



THURBER ENGINEERING LTD.

**PRELIMINARY FOUNDATION INVESTIGATION REPORT
HIGHWAY 401 WIDENING, HIGHWAY 16 TO MAITLAND ROAD
HIGHWAY 401W-416N RAMP REHABILITATION, SITE NO. 16X-0306
GWP 4024-20-00 / ASSIGNMENT NO. 4019-E-0010.2**

Geocres No.: 31B-109

Report to:

MTO c/o AECOM Canada Ltd.

Latitude: 44.747701°
Longitude: -75.488351°

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

Thurber Engineering Ltd. (Thurber) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation Ontario (MTO) under Assignment No. 4019-E-0010, Work Item No. 2, to carry out Foundation Investigations to support the Preliminary Design and Environmental Assessment for the widening of Highway 401 from Highway 16 to Maitland Road. The overall scope of work comprises replacement or rehabilitation of 14 existing structures, including 10 bridges and four structural culverts.

This report addresses the proposed rehabilitation of the Highway 401 and Cedar Grove Road underpass ramp bridge connecting traffic coming from the west on Highway 401 to travel north on Highway 416 (401W-416N). The bridge, Site No. 16X-0306, is located approximately 1.1 km west of Highway 401 Interchange 721 with Highway 16, near the town of Prescott, Ontario.

This section of the report presents the factual findings obtained from a foundation investigation completed at the site, as well as data from existing subsurface information pertinent to the site, obtained from the MTO's Foundation Library which included:

- Report prepared by Jacques, Whitford Limited titled, "*Report on Foundation Investigation, W.P. 374-89-02, Site 16-306, Ramp W-N Over Hwy 401 & Cedar Grove Road, Hwy. 401-416 Interchange, District 9, Ottawa*", dated March, 1992 (Geocres No. 31B-74).

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and rehabilitation of the structure was developed during the current investigation.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2 SITE DESCRIPTION

Highway 401 is generally oriented northeast to southwest and the 401W-416N ramp bridge is oriented roughly north to south with a total length of 163 m and a width of 11.2 m. For project



purposes, Highway 401 and the bridge are herein described as oriented east-west and north-south, respectively.

The land adjacent to the site typically consists of forests, wet ground, and agricultural fields. The terrain is relatively flat, apart from the existing highway and interchange embankments and associated drainage ditches.

Highway 401 in this area consists of a four-lane divided freeway with paved shoulders and a median barrier and median stormwater system. A guiderail is present along the outsides of the highway. Cedar Grove Road is a two-lane, local roadway with narrow granular shoulders and a guiderail on the south side of the road. The ramp consists of one travelled lane with wide, paved shoulders. Steel beam guiderails are present along the approaches and abut the concrete barrier walls along the bridge.

Within the vicinity of the bridge, the embankments are partially retained by RSS walls near the abutments, below which the slopes are at approximately 2H:1V. The slopes are generally vegetated with bushes and small trees growing around the abutments. At the time of the field work, the embankments did not show any visible signs of distress or other performance issues.

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies on the border of the physiographic regions known as the Smith's Falls Limestone Plain and the Glengarry Till Plain.

The Smith's Falls Limestone Plain is characterized by typically shallow bedrock but includes a few localized deep areas of highly variable soils consisting of clays, sands, and gravels. The Glengarry Till Plain is characterized by an undulating surface consisting of morainic ridges and intervening clay flats and swamps, overlying till and similar glaciofluvial deposits containing many cobbles and boulders. Both areas are known to be underlain by limestone and sandstone bedrock.

Photographs showing the existing conditions at the site at the time of the field investigation are included in Appendix D for reference.

3 SITE INVESTIGATIONS AND FIELD TESTING

The original foundation investigation for design of the bridge was carried out in April 1991. The current investigation was carried out in April/May 2021 to collect additional subsurface information near the existing bridge abutments. Summaries of the investigations are provided in the following sections.

3.1 Previous Investigation (1991)

A total of seventeen test holes were put down at the site as part of the 1991 investigation. Boreholes relevant to the current study include those numbered 91-2 to 91-7 which were put down at the then-proposed foundation element locations for the bridge between April 8 and 16, 1991.



The six relevant 1991 boreholes were advanced to depths ranging from 4.5 m to 12.6 m below the existing ground surface at the time of the investigation (prior to construction of the bridge). A standpipe piezometer or monitoring well was installed each of the boreholes, with double installations in Boreholes 91-5 and 91-6.

The locations of the 1991 boreholes were surveyed by others prior to the initiation of the field work, unless they were subsequently relocated due to site constraints, in which case the as-drilled borehole location was subsequently surveyed.

The northings, eastings, and elevations of the boreholes used in this report are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A and in Table 3-1, below. The site is located within MTM Zone 9. The borehole locations were originally surveyed relative to NAD27 horizontal datum and have been converted relative to NAD83 in the drawing, on the Record of Borehole Sheets (where appropriate), and in Table 3-1, below.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing¹ (Latitude)	Easting¹ (Longitude)	Ground Surface² Elevation (m)	Termination Depth (m)
91-2	Near the North Abutment	4 957 043.0 (44.748900)	384 922.5 (-75.488127)	87.3	10.8
91-3	Near the North Pier	4 957 003.1 (44.748541)	384 920.6 (-75.488157)	87.4	12.6
91-4	Near the Centre Pier	4 956 959.1 (44.748146)	384 916.2 (-75.488220)	85.7	7.7
91-5	Near the South Pier	4 956 915.3 (44.747753)	384 909.1 (-75.488316)	86.1	8.1
91-6	Near the South Abutment	4 956 876.9 (44.747408)	384 900.6 (-75.488430)	85.2	7.0
91-7	South Approach Fill	4 956 847.7 (44.747146)	384 893.2 (-75.488528)	84.3	4.5

Notes: 1) Boreholes were surveyed relative to NAD27; coordinates listed above were converted relative to NAD83.

2) Boreholes were put down prior to construction of the existing ramp and bridge.

3.2 Current Investigation (2021)

The current site investigation was carried out in the Spring of 2021. Two boreholes were put down at the site: one near the south abutment on April 19, 2021 (Borehole 306-21-1) and one near the north abutment between April 20, 2021 and May 4, 2021 (Borehole 306-21-2). The boreholes were put down with a truck-mounted CME 55 drill rig.

The locations of 2021 boreholes were surveyed by Thurber for both location and elevation with a Trimble Catalyst DA1 antenna with centimeter accuracy. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A, the individual Record of Borehole sheets in Appendix B, and in Table 3-2 below. The site is located within MTM Zone 9.

Table 3-2: Borehole Summary

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
306-21-1	Near the South Abutment	4 956 859.3 (44.747256)	384 903.0 (-75.488405)	94.8	16.4
306-21-2	Near the North Abutment	4 957 047.6 (44.748948)	384 928.6 (-75.488052)	95.5	26.5

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A standpipe piezometer was installed in Borehole 306-21-1 following completion of the drilling to allow for subsequent groundwater level measurements. It was decommissioned in December 2022. Borehole 306-21-2 was abandoned after drilling by backfilling with bentonite and drill cuttings.

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

4 LABORATORY TESTING

Geotechnical laboratory testing carried out as part of the current investigation included natural moisture content determination and visual identification of all retained soil samples. Testing for grain size distribution and Atterberg Limits was also carried out on selected samples to MTO and ASTM standards. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured. One Unconfined Compressive Strength (UCS) Test was conducted on a recovered core sample from Borehole 306-21-2. Laboratory testing carried out as part of the 1991 investigation included natural moisture content, grain size distribution, Atterberg limit determination, and laboratory vane testing on selected soil samples.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory test results are presented on the figures included in Appendix C.

5 GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy based on the conditions encountered in the boreholes is given in the following sections. However, the factual data presented on the Borehole Records takes precedence over the Soil Strata Drawing and the general description. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations. Soil classification for the 2021 investigation is in accordance with ASTM D2487. Description of cohesive soils and secondary components of all deposits from the 2021 borehole



are described as outlined in the MTO Guideline for Foundation Engineering Services manual (October 2020). Terminology from the historic information may vary from current practice.

In general, the site is underlain by a layer of clayey silt to clay overlying glacial till at relatively shallow depth. The till is, in turn, underlain by limestone bedrock, which slopes down to the north.

The sections below describe subsurface conditions encountered at the time the boreholes were advanced. The conditions reported in the historic information may have been disturbed or altered, partially or completely during the construction of the W-N Ramp structure.

5.1 Embankment Fill

The asphalt surface was observed to be 150 mm and 125 mm thick in Boreholes 306-21-1 and 306-21-2. Granular embankment fill consisting of silty sand to sand to sand and gravel was encountered at the boreholes put down behind the abutments. At Boreholes 306-21-1 (south abutment) and 306-21-2 (north abutment) the embankment fill is 10.5 m and 9.0 m thick, respectively (extending down to Elevations 84.1 m and 86.4 m)

SPTs conducted in the embankment fill gave N-values ranging from 17 to 53 blows per 0.3 m of penetration, indicating a compact to very dense relative density.

The moisture content of the fill samples tested ranged from about 2 to 9%, and one moisture content of 17% in Borehole 306-21-2. The results of grain size analysis testing conducted on four samples of the embankment fill are summarized below and are illustrated on Figure C1 in Appendix C.1.

Summary of Grain Size Distribution Testing – Granular Fill

Soil Particle	Percentage (%)
Gravel	1 – 48
Sand	42 – 94
Silt and Clay	5 – 10

5.2 Surficial Deposits

Surficial deposits consisting of topsoil, underlain by fill and sand were encountered in Boreholes 91-3, 91-5, 91-6, and 91-7 which were put down prior to construction of the bridge. Though the surficial deposits within the embankment footprints and at the abutments may have been removed prior to construction, they may still be present beyond the embankment footprints and in the vicinity of the bridge piers, and are described in the following sections for information purposes only.

5.2.1 Topsoil

Topsoil was encountered at the ground surface in Boreholes 91-2, and 91-4 to 91-7. Topsoil ranged in thickness from 100 to 300 mm.



5.2.2 Fill

A deposit of fill was encountered in Boreholes 91-3 and 91-5, which were put down close to Cedar Grove Road and Highway 401, respectively. A deposit of sand and gravel fill was encountered at ground surface in Borehole 91-3 and a deposit of silt and sand fill was encountered at ground surface in Borehole 91-5. The fill was approximately 1.4 m thick in Borehole 91-3 and 0.9 m thick in Borehole 91-5.

Two SPTs conducted in the fill gave N-values of 6 and 13 blows per 0.3 m of penetration, indicating a loose to compact relative density. The moisture contents of the two samples tested were 8 and 20%.

5.3 Sand

A deposit of sand, some silt was encountered beneath the embankment fill in Borehole 306-21-1 and beneath the topsoil in Boreholes 91-6 and 91-7. Organics were observed in the deposit in Borehole 306-21-1. The thickness ranged from about 0.5 m to 1.5 m with base elevations ranging from 82.6 to 84.5 m. SPTs conducted in the sand deposit gave N-values of 2 to 14 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The moisture content of one sample tested was 23%. The results of a grain size analysis test conducted on a sample of this material obtained in Borehole 306-21-1 is summarized below and is illustrated on Figure C2 in Appendix C.1.

Summary of Grain Size Distribution Testing – Sand

Soil Particle	Percentage (%)
Gravel	8
Sand	76
Silt	10
Clay	6

5.4 Clayey Silt to Clay

A deposit of clayey silt to clay was encountered beneath the sand layer in Boreholes 306-21-1, 91-6, and 91-7, beneath the embankment fill in Boreholes 306-21-2, 91-3, and 91-5, and beneath the topsoil in Borehole 91-2, 91-4. The deposit was encountered near the original ground surface and ranged from 0.9 m to 2.8 m thick (base Elevations 81.7 m to 85.8 m).

SPTs conducted within this layer gave N-values generally ranging from 2 to 13 blows per 0.3 m of penetration. Field and laboratory vane tests conducted during the 1991 investigation indicated that the clay has an undrained shear strength ranging from 75 kPa to over 200 kPa, indicating a stiff to hard consistency.

The moisture content of the samples tested ranged from about 21 to 42%.



The results of four grain size analysis tests conducted on this deposit are summarized below and are illustrated on Figure C3 in Appendix C.1 and Figure 2 in Appendix C.2.

Summary of Grain Size Distribution Testing – Clayey Silt to Silty Clay to Clay

Soil Particle	Percentage (%)
Gravel	0 – 1
Sand	0 – 4
Silt	33 – 70
Clay	29 – 67

The results of Atterberg Limits testing carried out on five samples of this deposit are summarized below and are illustrated on Figure C4 in Appendix C.1 and Figure 1 in Appendix C.2. The laboratory results indicate that the material is generally a clay of intermediate plasticity (CI) to high plasticity (CH), with the exception of one test carried out in the relatively thin deposit in Borehole 306-21-2 which plotted as a clay of low plasticity (CL, clayey silt).

Summary of Atterberg Limit Testing – Clayey Silt to Silty Clay to Clay

Parameter	Value
Liquid Limit	28 – 54
Plastic Limit	18 – 27
Plasticity Index	10 – 30

5.5 Glacial Till

A basal till deposit consisting of a heterogeneous mixture of silty sand with to some gravel was encountered beneath the clay deposit in Borehole 306-21-2 and 91-2 to 91-7. Cobbles and boulders were present in the glacial till in all boreholes where the deposit was encountered. The glacial till was encountered at Elevations ranging from 81.7 m to 85.8, with thicknesses ranging from 0.1 m to 12.2 m (base elevation ranging from 72.6 m to 81.7 m). The glacial till deposit generally becomes thicker to the north.

SPTs conducted in this layer gave N-values ranging from 3 blows to greater than 50 blows for 150 mm of penetration but were generally between 10 and 50 blows per 0.3 m of penetration, indicating a compact to very dense relative density. Refusals within this deposit are likely due to presence of cobbles and boulders. Penetration through this layer required the use of coring techniques in a few locations.

Summary of Grain Size Distribution Testing – Glacial Till

Soil Particle	Percentage (%)	
Gravel	10 – 31	
Sand	26 – 39	
Silt	43 – 52	27 – 36
Clay		11 – 22

The moisture content of samples obtained from this unit ranged from 7 to 14%. The results of grain size distribution testing carried out on six samples of the till from the 1991 and 2021 investigations are summarized in the table above. The results from the 2021 investigation are illustrated on Figure C5 in Appendix C.1 and an envelope summarizing the results from the 1991 investigation is illustrated on Figure 3 in Appendix C.2.

The results of Atterberg Limits testing carried out on the fines of three samples of the glacial till from the 1991 boreholes are summarized below and are illustrated on Figure 4 in Appendix C.2. The laboratory results indicate that the fines are non-plastic to slightly plastic (ML to CL-ML).

Summary of Atterberg Limit Testing – Glacial Till Fines

Parameter	Value
Liquid Limit	14 – 15
Plastic Limit	10 – 11
Plasticity Index	3 – 5

5.6 Bedrock

Bedrock was proven by coring in Boreholes 306-21-1, 306-21-2, and 91-3 to 91-7. The bedrock encountered consisted of fresh, very strong, fine grained, grey, interbedded dolostone and limestone. Photographs of the bedrock cores are provided in Appendix C. The following table summarizes the rock core quality:

Table 5-1: Summary of Rock Core Quality

Parameter	Range
Total Core Recovery (TCR), %	93 to 100
Solid Core Recovery (SCR), %	59 to 100
Rock Quality Designation (RQD), %	41 to 100
Fracture Index	0 to >10

The RQD values encountered in the upper run of bedrock core in Boreholes 306-21-1, 306-21-2 and 91-3 were between 41% and 58%. All other RQD values ranged from about 75% to 100%, indicating a bedrock of good to excellent quality.

Unconfined compressive strength (UCS) testing was carried out on a sample of the bedrock from Borehole 306-21-2. The results indicated a UCS value of 220 MPa, indicating a very strong rock. The results of the UCS testing are included in Appendix C.

A summary of the bedrock surface information is provided in Table 5 2, below.

Table 5-2: Summary of Bedrock Depth/Elevation

Borehole No.	Depth to Bedrock Surface (mbgs)¹	Bedrock Surface Elevation (m)
91-2	Refusal at 10.8	Refusal at 76.5
91-3	9.6	77.8
91-4	4.6	81.1
91-5	5.2	80.9
91-6	4.0	81.2
91-7	2.6	81.7
306-21-1	13.1	81.7
306-21-2	22.9	72.6

Note: Depths below ground surface at the time of drilling; ground surface may have changed since.

5.7 Groundwater

Standpipe piezometers or monitoring wells were installed in all of the relevant boreholes put down as part of the 1991 investigation, and in Borehole 306-21-1 put down as part of the current investigation. Groundwater levels recorded are presented in Table 5-3.

Table 5-3: Summary of Groundwater Levels

Borehole No.	Bottom of Screen Elev. (m)	Screened Unit	Depth (mbgs)¹	Groundwater Elevation (m)	Date of Measurement
91-2	76.5	Glacial Till	0.6	86.7	May 10, 1991
91-3	74.8	Bedrock	0.8	86.6	May 10, 1991
91-4	81.3	Glacial Till	0.1	85.6	May 10, 1991
91-5	78.0	Bedrock	0.7	85.4	May 10, 1991
91-6	82.2	Clay	0.3	84.9	May 10, 1991
91-6	78.2	Bedrock	-0.2	85.4	May 10, 1991
91-7	79.9	Bedrock	0.0	84.3	May 10, 1991
306-21-1	82.6	Sand	9.6	85.2	July 1, 2021
			9.4	85.4	December 19, 2022

Note: Depths below ground surface at the time of reading; ground surface may have changed since.

These observations are considered short term and it should be noted that the groundwater level may vary with season and fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation.



6 MISCELLANEOUS

It is noted that the conditions reported on the 1991 borehole records may not reflect current conditions due to construction or other activities in the area subsequent to those investigations.

The 2021 borehole locations were selected by Thurber relative to existing site features. The as-drilled locations and ground surface elevations of the boreholes were surveyed by Thurber following completion of the field program. The elevation survey of the boreholes was carried out with reference to geodetic elevation benchmarks provided by the MTO. Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, and borehole decommissioning.

The field investigation was supervised on a full-time basis by Jamil Pirani of Thurber. Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Unconfined Compressive Strength Testing of the bedrock was carried out by Stantec's laboratory in Ottawa.

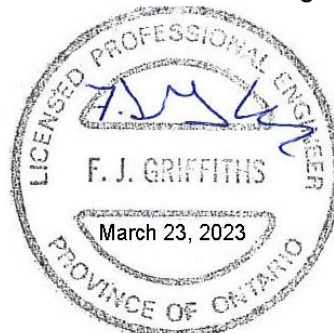
Overall project management and direction of the field investigation was provided by Matt Kennedy, P.Eng. Interpretation of the factual data and preparation of this report was carried out by Sarah Harrold, EIT and Matt Kennedy, P.Eng. The report was reviewed by Paul Carnaffan, P.Eng. and Fred Griffiths, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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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.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

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5. INTERPRETATION OF THE REPORT

- 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

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

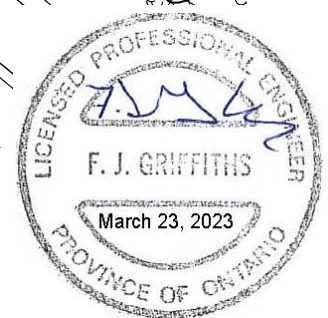
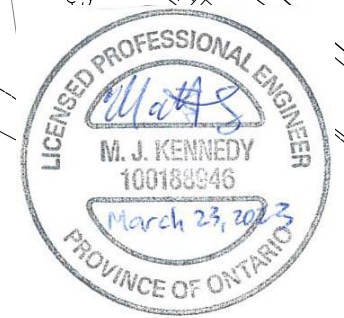
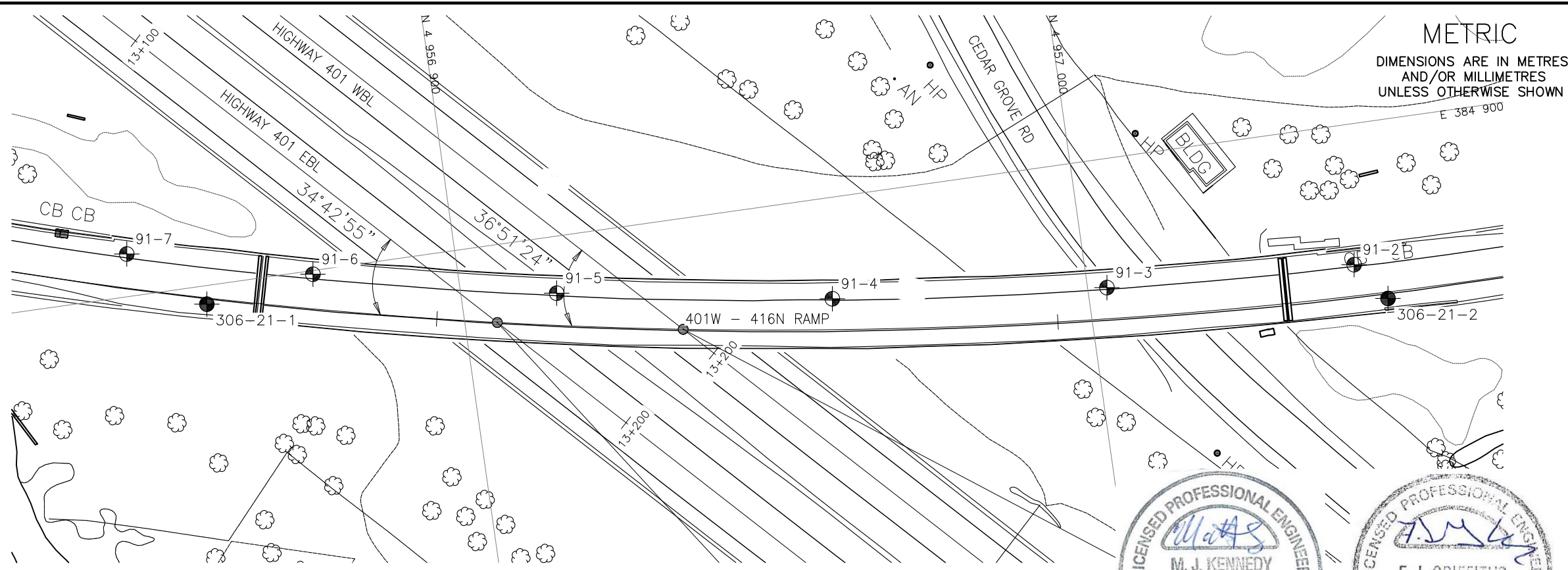
7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.



Appendix A.

Borehole Location Plan and Stratigraphic Drawings

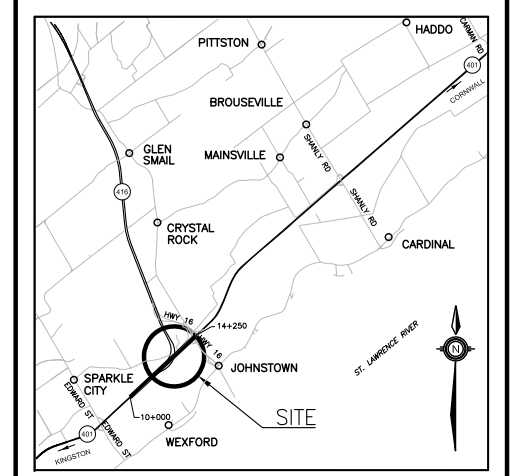


CONT No
GWP No 4024-20-00

HIGHWAY 401
401W - 416N RAMP
BRIDGE REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario

SHEET



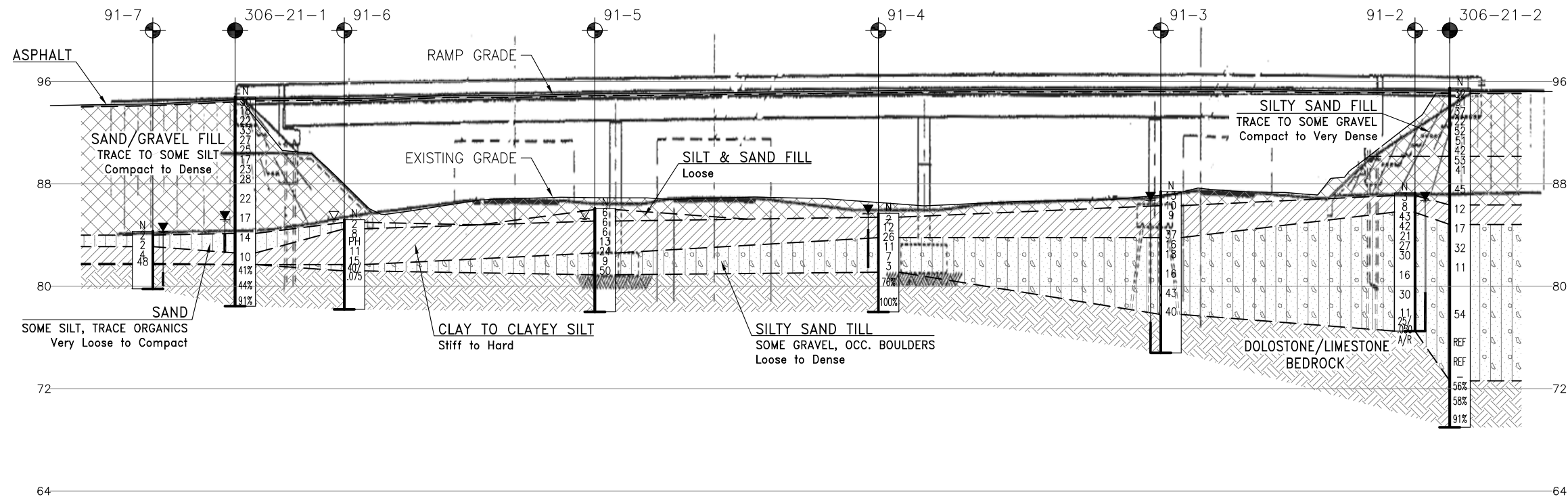
KEYPLAN

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

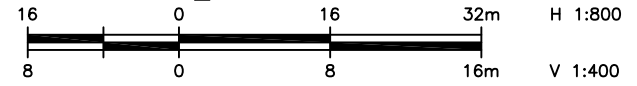
NO	ELEVATION	NORTHING	EASTING
306-21-1	94.8	4 956 859.3	384 903.0
306-21-2	95.5	4 957 047.6	384 928.6
91-2	87.3	4 957 043.0	384 922.5
91-3	87.4	4 957 003.1	384 920.6
91-4	85.7	4 956 959.1	384 916.2
91-5	86.1	4 956 915.3	384 909.1
91-6	85.2	4 956 876.9	384 900.6
91-7	84.3	4 956 847.7	384 893.2

- NOTES-**
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
 - This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
 - Coordinate system is MTM NAD 83 Zone 9.

GEOCRES No. 31B-109



PROFILE ALONG C 401W - 416N RAMP



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MJK	CHK -	CODE
DRAWN	MFA	CHK MK	SITE 16-306
			LOAD
			DATE MAR 2023
			DWG 1



Appendix B.

Record of Borehole Sheets



Appendix B.1

Current (2021) Investigation



SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

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 sizes 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	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 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. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

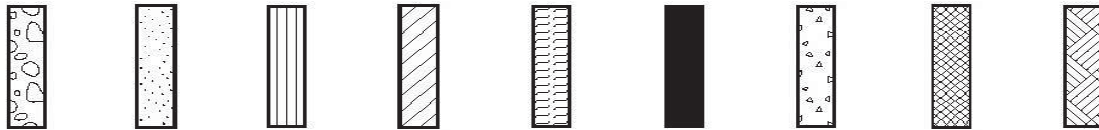
DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "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.



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.



Boulders
Cobbles
Gravel Sand Silt Clay Organics Asphalt Concrete Fill Bedrock

TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
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
ST	Shelby tube or thin wall tube
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 (COHESIONLESS 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 Divisions		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 $W_L < 35\%$	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 $35\% < W_L < 50\%$	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 $W_L > 50\%$	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 - W_L = Liquid Limit



EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved.

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 Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 to 2 m
Medium bedded	0.2 to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 to 60 mm
Laminated	6 to 20 mm
Thinly laminated	Less than 6 mm

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

RECORD OF BOREHOLE No 306-21-1

1 OF 2

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.747256°, Long: -75.488405°
N 4 956 859.3 E 384 903.0 ORIGINATED BY JP
HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2021.04.19 - 2021.04.19 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									WATER CONTENT (%)
94.8								20	40	60	80	100					
0.0	ASPHALT (150 mm)							20	40	60	80	100					
0.2	GRAVELLY SAND, trace fines Grey-brown to brown Compact to dense FILL		1	SS	30												
			2	SS	18												
			3	SS	22												
			4	SS	33												
91.8																	
3.0	SAND, trace to some gravel Trace fines Brown Compact FILL		5	SS	27												
			6	SS	25												
			7	SS	17												
89.5																	
5.3	SAND and GRAVEL Trace to some silt Grey-brown to brown Compact FILL		8	SS	23												
			9	SS	28												
			10	SS	22												
			11	SS	17												
																</	

Continued Next Page

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

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

RECORD OF BOREHOLE No 306-21-1

2 OF 2

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.747256°, Long: -75.488405° N 4 956 859.3 E 384 903.0 ORIGINATED BY JP
 HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
 DATUM Geodetic DATE 2021.04.19 - 2021.04.19 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
	Continued From Previous Page						20	40	60	80	100	20	40	60						
84.1	SAND and GRAVEL Trace to some silt Grey-brown to brown Compact FILL																			
10.7	SAND some silt Trace organics Grey Compact		12	SS	14								o			8 76 10 6				
82.6																				
12.2	CLAYEY SILT Grey Compact/very stiff		13	SS	10								h-l			0 1 70 29				
81.7																				
13.1	Interbedded DOLOSTONE and LIMESTONE Fresh Grey Smooth Fine grained Very strong		1	RUN												RUN #1 TCR=97% SCR=59% RQD=41%				
														</						

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 306-21-2

1 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.748948°, Long: -75.488052° N 4 957 047.6 E 384 928.6 ORIGINATED BY JP
 HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
 DATUM Geodetic DATE 2021.04.20 - 2021.05.05 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
95.5														
0.0	ASPHALT (125 mm)													
0.1	SILTY SAND, trace to some gravel Grey-brown to brown Compact to very dense FILL		1	SS	32		95							
			2	SS	31		94							
			3	SS	37		93							
			4	SS	22		92							
			5	SS	52		91							
			6	SS	51		90							
			7	SS	42		89							
90.2	SAND, trace to some silt Trace organics Brown Very dense to dense		8	SS	53		88							
5.3			9	SS	41		87							
			10	SS	45		86							
86.4	SILTY CLAY grey-brown Very stiff WEATHERED CRUST		11	SS	12									
9.1														

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

Continued Next Page

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

RECORD OF BOREHOLE No 306-21-2

2 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.748948°, Long: -75.488052° N 4 957 047.6 E 384 928.6 ORIGINATED BY JP
 HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
 DATUM Geodetic DATE 2021.04.20 - 2021.05.05 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page							SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
								WATER CONTENT (%)						
								20	40	60	80	100		
84.8	SILTY CLAY Grey-brown Very stiff WEATHERED CRUST						85							
10.7	SILTY SAND some gravel Grey Compact to dense Frequent cobbles/boulders GLACIAL TILL		12	SS	17		84							22 33 34 11
			13	SS	32		83							
81.8							82							
13.7	SILTY SAND some gravel Grey Compact GLACIAL TILL		14	SS	11									15 38 36 11
81.2							81							
14.3	SILTY SAND some gravel Grey Very dense Frequent cobbles/boulders GLACIAL TILL						80							
							79							
			15	SS	54		78							
							77							
							76							
			16	SS	REF									

Continued Next Page

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

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

3 OF 3

METRIC

[illegible]

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

+³, ×³: Numbers refer to Sensitivity



Appendix B.2

Previous (1991) Investigation

METRIC

W P 374-89-02

LOCATION Co-ords: N: 4 957 043.0 E: 384 922.5

ORIGINATED BY Y.L.

DIST 9 HWY 416




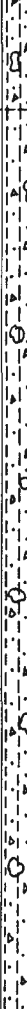



BOREHOLE TYPE Hollow Stem Auger

COMPILED BY C.K.K.

DATUM Geodetic

DATE April 9, 1991

CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa						WATER CONTENT (%)				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE										
87.3	Ground Surface							20 40 60 80 100										
87.1	Topsoil																	
0.2	Clay Stiff to Very Stiff Brown/Grey		1	SS	3		Seal May 10, 1991											
			2	SS	8			x										
85.8																		
1.5	Het. Mixture of Silty Sand, some clay & gravel, occ. boulders (Glacial Till) Compact to Dense <u>Brown</u> Grey		3	SS	43		Native Backfill											
			4	SS	42													
			5	SS	21								15 39 (46)					
			6	SS	27													
			7	SS	30													
			8	SS	16													
			9	SS	30													
			10	SS	11		Seal											
							Sand Backfill											
							Piezometer											
76.5							Seal											
10.8	End of Borehole Refusal on probable bedrock		11	SS	25/50mm													

OFFICE REPORT ON SOIL EXPLORATION

+3, x⁵: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 91-3

METRIC

W P 374-89-02 LOCATION Co-ords: N: 4 957 003.1 E: 384 920.6 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing, Rock coring COMPILED BY C.K.K.
 DATUM Geodetic DATE April 8, 1991 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
87.4	Ground Surface															
0.0	Sand and Gravel, some Silt (Fill) Compact Brown to Black		1	SS	13	Seal										
86.0						May 10, 1991										
86.4	Clay Stiff to Hard Brown/Grey		2	SS	10	85										
			3	SS	9	85										
						Native Backfill										
83.8			4	SS	37	84										
3.6	Het. Mixture of Silty Sand, some clay & gravel, occ. boulders (Glacial Till) Compact to Dense Grey		5	SS	16	83										
			6	SS	18	82										
			7	SS	16	81										
			8	SS	43	80										
77.8			9	Ss	40											
9.6	Bedrock Limy Dolostone Fair to Excellent		10	NX RC	REC 80%	Seal										
			11	NX RC	REC 100%	Sand Backfill										
						Piezometer										
74.8						Seal										
12.6	End of borehole															

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 ± 5 (%) STRAIN AT FAILURE
10



RECORD OF BOREHOLE No 91-4

METRIC

W P 374-89-02 LOCATION Co-ords: N: 4 956 959.1 E: 384 916.2 ORIGINATED BY Y.L.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing, Rock Coring COMPILED BY C.K.K.
DATUM Geodetic DATE April 12, 1991 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
85.7	Ground Surface															GR SA SI CL
0.3	Topsoil					May 10, 1991 Seal										
	Clay Stiff to Hard Brown/Grey		1	SS	2			x					o			
			2	SS	12					*			o			
83.8						84 Sand Backfill										
1.9	Het. Mixture of Silty Sand, Brown some clay & Grey gravel, occ. boulders (Glacial Till) Loose to Compact		3	SS	26											
			4	SS	11	Piezometer							o			
			5	SS	7								o			10 38 30 22
			6	SS	3								H			
81.1						Seal										
4.6	Bedrock Dolostone Good to Excellent		7	NX RC	REC 98%	81										RQD = 76%
			8	NX RC	REC 100%	80 Native Backfill										RQD = 100%
78.0						79										
7.7	End of Borehole															

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 91-5

METRIC

W P 374-89-02 LOCATION Co-ords: N: 4 956 915.3 E: 384 909.1 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing, Rock Coring COMPILED BY C.K.K.
 DATUM Geodetic DATE April 15, 1991 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
86.1	Ground Surface													GR SA SI CL
0.1	Topsoil						Native Backfill							
	Silt and Sand (Fill)		1	SS	6		Seal							
	Loose	Brown					May 10, 1991							
85.1														
1.0	Clay Stiff to Hard		2	SS	6				x					
		Brown/Grey	3	SS	6		Sand Backfill		x					
		Brown					84							
			4	SS	13				x					
										x				
82.6							Seal							
			5	SS	24					x				
3.5	Het. Mixture of Silty Sand, some clay & gravel, occ. boulders (Glacial Till) Loose to Dense Grey						Native Backfill							
			6	SS	9									
80.9			7	SS	50									31 26 (43)
							Seal							
5.2	Bedrock Dolostone interbedded with shale Excellent		8	NX RC	REC 88%		Sand Backfill							RQD = 86%
			9	NX RC	REC 100%									
							Piezometer							RQD = 90%
78.0							Seal							
8.1	End of borehole * Standpipe Damaged													

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 91-6

METRIC

W P 374-89-02 LOCATION Co-ords: N: 4 956 876.9 E: 384 900.6 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing, Rock Coring COMPILED BY C.K.K.
 DATUM Geodetic DATE April 16, 1991 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE			SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
85.2	Ground Surface																GR SA SI CL
85.0	Topsoil																
0.2	Sand, some silt	Brown	1	SS	2		May 10, 1991										
84.5	Very Loose						Seal										
0.7	Clay Stiff to Very Stiff		2	SS	8		Native Backfill										
	Brown/Grey		3	TW	PH		Seal										0 0 37 63
			4	SS	11		83 Sand Backfill										
			5	SS	15		82 Native Backfill										
3.5	Het. Mixture of Silty Sand, some clay & gravel, occ. boulders (Glacial Till)		6	SS	40/75		Seal										
81.2	Dense	Grey	7	NX RC	REC 100%		81 Sand Backfill										RDQ = 87%
4.0	Bedrock Dolostone with large particles of sparry calcite Good to Excellent		8	NX RC	REC 92%		80 Piezometer										RDQ = 80%
			9	NX RC	REC 93%		79 Seal										RDQ = 93%
78.2																	
7.0	End of borehole																
	* Artesian head 0.2 m above ground surface encountered on May 10, 1991																

RECORD OF BOREHOLE No 91-7

METRIC

W P 374-89-02 LOCATION Co-ords: N: 4 956 847.7 E: 384 893.2 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing, Rock Coring COMPILED BY C.K.K.
 DATUM Geodetic DATE April 16, 1991 CHECKED BY G.J.K.

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20	40	60	80	100					
84.3	Ground Surface															GR SA SI CL
84.0	Topsoil					May 10, 1991										
0.3	Sand, some Silt Very Loose Brown		1	SS	2	Seal										
83.1			2	SS	2											
1.2	Clay Stiff to Very Stiff Grey		3	SS	4											
81.8			4	SS	48											
2.5	Het Mixture of Silty															
2.6	Sand, some clay & gravel, occ. boulders (Glacial Till)		5	NX RC	REC 99%											RQD = 99%
	Bedrock Limy Dolostone Good to Excellent		6	NX RC	REC 95%											RQD = 80%
79.8																
4.5	End of borehole															



Appendix C.

Laboratory Testing



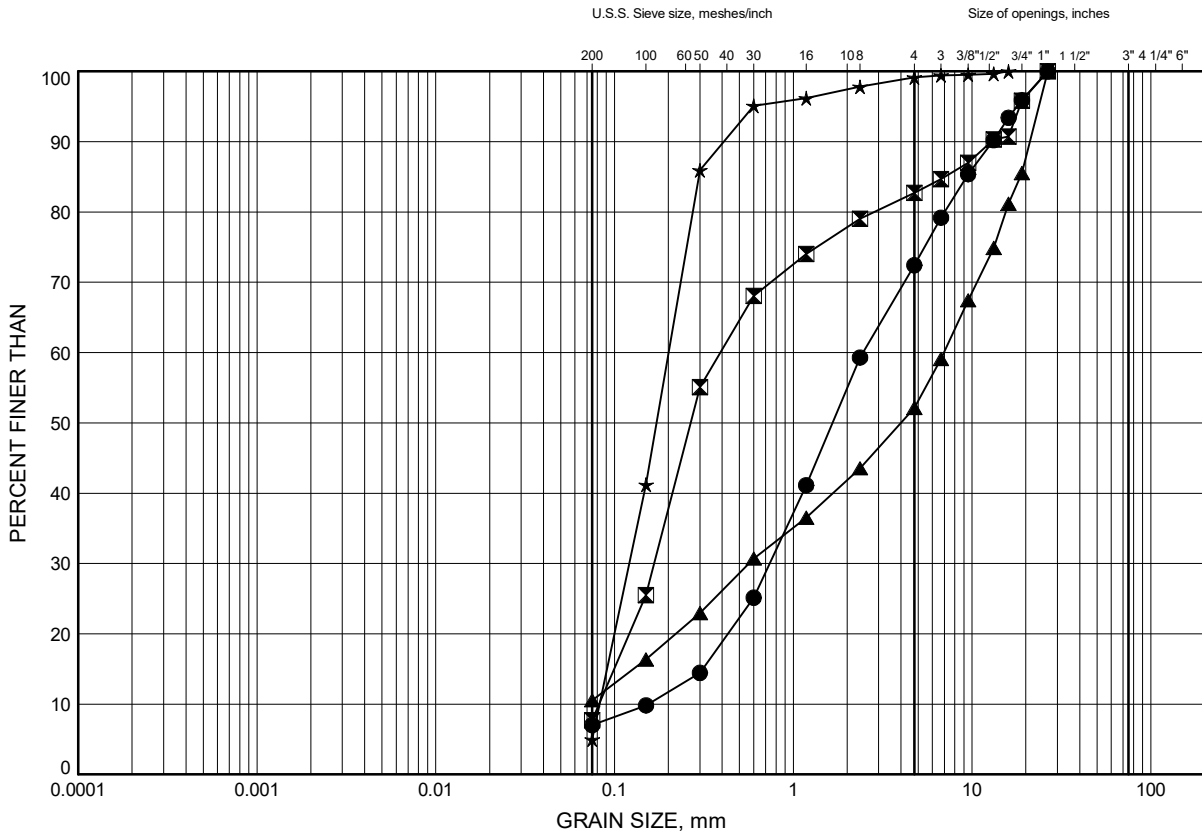
Appendix C.1
Particle Size Analysis Figures (2021)
Atterberg Limit Test Results (2021)

Hwy 401W - 416N Ramp (Site No. 16X-0306)

GRAIN SIZE DISTRIBUTION

FIGURE C1

EMBANKMENT FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	306-21-1	1.1	93.7
⊠	306-21-1	4.1	90.7
▲	306-21-1	6.4	88.4
★	306-21-2	6.4	89.1

Date December 2021

WP# 4024-20-00



Prep'd SH

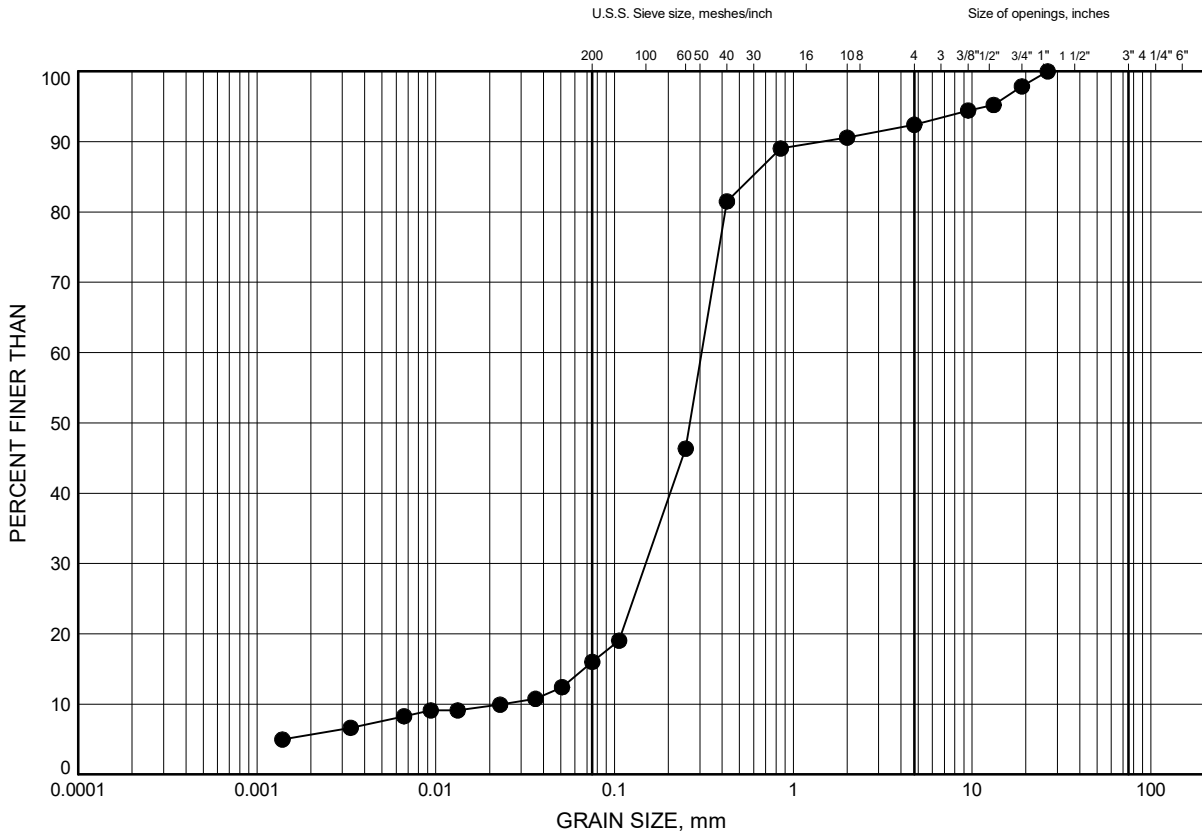
Chkd. MJK

Hwy 401W - 416N Ramp (Site No. 16X-0306)

GRAIN SIZE DISTRIBUTION

FIGURE C2

SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	306-21-1	11.0	83.8

Date December 2021

WP# 4024-20-00

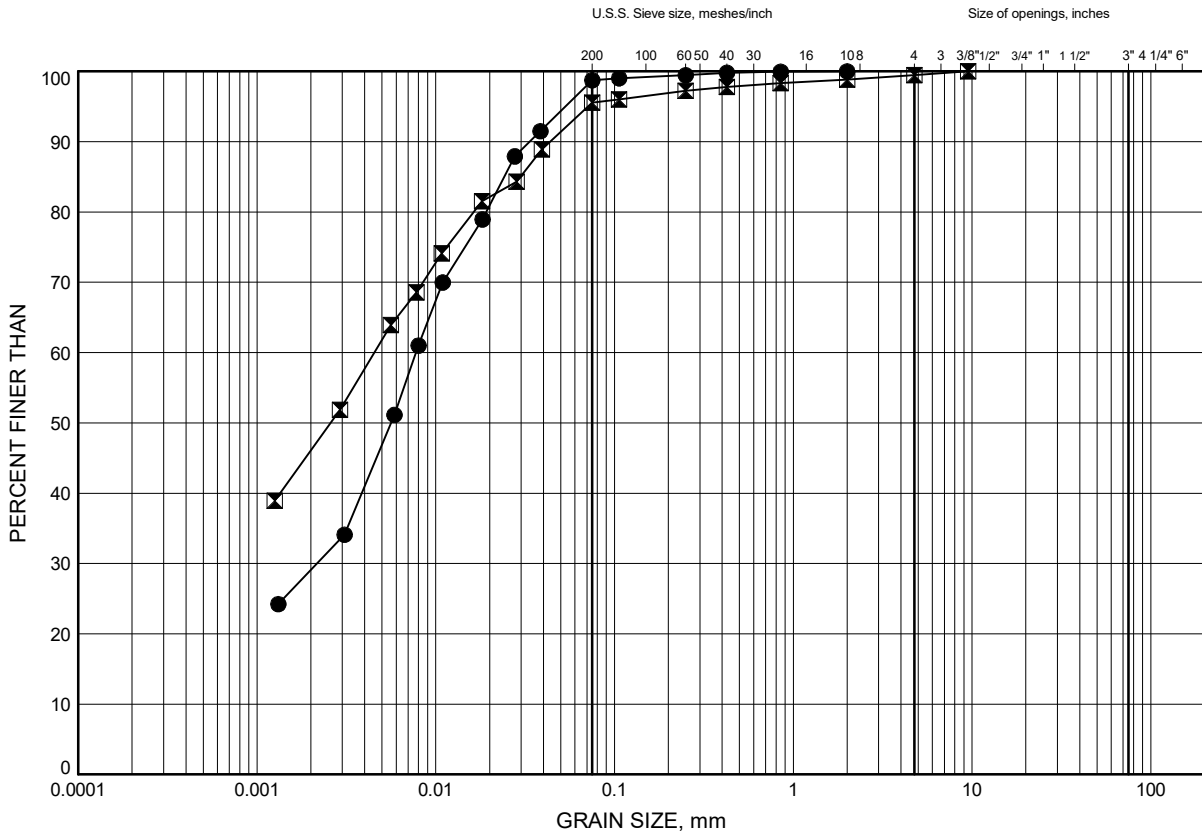


Prep'd SH

Chkd. MJK

GRAIN SIZE DISTRIBUTION

CLAYEY SILT TO SILTY CLAY



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	306-21-1	12.5	82.3
⊠	306-21-2	9.4	86.0

Date December 2021

WP# 4024-20-00



Prep'd SH

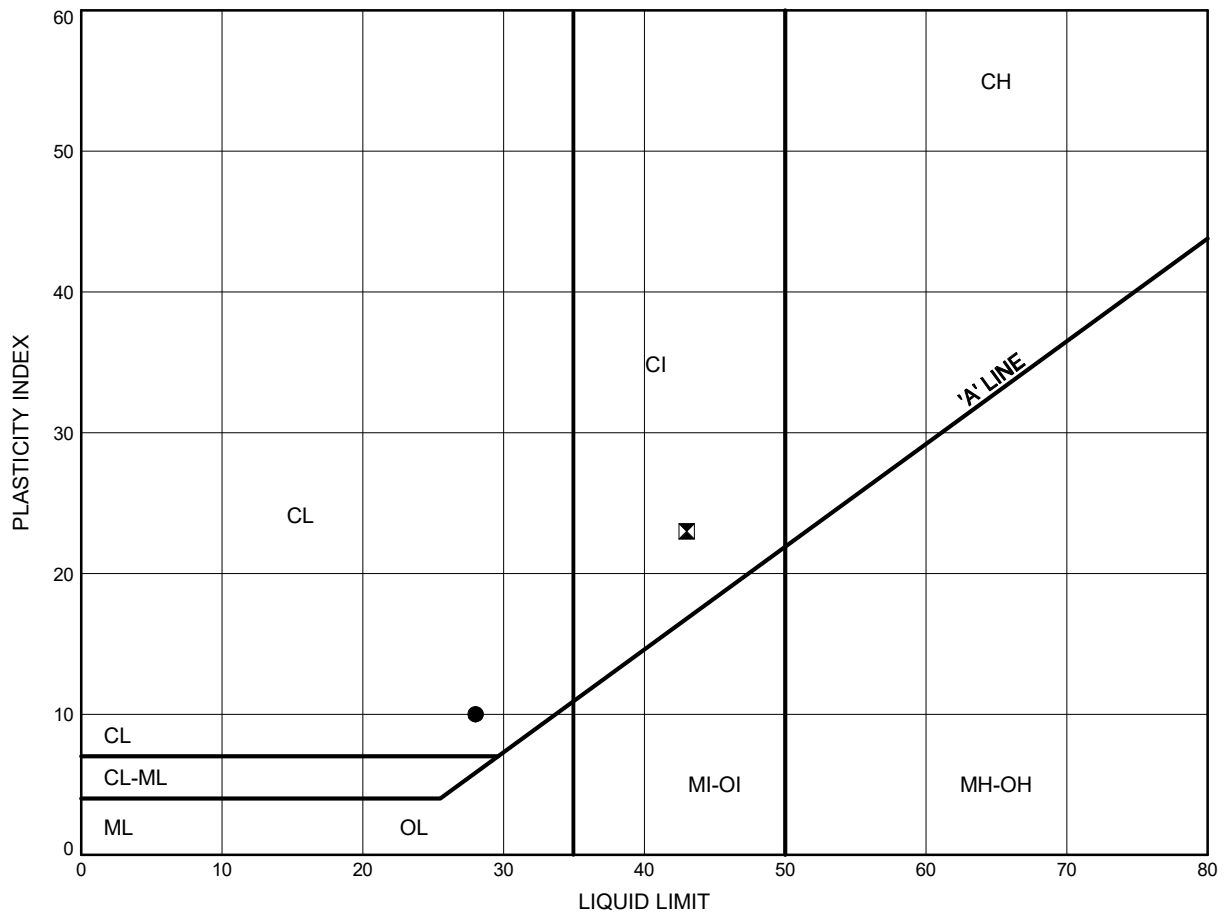
Chkd. MJK

Hwy 401W - 416N Ramp (Site No. 16X-0306)

ATTERBERG LIMITS TEST RESULTS

FIGURE C4

CLAYEY SILT TO SILTY CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	306-21-1	12.5	82.3
⊠	306-21-2	9.4	86.0

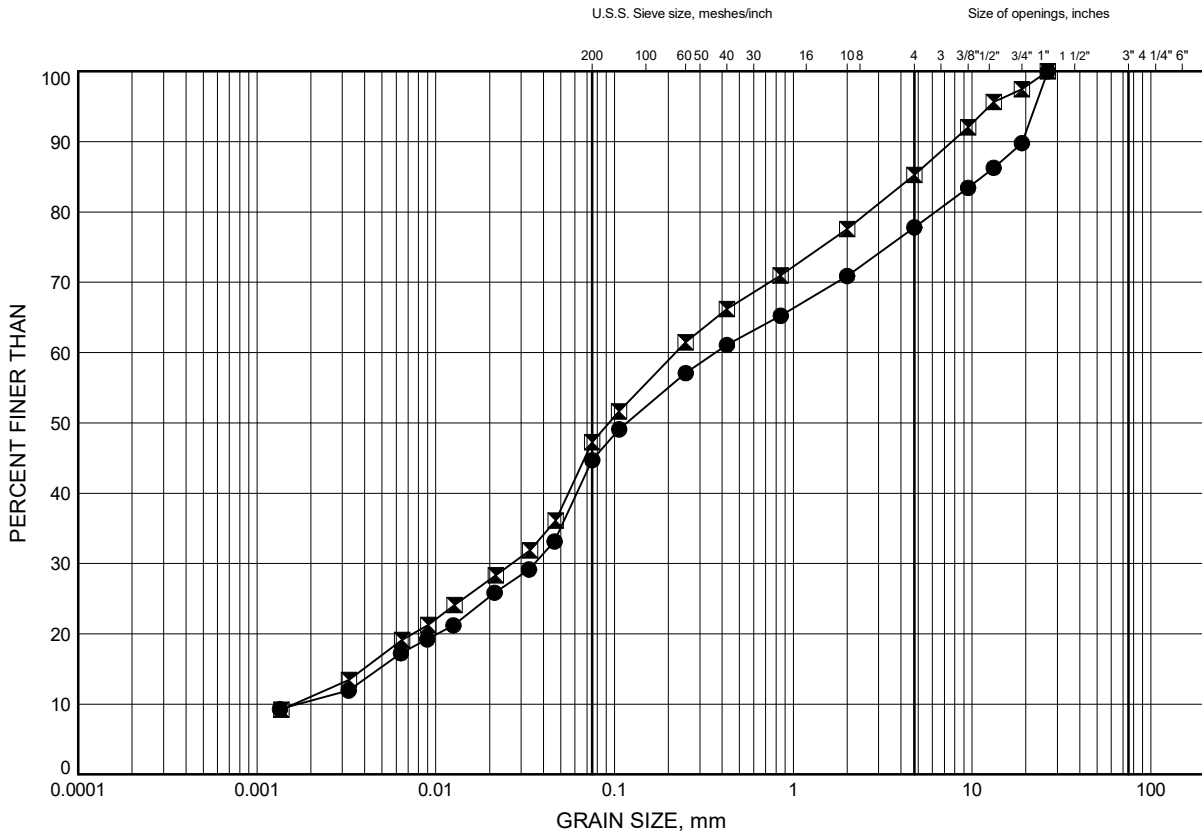
Date December 2021
 WP# 4024-20-00



Prep'd SH
 Chkd. MJK

GRAIN SIZE DISTRIBUTION

GLACIAL TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	306-21-2	11.0	84.5
⊠	306-21-2	14.0	81.4

Date December 2021

WP# 4024-20-00

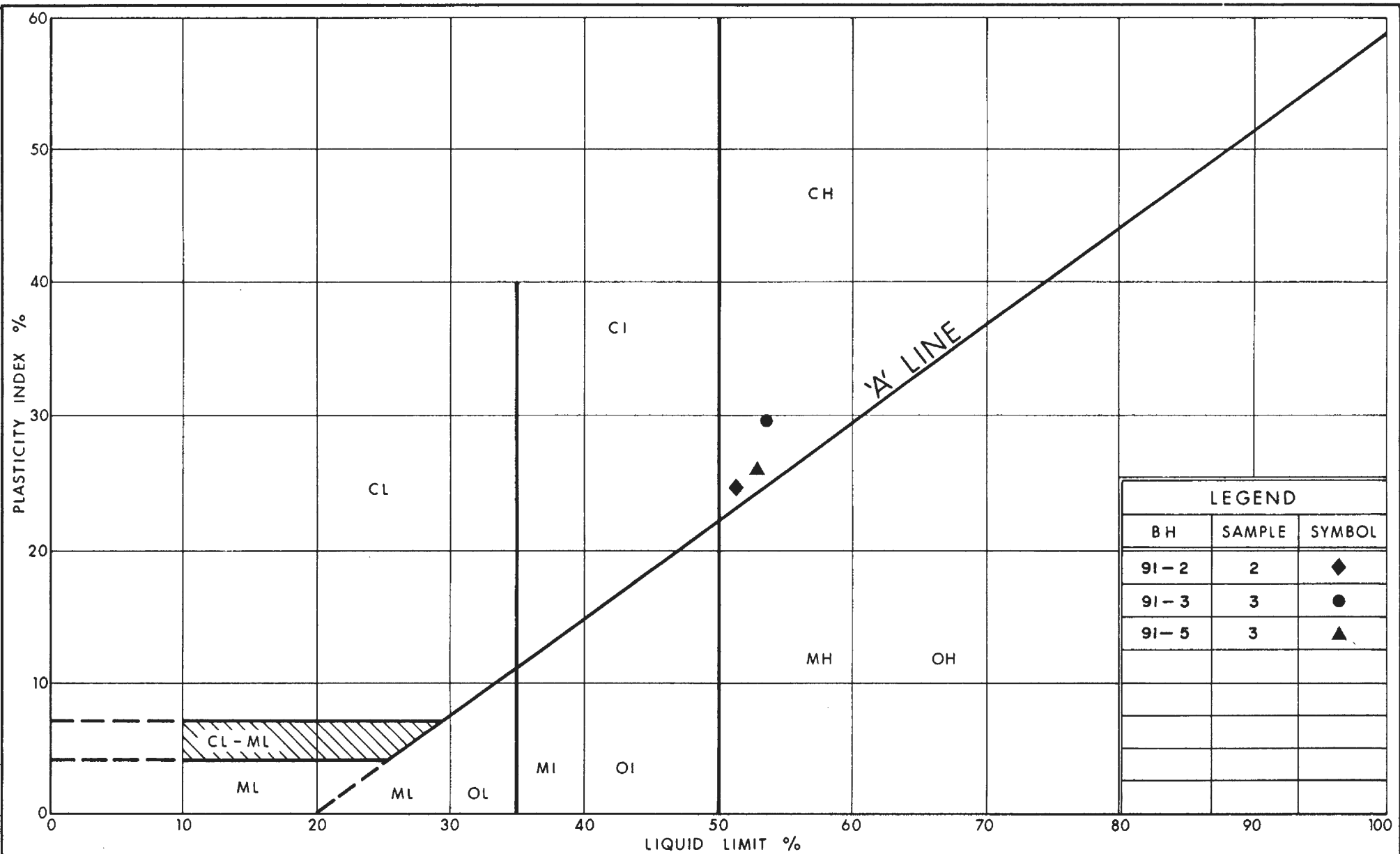


Prep'd SH

Chkd. MJK



Appendix C.2
Particle Size Analysis Figures (1991)
Atterberg Limit Test Results (1991)



Ministry of
Transportation

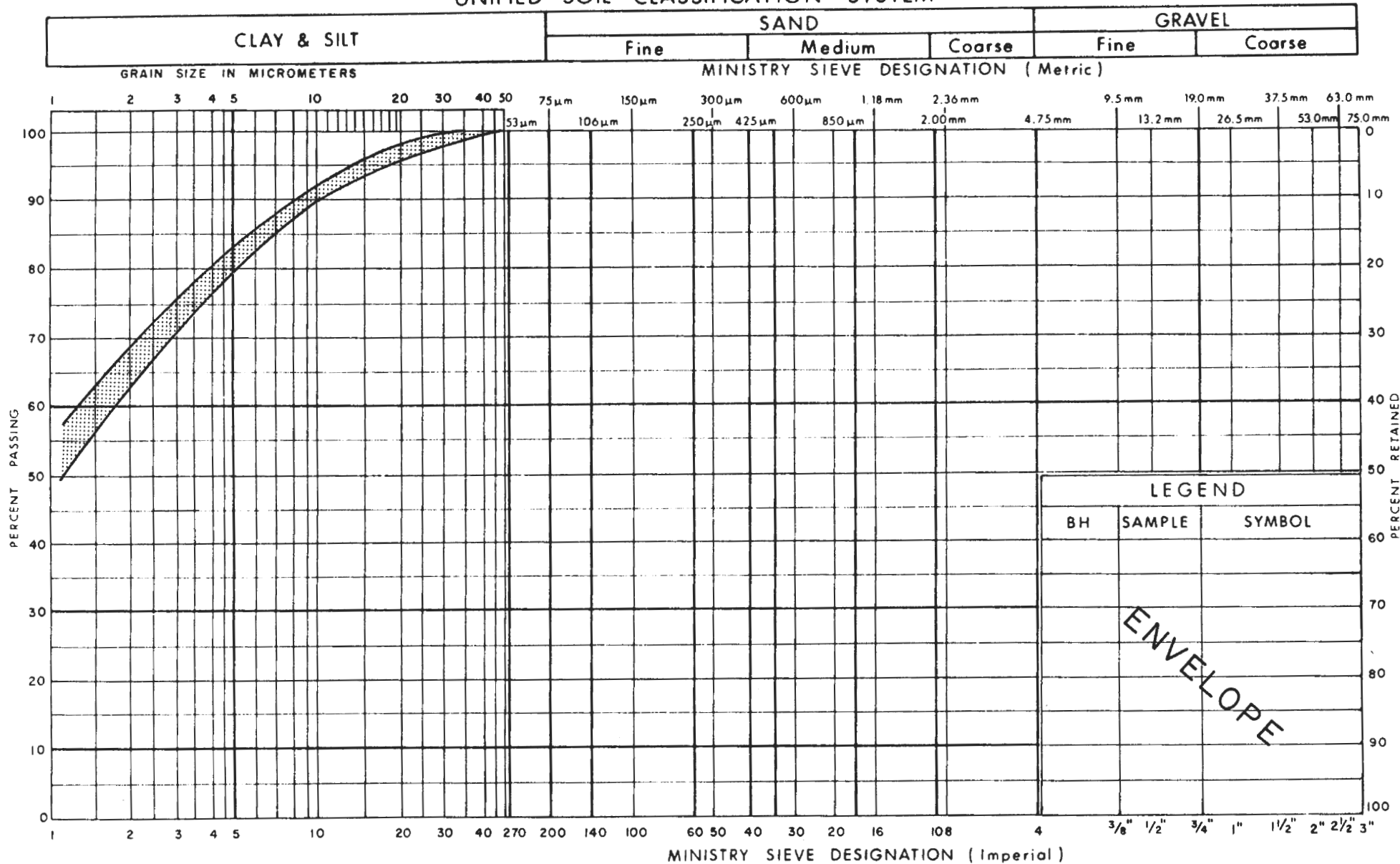
Ontario

PLASTICITY CHART CLAY

FIG No 1

W P 374 - 89 - 02

UNIFIED SOIL CLASSIFICATION SYSTEM



Ontario

Ministry of
Transportation

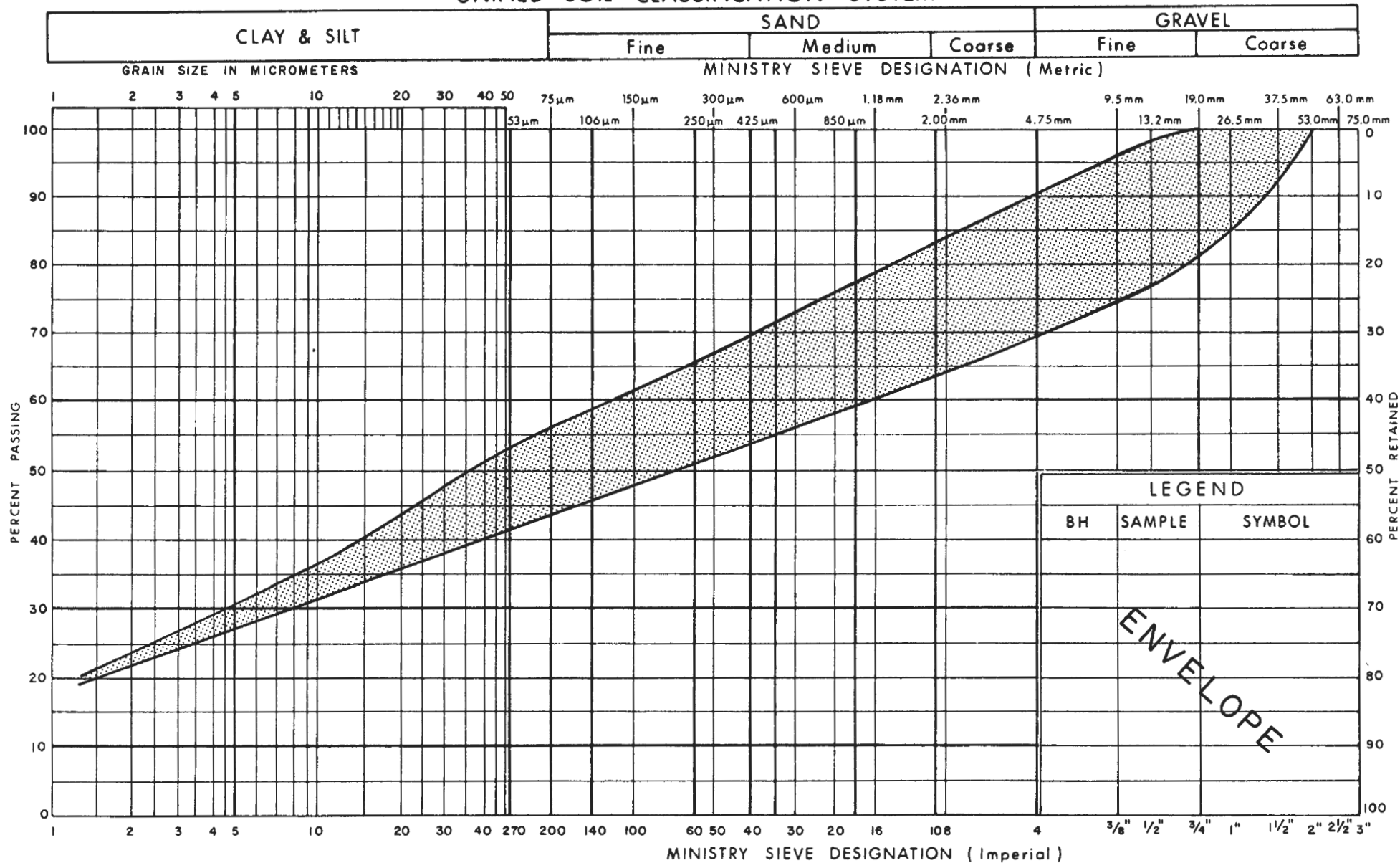
GRAIN SIZE DISTRIBUTION

CLAY

FIG No 2

W P 374 - 89 - 02

UNIFIED SOIL CLASSIFICATION SYSTEM

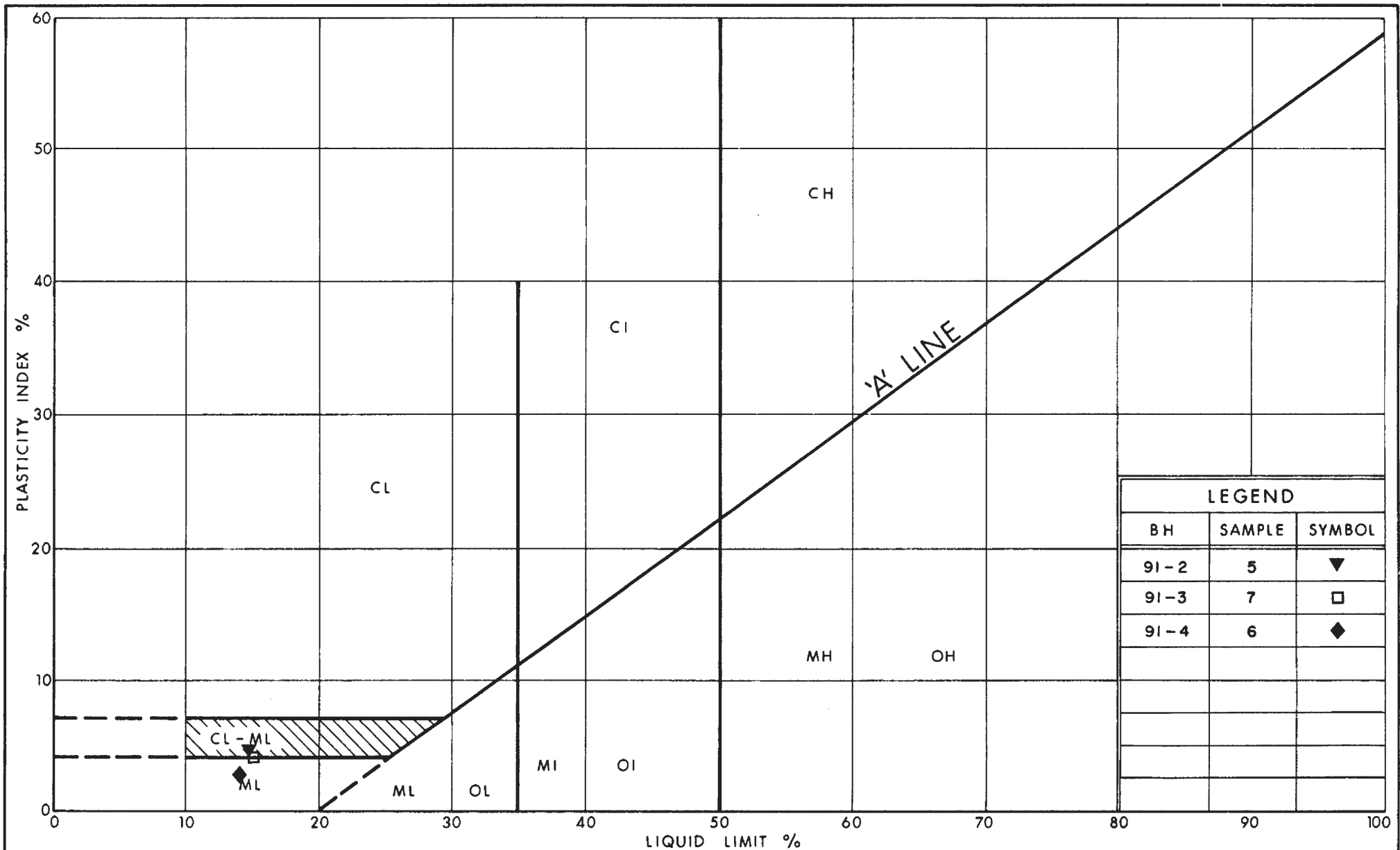


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF SILTY SAND,
SOME CLAY & GRAVEL, OCCASIONAL BOULDERS (Glacial Till)

FIG No 3

W P 374-89-02



Ministry of
Transportation

Ontario

PLASTICITY CHART
HET MIXTURE OF SILTY SAND,
SOME CLAY & GRAVEL, OCCASIONAL BOULDERS (Glacial Till)

FIG No 4

W P 374 - 89 - 02



Appendix C.3

UCS Test Results



Stantec

Stantec Consulting Ltd
2781 Lancaster Rd, Suite 100 A&B
Ottawa, ON K1B 1A7
Tel: (613) 738-6075
Fax: (613) 722-2799

May 25, 2021
File: 122410864

Attention: Thurber Engineering, File #29381

Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core
Highway 401/416 Interchange

The following table summarizes unconfined compressive strength results for five intact rock cores.

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
259-21-1 Run-2	8'6"-9'1"	205.3	Well-formed cone at both ends
306-21-2 Run-1	77'2"-77'9"	219.8	Well-formed cone at both ends
307-21-1 Run-1	55'-55'7"	162.4	Well-formed cone at both ends
308-21-1 Run-2	72'6"-73'3"	216.9	Vertical cracking throughout, no well-formed cones.
250-21-21 Run-2	24'8"-25'3"	181.6	Well-formed cone at both ends

Sincerely,

Stantec Consulting Ltd

Brian Prevost

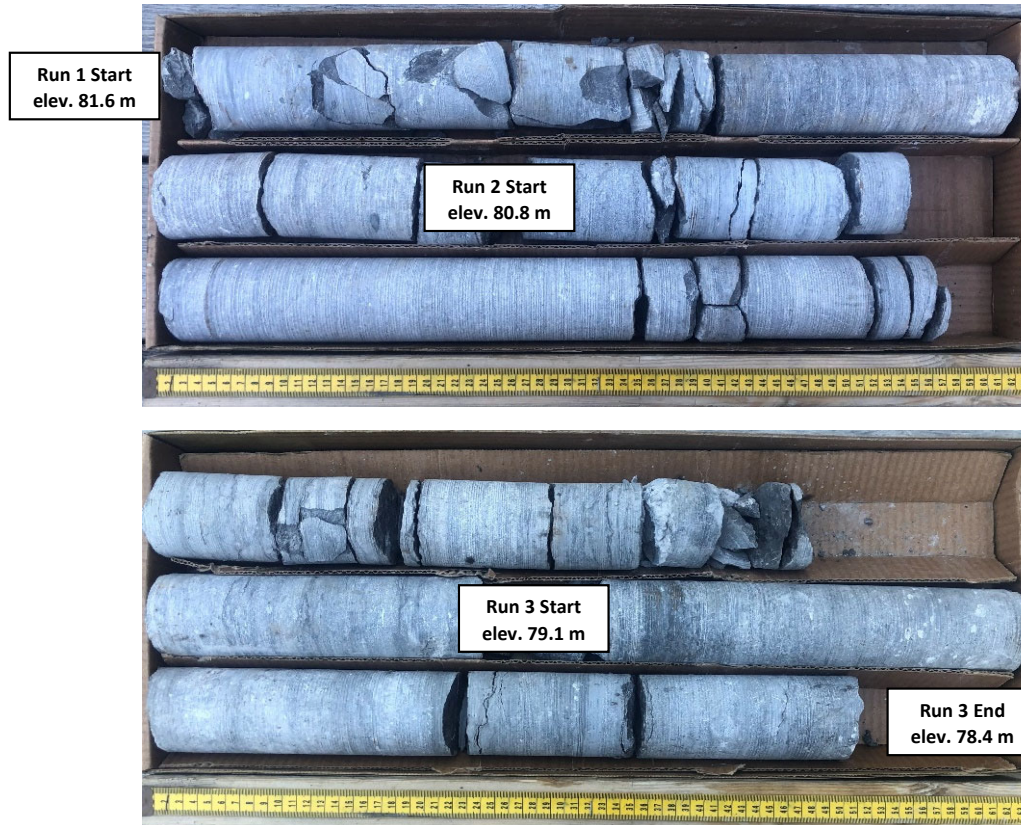
Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
brian.prevost@stantec.com



Appendix C.4

Bedrock Core Photographs

Borehole 306-21-1
Run 1 to 3 (of 3)
Elevation 81.6 m to 78.4 m
Dry

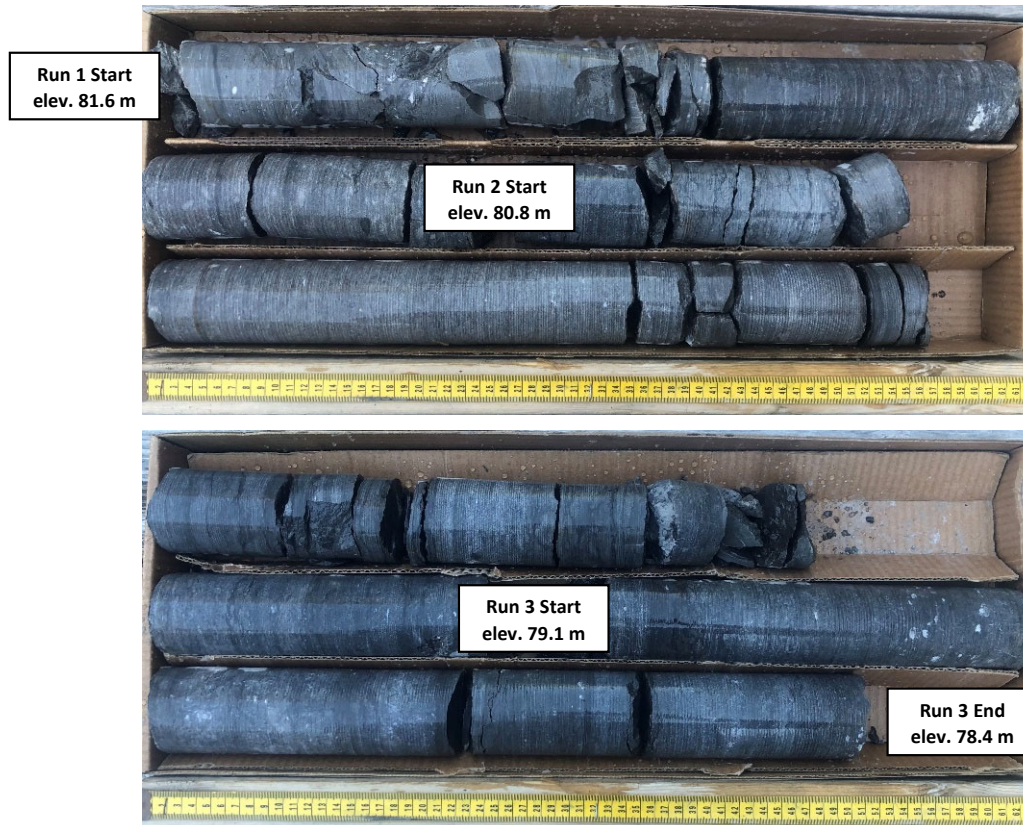


THURBER ENGINEERING LTD.

Highway 401/416 Interchange
Hwy 401W – 416N Ramp (Site No. 16X-0306)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 306-21-1
Project No.: 29381

Borehole 306-21-1
Run 1 to 3 (of 3)
Elevation 81.6 m to 78.4 m
Wet

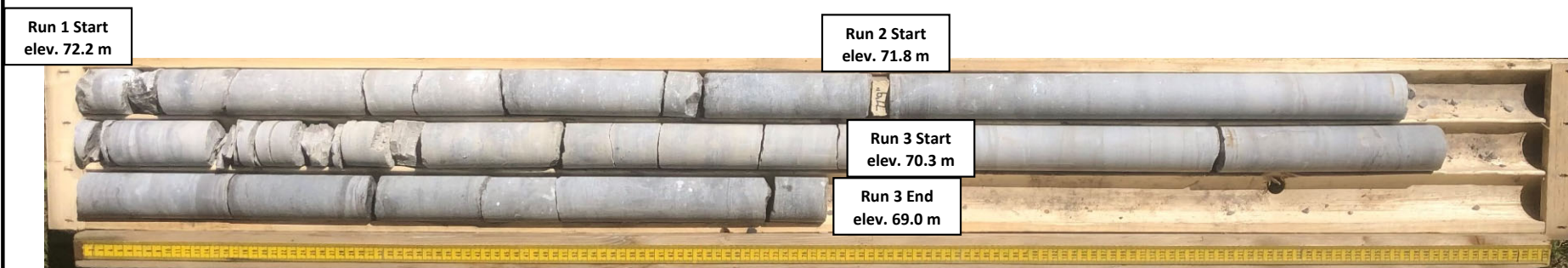


THURBER ENGINEERING LTD.

Highway 401/416 Interchange
Hwy 401W – 416N Ramp (Site No. 16X-0306)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 306-21-1
Project No.: 29381

Borehole 306-21-2
Run 1 to 3 (of 3)
Elevation 72.6 m to 69.0 m
Dry

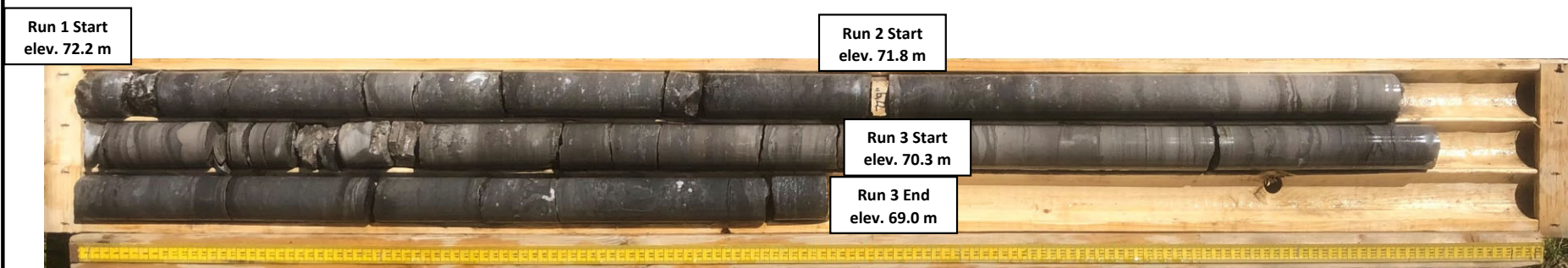


THURBER ENGINEERING LTD.

Highway 401/416 Interchange
Hwy 401W – 416N Ramp (Site No. 16X-0306)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 306-21-2
Project No.: 29381

Borehole 306-21-2
Run 1 to 3 (of 3)
Elevation 72.6 m to 69.0 m
Wet



THURBER ENGINEERING LTD.

Highway 401/416 Interchange
Hwy 401W – 416N Ramp (Site No. 16X-0306)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 306-21-2
Project No.: 29381



Appendix D.

Site Photographs



Photo 1. Looking north at northwest embankment (2021/03/29)



Photo 2. Looking north at northeast embankment (2021/03/29)



Photo 3. Looking south along deck. (2021/03/29)



Photo 4. Looking north at southeast embankment and culvert 16-259/C outlet (below/right). (2021/03/29)



Photo 5. Looking south at southwest embankment. (2021/03/29)



Photo 6. Looking west at south abutment bearings. (2021/03/29)