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: LRT Bridge over Excelsior Boulevard
Southwest Light Rail Transit Project
Hopkins, Minnesota
AET No. 01-05697.08

1.0 PROJECT INFORMATION

This report provides foundation analysis and recommendations for the bridge which will carry the light rail transit (LRT) tracks over Excelsior Boulevard in Hopkins, Minnesota. The new bridge will be a seven span, post-tensioned box girder structure, having a total length of 1,720 feet and width of 30.33 feet. Current substructure data is presented in Table 1.0.

Table 1.0 – Bridge Substructure Data

Substructure	Station	Span Length (from prior substructure)	Bottom of Foundation Elevation
West Abutment	2543+75.36		*918.5'
Pier 1	2544+95.36	120'	914.3'
Pier 2	2546+75.36	180'	914.2'
Pier 3	2550+35.36	360'	913.1'
Pier 4	2554+35.36	400'	911.2'
Pier 5	2557+95.36	360'	916.5'
Pier 6	2559+75.36	180'	916.9'
East Abutment	2560+95.36	120'	*921.5'

*approximate

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

The approaches will be contained within parallel retaining walls, which will have a face-to-face width matching the bridge width. The wall heights from ground surface will be about 11 feet and 18½ feet at the contacts with the west and east abutments, respectively.

2.0 SUBSURFACE EXPLORATION AND TESTING SUMMARY

2.1 Field Exploration Scope

The exploratory test program performed specific to this bridge consisted of eleven standard penetration test (SPT) "foundation" borings. Two of these borings included coring of the bedrock (1141 SB and 1142 SB). Four shallower SPT borings were also conducted in the retained wall

approach areas, and are also included with this report. The locations of the borings appear on attached Figures 1 to 3. The County coordinates also appear on the logs.

2.2 Laboratory Scope

During laboratory classification logging, water content tests were conducted on cohesive soil samples. In addition, two unconfined compression tests with density and one organic content test were performed (Boring 1001 SB). The test results appear on the individual boring logs, opposite the samples upon which they were performed.

2.3 Methods

Logs of the SPT borings are attached. The borings were drilled using 3.25 inch diameter hollow stem augers and mud rotary drilling (plug drilling) techniques. 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 per MnDOT requirements. Rock coring was performed in general accordance with ASTM:D2113, using an NQ size wireline system.

The soils were visually-manually classified per the Unified Soil Classification System. The soil group category per the AASHTO Soil Classification System is also noted on most of the logs. Please refer to the attachments entitled *Exploration/Classification Methods, Boring Log Notes, Unified Soil Classification System,* and *AASHTO Soil Classification System* for additional details.

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 Geology/Soils Review

2.4.1 Bedrock

The bedrock beneath the bridge ranges in depth from about 85 feet to 98 feet (corresponding to approximate elevation 837 feet to 825½ feet). The greater depths are found in the more central portion of the bridge. The bedrock is limestone of the Platteville Formation. Much of the upper Platteville Formation present appears to be the Magnolia member, although the Magnolia appears to be absent in the deeper central portion, thereby making the Hidden Falls member the upper portion of the in-place bedrock. Both the Magnolia and the Hidden Falls members appear to be weathered to varying degrees, with some zones being highly weathered. The Mifflin member underlies the Hidden Falls member, below about elevation 823½ feet, and is expected to be fresh, highly competent bedrock. As much of the penetration into the bedrock was done with tricone advancement (i.e., plug drilling), much of the samples retrieved were "wash samples" from the drilling fluid. This limits our ability to identify whether the material were weathered bedrock or colluvium (rock pieces/residual rock which has fallen into place). In any event, N-values could be recorded, and highly resistant materials were reached.

2.4.2 Natural Overburden Soils

The generalized natural soil profile consists of alluvium (water-deposited soils) over glacially-deposited till soils, although alluvium is usually interbedded in the till and is sometimes substantial in thickness.

The alluvium is mostly granular, mainly consisting of sand and sand with silt having varying gravel content. In some areas, clay alluvium is present, including at the top of the natural soil deposit at some on the more centrally located borings. Boring 1001 SB includes organic clay topsoil buried below 6½ feet of fill.

The till mostly consists of clayey sand and silty sand, again having varying gravel content. Typically, till exhibits high N-values due to glacial ice overconsolidation. However, a number of the borings indicate substantial thickness zones of "lower than normal" N-values (3 to 7 bpf) in the 865 feet to 895 feet elevation range. In some cases, split-spoon sample recovery did not occur or was limited. Considering the non-uniform profile (substantial thickness of till in close proximity to substantial thickness of alluvium at common depth), it appears some depositional anomalies may exist which may account for the N-value variation. Still, we expect the lower N-value tills to have some degree of overconsolidation.

2.4.3 Upper Fill

Fill is present over the natural soils in this existing rail corridor. The fill thickness ranges from about 4 feet to 11½ feet. The fill is primarily granular (sands to silty sands), although does include intermixing with clayey sands and clays. The fill sometimes includes organic fines, ash/cinders, and debris.

2.5 Ground Water

Ground-water levels were encountered during drilling. Most of these levels were recorded in faster draining alluvial granular soils which should provide a relatively good indication of the true hydrostatic level for that time and location. Based on those borings, the steady-state ground-water level is in the elevation range of 904 feet to 907 feet. Borings showing lower ground-water elevations were recorded in slower draining soils; and it is expected that the levels would have risen given more time. Water levels are expected to fluctuate both seasonally and annually. The 3-foot elevation range stated appears to be a result of seasonal fluctuations, as the more recent borings drilled this spring show higher elevations than those drilled during the early stage of the project (March of 2013).

3.0 FOUNDATION ANALYSIS

3.1 Foundation Analysis

3.1.1 Foundation Type

Spread foundation support was not analyzed. Some soil correction would be needed at many locations. The correction would require excavation of all fill, topsoil, and upper clay alluvium, resulting in excavation depths up to 11½ feet or more, which is likely complicated by space limitations. Even with this correction, it is anticipated that foundation sizes would be quite large due to the combination of high loads and apparent variation in compressibility properties. In order to provide confidence in uniform support across the bridge, it is recommended that deep foundation support be used. Spread footing support for the retained approaches may be acceptable, however, if space allows for the necessary correction.

Considering the varying depth of looser soils, which often extend to considerable depth, it is expected that the use of driven piles will be more economical than drilled shafts. Since the overburden soils are not expected to provide high levels of nominal resistance, it is expected that piles driven to "refusal" in the bedrock will be required to support the bridge. In this area, the use of H-pile is the common pile type for this case, and is the pile type analyzed and recommended in this report. Our analysis focused on the use of HP12x53 and HP14x117 piles sizes, largely to show a range. Our recommendations will include maximum Factored Pile Bearing Resistance values for other sizes as well.

3.1.2 Pile Foundation Analysis Methods

Pile bearing resistance versus pile length 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.

DRIVEN does not specifically address bedrock resistance (other than allowing input of very high values of cohesion). However, it is expected that if nominal resistance needs are not met prior to reaching the bedrock, high tip resistance will be gained with minimal penetration into the bedrock. Therefore, the *DRIVEN* analysis performed only evaluates whether resistance is met before reaching the highly resistant bedrock.

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. A Resistance Factor (φ) of 0.60 can be used when the MPF12 driving formula (MnDOT's new formula) is used.

Where H-pile is used, either the MPF12 driving formula or dynamic analysis could be used for field evaluation, 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. In the case of HP14x117 pile designed for φR_n of 300 tons, a nominal resistance of 923 kips (PDA verification) or 1000 kips (MPF12 verification) would then need to be demonstrated.

Our analysis was not conducted for all of the borings performed. The reason is that the analysis conducted on a few representative locations demonstrates that the nominal resistance will need to be gained by driving the piles into the bedrock where high tip resistance is expected. The analysis was conducted based on the following borings:

- 1188 SB (Pier 3)
- 1190 SB (West Abutment)
- 1218 SB (Pier 5)

The *DRIVEN* results for HP12x53 and HP14x117 piles based on the above listed borings are presented on attached Figures 4 to 6. As shown, nominal resistance needs was not met in the overburden soils, or was met a short distance above the bedrock. Upon reaching bedrock, it is expected that tip resistance will be significantly increased to the point of meeting nominal resistance requirements. Some minor penetration into more highly weathered bedrock zones may occur, but it is expected resistance needs will be quickly gained with this rock penetration.

The lengths predicted at each boring location are shown in Table 3.1.3. These lengths are based on penetration into the bedrock based on our interpretation of the bedrock quality; and should generally be similar for all H-pile sizes.

Table 3.1.3 – Estimated Pile Lengths

Substructure	Boring/CPT No.	Proposed Bottom of Footing Elevation, ft	Estimated Tip Elevation, ft	Estimated Pile Length, ft
West Abutment	1141 SB	918.5	836	83
West Abutment	1190 SB	918.5	836	83
Pier 1	1001 SB	914.3	833	82
Pier 2	1189 SB	914.2	818	96
Pier 3	1188 SB	913.1	825	88
E of Pier 3	1002 SB	913.1	826	87
Pier 4	1187 SB	911.2	828	83
Pier 5	1218 SB	916.5	836	80
Pier 6	1201 SB	916.9	837	80
East Abutment	1186 SB	921.5	836	86
East Abutment	1142 SB	921.5	836	86

3.2 Retained Wall Approach Settlement Review

The proposed bridge approaches will be about 30 feet wide and will raise grade by about 11 feet at the west abutment to 18½ at the east abutment. Assuming the retained wall approach were to be supported on spread foundations rather than piles, soil correction would be needed to remove the fill and alluvial clays and be replaced with engineered fill. The borings show that excavation depths near the abutments are expected to be on the order of 4 to 6½ feet, which is only several feet below anticipated frost foundation depths. However, this will increase in areas away from the abutments.

Several borings are available at or near each abutment. Based on these borings and assuming Select Granular backfill is placed, we estimate approach settlements will be less ½ inch at the west abutment and less than 1 inch at the east abutment. Also, the majority of this settlement will occur shortly after load application such that track settlement tolerance requirements are expected to be met.

4.0 FOUNDATION RECOMMENDATIONS

4.1 HP12x53 Piles

The bridge foundations can be supported on H-piles, meeting ASTM A572, Grade 50 (f_y = 50 ksi). The piles should be equipped with rock points. Various sizes of H-piles can be considered, as listed below. These piles can be designed based on the maximum Factored Pile Bearing Resistance (φR_n) values shown for each size.

- HP12x53, 140 tons
- HP12x84, 215 tons
- HP14x73, 190 tons
- HP14x89, 225 tons
- HP14x102, 260 tons
- HP14x117, 300 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 3.1.3.

Based on the anticipated settlement around the piles due to the retained wall approach system, it is our opinion that downdrag (DD) loads do not need to be considered in the pile 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.

4.4 Approach Retaining Wall Foundation Support

The borings in the abutment areas indicate fill soils and/or alluvial clays are present to depths of 4 feet to 6½ feet below the current surface. These upper soils are underlain by more competent granular soils which are judged to be capable of supporting the wall foundations and interior fill

system, provided exposed looser sands are densified. Borings away from the abutments indicate greater depths of soils needing excavation and the bottoms will expose clayey till soils.

To allow spread foundation support of the wall and of the interior fill system, the soils should be subcut to the natural granular soils present beneath the fill and clay alluvium or to the till soils. Where granular soils are exposed, they should be surface compacted with a vibratory roller compactor. The excavation bottoms should be laterally oversized beyond the planned footing edges at a 1:1 ratio. If space is limited, it would be possible to lower the footing to meet oversize requirements.

Preliminary excavation depths anticipated to allow spread foundation support is shown in Table 4.4.

Table 4.4 – Excavation Depths

Approach	Boring No.	Boring Ground Elevation, ft	Excavation Depth, ft	Excavation Elevation, ft
West	1141 SB	921.6	4	917½
West	1190 SB	922.7	6½	916
West	1191 SW	921.9	9	913
West	1200 SW	921.9	11½	910½
East	1091 ST	925.4	2	923
East	1142 SB	925.1	4	921
East	1186 SB	924.7	6½	918
East	1202 SW	924.5	9	915½

Engineered fill placed to establish foundation grade should meet the requirements of MnDOT Specification 3149.2B2, Select Granular Borrow.

The granular fill should be placed and compacted in accordance with MnDOT Specification 2105. Compaction should meet the Specified Density Method, with the modification that the entire thickness of the new fill below the footing be compacted to a minimum of 100% of the Standard Proctor density.

If spread foundation support is used (in lieu of pile support), additional testing and analysis should be performed with regards to this element of the bridge design during the final design stage of the project. This should include additional borings to better determine soil correction needs. LRFD foundation analysis considering Bearing Resistance in the strength and service

limit states, sliding resistance, and global stability should be evaluated. For preliminary price evaluation, a 3000 psf allowable bearing pressure (using ASD methods) can be assumed.

4.5 Abutment/Retaining Wall 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 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).

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

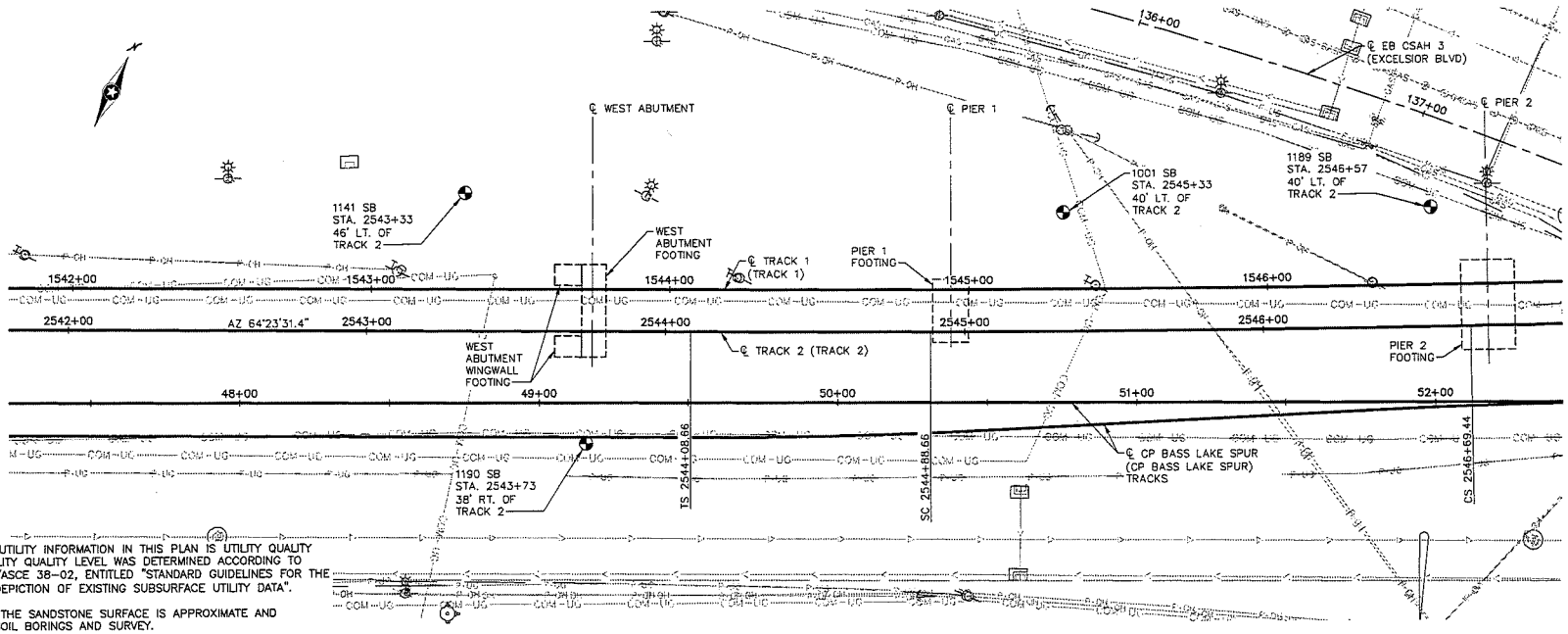
Name: Jeffery K. Voyen
Jeffery K. Voyen

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

Report Reviewed By: _____
Gregory R. Reuter, PE, PG, Principal Engineer

Attachments:

- Preliminary Bridge Plan-Profile Sheets
- Figures 1 to 3 – Boring Locations
- Figures 4 to 6 – *DRIVEN* Pile Analyses
- Subsurface Boring Logs
- Exploration/Classification Methods
- Boring Log Notes
- Unified Soil Classification System
- AASHTO Soil Classification System
- MnDOT Diagram F-1



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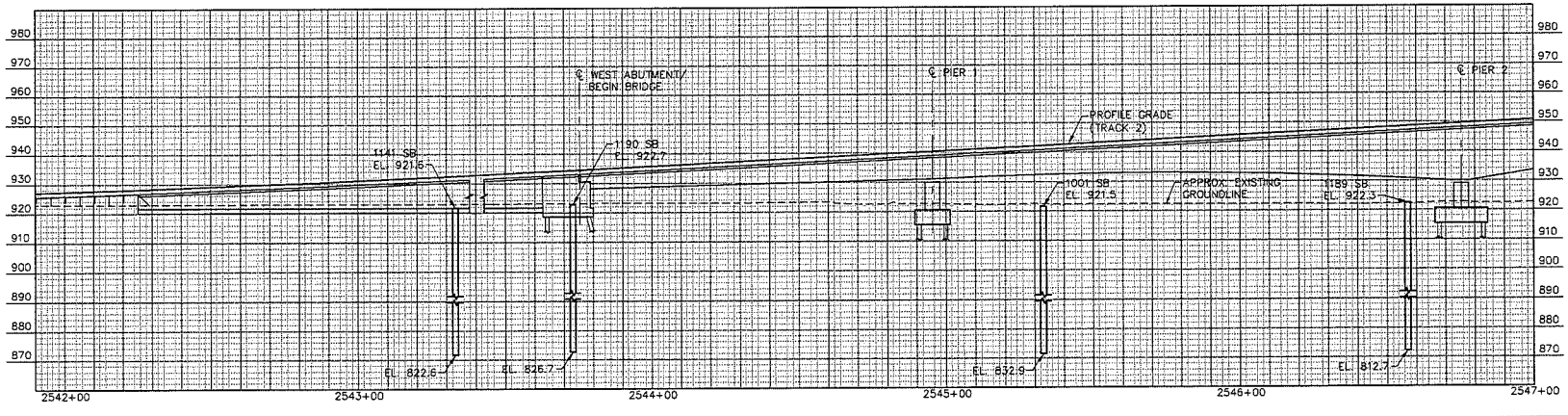

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CHK. SC	CHK. ML

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PRELIMINARY PLANS

METROPOLITAN COUNCIL

SOUTHWEST Green Line LRT Extension

EAST - VOLUME 2 (STRUCTURES)
EXCELSIOR BLVD
BRIDGE XXXXX
BORINGS (1 OF 8)

DISCIPLINE: STRUCTURES

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SHEET 25 OF 277

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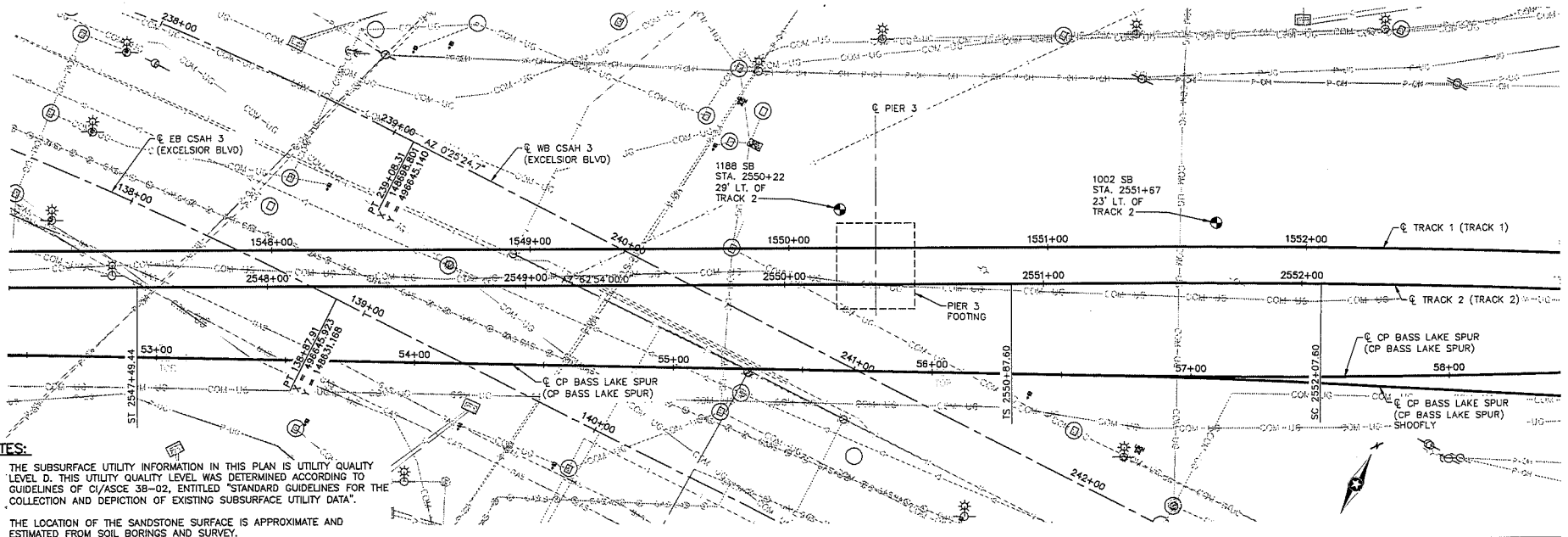

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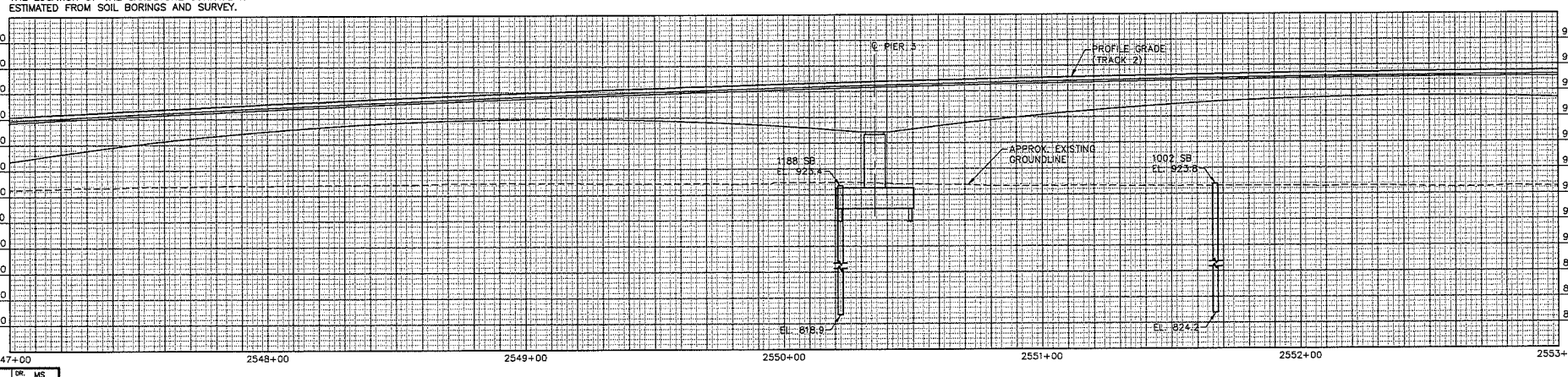

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SOUTHWEST Green Line LRT Extension

EAST - VOLUME 2 (STRUCTURES)
EXCELSIOR BLVD
BRIDGE XXXXX
BORINGS (2 OF 8)

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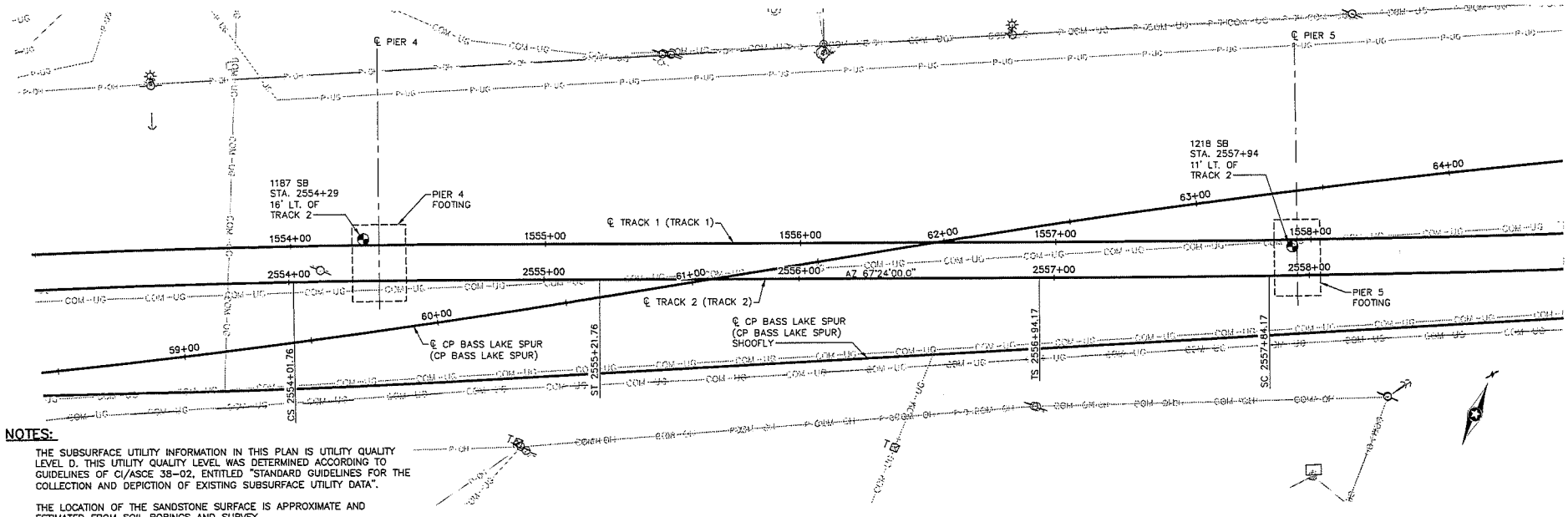

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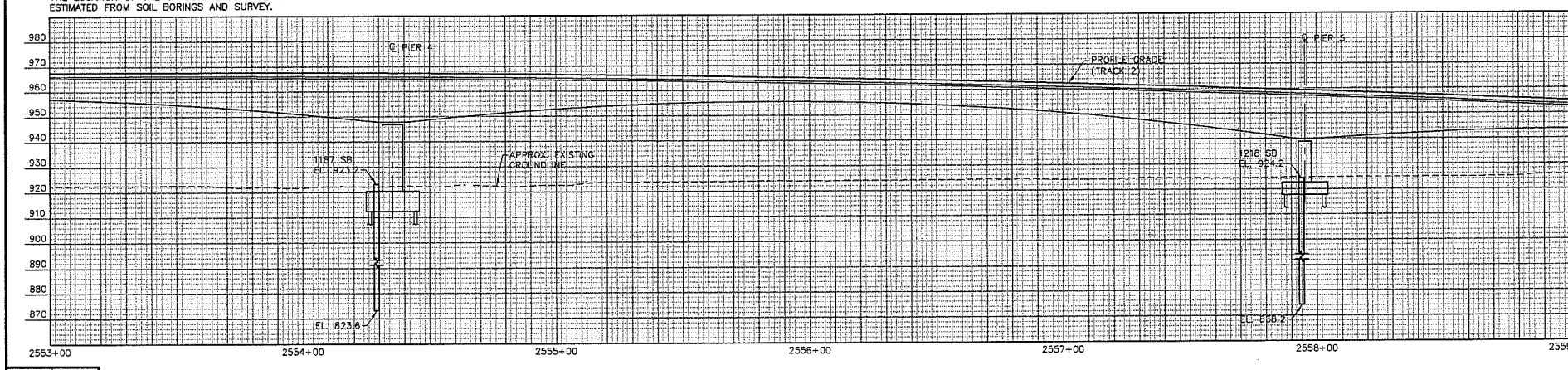

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SOUTHWEST Green Line LRT Extension

EAST - VOLUME 2 (STRUCTURES)
EXCELSIOR BLVD
BRIDGE XXXXX
BORINGS (3 OF 8)

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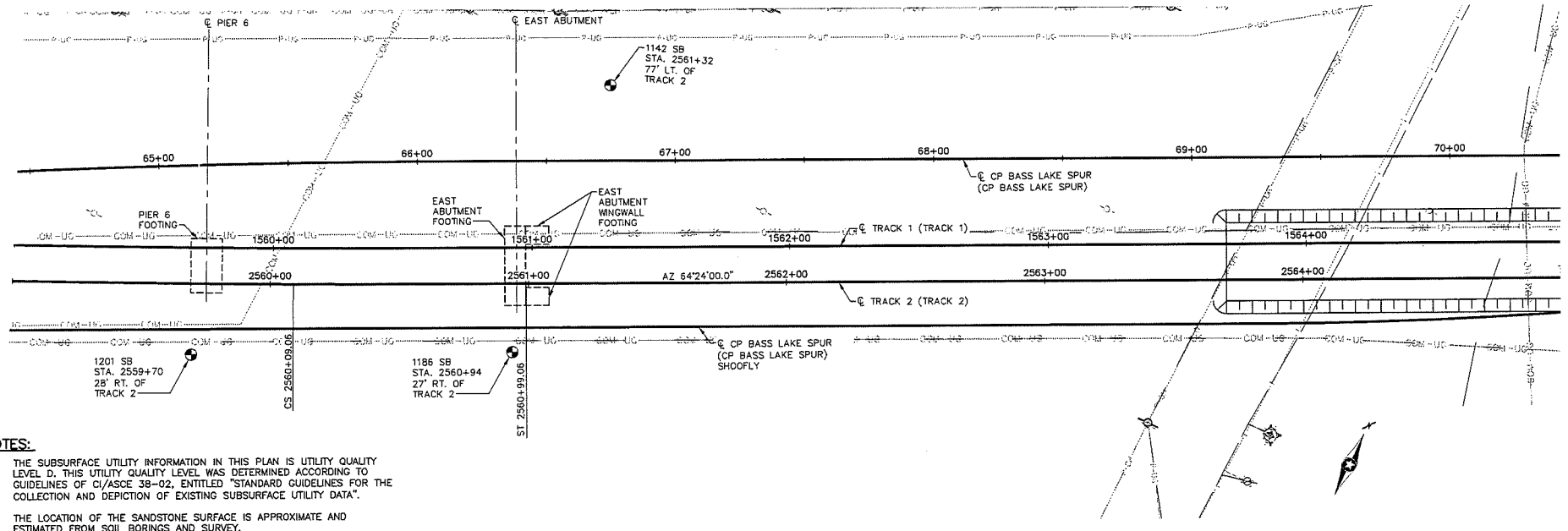

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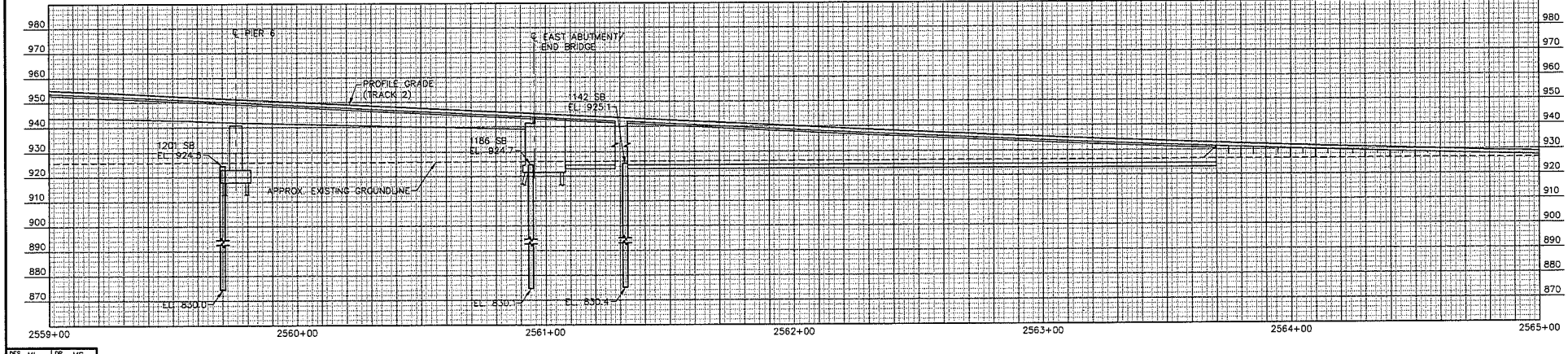

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SOUTHWEST Green Line LRT Extension

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BORINGS (4 OF 8)

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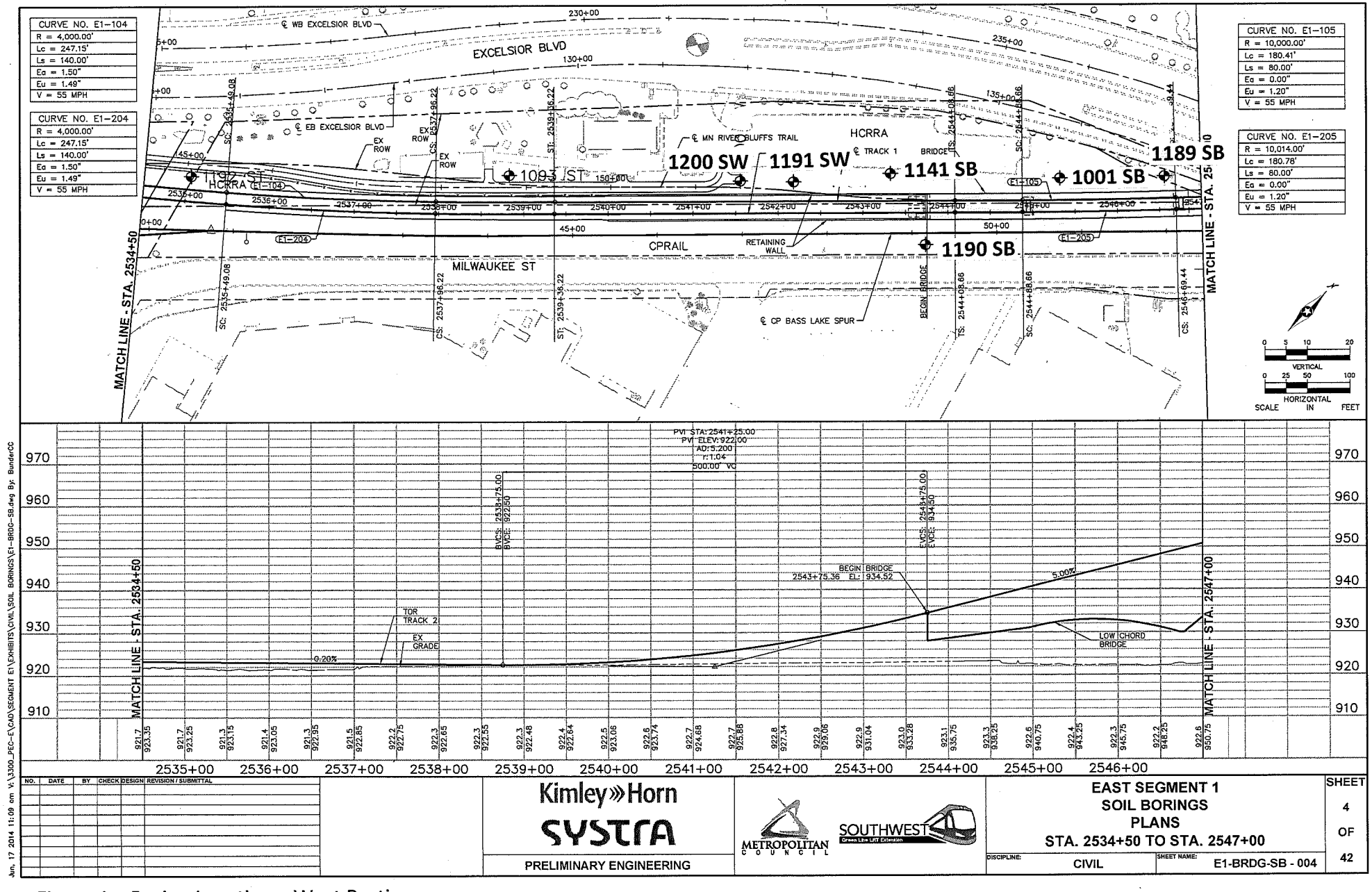

Figure 1 – Boring Locations, West Portion

LRT Bridge over Excelsior Blvd.

AET No. 01-05697.08

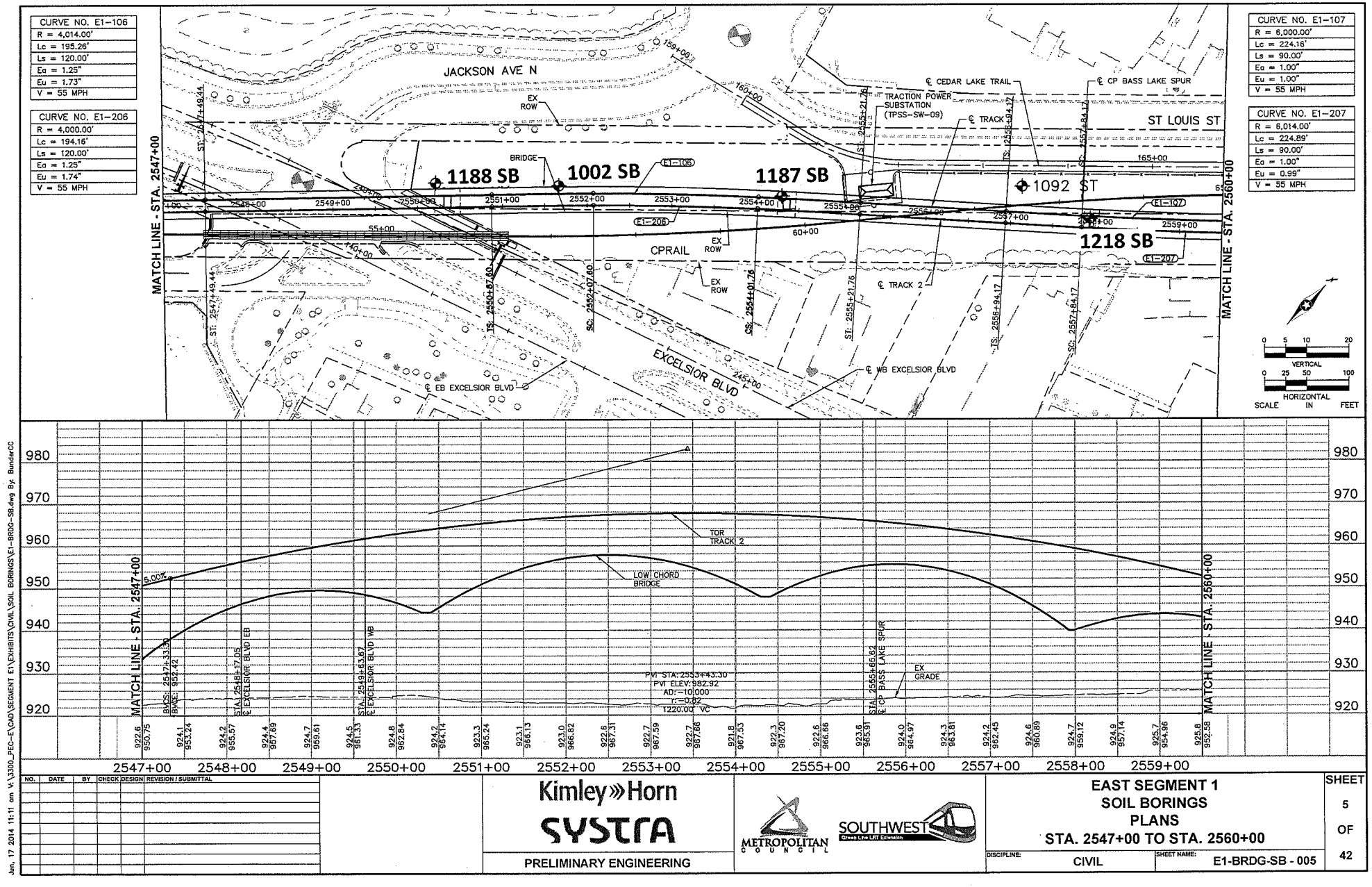

Figure 2 – Boring Locations, Central Portion

LRT Bridge over Excelsior Blvd.

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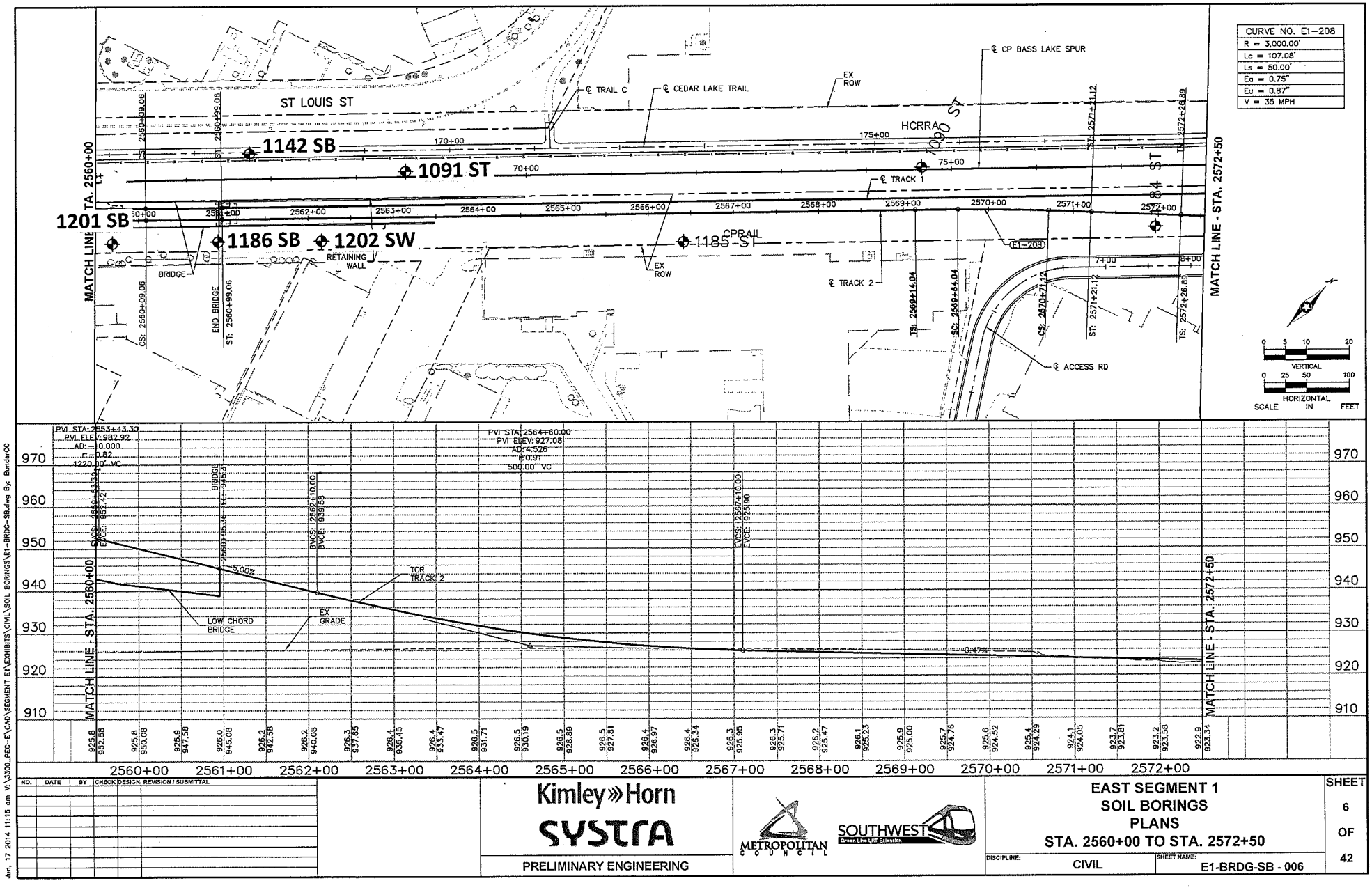

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SOUTHWEST Green Line LRT Extension

EAST SEGMENT 1
SOIL BORINGS
PLANS
STA. 2560+00 TO STA. 2572+50

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Figure 3 – Boring Locations, East Portion
LRT Bridge over Excelsior Blvd.
AET No. 01-05697.08

Figure 4.1 – *DRIVEN* Analysis, HP12x53 Piles

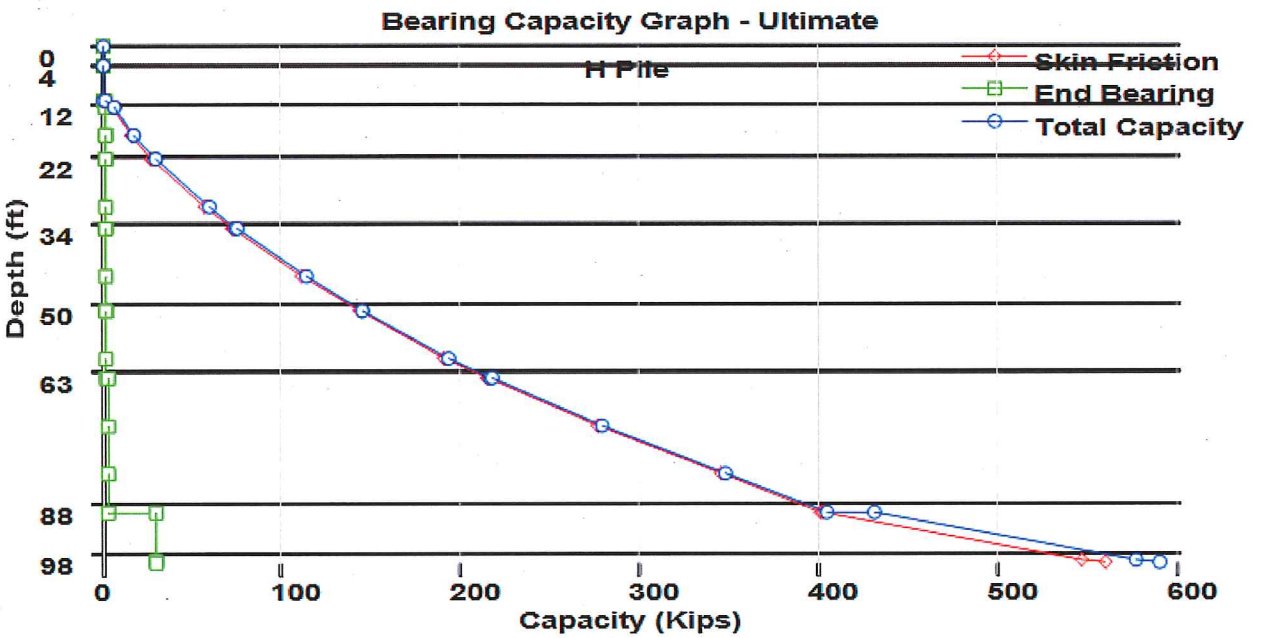

Figure 4.2 – *DRIVEN* Analysis, HP14x117 Piles

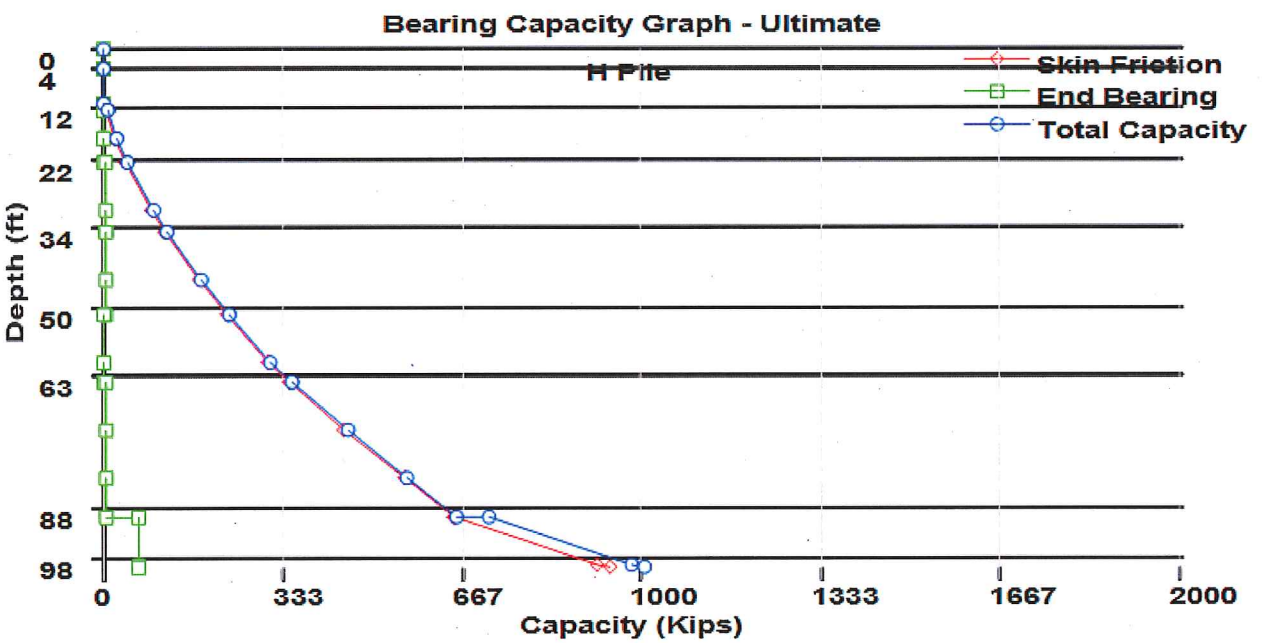

Figure 4 *DRIVEN* Analyses, Boring 1188 SB
LRT Bridge Over Excelsior Blvd, Southwest LRT
AET No. 01-05697.08

Figure 5.1 – *DRIVEN* Analysis, HP12x53 Piles

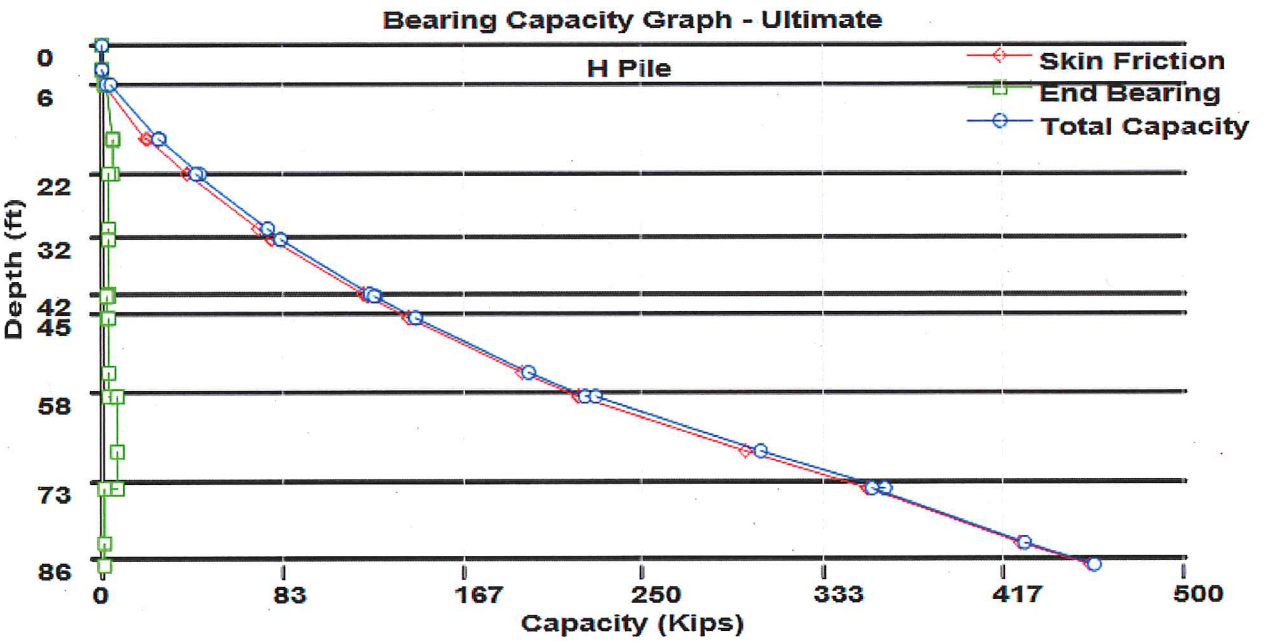

Figure 5.2 – *DRIVEN* Analysis, HP14x117 Piles

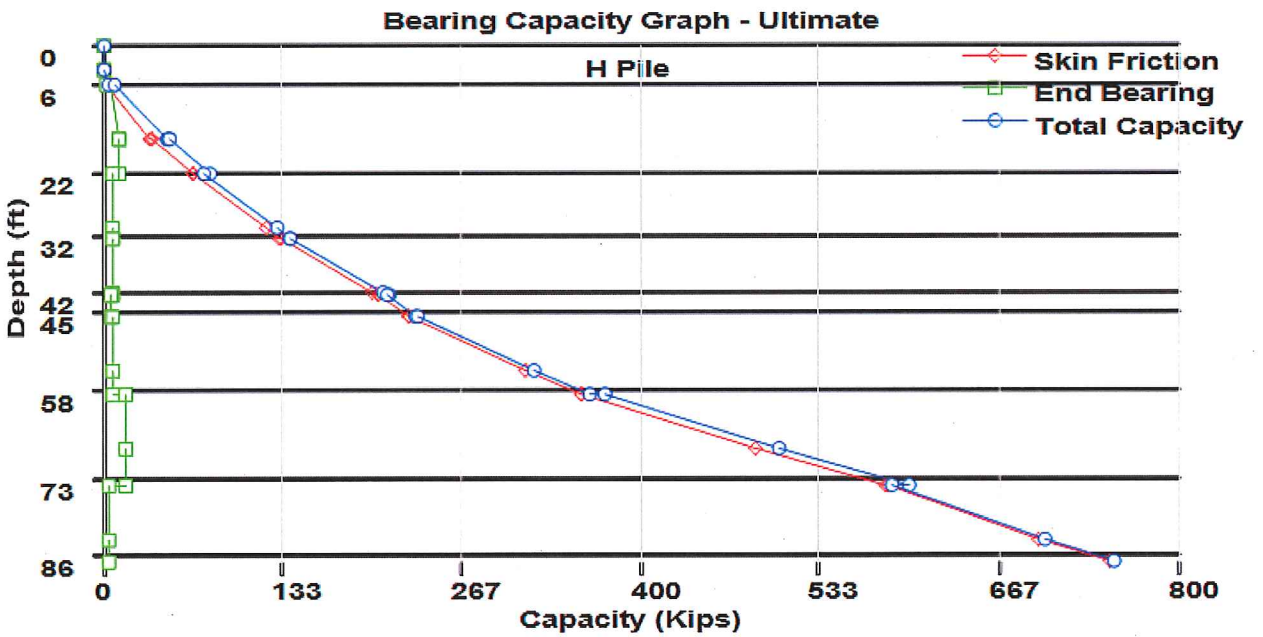

Figure 5 *DRIVEN* Analyses, Boring 1190 SB
LRT Bridge Over Excelsior Blvd, Southwest LRT
AET No. 01-05697.08

Figure 6.1 – *DRIVEN* Analysis, HP12x53 Piles

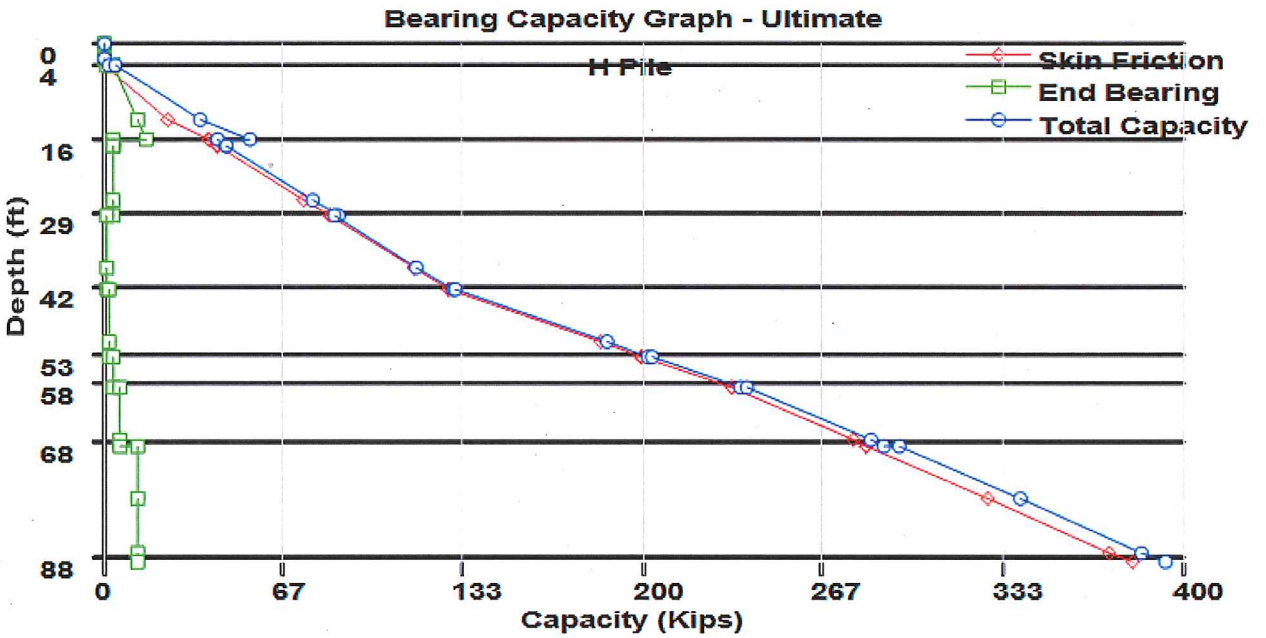

Figure 6.2 – *DRIVEN* Analysis, HP14x117 Piles

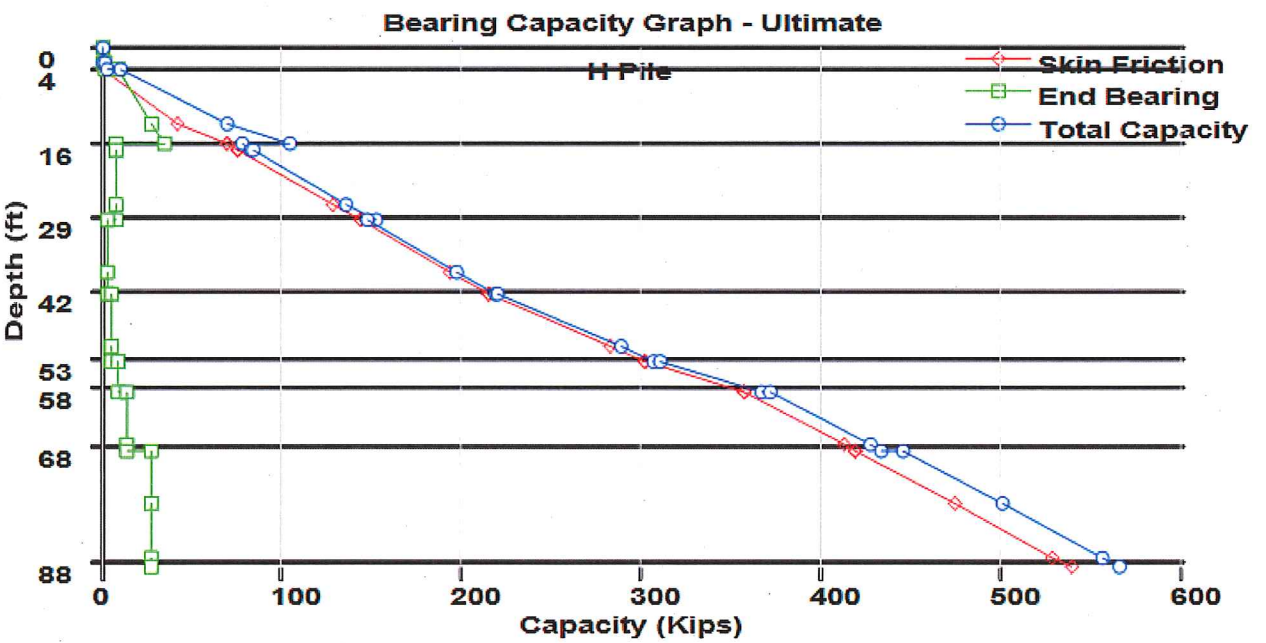

Figure 6 *DRIVEN* Analyses, Boring 1218 SB
LRT Bridge Over Excelsior Blvd, Southwest LRT
AET No. 01-05697.08

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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1001 SB**	**921.5** (Surveyed)

Location , , **ft. LT**

Co. Coordinate: X=496364 Y=148539 (ft.)

Latitude (North)=44.9242352 Longitude (West)=-93.3973700

Drill Machine **85C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed **3/21/13**

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
0	0.0 / 921.5		Mixture of silty sand and sand with silt, with gravel and organic fines, a little clayey sand, trace roots, dark brown, frozen (A-2-4, A-1-b) fill		26					Hammer Calibration: 66% efficiency with 105 lb hammer, 10/31/12
5	6.5 / 915.0		ORGANIC CLAY, black, firm (OL/OH) (A-7-6) topsoil		43					
	9.0 / 912.5		SANDY LEAN CLAY, a little gravel, brown, lenses of silty sand (CL) (A-6) alluvium		5	50				Organic Content = 7.4%
10	10.0 / 911.5		SAND WITH SILT AND GRAVEL, fine to medium grained, brown (SP-SM) alluvium			23	275	132		
	11.5 / 910.0		SAND, a little gravel, medium to fine grained, brown, moist, medium dense to loose, laminations of sandy lean clay (SP) (A-1-b) alluvium		15					
15	16.5 / 905.0		GRAVELLY SAND WITH SILT, medium to fine grained, waterbearing, loose (SP-SM) (A-1-b) alluvium		8					Water level measured at 17.7' deep with HSA to 19.5' deep
	19.0 / 902.5		SAND WITH SILT, a little gravel, medium to fine grained, brown, waterbearing, medium dense (SP-SM) (A-1-b) alluvium		10					
20	21.5 / 900.0		CLAYEY SAND, a little gravel, grayish brown, very stiff (SC/SM) (A-2-4) till		16					
	24.0 / 897.5				16					
25					26					
					13					
30			SILTY SAND, a little gravel, brown to grayish brown, medium dense to loose, lenses of clayey sand (SM/SC) (A-2-4) till		10					
					7					
35						9	320	143		
					6					
40					5					

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

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1001 SB**	**921.5** *(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
45					6					
					6					
					6					
50					11					
				PD						
55					22					
			SILTY SAND, a little gravel, brown to grayish brown, medium dense to loose, lenses of clayey sand (SM/SC) (A-2-4) till *(continued)*	PD						
60					9					
				PD						
65					20					
				PD						
70					24					
	73.0 / 848.5			PD						
75			SILTY SAND WITH GRAVEL, grayish brown, dense, lenses of clayey sand (SM/SC) till		32					
	78.0 / 843.5			PD						
80			CLAYEY SAND WITH GRAVEL, possible cobble at 86', brown, very stiff to hard (SC) (A-6) till		18	11				
				PD						

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

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AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1001 SB**	**921.5** *(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
85		CLAYEY SAND WITH GRAVEL, possible cobble at 86', brown, very stiff to hard (SC) (A-6) till *(continued)*	PD	33					
			PD	100/.1					
88.5 833.0		Top of Bedrock LIMESTONE, weathered, gray							PLATTEVILLE FORMATION
88.6 832.9		**END OF BORING**							

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

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

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U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1002 SB**	**923.8** *(Surveyed)*

Location , , **ft. LT**

Co. Coordinate: X=496936 Y=148811 (ft.)

Latitude (North)=44.9249815 Longitude (West)=-93.3951620

Drill Machine **85C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed **3/21/13**

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
	2.0 / 921.8		Mixture of sandy lean clay and silty sand, with gravel, trace roots, brown and dark brown, frozen (A-6, A-4) fill			24				Hammer Calibration: 66% efficiency with 105 lb hammer, 10/31/12
	4.0 / 919.8		Sand with silt and gravel, brown (A-2-4/A-1-b) fill		45					
5	6.5 / 917.3		SAND WITH GRAVEL, fine to medium grained, light brown, moist, dense (SP) (A-1-b) alluvium or fill		33					
			GRAVELLY SAND WITH SILT, apparent cobble at 8', fine to medium grained, brown, moist, dense to medium dense (SP-SM) (A-1-b) alluvium or fill		36					
10	11.5 / 912.3		GRAVELLY SAND, medium to fine grained, light brown, moist, medium dense (SP) (A-1-b) alluvium		22					
	14.0 / 909.8		CLAYEY SAND, a little gravel, brown, very stiff (SC) (A-2-4) till		23					
15					22	8				
	19.0 / 904.8		SILTY SAND, a little gravel, brown, medium dense (SM/SC) (A-2-4) till		16	11				
20	21.5 / 902.3		SILTY SAND, a little gravel, brown, medium dense to loose, lenses of clayey sand (SM/SC) (A-2-4) till		12					Water level measured at 22.5' deep with HSA to 24.5' deep (rose from 24.2' deep 15 minutes earlier)
▼					20					
25					8					
					9					
30					9					
	31.5 / 892.3		SAND, a little gravel, medium to fine grained, brown, waterbearing, very loose to medium dense (SP) (A-1-b) alluvium		3					
35					20					
	36.5 / 887.3		SAND WITH SILT, fine grained, brown, waterbearing, medium dense (SP-SM) (A-3) alluvium		22	8				
40					28	11				
	41.5									

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

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

METROPOLITAN COUNCIL

MINNESOTA DEPARTMENT OF TRANSPORTATION

AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1002 SB**	**923.8** *(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
45	882.3		SAND, fine to medium grained, brown, waterbearing, medium dense to dense (SP) (A-3) alluvium *(continued)*		30 / 35 / 40					
50	49.0 / 874.8		SAND WITH SILT, fine grained, brown, waterbearing, dense (SP-SM) (A-3) alluvium		40					
55	52.5 / 871.3		SAND, fine to medium grained, brown, waterbearing, very dense to dense (SP) (A-3) alluvium	PD	54					
60					43					
65	62.5 / 861.3		SAND, medium to fine grained, brown, waterbearing, dense (SP) (A-1-b) alluvium	PD	50					
70	68.0 / 855.8		SAND, medium grained, brown, waterbearing, medium dense (SP) (A-1-b) alluvium	PD	30					
75	73.0 / 850.8		LEAN CLAY, brownish gray mottled, hard, laminations of fat clay (CL/CH) (A-7-6) alluvium	PD	40	19				
80	78.0 / 845.8		SILTY SAND, grayish brown, loose (SM/SC) (A-2-4) alluvium	PD	7					
	82.5 / 841.3		GRAVELLY SILTY SAND, brown, very dense, lenses of lean clay and sand with silt (SM) (A-2-4) alluvium	PD						

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1002 SB**	**923.8** *(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
85			GRAVELLY SILTY SAND, brown, very dense, lenses of lean clay and sand with silt (SM) (A-2-4) alluvium *(continued)*	PD	100					
90				PD	90					
	93.0 / 830.8			PD						
95			SILTY SAND, a little gravel, brown, dense, a lens of clayey sand (SM/SC) (A-2-4) alluvium		35					
	97.5 / 826.3		Top of Bedrock	PD						PLATTEVILLE FORMATION
	99.6 / 824.2		LIMESTONE, weathered, gray END OF BORING		100/.1					

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

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1091 ST**	**925.4** *(Surveyed)*

Location **, , ft. LT**

Co. Coordinate: X=497970 Y=149310 (ft.)

Latitude (North)=44.9263504 *Longitude (West)=-93.3911704*

Drill Machine **1C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 1

Drilling Completed **6/28/13**

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
	2.0 923.4		Gravelly silty sand, a little silty sand with organic fines, trace roots, dark brown and black (A-1-b) fill		15					Hammer Calibration: 66% efficiency with 105 lb. hammer, 9/18/13
	4.5		SAND WITH GRAVEL, medium grained, light brown, moist, medium dense (SP) (A-1-b) alluvium or fill		21					
5	920.9		SAND, a little gravel, fine to medium grained, light grayish brown to light brown, a little brown, moist, medium dense, laminations of silt (SP) (A-3) alluvium		23					
	9.5				13					
10	915.9 12.0		SAND WITH GRAVEL, medium to fine grained, brown, moist, medium dense, laminations of silt (SP) (A-1-b) alluvium		20					
	913.4		GRAVELLY SAND, medium grained, grayish brown to brown, moist, medium dense (SP) (A-1-b) alluvium		14					
15	17.0				21					
	908.4		CLAYEY SAND, a little gravel, brown, stiff to very stiff (SC/SM) (A-2-4) till		14	10				
20	21.0				22	10				
	904.4		**END OF BORING**							

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

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1141 SB**	**921.6** (Surveyed)

Location **, , ft. LT**

Co. Coordinate: X=496181 Y=148458 (ft.)

Latitude (North)=44.9240130 Longitude (West)=-93.3980765

Drill Machine **85C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed **9/11/13**

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
	0.4 921.2		Silty sand with organic fines, trace roots, dark brown (A-2-4) fill		18					Hammer Calibration: 66% efficiency with 105 lb hammer, 10/31/12
	4.0 917.6		Mixture of silty sand, sand with silt and clayey sand, with gravel, pieces of bituminous, black, brownish gray and brown (A-1-b, A-6) fill		10	9				
5	6.5 915.1		SAND WITH SILT AND GRAVEL, possible cobbles, fine to medium grained, brown, moist, medium dense (SP-SM) (A-1-b) alluvium or fill		14					
	9.0 912.6		SAND WITH GRAVEL, possible cobbles, fine to medium grained, light brown, moist, medium dense (SP) (A-1-b) alluvium or fill		18					
10	11.5 910.1		GRAVELLY SAND WITH SILT, medium to fine grained, light brown to brown, moist, dense (SP-SM) (A-1-b) alluvium		45					
	14.0 907.6		SANDY LEAN CLAY, a little gravel, brownish gray, stiff (CL) (A-6) till		13	19				
15	16.5 905.1		SILTY SAND, a little gravel, brown, medium dense (SM) (A-2-4) till		18					
▼	19.0 902.6		CLAYEY SAND, a little gravel, brown, stiff, laminations of sand (SC/SM) (A-2-4) till		12	12				Water level measured at 16.4' deep with HSA to 19.5' deep (rose from 19.0' deep 5 minutes earlier)
20					11	12				
					11	10				
25					11	11				
			CLAYEY SAND, a little gravel, brown to grayish brown, stiff, laminations of sand (SC) (A-2-6) till		14	11				
30					10	10				
					9	11				
35					9	12				
	36.5 885.1		CLAYEY SAND, a little gravel, grayish brown, very stiff, laminations of sand (SC) (A-6) till		17	15				
	39.0 882.6		SAND, a little gravel, medium grained, brown, waterbearing,							
40	40.5 881.1		loose (SP) (A-1-b) alluvium SILTY SAND, a little gravel, brown, loose (SM/SC) (A-2-4)		8					

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

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1141 SB**	**921.6** *(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
	41.5 880.1		till SAND WITH SILT, fine grained, grayish brown, waterbearing, loose (SP) (A-3) alluvium *(continued)*		5					
	44.0 877.6		GRAVELLY CLAYEY SAND, possible cobble, brown, hard (SC) (A-2-6) till	PD	88	15				
45	46.5 875.1		GRAVELLY SAND WITH SILT, medium to fine grained, brown, waterbearing, dense (SP-SM) (A-1-b) alluvium	PD	40					
	49.0 872.6		SAND, medium to fine grained, brown, waterbearing, very dense (SP) (A-1-b) alluvium	PD	77					
50	53.0 868.6		SAND WITH GRAVEL, medium to fine grained, brown, waterbearing, dense (SP) (A-1-b) alluvium	PD	41					
55	58.0 863.6		SAND WITH SILT, fine grained, brown, waterbearing, very dense (SP-SM) (A-3) alluvium	PD	*					*43/.5 + 57/.5 + 43/.4
60	63.0 858.6		SAND, a little gravel, medium to fine grained, brown, waterbearing, dense to medium dense, lenses of clayey sand below 69' (SP) (A-1-b) alluvium	PD	43					
65				PD	30					
70	73.0 848.6		SAND, fine grained, light grayish brown, waterbearing, medium dense, lenses of silty sand (SP) (A-3) alluvium	PD	27					
75	78.0 843.6		CLAYEY SAND, a little gravel, brown, stiff, laminations of silty sand (SC/SM) (A-2-6) till	PD	9					
80	83.0 838.6			PD						

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1141 SB**	**921.6** *(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
85	85.6 836.0		SAND, a little gravel, medium grained, brown, waterbearing, medium dense (SP) (A-1-b) alluvium *(continued)* Top of Bedrock	PD	83					N-value: 15/.5 + 15/.5 + 68/.5 PLATTEVILLE FORMATION
			LIMESTONE, weathered, light brownish gray	PD						
	89.0 832.6		LIMESTONE, light brownish gray, fossiliferous Weathering: Slightly weathered Fracturing: Very fractured Stratification: Thinly bedded Hardness: Hard		63	8				
90	93.0 828.6		LIMESTONE, brownish gray, argillaceous Weathering: Slightly to moderately weathered Fracturing: Very fractured Stratification: Thickly bedded Hardness: Hard		40	23				
95	98.2 823.4		LIMESTONE, light gray and gray, crinkley bedded Weathering: Fresh Fracturing: Moderately fractured Stratification: Very thinly bedded Hardness: Hard to very hard							
	99.0 822.6		**END OF BORING**							

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

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AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1142 SB**	**925.1** (Surveyed)

Location , , **ft. LT**

Co. Coordinate: X=497795 Y=149252 (ft.)

Latitude (North)=44.9261912 Longitude (West)=-93.3918460

Drill Machine **85C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed **9/3/13**

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
			Mixture of silty sand and sand with silt, with gravel, trace roots, brown, dark brownish gray and light brown (A-1-b) fill		25 / 68					Hammer Calibration: 66% efficiency with 105 lb hammer, 10/31/12
	4.0 / 921.1		SAND, a little gravel, medium grained, light brown, moist, medium dense (SP) (A-1-b) alluvium or fill		24					
5	6.5 / 918.6		GRAVELLY SAND, medium grained, light brown, moist, medium dense (SP) (A-1-b) alluvium or fill		16					
	9.0 / 916.1		SAND WITH GRAVEL, medium grained, brown, moist, medium dense (SP) (A-1-b) alluvium or fill		12					
10	11.5 / 913.6		SAND, fine grained, light brown, moist, medium dense (SP) (A-3) alluvium		12					
	14.0 / 911.1		SAND WITH GRAVEL, medium grained, brown, moist, medium dense (SP) (A-1-b) alluvium		16					
15	15.5 / 909.6		SILTY SAND, a little gravel, brown, medium dense, lenses and laminations of clayey sand (SM) (A-2-4) till		16					
	19.0 / 906.1		CLAYEY SAND, a little gravel, brown, stiff (SC/SM) (A-2-6) till		11	10				
20					9	11				
25					15	11				
	26.5 / 898.6		CLAYEY SAND, a little gravel, brown, stiff (SC) (A-6) till		10	11				
30					11	12				Water level measured at 30.5' deep with HSA to 32' deep
	31.5 / 893.6		CLAYEY SAND, a little gravel, grayish brown, firm, laminations of wet silty sand (SC/SM) (A-2-6) till		8	11				
	34.0 / 891.1		LEAN CLAY, grayish brown, firm (CL) (A-4) alluvium	PD	8	23				
35	36.5 / 888.6		CLAYEY SAND, a little gravel, brown, stiff (SC/SM) (A-2-6) till	PD	10	12				
	40.0 / 885.1		SAND, fine grained, grayish brown, waterbearing, medium dense to dense (SP) (A-3) alluvium	PD	21	14				
40										

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

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1142 SB**	**925.1** (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
45	46.5 878.6		SAND, fine grained, grayish brown, waterbearing, medium dense to dense (SP) (A-3) alluvium *(continued)*	PD	46					
				PD	48					
50	53.0 872.1		SAND, fine to medium grained, grayish brown, waterbearing, dense (SP) (A-3) alluvium	PD	38					
				PD	37					
55	57.5 867.6		SAND, medium to fine grained, grayish brown, waterbearing, dense (SP) (A-1-b) alluvium	PD	48					
60			SAND, fine grained, grayish brown, waterbearing, dense (SP) (A-3) alluvium	PD	43					
				PD						
65	68.0 857.1			PD	33					
70	73.0 852.1		SAND, medium to fine grained, grayish brown, waterbearing, medium dense (SP) (A-1-b) alluvium	PD	30					
75	78.5 846.6		SAND, fine to medium grained, grayish brown, waterbearing, dense (SP) (A-3) alluvium	PD	36					
80	83.0 842.1		GRAVELLY SAND, medium to coarse grained, grayish brown, waterbearing, dense (SP) (A-1-b) alluvium	PD	43					

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1142 SB**	**925.1** *(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
85			SAND, a little gravel, medium grained, brown, waterbearing, dense (SP) (A-1-b) alluvium *(continued)*	PD	33					
	89.0		Top of Bedrock							
	836.1		LIMESTONE, weathered, gray		100/.05					
90	89.4		LIMESTONE, light gray and light grayish brown, fossiliferous Weathering: Slightly weathered Fracturing: Very to moderately fractured Stratification: Thinly bedded Hardness: Hard		97 / 100	0 / 42				PLATTEVILLE FORMATION
	835.7									
	94.7									
	830.4		**END OF BORING**							

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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1186 SB**	**924.7** (Surveyed)

Location , , **ft. LT**

Co. Coordinate: X=497805 Y=149142 (ft.)

Latitude (North)=44.9252695 Longitude (West)=-93.3942278

Drill Machine **68C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed **5/20/14**

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
			Silty sand with gravel, brown (A-1-b) fill		20					Hammer Calibration: 68% efficiency with 110 lb. hammer, 6/9/14
					10					
	4.0 / 920.7									
5			LEAN CLAY WITH SAND, trace roots, brown, a little dark brown, soft (CL) (A-6) alluvium or fill		4	24				
	6.5 / 918.2									
			SAND WITH SILT AND GRAVEL, medium to fine grained, brown, moist, medium dense (SP-SM) (A-1-b) alluvium		19					
10					26					
					27					
	14.0 / 910.7									
15			SAND WITH SILT, a little gravel, fine to medium grained, brown, waterbearing, medium dense, lens of clayey sand at 18' (SP-SM) (A-3) alluvium		24					
▼					23					Water level measured at 17.8' deep with HSA to 19.5' deep
	19.0 / 905.7									
20			GRAVELLY SAND, medium to coarse grained, brown, waterbearing, medium dense (SP) (A-1-b) alluvium		30					
	21.5 / 903.2			PD						
			SAND WITH SILT AND GRAVEL, medium to fine grained, brown, waterbearing, medium dense to loose (SP-SM) (A-1-b) alluvium		27					
				PD						
25					26					
				PD						
					10					No recovery
	29.0 / 895.7			PD						
30			CLAYEY SAND, a little gravel, brown to gray, firm to hard (SC/SM) (A-2-4) till		6	12				
				PD						
					10	13				
				PD						
35					8	13				
				PD						
					16					No recovery
	39.0 / 885.7			PD						
40			CLAYEY SAND, a little gravel, brown, hard (SC) (A-6) till		34	10				
	41.5			PD						

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

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1186 SB**	**924.7** (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
	883.2		SILTY SAND, a little gravel, brown, dense (SM/SC) (A-2-4) till *(continued)*							
	44.0			PD	33	12				
45	880.7		CLAYEY SAND, a little gravel, brown, very stiff to stiff (SC/SM) (A-2-4) till	PD	16	12				
	49.0			PD	15	11				
50	875.7		SILTY SAND WITH GRAVEL, gray, wet, dense (SM/SC) (A-2-4/A-1-b) till	PD	41					
55				PD	49					
	58.0			PD						
	866.7		SANDY LEAN CLAY, a little gravel, gray, hard, laminations of silty sand (CL) (A-6) till		37	14				
	63.0			PD						
	861.7		SAND WITH SILT, a little gravel, fine to medium grained, brownish gray, waterbearing, medium dense (SP-SM) (A-2-4) alluvium		21					
65				PD						
	68.0			PD						
	856.7		SANDY LEAN CLAY, a little gravel, gray, hard (CL) (A-6) till		31	16				
70				PD						
	73.0			PD						
	851.7		SILTY SAND, a little gravel, brown, gray, dense (SM) (A-2-4) till		32					
75				PD						
	78.0			PD						
	846.7		SAND WITH SILT, a little gravel, fine grained, gray, waterbearing, dense (SP-SM) alluvium		54					
80				PD						

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1186 SB**	**924.7** *(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
85		SAND WITH SILT, a little gravel, fine grained, gray, waterbearing, dense (SP-SM) alluvium *(continued)*	PD	46					
88.3 / 836.4		Top of Bedrock	PD						PLATTEVILLE FORMATION
90		LIMESTONE, weathered, light brown to gray		100/.1					
94.6 / 830.1		**END OF BORING**	PD	100/.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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1187 SB**	**923.2** *(Surveyed)*

Location **, , ft. LT**

Co. Coordinate: X=497178 Y=148916 (ft.)

Latitude (North)=44.9248141 *Longitude (West)=-93.3956716*

Drill Machine **68C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed **5/20/14**

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
			Silty sand with gravel, pieces of glass, trace roots, dark brown to brown (A-1-b) fill		23					Hammer Calibration: 68% efficiency with 110 lb. hammer, 6/9/14
	4.0 / 919.2				21					
5			LEAN CLAY, dark brown, a little brown, firm to stiff (CL) (A-6) alluvium or fill		7	23				
					11	22				
10					12	18				
	11.5 / 911.7		SAND WITH SILT, a little gravel, fine to medium grained, brown, medium dense (SP-SM) (A-1-b) alluvium		22					
	14.0 / 909.2		SAND WITH GRAVEL, medium to fine grained, light brown, moist, medium dense (SP) (A-1-b) alluvium		20					
15 ▼	16.5 / 906.7		GRAVELLY SILTY SAND, medium to fine grained, brown, wet, medium dense (SM) (A-1-b) alluvium		27					Water level measured at 16.5' deep with HSA to 17' deep
	19.0 / 904.2		SAND WITH SILT AND GRAVEL, medium grained, brown, waterbearing, medium dense (SP-SM) (A-1-b) alluvium	PD	16					
20	21.5 / 901.7		SAND, a little gravel, medium grained, brown, waterbearing, medium dense (SP) (A-1-b) alluvium	PD	25					
	24.0 / 899.2		SAND, a little gravel, medium to fine grained, brown, waterbearing, medium dense (SP) (A-1-b) alluvium	PD	29					
25	26.5 / 896.7		SAND WITH GRAVEL, medium to fine grained, brown, waterbearing, dense (SP) (A-1-b) alluvium	PD	34					
	29.0 / 894.2		SAND, fine to medium grained, brown, waterbearing, medium dense (SP) (A-3) alluvium	PD	36					
	31.5 / 891.7		SAND WITH GRAVEL, medium to fine grained, brown, waterbearing, very dense (SP) (A-1-b) alluvium	PD	53					
	34.5 / 888.7				7					
35			No samples recovered (gravelly)	PD	7					
				PD	7					
40	42.0			PD						

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

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1187 SB**	**923.2** (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
45	881.2 44.5 878.7		GRAVELLY CLAYEY SAND, brown, firm (SC/SM) (A-2-4/A-1-b) till	PD	5	13				
				PD	3					
				PD	3					
50				PD	12					
			No samples recovered (gravelly)	PD						
55					27					
	58.0 865.2			PD						
60					8	11				
				PD						
65					10					
				PD						
70			CLAYEY SAND, a little gravel, brownish gray, firm to very stiff, laminations of sand at 80' (SC/SM) (A-2-4) till		21					
				PD						
75					11					
				PD						
80					20					
				PD						

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1187 SB**	**923.2** (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
85	85.0 838.2			PD	22					
				PD	100/.1					
90			GRAVEL, grayish brown, waterbearing, very dense (GP) (A-1-a) alluvium or colluvium	PD						
	94.5		Top of Bedrock		100/.1					
95	828.7		LIMESTONE, weathered, gray and grayish brown	PD						PLATTEVILLE FORMATION
	99.6 823.6		END OF BORING		100/.1					

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

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1188 SB**	**923.4** *(Surveyed)*

Location **, , ft. LT**

Co. Coordinate: X=496804 Y=148750 (ft.)

Latitude (North)=44.9243861 *Longitude (West)=-93.3969454*

Drill Machine **91C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed **5/12/14**

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} (%) REC	MC (%) RQD	COH (psf) ACL	γ (pcf) Core Breaks	Soil / Rock	Other Tests Or Remarks / Formation or Member
	0.5 922.9		Clayey sand, with organic fines, a little gravel, trace roots, dark brown (A-6) fill		40	17				Hammer Calibration: 68% efficiency with 110 lb. hammer, 5/27/14
	4.0 919.4		Mixture of silty sand with gravel and sand with silt, a little clayey sand with organic fines, brown, a little black and dark brown (A-1-b) fill		19					
5	6.5 916.9		SANDY LEAN CLAY, dark brown, a little black, stiff, laminations of silty sand (CL) (A-6) alluvium		10	26				
	11.5 911.9		LEAN CLAY, dark brown to brown, stiff to very stiff, laminations of silt (CL) alluvium		11	30				
10	12.5 910.9		SAND WITH SILT AND GRAVEL, medium to fine grained, brown, moist, medium dense (SP-SM) (A-1-b) alluvium		19	19				
	14.0 909.4		SAND WITH SILT, fine grained, brown, moist, medium dense (SP-SM) (A-3) alluvium		12					
15	16.5 906.9		SAND WITH SILT AND GRAVEL, medium to fine grained, brown, moist, loose, laminations of silty sand (SP-SM) (A-1-b) alluvium		8					
▼			SAND WITH SILT, a little gravel, medium to fine grained, brown, waterbearing, very loose to loose (SP-SM) alluvium		3					Water level measured at 17.0' deep with HSA to 19.5' deep
20	21.5 901.9		CLAYEY SAND, a little gravel, brown, stiff (SC/SM) (A-2-4) till		5					
					12	11				
25					12	9				
					16					No recovery
30	31.5 891.9		CLAYEY SAND WITH GRAVEL, brown, very stiff (SC/SM) (A-2-4) till		12	12				
	34.5 888.9		SAND WITH GRAVEL, medium grained, brown to light brownish gray, waterbearing, very loose (SP) (A-1-b) alluvium		16	12				
35					1					
	39.0 884.4		SAND, a little gravel, medium grained, light grayish brown, a little gray, waterbearing, medium dense, lenses of lean clay (SP) (A-1-b) alluvium	PD PD PD	18 17					
40										

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

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1188 SB**	**923.4** *(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
	44.0 / 879.4				15					
45	46.5 / 876.9		SAND WITH GRAVEL, medium to coarse grained, light grayish brown, waterbearing, medium dense (SP) (A-1-b) alluvium	PD	13					
			SAND, a little gravel, medium grained, light grayish brown, a little brown, waterbearing, medium dense, a lens of clayey sand (SP) (A-1-b) alluvium	PD	16					
50	50.0 / 873.4			PD	15					No recovery
55			CLAYEY SAND, a little gravel, brown, stiff (SC/SM) (A-2-4) till	PD	12	14				
60				PD	19	17				
	63.0 / 860.4			PD						
65			SAND WITH SILT, medium to fine grained, grayish brown, waterbearing, medium dense (SP-SM) (A-1-b) alluvium	PD	20					
	68.0 / 855.4			PD						
70			SAND, a little gravel, medium grained, brown, waterbearing, medium dense (SP) (A-1-b) alluvium	PD	21					
	73.0 / 850.4			PD						
75			SAND WITH SILT, fine to medium grained, brown, waterbearing, medium dense (SP-SM) (A-3) alluvium	PD	22					
	78.0 / 845.4			PD						
80			No recovery. Driller described as gravelly.	PD	47					

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1188 SB**	**923.4** *(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
85			No recovery. Driller described as gravelly. *(continued)*	PD	25					
	88.0 835.4			PD						
90			SILTY SAND, brown, very dense, laminations of sand (SM) (A-2-4) till		76					
				PD						
95			*52/.5 + 100/.1		*					
	97.8 825.6		Top of Bedrock	PD						
	99.5 823.9		LIMESTONE, weathered, gray		138/.1					PLATTEVILLE FORMATION
100			LIMESTONE, generally fresh	WS						
				WS	100/0					
				WS						
	104.5 818.9		**END OF BORING**		100/0					

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

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1189 SB**	**922.3** (Surveyed)

Location , , **ft. LT**

Co. Coordinate: X=496474 Y=148594 (ft.)

Latitude (North)=44.9238539 Longitude (West)=-93.3977946

Drill Machine **91C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed **5/8/14**

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
			Mixture of silty sand and sand, a little gravel, trace roots, pieces of brick, ash/cinders, dark brown, a little brown (A-2-4) fill		25 / 18					Hammer Calibration: 68% efficiency with 110 lb. hammer, 5/27/14
	4.0 / 918.3		Mixture of clayey sand and silty sand, a little gravel, dark brown and brown (A-6) fill		12	16				
5	6.5 / 915.8		LEAN CLAY WITH SAND, black and dark brown, a little brown, firm, laminations of sand (CL) (A-6) alluvium		5	28				
	9.0 / 913.3		LEAN CLAY, grayish brown, a little brown, firm, laminations of sandy silt (CL) (A-6) alluvium		6	28				
10	11.5 / 910.8		SAND, a little gravel, medium to fine grained, brown, moist, loose (SP) (A-1-b) alluvium		8					
	14.0 / 908.3		SAND, fine to medium grained, light grayish brown, moist to waterbearing, loose to waterbearing (SP) (A-3) alluvium		7					Water level measured at 15.7' deep with HSA to 19.5' deep
▼15	16.5 / 905.8		SAND WITH SILT AND GRAVEL, medium grained, dark brown, waterbearing, very loose (SP-SM) (A-1-b) alluvium		3					
	19.0 / 903.3		GRAVEL WITH SILT AND SAND, brown, waterbearing, medium dense (GP-GM) (A-1-b) alluvium		16					
20	21.5 / 900.8				12	12				
					13	11				
25					17	11				
					14	13				
30			CLAYEY SAND, a little gravel, brown, stiff to very stiff to firm, laminations of waterbearing sand (SC/SM) (A-2-4) till		7	11				
					7	13				
35					5	12				
					5	13				
40										

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

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1189 SB**	**922.3** *(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
45			CLAYEY SAND, a little gravel, brown, stiff to very stiff to firm, laminations of waterbearing sand (SC/SM) (A-2-4) till *(continued)*		5	13				
				PD	4	13				
					7	11				
				PD						
50					8	14				
				PD						
55					8	12				
				PD						
60					9	12				
				PD						
65					20					No recovery
				PD						
70	70.0 / 852.3		SAND, a little gravel, medium grained, grayish brown, waterbearing, dense (SP) (A-1-b) alluvium		35					
	73.0 / 849.3			PD						
75			CLAYEY SAND, a little gravel, brown, very stiff, laminations of waterbearing sand (SC/SM) (A-2-4) till		18	11				
				PD						
80					20	12				
				PD						

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

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

SHEET 3 of 3

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1189 SB**	**922.3** (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
85			CLAYEY SAND, a little gravel, brown, very stiff, laminations of waterbearing sand (SC/SM) (A-2-4) till *(continued)*	PD	11	12				
	88.0 834.3			PD						
90			CLAYEY SAND WITH GRAVEL, brown, hard (SC/SM) (A-2-4) till		33	11				
	92.0 830.3		Top of Bedrock	PD						PLATTEVILLE FORMATION
95			LIMESTONE, highly weathered, gray		47					
				PD						
100					31					
				PD						
	104.5				100/0					
105	817.8		LIMESTONE, generally fresh, gray	WS						
	109.5 812.8		**END OF BORING**		100/0					

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

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

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U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1190 SB**	**922.7** (Surveyed)

Location , , **ft. LT**

Co. Coordinate: X=496254 Y=148400 (ft.)

Latitude (North)=44.9238538 Longitude (West)=-93.3984586

Drill Machine **68C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed **5/15/14**

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
	2.0 920.7		Silty sand with gravel, trace roots, brown (A-2-4) fill		21	6				Hammer Calibration: 68% efficiency with 110 lb. hammer, 6/9/14
	4.0 918.7		Gravelly silty sand with organic fines, black (A-2-4) fill		6					
5	6.5 916.2		Sand with gravel, a little clayey sand with organic fines, brown, a little black (A-1-b) fill		4					
10	11.5 911.2		SAND WITH GRAVEL, medium grained, light brown, moist, medium dense (SP) (A-1-b) alluvium		13 19					
15 ▼	16.5 906.2		GRAVELLY SAND, medium to fine grained, light brown, moist, medium dense (SP) (A-1-b) alluvium		26 23					Water level measured at 15.8' deep with HSA to 17' deep
	19.0 903.7		SAND WITH GRAVEL, medium grained, light brown, waterbearing, medium dense (SP) (A-1-b) alluvium		13					
20	21.5 901.2		GRAVEL WITH SILT AND SAND, brown, waterbearing, medium dense (GP) (A-1-b) alluvium		25					
25			CLAYEY SAND, a little gravel, brown to grayish brown, very stiff to stiff (SC/SM) (A-2-4) till	PD PD PD PD PD PD PD PD	25 14 18 15 21 23 15	9 11 11 11 11 12 10				
40	39.0 883.7 41.5		CLAYEY SAND, a little gravel, grayish brown, very stiff, a lens of waterbearing sand (SC/SM) (A-2-4) till	PD PD	19	13				

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

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

SHEET 2 of 3

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1190 SB**	**922.7** (Surveyed)

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N60 (%)	MC (%)	COH (psf)	γ (pcf)	Soil	Other Tests Or Remarks
					REC (%)	RQD (%)	ACL (ft)	Core Breaks	Rock	Formation or Member
	881.2		CLAYEY SAND WITH GRAVEL, grayish brown, very stiff (SC) (A-6) till *(continued)*							
45	45.0 / 877.7			PD	23	10				
					22	9				
				PD						
					18					No recovery
				PD						
50			CLAYEY SAND, a little gravel, brownish gray to brown, very stiff, a lens of waterbearing sand at 45½' (SC/SM) (A-2-4) till		17	11				
				PD						
55					26	11				
	58.0 / 864.7			PD						
60					32	10				
				PD						
65			CLAYEY SAND WITH GRAVEL, brown, a little light grayish brown, hard, a lens of sand at 60' (SC/SM) (A-2-4) till		37	15				
				PD						
70					34					No recovery
	73.0 / 849.7			PD						
75					16					No recovery
			CLAYEY SAND WITH GRAVEL, brown, very stiff (SC/SM) (A-2-4) till	PD						
80					22	12				
				PD						

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

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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UNIQUE NUMBER

U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1190 SB**	**922.7** *(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
85	85.9 836.8		*8/.5 + 10/.5 + 50/.4 CLAYEY SAND WITH GRAVEL, brown, very stiff (SC/SM) (A-2-4) till *(continued)* Top of Bedrock	PD	*	14				PLATTEVILLE FORMATION
90	93.0 829.7		LIMESTONE, weathered, light brown	PD	50/.3					
95	96.0 826.7		LIMESTONE, highly weathered, gray **END OF BORING**	PD	80					

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

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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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**	**1191 SW**	**921.9** *(Surveyed)*

Location **, , ft. LT**

Co. Coordinate: X=496082 Y=148400 (ft.)

Latitude (North)=44.9230335 Longitude (West)=-93.4009445

Drill Machine **1C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 1

Drilling Completed **3/7/14**

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
	4.0 / 917.9		Gravelly silty sand, dark brown, frozen (A-1-b) fill							Hammer Calibration: 66% efficiency with 105 lb. hammer, 9/18/13
5	9.0 / 912.9		Mixture of sand with silt and sand, with gravel, a little clayey sand, pieces of concrete, brown, a little dark brown (A-1-b) fill		18 / 17					
10	11.5 / 910.4		SAND WITH GRAVEL, medium grained, light brown, moist, medium dense (SP) (A-1-b) alluvium or fill		30 / 35					
	14.0 / 907.9		SAND WITH GRAVEL, medium to fine grained, light brownish gray, moist, dense (SP) (A-1-b) alluvium							
15	16.5 / 905.4		SAND WITH SILT AND GRAVEL, medium to fine grained, brown, moist, dense (SP-SM) (A-1-b) alluvium		40 / 20					
▼	19.0 / 902.9		SAND WITH SILT, a little gravel, fine to medium grained, brown, a little dark brown, moist to waterbearing, medium dense (SP-SM) (A-3) (petroleum-type odor) alluvium							Water level measured at 17.9' deep with HSA to 22' deep (maintained level for 10 minutes)
20	21.5 / 900.4		SILTY SAND WITH GRAVEL, fine to medium grained, brown, wet, medium dense (SM) (A-2-4) alluvium		25 / 16					
25	26.5 / 895.4		SAND WITH SILT, a little gravel, fine to medium grained, brown, a little light brown, waterbearing, medium dense, laminations of sand (SP-SM) (A-3) alluvium		12 / 9					
	29.0 / 892.9		SILTY SAND, a little gravel, medium to fine grained, brown, wet, loose (SM) (A-1-b) alluvium							
30	34.0 / 887.9		CLAYEY SAND, a little gravel, brown, stiff to firm, a lens of silty sand around 30' (SC/SM) (A-2-4) alluvium		14 / 6					
35	36.5 / 885.4		SAND WITH GRAVEL, fine to medium grained, light brown, a little brown, waterbearing, medium dense, a lens of sand with silt (SP) (A-3) alluvium		13 / 12					
40	41.0 / 880.9		SAND WITH SILT, a little gravel, fine to medium grained, brown, moist, medium dense, lenses of clayey sand (SP-SM) (A-3, A-6) alluvium		13					
			END OF BORING							

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

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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**	**1200 SW**	**921.9** (Surveyed)

Location , , **ft. LT**

Co. Coordinate: X=496025 Y=148374 (ft.)

Latitude (North)=44.9257414 Longitude (West)=-93.3922397

Drill Machine **91C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 2

Drilling Completed **5/8/14**

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
	0.5 / 921.4		Sandy lean clay, a little gravel, trace roots, dark brown (A-6) fill		18					Hammer Calibration: 68% efficiency with 110 lb. hammer, 5/27/14
	2.0 / 919.9		Gravelly sand with silt, a little clayey sand, grayish brown, a little black (A-1-b) fill		7					
	4.0 / 917.9		Silty sand, a little ash/cinders, brown and black (A-2-4) fill							
5			Sand with gravel, light brown and brown (A-1-b) fill		16					
	9.0 / 912.9		Mixture of sand with silt, clayey sand and lean clay, brown and light gray (A-3, A-6) fill		16					
10	11.5 / 910.4		CLAYEY SAND, a little gravel, dark brownish gray, firm (SC) (A-6) till		13	18				
	14.0 / 907.9		GRAVELLY SAND WITH SILT, medium to fine grained, brownish gray to brown, moist to waterbearing, medium dense (SP-SM) (A-1-b) alluvium		5	17				
▼15					19					Water level measured at 15' with HSA to 17' (rose from 16' 10 minutes earlier)
	19.0 / 902.9		SAND WITH SILT, a little gravel, fine to medium grained, grayish brown, waterbearing, medium dense (SP-SM) (A-3) alluvium		11					
20	21.5 / 900.4		CLAYEY SAND, a little gravel, brown, a little light brown, very stiff, a lens of sand (SC/SM) (A-2-4) till		21					
	24.0 / 897.9		CLAYEY SAND, a little gravel, gray to brown, very stiff, a lens of silty sand (SC) (A-6) till		21	11				
25	26.5 / 895.4		SILTY SAND, a little gravel, fine to medium grained, brown, a little light brown, wet, medium dense, lenses and laminations of sand (SM) (A-2-4) alluvium		23	17				
	30.0 / 891.9		CLAYEY SAND, a little gravel, grayish brown, very stiff to soft, a lens of waterbearing sand with gravel at 45½' (SC/SM) (A-2-4) till		18					
30					16					
					4	12				
35					4	12				
					9	11				
40					5	12				

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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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**	**1200 SW**	**921.9** *(Surveyed)*

DEPTH	Depth / Elev.	Lithology	Classification	Drilling Operation	SPT N_{60} (%)	MC (%)	COH (psf)	γ (pcf)	Soil	Other Tests Or Remarks
					REC (%)	RQD (%)	ACL (ft)	Core Breaks	Rock	Formation or Member
45	46.0 875.9		CLAYEY SAND, a little gravel, grayish brown, very stiff to soft, a lens of waterbearing sand with gravel at 45½' (SC/SM) (A-2-4) till *(continued)* END OF BORING		5 8	12 11				

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

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

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U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1201 SB**	**924.5** *(Surveyed)*

Location **, , ft. LT**

Co. Coordinate: X=497693 Y=149088 (ft.)

Latitude (North)=44.9260322 Longitude (West)=-93.3913827

Drill Machine **91C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed

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		
	1.0 / 923.5		Wood chips, dark brown, fill		13					Hammer Calibration: 68% efficiency with 110 lb. hammer, 5/27/14
	2.0 / 922.5		Silty sand with gravel, dark brown (A-1-b) fill		13					
5	6.5 / 918.0		Sand with silt, a little gravel, brown (A-1-b) fill		10					
	9.0 / 915.5		Silty sand, a little gravel, zones with organic fines, pieces of wood, trace roots, brown and dark brown (A-2-4) fill		3					
10	11.5 / 913.0		Silty sand with gravel, brown (A-1-b) fill		7					
15			SAND WITH SILT AND GRAVEL, medium to fine grained, brown, moist, medium dense (SP-SM) (A-1-b) alluvium		28					
▼	19.0 / 905.5				29					Water level measured at 17.9' deep with HSA to 19.5' deep
20			GRAVELLY SAND, medium to coarse grained, brown, waterbearing, medium dense (SP) (A-1-a) alluvium		22					
25	24.0 / 900.5		SAND WITH GRAVEL, medium grained, grayish brown, waterbearing, medium dense (SP) (A-1-b) alluvium		19					
	29.0 / 895.5				16					
30			GRAVELLY SAND WITH SILT, medium to coarse grained, brown, waterbearing (SP-SM) alluvium		17					
	34.0 / 890.5				24					
35			CLAYEY SAND, a little gravel, brown, stiff (SC) (A-2-6) till		27					No recovery
					15					
					11	14				
					9	13				
40					13	13				

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LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

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U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1201 SB**	**924.5** *(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
45			CLAYEY SAND, a little gravel, brown, stiff (SC) (A-2-6) till *(continued)*		8	13				
					11	16				
					18	13				
50	49.5 / 875.0				21					
				PD						
55					14					
			SILTY SAND, a little gravel, brown to grayish brown, very stiff (SM/SC) (A-2-4) till	PD						
60					32					
				PD						
65					36					
	68.0 / 856.5			PD						
70			CLAYEY SAND, a little gravel, grayish brown, medium dense to dense (SC) (A-2-6) till		23	12				
				PD						
75					19	11				
	78.0 / 846.5			PD						
80			GRAVELLY SILTY SAND, brownish gray, very dense (SM) (A-1-b) colluvium		58					
				PD						

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U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1201 SB**	**924.5** *(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
85			GRAVELLY SILTY SAND, brownish gray, very dense (SM) (A-1-b) colluvium *(continued)*	PD	145					
	87.3 / 837.2		Top of Bedrock	PD	100/.05					PLATTEVILLE FORMATION
90			LIMESTONE, weathered, light brown	WS						
				WS						
	94.5 / 830.0		**END OF BORING**		100/0					

LABORATORY LOG & TEST RESULTS - SUBSURFACE EXPLORATION

AMERICAN ENGINEERING TESTING, INC.

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U.S. Customary Units

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Boring No.	Ground Elevation
	Retaining Wall	**Southwest LRT, PEC East**	**1202 SW**	**924.5** (Surveyed)

Location , , **ft. LT**

Co. Coordinate: X=497915 Y=149194 (ft.)

Latitude (North)=44.9342538 Longitude (West)=-93.3678540

Drill Machine **91C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 1

Drilling Completed **4/21/14**

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
	3.0 921.5		Silty sand with gravel, dark brown (A-1-b) fill		18					Hammer Calibration: 68% efficiency with 110 lb. hammer, 5/27/14
5	6.5 918.0		LEAN CLAY WITH SAND, slightly organic, trace roots, black to dark brown, firm to soft (CL) (A-6) topsoil		5	43				
	9.0 915.5		LEAN CLAY, trace roots, brown, stiff (CL) (A-6) alluvium		3	29				
10	11.5 913.0		CLAYEY SAND, a little gravel, brown, a little dark brown, firm, lenses and laminations of silty sand (SC) (A-6) alluvium		9	27				
			SILTY SAND WITH GRAVEL, medium to fine grained, dark brown, wet, loose (SM) (A-1-b) alluvium		8	17				
15	16.5 908.0		SAND WITH SILT, a little gravel, fine to medium grained, brown, waterbearing, medium dense to loose (SP-SM) (A-3) alluvium		6					
20	21.5 903.0		SAND, a little gravel, medium to fine grained, brown, waterbearing, loose (SP) (A-1-b) alluvium		8					Water level measured at 18.2' deep with HSA to 19.5' deep (rose from 18.8' deep 19 minutes earlier)
	24.0 900.5		SAND, fine to medium grained, brown, waterbearing, medium dense (SP) (A-3) alluvium		17					
25	26.5 898.0		SILTY SAND, a little gravel, brown, medium dense (SM) (A-2-4) till	PD	6					
	29.0 895.5		CLAYEY SAND, a little gravel, brown, firm to stiff, laminations of silty sand (SC) (A-2-6) till	PD	9					
30				PD	17					
	34.0 890.5		CLAYEY SAND, a little gravel, grayish brown, stiff to very stiff (SC/SM) (A-2-4) till	PD	7	14				
35				PD	10	14				
				PD	13	13				
40				PD	11	13				
	44.0 880.5			PD	17	13				
45	46.0 878.5		SILTY SAND, a little gravel, fine to medium grained, brown, wet, medium dense (SM) (A-2-4) alluvium END OF BORING	PD	17					
					16					

Index Sheet Code

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

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1218 SB**	**924.2** (Surveyed)

Location , , **ft. LT**

Co. Coordinate: X=497516 Y=149052 (ft.)

Latitude (North)=44.9351391 Longitude (West)=-93.3643864

Drill Machine **68C**

Hammer **CME Automatic Calibrated**

SHEET 1 of 3

Drilling Completed

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
	2.0 922.2		Silty sand with organic fines, a little gravel, trace roots, dark brown (A-1-b) fill		15					Hammer Calibration: 68% efficiency with 110 lb. hammer, 6/9/14
	4.0 920.2		Clayey sand with organic fines, a little gravel, dark brown (A-2-6) fill		11					
5					30					
					24					
10			SAND WITH GRAVEL, medium to fine grained, light brown, moist, medium dense to dense (SP) (A-1-b) alluvium		29					
					25					
15					46					
▼	16.5 907.7		SAND, a little gravel, medium grained, brown, waterbearing, medium dense (SP) (A-1-b) alluvium		14					Water level measured at 17.6' deep with HSA to 19.5' deep
20					14					
	21.5 902.7		SAND WITH SILT AND GRAVEL, medium to fine grained, brown, waterbearing, medium dense (SP-SM) (A-1-b) alluvium		17					
	24.0 900.2		GRAVEL WITH SAND, brown, waterbearing, medium dense (GP) (A-1-b) alluvium		24					
25	26.5 897.7		SILTY SAND, a little gravel, brown, medium dense to loose (SM/SC) (A-2-4) till		21					
30					8					
	31.5 892.7		CLAYEY SAND, a little gravel, brown, firm (SC) (A-2-6) till	PD	7	11				
35				PD	8	12				
	36.5 887.7		SILTY SAND, a little gravel, brown, loose (SM) (A-2-4) till	PD	9					
	39.0 885.2		CLAYEY SAND, a little gravel, brown to brownish gray, firm to stiff (SC) (A-2-6) till	PD	7	13				
40				PD						

Index Sheet Code

(Continued Next Page)

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

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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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1218 SB**	**924.2** (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
45	44.0 880.2		CLAYEY SAND, a little gravel, brown to brownish gray, firm to stiff (SC) (A-2-6) till *(continued)*	PD	13	13				
	46.5 877.7		SANDY LEAN CLAY, a little gravel, brownish gray, very stiff, laminations of silty sand (CL) (A-6) till	PD	22	15				
	49.0 875.2		CLAYEY SAND, a little gravel, grayish brown, very stiff (SC) (A-6) till	PD	22	12				
50			CLAYEY SAND, a little gravel, gray, very stiff, laminations of silty sand (SC) (A-2-6) till	PD	21	12				
	53.0 871.2		SAND WITH SILT AND GRAVEL, medium to fine grained, light brown, waterbearing, medium dense (SP-SM) (A-1-b) alluvium	PD	24					
55	58.0 866.2		CLAYEY SAND WITH GRAVEL, gray, hard (SC) (A-6) till	PD	71	12				
	63.0 861.2		CLAYEY SAND, a little gravel, gray, hard (SC) (A-2-6) till	PD	35	13				
60				PD	50/.5	11				
				PD	50/.3	13				
65				PD						
	78.0 846.2		CLAYEY SAND WITH GRAVEL, grayish brown, hard (SC/SM) (A-2-4) till	PD	91/.9	10				
70										
75										
80										

(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
	Excelsior Blvd.	**Southwest LRT, PEC East**	**1218 SB**	**924.2** *(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
85			CLAYEY SAND WITH GRAVEL, grayish brown, hard (SC/SM) (A-2-4) till *(continued)*	PD	84	9				
	87.7 836.5		Top of Bedrock	PD	100/0					PLATTEVILLE FORMATION
90			LIMESTONE, generally fresh, gray	PD						
	94.0 830.2		END OF BORING		100/0					

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

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]

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.

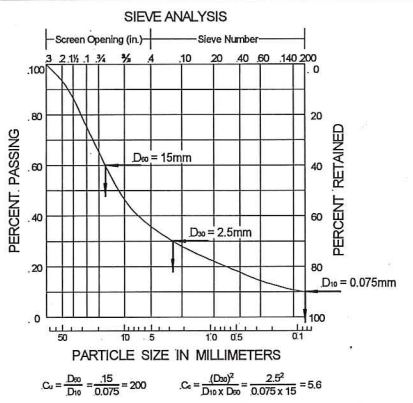
[N]PI≥4 and plots on or above "A" line.

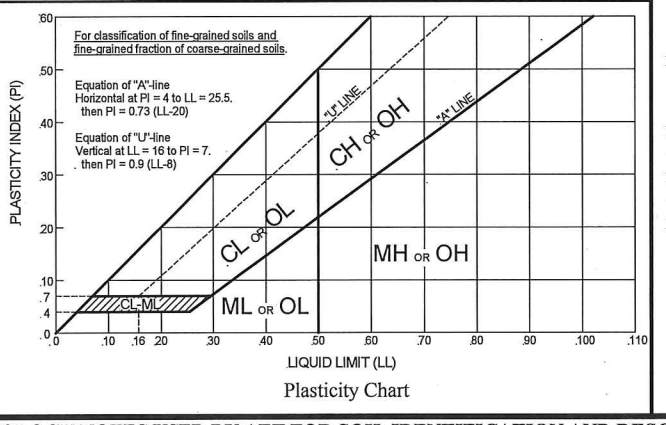
[O]PI<4 or plots below "A" line.

[P]PI plots on or above "A" line.

[Q]PI plots below "A" line.

[R]Fiber Content description shown below.





Plasticity Chart

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

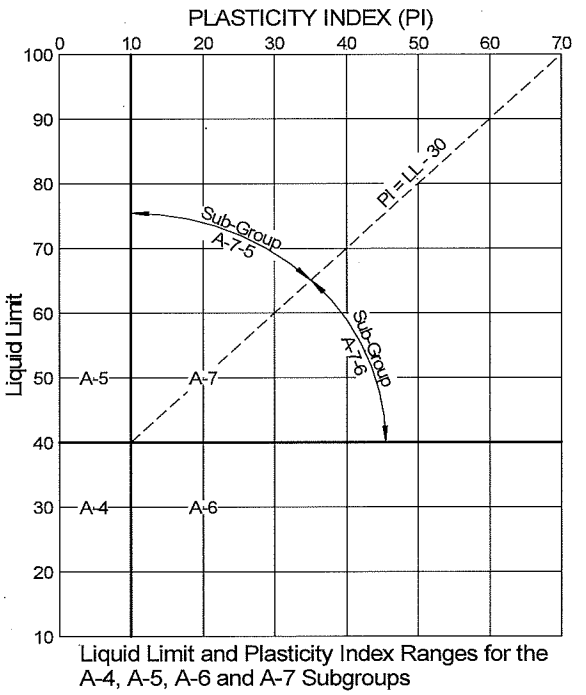
Classification of Soils and Soil-Aggregate Mixtures

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			

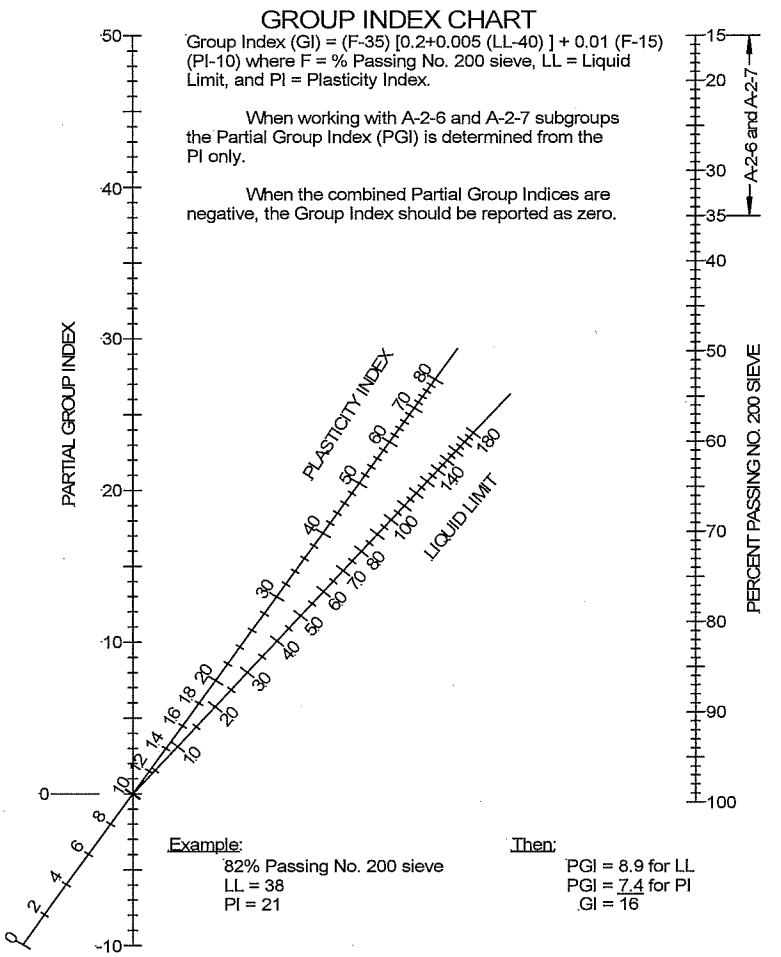
The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.

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



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.

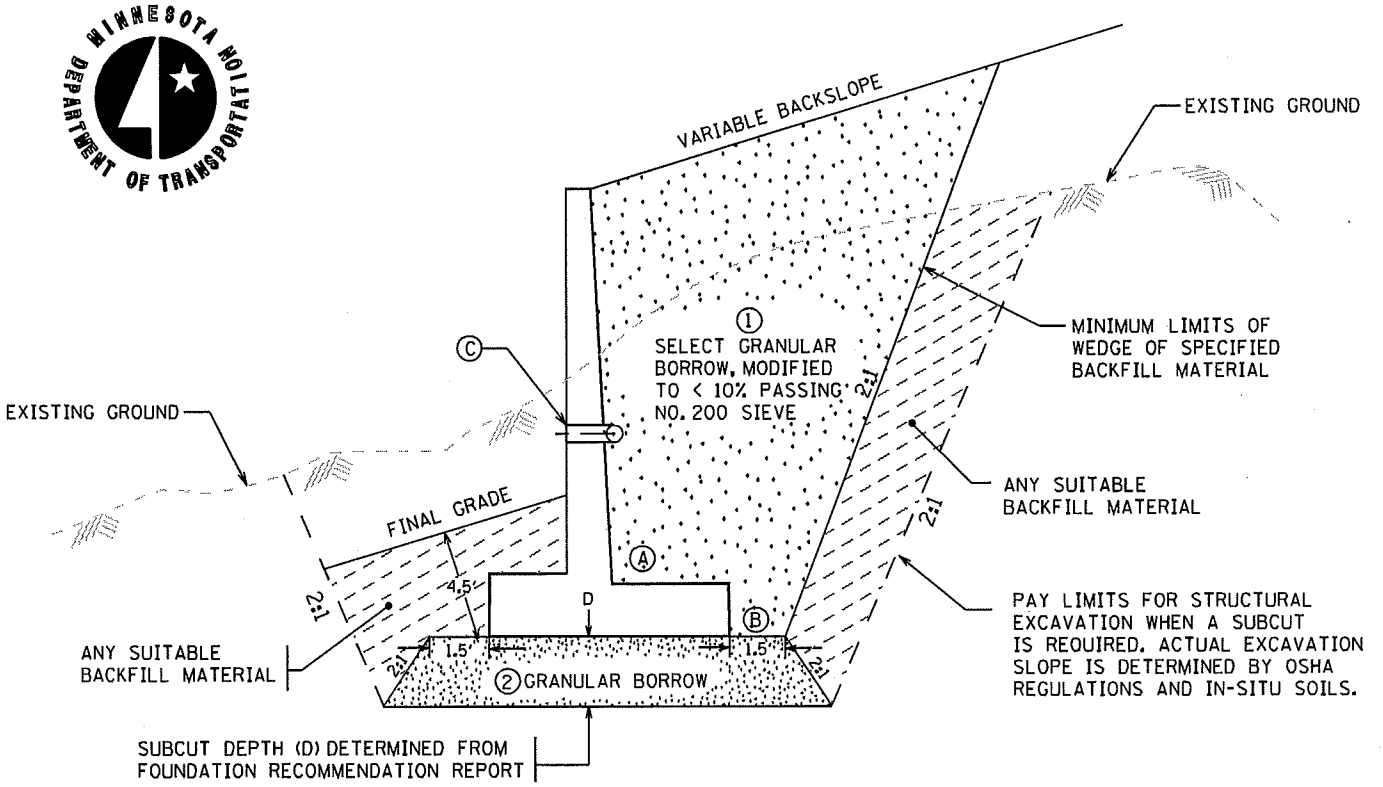
COARSE SAND - Material passing the No. 10 sieve and retained on the No. 40 sieve.

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.



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