring logs include descriptions of apparent geology. The geologic depositional origin of each soil layer is interpreted primarily by observation of the soil samples, which can be limited. Observations of the surrounding topography, vegetation, and development can sometimes aid this judgment.

WATER LEVEL MEASUREMENTS

The ground-water level measurements/comments are shown on the boring logs in the remarks section. The true location of the water table at the boring locations may be different than the water levels measured in the boreholes. This is possible because there are several factors that can affect the water level measurements in the borehole. Some of these factors include: permeability of each soil layer in profile, presence of perched water, amount of time between water level readings, presence of drilling fluid, weather conditions, and use of borehole casing.

SAMPLE STORAGE

Unless notified to do otherwise, we routinely retain representative samples of the soils recovered from the borings for a period of 30 days.

BORING LOG NOTES

DRILLING AND SAMPLING SYMBOLS

Symbol	Definition
AR:	Sample of material obtained from cuttings blown out the top of the borehole during air rotary procedure.
B, H, N:	Size of flush-joint casing
CAS:	Pipe casing, number indicates nominal diameter in inches
COT:	Clean-out tube
DC:	Drive casing; number indicates diameter in inches
DM:	Drilling mud or bentonite slurry
DR:	Driller (initials)
DS:	Disturbed sample from auger flights
DP:	Direct push drilling; a 2.125 inch OD outer casing with an inner 1½ inch ID plastic tube is driven continuously into the ground.
FA:	Flight auger; number indicates outside diameter in inches
HA:	Hand auger; number indicates outside diameter
HSA:	Hollow stem auger; number indicates inside diameter in inches
LG:	Field logger (initials)
MC:	Column used to describe moisture condition of samples and for the ground water level symbols
N (BPF):	Standard penetration resistance (N-value) in blows per foot (see notes)
NQ:	NQ wireline core barrel
PD:	Plug Drilling (same as RDF)
PQ:	PQ wireline core barrel
RDA:	Rotary drilling with compressed air and roller or drag bit.
RDF:	Rotary drilling with drilling fluid and roller or drag bit
REC:	In split-spoon (see notes), direct push and thin-walled tube sampling, the recovered length (in inches) of sample. In rock coring, the length of core recovered (expressed as percent of the total core run). Zero indicates no sample recovered.
SS:	Standard split-spoon sampler (steel; 1.5" is inside diameter; 2" outside diameter); unless indicated otherwise
SU	Spin-up sample from hollow stem auger
TW:	Thin-walled tube; number indicates inside diameter in inches
WASH:	Sample of material obtained by screening returning rotary drilling fluid or by which has collected inside the borehole after "falling" through drilling fluid
WH:	Sampler advanced by static weight of drill rod and hammer
WR:	Sampler advanced by static weight of drill rod
94mm:	94 millimeter wireline core barrel
▼:	Water level directly measured in boring
▽:	Estimated water level based solely on sample appearance

TEST SYMBOLS

Symbol	Definition
COH:	Cohesion, psf (0.5 x q_u)
CONS:	One-dimensional consolidation test
γ:	Wet density, pcf
DST:	Direct shear test
E:	Pressuremeter Modulus, tsf
HYD:	Hydrometer analysis
LL:	Liquid Limit, %
LP:	Pressuremeter Limit Pressure, tsf
MC:	Moisture Content, %
OC:	Organic Content, %
PERM:	Coefficient of permeability (K) test; F - Field; L - Laboratory
PL:	Plastic Limit, %
q_p:	Pocket Penetrometer strength, tsf (approximate)
q_c:	Static cone bearing pressure, tsf
q_u:	Unconfined compressive strength, psf
R:	Electrical Resistivity, ohm-cms
RQD:	Rock Quality Designation of Rock Core, in percent (aggregate length of core pieces 4" or more in length as a percent of total core run)
SA:	Sieve analysis
TRX:	Triaxial compression test
VSR:	Vane shear strength, remolded (field), psf
VSU:	Vane shear strength, undisturbed (field), psf
%-200:	Percent of material finer than #200 sieve

STANDARD PENETRATION TEST NOTES

(Calibrated Hammer Weight)

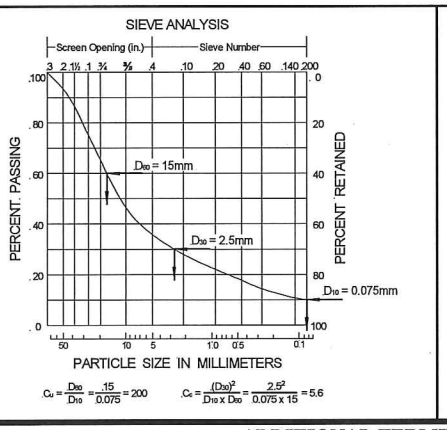
The standard penetration test consists of driving a split-spoon sampler with a drop hammer (calibrated weight varies to provide N_{60} values) and counting the number of blows applied in each of three 6" increments of penetration. If the sampler is driven less than 18" (usually in highly resistant material), permitted in ASTM: D1586, the blows for each complete 6" increment and for each partial increment is on the boring log. For partial increments, the number of blows is shown to the nearest 0.1' below the slash.

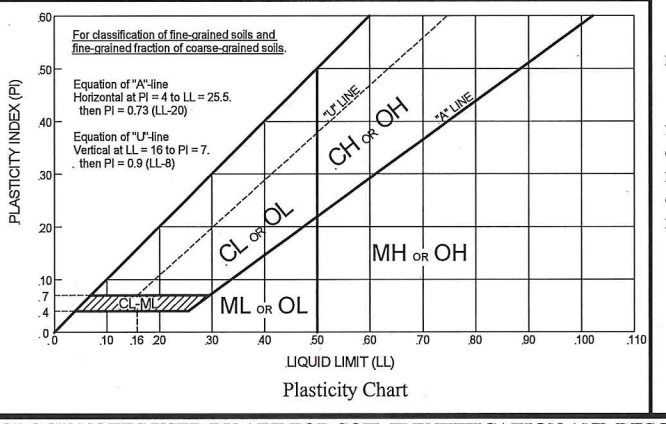
The length of sample recovered, as shown on the "REC" column, may be greater than the distance indicated in the N column. The disparity is because the N-value is recorded below the initial 6" set (unless partial penetration defined in ASTM: D1586 is encountered) whereas the length of sample recovered is for the entire sampler drive (which may even extend more than 18").

UNIFIED SOIL CLASSIFICATION SYSTEM
ASTM Designations: D 2487, D2488

AMERICAN ENGINEERING TESTING, INC.

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3^E$	GW	Well graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3^E$	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]	$Cu \geq 6$ and $1 \leq Cc \leq 3^E$	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3^E$	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 (see Plasticity Chart below)	Silts and Clays Liquid limit less than 50	inorganic	PI>7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI<4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	Liquid limit–oven dried / Liquid limit – 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	Liquid limit–oven dried / Liquid limit – not dried < 0.75	OH	Organic clay[K,L,M,P] / Organic silt[K,L,M,Q]
Highly organic soil			Primarily organic matter, dark in color, and organic in odor	PT	Peat[R]





Plasticity Chart

Notes

[A]Based on the material passing the 3-in (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]$Cu = D_{60}/D_{10}$, $Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[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 is hatched area, soils 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.

[R]Fiber Content description shown below.

ADDITIONAL TERMINOLOGY NOTES USED BY AET FOR SOIL IDENTIFICATION AND DESCRIPTION

Grain Size

Term	Particle Size
Boulders	Over 12"
Cobbles	3" to 12"
Gravel	#4 sieve to 3"
Sand	#200 to #4 sieve
Fines (silt & clay)	Pass #200 sieve

Gravel Percentages

Term	Percent
A Little Gravel	3% - 14%
With Gravel	15% - 29%
Gravelly	30% - 50%

Consistency of Plastic Soils

Term	N-Value, BPF
Very Soft	less than 2
Soft	2 - 4
Firm	5 - 8
Stiff	9 - 15
Very Stiff	16 - 30
Hard	Greater than 30

Relative Density of Non-Plastic Soils

Term	N-Value, BPF
Very Loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	Greater than 50

Moisture/Frost Condition (MC Column)

D (Dry): Absence of moisture, dusty, dry to touch.

M (Moist): Damp, although free water not visible. Soil may still have a high water content (over "optimum").

W (Wet/ Waterbearing): Free water visible intended to describe non-plastic soils. Waterbearing usually relates to sands and sand with silt.

F (Frozen): Soil frozen

Layering Notes

Laminations: Layers less than ½" thick of differing material or color.

Lenses: Pockets or layers greater than ½" thick of differing material or color.

Peat Description

Term	Fiber Content (Visual Estimate)
Fibric Peat:	Greater than 67%
Hemic Peat:	33 – 67%
Sapric Peat:	Less than 33%

Organic Description (if no lab tests)

Soils are described as *organic*, if soil is not peat and is judged to have sufficient organic fines content to influence the Liquid Limit properties. *Slightly organic* used for borderline cases.

Root Inclusions

With roots: Judged to have sufficient quantity of roots to influence the soil properties.

Trace roots: Small roots present, but not judged to be in sufficient quantity to significantly affect soil properties.

AASHTO SOIL CLASSIFICATION SYSTEM

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

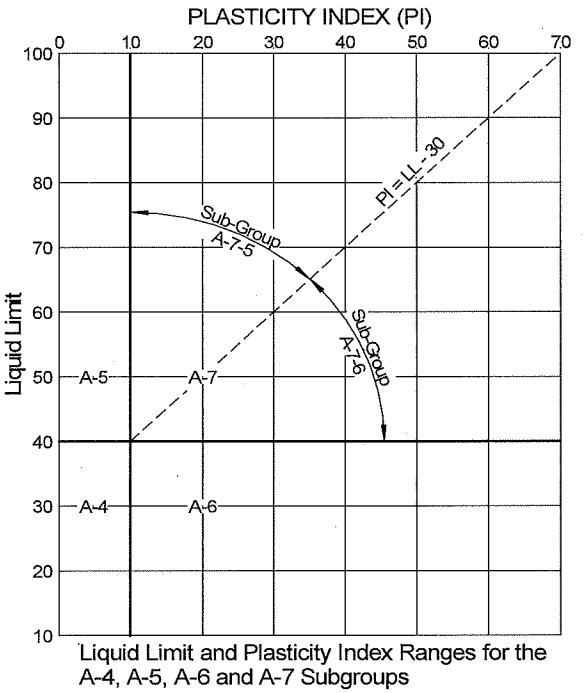
Classification of Soils and Soil-Aggregate Mixtures

General Classification	Granular Materials (35% or less passing No. 200 sieve)							Silt-Clay Materials (More than 35% passing No. 200 sieve)			
Group Classification	A-1			A-2							A-7
	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5 A-7-6
Sieve Analysis, Percent passing:											
No. 10 (2.00 mm)	50 max.	....	....	....	....	....	....	....	....	....	....
No. 40 (0.425 mm)	30 max.	50 max.	51 min.	....	....	....	....	....	....	....	....
No. 200 (0.075 mm)	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of Fraction Passing No. 40 (0.425 mm)											
Liquid limit	....		....	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		N.P.	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.
Usual Types of Significant Constituent Materials	Stone Fragments, Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General Ratings as Subgrade	Excellent to Good							Fair to Poor			

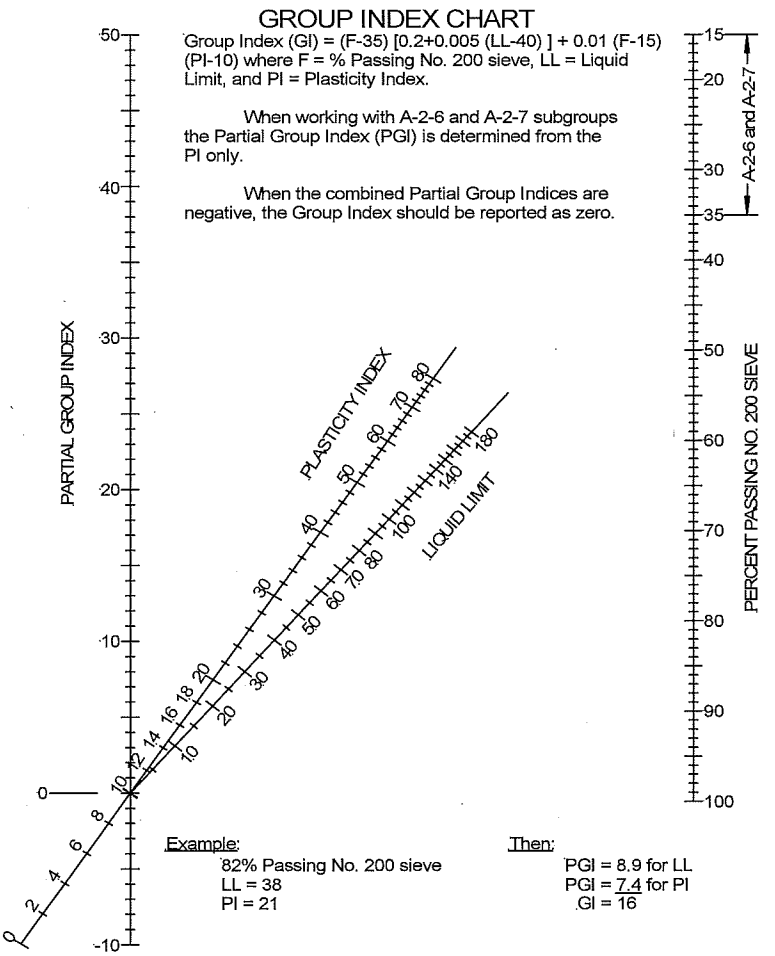
The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.

Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30.

Group A-8 soils are organic clays or peat with organic content >5%.



Liquid Limit and Plasticity Index Ranges for the A-4, A-5, A-6 and A-7 Subgroups



Example:
82% Passing No. 200 sieve
LL = 38
PI = 21

Then:
PGI = 8.9 for LL
PGI = 7.4 for PI
GI = 16

Definitions of Gravel, Sand and Silt-Clay

The terms "gravel", "coarse sand", "fine sand" and "silt-clay", as determinable from the minimum test data required in this classification arrangement and as used in subsequent word descriptions are defined as follows:

GRAVEL - Material passing sieve with 3-in. square openings and retained on the No. 10 sieve.

COARSE SAND - Material passing the No. 10 sieve and retained on the No. 40 sieve.

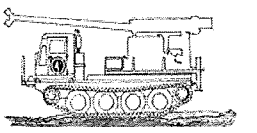
FINE SAND - Material passing the No. 40 sieve and retained on the No. 200 sieve.

COMBINED SILT AND CLAY - Material passing the No. 200 sieve

BOULDERS (retained on 3-in. sieve) should be excluded from the portion of the sample to which the classificaiton is applied, but the percentage of such material, if any, in the sample should be recorded.

The term "silty" is applied to fine material having plasticity index of 10 or less and the term "clayey" is applied to fine material having plasticity index of 11 or greater.

Minnesota Department of Transportation
Geotechnical Section
Cone Penetration Test Index Sheet 1.0 (CPT 1.0)



USER NOTES, ABBREVIATIONS AND DEFINITIONS

This Index sheet accompanies Cone Penetration Test Data. Please refer to the Boring Log Descriptive Terminology Sheet for information relevant to conventional boring logs.

This Cone Penetration Test (CPT) Sounding follows ASTM D 5778 and was made by ordinary and conventional methods and with care deemed adequate for the Department's design purposes. Since this sounding was not taken to gather information relating to the construction of the project, the data noted in the field and recorded may not necessarily be the same as that which a contractor would desire. While the Department believes that the information as to the conditions and materials reported is accurate, it does not warrant that the information is necessarily complete. This information has been edited or abridged and may not reveal all the information which might be useful or of interest to the contractor. Consequently, the Department will make available at its offices, the field logs relating to this sounding.

Since subsurface conditions outside each CPT Sounding are unknown, and soil, rock and water conditions cannot be relied upon to be consistent or uniform, no warrant is made that conditions adjacent to this sounding will necessarily be the same as or similar to those shown on this log. Furthermore, the Department will not be responsible for any interpretations, assumptions, projections or interpolations made by contractors, or other users of this log.

Water pressure measurements and subsequent interpreted water levels shown on this log should be used with discretion since they represent dynamic conditions. Dynamic Pore water pressure measurements may deviate substantially from hydrostatic conditions, especially in cohesive soils. In cohesive soils, water pressures often take extended periods of time to reach equilibrium and thus reflect their true field level. Water levels can be expected to vary both seasonally and yearly. The absence of notations on this log regarding water does not necessarily mean that this boring was dry or that the contractor will not encounter subsurface water during the course of construction.

CPT Terminology

CPT ..... Cone Penetration Test
CPTU ..... Cone Penetration Test with Pore Pressure measurements
SCPTU ..... Cone Penetration Test with Pore Pressure and Seismic measurements
Piezocone...Common name for CPTU test

(Note: This test is not related to the Dynamic Cone Penetrometer DCP)

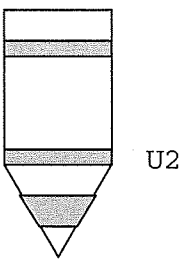
q_T TIP RESISTANCE
The resistance at the cone corrected for water pressure. Data is from cone with 60 degree apex angle and a 10 cm² end area.

f_s SLEEVE FRICTION RESISTANCE
The resistance along the sleeve of the penetrometer.

FR Friction Ratio
Ratio of sleeve friction over corrected tip resistance.
FR = fs/qt

V_s Shear Wave Velocity
A measure of the speed at which a siesmic wave travels through soil/rock.

PORE WATER MEASUREMENTS
Pore water measurements reported on CPT Log are representative of water pressures measured at the U2 location, just behind the cone tip, prior to the sleeve, as shown in the figure below. These measurements are considered to be dynamic water pressures due to the local disturbance caused by the cone tip. Dynamic water pressure decay and Static water pressure measurements are reported on a Pore Water Pressure Dissipation Graph.



SBT SOIL BEHAVIOR TYPE
Soil Classification methods for the Cone Penetration Test are based on correlation charts developed from observations of CPT data and conventional borings. Please note that these classification charts are meant to provide a guide to Soil Behavior Type and should not be used to infer a soil classification based on grain size distribution.

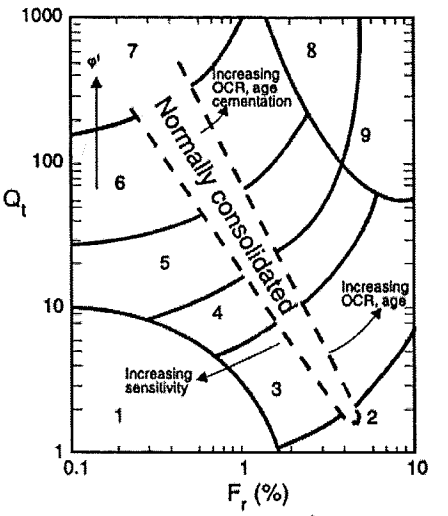
The numbers corresponding to different regions on the charts represent the following soil behavior types:

1. Sensitive, Fine Grained
2. Organic Soils - Peats
3. Clays - Clay to Silty Clay
4. Silt Mixtures - Clayey Silt to Silty Clay
5. Sand Mixtures - Silty Sand to Sandy Silt
6. Sands - Clean Sand to Silty Sand
7. Gravelly Sand to Sand
8. Very Stiff Sand to Clayey Sand
9. Very Stiff, Fine Grained

Note that engineering judgment, and comparison with conventional borings is especially important in the proper interpretation of CPT data in certain geo-materials.

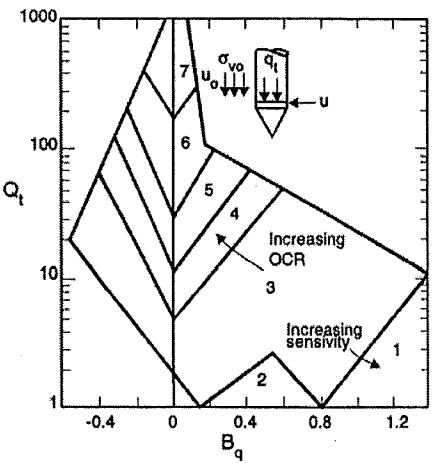
The following charts are used to provide a Soil Behavior Type for the CPT Data.

Robertson CPT 1990
Soil Behavior type based on friction ratio



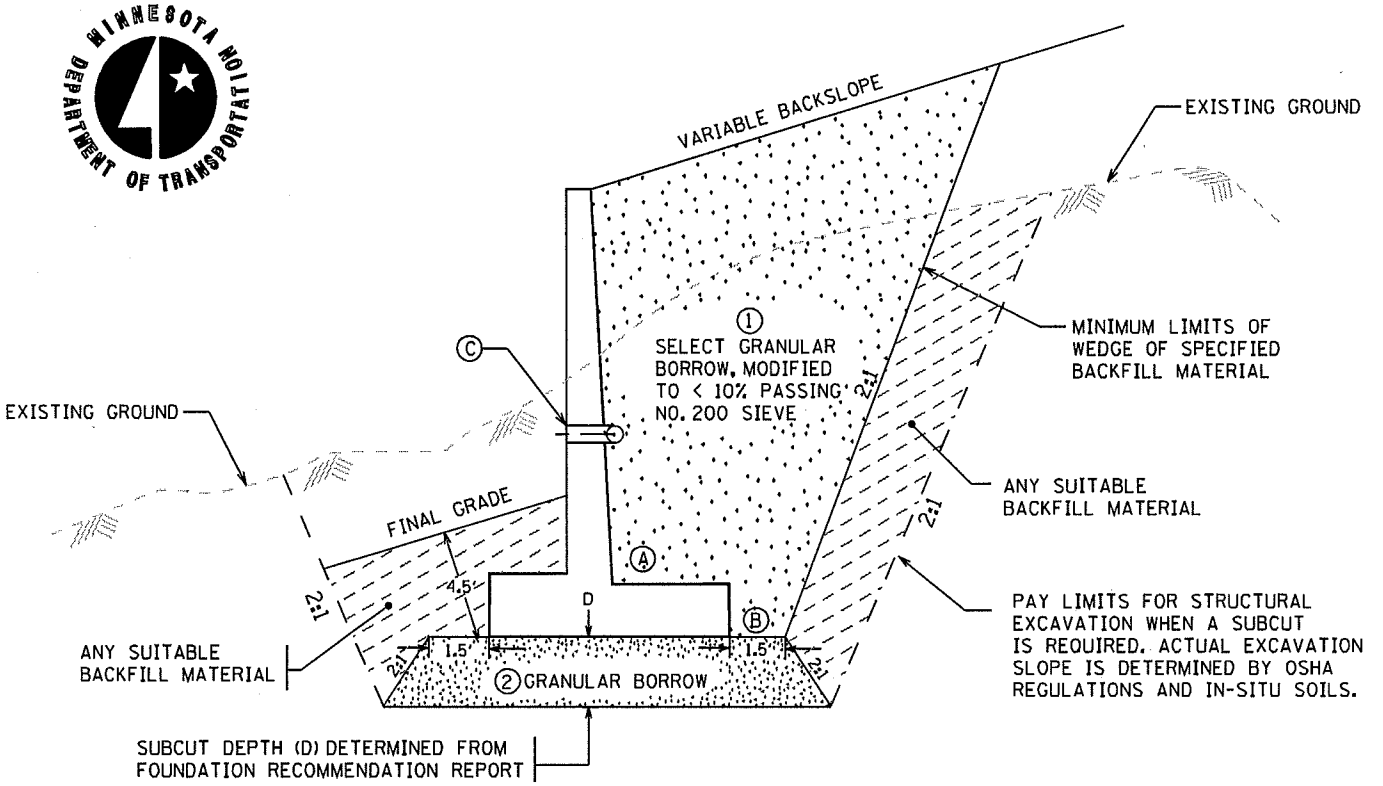
$$Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \qquad F_r = \frac{f_s}{q_t - \sigma_{vo}} \times 100\%$$

Robertson CPTU 1990
Soil Behavior type based on pore pressure



$$Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \qquad B_q = \frac{u_2 - u_o}{q_t - \sigma_{vo}}$$

where ...
QT ..... normalized cone resistance
Bq ..... pore pressure ratio
Fr ..... Normalized friction ratio
σvo ..... overburden pressure
σ'vo ..... effective over burden pressure
U2 ..... measured pore pressure
U0 ..... equilibrium pore pressure



NOT TO SCALE

All slope dimensions shown as V:H

THE RECOMMENDATIONS MAY BE MODIFIED AS PER THE ATTACHED FOUNDATIONS INVESTIGATION AND RECOMMENDATION REPORT

EXCAVATION AND BACKFILL NOTES:

① Mn/DOT SPEC. 3149.2B2 MODIFIED TO 10% PASSING THE NO. 200 SIEVE COMPACT BACKFILL TO SPECIFIED DENSITY METHOD Mn/DOT SPEC. 2105.3F1

② IF SUBCUT IS REQUIRED, BACKFILL WITH GRANLAR BORROW, Mn/DOT SPEC. 3149.2B1. COMPACT BACKFILL TO 100% OF STANDARD PROCTOR (T-99). REFER TO FOUNDATION RECOMMENDATION LETTER FOR SUBCUT DEPTHS.

DRAINAGE SYSTEM NOTES:

PROVIDE WALL DRAINAGE SYSTEM A, B OR C

Ⓐ Ⓑ PLACE A 6 IN. I.D. NON-STEEL PERFORATED PIPE(Mn/DOT SPEC. 3245) WRAPPED WITH A TYPE I GEOTEXTILE FABRIC (Mn/DOT SPEC. 3733) RUNNING THE ENTIRE LENGTH OF THE WALL AND LAID A MINIMUM OF 2 IN. ABOVE THE TOP OF FOOTING (OPTION A) OR BOTTOM ELEVATION OF THE FOOTING (OPTION B). STRUCTURAL BACKFILL MATERIALS SHALL COMPLETELY SURROUND THE PIPE. AT ALL TIMES, THE SLOPE OF THE PIPE SHALL BE CHECKED TO ENSURE POSITIVE DRAINAGE. FREQUENT TIES (SPACED APPROXIMATELY 200 FT. APART) SHALL BE MADE FROM THE PIPE TO THE INPLACE OR PROPOSED DRAINAGE SYSTEM.

Ⓒ PROVIDE WEEP HOLES AS SPECFIED IN THE BRIDGE STANDARD PLANS MANUAL, STANDARD SHEET 5-297.621 TO 5-297.623.

STATE OF MINNESOTA DEPARTMENT OF TRANSPORTATION
STRUCTURAL BACKFILL, FOOTING SUBCUT & DRAINAGE SYSTEM TREATMENT
(STANDARD CANTILEVER RETAINING WALL DESIGN)

DIAGRAM NO.

F–1

November 2005

PREPARED BY THE FOUNDATIONS UNIT

GEOTECHNICAL ENGINEERING SECTION – OFFICE OF MATERIALS