



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
TEMPORARY PROTECTION SYSTEM FOR BRIDGE REHABILITATION
HIGHWAY 401 AND THICKSON ROAD UNDERPASS
WHITBY, ONTARIO
G.W.P. 2165-16-00, SITE NO. 22-171/1&2
LATITUDE: 43.868892°, LONGITUDE: -78.904697°**

GEOCRES No.: 30M15-332

Report

to

Consor Engineers, LLC

Date: May 17, 2021
File: 25682



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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the Highway 401 and Thickson Road Underpass, located in the town of Whitby, Regional Municipality of Durham, Ontario.

The purpose of this investigation was to explore the subsurface conditions near the bridge abutments and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to Consor Engineers, LLC, under the Ministry of Transportation Ontario (MTO) Agreement Number 2018-E-0066.

Reference has been made to information on subsurface conditions contained in a previous foundation report prepared by others for this site. The title of this report is:

- Foundation Investigation Report for Thickson Road Underpass, 3.0 Miles West of Oshawa, W.P 38-77-01, Site 22-171, Hwy. 401, District 6, Toronto, prepared by the then Ministry of Transportation and Communications, GEOCRES No. 30M15-44, dated April 17, 1978. (Reference 1).



2. SITE DESCRIPTION

The Highway 401 and Thickson Road Underpass is located approximately 4.2 km west of the City of Oshawa in the Town of Whitby, Ontario. The structure consists of a six-lane, double span bridge crossing over Highway 401. The existing bridge is a twin post-tensioned concrete voided-slab structure supported on two abutments and a single pier. The total length of the bridge is approximately 70 m with two spans each of approximately 35 m, and an approximate width of 30m.

Road grade on the Thickson Road structure varies between approximate Elevations 101.5 and 102.5. Road grade on Highway 401 below the underpass is near Elevation 95.2. The approach embankments rise above the adjacent lands.

Photographs in Appendix C show the general nature of the site and the Thickson Road bridge.

The site lies within the physiographical region known as the Iroquois Plain, based on L.J. Chapman and D.F. Putnam's 1984 edition of *The Physiography of Southern Ontario*. The area typically consists of a mosaic of till plains, drumlins and areas of silty lacustrine deposits. Based on the Ontario Geological Survey (OGS) Map MRD128, titled "Surficial Geology of Southern Ontario", dated 2010, the surficial geology typically consists of fine-textured glaciolacustrine deposits of silt and clay, with minor sand and gravel. Based on local geological maps bedrock consists of shale and limestone of the Georgian Bay formation anticipated at depths of greater than 10 m.

3. INVESTIGATION PROCEDURES

The site investigation and field testing for this project was carried out on April 9, 2020. A total of two sampled boreholes, identified as TR20-01 and TR20-02, were advanced. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

Borehole TR20-01 was drilled approximately 7.6 m north of the expansion joint in the outer southbound lane of the Thickson Road Underpass. Borehole TR20-02 was drilled approximately 8.1m south of the expansion joint in the outer northbound lane of the Thickson Road Underpass. Both boreholes 20-01 and 20-02 were terminated at a depth of 12.3 m (Elevations 88.7 m and 89.8 m, respectively).

No piezometer was installed in the boreholes which were located within the travelled roadway. Groundwater conditions were observed in the open boreholes during the drilling operations.



Reference is made to groundwater information reported for selected boreholes from a previous investigation by MTO (Reference 1).

Details of the drilling program, including drilling depths, and completion details are summarized in Table 3.1 below.

Table 3.1 – Borehole Completion Details

Location	Boreholes	Borehole Depth / Bottom of Hole Elevation (m)	Completion Details
SBL of Thickson Rd Overpass	TR20-01	12.3 / 88.7	Borehole backfilled with bentonite holeplug to 1.8 m, cuttings to 0.45 m, concrete to 0.15 m, then asphalt to surface.
NBL of Thickson Rd Overpass	TR20-02	12.3 / 89.8	Borehole backfilled with bentonite holeplug to 1.8 m, cuttings to 0.60 m, concrete to 0.15 m, then asphalt to surface.

All boreholes were advanced using a Unit 150/B-53 Explorer truck-mounted drill rig in conjunction with solid stem augers. Samples of the encountered soils were obtained from the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in general accordance with ASTM D1586.

Thurber obtained the borehole co-ordinates in the field using a hand-held GPS unit and provided those co-ordinates to Consor, who in turn provided the ground surface elevations based on their topographic survey data. The coordinates and elevations of the boreholes are given on the individual Record of Borehole Sheets and the drawing in Appendices A and D, respectively.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full-time basis. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification and natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets included in Appendix A. Selected samples were subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing, and the results of this testing program are summarized



on the Record of Borehole sheets in Appendix A and are shown on the figures included in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented on these sheets and on the Borehole Locations and Soil Strata drawing in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond the borehole locations.

In summary, the subsurface stratigraphy generally consisted of compact to dense sand to silty sand embankment fill overlying firm to hard silty clay fill, which is underlain by native very dense sand and silt till. More detailed descriptions of individual strata are presented below.

5.1 Asphalt

Asphalt pavement was encountered in Boreholes TR20-01 and TR20-02. The thickness of the asphalt was measured to be 125 mm in both boreholes. The asphalt thickness may vary between and beyond borehole locations.

5.2 Silty Sand to Sand Fill

Embankment fill comprised of silty sand to sand was encountered below the asphalt in both boreholes at this site. Brown sand fill containing some gravel to gravelly and some silt and clay was encountered below the asphalt in Borehole TR20-01, and brown silty sand fill containing some gravel and some clay was encountered below the asphalt in Borehole TR20-02. Organics, dark brown staining and clayey silt zones were observed in the silty sand fill in Borehole TR20-02 from approximate depths of 1.5 m to 3.0 m (Elevation 100.7 m to 99.2 m).

The thickness of the cohesionless fill in Boreholes TR20-01 and TR20-02 was 2.1 m and 4.6 m, with an underside depth of 2.2 m and 4.7 m (Elevations 98.8 and 97.4 m), respectively.

SPT N-Values measured in the cohesionless fill ranged from 12 blows to 41 blows per 0.3 m penetration, indicating a compact to dense condition. Recorded moisture contents typically ranged from 3 percent to 10 percent. A higher value of 16 percent was measured for the organic/clayey silt zone discussed above.

The results of grain size analyses conducted on two samples of the cohesionless fill are provided on the Record of Borehole sheets in Appendix A and plotted in Figures B1 and B2 of Appendix B. The results are summarized as follows:

Soil Particle	Gravelly Sand Fill Percentage (%)	Silty Sand Fill Percentage (%)
Gravel	29	18
Sand	59	45
Silt	12	25
Clay		12

5.3 Silty Clay Fill

Silty clay fill was encountered below the cohesionless fill in both boreholes at this site. The silty clay fill was brown in colour and contained some sand to sandy and trace gravel. Trace organics and dark brown staining were observed in the silty clay fill in Borehole TR20-02. A 125 mm thick sand layer was also observed in the silty clay fill in Borehole TR20-01, at a depth of approximately 5.0 m (Elevation 96.0 m).

The thickness of the silty clay fill in Boreholes TR20-01 and TR20-02 were 2.9 m and 0.9 m, with an underside depth of 5.1 m and 5.6 m (Elevations 95.9 m and 96.5 m), respectively.

SPT N-Values measured in the silty clay fill generally ranged from 6 blows to 22 blows per 0.3 m penetration, indicating a firm to very stiff consistency. A SPT N-Value of 67 blows was recorded at a depth of approximately 4.9 m (Elevation 96 m) near the base of the fill in Borehole TR20-01, indicating a hard consistency. Recorded moisture contents ranged from 3 percent to 18 percent.

The results of grain size analyses conducted on two samples of the silty clay fill are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B3 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	3 to 4
Sand	24 to 38
Silt	38 to 43
Clay	20 to 30

The results of Atterberg limit testing conducted on two samples of the silty clay fill are also shown on the Record of Borehole sheets in Appendix A and plotted in Figure B5 of Appendix B. The



laboratory results typically indicate the silty clay fill exhibits low to intermediate plasticity (CL – CI). The results are summarized in the table below.

Index Property	Percentage (%)
Liquid Limit	22 to 37
Plastic Limit	12 to 19
Plasticity Index	10 to 18

5.4 Sand and Silt Till

Native sand and silt till was encountered below the silty clay fill in both boreholes. Borehole TR20-01 was terminated in this till at a depth of 12.3 m (Elevation 88.7 m). Borehole TR20-02 was terminated in this till at a depth of 12.3 m (Elevation 89.8 m).

The sand and silt till was brown in colour and contained trace to some gravel and trace clay. Clayey silt interbeds were observed within this till deposit in Borehole TR20-01 at depths of approximately 9.1 m to 10.7 m (Elevations 91.9 m to 90.3 m).

SPT N-Values measured in the sand and silt till ranged from 77 blows per 0.3 m penetration to greater than 100 blows for less than 0.3 m penetration, indicating a very dense condition. The higher values may also be indicating the presence of cobbles and boulders.

Recorded moisture contents ranged from 7 percent to 11 percent. The results of grain size analyses conducted on three samples of the sand and silt till deposit are provided on the Record of Borehole sheets in Appendix A and plotted in Figure B4 of Appendix B. The results are summarized below.

Soil Particle	Percentage (%)
Gravel	8 to 14
Sand	41 to 46
Silt	36 to 38
Clay	8 to 9

The results of Atterberg limit testing conducted on one sample from the clayey silt zone within the till is also shown on the Record of Borehole sheets in Appendix A and plotted in Figure B6 of Appendix B. The laboratory results indicate that this zone exhibits low plasticity (ML). The results are summarized in the table below.



Index Property	Percentage (%)
Liquid Limit	15
Plastic Limit	11
Plastic Index	4

It should be noted that glacial till inherently contains cobbles and boulders.

5.5 Groundwater Conditions

No piezometer was installed in the boreholes at this site. Groundwater conditions were observed during the drilling operations and upon completion of drilling. All boreholes were noted to be dry and open to the bottom of the borehole upon completion.

A borehole numbered 5 (see drawing in Appendix D) from a 1978 MTO investigation (Reference 1) reported a groundwater level at approximate Elevation 92 m. This level corresponds to the lower elevations of our boreholes within the till. The investigation also reported water levels in the area ranged from Elevations 86 to 95 m.

Groundwater levels are short-term observations and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

6. MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. The coordinates of the boreholes were obtained in the field using a hand-held GPS unit and the ground surface elevations corresponding to those co-ordinates were provided by Consor Engineers, LLC.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Drilltech Drilling Ltd. of Newmarket, Ontario supplied a truck-mounted Unit 150/B-53 Explorer drill rig, and conducted the drilling, sampling and in-situ testing operations for the boreholes.

Traffic control during the field investigation was provided by Direct Traffic Management Inc. of Hamilton, Ontario. Traffic control was carried out in accordance with Ontario Traffic Manual (OTM) Book 7, the Occupational Health and Safety Act (OHSA), and Thurber's Safety Manual.

The drilling operations were supervised by Mr. Stephane Loranger, C.E.T. of Thurber. Overall supervision of the field program was carried out by Ms. Nancy Berg, P.Eng, and compilation of the data was carried out by Ms. Judy Mei, E.I.T.



The report was prepared by Ms. Judy Mei, E.I.T and Mr. Cory Zanatta, P.Eng., and reviewed by Dr. Sydney Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.



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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides foundation recommendations pertinent to the design of a suitable Temporary Protection System (TPS) for the rehabilitation of the Thickson Road Underpass. It is understood that the rehabilitation will include conversion to semi integral abutments, traffic staging, concrete deck patching and crack injection at the bridge location. TPS is required to maintain stability and minimize movements of the highway during the rehabilitation works, especially during the abutment conversion where excavations up to the order of 2 to 3 m will be required.

This foundation investigation and design report with the interpretations and recommendations is intended for the use of the Ministry of Transportation and Consor, and shall not be used or relied upon for any other purposes or by any other parties including the construction contractors. The contractors must make their own interpretations based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

8. TEMPORARY PROTECTION SYSTEM

It is understood that work to convert to a semi integral abutment will require excavations in conjunction with staging and maintaining two-way traffic on Thickson Road.



The temporary roadway protection system should be designed and implemented to Performance Level 2 in accordance with OPSS.PROV 539.

Depending on the excavation depth, the protection system may need to be extended through the existing embankment fill into the underlying native dense glacial tills to develop the required toe resistance. Installation of roadway protection should consider that the glacial till may contain cobbles and boulders. It is anticipated that the shoring system may be stiffened by cross bracings, where applicable.

Interlocking sheet piles or soldier piles and lagging could be considered at this site. Should the temporary works require penetration through the fill into the very dense till soils which may contain cobbles and boulders, driving of sheet piles may be difficult, and soldier piles with timber lagging is the preferred option.

The soil parameters provided below may be used for design of the temporary roadway protection system.

Soil Bulk Unit Weight	γ	=	20 kN/m ³ (sand fill, silty sand fill)
		=	19 kN/m ³ (silty clay fill)
		=	21 kN/m ³ (sand and silt till)
Submerged Unit Weight (below gwl)	γ'	=	10 kN/m ³ (sand fill, silty sand fill)
		=	9 kN/m ³ (silty clay fill)
		=	11 kN/m ³ (sand and silt till)
Coefficient of Active Pressure	K_a	=	0.33 (sand fill, silty sand fill)
		=	0.35 (silty clay fill)
		=	0.29 (sand and silt till)
Coefficient of Passive Pressure	K_p	=	3.0 (sand fill, silty sand fill)
		=	2.9 (silty clay fill)
		=	3.4 (sand and silt till)

It is recommended that the lateral earth pressures acting on the wall be computed in accordance with the CHBDC 2019. The surcharge should include soil loadings above the retained soil and other loadings adjacent to the wall including traffic loading. The actual pressure distribution acting on the shoring system is a function of construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system.



The temporary protection system should be designed based on a reported groundwater level at approximate Elevation 92 m from the GEOCREC information.

The design of the temporary protection system should be the responsibility of the contractor and all shoring systems should be designed by a Professional Engineer experienced in such design

The depth of frost penetration at this site is approximately 1.4 m as per OPSD 3090.101. The soils above the frost penetration depth should not be considered for providing lateral resistance should the temporary protection be used through the winter months.

9. TEMPORARY EXCAVATIONS AND DEWATERING

All excavations at this site must be carried out in accordance with the latest edition of the Occupational Health and Safety Act (OHSA). The excavation and backfilling for foundations must be carried out in accordance with OPSS.PROV 902. All excavations must be carried out in a manner that avoids undermining or destabilising the foundations of the existing bridges and slopes.

During drilling operations, the current boreholes were observed to be dry upon completion down to depths below grade of 12.3 m (Elevations 88.7 m to 89.8 m). However, for design purposes, the groundwater level should be assumed to be at Elevation 92 m based on GEOCREC information. It is anticipated that the base of excavations during bridge rehabilitation will be above the groundwater level.

For the purposes of OHSA, the fill at this site may be classified as Type 3 materials. The native till, if encountered, may be classified as Type 2 materials.

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions. Excavations should be inspected regularly for evidence of instability if they have been left open for extended periods of time and following periods of heavy rain or thawing. If required, remedial actions must be taken to ensure the stability of the excavation and the safety of workers. Exposed soil slopes should be covered with plastic sheeting to protect against precipitation and surface runoff.

In general, seepage or perched water from the embankment fill is to be expected. The amount of perched water within the fill is expected to be limited. For the temporary excavations at this site, groundwater control will likely be limited to diverting surface runoff and preventing precipitation from entering the excavations, and supplemented by sump pumping within the excavation. Filtered sumps must be designed and operated properly so that construction drainage water



containing eroded soil and fines does not flow onto the highway. Unwatering must remain operational and effective until the excavation is backfilled.

The design of the dewatering system that may be required is the responsibility of the contractor and the contract documents must alert the contractor to this responsibility.

10. CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to, the following:

- Cobbles, boulders or other buried obstructions may be encountered during excavation in the fill and native glacial till, which may interfere with installation of the TPS. Suggested working for an NSSP on obstructions is included in Appendix E.
- The very dense till which may contain cobbles and boulders will be difficult for penetration of sheet piles. A soldier pile and timber lagging temporary protection is the preferred alternative should the system need to penetrate into the till.
- Seasonal fluctuations of the groundwater are to be expected. In particular, the amount of perched water within the fill after the spring snowmelt or after periods of heavy rainfall may impact the construction.
- Care must be taken during excavation to avoid disturbing and undermining travelled lanes of the roadways that will remain open.

11. CLOSURE

Engineering analysis and preparation of this foundation design report was carried out by Ms. Judy Mei, E.I.T. and Mr. Cory Zanatta, P.Eng.

Dr. Sydney Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects, reviewed the report.



THURBER ENGINEERING LTD.



Sydney Pang, P.Eng
Associate, Senior Foundation Engineer



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Review Principal, Designated MTO Contact



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$

 Water Level


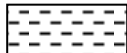



C_{pen} Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W _L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W _L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W _L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W _L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				

<u>TERMS</u>						
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty Can be peeled by a pocket knife, crumbles under firm blows of geological pick. Indented by thumbnail	
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750		
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150		
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen					
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.					

METRIC

W.P.	2165-16-00	LOCATION	Thickson Road Underpass Bridge N 4 859 019.0 E 352 598.4				ORIGINATED BY	SLL	
DIST	Central	HWY	401	BOREHOLE TYPE	Solid Stem Augers			COMPILED BY	BH
DATUM	Geodetic	DATE	2020.04.09 - 2020.04.09	LATITUDE	43.869595	LONGITUDE	-78.905298	CHECKED BY	CZ

[illegible]

+³, ×³: Numbers refer to Sensitivity

METRIC

[illegible]

RECORD OF BOREHOLE No TR 20-02

1 OF 2

METRIC

W.P. 2165-16-00 LOCATION Thickson Road Underpass Bridge N 4 858 943.4 E 352 647.6 ORIGINATED BY SLL
DIST Central HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY BH
DATUM Geodetic DATE 2020.04.09 - 2020.04.09 LATITUDE 43.868912 LONGITUDE -78.904692 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100					
102.2	GROUND SURFACE														
0.0	ASPHALT: (125mm)														
0.1	Silty SAND, some gravel, some clay Compact to Dense Brown Moist (FILL)		1	GS			102								
			2	SS	21		101								
	with organics, dark brown staining and clayey silt zones from 1.5m to 3.0m		3	SS	20		100								18 45 25 12
			4	SS	12		99								
			5	SS	41		98								
97.4							97								
4.7	Silty CLAY, sandy, trace gravel, trace organics Very Stiff Dark Brown Moist (FILL)		6	SS	22		96								3 24 43 30
96.5							95								
5.6	SAND and SILT, some gravel, trace clay Very Dense Brown Moist (TILL)		7	SS	77		94								
			8	SS	87		93								14 41 36 9
			9	SS	100/ 0.175										

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No TR 20-02

2 OF 2

METRIC

W.P. 2165-16-00 LOCATION Thickson Road Underpass Bridge N 4 858 943.4 E 352 647.6 ORIGINATED BY SLL
DIST Central HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY BH
DATUM Geodetic DATE 2020.04.09 - 2020.04.09 LATITUDE 43.868912 LONGITUDE -78.904692 CHECKED BY CZ

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page																
	SAND and SILT, some gravel, trace clay Very Dense Brown Moist (TILL)	0					92										
		4															
		0	10	SS	100/	0.150											
		4															
		0					91										
		0															
		0															
89.8		0	11	SS	100/		90										
12.3	END OF BOREHOLE AT 12.3m. BOREHOLE OPEN AND DRY TO BOTTOM UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.8m, CUTTINGS TO 0.60m, CONCRETE TO 0.15m, THEN ASPHALT COLD PATCH TO SURFACE.				0.150												



RECORD OF BOREHOLE No 1

W P 38-77-01 LOCATION Co-ords. N. 15,940,906; E 1,56,759 ORIGINATED BY V.K.
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.
DATUM Geodetic DATE February 14, 1978 CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION, RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
329.0	Ground Level																GR SA SI CL
0.0	Fill																
	Clayey Silt with sand		1	SS	10												4 44 36 16
	and traces of gravel		2	SS	5												
	and organic		3	SS	11												3 31 36 30
	Firm to Stiff		4	SS	31												
313.0	Glacial Till		5	SS	100	/5"											
16.0	Het. Mix. Clayey		6	SS	110	/10"											21 39 27 13
	Silt Sand and		7	SS	50												
	Gravel Hard		8	SS	95	/9"											
	Brown-Grey Changing to		9	SS	129												
	Het. Mix. Silt		10	SS	126	/9"											8 43 43 6
	Sand and Gravel																
	V. Dense																
283.2	End of Borehole																
45.8																	

RECORD OF BOREHOLE No 2

W P 38-77-01 LOCATION Co-ords. N. 15,940,935; E 1,156,861 ORIGINATED BY V.K.
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.
DATUM Geodetic DATE February 14, 1978 CHECKED BY [Signature]

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
322.2	Ground Level																GR SA SI CL
0.0	Topsoil																
	Glacial Till		1	SS	53												
	Het. Mix. Claye Silt		2	SS	153	/11"											6 42 42 10
	Sand and Gravel		3	SS	137												
	Hard		4	SS	79												7 35 43 15
	Changing to Het. Mix.		5	SS	156												
	Silt, Sand and Gravel		6	SS	157												
	V. Dense		7	SS	171	/9"											
	Brown-Grey		8	SS	100	/3"											4 25 57 14
293.0	End of Borehole																
29.2																	

+3, x5: Numbers refer to
Sensitivity

20
15
10
5 (%) STRAIN AT FAILURE



HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 3

W P 38-77-01 LOCATION Co-ords. N. 15,940,779; E. 1,156,791 ORIGINATED BY V.K.
 DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.
 DATUM Geodetic DATE February 16, 1978 CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
309.2	Ground Level																GR SA SI CL
0.0	Topsoil																
	Glacial Till		1	SS	35												
	Het. Mix. Clayey Silt, Sand and Gravel		2	SS	77												
	Hard		3	SS	81												
			4	SS	174	/10"											
	Brown Grey		5	SS	156												
	Changing to Het. Mix. silt sand and gravel.		6	SS	184	/11"											
			7	SS	181	/10"											
	Very Dense		8	SS	103	/6"											
278.7	End of Borehole																

RECORD OF BOREHOLE No 4

W P 38-77-01 LOCATION Co-ords. N. 15,940,833; E. 1,156,888 ORIGINATED BY V.K.
 DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.
 DATUM Geodetic DATE February 16, 1978 CHECKED BY CP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
312.5	Ground Level																GR SA SI CL
0.0	Topsoil																
	Glacial Till		1	SS	49												
	Het. Mixture of Clayey Silt, Sand and Gravel		2	SS	121	/10"											
	Hard		3	SS	76												
	Changing to Het. Mix. Silt, Sand and Gravel		4	SS	100	/5"											
	V. Dense		5	SS	144	/11"											
			6	SS	153	/10"											
			7	SS	101												
			8	SS	155												
281.0	End of Borehole																

+3, x5: Numbers refer to Sensitivity

20
15 5 (%) STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION



Ontario Communications

HIGHWAY ENGINEERING DIVISION-ENGINEERING MATERIALS OFFICE-SOIL MECHANICS SECTION

RECORD OF BOREHOLE No 5

W P 38-77-01 LOCATION Co-ords. N. 15,940,677; E. 1,156,833 ORIGINATED BY V.K.
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.
DATUM Geodetic DATE February 15, 1978 CHECKED BY *CP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
329.0	Ground Level										
0.0	Fill Clayey silt with sand and some gravel and traces of organics		1	SS	22						16 37 32 15
			2	SS	12						0 43 39 18
			3	SS	7						
314.0	Firm to V. Stiff		4	SS	9						
15.0	Glacial Till Het. Mixture of Clayey Silt, Sand and Gravel		5	SS	37						26 35 29 10
	Hard brown grey		6	SS	133						
	Changing to Het. Mixture of Silt Sand and gravel		7	SS	153						10 37 43 10
	V. Dense		8	SS	145						
			9	SS	126						
282.5			10	SS	91						
46.5	End of Borehole										

RECORD OF BOREHOLE No 6

W P 38-77-01 LOCATION Co-ords. N. 15, 940,706; E 1,156,934 ORIGINATED BY V.K.
DIST 6 HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY V.K.
DATUM Geodetic DATE February 15, 1978 CHECKED BY *CP*

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES						
321.0	Ground Level										
0.0	Topsoil										
	Glacial Till Het. Mixture Clayey Silt Sand and Gravel		1	SS	129						13 36 31 20
	Hard		2	SS	122						
	Changing to Het. Mixture of Silt Sand and Gravel		3	SS	120						28 34 29 9
	V. Dense		4	SS	115						
			5	SS	162						
			6	SS	154						
			7	SS	192						7 43 41 9
290.5			8	SS	94						
30.5	End of Borehole										

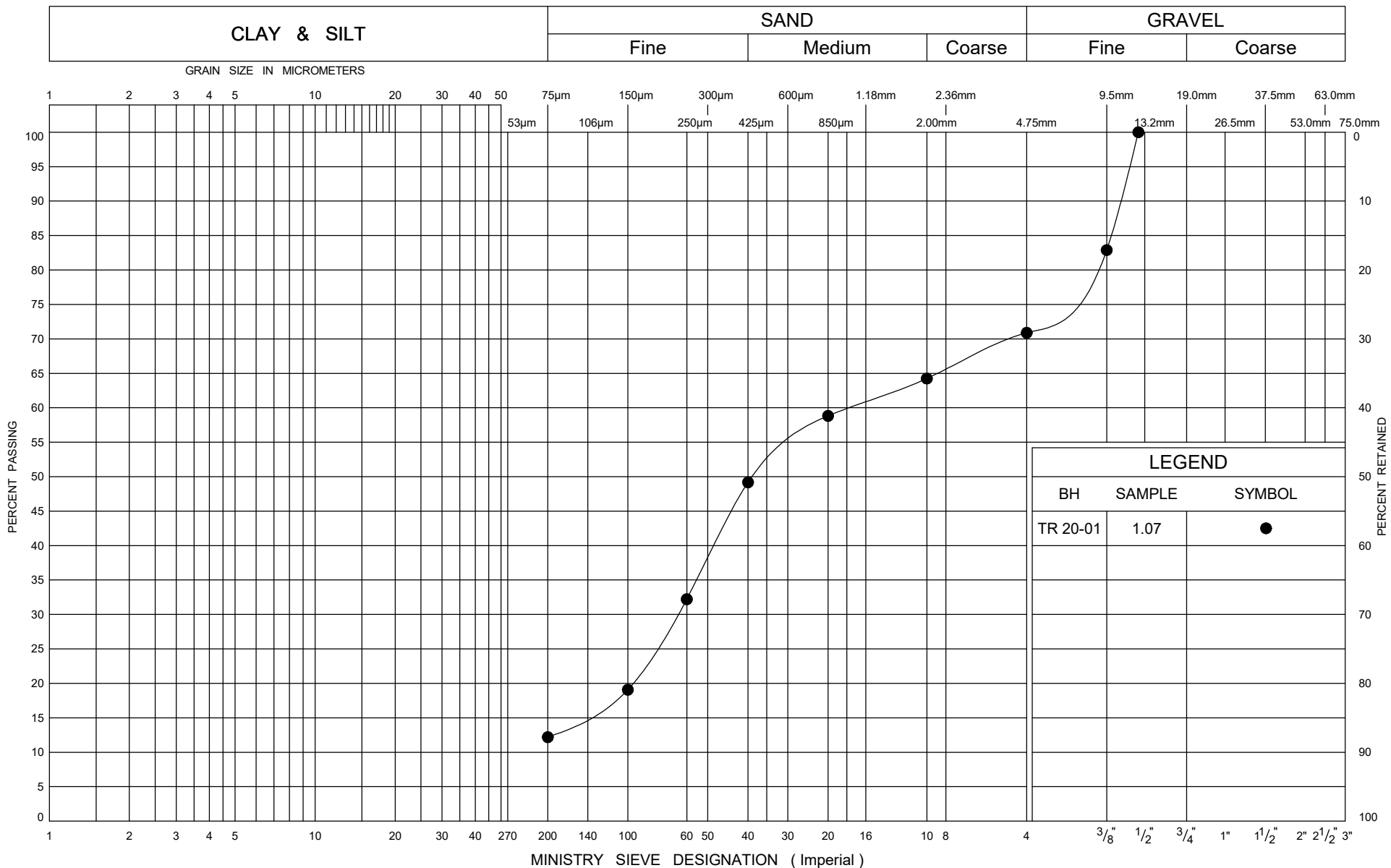
+3, x5: Numbers refer to Sensitivity

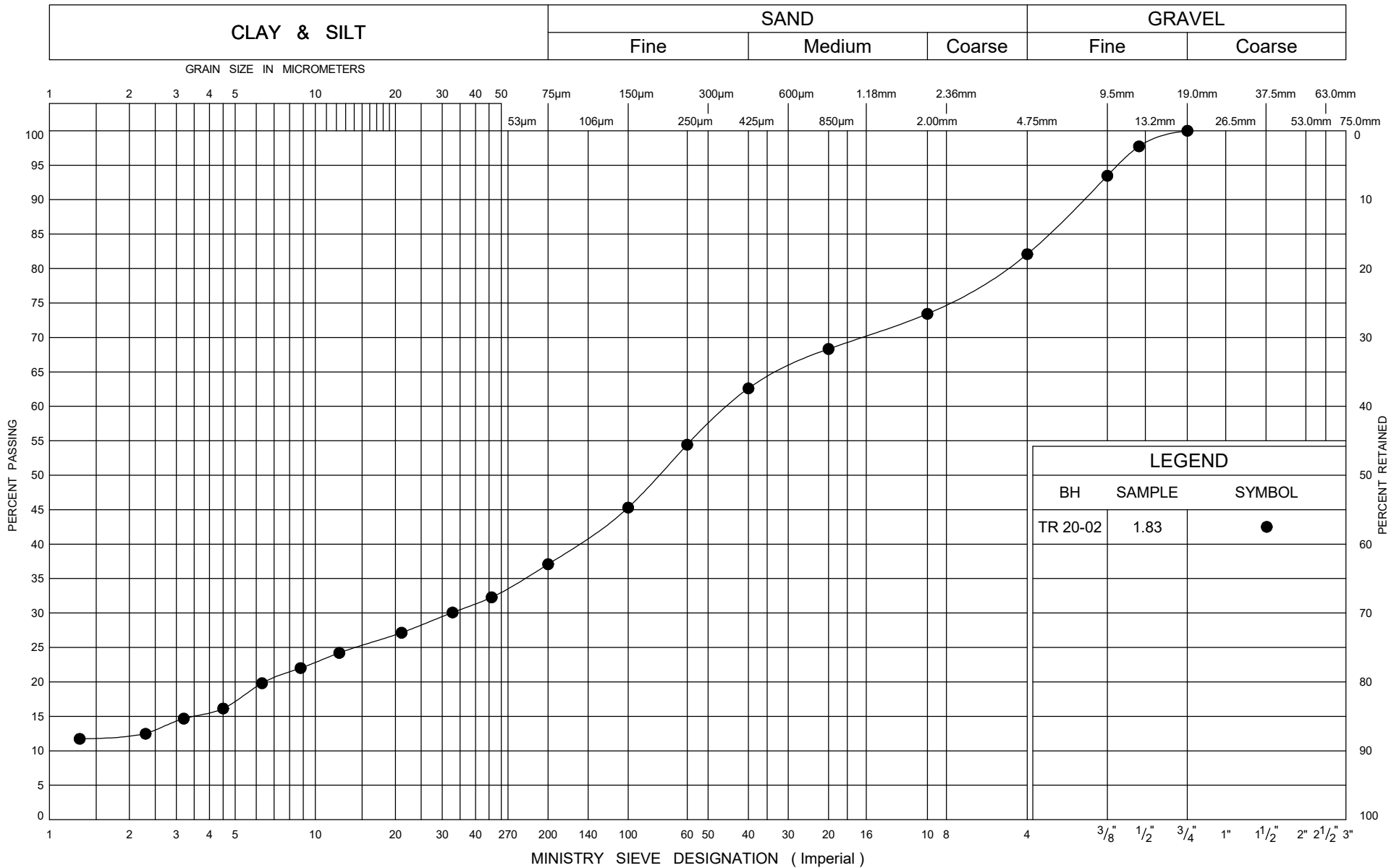
20
15-5 (%) STRAIN AT FAILURE
10



Appendix B

Laboratory Test Results





Ministry of
Transportation

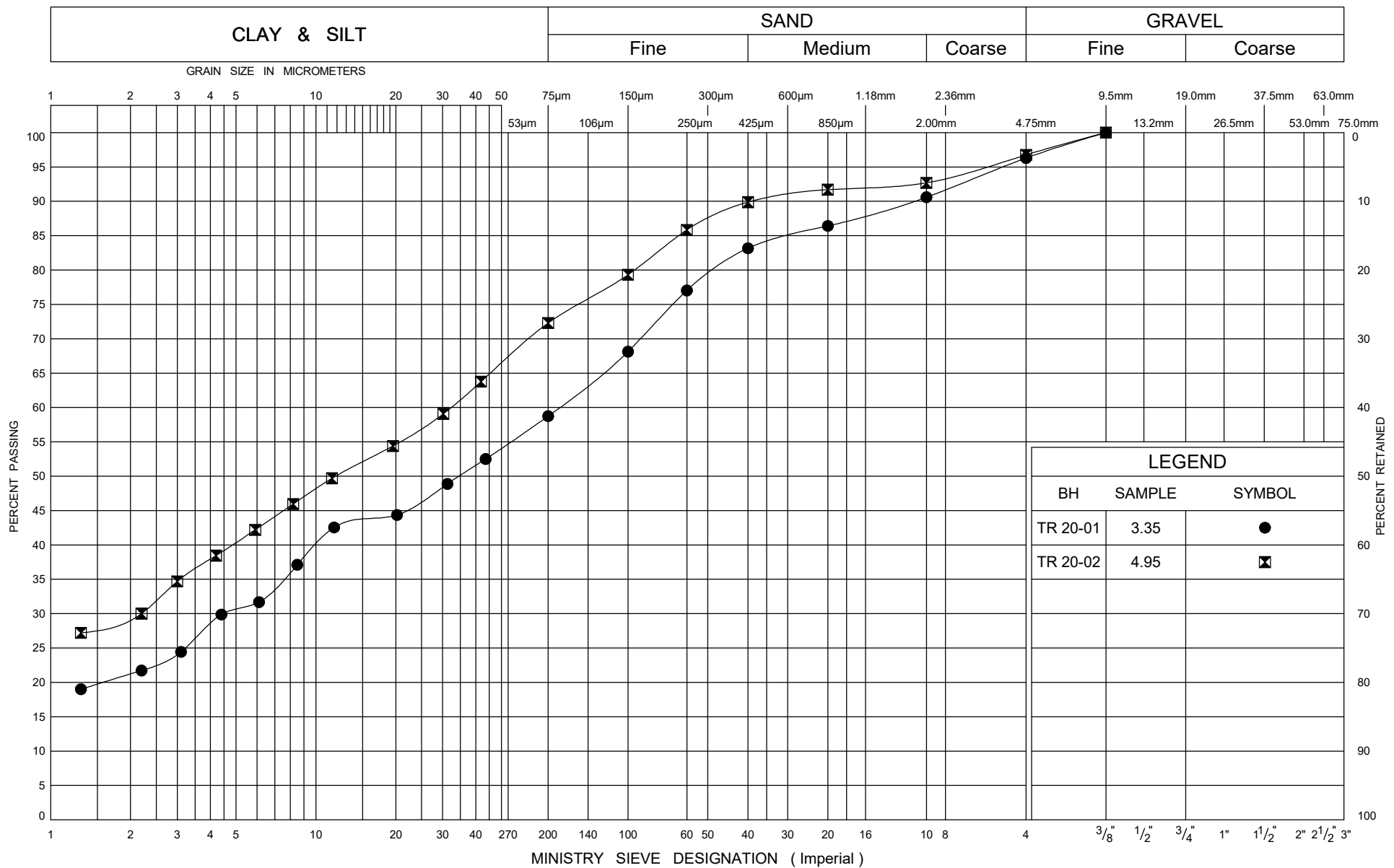
GRAIN SIZE DISTRIBUTION

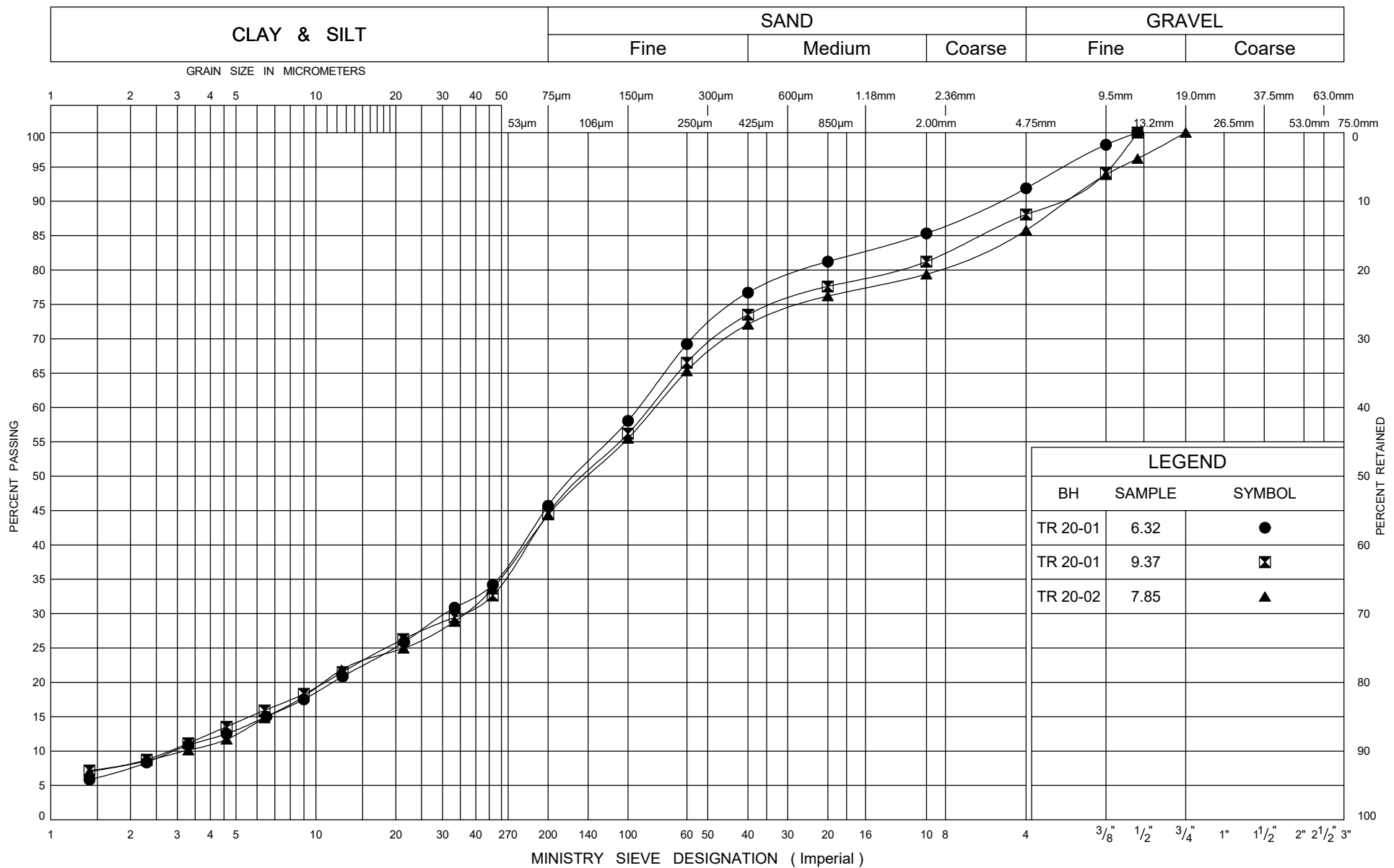
Silty SAND FILL

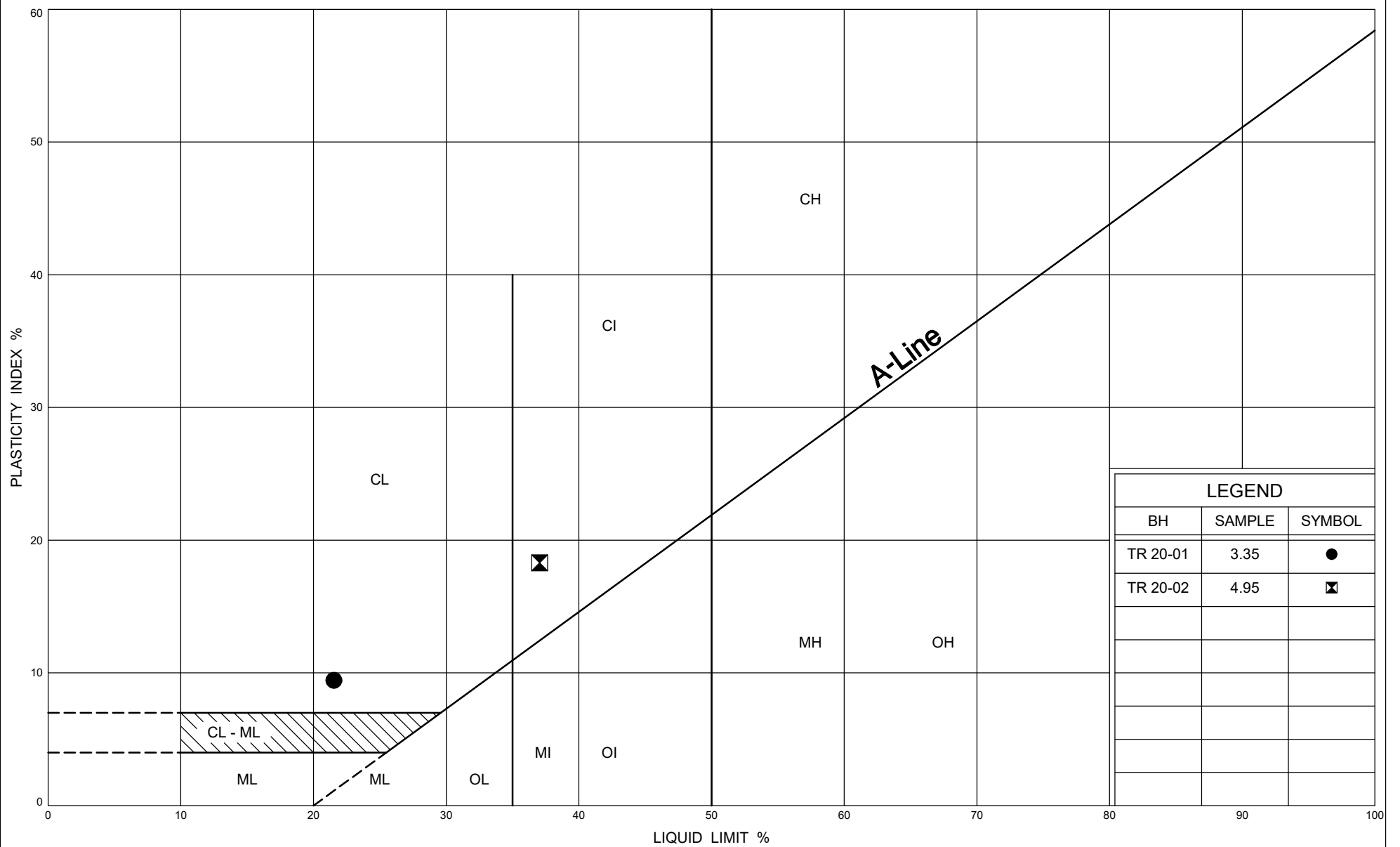
FIG No B2

W P 2165-16-00

Thickson Road Underpass Bridge







Ministry of
Transportation

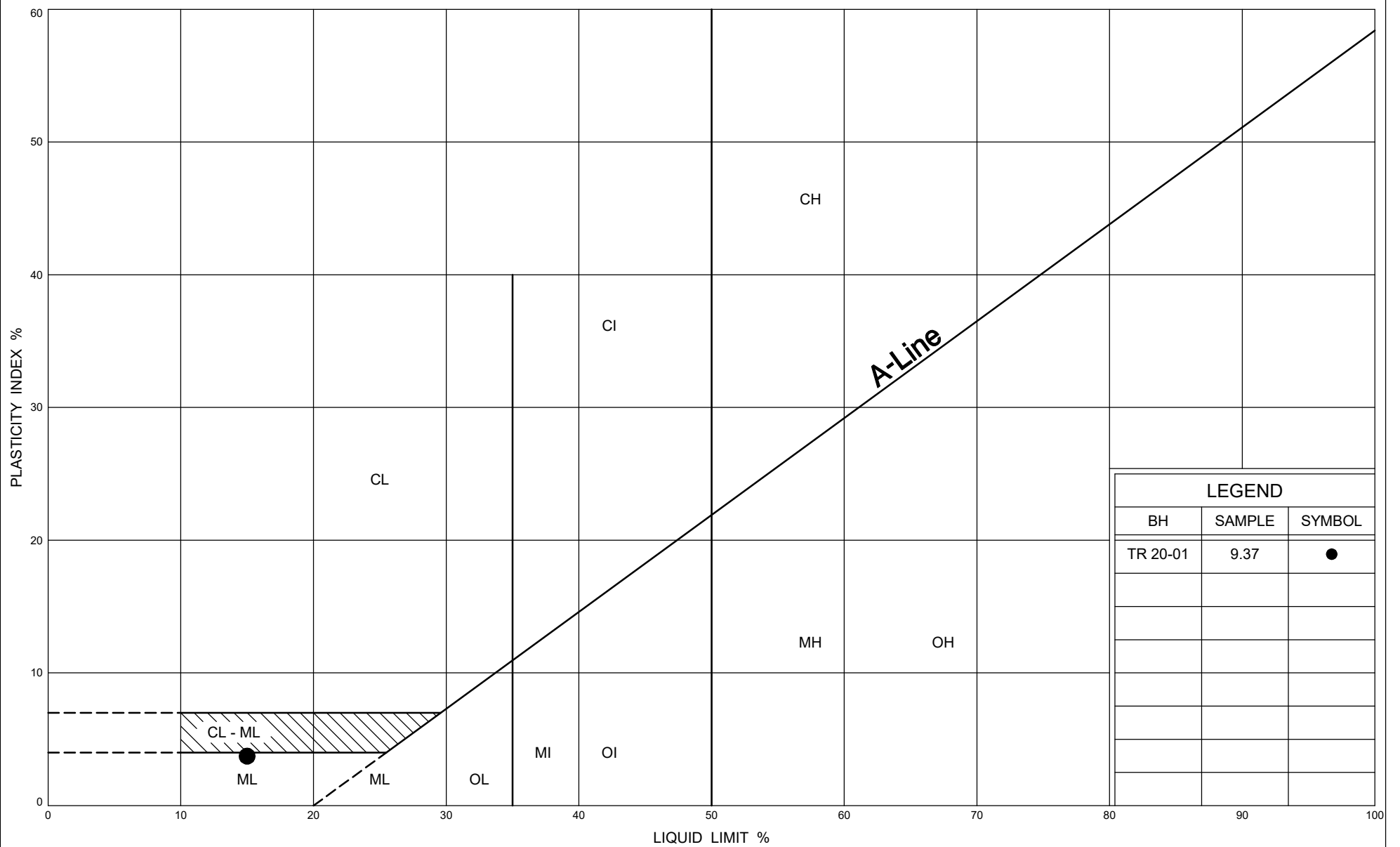
PLASTICITY CHART

Silty CLAY FILL

FIG No B5

W P 2165-16-00

Thickson Road Underpass Bridge



Ministry of
Transportation

PLASTICITY CHART

Sandy SILT TILL (Silt Zone)

FIG No B6

W P 2165-16-00

Thickson Road Underpass Bridge



Appendix C

Site Photographs



Figure 1: Looking southbound at TR20-01 on Thickson Road



Figure 2: Looking northbound at TR20-02 on Thicksen Road

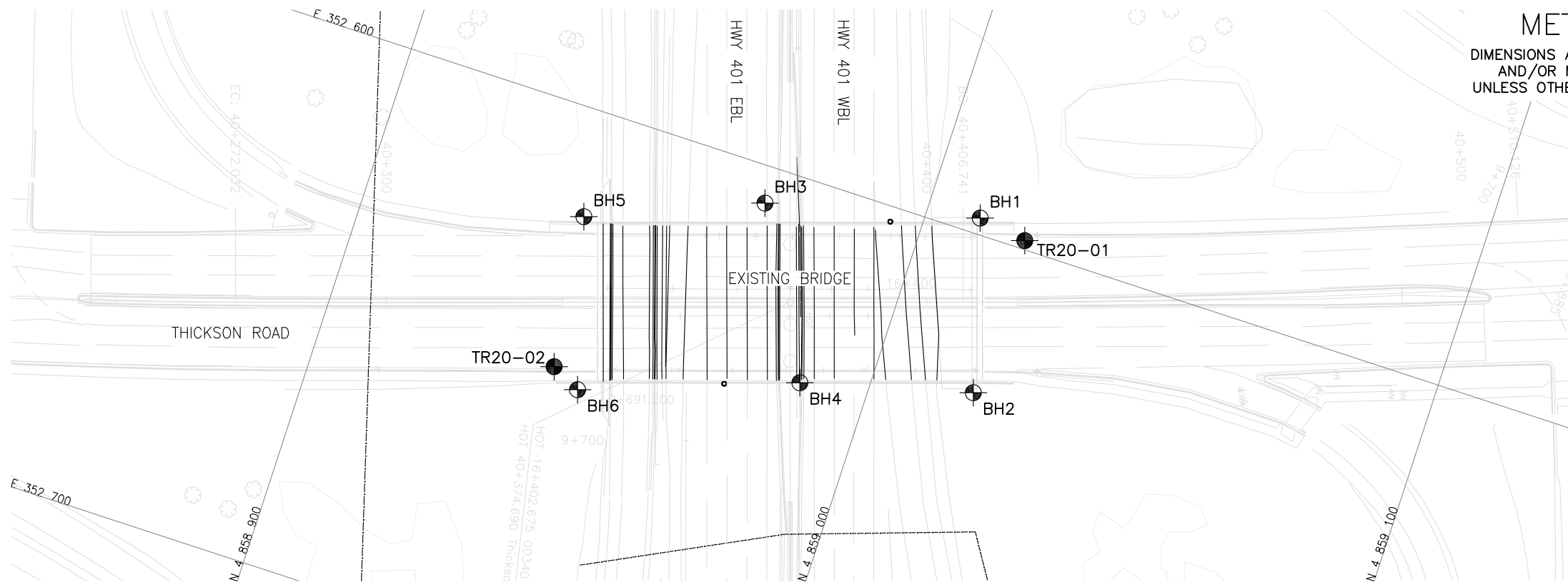


Figure 3: Looking west at the south abutment of the Thickson Road Underpass



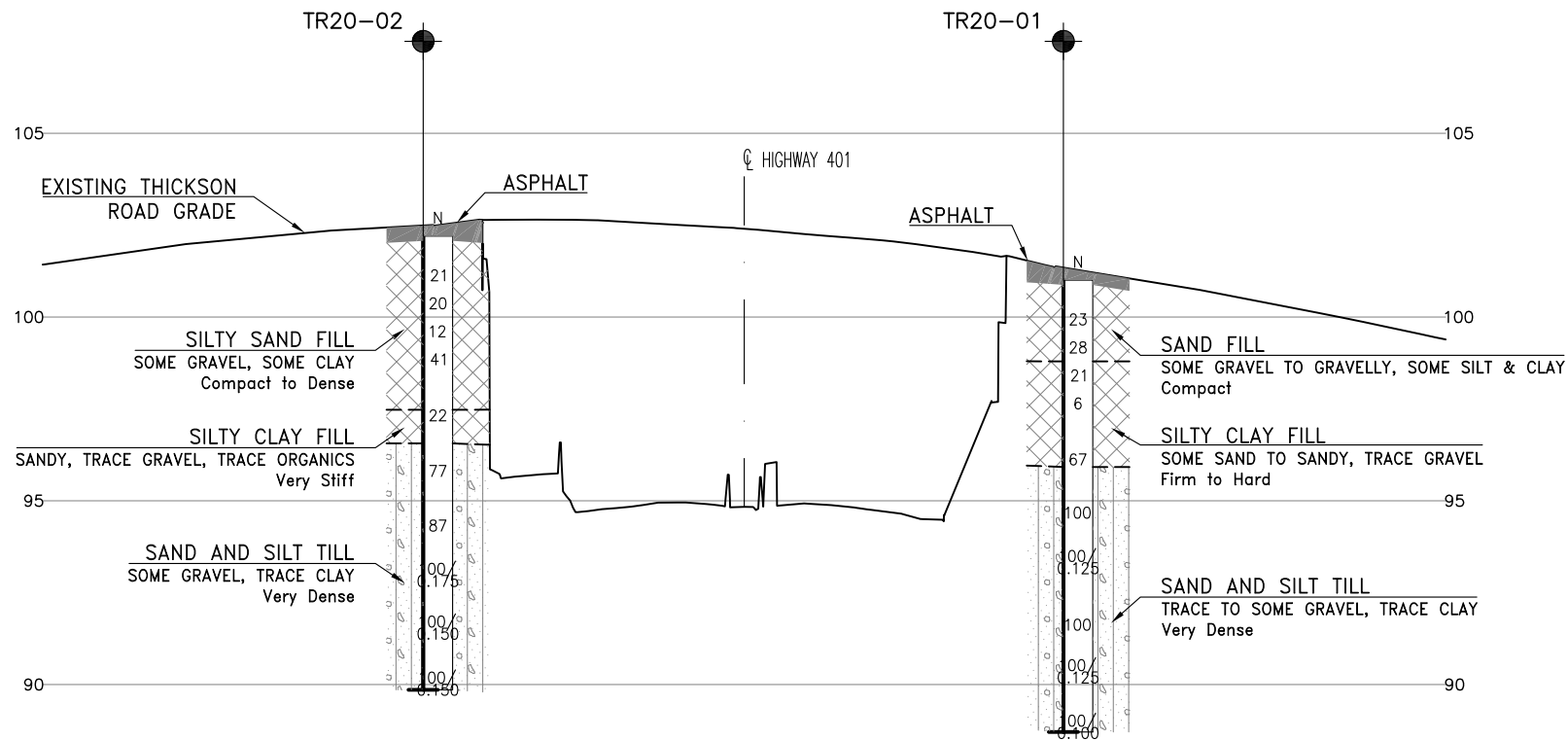
Appendix D

Borehole Locations and Soil Strata Drawing



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

PLAN
SCALE 1:1000



PROFILE ALONG THICKSON ROAD

SCALE 1:1000
SCALE 1:200

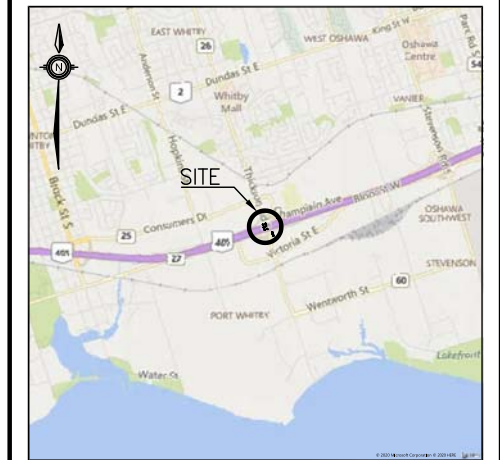


CONT No
WP No 2165-16-00

HIGHWAY 401
THICKSON ROAD UNDERPASS
BRIDGE REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

CONSOR

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole (Current Investigation)
⊕	Borehole (Previous Investigation By Others)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
≡	Water Level
≡	Water Level
≡	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
BH1	100.3	4 859 009.8	352 597.0
BH2	98.2	4 859 018.6	352 628.1
BH3	94.2	4 858 971.1	352 606.8
BH4	95.3	4 858 987.6	352 636.3
BH5	100.3	4 858 940.0	352 619.6
BH6	97.8	4 858 948.8	352 650.3
TR20-01	101.1	4 859 019.0	352 598.4
TR20-02	102.2	4 858 943.4	352 647.6

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 30M15-332

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	JM	CHK NB	CODE
DRAWN	BH	CHK JM	SITE
LOAD			
STRUCT			
DWG	1		
DATE	MAY 2021		



Appendix E

List of OPS Specifications and Suggested NSSP Wording



1. List of Special Provisions and OPSS Documents Referenced in this Report

- OPSS.PROV 902
- OPSS.PROV 539
- OPSD 3090.101

2. Suggested Wording for NSSP on Obstructions

Excavations and installation of temporary protection systems may encounter obstructions such as cobbles and boulders embedded in the embankment fill and native till soils. Such obstructions may impede excavation progress and/or protection system installation. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths.