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FOUNDATION INVESTIGATION AND DESIGN REPORT
REPLACEMENT OF LINE 9 CULVERT AND NEW HIGHWAY 400 E-N RAMP CULVERT
SITE NO. 30X-0876/C0 & 30X-0877/C0
BRADFORD WEST GWILLIMBURY, ONTARIO
G.W.P. No. 2026-23-00
GEOCRES No. 31D04-030

Client Name: AECOM
Date: March 20, 2026
File: 48856

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PART A: FOUNDATION INVESTIGATION REPORT

1. INTRODUCTION

Thurber was retained by AECOM on behalf of the Ministry of Transportation Ontario (MTO) to carry out detail foundation investigation services for the western portion of the new Bradford Bypass under Assignment No. 2023-E-0068. The proposed Bradford Bypass will be a four-lane rural divided freeway connecting Highway 400 to Highway 404 and can accommodate future widening of up to eight lanes.

The proposed work for this assignment involves the design of a 6.5 km stretch of Bradford Bypass from Highway 400 to west of Artesian Industrial Parkway. This report only addresses the investigation carried out for the proposed replacement of the existing 9th Line Culvert and the new Highway 400 E-N Ramp Culvert in the Town of Bradford West Gwillimbury, Ontario.

The purpose of this investigation is to establish the subsurface conditions at the proposed culvert locations by borehole drilling, in situ testing, and laboratory testing on selected samples.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement for Use and Interpretation of Report.

2. SITE DESCRIPTION

The 9th Line is located approximately 2.7 km north of the Simcoe Road 88 (commonly known as Highway 88) interchange in the Town of Bradford West Gwillimbury, Ontario.

Highway 400 is currently a six-lane highway oriented in a north to south direction, with three lanes in each NBL and SBL direction, separated by a concrete median. 9th Line is generally oriented in an east to west direction and carries one lane of traffic in each direction under Highway 400 with narrow shoulders on both sides.

The existing 9th Line culvert consists of a concrete box culvert oriented in the north-south direction with a current finished grade elevation of about Elev. 271.5 m at the centreline of 9th Line. The existing slopes were heavily vegetated with no signs of slope instability or settlement across the span of the 9th Line culvert at the time of drilling. The proposed Highway 400 Bradford Bypass E-N Ramp Culvert 2025 site is currently situated in a farm field located approximately 180 metres east of the existing Highway 400 and 280 m south of 9th Line.

The land adjacent to the sites generally consists of farmland and the vegetative cover generally consists of tall grass, shrubs, and crop residue. The topography northwest of Highway 400 and 9th Line is elevated and slopes downwards towards the southeast. Overhead wires are present to the south of 9th Line and traverses over Highway 400.

2.1 Site Geology

Based on published geological information, The Town of West Gwillimbury is located within three major physiographic regions of southern Ontario: the Simcoe Lowlands, the Schomberg Clay Plains, the Peterborough Drumlin Field.

The Simcoe Lowlands form part of the larger Great Lakes–St. Lawrence Lowlands and are characterized by flat to gently undulating terrain. This region predominantly consists of clayey to silty glaciolacustrine deposits overlying till or glaciofluvial materials. The soils tend to have low permeability, and the area is often associated with poor drainage, wetlands, and organic deposits in depressions.

The Schomberg Clay Plains extend across parts of southern Simcoe County, northern York Region, and adjacent areas. These clay plains are characterized by flat to gently undulating topography and are underlain predominantly by glaciolacustrine silts and clays, which were deposited in the post-glacial Lake Algonquin and Lake Iroquois basins. In the West Gwillimbury area, particularly west and southwest of Bradford, the Schomberg Clay Plain dominates the surface geology, forming thick, cohesive deposits with low permeability.

The Peterborough Drumlin Field covers approximately 900 km^2 on a Paleozoic limestone plain and is one of the largest drumlin fields in southern Ontario. This physiographic region is located between the Oak Ridges Moraine and the area of shallow overburden on the limestones of the Gull River Formation, extending from Hastings County in the east to Simcoe County in the west, and including the drumlins south of the moraine in Northumberland County. The surficial soils in the Peterborough Drumlin Field consist primarily of gravelly sand till or sand and gravel deposits. Deposits of silt, clay or peat may be found in the low-lying areas between drumlins.

The bedrock in this region is predominantly composed of limestone belonging to the Lindsay and Verulam Formations, which are part of the Upper Ordovician sequence. These formations are typically softer, more thinly bedded, and less massive than the older Gull River Formation, which lies stratigraphically below.

3. SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing program completed for the proposed 9th Line Culvert and Highway 400 Bradford Bypass E-N Ramp Culvert were carried out from October 22, 2025 to November 29, 2024, and from July 30 to August 1, 2025, respectively and consisted of drilling and sampling six (6) boreholes, designated as Boreholes 9CULV-01 to 9CULV-03, RCULV25-01 to RCULV25-03.1

Three (3) previous boreholes were completed for the Highway 400 E-N Ramp Culvert, designated as Boreholes RCULV-01 to RCULV-03, at a different site location. These boreholes are not discussed within this report and are included within Appendix D.

At each proposed culvert location, the boreholes were drilled near the locations of the proposed culvert inlet, outlet and middle section.

Details of the borehole locations, ground surface elevations and termination depths and elevations are summarized in Table 3.1 below.

Table 3.1: Borehole Locations

Structure	Borehole	Co-ordinates MTM (1) NAD 83 Zone 10		Ground Surface Elevation (m)	Borehole Termination Depth (m)	Borehole Termination Elevation (m)
		Northing	Easting			
9th Line Culvert	9CULV-01(2)	4,887,173.2	293,950.2	271.3	15.8	255.5
	9CULV-02	4,887,153.0	293,940.7	271.3	18.9	252.4
	9CULV-03	4,887,145.2	293,956.1	271.7	9.8	261.9
Highway 400 – Bradford Bypass E-N Ramp Culvert	RCULV25-01(2)	4,886,935.0	294,101.6	268.2	15.8	252.3
	RCULV25-02	4,886,902.4	294,085.4	265.1	20.1	245.0
	RCULV25-03(2)	4,886,891.0	294,076.9	264.4	19.2	245.2

Notes: 1. Survey of all as-drilled borehole locations was carried out by AECOM.
2. Monitoring well was installed at borehole location.

The approximate locations of the boreholes are shown on the Borehole Location Plan and Soil Strata drawings in Appendix B. The Record of Borehole sheets of the investigation are provided in Appendix C.

It should be noted that the surveying of the as-drilled borehole locations was completed by AECOM in accordance with MTO's requirements for the horizontal and vertical accuracy. The coordinates and elevations of the boreholes are given on the Borehole Location Plan and Soil Strata drawing and Record of Borehole sheets in Appendices B and C, respectively.

Lane and/or shoulder closures and traffic control were implemented, where required, for drilling the boreholes. Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

The boreholes were advanced using track-mounted and truck-mounted drill rigs. Hollow stem augers and mud rotary with casing were used to advance the boreholes to final depth. Where mud rotary drilling was used, water was delivered from off-site locations. Soil samples were obtained at selected depth intervals using a 50 mm outside diameter split-spoon sampler driven in conjunction with the Standard Penetration Test (SPT) which was performed in accordance with ASTM D1586.

The field investigation was observed on a full-time basis by a member of Thurber's technical staff who marked/staked the boreholes in the field, directed the drilling, sampling and in-situ testing operations, logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Three (3) monitoring wells (50 mm diameter Schedule 40 PVC) were installed and enclosed in filter sand in Boreholes 9CULV-01, RCULV25-01 and RCULV25-03 to permit groundwater level monitoring. Details of the monitoring well installations are shown in Table 3.2 below.

Table 3.2: Monitoring Well Installation Details

Foundation Unit	Borehole	Monitoring Well Tip Depth / Elevation (m)	Completion Details
9th Line Culvert	9CULV-01	5.2 / 266.1	Monitoring well was installed in Borehole 9CULV-01. Borehole was backfilled with bentonite holeplug and cuttings from 15.8 m to 5.5 m. Monitoring well with 3.0 m slotted screen installed with sand filter from 5.5 m to 3.0 m, then backfilled with bentonite holeplug from 3.0 m to 2.1 m, cuttings from 2.1 m to 0.9 m, and bentonite holeplug from 0.9 m to ground surface.
HWY 400 – Bradford Bypass E-N Ramp Culvert	RCULV25-01	7.6 / 260.6	Monitoring well was installed in Borehole RCULV25-01. Borehole was backfilled with bentonite holeplug from 15.8 m to 8.2 m. Monitoring well with 3.0 m slotted screen installed with sand filter from 8.2 m to 4.0 m, then backfilled with bentonite holeplug from 4.0 m to ground surface.
	RCULV25-03	4.6 / 259.8	Monitoring well was installed adjacent to Borehole RCULV25-03. Monitoring well with 3.0 m slotted screen installed with sand filter from 4.6 m to 0.9 m, then backfilled with bentonite holeplug from 0.9 m to ground surface.

All boreholes without monitoring well installations were backfilled upon completion of drilling in general accordance with O.Reg. 903. Monitoring wells are to remain in place to permit groundwater level measurements prior to and during construction operations and is to be decommissioned by the Contractor in accordance with O.Reg. 903. Asphalt was reinstated in Borehole 9CULV-02 drilled on the 9th Line platform.

4. LABORATORY TESTING

The recovered soil samples were subjected to visual identification and natural moisture content determination. Selected soil samples were subjected to grain size distribution analyses (sieve and/or hydrometer), and Atterberg Limits testing. Geotechnical laboratory testing results of the current investigation are summarized on the Record of Borehole sheets in Appendix C and are presented on the figures in Appendix E.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for metal corrosion associated with the structure, samples of the native soils were collected and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing for corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 5.10 and are presented in Appendix E.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered subsurface stratigraphy from the two (2) investigation areas are presented on the Record of Borehole sheets included in Appendix C, and on the Borehole Locations and Soil Strata drawings in Appendix B. An overall description of the stratigraphy is given in the following paragraphs for each of those areas. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions. It must be recognized and anticipated that soil conditions may vary between and beyond the borehole locations.

5.1 9th Line Culvert

In general, the subsurface stratigraphy at the site consists of surficial topsoil or asphalt on road embankment fill (very dense to compact, sandy silt to silt) overlying an extensive deposit of loose to compact silty sand till. Beyond the proposed culvert footprint to the north, a 2.2 m thick, soft to firm clay deposit was encountered at ground surface. Underlying the cohesionless till deposit is a stiff clay up to 2.6 m thick. The groundwater was measured in a monitoring well at depths ranging from 1.1 m to 1.6 m (Elevations 270.2 to 269.7) below the existing ground surface, or up to about 2 m above the proposed culvert invert.

More detailed descriptions of the individual stratum are presented below.

5.1.1 Topsoil

Topsoil was encountered at ground surface in Boreholes 9CULV-01 and 9CULV-03, with thicknesses of 50 mm and 100 mm, respectively.

The topsoil thickness may vary between and beyond the borehole locations, and the data is not intended for the purpose of estimating quantities.

5.1.2 Pavement Structure

Pavement structure consisting of 60 mm of asphalt overlying fill (sandy silt to silt with sand) road base was encountered at the ground surface in Borehole 9CULV-02, which was advanced through the 9th Line platforms. The granular fill was 2.1 m thick where encountered.

SPT 'N' values of the granular fill varied from 66 to 14 blows per 0.3 m of penetration, indicating a very dense to compact state. The natural moisture content measured on granular road base fill samples was of 5 to 29 percent.

The results of a grain size analysis conducted on a sample of the fill is provided on the Record of Borehole sheets in Appendix C and illustrated on Figure E1 in Appendix E. The results are summarized in Table 5.1.

Table 5.1: Grain Size Distribution of Fill

Particle Size	Percentage (%)
Gravel	0
Sand	29
Silt	49
Clay	22

5.1.3 Silty Sand Till

A deposit of interbedded cohesionless till consisting of brown to grey silty sand was observed in Boreholes 9CULV-01, 9CULV-02 and 9CULV-02 at 2.2 m, 2.2 m and 0.1 m depth, respectively. Locally, in Borehole 9CULV-01, the silty sand till was contacted at 15.5 m depth, interbedded within the cohesive clay. The thickness of the interbedded cohesionless till ranged from 9.7 m to greater than 14.1 m.

The cohesionless till deposit was not fully penetrated, as all boreholes, except 9CULV-02, were terminated within this unit. This deposit is at least 14.1 m thick and likely extends to greater depths beyond the current borehole terminations.

SPT 'N' values recorded in the cohesionless till ranged from 4 to 26 blows per 0.3 m of penetration, indicating a loose to compact consistency. The natural moisture content measured on the cohesive samples varied from 8 to 29 percent.

The results of a grain size analyses conducted on samples of the cohesionless till are provided on the Record of Borehole sheets in Appendix C and illustrated on Figure E2 in Appendix E. The results are summarized as follows:

Table 5.2: Grain Size Distribution of Silty Sand Till

Particle Size	Percentage (%)
Gravel	1 to 11
Sand	47 to 53
Silt	31 to 42
Clay	8 to 12

The result of a Atterberg Limit test conducted on a sample of the silty sand till is presented on the Record of Borehole sheets in Appendix C and illustrated in Figure E3 in Appendix E. The result is summarized as follows:

Table 5.3: Atterberg Limit of Silty Sand Till

Parameter	Value
Liquid Limit	13
Plastic Limit	10
Plasticity Index	3

The results of the Atterberg Limit test indicate that the silty sand till is non-plastic, with a group symbol ML.

Glacial tills inherently contain cobbles and boulders.

5.1.4 Clay

Locally, a surficial layer of brown clay was observed in Borehole 9CULV-01 at 0.1 m depth with a thickness of 2.1 m. Interbedded layers of grey clay were observed in Boreholes 9CULV-01 and 9CULV-02 at 14.8 m and 16.3 m depth, respectively. The thickness of the interbedded cohesive material ranged from 0.7 m to greater than 2.6 m.

SPT ‘N’ values recorded in the clay ranged from 2 to 15 blows per 0.3 m of penetration, indicating a soft to stiff density. The natural moisture content measured on the cohesive samples varied from 11 to 36 percent.

The result of a grain size analyses conducted on a sample of the clay is provided on the Record of Borehole sheets in Appendix C and illustrated on Figure E4 in Appendix E. The result is summarized as follows:

Table 5.4: Grain Size Distribution of Clay

Particle Size	Percentage (%)
Gravel	0
Sand	7
Silt	45
Clay	48

The result of a Atterberg Limit test conducted on a sample of the clay is presented on the Record of Borehole sheets in Appendix C and illustrated on Figure E5 in Appendix E. The result is summarized as follows:

Table 5.5: Atterberg Limits of Clay

Parameter	Value
Liquid Limit	30
Plastic Limit	18
Plasticity Index	12

The result of the Atterberg Limit test indicate that the clay is low plasticity, with a group symbol CL.

5.1.5 Groundwater Conditions

Groundwater levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. A monitoring well was installed in Borehole 9CULV-01 to permit monitoring of groundwater levels.

Water levels measured in the monitoring well is presented in the table below.

Table 5.6: Groundwater Level Measurements

Foundation Element	Borehole	Date	Groundwater Level		Comments
			Depth (m)	Elevation (m)	
9th Line Inlet	9CULV-01	November 5, 2024	1.5	269.8	Monitoring well
		November 14, 2024	1.4	269.9	
		April 9, 2025	1.1	270.2	
		May 29, 2025	1.2	270.1	
		September 9, 2025	1.6	269.7	
		November 25, 2025	1.3	270.0	

No signs of artesian conditions were observed during the completion of drilling or groundwater level monitoring events. Table 5.6 are short term readings where seasonal fluctuations are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation. Seasonal fluctuations of the groundwater levels are to be expected.

5.2 Highway 400 – Bradford Bypass E-N Ramp Culvert

In general, the subsurface stratigraphy at the site consists of surficial topsoil and sandy silt to silty organics, underlain by an extensive deposit of very loose to compact, silty sand to silty clayey sand till. Near the inlet (east end) of the proposed culvert, a surficial compact sandy silty clay of about 0.8 m thick is present. Underlying the cohesionless till deposit near the outlet (west end) is a deposit of soft to very stiff clay till of at least 2.5 m thick. A DCPT was advanced in Borehole RCULV25-03 to a depth of 19.2 m (Elevation 245.2).

The groundwater was measured in the monitoring wells at depths ranging from 0.6 m to 2.3 m (Elevations 267.6 to 265.9) below the existing ground surface, near the inlet (higher ground), and depths ranging from 1.2 m to 1.7 m (Elevations 263.2 to 262.7) below the existing ground surface, near the outlet (lower ground). These water levels will be greater than 3 m above the inlet invert and just below the outlet invert.

More detailed descriptions of the individual stratum are presented below.

5.2.1 Topsoil

Topsoil was encountered at ground surface in all three (3) boreholes RCULV25-01 to RCULV25-03, with thicknesses ranging between 75 mm and 150 mm.

The topsoil thickness may vary between and beyond the borehole locations, and the data is not intended for the purpose of estimating quantities.

5.2.2 Silty Organic Soil

A layer of brown silty organic soil with some rootlets and trace clay was observed in Borehole RCULV25-03 below the topsoil. The thickness of the organic soil layer was 0.6 m.

A SPT ‘N’ value recorded in the organic soils was 7 blows per 0.3 m of penetration, indicating a loose consistency. The natural moisture content measured on the organic soil was 28 percent.

5.2.3 Silty Clay

A layer consisting of brown silty clay was observed in Borehole RCULV25-01 below the topsoil with a thickness of 0.8 m.

A SPT 'N' value recorded in the silty clay was 13 blows per 0.3 m of penetration, indicating a stiff consistency. A natural moisture content measured on the sandy silt was 9 percent.

The result of a grain size analysis conducted on a sample of the silty clay is provided on the Record of Borehole sheets in Appendix C and illustrated on Figure E6 in Appendix E. The results are summarized as follows:

Table 5.7: Grain Size Distribution of Sandy Silt

Particle Size	Percentage (%)
Gravel	0
Sand	31
Silt	43
Clay	26

5.2.4 Silty Sand to Silty, Clayey Sand to Clayey Sand Till

A deposit of cohesionless till consisting of brown to grey silty sand to silty, clayey to clayey sand was observed in all Boreholes RCULV-01, RCULV-02 and RCULV-03 at 0.9 m, 0.2 m and 0.8 m depth, respectively.

This deposit is at least 19.4 m thick and likely extends to greater depths beyond the current borehole terminations.

SPT 'N' values recorded in the cohesionless till ranged from 3 to 34 blows per 0.3 m of penetration, indicating a very loose to dense consistency. The natural moisture content measured on the cohesionless samples varied from 9 to 13 percent. An individual moisture content of 24 percent was recorded locally within the cohesionless till deposit in Borehole RCULV25-02 and is provided on the Record of Borehole sheets in Appendix B.

The results of a grain size analyses conducted on samples of the cohesionless till are provided on the Record of Borehole sheets in Appendix C and illustrated on Figure E7 and E8 in Appendix E. The results are summarized as follows:

Table 5.8: Grain Size Distribution of Silty Sand to Silty, Clayey Sand to Clayey Sand Till

Particle Size	Percentage (%)
Gravel	1 to 7
Sand	49 to 56
Silt	27 to 34
Clay	12 to 16

The results of a Atterberg Limit tests conducted on samples of the cohesionless till are presented on the Record of Borehole sheets in Appendix C and illustrated on Figure E9 and E10 in Appendix E. The result is summarized as follows:

Table 5.9: Atterberg Limits of Silty Sand to Silty, Clayey Sand to Clayey Sand Till

Parameters	Values
Liquid Limit	14 to 21
Plastic Limit	5 to 13
Plasticity Index	4 to 10

The results of the Atterberg Limit test indicate that the fine portions of the material are plastic. Overall, the silty sand to silty, clayey sand is considered is non-plastic, with a group symbol CL-ML.

Glacial tills inherently contain cobbles and boulders.

5.2.5 Sandy Clay Till

A layer of cohesive till consisting of grey sandy clay was observed in Borehole RCULV25-01 at 5.6 m depth. The cohesive till layer was observed to have a thickness of 2.4 m, interbedded within the silty, clayey sand till deposit.

A SPT ‘N’ value recorded in the cohesive till was 15 blows per 0.3 m of penetration, indicating a very stiff consistency. A natural moisture content measured on the cohesive samples was 12 percent.

The results of a grain size analysis conducted on a sample of the cohesive till is provided on the Record of Borehole sheets in Appendix C and illustrated on Figure E11 in Appendix E. The results are summarized as follows:

Table 5.10: Grain Size Distribution of Sandy Clay Till

Particle Size	Percentage (%)
Gravel	4
Sand	36
Silt	34
Clay	26

The result of a Atterberg Limit test conducted on a sample of the cohesive till is presented on the Record of Borehole sheets in Appendix C and illustrated on Figure E12 in Appendix E. The result is summarized as follows:

Table 5.11: Atterberg Limit of Sandy Clay Till

Parameter	Value
Liquid Limit	15
Plastic Limit	10
Plasticity Index	5

The results of the Atterberg Limit test indicate that the sandy clay till is plastic, with a group symbol CL.

Glacial tills inherently contain cobbles and boulders.

5.2.6 Clay Till

A deposit of cohesive till consisting of grey clay was observed in Borehole RCULV25-03 at 13.3 m. The cohesive till layer was observed to extend to the SPT termination depth of 15.8 m, prior to the advancement of a DCPT.

SPT ‘N’ values recorded in the cohesive till ranged from 3 to 18 blows per 0.3 m of penetration, indicating a soft to very stiff consistency. Natural moisture contents measured on the cohesive samples ranged from 12 to 21 percent.

The result of a grain size analysis conducted on a sample of the cohesive till is provided on the Record of Borehole sheets in Appendix C and illustrated on Figure E13 in Appendix E. The results are summarized as follows:

Table 5.12: Grain Size Distribution of Clay Till

Grain Size	Percentage (%)
Gravel	0
Sand	13
Silt	48
Clay	39

The result of a Atterberg Limit test conducted on a sample of the cohesive till is presented on the Record of Borehole sheets in Appendix C and illustrated on Figure E14 in Appendix E. The result is summarized as follows:

Table 5.13: Atterberg Limit of Clay Till

Parameter	Value
Liquid Limit	27
Plastic Limit	13
Plasticity Index	14

The results of the Atterberg Limit test indicate that the clay till is plastic, with a group symbol CL.

Glacial tills inherently contain cobbles and boulders.

5.2.7 Silty Sand with Gravel

A deposit of consisting of grey silty sand with gravel was observed in Borehole RCULV25-02 at 19.4 m. The silty sand with gravel layer was observed to extend to the SPT termination depth of 20.1 m.

A SPT ‘N’ value recorded in the silty sand with gravel was 100 blows per 0.1 m of penetration, indicating a very dense consistency. A natural moisture content measured on the silty sand with gravel material was 9 percent.

The result of a grain size analysis conducted on a sample of the silty sand with gravel is provided on the Record of Borehole sheets in Appendix C and illustrated on Figure E15 in Appendix E. The results are summarized as follows:

Table 5.14: Grain Size Distribution of Silty Sand with Gravel

Particle Size	Percentage (%)
Gravel	25
Sand	55
Silt	14
Clay	6

5.2.8 Groundwater Conditions

Groundwater levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. Monitoring wells were installed in RCULV25-01 and RCULV25-03 to permit monitoring of groundwater levels.

Water levels measured in the monitoring wells are presented in Table 5.2 below.

Table 5.15: Groundwater Level Measurements

Foundation Element	Borehole	Date	Groundwater Level		Comments
			Depth (m)	Elevation (m)	
HWY 400 – Bradford Bypass E-N Ramp Culvert	RCULV25-01	August 7, 2025	-0.5[(1)]	268.7	Monitoring well
		August 22, 2025	2.2	266.0	
		September 10, 2025	2.3	265.9	
		November 26, 2025	0.6	267.6	
	RCULV25-03	August 7, 2025	1.5[(1)]	262.9	Monitoring well
		August 22, 2025	1.5	262.9	
		September 10, 2025	1.2	263.2	
		November 26, 2025	1.7	262.7	

Notes: 1. Water level recorded prior to well development and may be influenced by residual drilling fluids.

Table 5.15 are short term readings where seasonal fluctuations are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation. Seasonal fluctuations of the groundwater levels are to be expected.

6. ANALYTICAL LABORATORY TESTING

Selected soil samples were submitted for analytical testing of corrosivity parameters including sulphate content, the results of which are summarized in Table 6.1. The laboratory certificates of analysis are presented in Appendix E.

Table 6.1: Analytical Corrosivity Test Results

Sample ID / Description	Sample Depth / Elevation (m)	pH	Soil Redox Potential (mV)	Sulphide (Na_2CO_3) %	Resistivity (ohm-cm)	Electrical Conductivity (µS/cm)	Sulphate (µg/g)	Chloride (µg/g)
9CULV-02	3.0 / 268.3	8.25	276	<0.01	4050	247	94	60
RCULV25-02	1.8 / 263.3	8.78	279	<0.01	10200	98	3.8	4.5

7. MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling.

AECOM obtained the co-ordinates and ground surface elevations of the as-drilled borehole locations in the field.

3D Drilling Inc. from Uxbridge, Ontario supplied and operated the drilling and sampling equipment for the field program.

Corrosivity testing was carried out by SGS Canada Inc. of Lakefield, Ontario, a CALA accredited analytical laboratory.

Full time observation of the field activities was carried out by Ms. Fernanda Croce, Mr. George Azzopardi, Mr. Jakob Flood and Mr. Kamil Feszak of Thurber. Overall supervision of the field program was performed by Messrs. Rod de Castro, P.Eng. and Joshua Alexander, P.Eng. of Thurber.

8. CLOSURE

Interpretation of the field data and preparation of the report was carried out by Mr. Joshua Alexander, P.Eng., a Geotechnical Engineer, and Mr. Sydney Pang, P.Eng., a Senior Geotechnical Engineer. This report was reviewed by Mr. Jason Lee, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART B: FOUNDATION DESIGN REPORT

9. GENERAL

This report provides an interpretation of the subsurface information obtained from the foundation investigations and provides foundation recommendations for the replacement of the 9th Line culvert and the proposed Highway 400 Bradford Bypass E-N Ramp Culvert in the Town of Bradford West Gwillimbury, Ontario.

The discussions and recommendations presented in this report are intended for the use of the Ministry of Transportation, Ontario and their designers AECOM, but should not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The contractor undertaking the work must make their own interpretation based on the information presented in the factual sections of the report (Part A of this report). Where comments are made on construction, they are provided to highlight those aspects which could affect the design of the project. The contractor must make their own interpretation of the data provided as it may affect equipment selection, proposed construction methods, scheduling, and the like.

Highway 400 is currently a six-lane highway oriented in a north to south direction, with three lanes in each NBL and SBL direction, separated by a concrete median. Ninth Line is two-lane road with narrow shoulders crossing under Highway 400 and is generally oriented in an east to west direction.

The existing 9th Line culvert consists of a concrete box culvert oriented in the north-south direction with a current finished grade elevation of about Elev. 271.5 m at the centreline of 9th Line. The existing slopes were heavily vegetated with no signs slope instability or settlement across the span of the culvert. The proposed Highway 400 Bradford Bypass E-N Ramp Culvert 2025 site is currently situated in a farm field located approximately 180 metres east of the existing Highway 400 and 280 m south of 9th Line.

Based on General Arrangement (GA) drawing dated January 2026 provided by AECOM, the existing 9th Line Culvert will be replaced with a 5.7 m wide, 14.0 m long rigid concrete frame box culvert with a founding elevation at approximate Elev. 267.6 m. A distribution slab with a minimum 150 mm thickness and asphalt is proposed over the culvert. A 4 m long retaining wall is proposed at each of the four corners of the culvert box. The culvert replacement will be approximately 15 m east of the current box culvert.

Based on General Arrangement (GA) drawing dated January 2026 provided by AECOM, the proposed Highway 400 Bradford Bypass E-N Ramp Culvert will be a 5.7 m wide, 36.5 m long rigid concrete frame box culvert with an approximate founding elevation of 264.2 m near the inlet (west) and 263.6 m near the outlet (east). An approximate maximum embankment height of 3.2 m is proposed. Cast-in-place wingwalls (retaining walls), ranging between 3.5 m and 8.0 m in length, are proposed at all four corners of the box culvert.

The General Arrangement drawings are included in Appendix F.

9.1 Summary of Subsurface Conditions

9.1.1 9th Line

In general, the subsurface stratigraphy at the site consists of surficial topsoil or asphalt on road embankment fill (very dense to compact, sandy silt to silt) overlying an extensive deposit of loose to compact silty sand till. Beyond the proposed culvert footprint to the north, a 2.2 m thick, soft to firm clay deposit was encountered at ground surface. Underlying the cohesionless till deposit is a stiff clay up to 2.6 m thick. The groundwater was measured in a monitoring well at depths ranging from 1.1 m to 1.6 m (Elevations 270.2 to 269.7) below the existing ground surface, or up to about 2 m above the proposed culvert invert.

9.1.2 Highway 400 – Bradford Bypass E-N Ramp

In general, the subsurface stratigraphy at the site consists of surficial topsoil and sandy silt to silty organics, underlain by an extensive deposit of very loose to compact, silty sand to silty clayey sand till. Near the inlet (east end) of the proposed culvert, a surficial compact sandy silty clay of about 0.8 m thick is present. Underlying the cohesionless till deposit near the outlet (west end) is a deposit of soft to very stiff clay till of at least 2.5 m thick. The groundwater was measured in the monitoring wells at depths ranging from 0.6 m to 2.3 m (Elevations 267.6 to 265.9) below the existing ground surface, near the inlet (higher ground), and depths ranging from 1.2 m to 1.7 m (Elevations 263.2 to 262.7) below the existing ground surface, near the outlet (lower ground). These water levels will be greater than 3 m above the inlet invert and just below the outlet invert.

10. CULVERT DESIGN

10.1 Culvert Alternatives

This section presents discussions on alternate types of culverts for the proposed culverts, foundation alternatives, and provides recommendations for feasible and/or preferred foundation options. Based on the GA drawings, it is understood that the proposed culverts will both consist of a precast segmental concrete box structure.

Several common culvert types that may be considered for the culvert replacement and extension at this site are listed below:

- Concrete box (closed) culvert
- Concrete open frame culvert on strip footings
- Circular pipe culvert

Discussions on feasible culvert alternatives are presented in the following paragraphs.

10.1.1 Precast Concrete Box (Closed) Culvert

A concrete box culvert is considered feasible for replacing the existing culvert at Line 9 and for a new culvert along the proposed Highway 400 E-N Ramp. Precast sections, rather than cast-in-place construction, can be installed rapidly with less potential for disturbance of the founding soils during installation. A segmental box structure can accommodate some potential differential settlement along the culvert axis. Effective groundwater control will be required at these sites to maintain dry excavations during the course of the staged construction. Temporary protection (shoring), where required, must be implemented at these sites prior to excavation.

10.1.2 Concrete open frame culvert on strip footings

Concrete, open frame, culvert is a typical alternative to a concrete box culvert. At these two sites, however, very loose to loose zones within the silty sand till deposits are frequently present below the proposed culvert inverts. These soils will provide lower geotechnical resistances and may also result in inadequate culvert subgrade. Therefore, deeper excavations and/or wider footings would be required to provide adequate foundation support. Additionally, due to the presence of permeable soils (sands and silts) and high groundwater table, more extensive temporary protection and effective dewatering efforts will be required. This is not a cost-effective and certainly riskier option than a box culvert. Further recommendations for this option have not been developed.

10.1.3 Circular Pipes

From a foundation engineering standpoint, concrete, steel and HDPE pipes are technically feasible alternatives provided that other design issues including flow capacity, hydraulic properties and durability can be satisfied. Multiple pipes may be required to provide adequate hydraulic capacity.

It is understood that this option is not considered at these sites and therefore foundation recommendations for pipe culverts are not further developed.

10.1.4 Recommended Approach

From a foundation engineering perspective, and given the soil and groundwater conditions at these sites, Thurber concurs with the selection of precast concrete box culverts for both sites. This report focuses on providing foundation recommendations for the design and construction of a box culvert at each of the two sites. Refer to Appendix H for a comparison table of the different options.

10.2 Foundation Design for Culverts

Foundation design aspects for the replacement culvert include subgrade conditions and preparation, geotechnical bearing capacities, settlement of foundation soils under any grade raise, lateral earth pressures, groundwater control, cofferdams, temporary stream diversion pipes, temporary roadway protection system design and restoration of the roadway embankment.

10.2.1 Concrete Box Culvert

At 9th Line, the box culvert replacement is proposed to be on a shifted alignment of approximately 15 m east of the existing culvert. Dimensions and invert elevations for the proposed culverts are presented in the table below.

The following geotechnical resistances are recommended for the design of a box culvert based on the width of each culvert provided below with a 300 mm thick granular pad over the native compact silty sand till (with some loose zones):

Table 10.1: Geotechnical Resistances for Box Culvert Options

Culvert	Proposed Dimensions (L x W x H)	Invert Elev. (m) / Underside of Bedding Elev. (m)	Founding Material	Factored Geotechnical Resistance at ULS	Factored Geotechnical Resistance at SLS
9th Line	14.0 m x 5.7 m x 2.4 m	267.6 / 267.3	Native, Compact Silty Sand Till	300 kPa	150 kPa[1]
Highway 400 – Bradford Bypass E-N Ramp	36.5 m x 5.7 m x 3.5 m	Inlet 264.2 / 263.9 Outlet 263.6 / 263.3	Native, Loose to Compact Silty Sand to Silty Clayey Sand Till	275 kPa	175 kPa[2]

1. For up to 25 mm settlement
2. For up to 65 mm settlement

A consequence factor of 1.0 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per Canadian Highway Bridge Design Code (CHBDC) 2019, Section 6.9.

The factored ultimate resistance and settlement are dependent on the culvert size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the culvert width or founding/invert elevation differs significantly from that given above.

The above geotechnical resistances are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with CHBDC 2019, Clause 6.10.5.3.

Resistance to sliding should be calculated assuming ultimate coefficients of friction of 0.45 between the precast concrete and the underlying Granular A bedding material.

The culvert should be designed to resist external loadings including frost forces, lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment.

10.3 Static Lateral Earth Pressures

The lateral earth pressures acting on the culvert box and wingwalls will depend on the type and method of placement of the backfill materials, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls.

Backfill placed behind the walls should consist of free-draining, non-frost susceptible granular materials such as OPSS.PROV 1010 Granular A or B Type II and placed in accordance with OPSS.PROV 902, as amended by Special Provision 109S61. The granular backfill should be placed to the extents as shown on OPSD 802.010 (as applicable). Compaction equipment to be used adjacent to the walls should be restricted in accordance with OPSS.PROV 501.

Earth pressures acting on the structures may be assumed to impose a triangular distribution governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC (2019) but generally are given by the expression:

$$p_h = K(\gamma h + q)$$

Where:
p_h = horizontal pressure on the wall at depth h (kPa)
K = coefficient of lateral earth pressure (see Table 10.2 below)
γ = unit weight of retained soil (see Table 10.2 below)
h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment walls are dependent on the material used as backfill. Typical values are provided below.

Table 10.2: Static Coefficient of Lateral Earth Pressures

Static Earth Pressure	**Granular A (1)** **ϕ = 39°, γ = 22.9 kN/m^3**		**Granular B Type II** **ϕ = 35°, γ = 22.8 kN/m^3**		**Granular B Type I** **ϕ = 32°, γ = 21.2 kN/m^3**	
	Horizontal Backfill	**2H:1V Sloping Backfill**	**Horizontal Backfill**	**2H:1V Sloping Backfill**	**Horizontal Backfill**	**2H:1V Sloping Backfill**
Active, K_a (2) (Unrestrained Wall)	0.23	0.31	0.27	0.39	0.31	0.47
At-rest K_o (Restrained Wall)	0.37	0.54	0.43	0.62	0.47	0.68
Passive, K_p (2)	4.40	15.15	3.69	10.82	3.26	8.61

Notes: 1. Friction angle and unit weight of Granular A are based on the results from technical memorandum titled " Innovation Study – Memo, Determination of Strength Parameters of Granular Materials, Bradford Bypass West Contractor, CMGC 2023-E-0068", dated December 12, 2025.

2. The values of K_a and K_p correspond to full mobilization of active and passive earth pressures and require certain relative movements between the wall and adjacent soil to produce these conditions. Figures C6.27 and Table C6.12 of the Commentary to the CHBDC (2019) indicate relative movement required to fully mobilize the active and passive earth pressures.

In accordance with Clause 6.12.3 of *the CHBDC (2019*), a compaction surcharge should be added to the lateral force caused by compaction.

If lateral movement is not permissible and/or the wall is restrained, the at-rest/non-yielding coefficient of lateral earth pressures, K_o, should be used. If the wall allows for lateral movement, the active/yielding earth pressures, K_a, should be used.

A geotechnical resistance factor, ϕ_{gu}, of 0.5 should be applied in static design to the passive coefficient of lateral earth pressure, K_p, in accordance with Table 6.2 of *the CHBDC (2019)* for static analysis and typical understanding (consequence factor, $\Psi = 1.0$). The soils within the depth of frost penetration should be ignored from the passive lateral resistance; however, the equivalent surcharge loading from the weight of the soils above the depth of frost penetration should be incorporated in the soils below.

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular Type II) is preferred as it results in lower earth pressures acting on the culvert.

In accordance with Clause 6.12.3 of the CHBDC (2019), a compaction surcharge should be added.

10.4 Seismic Lateral Earth Pressures

In accordance with Clause 6.14.7 of the CHBDC (2019), structures should be designed using active $(\mathrm{K_{AE}})$ and passive $(\mathrm{K_{PE}})$ earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in the following table may be used:

Table 10.3: Seismic Coefficient of Lateral Earth Pressures

Seismic Earth Pressure $^{(1,2)}$	**Granular A** $^{(3)}$ ϕ **= 39°,** γ **= 22.9 kN/m**^{3}		**Granular B Type II** ϕ **= 35°,** γ **= 22.8 kN/m**^{3}		**Granular B Type I** ϕ **= 32°,** γ **= 21.2 kN/m**^{3}	
	Horizontal Backfill	**2H:1V Sloping Backfill**	**Horizontal Backfill**	**2H:1V Sloping Backfill**	**Horizontal Backfill**	**2H:1V Sloping Backfill**
Active (K_{AE})	0.26	0.50	0.31	0.55	0.35	0.59
Passive (K_{PE})	4.24	2.68	3.55	2.41	3.12	2.24

Notes:
1. After Mononobe and Okabe (1924).
2. The site-specific PGA is 0.102.
3. Friction angle and unit weight of Granular A are based on the results from technical memorandum titled "Innovation Study – Memo, Determination of Strength Parameters of Granular Materials, Bradford Bypass West Contractor, CMGC 2023-E-0068", dated December 12, 2025.

For force-based designs, a seismic geotechnical resistance factor, $\phi_{gu\,(seismic)}$, should be applied to the calculated the seismic earth pressure. In accordance with Table 6.3 of *the CHBDC (2019)*, seismic geotechnical resistance factors, $\phi_{gu(static)}$, is equal to the static geotechnical resistance factor plus 0.2 but must not be greater than 1.0 (i.e., $\phi_{gu(seismic)} = \phi_{gu\,(static)} + 0.2 \leq 1$). For seismic design, the consequence factor, Ψ, is equal to 1.0 as per Section 6.14.4 of *the CHBDC (2019)*.

10.5 Frost Cover

The depth of frost penetration at this site is approximately 1.5 m based on OPSD 3090.100. The frost cover requirement does not apply to the box culvert option.

Frost treatment / tapers should be in accordance with OPSD 803.010 for a box culvert. Pavement designers should be consulted on whether a new frost taper is required at this site.

11. SUB-EXCAVATION AND BACKFILLING

11.1 Sub-Excavation

All topsoil/organic matter, embankment fill, soft to loose soil deposits, debris and other deleterious materials should be removed from the area of the proposed culvert footprints. The exposed subgrade should be proof-rolled and be inspected by qualified geotechnical engineer. Any softened/loosened or poorly performing areas of the subgrade should be sub-excavated and replaced with compacted engineered fill as directed by a qualified geotechnical engineer but must be approved by the Contract Administrator.

11.2 Subgrade Preparation and Bedding Materials

After the excavation reaches the design founding elevation of the bedding, any remaining fill, topsoil, alluvial deposits, soft/loose or disturbed soils, organic or other deleterious materials encountered during subgrade preparation should be sub-excavated and replaced with compacted granular material to provide a uniformly competent subgrade condition. Subgrade preparation, placement and compaction of the bedding material should be carried out in the dry. Adequate preparation of the subgrade will be essential for performance of the culvert.

To provide a uniform foundation subgrade, a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A requirements should be provided under the base of the box culvert. The bedding material should be placed on the native, undisturbed, prepared subgrade as soon as practicable following its inspection and approval, and be compacted as per OPSS.PROV 501. OPSS.PROV 1004, 19 mm clear stones may be used as a substitute for the first lift of compacted granular materials, should the subgrade be considered too wet for granular placement and compaction. The underside of the bedding layer for the replacement culvert should be in contact with the generally compact, native silty sand till at or below the elevations quoted in Table 10-1. A 75 mm thick uncompacted Granular A levelling course should be placed above the compacted granular pad.

Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction.

Granular fill for any grade raise should meet the specifications of OPSS.PROV 1010 OPSS.PROV 1010 Granular A or Granular B Type II, while granular fill for the embankment widening should meet the specifications of OPSS.PROV 1010 Select Subgrade Material (SSM) or better.

Site grading should be carried out in accordance with OPSS.PROV 206, as amended by Special Provision 102S05.

11.3 Culvert Backfill

Backfill to the culverts should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS.PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 802.010 or 803.010, if applicable. Backfilling for the culverts should be in accordance with OPSS.PROV 902 for a box culvert. All fills should be placed in regular lifts and be compacted in accordance with OPSS.PROV 501. The backfill should be placed and compacted in simultaneous lifts on both sides of the culvert, and the top of backfill elevation should not differ by more than 500 mm on each side of each culvert at all times. Heavy compaction equipment should not be used adjacent to the walls and on the roof / obvert of the culverts. Compaction equipment to be used adjacent to the culvert should be restricted in accordance with OPSS.PROV 501.

11.4 Backfill Behind Wing Walls

Based on the GA's provided, both culverts are designed to have wing walls as outlined above. Granular backfill behind the retaining structures should meet the specifications of OPSS.PROV 1010 Granular A or Granular B Type II, constructed in accordance with OPSS.PROV 902, as amended by Special Provision 109S61, and OPSD 3101.150. Compaction equipment to be used adjacent to retaining structures must be restricted in accordance with OPSS.PROV 501 as amended by Special Provision 105S22.

12. RETAINING WALL

Based on the available GA Drawings, both sites will have retaining walls at both ends of the culverts. These wingwalls may be in the form of concrete cantilever walls to retain the backfill at 9th Line and the new embankments along the Highway 400 – Bradford Bypass E-N Ramp Culvert. It is understood that the fill will consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS.PROV 1010.

Based on existing boreholes at 9th Line, compact silty sand till is present at and below Elevation 268.0. The groundwater level measured in the piezometer was at Elevation 270.2, which is above the proposed founding elevation.

Based on existing boreholes at Highway 400 – Bradford Bypass E-N Ramp, loose to compact silty sand to silty, clayey sand till is present at and below Elevation 263.9. The groundwater level measured in the piezometers were at or below Elevation 267.6 (inlet) and 263.2 (outlet), which is above the proposed founding elevation.

Assuming TPS and dewatering are implemented, the exposed subgrade is likely to remain saturated. In order to have adequate bearing resistances to withstand the loading imposed by the footing and to enhance subgrade uniformity for minimizing differential settlement, the wall footings may be founded on a minimum 500 mm thick mass concrete pad at both sites.

12.1 Geotechnical Resistances

For a minimum 2.0 m wide footing, geotechnical resistances recommended for design are presented in the table below.

Table 12.1: Retaining Wall Founding Elevations

Culvert	Reference Boreholes	Highest Founding Elevation (m)	Founding Soil Type	Factored Geotechnical Resistance	
				ULS (kPa)	SLS (kPa)
9th Line	9CULV-01 to 9CULV-03	267.6	Compact, Silty Sand Till	300	150
Highway 400 – Bradford Bypass E-N Ramp	RCULV25-01 to RCULV25-03	263.5 to 264.5	Compact, Silty Sand to Silty, Clayey Sand Till	275	135

A consequence factor of 1.0 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per Canadian Highway Bridge Design Code (CHBDC) 2019, Section 6.9.

The factored ultimate resistance and settlement are dependent on the wall footing size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the footing width or founding/invert elevation differs significantly from that given above.

The above geotechnical resistances are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with CHBDC 2019, Clause 6.10.2, 6.10.3 and 6.10.5.

The factored geotechnical SLS values given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 20 mm across the width of the wall footing.

Resistance to sliding should be calculated assuming ultimate coefficients of friction of 0.45 for pre-cast walls and 0.6 for cast-in-place walls between the concrete and the underlying Granular A or B Type II bedding material.

It is recommended that sub-drains be provided behind the walls to promote positive drainage of the wall backfill for minimizing the risk of hydrostatic build-up behind the wall.

For frost protection purposes, all footing bases should have a minimum earth cover of 1.5 m or its thermal equivalent. Footing construction should be conducted as per Section 10.2.

13. TEMPORARY EXCAVATIONS AND PROTECTION SYSTEMS

13.1 Excavations

At the 9th Line culvert, excavation into the existing embankment fill and the underlying silty sand till deposit will be required for culvert installation. The temporary excavation is anticipated to extend to depths of up to 4 to 5 m below road grade.

At the Highway 400 Bradford Bypass E-N Ramp culvert, excavation into the existing native silty sand to silty clayey sand till deposit will be required for culvert installation. The temporary excavation is anticipated to extend to depths of up to 3 to 4 m in the inlet area and about 2 m in the outlet area.

All excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA) of Ontario and OPSS.PROV 902, as amended by Special Provision 109S61. A summary of soil types has been provided below.

Table 13.1: Excavation Soil Types

Culvert	Material	Above Groundwater Table	Below Groundwater Table
9th Line	Very Dense to Compact embankment fill	Type 3	Type 4
	Loose to Compact Silty Sand Till	Type 3	Type 4

Culvert	Material	Above Groundwater Table	Below Groundwater Table
Highway 400 Bradford Bypass E-N Ramp	Loose to Compact Silty Sand to Silty Clayey Sand Till	Type 3	Type 4

In accordance with O.Reg. 213, temporary cut slopes for Type 3 and Type 4 soils should have a minimum gradient of 1H : 1V, and 3H : 1V, respectively.

As an alternative to temporary cut slopes for the excavation, temporary protection systems may be designed and constructed as described in Section 13.2.

Excavations should regularly be inspected 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.

13.2 Protection Systems

The temporary protection systems, where required, shall be designed and constructed for Performance Level 2 in accordance with OPSS.PROV 539 as amended by Special Provision 105S09. All protection systems shall be designed by a licensed Professional Engineer in Ontario with experience in design of shoring systems with consideration for adjacent traffic loads and placement of new engineered embankment fill.

The following engineering parameters may be used for design of the temporary protection systems with horizontal backfill:

Table 13.2 Engineering Parameters for the Design of Temporary Protection Systems

Stratigraphic Unit	**Unit Weight of Material, γ' (kN/m^3)**	**Angle of Internal Friction, φ (kN/m^3)**	**Coefficient of Static Lateral Earth Pressure**	
			Active, K_a	**Passive, K_p**
New Granular Fill	22.8	35	0.27	3.69
Existing Embankment Fill	20	35	0.27	3.69
Loose to Compact Silty Sand Till	21	32	0.31	3.25
Loose to Dense Silty Sand to Silty, Clayey Sand to Clayey Sand Till	21	32	0.31	3.25
Soft to Firm Clay	20	30	0.33	3.00

Notes:
1. The lateral earth pressure coefficients presented above are based on static loading conditions and level backfill/ground surface behind the protection system. Where there is sloping ground behind the protection system, the coefficient of lateral earth pressure must be adjusted such as to consider the slope as a surcharge.
2. The total passive resistance below the base of excavation, if required, may be calculated based on the values of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.27 of the Canadian Highway Bridge Design Code *(2019 CHBDC)*.

In accordance with OPSS.PROV 539, should the temporary protection systems be left in place after completion of construction, the top of the system shall be removed to at least 1.2 m below the finished grade or ground level.

14. CONTROL OF GROUNDWATER AND SURFACE WATER

Groundwater is expected to be encountered during construction and dewatering measures will be required for construction in dry conditions. Surface water from runoff and precipitation events should be directed away from any excavations and low-lying construction areas.

Dewatering involving groundwater drawdown, where required, should be carried out in accordance with OPSS.PROV 517, as amended by SP 517F01 (issued February 2024). A design engineer with a minimum five years relevant experience will be required to design and implement a dewatering system.

The design of an effective dewatering system that will be required is the responsibility of the Contractor and the Contract Documents must alert them to this responsibility and the need to engage a dewatering specialist. Dewatering must remain operational and effective until the new culverts are installed and backfilled.

Reference should be made to the Hydrogeological Investigation and Design Report regarding dewatering assessment as well as Appendix K for NSSP.

15. SEISMIC CONSIDERATIONS

In accordance with Clause 4.4.3.2 of the CHBDC (2019), the section of the seismic site classification is based on the soil deposits within the upper 30 m of the stratigraphy.

In general, the stratigraphy at the 9th Line culvert site consists of very dense to compact silt with sand fill, underlain by a native deposit of loose to compact silty sand till, which in turn is underlain by a native deposit of firm to stiff clay. Based on the shear wave velocity test results from the nearby CPT boreholes within the silty sand till deposit and the inferred shear strength of the underlying clay deposit from SPT N-values, the site classification for the seismic site response is C (i.e., Site Class C) in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC (2019).

In general, the stratigraphy at the Highway 400 Bradford Bypass E-N Ramp culvert site consists of a native deposit of compact to very loose silty sand to silty clayey sand till, underlain by a native deposit of very stiff to soft clay. Based on the shear wave velocity test results from the nearby CPT boreholes within the silty sand till deposit and the shear strength of the underlying clay deposit from SPT N-values, the site classification for the seismic site response is C (i.e., Site Class C) in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC (2019).

The site-specific peak ground acceleration, PGA, for a 2,475-year return period earthquake at these sites is 0.102 g as per the 2020 National Building Code of Canada (NBCC) (refer to Appendix G).

The new structure is considered as Seismic Performance Category 1 based on Table 4.10 of the CHBDC 2019.

16. CONSEQUENCE AND SITE UNDERSTANDING CLASSIFICATION

It is assumed that the proposed structure has a “typical consequence level” associated with exceeding limits states design in accordance with Clause 6.5 and Table 6.1 of the 2019 Canadian

Highway Bridge Design Code (2019 CHBDC) and as such, a consequence factor, Ψ, of 1.0 is used for the foundation design.

In addition, based on the level of foundation investigation completed, the site understanding is considered to be a “typical degree of site and prediction model understanding”. Accordingly, the appropriate ultimate and serviceability geotechnical resistance factors, ϕ_{gu} and ϕ_{gs}, from Tables 6.2 and 6.3 of the CHBDC (2019) have been used for foundation design.

17. STREAM DIVERSION PIPE AND COFFERDAMS

It is anticipated that the replacement culvert for 9th Line will be constructed prior to the removal of the existing culvert, eliminating the need for a stream diversion pipe. Additionally, it is understood that the new culvert for the Highway 400 Bradford Bypass E-N Ramp will not have any stream to divert at the time of construction.

If a stream diversion pipe is required, the temporary diversion pipe should be placed on a minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirement as per OPSD 802.010. The bedding material should be placed on the prepared subgrade as soon as practical, following its inspection and approval. The subgrade preparation should be carried out in the dry. The prepared subgrade should be protected from disturbance during construction.

Where required, construction of cofferdams may be considered for stream diversion and constructing the culverts the dry. Given the subsurface conditions at the vicinity of the culvert inlet and outlet, the preferred option for cofferdams is the use of interlocking sheet pile enclosures in conjunction with sump pumping inside the enclosure. The design of cofferdams is the responsibility of the Contractor. The recommendations provided in Section 13 for Temporary Protection Systems are also applicable to sheet pile cofferdams.

18. SLOPE STABILITY

Slope stability analyses were conducted for the high fill embankment at the proposed Highway 400 Bradford Bypass E-N Ramp near the location of the proposed culvert. The stability assessments assume the embankment fill will consist of approved earth fill. The results of the slope stability analyses are summarized in the following table.

Table 18.1 Summary of Stability Assessments

Embankment Location	Slope Gradient	Condition	Minimum Factor of Safety	Figure
Highway 400 Bradford Bypass E-N Ramp	3H:1V	Temporary	1.9	I1
		Permanent	1.9	I2
		Seismic	1.6	I3

As per typical MTO requirements and with reference to CHBDC 2019, Factors of Safety (FoS) of 1.3 and 1.5 are acceptable for short term (undrained) and long term (drained) conditions, respectively. For pseudo-static (seismic) conditions, a minimum FoS of 1.1 is considered acceptable. Based on the results in Table 19-1, all the analysed cases satisfy global stability requirements.

19. SETTLEMENT

The replacement culvert for 9th Line is proposed to be constructed approximately 15 m east of the existing culvert alignment and with a cut of the overlying embankment. As the replacement culvert will generally be of the same length as the existing culvert, placement of additional fill is not required to widen the embankment slopes in its final configuration. Foundation long term settlement of the native compact silty sand till is estimated to be negligible under the conditions that there is no additional loading due to no grade raise. In fact, unloading of the subgrade will occur within the footprint of the proposed culvert.

The new culvert options for Highway 400 Bradford Bypass E-N Ramp includes a grade raise up to approximately 5 m for the new alignment of the ramp. Placement of new fill for the proposed high fill embankments and culvert will induce settlements within both the native foundation soils and the newly placed embankment fills. The total settlement of the embankment will consist of settlement within the foundation soils and compression of the embankment fill itself.

Settlement analyses were carried out using the commercially available program Settle3 (Version 5.024), developed by Rocscience Inc., to estimate the magnitude of settlements associated with the proposed high fills. The modelling was based on the results of the field and laboratory program, as well as engineering experience with other high-fill embankments constructed on similar soil conditions. The sources of foundation settlement at these sites include immediate (short-term) settlement of the cohesionless deposits and time-dependent consolidation (longer-term) settlement of the cohesive till deposits.

It should be noted that the estimated foundation settlements may differ from the magnitude of settlement observed during and/or after construction due to variability of the soil thicknesses and characteristics along the high fill embankment alignments. Therefore, the results of the settlement analyses should be considered as a likely response of the foundation soils due to embankment loads.

For the purpose of the analyses, an embankment fill consisting of compacted granular fill with unit weight of 22 kN/m³ was assumed. Settlement due to fill compression was estimated to be approximately 0.25% of the fill height for compacted granular fill.

Where a grade raise is required, settlement of the foundation soils is expected to occur and the selected culvert option shall be designed to accommodate the settlement imposed by the additional embankment loading or consideration should be given to preloading within the embankment area prior to constructing the culvert within those areas. Alternatively, if preloading is not carried out, cambering of the culvert subgrade may be required.

The estimated settlement magnitudes under embankment grade raises are summarized below in Table 19.1. Based on the results below the proposed embankment will meet the MTO Embankment Settlement Criteria requirements.

Table 19.1: Estimated Magnitudes of Settlement Under Embankment Grade Raises for Highway 400 Bradford Bypass E-N Ramp

Culvert	Max. Fill Height (m)	Estimated Foundation Settlement (mm)	Embankment Compression (mm)	Total Estimated Settlement (mm)
Highway 400 – Bradford Bypass E-N Ramp	Up to 5	65	12.5	77.5

The analyses indicate that a total estimated foundation settlement at the centreline of the culvert (and embankment) is in the order of approximately 65 mm. A plot showing the total foundation settlement vs distance across the embankment is shown in Appendix J.

The design of the culvert sections should take into consideration the anticipated foundation settlements. It is recommended that this settlement profile shown in Appendix J be used for the culvert camber and articulated design. Should a proprietary product be selected for this culvert, the proprietary manufacturer/supplier will need to be consulted to determine if their project can sustain the estimated magnitude of settlement. Foundation settlement will occur as the fill is placed and is estimated to be largely completed shortly after construction. Particular measures including articulated joints and shorter culvert section should be considered to mitigate the adverse effects of differential settlement between adjacent sections.

It is understood that the culvert structure is designed to accommodate these estimated settlements, foundation preloading prior to culvert construction is not required.

20. EMBANKMENT RESTORATION

Embankment restoration after completion of the culvert replacement should be carried out in accordance with OPSS.PROV 206. The embankment reconstruction material should consist of imported Granular A or Granular B Type II or other approved inorganic fill. The restored embankment beyond the culvert should be reinstated at the existing slope inclination, but no steeper than 2H : 1V if constructed with approved fill. Soils generated from the culvert excavation should not be used for reinstatement of the embankment.

In general, surface vegetation, peat, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the areas around the culvert inlets and outlets, and within the embankment footprints. Inspection and approval of the foundation surfaces by qualified geotechnical personnel should be conducted.

Embankment widening and restoration should be carried out in accordance with OPSS.PROV 206. Granular A or Granular B Type II material in compliance with OPSS.PROV 1010 would be suitable. Compaction of these materials should be carried out in general accordance with OPSS.PROV 501. Where new embankment fill is placed against the existing embankment slopes, the existing fill slope must be benched in accordance with OPSD 208.010.

Preparation of the embankment subgrade for widening should include stripping of any topsoil, organic deposits and deleterious materials from within the proposed footprint of the embankment widening followed by proofrolling of the exposed subgrade with a heavy roller under visual observation to ensure adequate uniform support. Excessively loose, soft or compressible materials revealed during the proofrolling operations should be subexcavated and replaced with well compacted approved material.

Embankment slopes must be provided with erosion protection in accordance with OPSS.PROV 804. Vegetation must be sufficiently established before the onset of winter.

21. ADJACENT STRUCTURES AND BURIED UTILITIES

The potential presence of underground utilities at the site should be confirmed prior to construction. It is recommended that the exact locations and elevations of any utilities be established by the designer and compared with the extent of the potential work zones related to the proposed culvert replacement and extension, new fills and associated works. Protection and/or relocation of utilities, if necessary, should be provided. Underground utilities should not be undermined or damaged during the culvert construction and fill placement.

22. SCOUR AND EROSION PROTECTION

Erosion protection should be provided at the culvert inlet and outlet. Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field in accordance with OPSD 810.010, OPSS 511 and OPSS.PROV 804.

Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

A concrete cut-off wall (for box culvert options only) should be used to minimize the potential for erosion or piping around the culvert. The proposed culverts are planned to have a concrete cut-off wall that spans the width of the culvert and extends to approximately 0.8 to 0.9 meters below the underside of the box.

Selection of streambed material should be in accordance with OPSS 1005.

23. CORROSION POTENTIAL

Analytical testing was carried out to determine the pH, water soluble sulphate, sulphide, chloride concentration, resistivity, and electrical conductivity of selected soil samples. The analytical test results for the soils are presented in Appendix E and summarized in Section 5.10. The pH, resistivity and chloride concentration indicate a moderate degree of corrosiveness of the subsurface environment at the 9th Line Culvert location. The pH, resistivity and chloride concentration indicate a low degree of corrosiveness of the subsurface environment at the Highway 400 - E-N Ramp Culvert location.

The test results may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects. The corrosive effects of road deicing salts/brine should also be considered.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with soil and groundwater at the site. In accordance with Table 3 of Concrete Materials and Methods of Concrete Construction (CSA A23.1:24), water soluble sulphate concentrations of less than 0.1% (i.e., 1000 μg/g) in soil samples indicate a low degree of exposure to sulphate attack is expected. The selection for the class of concrete should include consideration of the effects of road de-icing salt/brine.

24. CONSTRUCTION CONCERNS

A qualified geotechnical engineer (Foundation Engineering Specialist) should be retained to observe activities during construction and advise the Contract Administrator on construction issues related to performance of the installation of concrete box culverts, dewatering, temporary protection systems, and the construction of the adjacent embankments.

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

- Creek water flow at 9th Line will be maintained inside the existing culvert until the new culvert is completed and operational.
- Effective groundwater control measures must be implemented during construction and prior to excavating below the groundwater level.
- Temporary Protection Systems (TPS) will be required at some locations during all stages of construction. The TPS may be used as a means of surface water and groundwater control and may be implemented in conjunction with other water control requirements.
- The embankment slopes should be inspected after construction for surficial disturbance. All exposed slopes should be re-vegetated.
- Removal of peat, organics, soft soils and alluvial deposits near creek channels particularly in the inlet and outlet areas.
- Confirmation that the culvert backfills ad embankment fills are adequately placed and compacted to specifications.
- Cobbles, boulders, and construction debris may be encountered within the existing embankment fill, which may affect excavation, and the installation of temporary protection systems. As such, considerations of such obstructions must be made in the selection of appropriate equipment and procedures for the work.

25. CLOSURE

Preparation of the design report and engineering analysis was carried out by Mr. Joshua Alexander, P.Eng, a Geotechnical Engineer and Mr. Sydney Pang, P.Eng., an Associate and Senior Geotechnical Engineer. This report was reviewed by Mr. Jason Lee, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

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2026-03-20
PROVINCE OF ONTARIO

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2026/03/20
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Partner, Senior Geotechnical Engineer
Designated MTO Contact

Date: ***March 20, 2026***
File: ***48856***

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

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a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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APPENDIX A

Site Photographs

Photograph 1: Borehole 9CULV-02 upon completion, Looking West

Photograph 2: Borehole 9CULV-03 upon completion, Looking North

Photograph 3: Borehole 9CULV-03 upon completion, Looking North

Photograph 4: Borehole RCULV25-02 upon completion, Looking West

Photograph 5: Borehole RCULV-01 upon completion, Looking North-East

APPENDIX B

Borehole Locations Plans and Soil Strata Drawings

MINISTRY OF TRANSPORTATION, ONTARIO

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

PLAN

10 0 10 20m
SCALE 1:500

S. PANG
35314509
Feb. 11, 2026

J.P.K. LEE
100086735
Feb. 11, 2026

CONT No
WP No

BRADFORD BYPASS
HWY 400 AND 9TH LINE
STRUCTURAL CULVERT
BOREHOLE LOCATION PLAN

SHEET

AECOM

THURBER

KEYPLAN

	L E G E N D
●	Borehole
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
▽	Water Level Upon Completion of Drilling
▼	Water Level in Monitoring Well/Piezometer
▮	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
9CULV–01	271.3	4 887 173.2	293 950.2
9CULV–02	271.3	4 887 153.0	293 940.7
9CULV–03	271.7	4 887 145.2	293 956.1

-NOTES-

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

GEOCRES No. 31D04-030

REVISIONS	DATE	BY	DESCRIPTION

DESIGN JA	CHK CN	CODE	LOAD	DATE JAN 2026
DRAWN MFA	CHK JA	SITE 30X–0877/C0	STRUCT	DWG 1

FILENAME: H:\Drafting\48000\48856\TED–48856–PLPR–9th Line Culvert.dwg
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MINISTRY OF TRANSPORTATION, ONTARIO

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

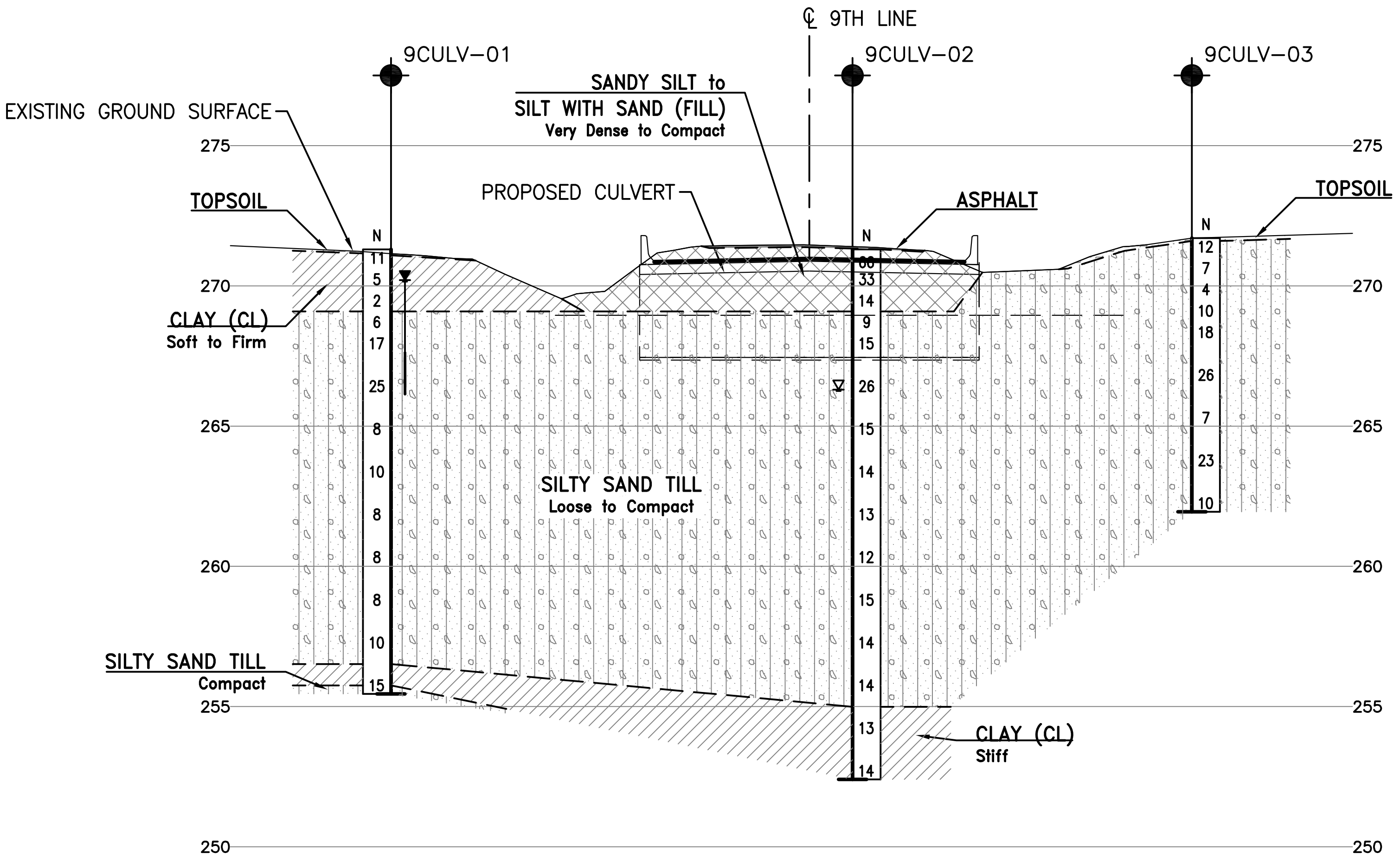
CONT No
WP No

BRADFORD BYPASS
HWY 400 AND 9TH LINE
STRUCTURAL CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

AECOM

THURBER



SECTION A–A

5 0 5 10m
SCALE 1:250

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Feb. 11, 2026

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Feb. 11, 2026

KEYPLAN

LEGEND

●	Borehole
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60˚ Cone, 475J/blow)
⊻	Water Level Upon Completion of Drilling
▼	Water Level in Monitoring Well/Piezometer
│	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
9CULV–01	271.3	4 887 173.2	293 950.2
9CULV–02	271.3	4 887 153.0	293 940.7
9CULV–03	271.7	4 887 145.2	293 956.1

-NOTES-

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

GEOCRES No. 31D04-030

REVISIONS	DATE	BY	DESCRIPTION

DESIGN JA	CHK CN	CODE	LOAD	DATE JAN 2026
DRAWN MFA	CHK JA	SITE 30X–0877/C0	STRUCT	DWG 2

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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

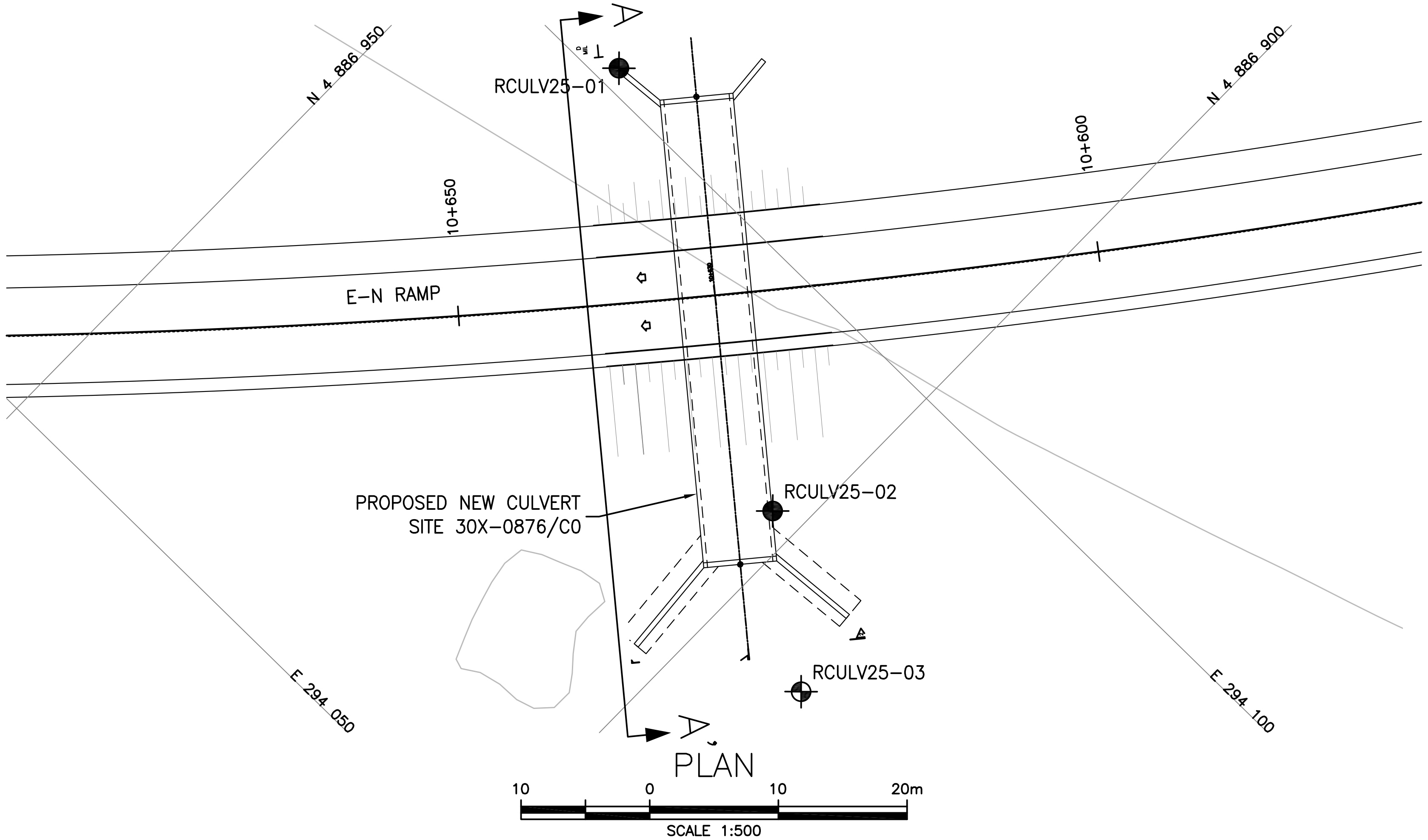
CONT No
WP No

SHEET

BRADFORD BYPASS
WEST CONTRACT HWY 400
E–N RAMP CULVERT
BOREHOLE LOCATIONS AND SOIL STRATA

AECOM

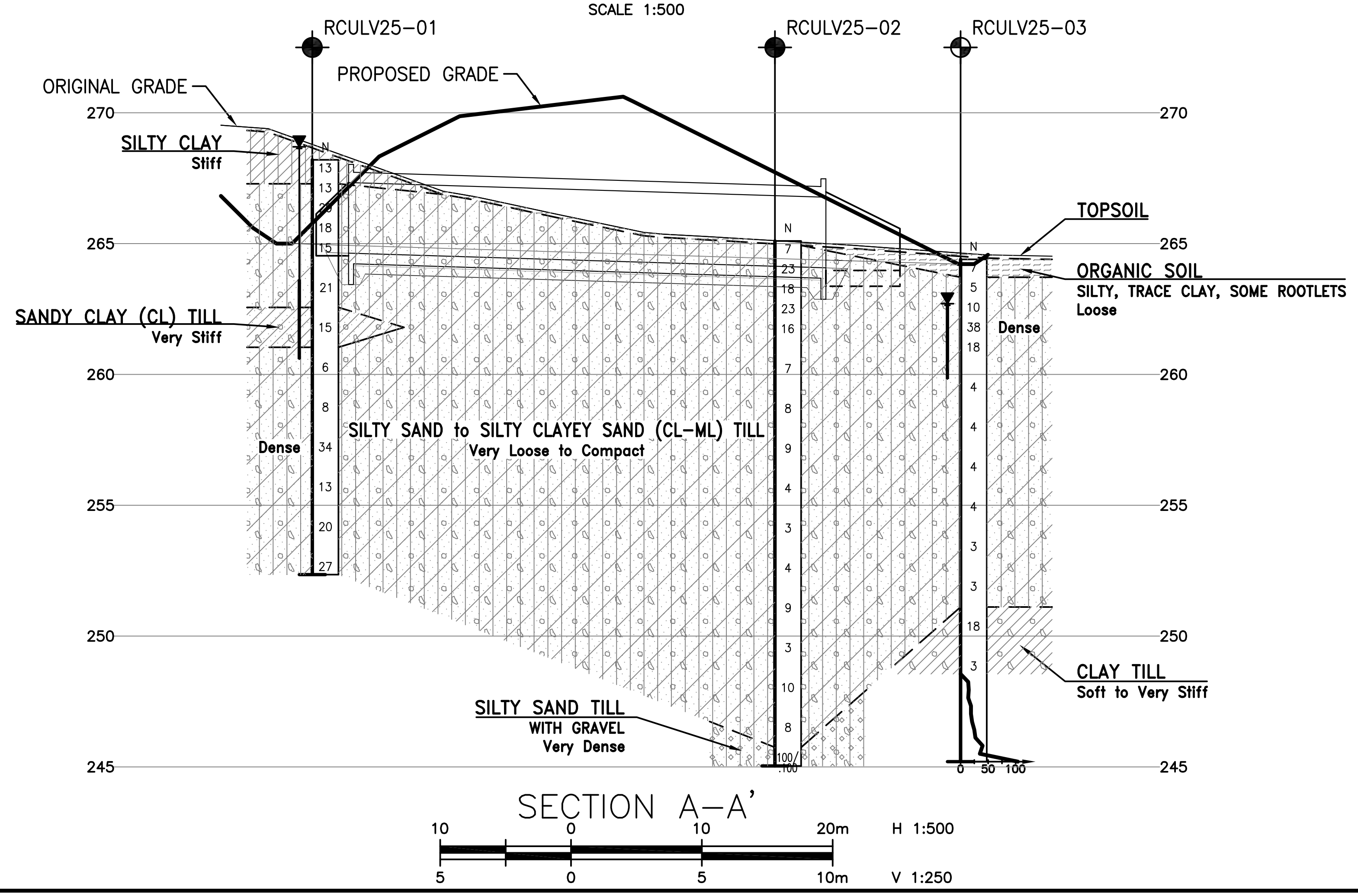
THURBER



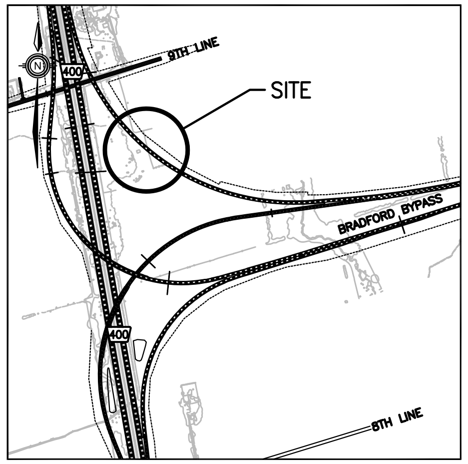
PLAN

S. PANG
35314509
Feb. 11, 2026

J. P. K. LEE
100086735
Feb. 11, 2026



SECTION A–A'



KEYPLAN

L E G E N D

●	Borehole
⊕	Borehole (Previous Investigation)
⊕	Previous Investigation (By Others)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
▽	Water Level Upon Completion of Drilling
▼	Water Level in Monitoring Well/Piezometer
▮	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
RCULV25–01	268.2	4 886 935.0	294 101.6
RCULV25–02	265.1	4 886 902.4	294 085.4
RCULV25–03	264.4	4 886 891.0	294 076.9

-NOTES-

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

GEOCRES No. 31D04-030

REVISIONS	DATE	BY	DESCRIPTION

DESIGN JA	CHK JPL	CODE	LOAD	DATE JAN 2026
DRAWN MFA	CHK JA	SITE 30X–0876/C0	STRUCT	DWG 1

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THURBER

APPENDIX C

Record of Borehole Sheets – Current Investigation

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORD OF BOREHOLES

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS:

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in size from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	greater than 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	less than 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. Where insufficient penetration was achieved, the number of blows are reported over the sampler penetration in metres (e.g. 50/0.15).

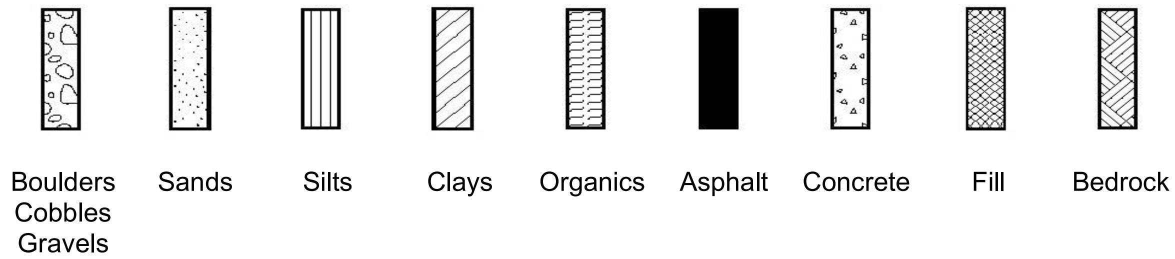
DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60-degree apex cone connected to “A” size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.

WATER LEVELS:

▽	Water level upon completion of drilling
▼	Water level in monitoring well / piezometer
┃	Monitoring well / piezometer screen

STRATA PLOT:
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



TEXTURING CLASSIFICATION OF SOILS

Classification	**Particle Size**
Clay	Less than 0.002 mm
Silt	0.002 mm – 0.075 mm
Sand	0.075 mm – 4.75 mm
Gravel	4.75 mm – 75 mm
Cobbles	75 mm – 300 mm
Boulders	Greater than 300 mm

TERMS DESCRIBING CONSISTENCY (FINE GRAINED SOILS ONLY)

Descriptive Term	**Undrained Shear Strength (kPa)**
Very Soft	Less than 12
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

SAMPLE TYPES

SS	Split-spoon samples
TW	Thin-wall (Shelby) tube sample
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ, etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING DENSITY (COARSE GRAINED SOILS ONLY)

Descriptive Term	**SPT ‘N’ Value**
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Division		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS LL < 35	ML	Inorganic silts, 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.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS 35 ≤ LL < 50	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS LL ≥ 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		PT	Peat and other organic soils.

Note – LL = Liquid Limit

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh, W1 (FR)	No visible signs of weathering.
Slightly Weathered, W2 (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered, W3 (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered, W4 (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered, W5 (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.
Residual Soil, W6 (RS)	Rock is completely changed into a soil, where the rock texture and structures have been completely destroyed.

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length.
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

Bedding	Bedding Thickness
Thinly laminated	Less than 6 mm
Laminated	6 mm – 20 mm
Very thinly bedded	20 mm – 60 mm
Thinly bedded	60 mm – 0.2 m
Medium bedded	0.2 m – 0.6 m
Thickly bedded	0.6 m – 2 m
Very thickly bedded	Greater than 2 m

STRENGTH CLASSIFICATION

Rock Strength	Uniaxial Compressive Strength (MPa)
Extremely Weak, R0	0.25 – 1
Very Weak, R1	1 – 5
Weak, R2	5 – 25
Medium Strong, R3	25 – 50
Strong, R4	50 – 100
Very Strong, R5	100 – 250
Extremely Strong, R6	Greater than 250

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 9CULV-01

1 OF 2

METRIC

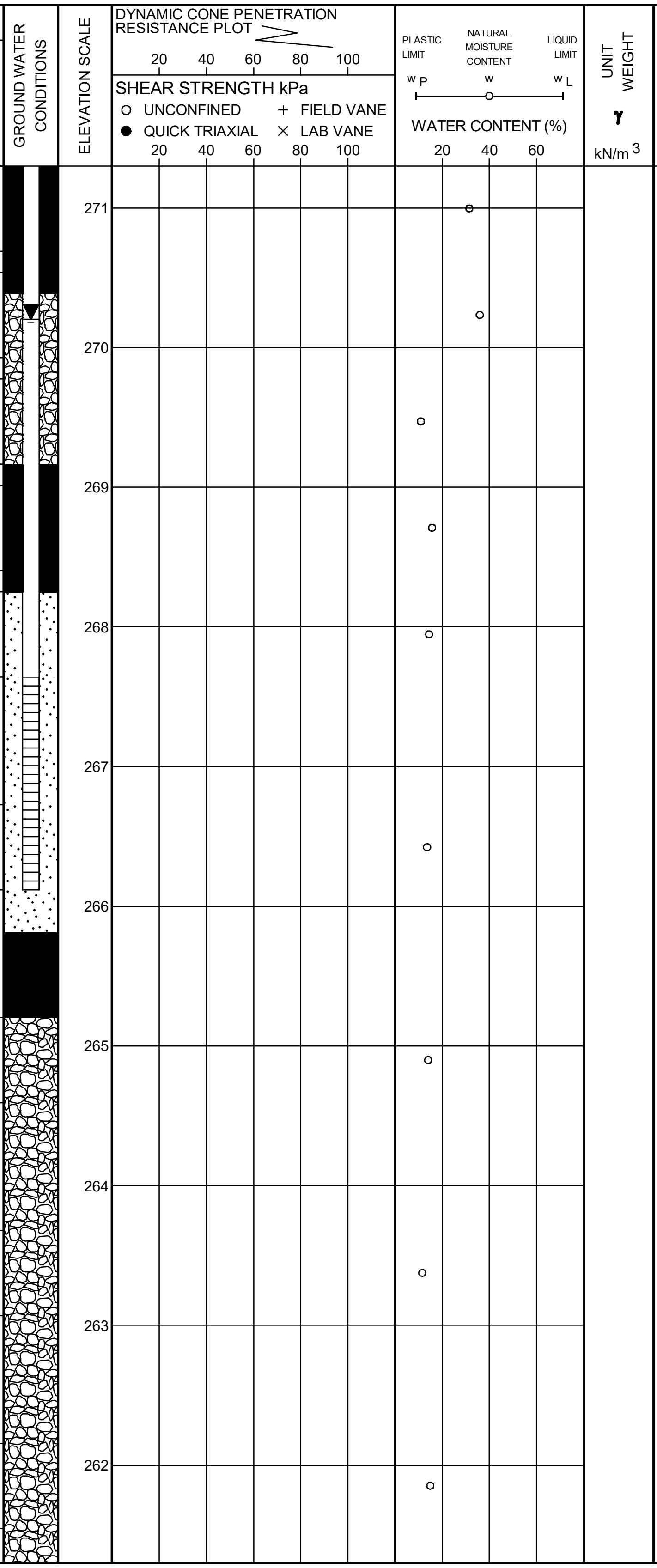
W.P. ______
LOCATION Bradford Bypass N 4 887 173.2 E 293 950.2
ORIGINATED BY KF
DIST Central HWY 400
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY JW
DATUM Geodetic
DATE 2024.10.23 - 2024.10.23
LATITUDE 44.124474
LONGITUDE -79.635571
CHECKED BY RR/JA

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
271.3	GROUND SURFACE
0.0	**TOPSOIL:** (50mm)
	CLAY (CL) Soft to Firm Brown Moist
	Auger grinding at 1.4m
269.1 2.2	Silty **SAND** Loose to Compact Brown to Grey Moist to Wet (TILL)

SAMPLES

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	11				
2	SS	5				
3	SS	2				
4	SS	6				
5	SS	17				
6	SS	25				
7	SS	8	2	49	39	10
8	SS	10				
9	SS	8				



REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 9CULV-01

2 OF 2

METRIC

W.P. ______ LOCATION Bradford Bypass N 4 887 173.2 E 293 950.2 ORIGINATED BY KF
DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JW
DATUM Geodetic DATE 2024.10.23 - 2024.10.23 LATITUDE 44.124474 LONGITUDE -79.635571 CHECKED BY RR/JA

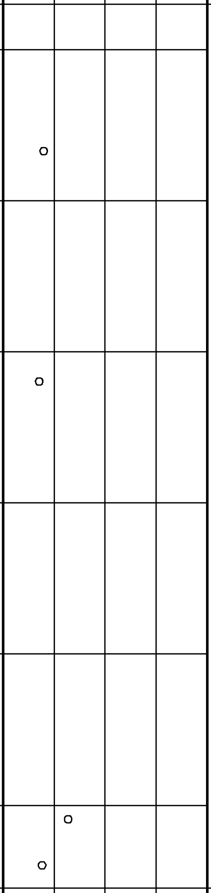
SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L – WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION
	Silty **SAND** Loose to Compact Grey Wet (TILL) No recovery
256.5 / 14.8	**CLAY** (CL) Stiff Grey Wet
255.8 / 15.5	Silty **SAND** Compact Grey Wet (TILL)
255.5 / 15.8	END OF BOREHOLE AT 15.8m.

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
10	SS	8				
11	SS	8	11	48	33	8
12	SS	10				
13	SS	15				

Elevation scale: 261, 260, 259, 258, 257, 256



END OF BOREHOLE AT 15.8m.
Monitoring well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2024.11.05	1.5	269.8
2024.11.14	1.4	269.9
2025.04.09	1.1	270.2
2025.05.29	1.2	270.1
2025.09.09	1.6	269.7
2025.11.25	1.3	270.0

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 9CULV-02

1 OF 3

METRIC

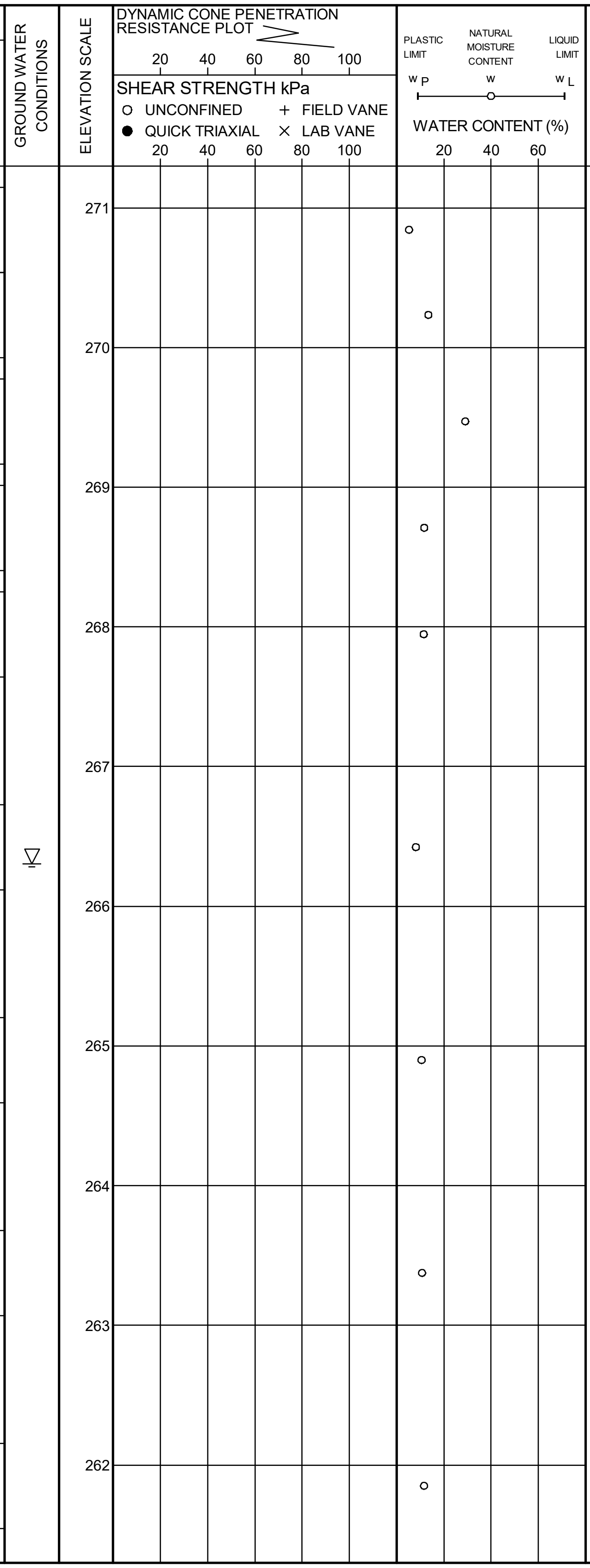
W.P. ______ LOCATION Bradford Bypass N 4 887 153.0 E 293 940.7 ORIGINATED BY KF

DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JW

DATUM Geodetic DATE 2024.11.29 - 2024.11.29 LATITUDE 44.124292 LONGITUDE -79.635690 CHECKED BY RR/JA

ELEV DEPTH	SOIL PROFILE DESCRIPTION
271.3	GROUND SURFACE
0.0 0.1	**ASPHALT:** (60mm)
	Sandy **SILT** Very Dense to Dense Brown Moist (FILL)
269.9 1.4	**SILT** with Sand Compact Grey Moist (FILL)
269.1 2.2	Silty **SAND** Loose to Compact Grey Wet (TILL)

SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	66	
2	SS	33	
3	SS	14	0 29 49 22 Non-plastic
4	SS	9	
5	SS	15	
6	SS	26	
7	SS	15	3 52 37 8 Non-plastic
8	SS	14	
9	SS	13	



UNIT WEIGHT γ kN/m³

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 9CULV-02

2 OF 3

METRIC

W.P. ______ LOCATION Bradford Bypass N 4 887 153.0 E 293 940.7 ORIGINATED BY KF

DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JW

DATUM Geodetic DATE 2024.11.29 - 2024.11.29 LATITUDE 44.124292 LONGITUDE -79.635690 CHECKED BY RR/JA

ELEV DEPTH	SOIL PROFILE: DESCRIPTION Continued From Previous Page	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	Silty **SAND** Compact Grey Wet (TILL)									
		10	SS	12						
		11	SS	15						
		12	SS	14			4 Non-plastic	53	31	12
		13	SS	14						
255.0 16.3	**CLAY** (CL) Stiff Grey Wet									
		14	SS	13						
		15	SS	14			0	7	45	48
252.4 18.9	END OF BOREHOLE AT 18.9m. WATER LEVEL MEASURED AT 5.0m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 1.1m, SAND FROM 1.1m TO 0.5m,									

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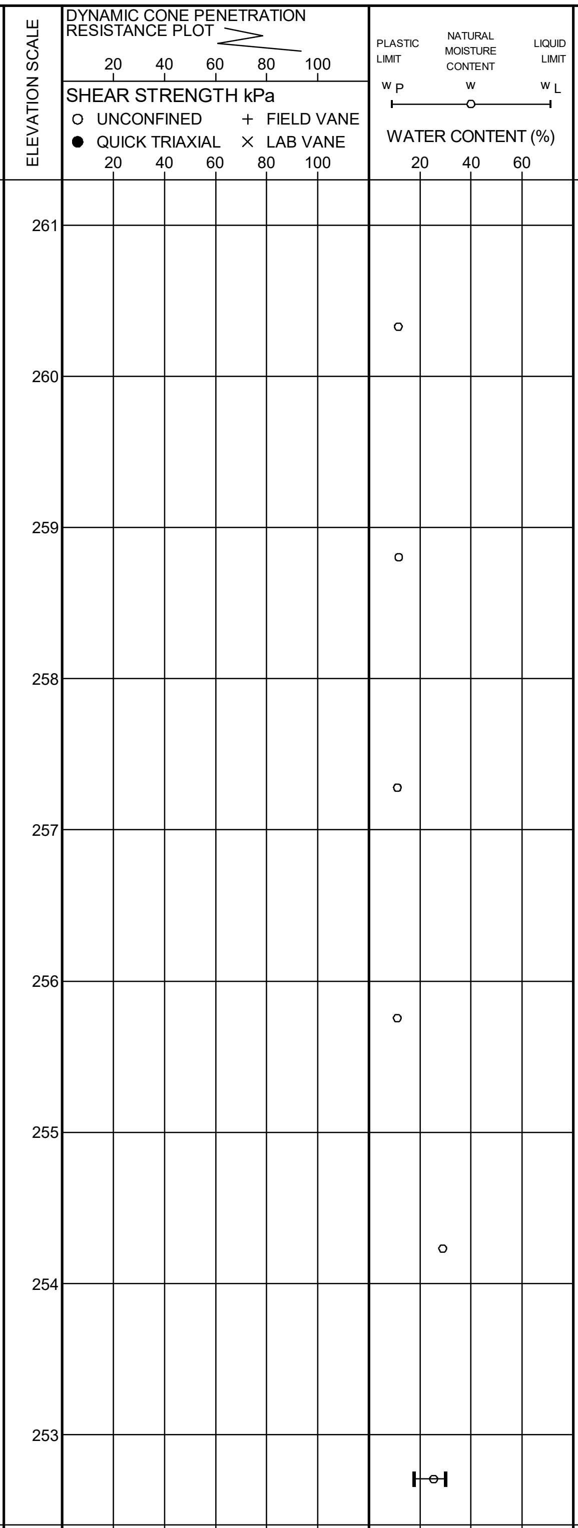


+³, ×³: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 9CULV-02

3 OF 3

METRIC

W.P. ______
LOCATION Bradford Bypass N 4 887 153.0 E 293 940.7
ORIGINATED BY KF
DIST Central HWY 400
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY JW
DATUM Geodetic
DATE 2024.11.29 - 2024.11.29
LATITUDE 44.124292
LONGITUDE -79.635690
CHECKED BY RR/JA

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m 3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	CONCRETE FROM 0.5m TO 0.1m, THEN COLDPATCH TO GROUND SURFACE.										

$+^3, \times^3$: Numbers refer to Sensitivity

$15 \overset{20}{\underset{10}{\oplus}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

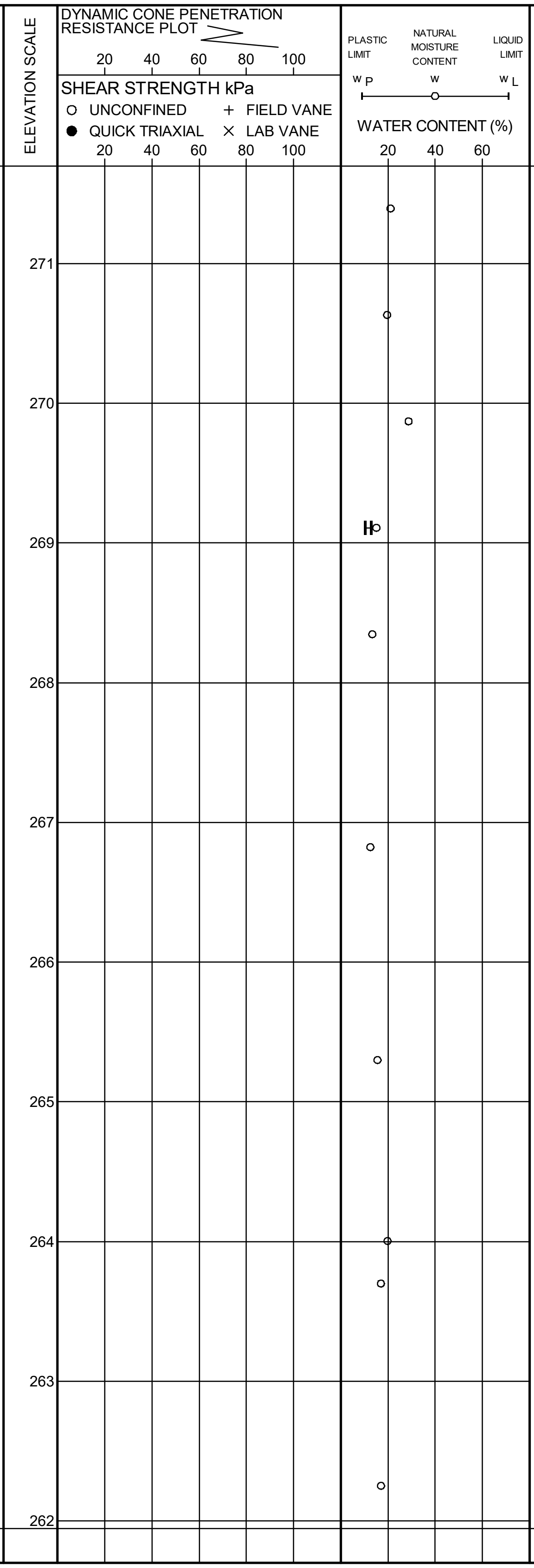
RECORD OF BOREHOLE No 9CULV-03 1 OF 2 METRIC

W.P. ______ LOCATION Bradford Bypass N 4 887 145.2 E 293 956.1 ORIGINATED BY KF

DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JW

DATUM Geodetic DATE 2024.10.22 - 2024.10.22 LATITUDE 44.124221 LONGITUDE -79.635497 CHECKED BY RR/JA

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
271.7	GROUND SURFACE									
0.0 0.1	**TOPSOIL:** (100mm)									
	Silty **SAND** Loose to Compact Brown to Grey Moist to Wet (TILL)	1	SS	12						
		2	SS	7						
		3	SS	4						
		4	SS	10			1	52	39	8
		5	SS	18						
		6	SS	26			1	51	37	11
		7	SS	7						
		8	SS	23			2	47	42	9
		9	SS	10						
261.9 9.8	END OF BOREHOLE AT 9.7m.									



REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 9CULV-03

2 OF 2

METRIC

W.P. ______ LOCATION Bradford Bypass N 4 887 145.2 E 293 956.1 ORIGINATED BY KF
DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JW
DATUM Geodetic DATE 2024.10.22 - 2024.10.22 LATITUDE 44.124221 LONGITUDE -79.635497 CHECKED BY RR/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m ^{3}	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO GROUND SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

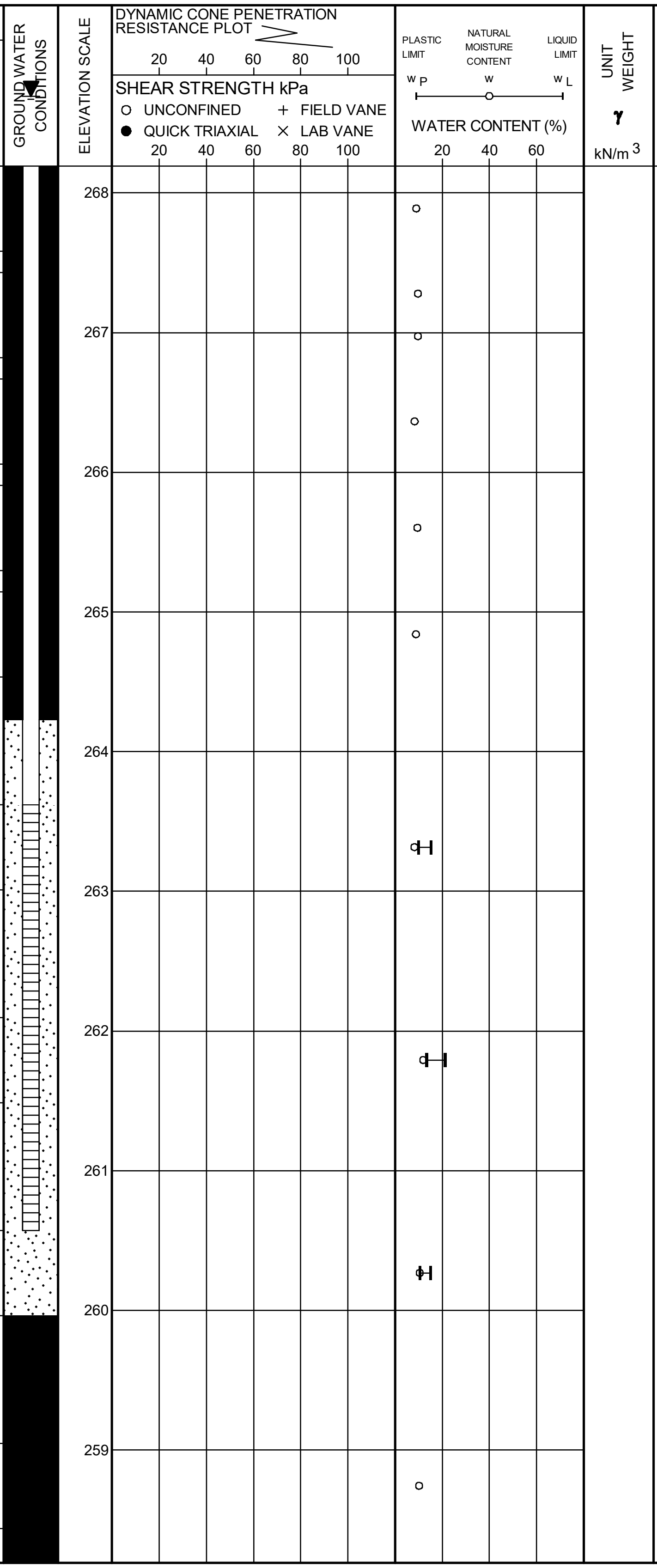
RECORD OF BOREHOLE No RCULV25-01

1 OF 2 **METRIC**

W.P. ______ LOCATION Bradford Bypass N 4 886 935.0 E 294 101.6 ORIGINATED BY FC
DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Auger/ Mud Rotary COMPILED BY JW
DATUM Geodetic DATE 2025.07.30 - 2025.07.30 LATITUDE 44.122332 LONGITUDE -79.633674 CHECKED BY RR/JA

ELEV DEPTH	SOIL PROFILE DESCRIPTION
268.2	GROUND SURFACE
0.0	**TOPSOIL:** (75 mm)
0.1	Silty **CLAY** Stiff Brown Moist
267.3 0.9	Silty **SAND** to Silty, Clayey **SAND** (CL-ML) Compact Brown to Grey Moist (TILL)
262.6 5.6	Sandy **CLAY** (CL) Very Stiff Grey Moist (TILL)
261.0 7.2	Silty, Clayey **SAND** (CL-ML) Loose to Dense Grey Moist (TILL)

SAMPLES NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL	REMARKS
1	SS	13	0	31	43	26	
2	SS	13					
3	SS	29	7	49	32	12	
4	SS	18					
5	SS	15					Mud rotary and tricone used from 3.0m to 15.8m.
6	SS	21	3	51	31	15	
7	SS	15	4	36	34	26	
8	SS	6	3	50	31	16	
9	SS	8					



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+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No RCULV25-01 2 OF 2 METRIC

W.P. ______ LOCATION Bradford Bypass N 4 886 935.0 E 294 101.6 ORIGINATED BY FC
DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Auger/ Mud Rotary COMPILED BY JW
DATUM Geodetic DATE 2025.07.30 - 2025.07.30 LATITUDE 44.122332 LONGITUDE -79.633674 CHECKED BY RR/JA

ELEV DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
	Continued From Previous Page				
	Silty, Clayey **SAND** (CL-ML) Loose to Dense Grey Moist (TILL)				258
		10	SS	34	257
	Tricone grinding at a depth of 11.3 m				
		11	SS	13	256
	Tricone grinding at a depth of 12.8 m				255
		12	SS	20	254
					253
252.3		13	SS	27	
15.8	END OF BOREHOLE AT 15.8 m. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05 m slotted screen.				

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL
GROUND WATER CONDITIONS

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2025.08.07	-0.5	268.7
2025.08.22	2.2	266.0
2025.09.10	2.3	265.9
2025.11.26	0.6	267.6

+ 3, × 3: Numbers refer to Sensitivity
20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RCULV25-02

1 OF 3

METRIC

W.P.

LOCATION Bradford Bypass N 4 886 902.4 E 294 085.4

ORIGINATED BY FC

DIST Central HWY 400

BOREHOLE TYPE Hollow Stem Auger/ Mud Rotary

COMPILED BY JW

DATUM Geodetic

DATE 2025.07.31 - 2025.07.31

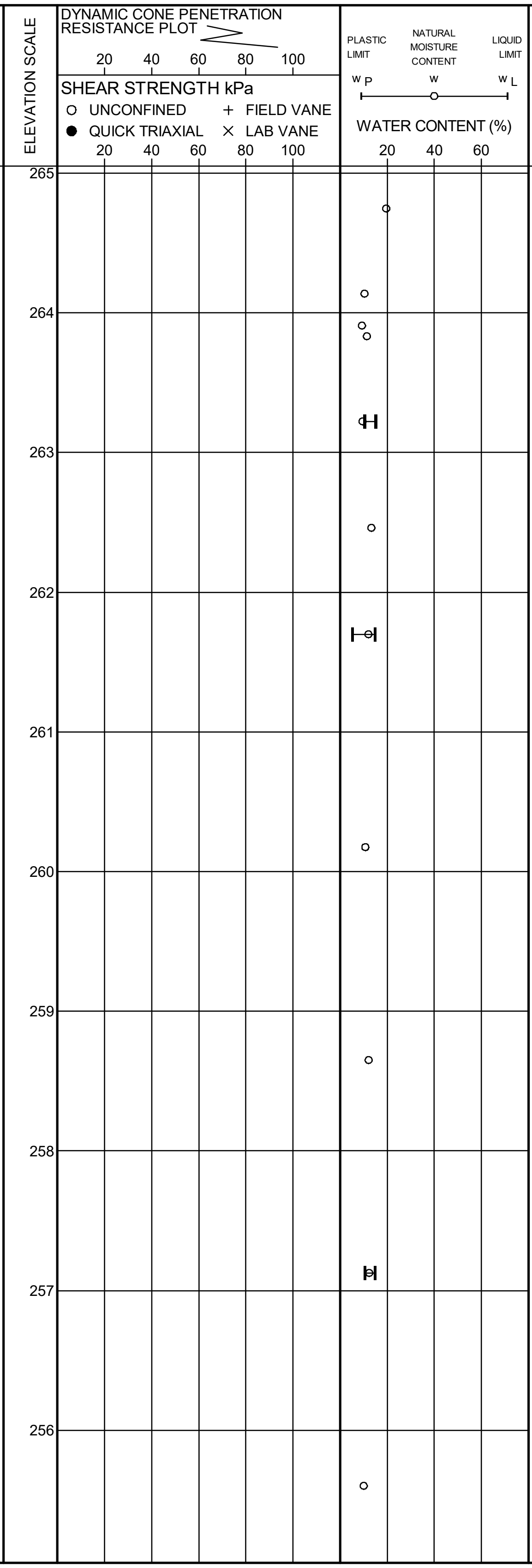
LATITUDE 44.122038

LONGITUDE -79.633876

CHECKED BY RR/JA

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL	REMARKS
265.1	GROUND SURFACE								
0.0	**TOPSOIL:** (150 mm)								
0.2	Silty, Clayey **SAND** (CL-ML) to Clayey **SAND** (CL) Very Loose to Compact Brown to Grey Moist (TILL)	1	SS	7					
		2	SS	23					
		3	SS	18	6	49	31	14	
		4	SS	23					
									Mud rotary and tricone used from 3.0 m to 20.1 m.
		5	SS	16	4	52	32	12	
		6	SS	7					
		7	SS	8					
		8	SS	9	1	51	34	14	
		9	SS	4					

STRAT POTT — GROUND WATER CONDITIONS — UNIT WEIGHT γ kN/m³



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+³, ×³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RCULV25-02 2 OF 3 METRIC

W.P. ______ LOCATION Bradford Bypass N 4 886 902.4 E 294 085.4 ORIGINATED BY FC

DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Auger/ Mud Rotary COMPILED BY JW

DATUM Geodetic DATE 2025.07.31 - 2025.07.31 LATITUDE 44.122038 LONGITUDE -79.633876 CHECKED BY RR/JA

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m3	GR	SA	SI	CL
	Silty, Clayey **SAND** (CL-ML) to Clayey **SAND** (CL) Very Loose to Compact Brown to Grey Moist (TILL)					255					
		10	SS	3		254					
		11	SS	4		253					
		12	SS	9		252 251					
		13	SS	3		250		7	51	27	15
		14	SS	10		249 248					
		15	SS	8		247					
245.7 19.4	Silty **SAND** with **GRAVEL** Very Dense Grey Moist	16	SS	100/		246		25	55	14	6

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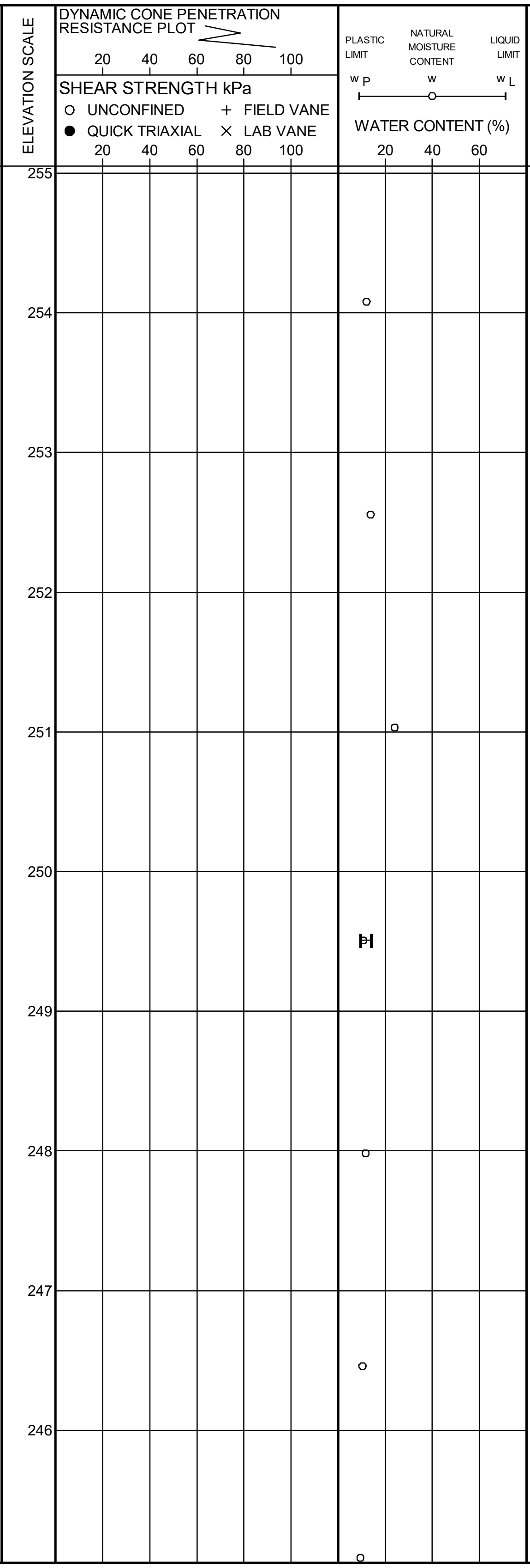


+ 3, × 3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RCULV25-02

3 OF 3

METRIC

W.P.

LOCATION Bradford Bypass N 4 886 902.4 E 294 085.4

ORIGINATED BY FC

DIST Central HWY 400

BOREHOLE TYPE Hollow Stem Auger/ Mud Rotary

COMPILED BY JW

DATUM Geodetic

DATE 2025.07.31 - 2025.07.31

LATITUDE 44.122038

LONGITUDE -79.633876

CHECKED BY RR/JA

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE			UNIT WEIGHT γ kN/m ^{3}	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
245.0 20.1	Silty **SAND** with **GRAVEL** Very Dense Grey Moist				0.100		245				Drilling mud added to borehole during drilling, therefore water level was not established upon completion of drilling.
	END OF BOREHOLE AT 20.1 m. BOREHOLE BACKFILLED WITH CEMENT GROUT FROM 20.1 m TO GROUND SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

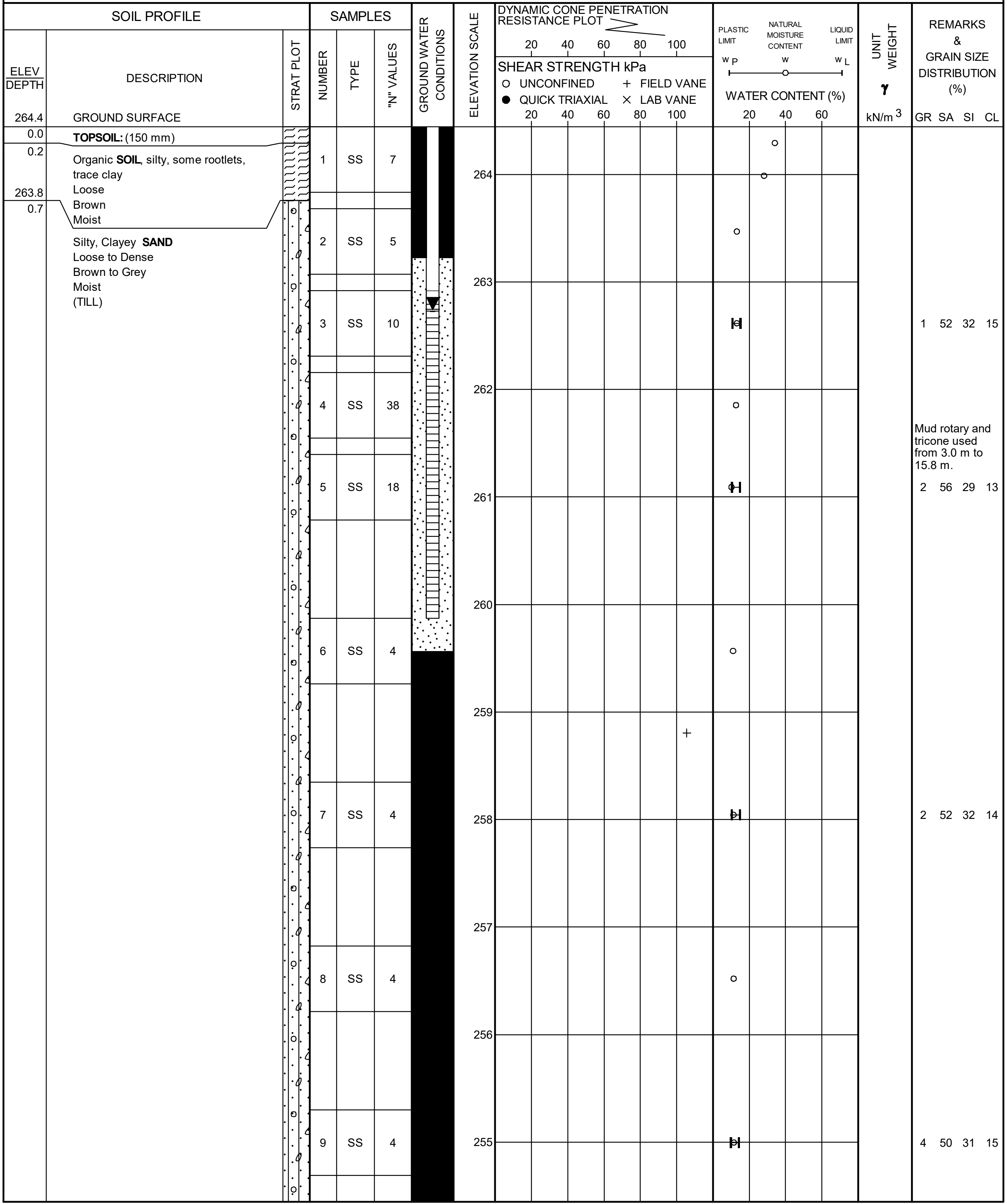
20
15 5
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RCULV25-03

1 OF 3

METRIC

W.P. ______
LOCATION Bradford Bypass N 4 886 891.0 E 294 076.9
ORIGINATED BY JF
DIST Central
HWY 400
BOREHOLE TYPE Hollow Stem Auger/ Mud Rotary
COMPILED BY JW
DATUM Geodetic
DATE 2025.08.01 - 2025.08.01
LATITUDE 44.121935
LONGITUDE -79.633982
CHECKED BY RR/JA



ELEV DEPTH	DESCRIPTION
264.4	GROUND SURFACE
0.0	**TOPSOIL:** (150 mm)
0.2	Organic **SOIL**, silty, some rootlets, trace clay Loose Brown Moist
263.8 0.7	Silty, Clayey **SAND** Loose to Dense Brown to Grey Moist (TILL)

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	7				
2	SS	5				
3	SS	10	1	52	32	15
4	SS	38				
5	SS	18	2	56	29	13
6	SS	4				
7	SS	4	2	52	32	14
8	SS	4				
9	SS	4	4	50	31	15

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Mud rotary and tricone used from 3.0 m to 15.8 m.

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

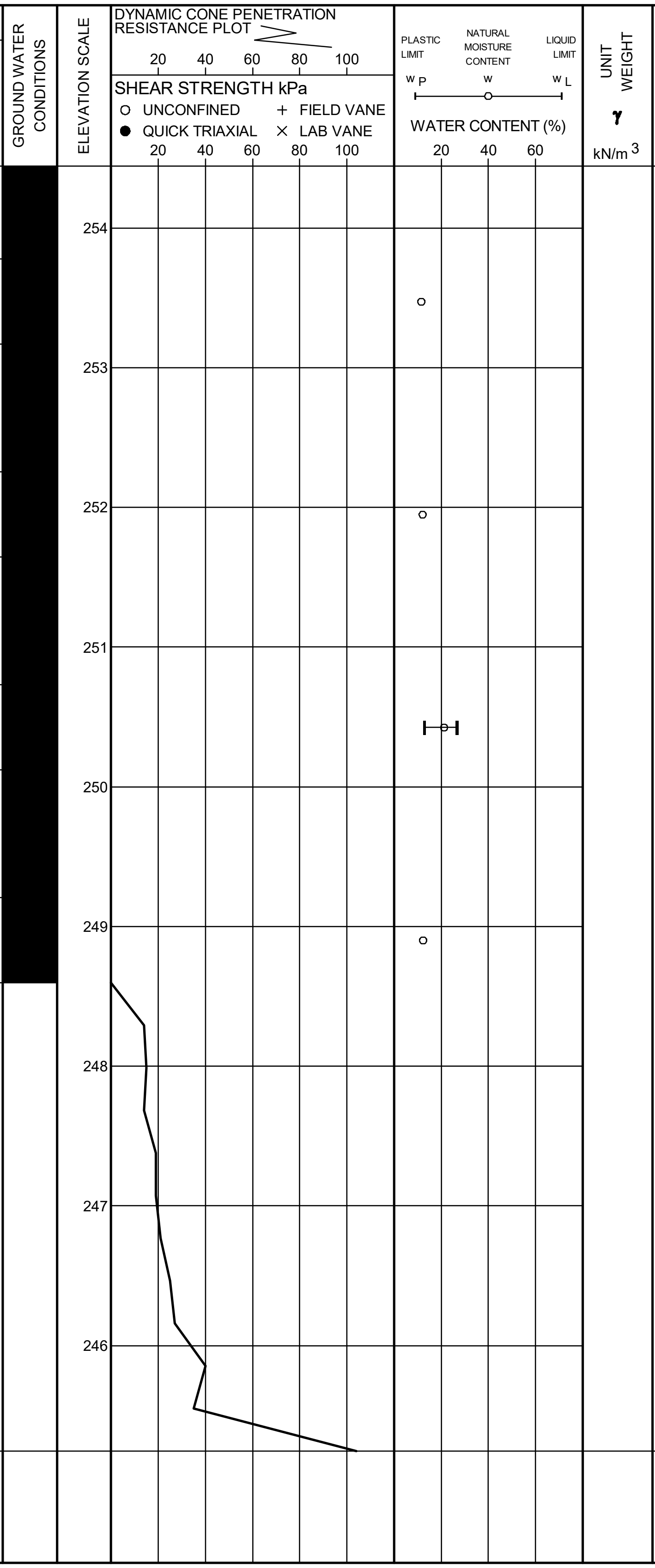
Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RCULV25-03 2 OF 3 METRIC

W.P. ______ LOCATION Bradford Bypass N 4 886 891.0 E 294 076.9 ORIGINATED BY JF
DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Auger/ Mud Rotary COMPILED BY JW
DATUM Geodetic DATE 2025.08.01 - 2025.08.01 LATITUDE 44.121935 LONGITUDE -79.633982 CHECKED BY RR/JA

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	Continued From Previous Page							
	Silty, Clayey **SAND** Loose to Dense Brown to Grey Moist to Wet	10	SS	3				
		11	SS	3				
251.2 13.3	**CLAY** Soft to Very Stiff Grey Moist to Wet (TILL)	12	SS	18	0	13	48	39
		13	SS	3				
248.6 15.8	End of sampling and start of DCPT							
245.2 19.2	END OF DCPT AT19.2 m UPON REFUSAL. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05 m slotted screen.							
	Continued Next Page							



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RCULV25-03

3 OF 3

METRIC

W.P.
LOCATION Bradford Bypass N 4 886 891.0 E 294 076.9
ORIGINATED BY JF
DIST Central HWY 400
BOREHOLE TYPE Hollow Stem Auger/ Mud Rotary
COMPILED BY JW
DATUM Geodetic
DATE 2025.08.01 - 2025.08.01
LATITUDE 44.121935
LONGITUDE -79.633982
CHECKED BY RR/JA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page WATER LEVEL READINGS										

DATE	DEPTH(m)	ELEV.(m)
2025.08.07	1.5	262.9
2025.08.22	1.5	262.9
2025.09.10	1.2	263.2
2025.11.26	1.7	262.7

+ 3, × 3: Numbers refer to Sensitivity

20
15 ⌖ 5
10
(%) STRAIN AT FAILURE

APPENDIX D

Record of Borehole Sheets – Current Investigation (Old Design Location)

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORD OF BOREHOLES

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS:

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in size from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	greater than 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	less than 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. Where insufficient penetration was achieved, the number of blows are reported over the sampler penetration in metres (e.g. 50/0.15).

DYNAMIC CONE PENETRATION TEST (DCPT):

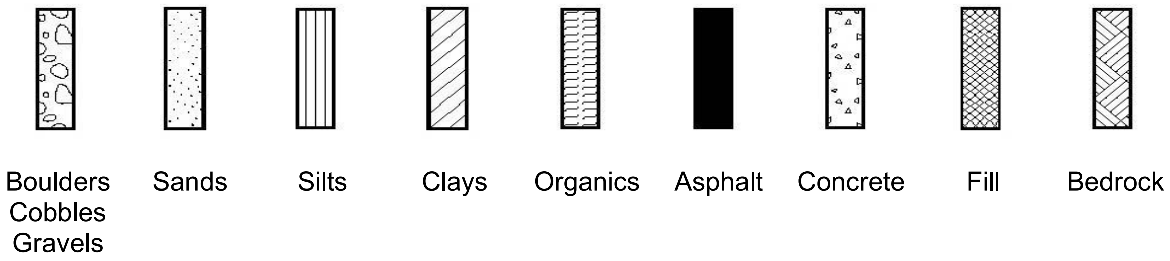
Dynamic cone penetration tests are performed using a standard 60-degree apex cone connected to “A” size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.

WATER LEVELS:

▽	Water level upon completion of drilling
▼	Water level in monitoring well / piezometer
┃	Monitoring well / piezometer screen

STRATA PLOT:

Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



TEXTURING CLASSIFICATION OF SOILS

Classification	**Particle Size**
Clay	Less than 0.002 mm
Silt	0.002 mm – 0.075 mm
Sand	0.075 mm – 4.75 mm
Gravel	4.75 mm – 75 mm
Cobbles	75 mm – 300 mm
Boulders	Greater than 300 mm

SAMPLE TYPES

SS	Split-spoon samples
TW	Thin-wall (Shelby) tube sample
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ, etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (FINE GRAINED SOILS ONLY)

Descriptive Term	**Undrained Shear Strength (kPa)**
Very Soft	Less than 12
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

TERMS DESCRIBING DENSITY (COARSE GRAINED SOILS ONLY)

Descriptive Term	**SPT ‘N’ Value**
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Division		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS LL < 35	ML	Inorganic silts, 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.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS 35 ≤ LL < 50	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS LL ≥ 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		PT	Peat and other organic soils.

Note – LL = Liquid Limit

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh, W1 (FR)	No visible signs of weathering.
Slightly Weathered, W2 (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered, W3 (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered, W4 (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered, W5 (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.
Residual Soil, W6 (RS)	Rock is completely changed into a soil, where the rock texture and structures have been completely destroyed.

TERMS

Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length.
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

Bedding	Bedding Thickness
Thinly laminated	Less than 6 mm
Laminated	6 mm – 20 mm
Very thinly bedded	20 mm – 60 mm
Thinly bedded	60 mm – 0.2 m
Medium bedded	0.2 m – 0.6 m
Thickly bedded	0.6 m – 2 m
Very thickly bedded	Greater than 2 m

STRENGTH CLASSIFICATION

Rock Strength	Uniaxial Compressive Strength (MPa)
Extremely Weak, R0	0.25 – 1
Very Weak, R1	1 – 5
Weak, R2	5 – 25
Medium Strong, R3	25 – 50
Strong, R4	50 – 100
Very Strong, R5	100 – 250
Extremely Strong, R6	Greater than 250

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THURBER

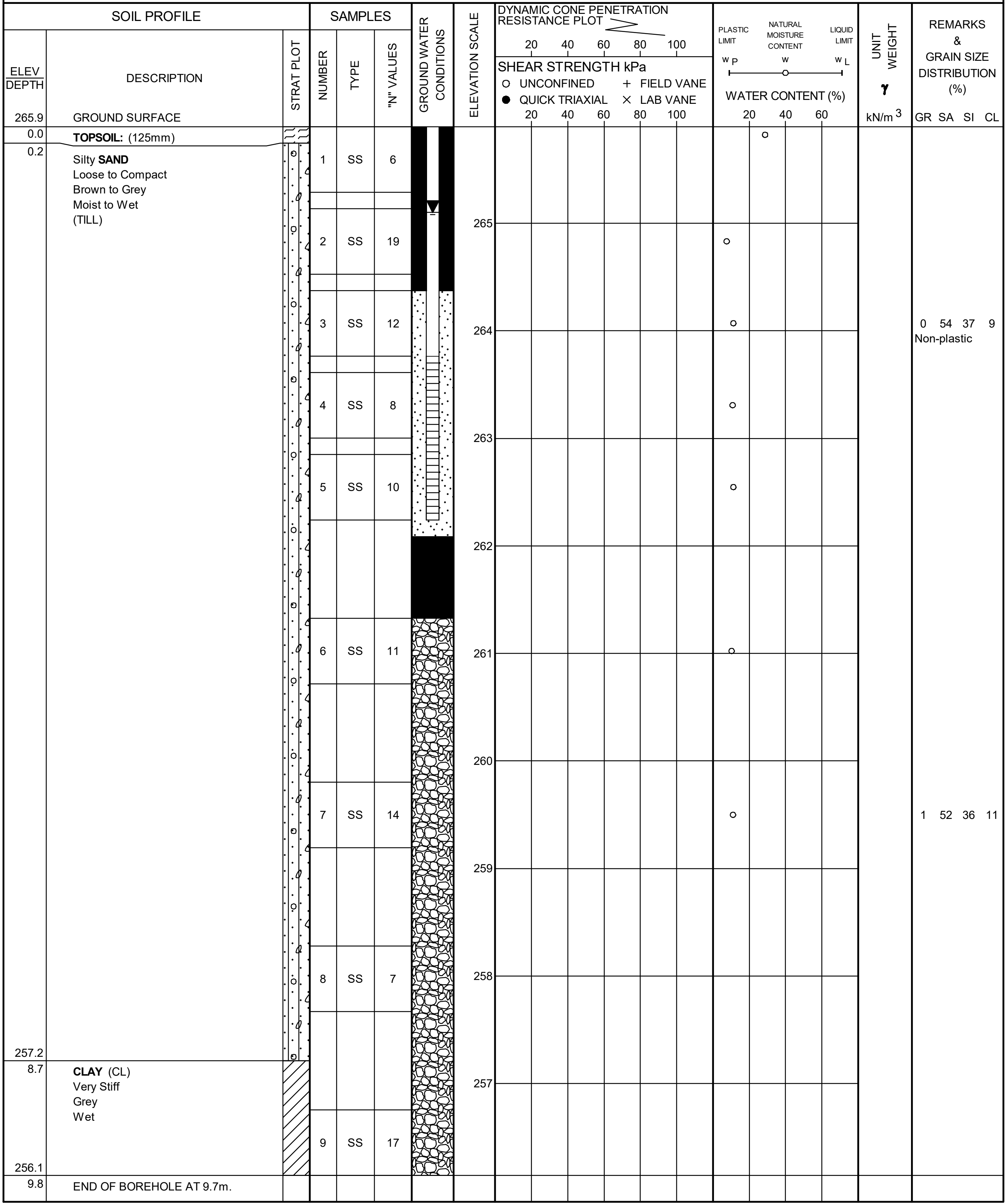
RECORD OF BOREHOLE No RCULV-01 1 OF 2 METRIC

W.P.		ORIGINATED BY	GA/KF
LOCATION	Bradford Bypass N 4 886 944.8 E 294 018.5		
DIST	Central	HWY	400
BOREHOLE TYPE	Hollow Stem Auger	COMPILED BY	JW
DATUM	Geodetic		
DATE	2024.10.28 - 2024.10.29	LATITUDE	44.122419
LONGITUDE	-79.634713	CHECKED BY	RR/JA

ELEV DEPTH	DESCRIPTION
265.9	GROUND SURFACE
0.0	**TOPSOIL:** (125mm)
0.2	Silty **SAND** Loose to Compact Brown to Grey Moist to Wet (TILL)
257.2 8.7	**CLAY** (CL) Very Stiff Grey Wet
256.1 9.8	END OF BOREHOLE AT 9.7m.

Continued Next Page

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	6	
2	SS	19	
3	SS	12	0 54 37 9 Non-plastic
4	SS	8	
5	SS	10	
6	SS	11	
7	SS	14	1 52 36 11
8	SS	7	
9	SS	17	



+ 3 , × 3 : Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

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Ontario

THURBER

RECORD OF BOREHOLE No RCULV-01

2 OF 2

METRIC

W.P. ______
LOCATION Bradford Bypass N 4 886 944.8 E 294 018.5
ORIGINATED BY GA/KF
DIST Central
HWY 400
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY JW
DATUM Geodetic
DATE 2024.10.28 - 2024.10.29
LATITUDE 44.122419
LONGITUDE -79.634713
CHECKED BY RR/JA

SOIL PROFILE: ELEV DEPTH | DESCRIPTION | STRAT PLOT
SAMPLES: NUMBER | TYPE | "N" VALUES
GROUND WATER CONDITIONS
ELEVATION SCALE
DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100
PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m^3
REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued From Previous Page

Monitoring well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2024.11.05	1.1	264.8
2024.11.14	1.1	264.8
2024.12.12	0.8	265.1
2025.03.21	0.6	265.3
2025.05.29	0.8	265.1
2025.09.10	1.1	264.8

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$+^3, \times^3$: Numbers refer to Sensitivity

20 15-5 10 (%) STRAIN AT FAILURE

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THURBER

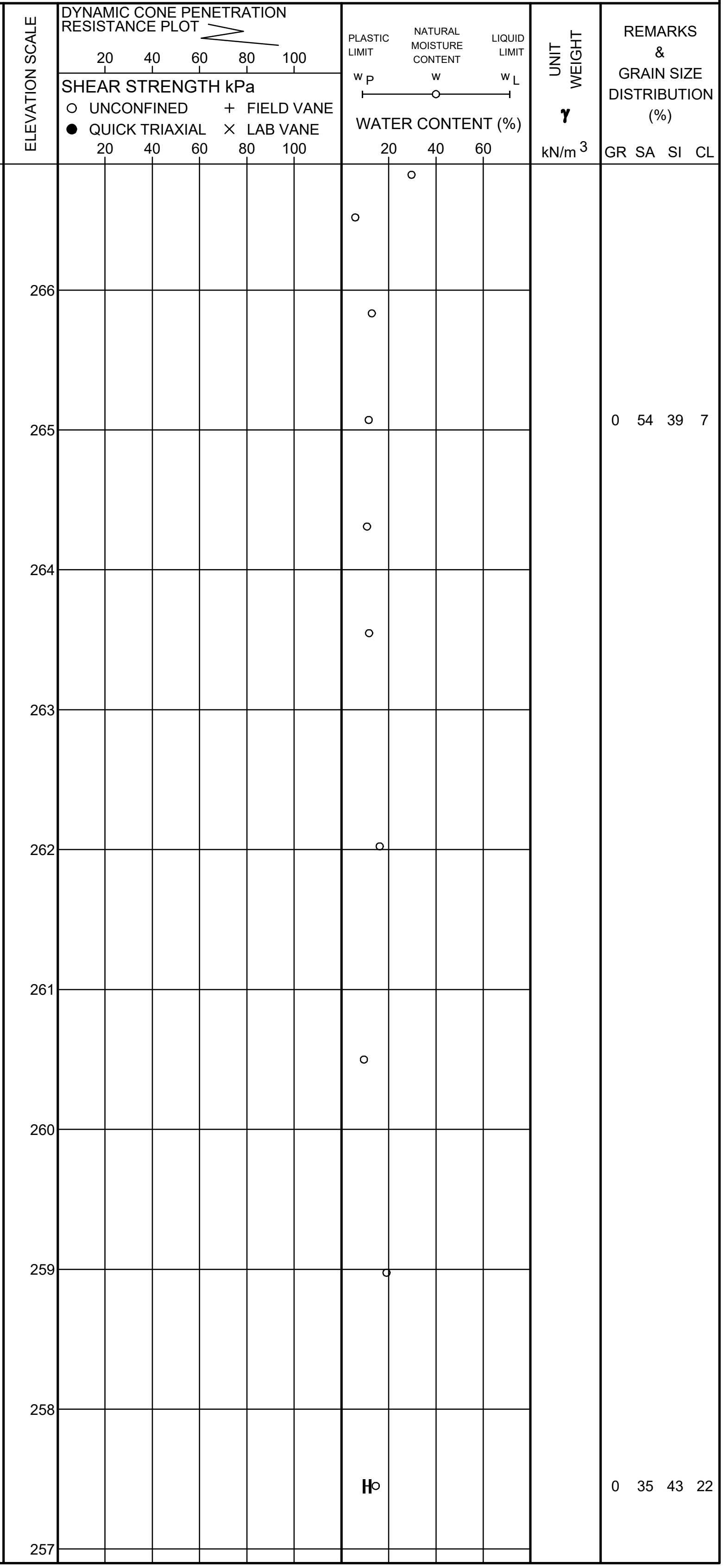
RECORD OF BOREHOLE No RCULV-02

1 OF 2 **METRIC**

W.P.
LOCATION Bradford Bypass N 4 886 963.9 E 294 048.6
ORIGINATED BY KF
DIST Central HWY 400
BOREHOLE TYPE Hollow Stem Auger
COMPILED BY JW
DATUM Geodetic
DATE 2024.10.17 - 2024.10.17 LATITUDE 44.122591 LONGITUDE -79.634338
CHECKED BY JA

ELEV DEPTH	SOIL PROFILE DESCRIPTION
266.9	GROUND SURFACE
0.0	**TOPSOIL:** (125mm)
0.1	Silty **SAND** Loose to Compact Brown to Grey Moist to Wet (TILL)
259.7 7.2	**CLAY** (CL) Stiff Grey Wet
258.2 8.7	Sandy **SILT** Compact Grey Wet (TILL)

NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	SS	8				
2	SS	5				
3	SS	4	0	54	39	7
4	SS	3				
5	SS	4				
6	SS	3				
7	SS	12				
8	SS	11				
9	SS	13	0	35	43	22



Continued Next Page

+3, ×3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No RCULV-02 2 OF 2 METRIC

W.P. ______ LOCATION Bradford Bypass N 4 886 963.9 E 294 048.6 ORIGINATED BY KF

DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JW

DATUM Geodetic DATE 2024.10.17 - 2024.10.17 LATITUDE 44.122591 LONGITUDE -79.634338 CHECKED BY JA

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	Continued From Previous Page								
256.7 10.2	Sandy **SILT** Compact Grey Wet (TILL)								
	Silty **SAND** Loose to Compact Grey Wet (TILL) Auger grinding from 11.6m to 13.1m				256				
		10	SS	26					
					255				
		11	SS	13					
					254				
					253				
		12	SS	7					
					252				
		13	SS	7		1	54	35	10
					251				
					250				
		14	SS	13					
249.5 17.4	END OF BOREHOLE AT 17.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO GROUND SURFACE.								

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No RCULV-03

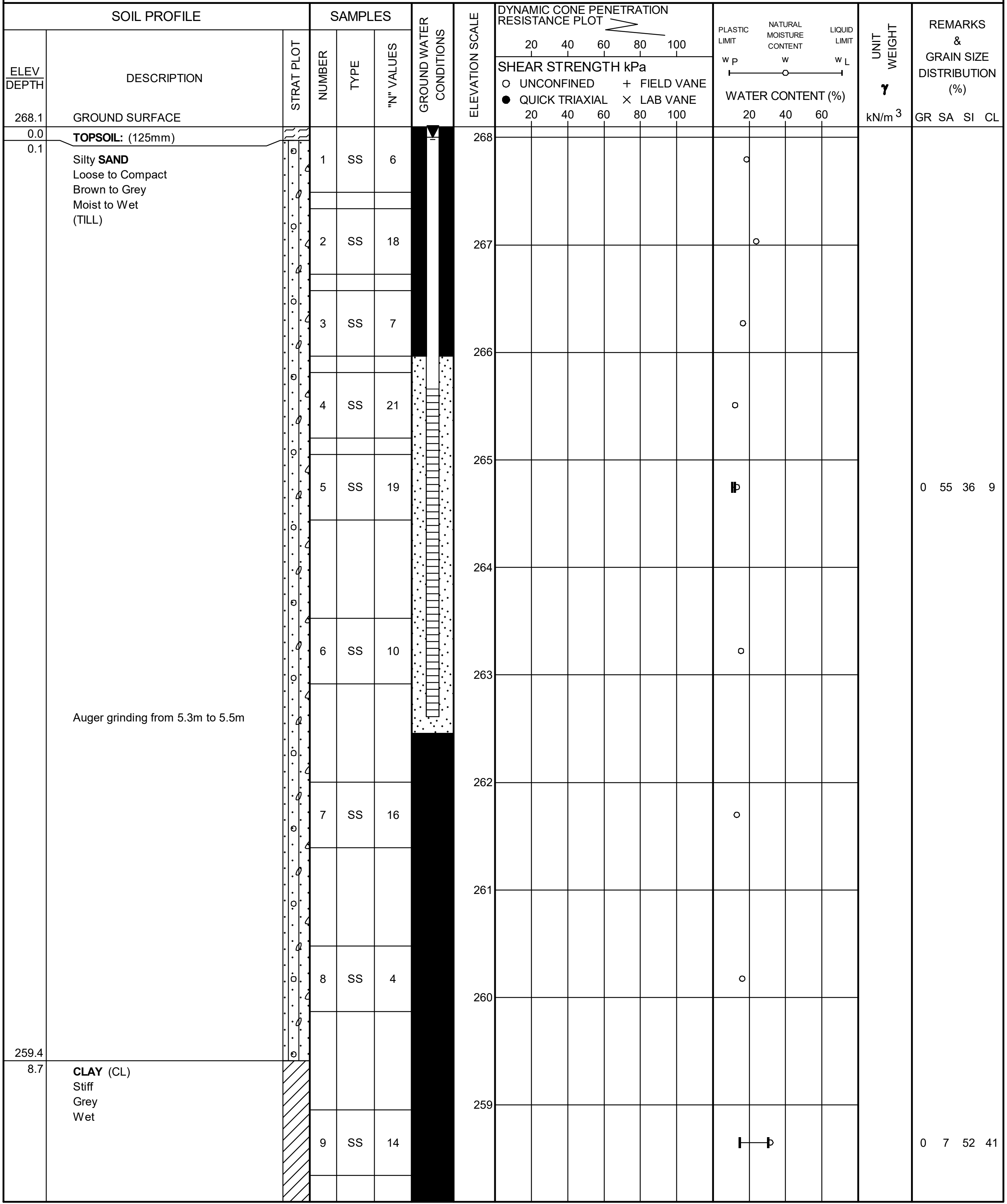
1 OF 2

METRIC

W.P. ______ LOCATION Bradford Bypass N 4 886 982.6 E 294 067.3 ORIGINATED BY KF

DIST Central HWY 400 BOREHOLE TYPE Hollow Stem Auger COMPILED BY JW

DATUM Geodetic DATE 2024.10.21 - 2024.10.21 LATITUDE 44.122759 LONGITUDE -79.634104 CHECKED BY RR/JA



ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
268.1	GROUND SURFACE							
0.0	**TOPSOIL:** (125mm)							
0.1	Silty **SAND** Loose to Compact Brown to Grey Moist to Wet (TILL)	1	SS	6				
		2	SS	18				
		3	SS	7				
		4	SS	21				
		5	SS	19	0	55	36	9
		6	SS	10				
	Auger grinding from 5.3m to 5.5m							
		7	SS	16				
		8	SS	4				
259.4 8.7	**CLAY** (CL) Stiff Grey Wet	9	SS	14	0	7	52	41

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

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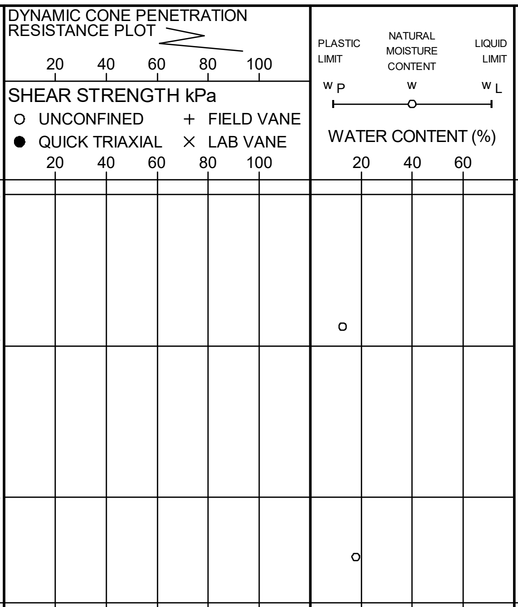
RECORD OF BOREHOLE No RCULV-03

2 OF 2

METRIC

W.P.		LOCATION	Bradford Bypass N 4 886 982.6 E 294 067.3	ORIGINATED BY	KF
DIST	Central HWY 400	BOREHOLE TYPE	Hollow Stem Auger	COMPILED BY	JW
DATUM	Geodetic	DATE	2024.10.21 - 2024.10.21 LATITUDE 44.122759 LONGITUDE -79.634104	CHECKED BY	RR/JA

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	Continued From Previous Page										
257.9	**CLAY** (CL) Stiff Grey Wet					258					
10.2	Silty **SAND** Loose to Dense Grey Wet (TILL)	10	SS	6		257					
						256					
		11	SS	32							
255.3 12.8	END OF BOREHOLE AT 12.8m. Monitoring well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.										



REMARKS & GRAIN SIZE DISTRIBUTION (%)

WATER LEVEL READINGS

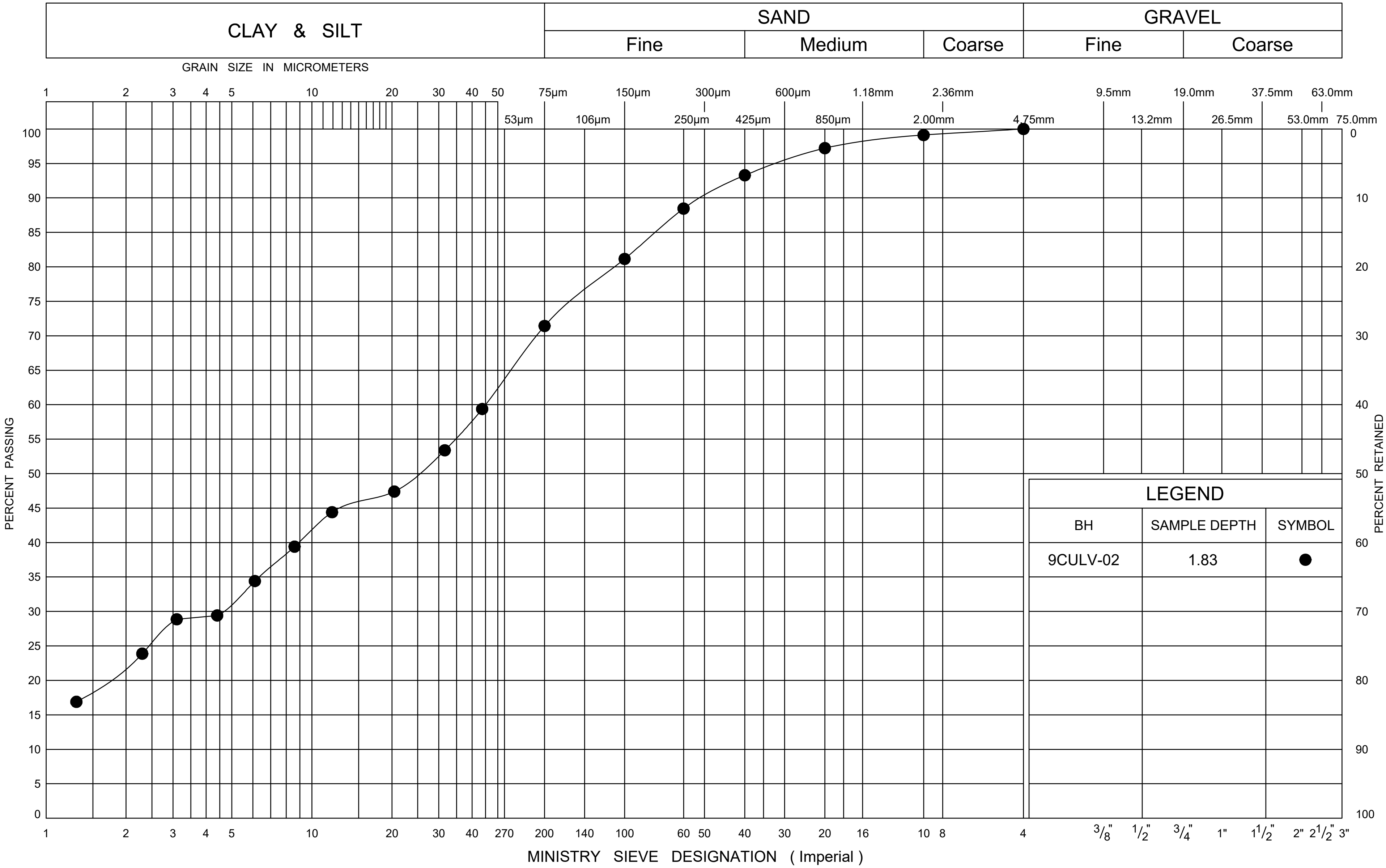
DATE	DEPTH(m)	ELEV.(m)
2024.11.01	1.3	266.8
2024.11.08	1.3	266.8
2025.04.09	0.1	268.0
2025.05.30	0.6	267.5
2025.09.10	1.7	266.4

$+^3, \times^3$: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

APPENDIX E

Geotechnical and Analytical Laboratory Test Results



LEGEND

BH	SAMPLE DEPTH	SYMBOL
9CULV-02	1.83	●

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GRAIN SIZE DISTRIBUTION

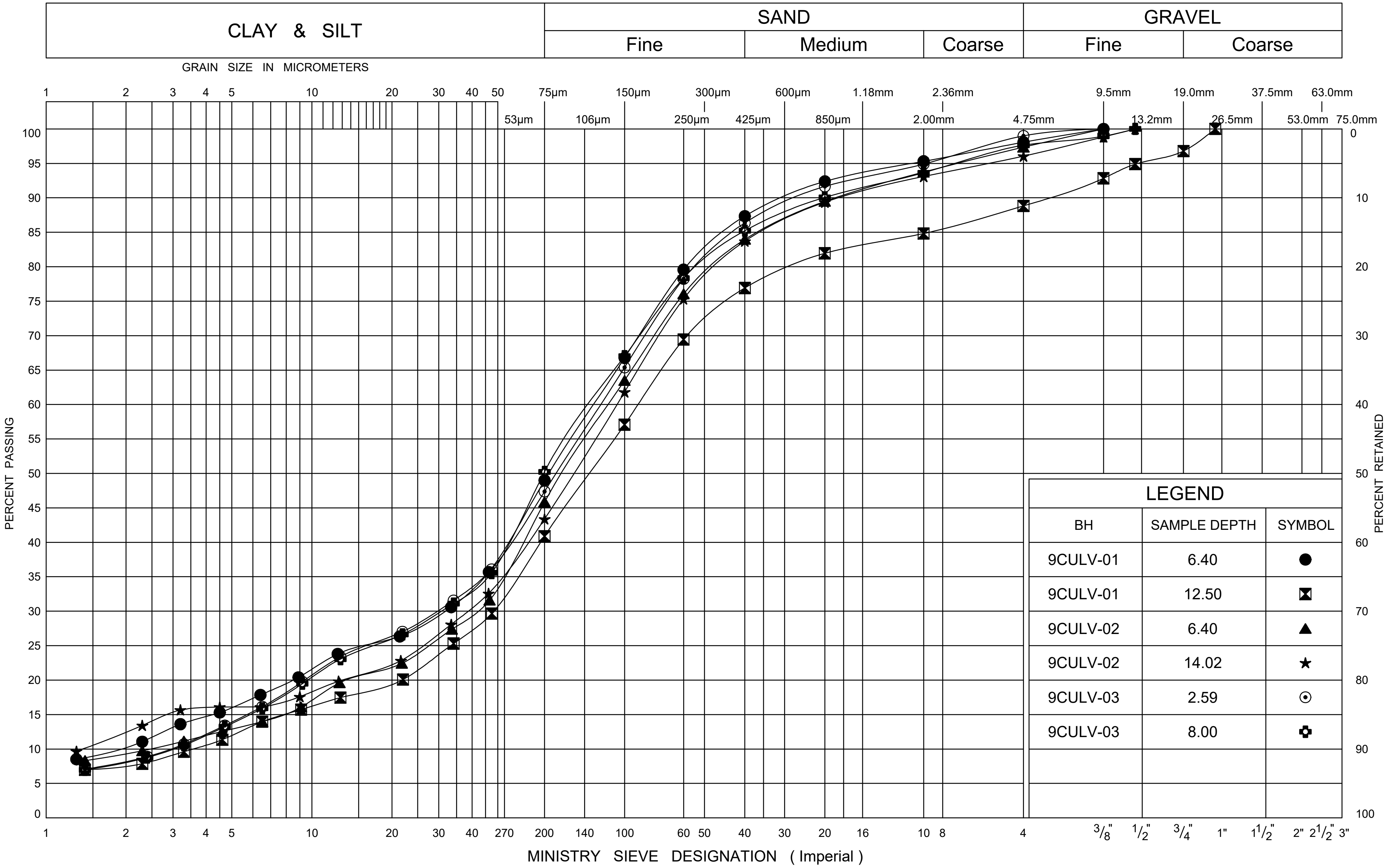
SILT with Sand FILL

FIG No E1

W.P.

Bradford Bypass

78 12 M



LEGEND

BH	SAMPLE DEPTH	SYMBOL
9CULV-01	6.40	●
9CULV-01	12.50	⧗
9CULV-02	6.40	▲
9CULV-02	14.02	★
9CULV-03	2.59	⊙
9CULV-03	8.00	✜

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GRAIN SIZE DISTRIBUTION

Silty SAND TILL

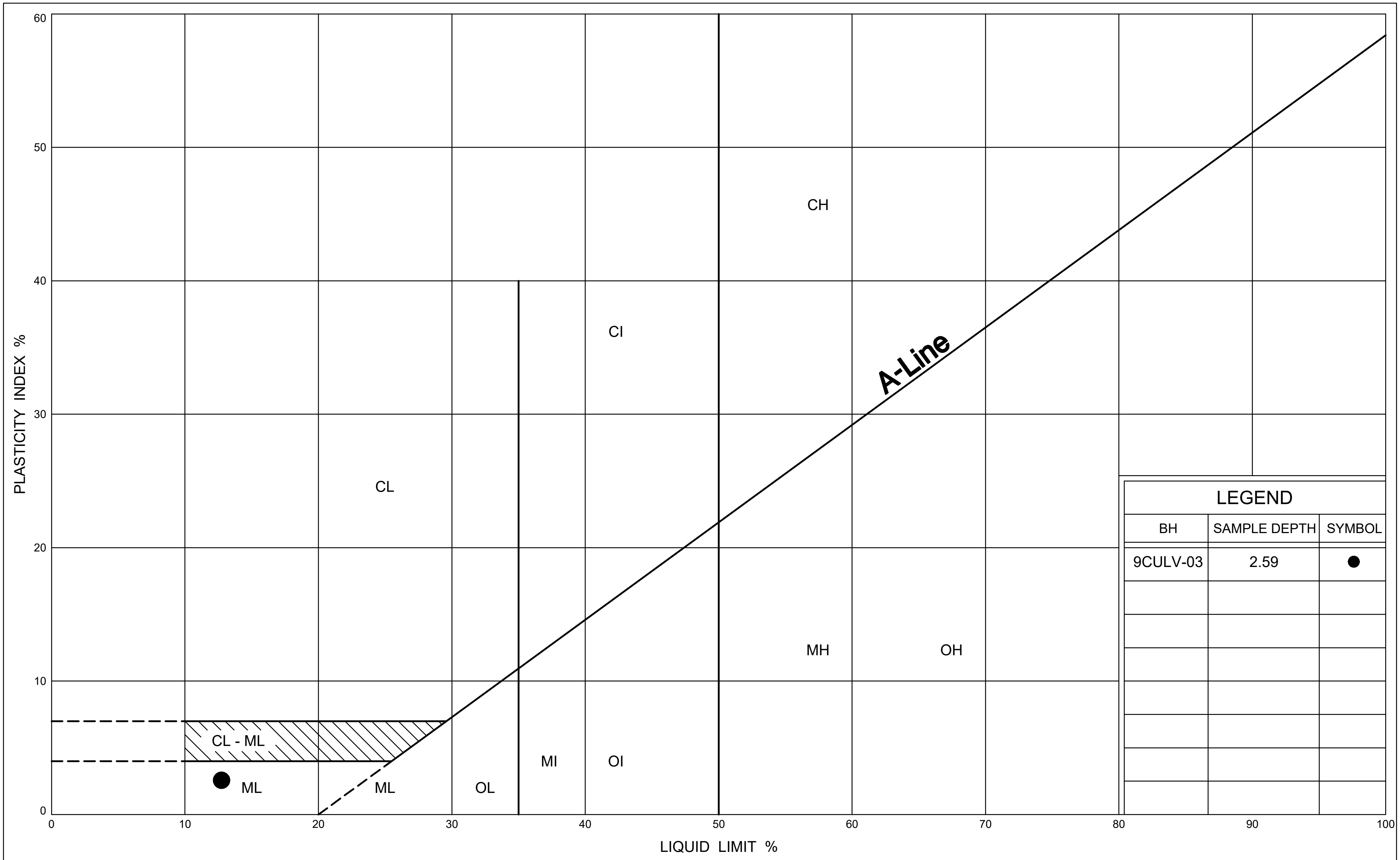
FIG No E2

W.P.

Bradford Bypass

ONTARIO MOT GRAIN SIZE 3 MTO-48856.GPJ ONTARIO MOT.GDT 5/27/25

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE DEPTH	SYMBOL
9CULV-03	2.59	●

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PLASTICITY CHART

Silty SAND TILL

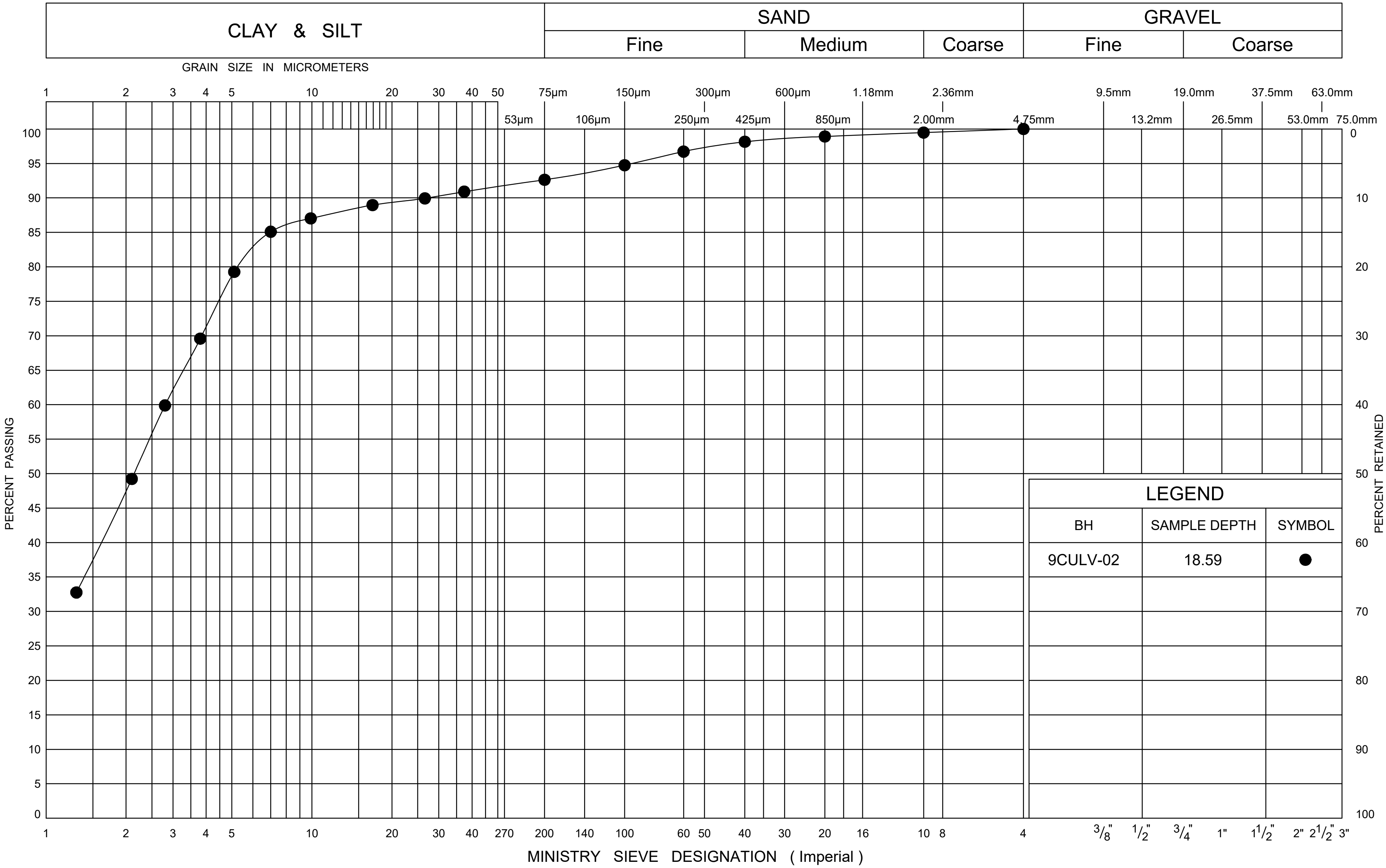
FIG No E3

W.P.

Bradford Bypass

ONTARIO MOT PLASTICITY CHART 2 MTO-48856.GPJ ONTARIO MOT.GDT 5/27/25

78 12 M



LEGEND

BH	SAMPLE DEPTH	SYMBOL
9CULV-02	18.59	●

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GRAIN SIZE DISTRIBUTION

CLAY (CL)

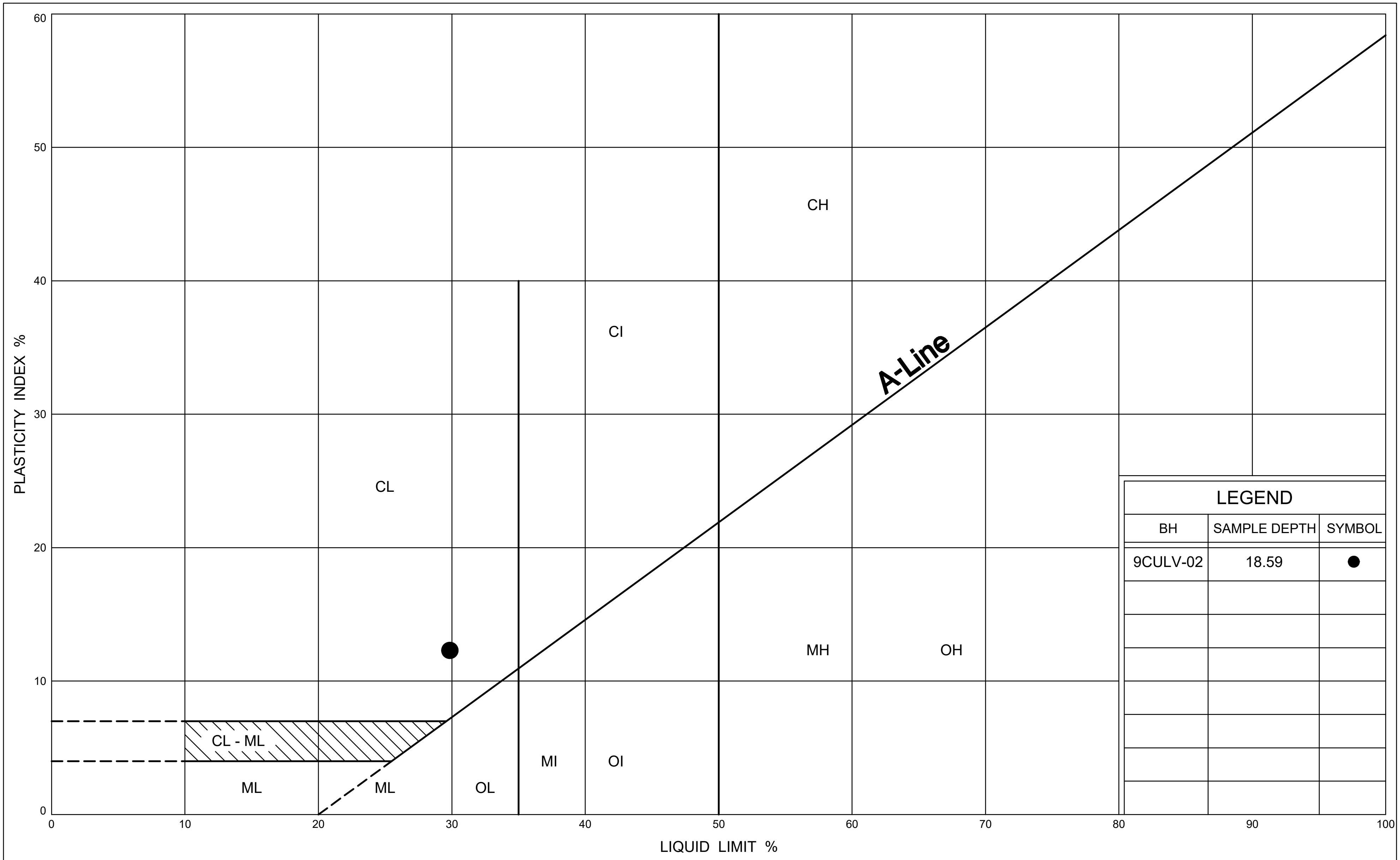
FIG No E4

W.P.

Bradford Bypass

ONTARIO MOT GRAIN SIZE 3 MTO-48856.GPJ ONTARIO MOT.GDT 5/27/25

Oct 75, FF - S - 21



BH	SAMPLE DEPTH	SYMBOL
9CULV-02	18.59	●

ONTARIO MOT PLASTICITY CHART 2 MTO-48856.GPJ ONTARIO MOT.GDT 5/27/25

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PLASTICITY CHART

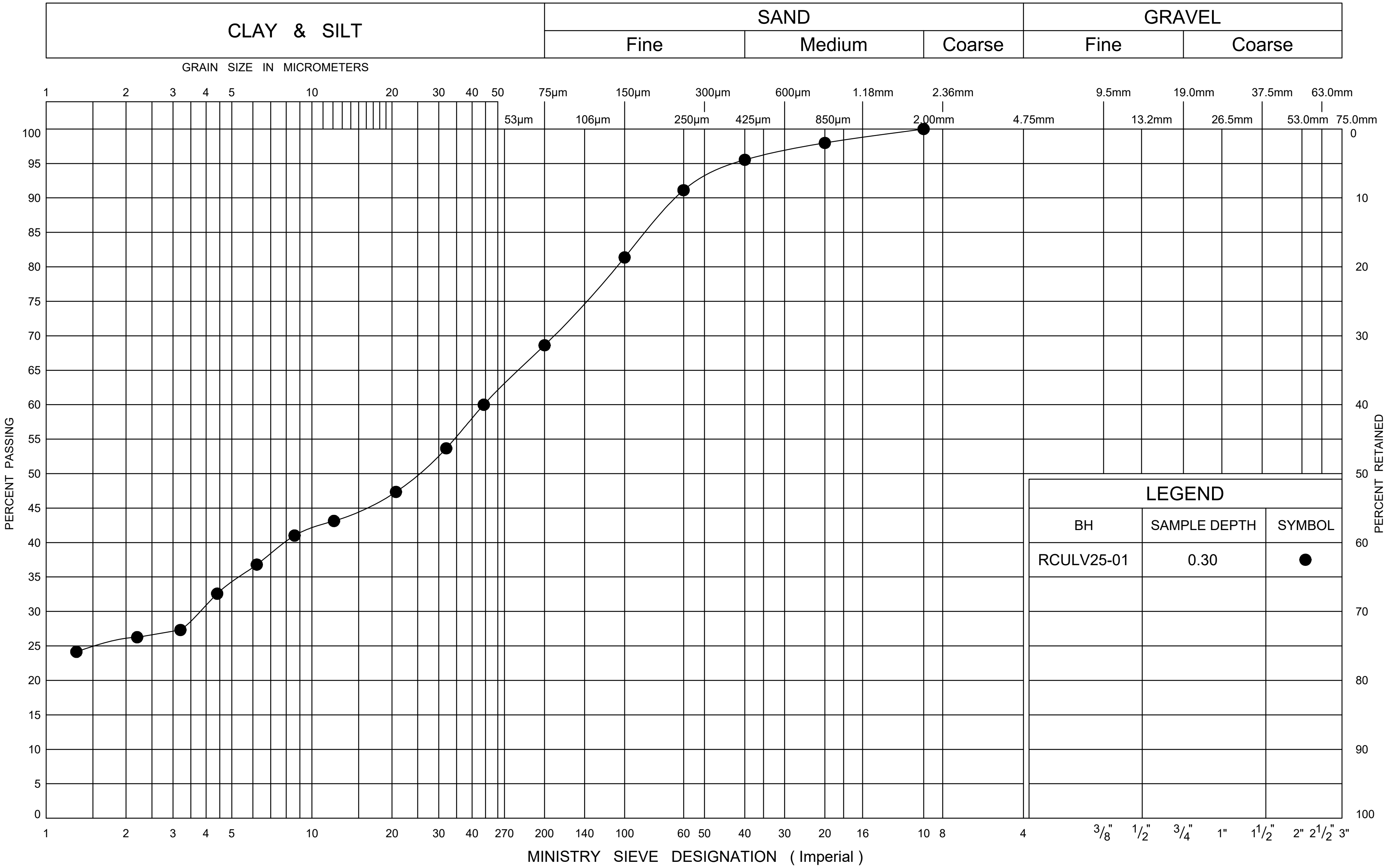
CLAY (CL)

FIG No E5

W.P.

Bradford Bypass

78 12 M



BH	SAMPLE DEPTH	SYMBOL
RCULV25-01	0.30	●

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GRAIN SIZE DISTRIBUTION

Silty CLAY

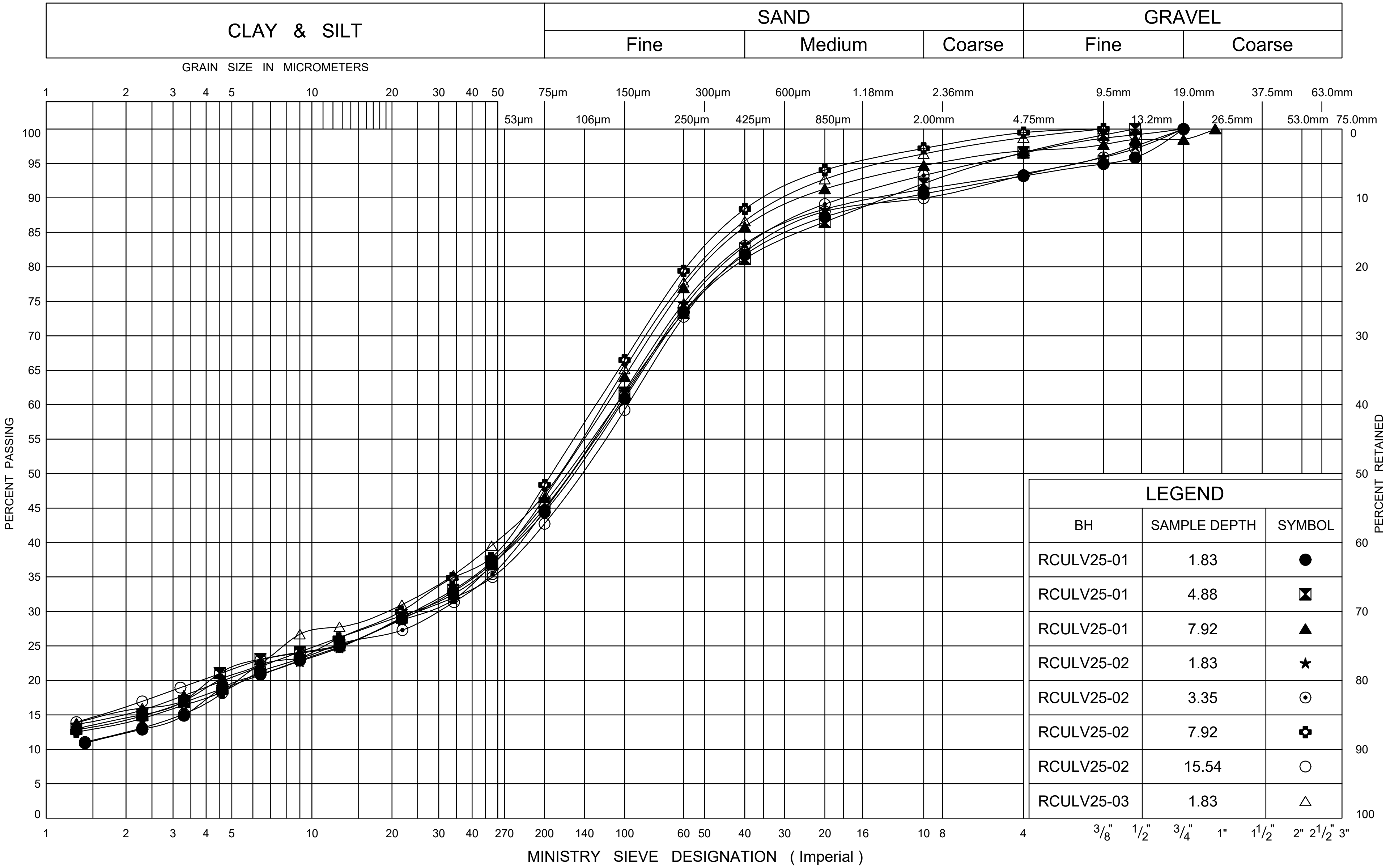
FIG No E6

W.P.

Bradford Bypass

ONTARIO MOT GRAIN SIZE 3 MTO-48856.GPJ ONTARIO MOT.GDT 10/20/25

78 12 M



LEGEND

BH	SAMPLE DEPTH	SYMBOL
RCULV25-01	1.83	●
RCULV25-01	4.88	⧗
RCULV25-01	7.92	▲
RCULV25-02	1.83	★
RCULV25-02	3.35	⊙
RCULV25-02	7.92	✤
RCULV25-02	15.54	○
RCULV25-03	1.83	△

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GRAIN SIZE DISTRIBUTION

Silty SAND to Silty, Clayey SAND to Clayey SAND TILL

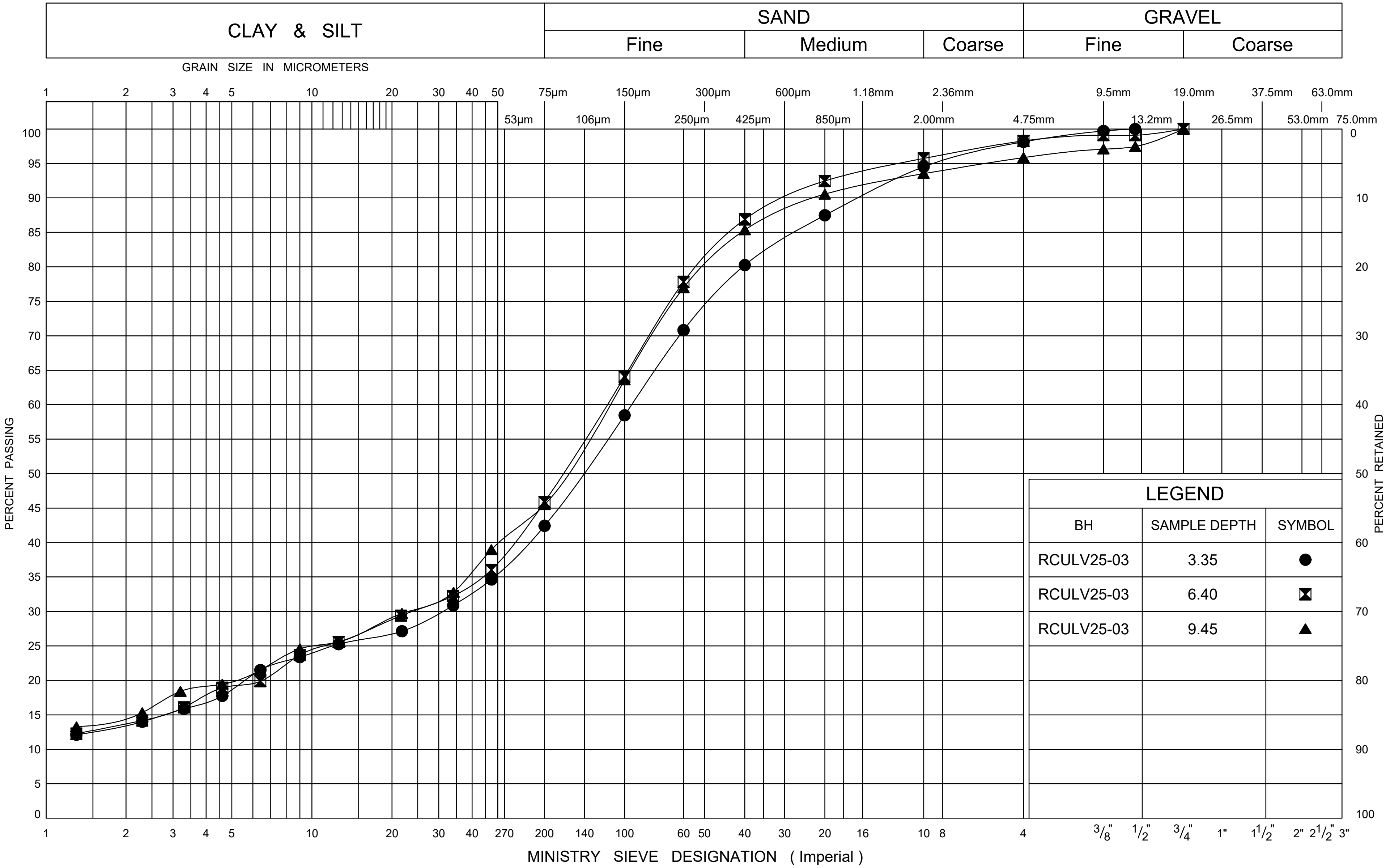
FIG No E7

W.P.

Bradford Bypass

ONTARIO MOT GRAIN SIZE 3 MTO-48856.GPJ ONTARIO MOT.GDT 10/21/25

78 12 M



LEGEND

BH	SAMPLE DEPTH	SYMBOL
RCULV25-03	3.35	●
RCULV25-03	6.40	⧗
RCULV25-03	9.45	▲

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Ontario

GRAIN SIZE DISTRIBUTION

Silty SAND to Silty, Clayey SAND to Clayey SAND TILL

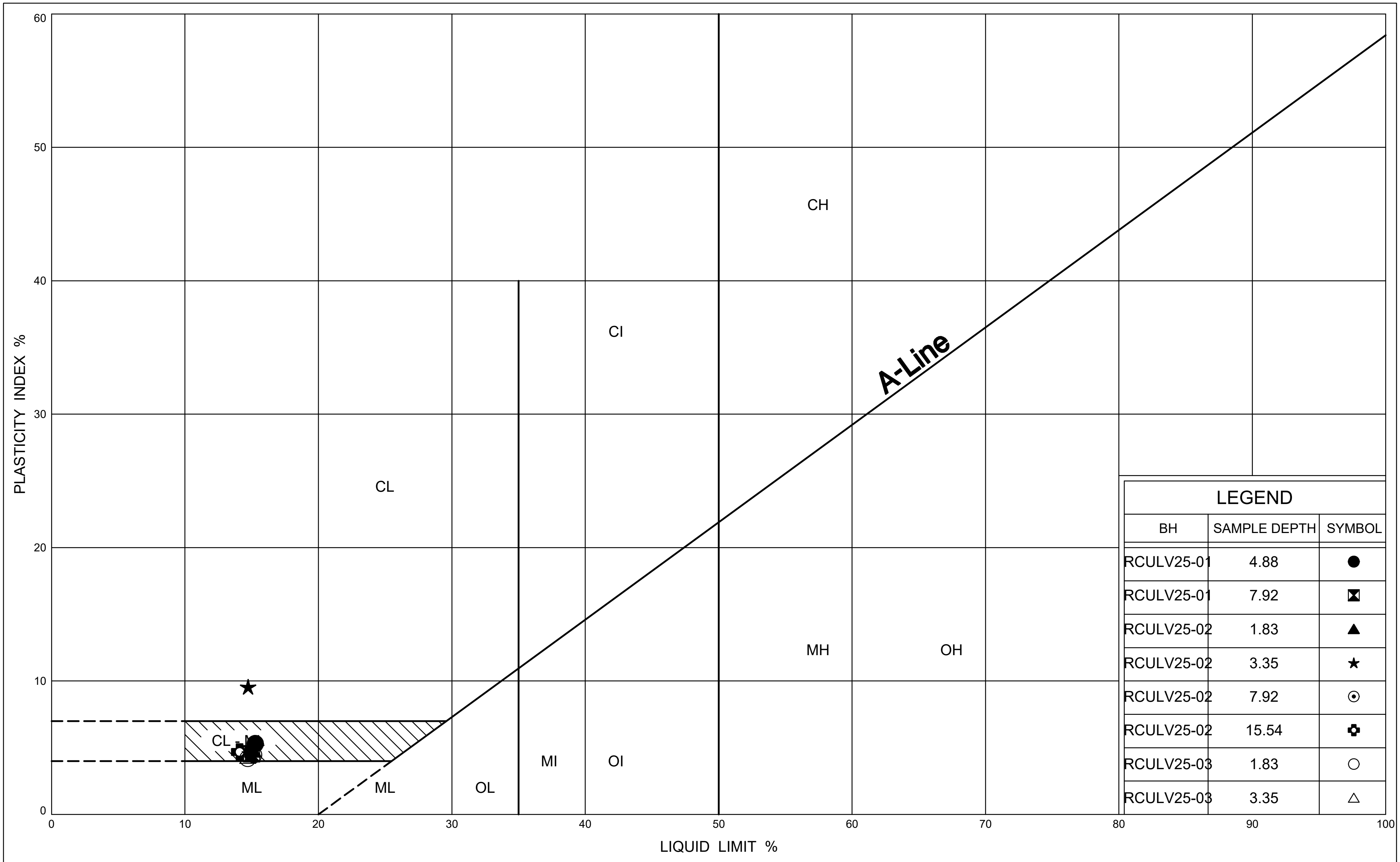
FIG No E8

W.P.

Bradford Bypass

ONTARIO MOT GRAIN SIZE 3 MTO-48856.GPJ ONTARIO MOT.GDT 10/21/25

Oct 75, FF - S - 21



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PLASTICITY CHART

Silty SAND to Silty, Clayey SAND to Clayey SAND TILL

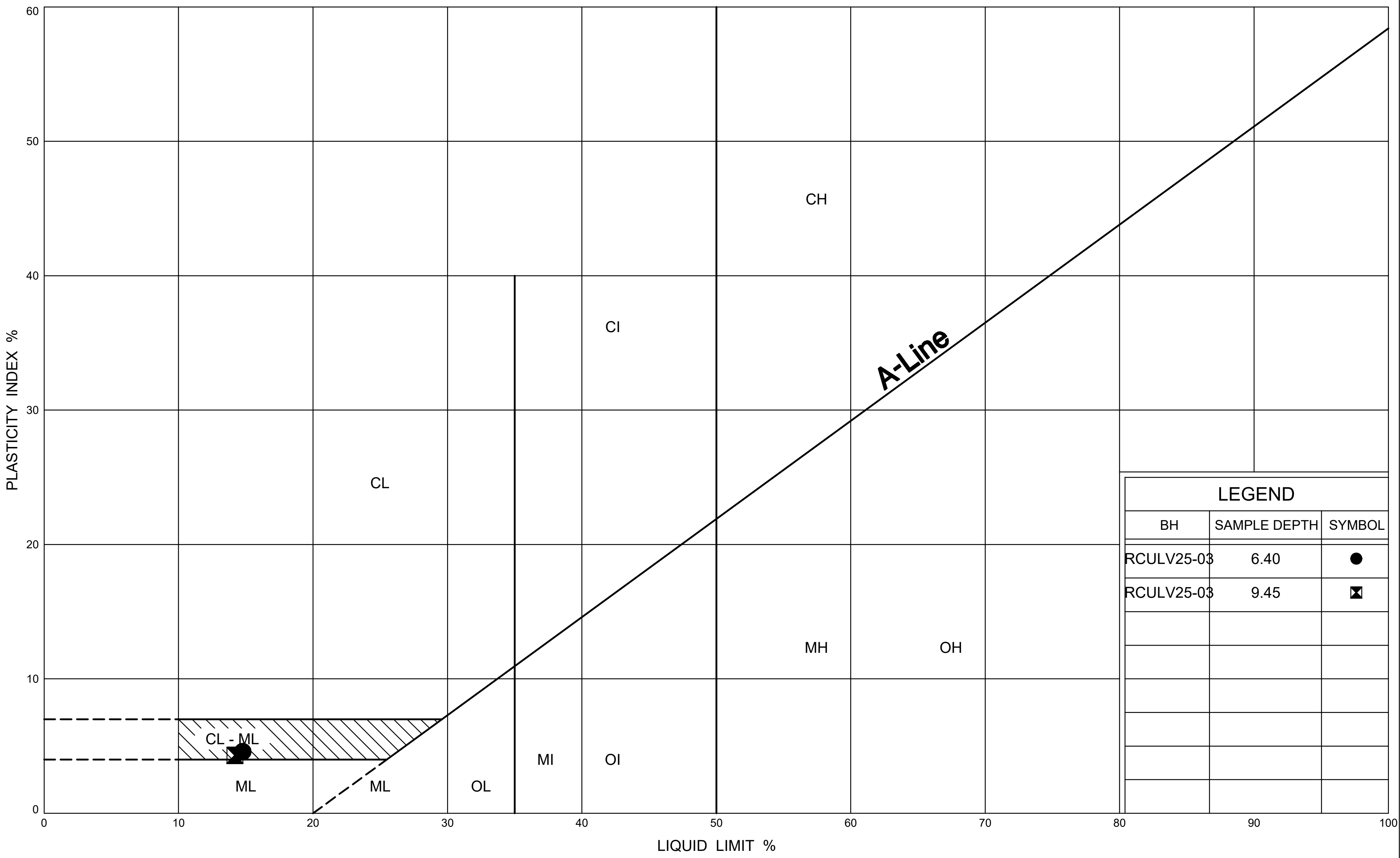
FIG No E9

W.P.

Bradford Bypass

ONTARIO MOT PLASTICITY CHART 2 MTO-48856.GPJ ONTARIO MOT.GDT 10/21/25

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE DEPTH	SYMBOL
RCULV25-03	6.40	●
RCULV25-03	9.45	⧗

ONTARIO MOT PLASTICITY CHART 2 MTO-48856.GPJ ONTARIO MOT.GDT 10/21/25

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PLASTICITY CHART

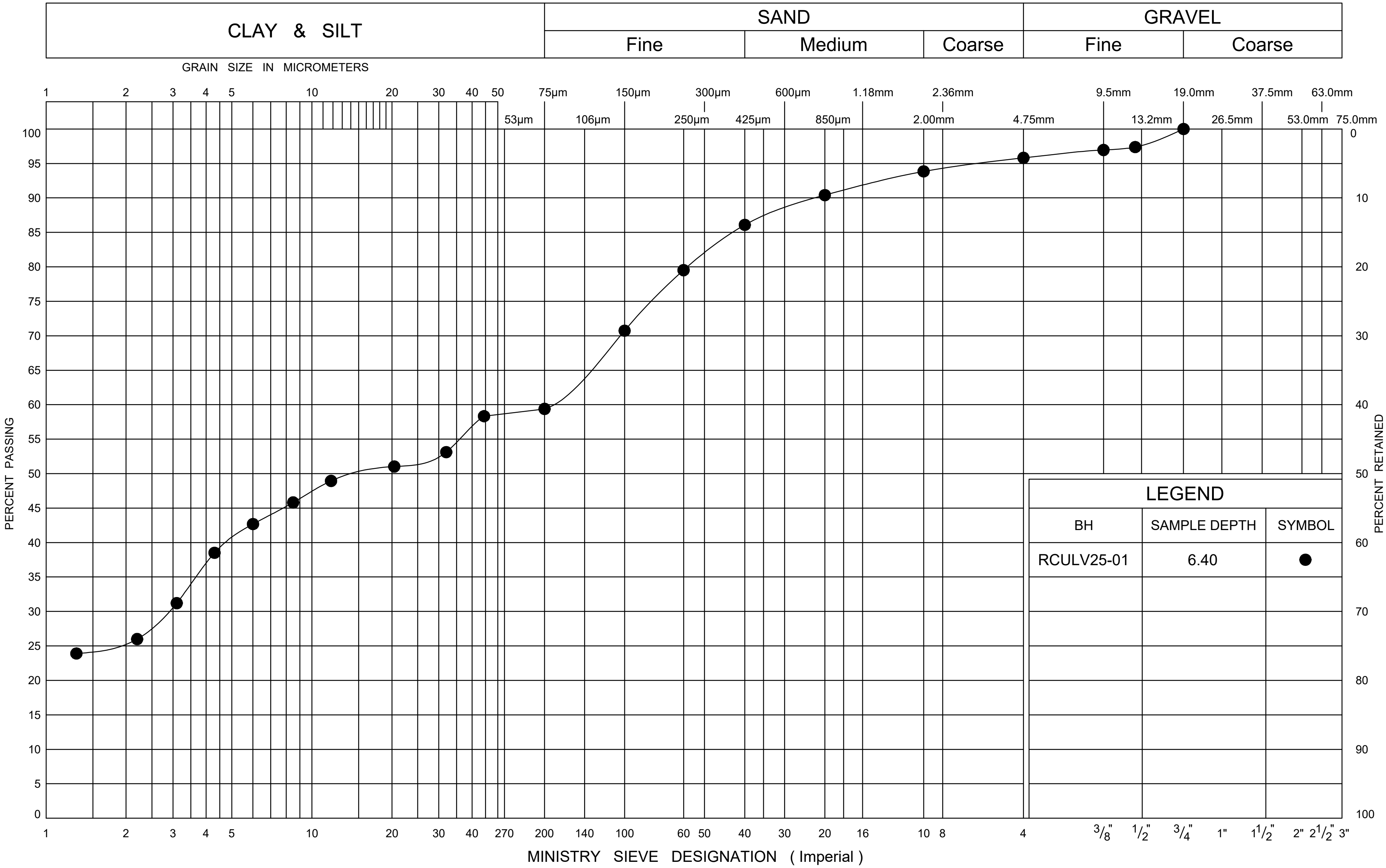
Silty SAND to Silty, Clayey SAND to Clayey SAND TILL

FIG No E10

W.P.

Bradford Bypass

78 12 M



LEGEND

BH	SAMPLE DEPTH	SYMBOL
RCULV25-01	6.40	●

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Ontario

GRAIN SIZE DISTRIBUTION

Sandy CLAY TILL

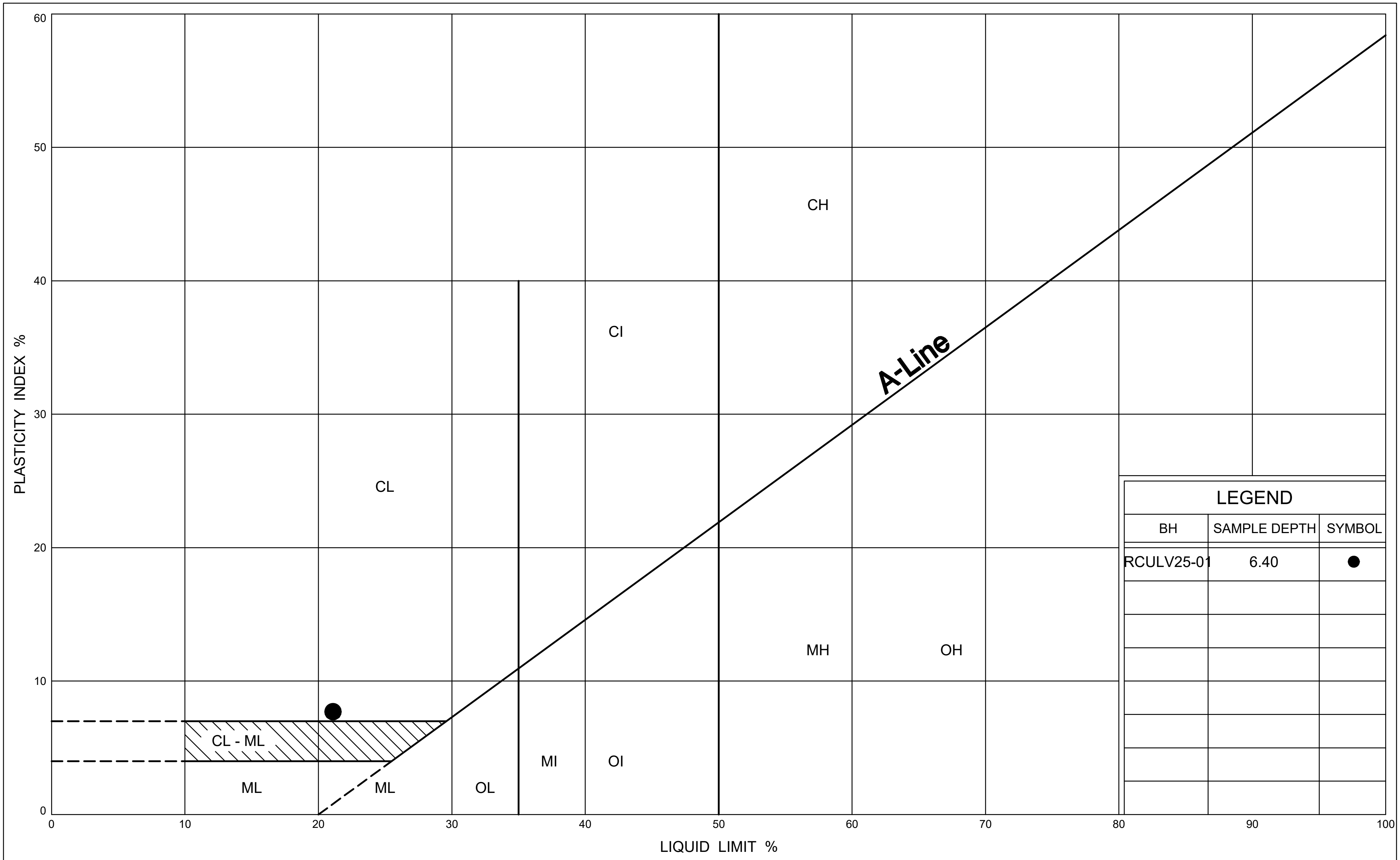
FIG No E11

W.P.

Bradford Bypass

ONTARIO MOT GRAIN SIZE 3 MTO-48856.GPJ ONTARIO MOT.GDT 10/21/25

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE DEPTH	SYMBOL
RCULV25-01	6.40	●

ONTARIO MOT PLASTICITY CHART 2 MTO-48856.GPJ ONTARIO MOT.GDT 10/21/25

Ministry of Transportation

Ontario

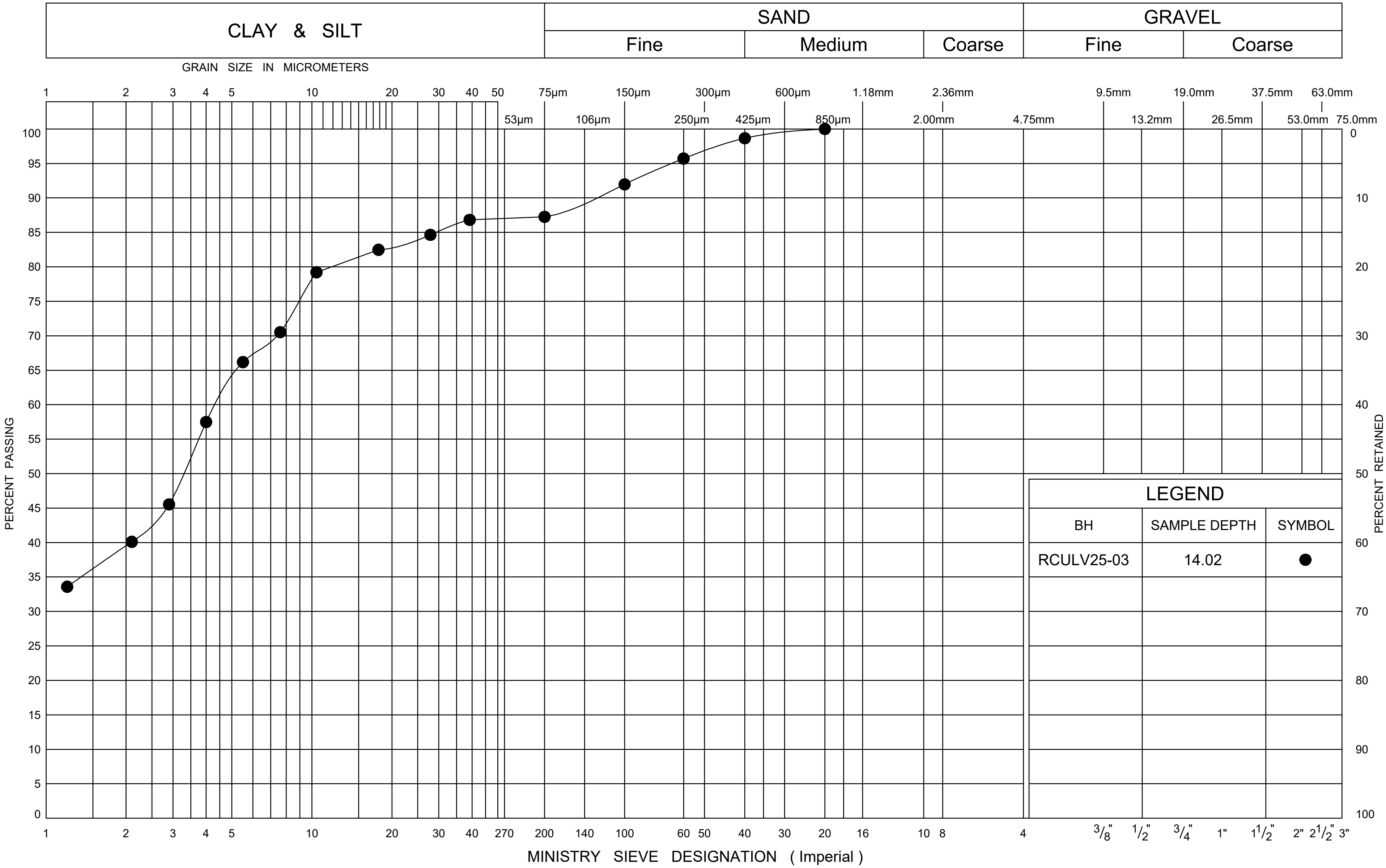
PLASTICITY CHART

Sandy CLAY TILL

FIG No E12

W.P.

Bradford Bypass



Ministry of
Transportation
Ontario

GRAIN SIZE DISTRIBUTION

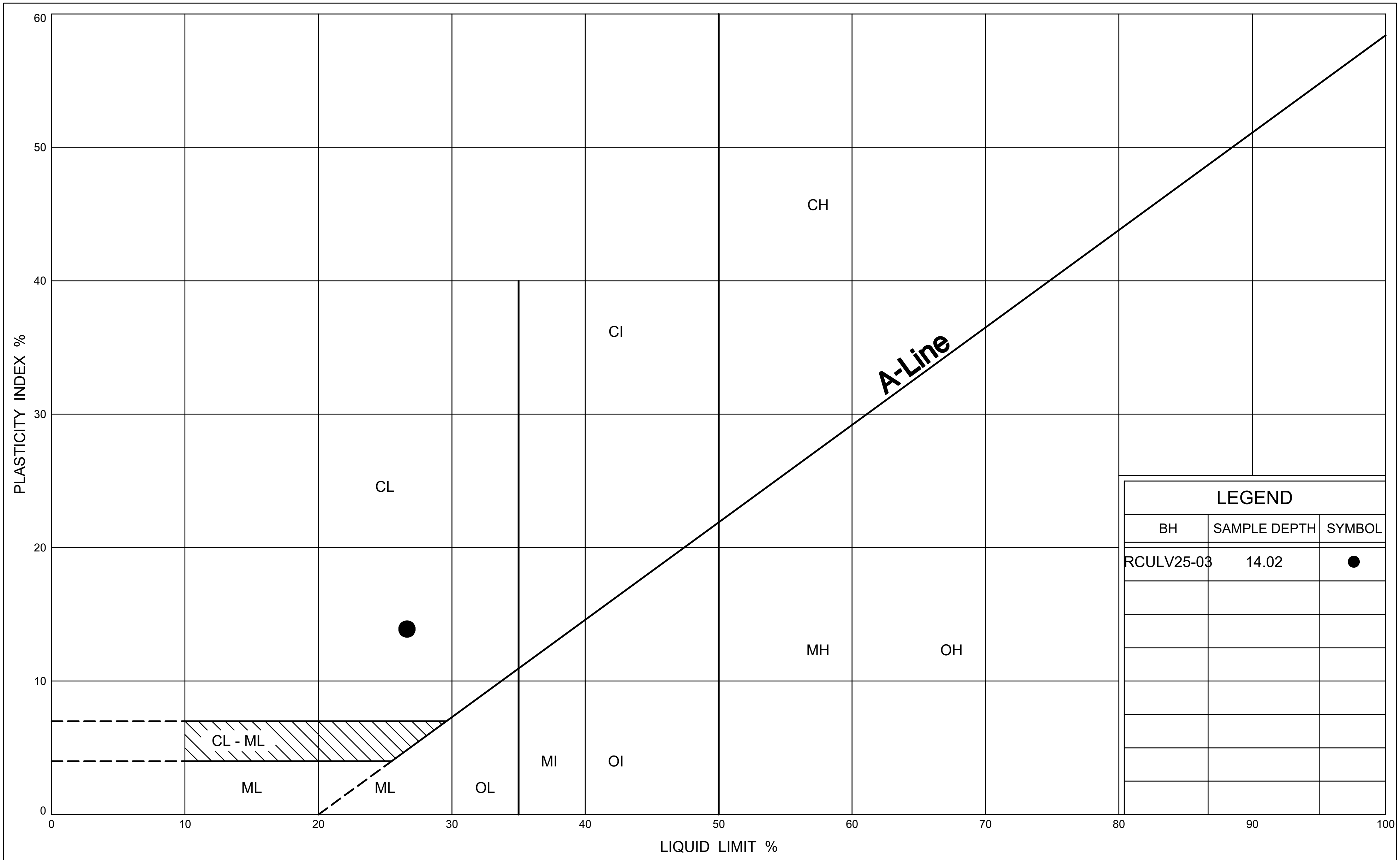
CLAY TILL

FIG No E13

W.P.

Bradford Bypass

Oct 75, FF - S - 21



Ministry of
Transportation
Ontario

PLASTICITY CHART

CLAY TILL

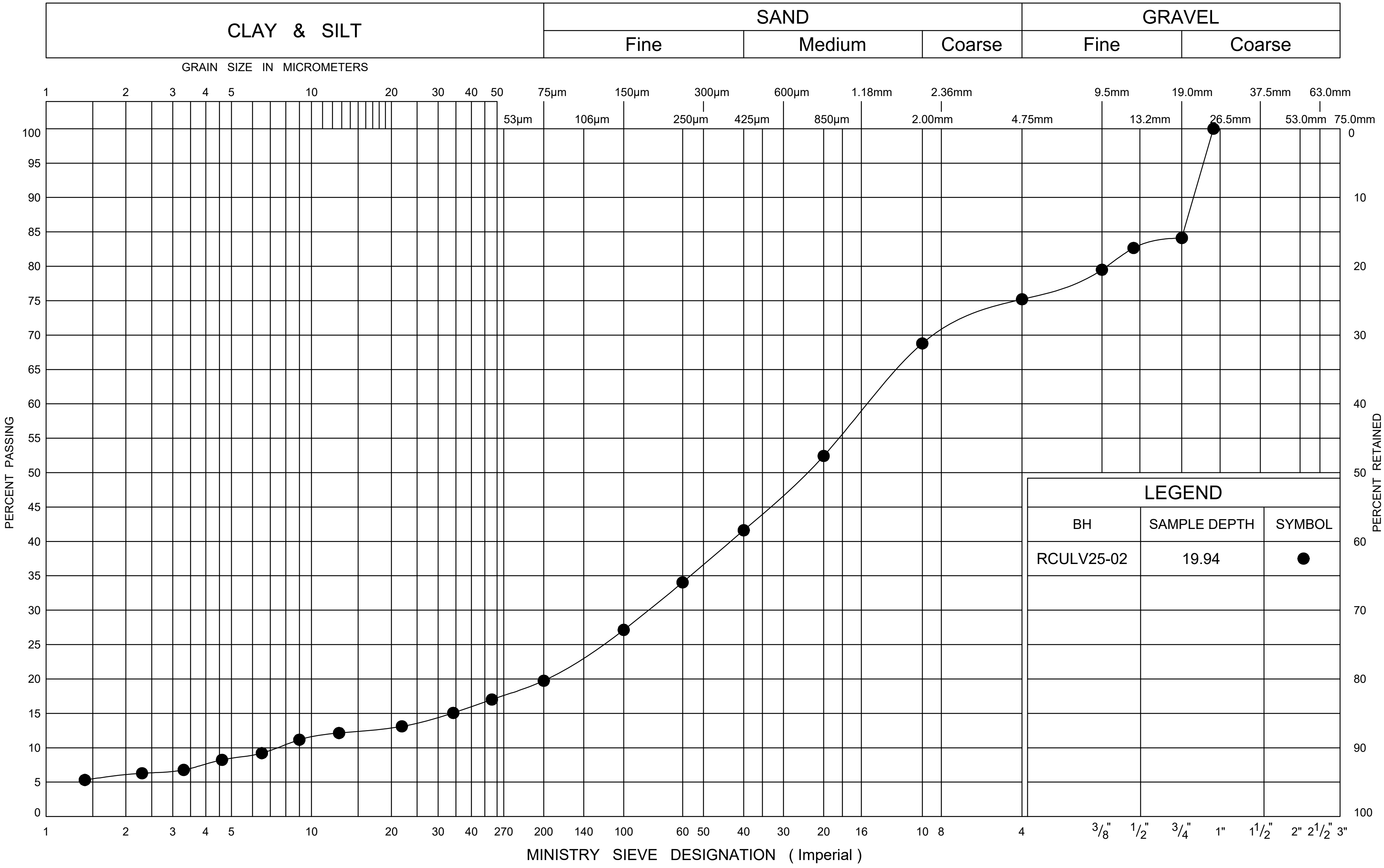
FIG No E14

W.P.

Bradford Bypass

ONTARIO MOT PLASTICITY CHART 2 MTO-48856.GPJ ONTARIO MOT.GDT 10/20/25

78 12 M



Ministry of
Transportation
Ontario

GRAIN SIZE DISTRIBUTION

Silty SAND with Gravel

FIG No E15

W.P.

Bradford Bypass

ONTARIO MOT GRAIN SIZE 3 MTO-48856.GPJ ONTARIO MOT.GDT 10/20/25

FINAL REPORT

CA40115-AUG25 R1

48858, Bradford Bypass West Contract

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS

Client	Thurber Engineering Ltd.
Address	1908 Ironoak Way, Suite 202 Oakville, ON L6H 0N1. Canada
Contact	Joshua Alexander
Telephone	613-606-7303
Facsimile	
Email	jalexander@thurber.ca
Project	48858, Bradford Bypass West Contract
Order Number	
Samples	Soil (3)

LABORATORY DETAILS

Project Specialist	Jill Campbell, B.Sc.,GISAS
Laboratory	SGS Canada Inc.
Address	185 Concession St., Lakefield ON, K0L 2H0
Telephone	2165
Facsimile	705-652-6365
Email	jill.campbell@sgs.com
SGS Reference	CA40115-AUG25
Received	08/12/2025
Approved	08/19/2025
Report Number	CA40115-AUG25 R1
Date Reported	08/19/2025

COMMENTS

Temperature of Sample upon Receipt: 8 degrees C

Cooling Agent Present:yes

Custody Seal Present:yes

Chain of Custody Number:1

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105.   An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Jill Campbell, B.Sc.,GISAS

Jill Campbell

TABLE OF CONTENTS

MATRIX: SOIL

			Sample Number	5	6	7
			Sample Name	PEN25-02 SS5	PEN25-05 SS3	RCULV25-02 SS3
			Sample Matrix	Soil	Soil	Soil
			Sample Date	25/07/2025	21/07/2025	31/07/2025
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**
Corrosivity Index						
Corrosivity Index	none	1		14	13	4
pH	pH Units	0.05		8.91	9.59	8.78
Soil Redox Potential	mV	no		279	230	279
Sulphide (Na2CO3)	%	0.01		< 0.01	< 0.01	< 0.01
Resistivity (calculated)	ohms.cm	-9999		778	543	10200
General Chemistry						
Conductivity	uS/cm	2		1280	1840	98
Metals and Inorganics						
Sulphate	µg/g	0.4		31	35	3.8
Other (ORP)						
Chloride	µg/g	0.4		510	1000	4.5

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 I Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0259-AUG25	µg/g	0.4	<0.4	4	35	101	80	120	104	75	125
Sulphate	DIO0259-AUG25	µg/g	0.4	<0.4	10	35	100	80	120	105	75	125

Carbon/Sulphur

Method: ASTM E1915-07A I Internal ref.: ME-CA-[ENV]ARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0043-AUG25	%	0.01	< 0.01								

Conductivity

Method: SM 2510 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0325-AUG25	uS/cm	2	< 2	1	20	99	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0325-AUG25	pH Units	0.05	NA	0		100			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS	Insufficient sample for analysis.
RL	Reporting Limit.
↑	Reporting limit raised.
↓	Reporting limit lowered.
NA	The sample was not analysed for this analyte
ND	Non Detect

Results relate only to the sample tested.

Data reported represent the sample as submitted to SGS. Solid samples expressed on a dry weight basis.

"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act and Excess Soil Quality" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

This report supersedes all previous versions.

-- End of Analytical Report --

SGS Environment, Health & Safety
- Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Fax: 705-652-6365 Web: www.sgs.com/environment
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

Request for Laboratory Services and CHAIN OF CUSTODY

No: 1
Page 1 of 2

Laboratory Information Section / Lab use only

Received By: Mageed Alm
Received Date: AUG 1 2 2025 (mm/dd/yy)
Received Time: ____ : ____ (hr : min)
Received By (signature): Mageed Alm
Custody Seal Present: Yes ☑ No ☐
Custody Seal Intact: Yes ☑ No ☐
Cooling Agent Present: Yes ☑ No ☐ Type: ______
Temperature Upon Receipt (°C) ____, 8, 0
LAB LIMS #: ______

CA 40115 AUG25 UA

REPORT INFORMATION	INVOICE INFORMATION
Company: Thurber Engineering Ltd.	☑ (same as Report Information)
Contact: Joshua Alexander	Company:
Address: 202 - 1908 Ironoak Way, Oakville, ON L6H 7G4	Contact:
	Address:
Phone: 613-606-7303	Phone:
Fax:	
Email: jalexander@thurber.ca	Email: accountingON@thurber.ca

Quotation #: ______
P.O. #: 48856
Project #: 48856
Site Location/ID: Bradford Bypass West Contract

TURNAROUND TIME (TAT) REQUIRED

☑ Regular TAT (5-7days)

TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 6pm or on weekends: TAT begins next business day

RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: ______

NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

REGULATIONS

Regulation 153/04:
☐ Table 1 ☐ Res/Park Soil Texture:
☐ Table 2 ☐ Ind/Com ☐ Coarse
☐ Table 3 ☐ Agri/Other ☐ Medium/Fine
☐ Table ____

Other Regulations:
☐ Reg 347/558 (3 Day min TAT)
☐ PWQO ☐ MMER
☐ CCME ☐ Other:
☐ MISA

Sewer By-Law:
☐ Sanitary
☐ Storm
Municipality: ______

RECORD OF SITE CONDITION (RSC) ☐ YES ☑ NO

ANALYSIS REQUESTED

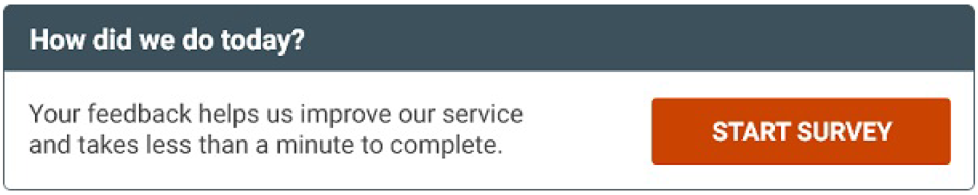
						M & I				SVOC		PCB	PHC		VOC		Pest	Other (please specify)							TCLP	
	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Field Filtered (Y/N)	**Metals & Inorganics** incl CrVI, CN,Hg pH,(B(HWS),EC,SAR-soil) (Cl, Na-water)	**Full Metals Suite** ICP metals plus B(HWS-soil only) Hg, CrVI	**ICP Metals only** Sb,As,Ba,Be,B,Cd,Cr,Co,Cu,Pb,Mo,Ni, Se,Ag,Tl,U,V,Zn	**PAHs**	**SVOCs** all incl PAHs, ABNs, CPs	**PCBs** Total ☑ Aroclor ☐	**F1-F4 + BTEX**	**F1-F4 only** no BTEX	**VOCs** all incl BTEX	**BTEX only**	**Pesticides** Organochlorine or specify other	Corrosivity Suite	1,4-dioxane	Dioxins and furans	PHC F1		**Sewer Use:** Specify pkg:	**Water Characterization Pkg** General ☐ Extended ☐	Specify TCLP tests ☐M&I ☐VOC ☐PCB ☐B(a)P ☐ABN ☐Ignit.	COMMENTS:
1	PEN25-02 SS5	Jul 25, 2025	-	1	soil													✓								
2	PEN25-05 SS3	Jul 21, 2025	-	1	soil													✓								
3	RCULV25-02 SS3	Jul 31, 2025	-	1	soil													✓								
4																										
5																										
6																										
7																										
8																										
9																										
10																										
11																										
12																										

Observations/Comments/Special Instructions

Sampled By (NAME): Smit Patel Signature: Smit Pa Date: 05 /08 /25 (mm/dd/yy) Pink Copy - Client
Relinquished by (NAME): Joshua Alexander Signature: Date: ____ /____ /____ (mm/dd/yy) Yellow & White Copy - SGS

Revision #: 1.3
Date of Issue: 13 Oct, 2019

Note: Submission of samples to SGS is acknowledgement that you have been provided direction on sample collection/handling and transportation of samples. {2} Submission of samples to SGS is considered authorization for completion of work. Signatures may appear on this form or be retained on file in the contract, or in an alternative format (e.g. shipping documents). {3} Results may be sent by email to an unlimited number of addresses for no additional cost. Fax is available upon request. This document is issued by the Company under its General Conditions of Service accessible at http://www.sgs.com/terms_and_conditions.htm. (Printed copies are available upon request.) Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.



FINAL REPORT

CA40201-OCT25 R1

48856, Bradford Bypass West Contract

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS

Client	Thurber Engineering Ltd.
Address	1908 Ironoak Way, Suite 202 Oakville, ON L6H 0N1. Canada
Contact	Joshua Alexander
Telephone	613-606-7303
Facsimile	
Email	jalexander@thurber.ca; ldinh@thurber.ca
Works #	
Project	48856, Bradford Bypass West Contract
Reference	
Batch	
Samples	SOIL (1)

LABORATORY DETAILS

Project Specialist	Brad Moore Hon. B.Sc
Laboratory	SGS Canada Inc.
Address	185 Concession St., Lakefield ON, K0L 2H0
Telephone	705-652-2143
Facsimile	705-652-6365
Email	brad.moore@sgs.com
SGS Reference	CA40201-OCT25
Received	2025-10-22
Approved	10/30/2025
Report Number	CA40201-OCT25 R1
Date Reported	10/30/2025

COMMENTS

Temperature of Sample upon Receipt: 9 degrees C

Cooling Agent Present:Yes

Custody Seal Present:Yes

Chain of Custody Number:N/A

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Brad Moore Hon. B.Sc

TABLE OF CONTENTS

MATRIX: SOIL

Sample Number 5
Sample Name 9CULV-02 SS5
Sample Matrix Soil
Sample Date 2025-10-27 00:00

Parameter	Units	RL		Result
Corrosivity Index				
Corrosivity Index	none	1		1
pH	pH Units	0.05		8.25
Soil Redox Potential	mV	no		276
Sulphide (Na2CO3)	%	0.01		< 0.01
Resistivity (calculated)	ohms.cm	-9999		4050
General Chemistry				
Conductivity	uS/cm	2		247
Metals and Inorganics				
Sulphate	μg/g	0.4		94
Other (ORP)				
Chloride	μg/g	0.4		60

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0663-OCT25	µg/g	0.4	<0.4	5	35	105	80	120	106	75	125
Sulphate	DIO0663-OCT25	µg/g	0.4	<0.4	10	35	103	80	120	100	75	125

Carbon/Sulphur

Method: ASTM E1915-07A | Internal ref.: ME-CA-[ENV]ARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0102-OCT25	%	0.01	< 0.01								

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0708-OCT25	uS/cm	2	< 2	1	20	98	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0708-OCT25	pH Units	0.05	NA	0		100			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

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RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

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Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS	Insufficient sample for analysis.
RL	Reporting Limit.
↑	Reporting limit raised.
↓	Reporting limit lowered.
NA	The sample was not analysed for this analyte
ND	Non Detect

Results relate only to the sample tested.

Data reported represent the sample as submitted to SGS.

Reproduction of this analytical report in full or in part is prohibited.

Please refer to SGS General Conditions of Services located at http://www.sgs.com/terms_and_conditions.htm (Printed copies are available upon request.)

Test method information available upon request.

"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

-- End of Analytical Report --

SGS Environment, Health & Safety - Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Fax: 705-652-6365 Web: www.sgs.com/environment
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

Request for Laboratory Services and CHAIN OF CUSTODY

No: 1

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: ED
Received Date: 10 22 25 (mm/dd/yy)
Received Time: 1035 (hr : min)

Received By (signature):
Custody Seal Present: Yes ☑ No ☐
Custody Seal Intact: Yes ☑ No ☐

Cooling Agent Present: Yes ☑ No ☐ Type: Ice
Temperature Upon Receipt (°C) 9X3

LAB LIMS #: CA40201Oct25

REPORT INFORMATION

Company: Thurber Engineering Ltd.
Contact: Joshua Alexander
Address: 202 - 1908 Ironoak Way,
Oakville, ON L6H 7G4
Phone: 613-606-7303
Fax:
Email: jalexander@thurber.ca

INVOICE INFORMATION

☑ (same as Report Information)
Company:
Contact:
Address:
Phone:
Email: accountingON@thurber.ca

Quotation #:
P.O. #: 48856
Project #: 48856
Site Location/ID: Bradford Bypass West Contract

TURNAROUND TIME (TAT) REQUIRED

☑ Regular TAT (5-7days)

TAT's are quoted in business days (exclude statutory holidays & weekends).
Samples received after 6pm or on weekends: TAT begins next business day

RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date:

NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

REGULATIONS

Regulation 153/04:
☐ Table 1 ☐ Res/Park Soil Texture:
☐ Table 2 ☐ Ind/Com ☐ Coarse
☐ Table 3 ☐ Agri/Other ☐ Medium/Fine
☐ Table ____

Other Regulations:
☐ Reg 347/558 (3 Day min TAT)
☐ PWQO ☐ MMER
☐ CCME ☐ Other:
☐ MISA

Sewer By-Law:
☐ Sanitary
☐ Storm
Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☑ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX
1	9CULV-02 SS4	11/29/25	-	1	soil
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

	M & I	M & I	M & I	M & I	SVOC	SVOC	PCB	PHC	PHC	VOC	VOC	Pest	Other (please specify)	Other (please specify)	Other (please specify)	Other (please specify)	Other (please specify)	Other (please specify)	Other (please specify)	TCLP	
	Field Filtered (Y/N)	Metals & Inorganics incl CrVI, CN,Hg pH,(B(HWS),EC,SAR–soil) (Cl, Na-water)	Full Metals Suite ICP metals plus B(HWS-soil only) Hg, CrVI	ICP Metals only Sb,As,Ba,Be,B,Cd,Cr,Co,Cu,Pb,Mo,Ni, Se,Ag,Tl,U,V,Zn	PAHs	SVOCs all incl PAHs, ABNs, CPs	PCBs Total ☑ Aroclor ☐	F1-F4 + BTEX	F1-F4 only no BTEX	VOCs all incl BTEX	BTEX only	Pesticides Organochlorine or specify other	Corrosivity Suite	1,4-dioxane	Dioxins and furans	PHC F1		Sewer Use: Specify pkg:	Water Characterization Pkg General ☐ Extended ☐	Specify TCLP tests ☐M&I ☐VOC ☐PCB ☐B(a)P ☐ABN ☐Ignit.	COMMENTS:
1	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	✓	☐	☐	☐	☐	☐	☐	☐	
2	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
3	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
4	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
5	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
6	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
7	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
8	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
9	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
10	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
11	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
12	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Observations/Comments/Special Instructions
Pickup from Thurber - Oakville

Sampled By (NAME): Signature: Date: ___/___/___ (mm/dd/yy)
Relinquished by (NAME): Joshua Alexander Signature: Date: 10 / 21 / 2025 (mm/dd/yy)

Pink Copy - Client
Yellow & White Copy - SGS

Revision #: 1.3
Date of Issue: 13 Oct, 2019

Note: Submission of samples to SGS is acknowledgement that you have been provided direction on sample collection/handling and transportation of samples. {2} Submission of samples to SGS is considered authorization for completion of work. Signatures may appear on this form or be retained on file in the contract, or in an alternative format (e.g. shipping documents). {3} Results may be sent by email to an unlimited number of addresses for no additional cost. Fax is available upon request. This document is issued by the Company under its General Conditions of Service accessible at http://www.sgs.com/terms_and_conditions.htm. (Printed copies are available upon request.) Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.

SGS Environment, Health & Safety - Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Fax: 705-652-6365 Web: www.sgs.com/environment
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

Request for Laboratory Services and CHAIN OF CUSTODY

No: 1

Page 1 of 1

Laboratory Information Section - Lab use only

Received By:

Received Date: 10 / 27 / 25 (mm/dd/yy)

Received Time: 11 : 30 (hr : min)

Received By (signature):

Custody Seal Present: Yes ☐ No ☐

Custody Seal Intact: Yes ☐ No ☐

Cooling Agent Present: Yes ☐ No ☐ Type: NA

Temperature Upon Receipt (°C) N/A

LAB LIMS #: CA40201 oct25

REPORT INFORMATION

Company: Thurber Engineering Ltd.

Contact: Joshua Alexander

Address: 202 - 1908 Ironoak Way,
Oakville, ON L6H 7G4

Phone: 613-606-7303

Fax:

Email: jalexander@thurber.ca

INVOICE INFORMATION

☑ (same as Report Information)

Company:

Contact:

Address:

Phone:

Email: accountingON@thurber.ca

Quotation #:

P.O. #: 48856

Project #: 48856

Site Location/ID: Bradford Bypass West Contract

TURNAROUND TIME (TAT) REQUIRED

☑ Regular TAT (5-7days)

TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 6pm or on weekends: TAT begins next business day

RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date:

NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

REGULATIONS

Regulation 153/04:
☐ Table 1 ☐ Res/Park
☐ Table 2 ☐ Ind/Com
☐ Table 3 ☐ Agri/Other
☐ Table ____

Soil Texture:
☐ Coarse
☐ Medium/Fine

Other Regulations:
☐ Reg 347/558 (3 Day min TAT)
☐ PWQO ☐ MMER
☐ CCME ☐ Other:
☐ MISA

Sewer By-Law:
☐ Sanitary
☐ Storm
Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☑ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	**DATE SAMPLED**	**TIME SAMPLED**	**# OF BOTTLES**	**MATRIX**	Field Filtered (Y/N)	M & I: **Metals & Inorganics** incl CrVI, CN,Hg pH,(B(HWS),EC,SAR–soil) (Cl, Na-water)	M & I: **Full Metals Suite** ICP metals plus B(HWS-soil only) Hg, CrVI	M & I: **ICP Metals only** Sb,As,Ba,Be,B,Cd,Cr,Co,Cu,Pb,Mo,Ni, Se,Ag,Tl,U,V,Zn	SVOC: **PAHs**	SVOC: **SVOCs** all incl PAHs, ABNs, CPs	PCB: **PCBs** Total ☑ Aroclor ☐	PHC: **F1-F4 + BTEX**	PHC: **F1-F4 only** no BTEX	VOC: **VOCs** all incl BTEX	VOC: **BTEX only**	Pest: **Pesticides** Organochlorine or specify other	Other (please specify): Corrosivity Suite	Other: 1,4-dioxane	Other: Dioxins and furans	Other: PHC F1	Other:	**Sewer Use:** Specify pkg:	**Water Characterization Pkg** General ☐ Extended ☐	TCLP: Specify TCLP tests ☐M&I ☐VOC ☐PCB ☐B(a)P ☐ABN ☐Ignit.	**COMMENTS:**
1	9CULV-02 SS5	11/29/25	-	1	soil													✓								
2																										
3																										
4																										
5																										
6																										
7																										
8																										
9																										
10																										
11																										
12																										

Observations/Comments/Special Instructions: Pickup from Thurber - Oakville

Sampled By (NAME): Signature: Date: ___ / ___ / ___ (mm/dd/yy) Pink Copy - Client

Relinquished by (NAME): Joshua Alexander Signature: Date: 10 / 27 / 2025 (mm/dd/yy) Yellow & White Copy - SGS

Revision #: 1.3
Date of Issue: 13 Oct, 2019

Note: Submission of samples to SGS is acknowledgement that you have been provided direction on sample collection/handling and transportation of samples. {2} Submission of samples to SGS is considered authorization for completion of work. Signatures may appear on this form or be retained on file in the contract, or in an alternative format (e.g. shipping documents). {3} Results may be sent by email to an unlimited number of addresses for no additional cost. Fax is available upon request. This document is issued by the Company under its General Conditions of Service accessible at http://www.sgs.com/terms_and_conditions.htm. (Printed copies are available upon request.) Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.

THURBER

APPENDIX F

General Arrangement (GA) Drawings

Ontario Ministry of Transportation

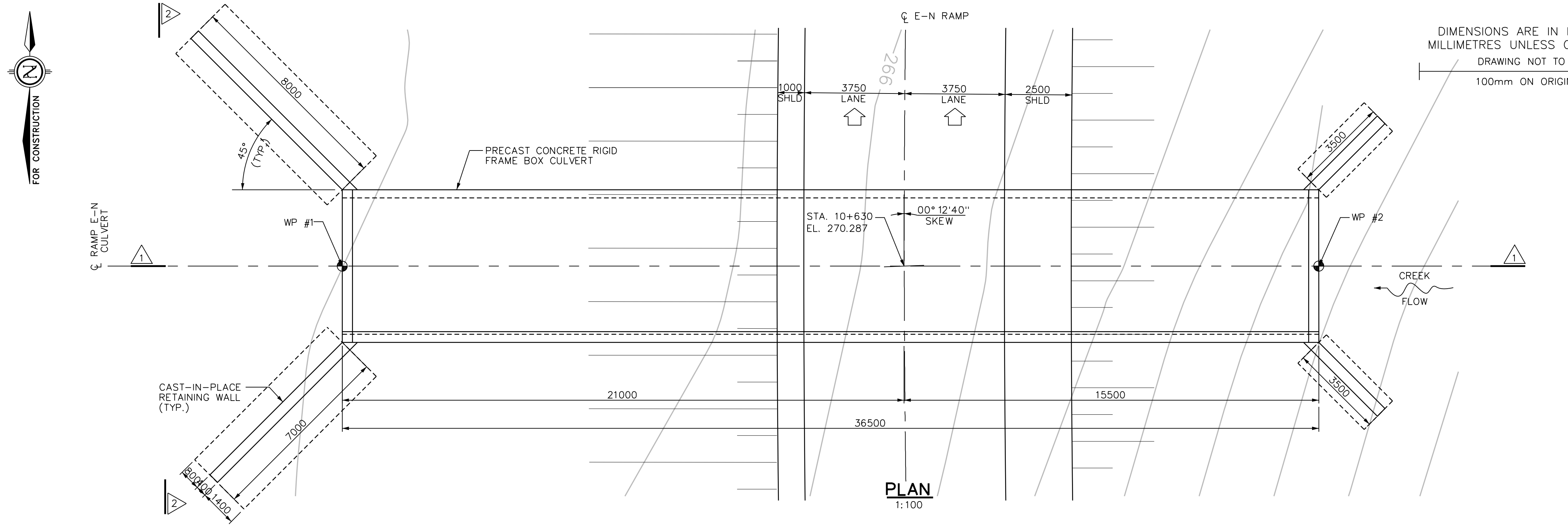
CONT 2026-2005
WP 2026-23-00

BRADFORD BYPASS
HWY 400/BBP E-N RAMP CULVERT
GENERAL ARRANGEMENT

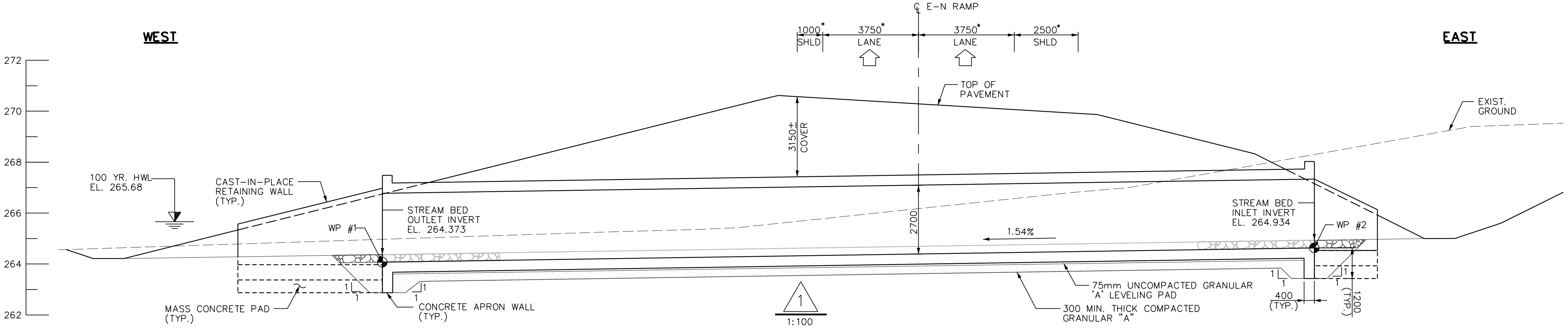
SHEET 1211

AECOM

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING



PLAN
1:100

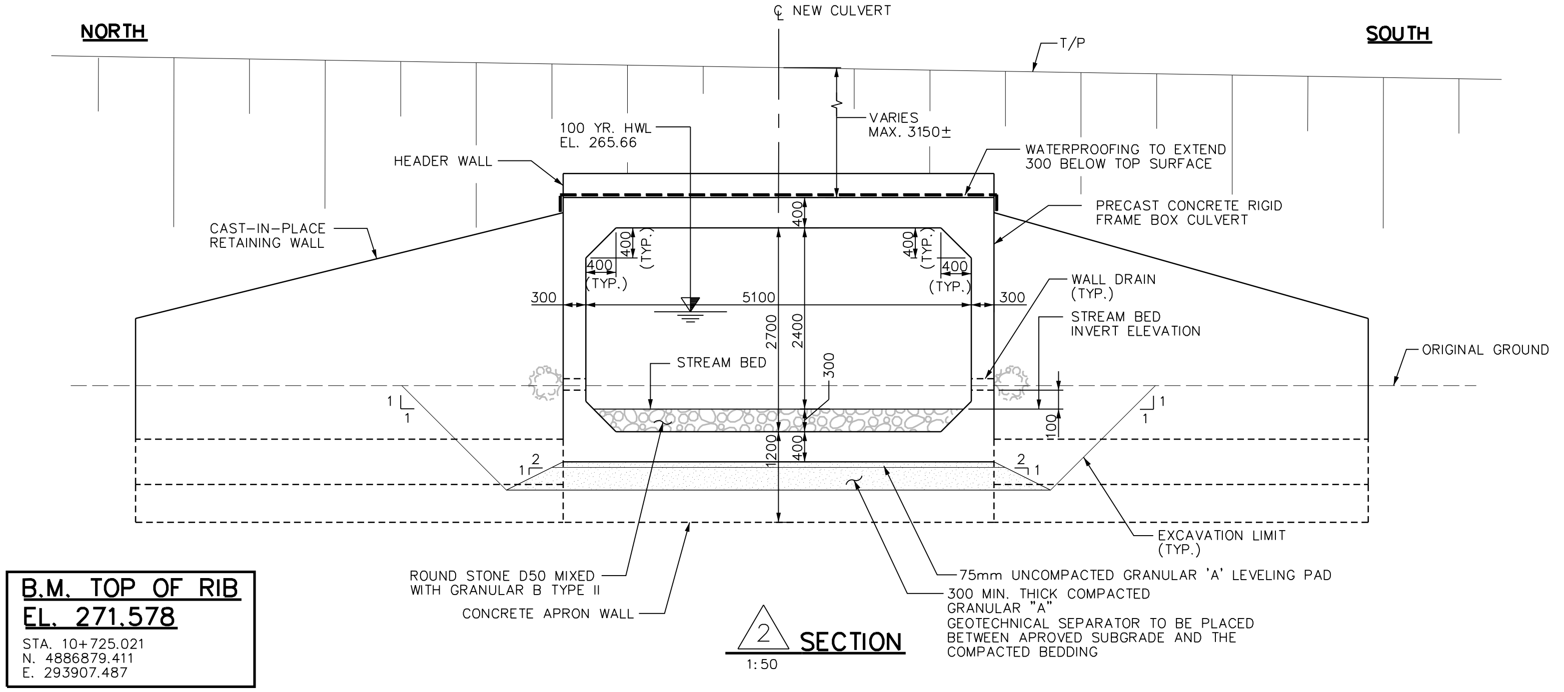


1
1:100

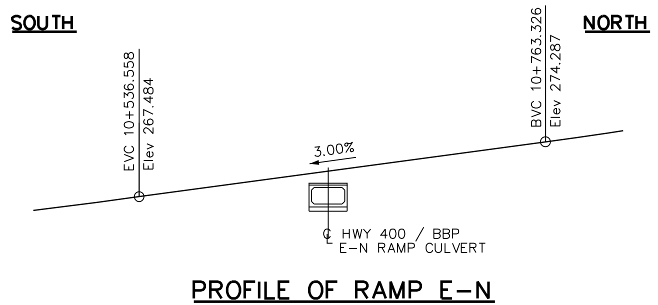
NOTE: * DENOTES DIMENSIONS MEASURED PERPENDICULAR TO ℄ E-N RAMP

	NORTHING	EASTING	ELEVATION
WP #1	4886901.321	294080.674	264.073
WP #2	4886929.175	294104.262	264.634

NOTE: ELEVATION OF WP PROVIDED TO TOP OF CONCRETE FLOOR SLAB.



2 SECTION
1:50



PROFILE OF RAMP E-N
N.T.S.

B.M. TOP OF RIB
EL. 271.578
STA. 10+725.021
N. 4886879.411
E. 293907.487

GENERAL NOTES:

CONCRETE:

SPECIFIED 28-DAY COMPRESSIVE STRENGTH:
PRECAST CONCRETE...45 MPa
CAST-IN-PLACE CONCRETE....................................30 MPa
MASS CONCRETE...20 MPa
UNLESS NOTED OTHERWISE

CLEAR COVER:

FOOTING..100 ± 25
PRECAST CONCRETE...50 ± 10
REMAINDER...70 ± 20
UNLESS NOTED OTHERWISE

REINFORCING STEEL:

1. REINFORCING STEEL SHALL BE GRADE 500W UNLESS OTHERWISE SPECIFIED.
2. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL CLASS B.
3. BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
4. STAINLESS REINFORCING STEEL BARS SHALL BE TYPE 316LN OF DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPa, UNLESS OTHERWISE SPECIFIED.
5. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS112-1 UNLESS INDICATED OTHERWISE.

CONSTRUCTION NOTES:

1. DEWATERING SYSTEM SHALL BE PROVIDED BY CONTRACTOR TO MAINTAIN THE EXCAVATION DRY AND TO ENSURE STABILITY OF THE EXCAVATION BASE DURING ALL EXCAVATIONS, INSPECTIONS AND PLACING OF CONCRETE CULVERT. THE PERCHED GROUNDWATER LEVEL SHALL BE LOWERED TO A MINIMUM 1M BELOW THE BASE OF THE EXCAVATION.
2. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH SIDES OF CULVERT KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.
3. THE CONTRACTOR SHALL ENSURE THE STABILITY OF THE PRECAST SEGMENTS DURING CONSTRUCTION.

SUBGRADE DESIGN DATA FOR CULVERT

FACTORED GEOTECHNICAL RESISTANCE AT SLS: 120 kPa
FACTORED GEOTECHNICAL RESISTANCE AT ULS: 240 kPa

LIST OF DRAWINGS:

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATION AND SOIL STRATA
3. PRECAST RIGID FRAME BOX CULVERT
4. RETAINING WALLS DETAILS
5. MISCELLANEOUS DETAILS

LIST OF ABBREVIATIONS:

EL.	DENOTES ELEVATION	STA.	DENOTES STATION
HWY	DENOTES HIGHWAY	T/P	DENOTES TOP OF PAVEMENT
MIN.	DENOTES MINIMUM	TYP.	DENOTES TYPICAL
MAX.	DENOTES MAXIMUM	HWL	DENOTES HIGH WATER LEVEL
SHLD	DENOTES SHOULDER	WP	DENOTES WORKING POINT

APPLICABLE STANDARD DRAWINGS:

OPSD 803.010	BACKFILL AND COVER FOR CONCRETE CULVERTS
OPSD 810.010	GENERAL RIP-RAP LAYOUT FOR SEWER AND CULVERT OULETS
OPSD 3910.100	WALLS, RETAINING WALL AND ABUTMENT WALL DRAIN
OPSD 3370.100	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE WITH PROTECTION BOARD
OPSD 3370.101	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE AT ACTIVE CRACKS GREATER THAN 2mm WIDE AND CONSTRUCTION JOINTS
OPSD 3941.200	FIGURES IN CONCRETE SITE NUMBER AND DATE LAYOUT
OPSD 3950.100	JOINTS, CONCRETE EXPANSION AND CONSTRUCTION ONSTRUCTURE

REVISIONS	DATE	BY	DESCRIPTION

DESIGN K.S.	CHK P.O.	CODE CSA S6-19	LOAD CL 625-ONT	DATE JAN. 2026
DRAWN T.K.	CHK K.S.	SITE 30X-0876/C0		DWG 1

MINISTRY OF TRANSPORTATION, ONTARIO ANSI-D 2017-08

CADD FILE NAME : C:\Users\typhoon.kim\OneDrive - AECOM\Desktop\KATE\30X-0876\01_30X-0876 Culvert_GA.dgn

MINISTRY OF TRANSPORTATION, ONTARIO ANSI-D 2017-08

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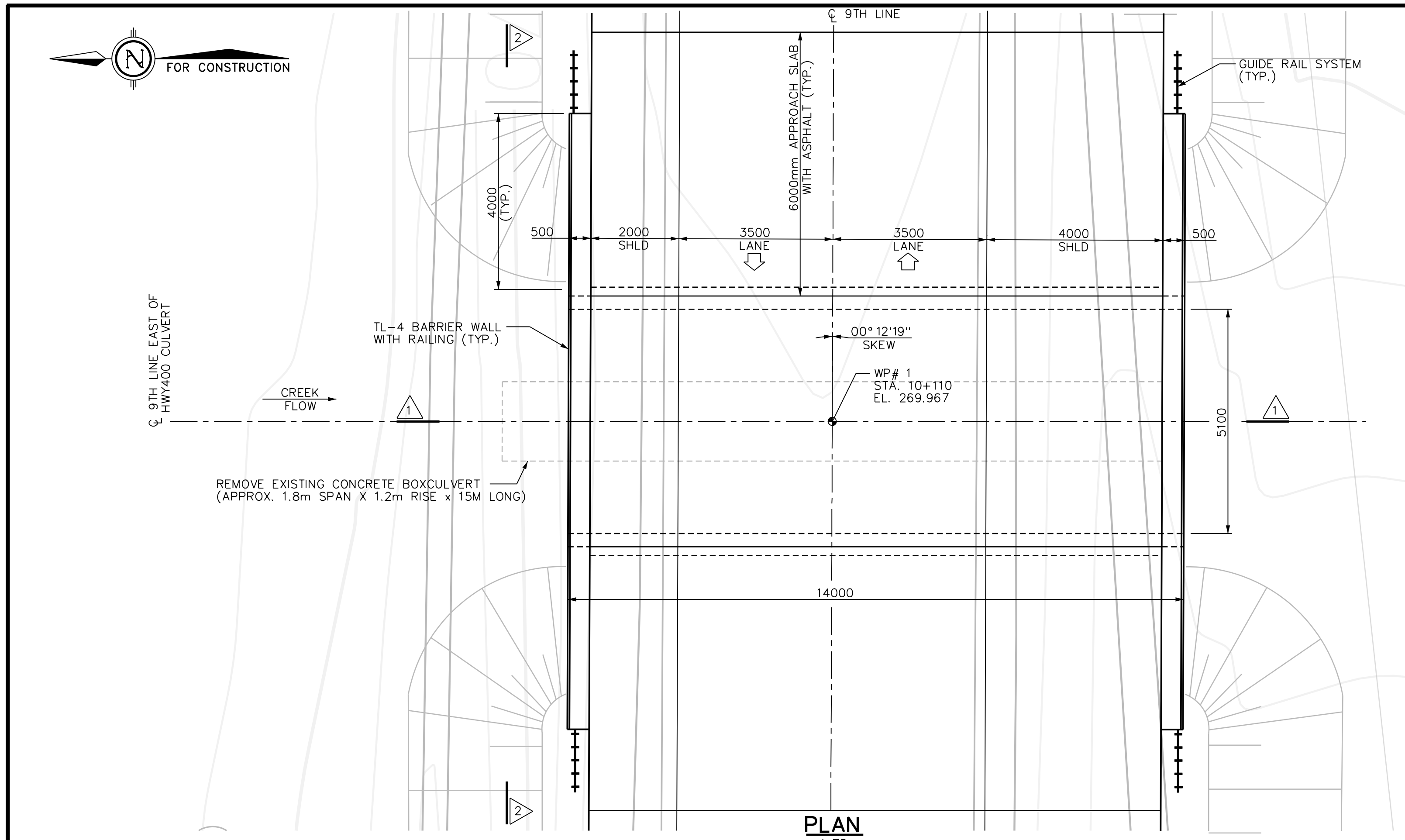
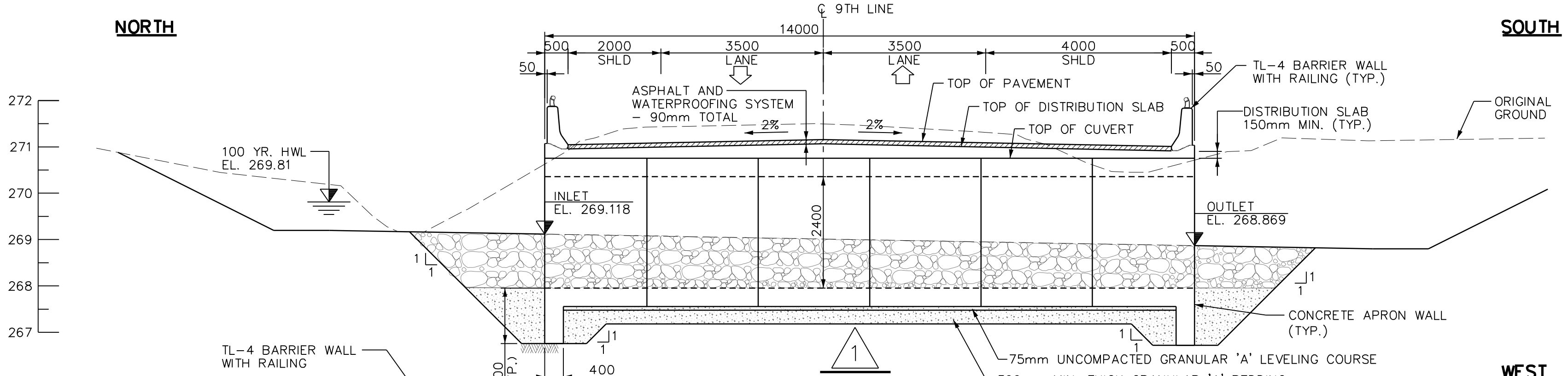
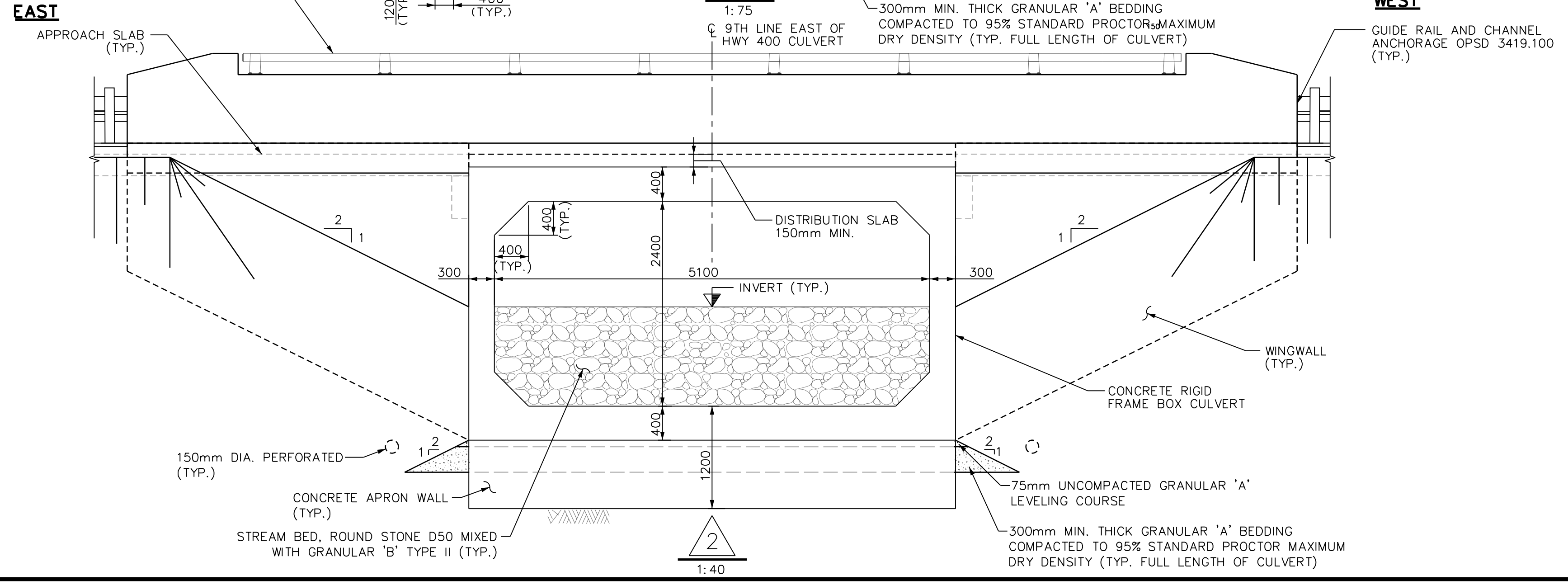


PLAN
1:75





DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

Ontario Ministry of Transportation
CONT 2026-2005
WP 2026-23-00
BRADFORD BYPASS
9TH LINE EAST OF HWY 400
CULVERT
GENERAL ARRANGEMENT
SHEET
1216
AECOM

GENERAL NOTES:

CONCRETE:

SPECIFIED 28-DAY COMPRESSIVE STRENGTH:
PRECAST CONCRETE..45 MPa
CAST-IN-PLACE CONCRETE.....................................30 MPa
UNLESS NOTED OTHERWISE

CLEAR COVER:

PRECAST CONCRETE	50 ± 10
REMAINDER	70 ± 20

UNLESS NOTED OTHERWISE

REINFORCING STEEL:

1. REINFORCING STEEL SHALL BE GRADE 500W UNLESS OTHERWISE SPECIFIED.
2. UNLESS SHOWN OTHERWISE, TENSION LAP SPLICES FOR REINFORCING STEEL BARS SHALL CLASS B.
3. BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
4. STAINLESS REINFORCING STEEL BARS SHALL BE TYPE 316LN OF DUPLEX 2205 AND HAVE A MINIMUM YIELD STRENGTH OF 500 MPa, UNLESS OTHERWISE SPECIFIED.
5. BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS112-1 UNLESS INDICATED OTHERWISE.

CONSTRUCTION NOTES:

1. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH SIDES OF CULVERT KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500 mm.
2. EXISTING CULVERT SHALL BE REMOVED AFTER THE FLOW HAS BEEN TEMPORARILY DIVERTED.
3. THE CONTRACTOR SHALL ENSURE THE STABILITY OF THE PRECAST SEGMENTS DURING CONSTRUCTION.

SUBGRADE DESIGN DATA FOR CULVERT

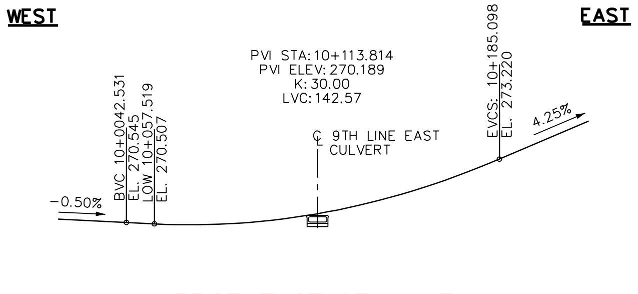
FACTORED GEOTECHNICAL RESISTANCE AT SLS: 120 kPa
FACTORED GEOTECHNICAL RESISTANCE AT ULS: 240 kPa

LIST OF DRAWINGS:

1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATION
3. SOIL STRATA
4. PRECAST BOX CULVERT
5. WINGWALLS
6. CULVERT DETAILS
7. BARRIER WALL
8. RAILING
9. APPROACH SLAB
10. MISCELLANEOUS DETAILS

LIST OF ABBREVIATIONS:

EL.	DENOTES ELEVATION
HWY	DENOTES HIGHWAY
MIN.	DENOTES MINIMUM
SHLD	DENOTES SHOULDER
STA.	DENOTES STATION
T/P	DENOTES TOP OF PAVEMENT
TYP.	DENOTES TYPICAL
WP	DENOTES WORKING POINT



PROFILE OF 9TH LINE
N.T.S.

	NORTHING	EASTING	ELEVATION
WP #1	4887158.066	293951.682	267.807

NOTE: ELEVATION OF WP PROVIDED TO TOP OF CONCRETE FLOOR SLAB.

APPLICABLE STANDARD DRAWINGS:

OPSD 803.010	BACKFILL AND COVER FOR CONCRETE CULVERTS
OPSD 3370.100	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE WITH PROTECTION BOARD
OPSD 3370.101	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE AT ACTIVE CRACKS GREATER THAN 2mm WIDE AND CONSTRUCTION JOINTS
OPSD 3941.200	FIGURES IN CONCRETE SITE NUMBER AND DATE LAYOUT
OPSD 3950.100	JOINTS, CONCRETE EXPANSION AND CONSTRUCTION ON STRUCTURE

REVISIONS	DATE	BY	DESCRIPTION

DESIGN K.S.	CHK P.O.	CODE CSA S6-25	LOAD CL 625-ONT	DATE JAN. 2026
DRAWN T.K.	CHK K.S.	SITE 30X-0877/C0		DWG 1

APPENDIX G

Seismic Hazard Values (2020 National Building Code of Canada)

Government of Canada Gouvernement du Canada

Canada.ca > Natural Resources Canada > Earthquakes Canada

2020 National Building Code of Canada Seismic Hazard Tool

This application provides seismic values for the design of buildings in Canada under Part 4 of the National Building Code of Canada (NBC) 2020 as prescribed in Article 1.1.3.1. of Division B of the NBC 2020.

Seismic Hazard Values

User requested values

Code edition	NBC 2020
Site designation X_S	X_C
Latitude (°)	44.124
Longitude (°)	-79.638

Please select one of the tabs below.

NBC 2020 | Additional Values | Plots | API | Background Information

The 5%-damped spectral acceleration ($S_a(T,X)$, where T is the period, in s, and X is the site designation) and peak ground acceleration (PGA(X)) values are given in units of acceleration due to gravity (g, 9.81 m/s^2). Peak ground velocity (PGV(X)) values are given in m/s. Probability is expressed in terms of percent exceedance in 50 years. Further information on the calculation of seismic hazard is provided under the *Background Information* tab.

The 2%-in-50-year seismic hazard values are provided in accordance with Article 4.1.8.4. of the NBC 2020. The 5%- and 10%-in-50-year values are provided for additional performance checks in accordance with Article 4.1.8.23. of the NBC 2020.

See the *Additional Values* tab for additional seismic hazard values, including values for other site designations, periods, and probabilities not defined in the NBC 2020.

NBC 2020 - 2%/50 years (0.000404 per annum) probability

$S_a(0.2, X_C)$	$S_a(0.5, X_C)$	$S_a(1.0, X_C)$	$S_a(2.0, X_C)$	$S_a(5.0, X_C)$	$S_a(10.0, X_C)$	$PGA(X_C)$	$PGV(X_C)$
0.22	0.154	0.0875	0.0424	0.0114	0.00397	0.102	0.0993

The log-log interpolated 2%/50 year $S_a(4.0, X_C)$ value is : **0.0157**

▶ Tables for 5% and 10% in 50 year values

Download CSV

← Go back to the seismic hazard calculator form

Date modified: 2021-04-06

APPENDIX H

Comparison of Foundation Alternatives

COMPARISON OF ALTERNATIVE CULVERT TYPES

Concrete Box Culvert	Concrete Open Frame Culvert on Strip Footing	Steel Pipe Culvert
Advantages: i. Relatively rapid installation and less disturbance to subgrade soils ii. Segmental option can accommodate limited amount of potential differential settlement along culvert axis. iii. Less requirement for soil geotechnical resistances as loading is spread over a larger width. iv. Can accommodate differential settlement. v. Shallower depth of excavation compared to open footing culvert. ***Disadvantages:*** i. Culvert subgrade preparation and bedding placement must be carried out in the dry. ii. Dewatering is required. iii. Requires subexcavation of soft or organic materials if encountered. iv. Temporary protection systems will be required.	***Advantages:*** i. Conventional construction. ii. Eliminates bedding requirement. iii. May have less environmental issues such as those involving spawning fish species. ***Disadvantages:*** i. Requires deeper excavation below the groundwater level. ii. Potentially longer and more extensive dewatering requirements. iii. Limited tolerance of differential settlement. iv. Temporary protection systems will be required.	***Advantages:*** i. May be installed using trenchless methods. ii. Steel pipes are likely to be more cost effective than concrete box or open footing culverts. iii. May require less co-ordination with staged construction. ***Disadvantages:*** i. Multiple pipes may be needed to meet hydraulic and hydrologic requirements. ii. Culvert subgrade preparation and bedding placement must be carried out in the dry. iii. Dewatering is required. iv. Requires subexcavation of soft or organic material if encountered. v. Temporary protection systems will be required.
RECOMMENDED	**NOT RECOMMENDED**	**NOT RECOMMENDED**

APPENDIX I

Stability Figures

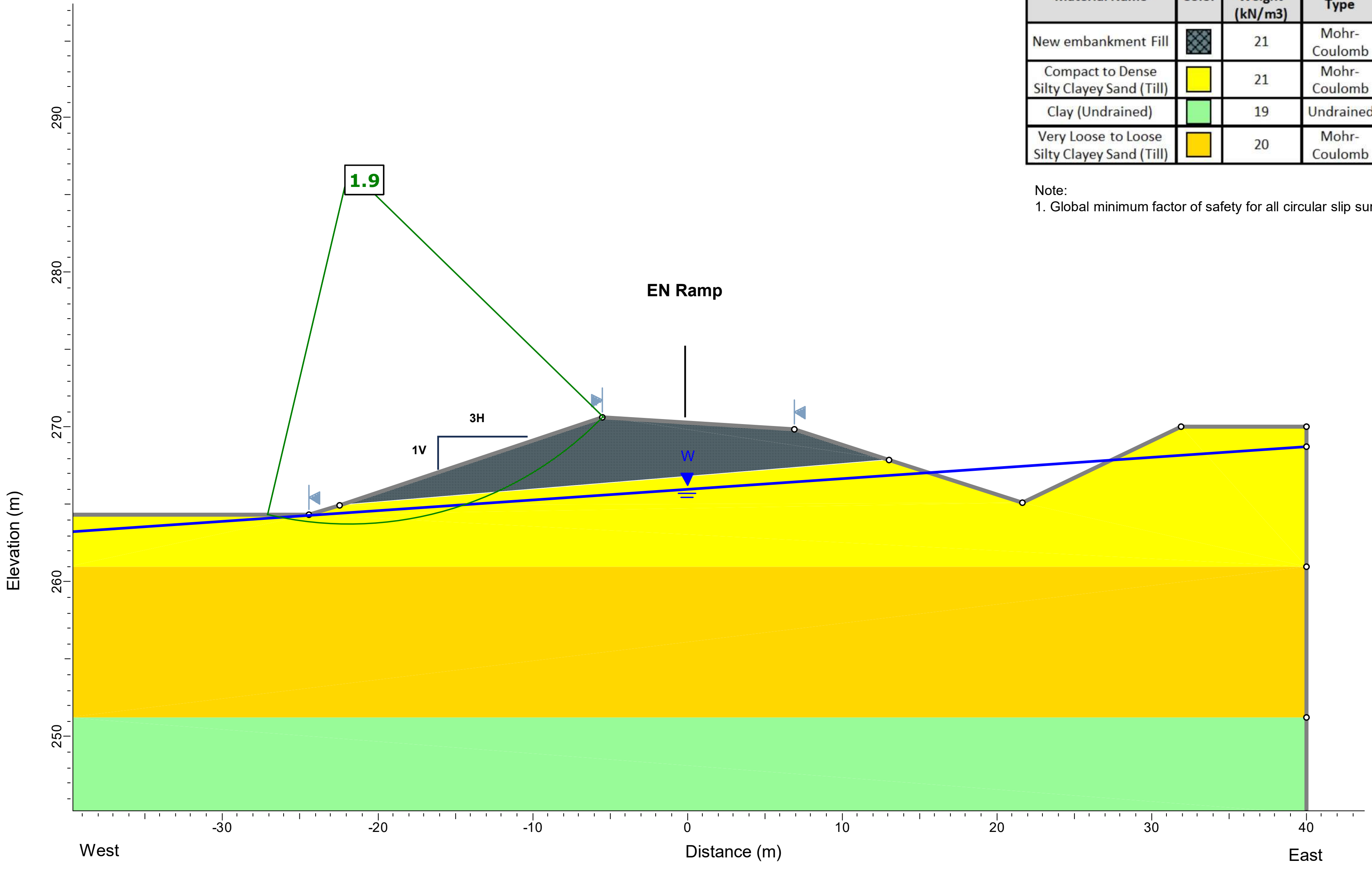
THURBER

High Fill Embankment at HWY 400 – EN Ramp Culvert
Global Slope Stability – Temporary Condition 3:1

Figure I1

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Cohesion Type
New embankment Fill	▨	21	Mohr-Coulomb	0	32	
Compact to Dense Silty Clayey Sand (Till)	🟨	21	Mohr-Coulomb	0	32	
Clay (Undrained)	🟩	19	Undrained	40	0	Constant
Very Loose to Loose Silty Clayey Sand (Till)	🟧	20	Mohr-Coulomb	0	30	

Note:
1. Global minimum factor of safety for all circular slip surfaces shown.



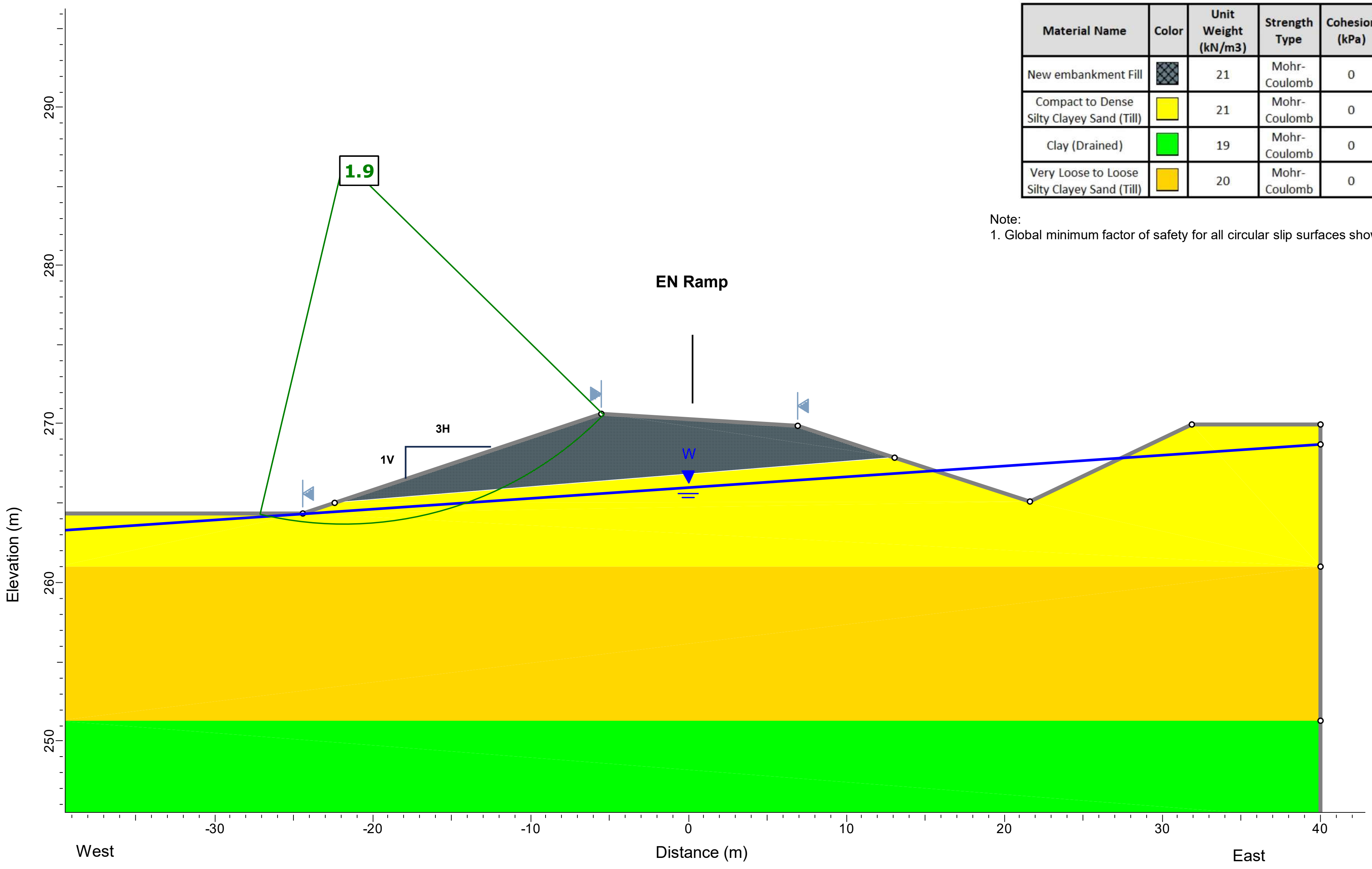
Date: December 2025
Thurber Project: 48856

Analysis By: JA
Checked By: SP

THURBER

High Fill Embankment at HWY 400 – EN Ramp Culvert
Global Slope Stability – Permanent Condition 3:1

Figure I2



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Ru Value
New embankment Fill	▨	21	Mohr-Coulomb	0	32	0
Compact to Dense Silty Clayey Sand (Till)	🟨	21	Mohr-Coulomb	0	32	
Clay (Drained)	🟩	19	Mohr-Coulomb	0	28	
Very Loose to Loose Silty Clayey Sand (Till)	🟧	20	Mohr-Coulomb	0	30	

Note:
1. Global minimum factor of safety for all circular slip surfaces shown.

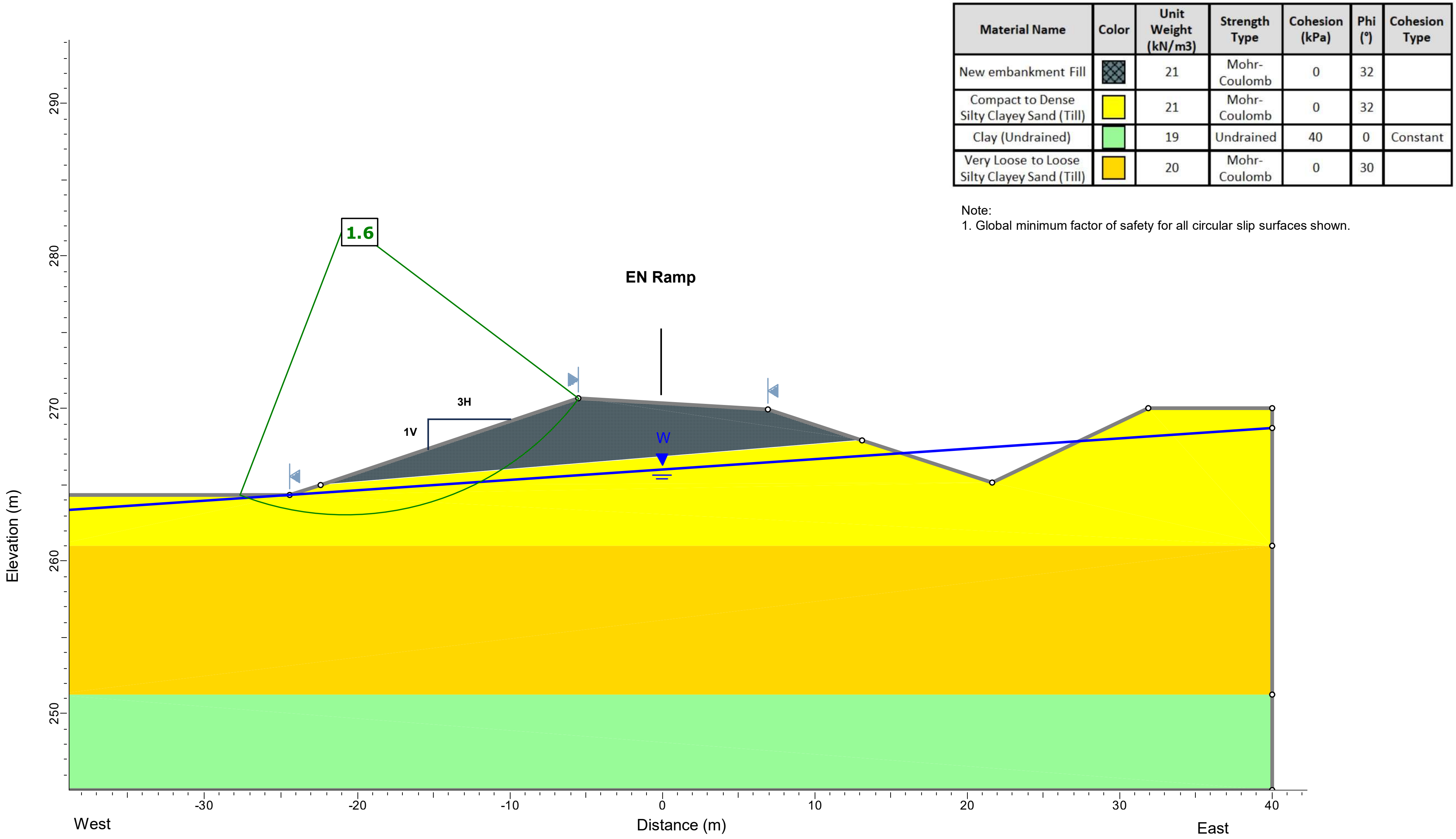
Date: December 2025
Thurber Project: 48856

Analysis By: JA
Checked By: SP

THURBER

High Fill Embankment at HWY 400 – EN Ramp Culvert
Global Slope Stability – Seismic Condition 3:1

Figure I3



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (°)	Cohesion Type
New embankment Fill	▩	21	Mohr-Coulomb	0	32	
Compact to Dense Silty Clayey Sand (Till)	🟨	21	Mohr-Coulomb	0	32	
Clay (Undrained)	🟩	19	Undrained	40	0	Constant
Very Loose to Loose Silty Clayey Sand (Till)	🟧	20	Mohr-Coulomb	0	30	

Note:
1. Global minimum factor of safety for all circular slip surfaces shown.

Date: December 2025
Thurber Project: 48856

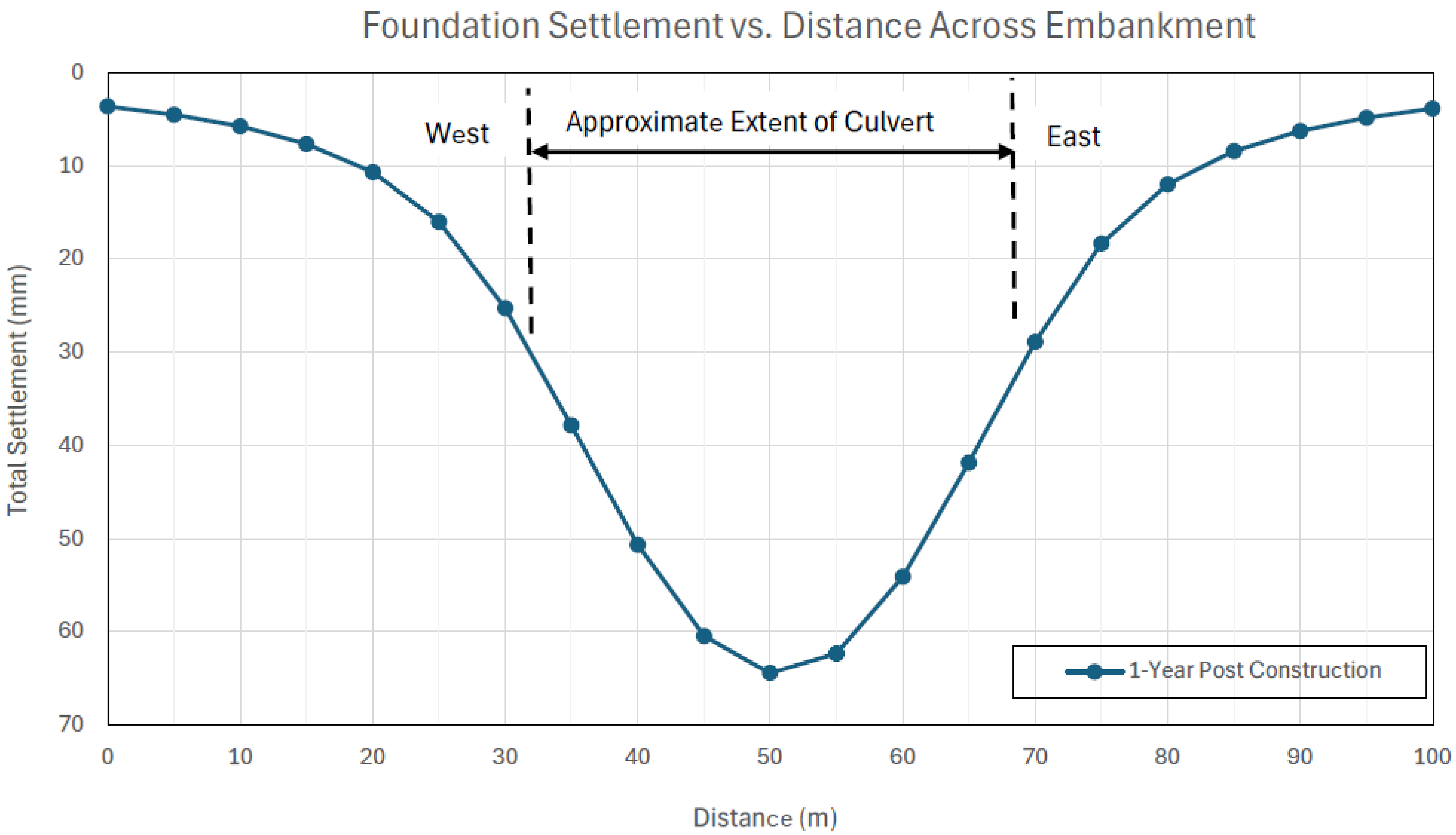
Analysis By: JA
Checked By: SP

APPENDIX J

Foundation Settlement Vs. Distance

Foundation Settlement Vs. Distance Across Embankment
HWY400 – EN Ramp Culvert

Figure J1



APPENDIX K

List of OPSS Documents and NSSP Wordings

1. List of OPSS and OPSD Referenced in this Report

OPSS PROV 206	Construction specification for grading
OPSS PROV 422	Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS PROV 501	Construction specification for compacting
OPSS.PROV 517	Construction specification for dewatering
SP 517F01	Amendment to OPSS 517
OPSS PROV 539	Construction specification for temporary protection systems
OPSS PROV 804	Construction Specification for Temporary Erosion Control
OPSS PROV 902	Construction specification for excavating and backfilling – Structures
NSSP FOUN0003	Amendment to OPSS.PROV 902
OPSS PROV 1004	Material Specification for Aggregates – Miscellaneous
OPSS PROV 1005	Material Specification for Aggregates – Waterbody
OPSS PROV 1010	Material specification for aggregates - base, subbase, select subgrade, and backfill material
OPSS PROV 1205	Material Specification for Clay
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans less than or equal to 3.0 m.
OPSD 208.010	Benching of Earth Slope
OPSS PROV 401	Construction specification for Trenching, Backfilling, and Compacting
OPSS PROV 912	Construction specifications for precast concrete culverts with spend greater than 3.0 m.
OPSD 3101.150	Walls, Abutment, Backfill, Minimum Granular Requirement

2. Suggested Text for NSSP on Groundwater Control

High groundwater levels and permeable soils are present at this site. Therefore, water inflow/seepage should be anticipated from the embankment fill and underlying native sands and silts, and surface runoff and precipitation will accumulate within the excavation. Excavation into the wet cohesionless soils below the water level will encounter sloughing of unsupported excavation sidewalls, caving and subgrade loosening/softening. The Contractor must implement effective dewatering measures during construction and prior to excavating below the water level. Effective dewatering shall be designed and provided by the Contractor during structure excavation, bedding placement and backfilling to allow the work to proceed in the dry. A combination of interlocking sheetpiles along the culvert alignment where required, cofferdam enclosures at the inlet and outlet areas, surface water diversion, vacuum well-points where required, and pumping from filtered sumps may be warranted. The dewatering system must be effective to maintain the water level at a minimum depth of 0.5 m below the final subgrade level throughout construction. The dewatering system must remain operational and effective until the culvert is installed and backfilled.

It is recommended that a Professional Engineer with more than 5 years of experience in designing dewatering systems be retained to design and implement a dewatering system.