Minnesota Department of Transportation
Office of Materials & Road Research
1400 Gervais Avenue, Maplewood, MN 55109

Memo

Date: October 27, 2020

To: Mathew Thibert, Project Manager
District 7

From: Chelsey A. Brummer, Graduate Engineer
Geotechnical Section

Concur: Rich Lamb, Foundations Engineer
Geotechnical Section

Subject: S.P. 5209-80 TH 169 New Bridge No. 52X09
Located 0.8 miles south of Jct. Co. Road 76 (Sta. 925+39 SB)
Foundations Investigation and Recommendations

1.0 Project Description

This letter provides a foundation analysis and set of recommendations for the replacement of in-place bridge No. 8649 with new bridge No. 52X09. The new bridge will be a single line 10'x6' reinforced concrete box culvert.

2.0 Field Investigation and Foundation Conditions

Two Cone Penetration Tests (CPT Soundings) were advanced in August of 2020 at the location the bridge will be placed by MnDOT staff. A copy of the CPT Sounding results is attached to this report.

The soils encountered at the culvert location vary significantly from the west to the east. The west CPT (C01) consists of an approximately 20-foot layer of soft silt and clay, followed by approximately 5 feet of dense sandy soils and approximately 20 feet of hard clay and silt. The east CPT (C02) consists of approximately 5 feet of loose sandy soils followed by approximately 25 feet of very soft to soft clay and silt with a few dense sandy seams, and approximately 2 feet of dense sand at the bottom of the sounding. The CPT soundings were terminated at depths ranging from 31 feet to 48 feet.

3.0 Foundation Analysis

The proposed culvert will be replacing a 56.5-foot-long 10'x 8' reinforced concrete box culvert (RCB) that has a 7.5-foot upstream extension and 92-foot down extension. Both extensions are 96" x 77" CMA and there is an 8.93' difference in elevation between the inlet and the outlet. Based on review of preliminary plans and hydraulic report, the new culvert will be a 164 foot, 10' x 6' single line broken back RCB. The proposed inlet elevation is 767.79' and the proposed outlet elevation is 758.86'with a total proposed grade change of 8.93'.

3.1 Bearing Resistance

The proposed box culvert was analyzed for a spread footing foundation with the bottom of the culvert (elevation 765.43-758.79 ft) considered as the footing.

The bearing resistance of the foundation soils is anticipated to be more than adequate to support the culvert sections below the roadway and soil cover above because the placement of the new box culvert sections is anticipated to either unload or keep the soil stresses unchanged below the culvert elevations. As an exception to this, the foundation soil stresses near the culvert ends will increase from the proposed widening fill and placement of culvert ends.

3.2 Settlement

The estimated settlement of the new box culvert was based on the following assumptions:

A. The roadway profile will not be raised
B. The foundation soils two feet directly below the culvert will be removed and replaced with compacted granular material

Taking all of this into account, we estimate the main culvert section may settle between ½ inch and 1 inch whereas the culvert ends may settle between 1 and 2 inches over the life of the culvert. Differential settlements between culvert sections is expected to be less than ½ inch under the current culvert section and as much as ½ inch to 1 inch near the culvert ends.

4.0 Foundation Recommendations

Based on the existing conditions along with an analysis of the project soils, we recommend that:

1. A 2-foot minimum Coarse Filter Aggregate Bedding (MnDOT Spec. 3149.2H) compacted to the requirement of Spec. 2211.3.D.2.b is placed below the bottom of the culvert to reduce differential settlement and provide for uniform foundation base.

2. A MnDOT Type IV separation geosynthetic (MnDOT Spec. 3733) should be placed at the base of the subcut excavation between the native soils and the replacement backfill. The geosynthetic should extend at least 3 feet beyond the side walls of the box culvert. In addition, seam all fabric sides and ends per Spec. table 3733-1 including footnote (e) or overlap a minimum of 3-feet.

3. The trench for the culvert replacement be excavated down at a 1:2 (V:H) slope and should include a 1:20 taper for frost differential protection.

Attachments: Culvert 52X09 CPT Location Plan
Culvert 52X09 Soil Profile
CPT Sounding Index
CPT Sounding Logs (C01 and C02)

cc: Brad Skow
Matt Rottermond
Charlie Kremer

PLOTTED/REVISED: $$$$@DATE@$$$$

DISTRICT: $@DISTRICT@$
(PLOT NAME: $$@PLOT$NAME@$$
PATH & FILENAME: $$$@FILENAME@$$$

C01

C02

925

LTH 169 SB

OHP

F/O-BUR

295500
5775000

295300
5775900

BRIDGE NO 52X09 CPT LAYOUT

S.P. 5209-80 (T.H. 169) SHEET 1 OF 1 SHEETS

1" = 20' HORIZ.
1" = 20' VERT.

EXISTING BRIDGE 8649

PROPOSED BRIDGE 52X09

PROPOSED GROUND

EXISTING GROUND

c01
Elevation 779.9
Depth
Interpreted N-60
0 10 20 30 40 50
Bottom of Hole 47.12

c02
Elevation 775.7
Depth
Interpreted N 60
0 10 20 30 40 50
Bottom of Hole 31.76

1:2

TYPE III END SECTION
925+02.2 R 9
77.4' LT
ELEV. 765.434

50.8' 10X8 RC
BOX @ 1.75%

60.5' 10X8 RC
BOX @ 9.19%

VERTICAL CULVERT BEN
STA. 925+22.0 R 9
30.7' LT
ELEV. 764.479

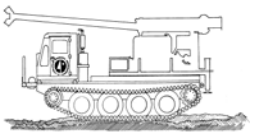
80.1' 10X8 RC
BOX @ 0.20%

VERTICAL CULVERT BEND
STA. 925+45.5 R 9
24.7' RT
ELEV. 758.948

TYPE III END SECTION
925+76.8 R 9
98.4' RT
ELEV. 758.787

810 800 790 780 770 760 750 740 730 720

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



USER NOTES, ABBREVIATIONS AND DEFINITIONS

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

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

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

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

CPT Terminology

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

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

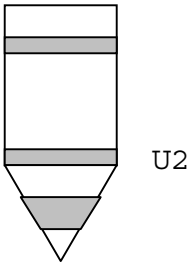
q_T TIP RESISTANCE
The resistance at the cone corrected for water pressure. Data is from cone with 60 degree apex angle and a 10 cm^2 end area.

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

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

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

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



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

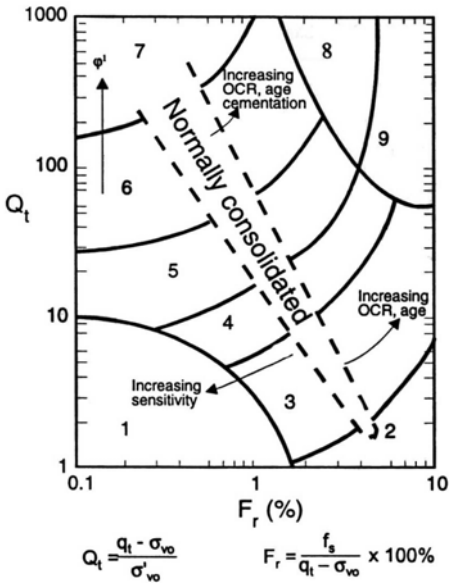
The numbers corresponding to different regions on the charts represent the following soil behavior types:

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

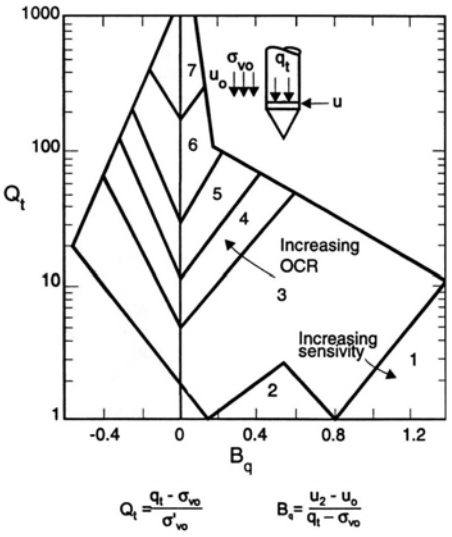
Note that engineering judgment, and comparison with conventional borings is especially important in the proper interpretation of CPT data in certain geo-materials.

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

Robertson CPT 1990
Soil Behavior type based on friction ratio



Robertson CPTU 1990
Soil Behavior type based on pore pressure



where ...
Q_T ..... normalized cone resistance
B_q ..... pore pressure ratio
F_r ..... Normalized friction ratio
σ_{vo} ..... overburden pressure
σ'_{vo} ..... effective over burden pressure
u_2 ..... measured pore pressure
u_0 ..... equilibrium pore pressure

DEPARTMENT OF TRANSPORTATION

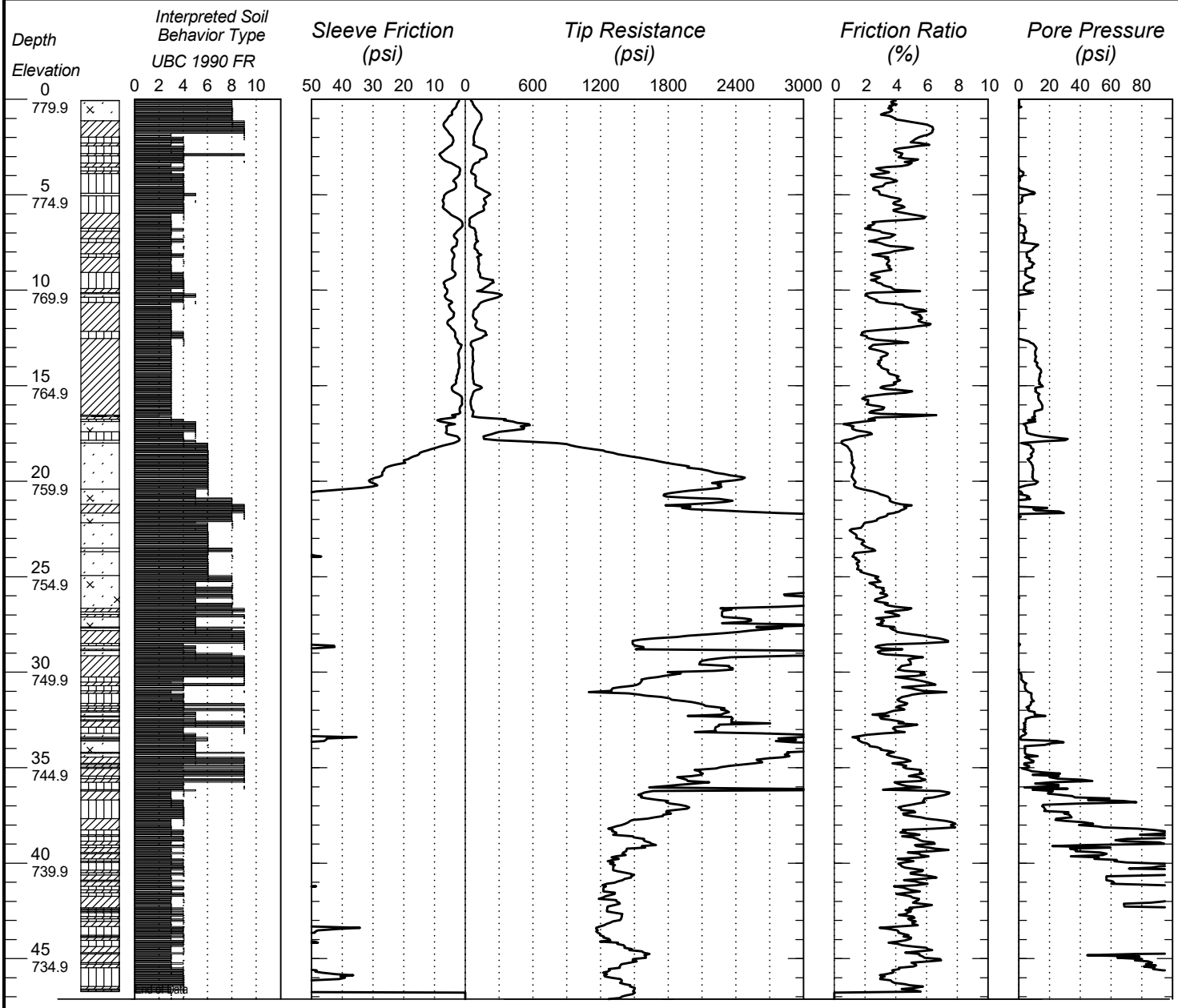
MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 85359

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
5209-80	**52X09**	**US Highway TH 169**	**c01**	**779.9** *(DTM)*

Location	CPT Machine	SHEET 1 of 1
Nicollet County Coordinate System	**211328 CPT Marooka Track**	
X=577774 Y=295503	CPT Operator **ODonnel**	Date Completed
Latitude (North)=44°23'02.18" Longitude (West)=93°58'09.10"	Hole Type **CPT-STD**	**8/31/20**



Bottom of Hole 47.12

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DEPARTMENT OF TRANSPORTATION

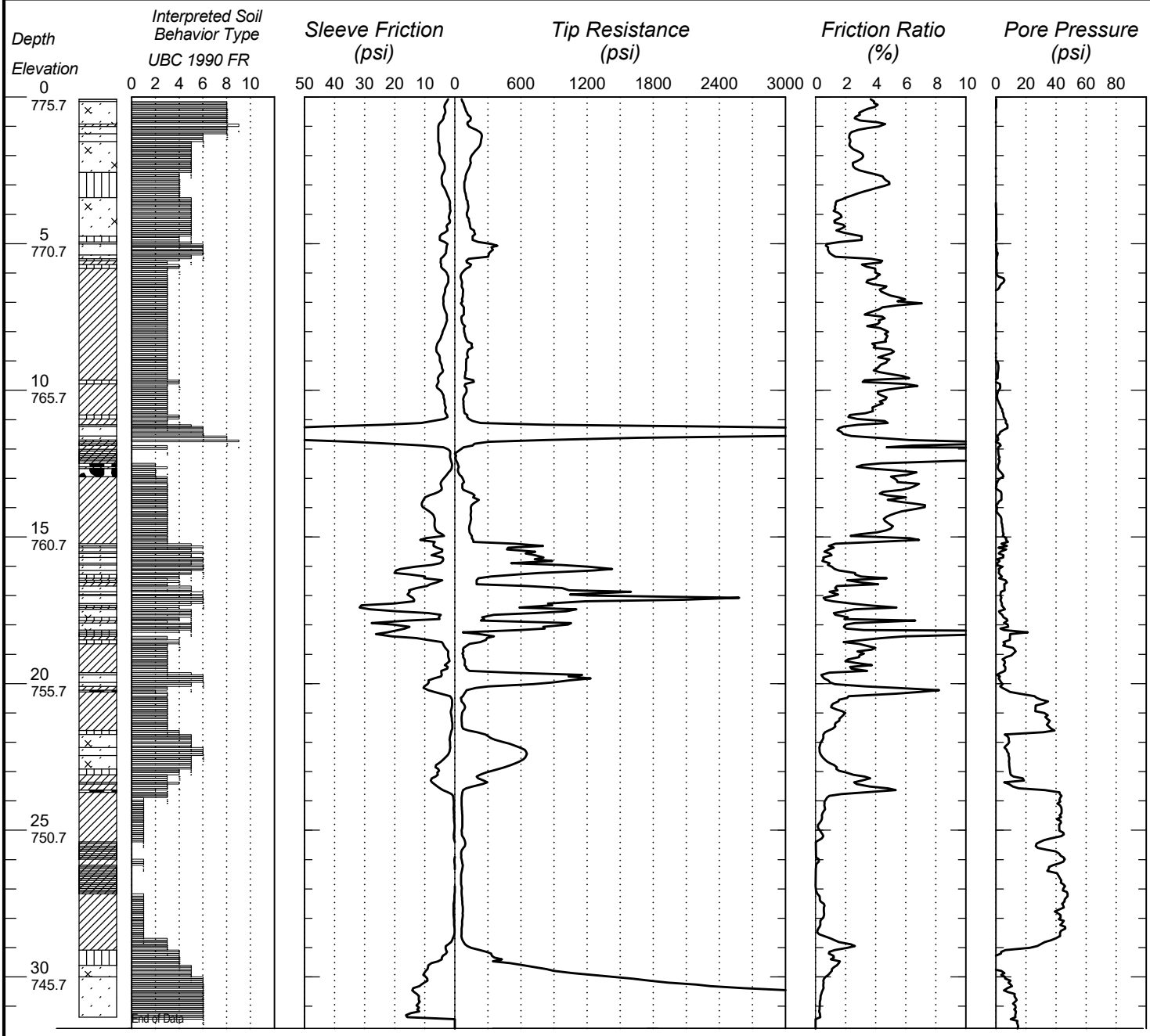
MINNESOTA DEPARTMENT OF TRANSPORTATION - GEOTECHNICAL SECTION

CONE PENETRATION TEST RESULTS

UNIQUE NUMBER 85360

State Project	Bridge No. or Job Desc.	Trunk Highway/Location	Sounding No.	Ground Elevation
5209-80	**52X09**	**US Highway TH 169**	**c02**	**775.7** *(DTM)*

Location	CPT Machine	SHEET 1 of 1
Nicollet County Coordinate System	**211328 CPT Marooka Track**	
X=577880 Y=295564	CPT Operator **ODonnel**	Date Completed
Latitude (North)=44°23'02.77" Longitude (West)=93°58'07.65"	Hole Type **CPT-STD**	**8/31/20**



Bottom of Hole 31.76

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