



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 101 GHOST RIVER BRIDGE REHABILITATION
SITE NO. 39E-0154/B0**

**DISTRICT OF COCHRANE, ONTARIO
MTO ASSIGNMENT NO. 5021-E-0027
G.W.P. 5185-16-00, W.P. 5343-19-01**

GEOCRES Number: 32D12-001

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PART A: FACTUAL INFORMATION

1. INTRODUCTION

Thurber Engineering (Thurber) has been retained by McIntosh Perry Consulting Engineers Ltd. (McIntosh Perry) on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the rehabilitation of Ghost River Bridge (Site No. 39E-0154/B0) under Assignment No. 5021-E-0027.

This report presents the results of the foundation investigation carried out for the proposed rehabilitation of Ghost River bridge on Highway 101.

The purpose of this investigation was to explore the subsurface conditions at the bridge site by borehole drilling and laboratory testing and to prepare a borehole location plan, stratigraphic profiles, records of boreholes, laboratory test results, and a description of the subsurface conditions.

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

The site is located approximately 4.3 km west of the junction of Highway 672 and Highway 101, in the District of Cochrane, Ontario. The existing structure was constructed in 1962 and is a three-span cast-in-place concrete slab on steel girder bridge, support on semi-integral abutments and piers, with an overall length and width of 61 m and 10.4 m, respectively.

In general, the topography in the area surrounding the existing structure consists of undulating terrain, including densely forested areas, rivers, and areas of standing water. Highway 101 is comprised of two paved lanes and narrow, partially paved shoulders. The highway grade is between Elev. 272.7 m and 273.1 m, gradually rising towards the west beyond the existing structure.

Site photographs taken during the foundation investigation are presented in Appendix A.

3. INVESTIGATION PROCEDURES

The foundation investigation was carried out between November 29 and December 1, 2023, and consisted of the drilling and sampling of two boreholes advanced through the existing highway embankment to a depth of 13.4 m. Upon reaching target depth of investigation, Dynamic Cone Penetration Testing (DCPT) was carried out through the base of each borehole to refusal/practical refusal.

The Record of Borehole sheets for the boreholes are included in Appendix B.

Utility clearances were obtained prior to mobilization to site. The coordinates of the as-drilled borehole locations were determined through offset measurements against the highway centreline and the existing structure. The ground surface elevations of the boreholes were obtained by superimposing the as-drilled locations on a contour plan provided by McIntosh Perry. The coordinate system MTM NAD 83, Zone 12 was used for the boreholes. The survey was carried out with accuracy consistent with MTO's Guideline for Foundation Engineering Services (version 3.0), date April 2022.

The boreholes were advanced using a truck-mounted Diedrich D90 drill rig with 205 mm outside diameter hollow stem augers, and soil samples were obtained at selected intervals using split-spoon samplers in general accordance with ASTM D1586.

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

Groundwater level readings observed upon completion of drilling are shown on the Record of Borehole sheets. The borehole completion details are summarized below.

Borehole	Depth of Borehole / Termination Elevation (m)	Depth of DCPT / Termination Elevation (m)	Northing and Easting MTM NAD83 Zone 12	Completion Details
GRB-01	13.4 / 259.1	15.1 / 257.4	N 5,337,138.3 E 388,172.6	Backfilled with bentonite and soil cuttings, sand and gravel, then concrete and asphalt patch at surface.
GRB-02	13.4 / 259.7	22.6 / 250.5	N 5,337,120.4 E 388,094.1	Backfilled with bentonite and soil cuttings, sand and gravel, then concrete and asphalt patch at surface.



All recovered soil samples were subjected to visual identification and natural moisture content determination. Selected samples were subjected to grain size distribution analysis and/or Atterberg Limits testing. The results of this testing program are summarized on the Record of Borehole sheets in Appendix B and are shown on the figures in Appendix C.

4. SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Site Geology

Based on Northern Ontario Engineering Geology Terrain Study (NOEGTS) mapping, the site is within a glaciolacustrine deposit comprised of silts and clays with minor sand.

4.2 Subsurface Conditions

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and interpreted stratigraphic profile and section are presented on the Borehole Locations and Soil Strata Drawings in Appendix D. 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 Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. Classification and descriptions of coarse- and fine-grained soils are made in accordance with ASTM D2487, and MTO's Soil Classification Manual (as amended), respectively.

The results of in-situ testing (i.e., standard penetration testing, shear vane testing and dynamic cone penetration testing) as presented in the record of boreholes and in the following sections are uncorrected. The boundaries between soil deposits on the record of boreholes have been inferred from non-continuous sampling, observation of the progress of drilling, and the results of Standard Penetration Testing. Therefore, the boundaries represent the transitions between soil deposits rather than exact planes of geological change. Variation on the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In general, the subsurface conditions encountered consisted of embankment fill comprised of sand to silty sand, underlain by a native deposit of silty clay to clay, which in turn is underlain by a deposit of silt.

4.3 Asphalt

Asphalt approximately 125 mm and 200 mm thick was encountered at ground surface in Boreholes GRB-01 and GRB-02, respectively.

4.4 Embankment Fill

Granular embankment fill was encountered below the asphalt and is comprised of sand, trace to some silt, trace gravel, to silty sand, trace gravel. Occasional cobbles were noted in the auger cuttings during the advancement of Borehole GRB-01.

The embankment fill was about 3.6 m and 3.5 m thick in Boreholes GRB-01 and GRB-02, respectively, and extends to a depth of 3.7 m below ground surface (Elev. 268.8 m and 269.4 m, respectively). Wood fragments were noted in samples from a depth of 3.0 m to 3.7 m in Borehole GRB-01 (Elev. 269.5 m to 268.8 m).

The SPT 'N' values recorded in the embankment fill ranged from 13 blows per 0.3 m of penetration to 50 blows per 0.125 m of penetration, indicating a compact to very dense condition. The measured moisture contents generally ranged from 2 per cent to 19 per cent.

The results of grain size analyses carried out on selected samples of the embankment fill are shown on the Record of Borehole sheets in Appendix B and presented in Figure C1 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	3 to 4
Sand	76 to 84
Silt	11 to 18
Clay	1 to 3

4.5 Silty Clay to Clay

A 6.5 m to 8 m thick deposit of silty clay to clay, containing organics was encountered below the embankment fill. The cohesive deposit extends to a depth of 10.8 m (Elev. 261.7 m) and 11.7 m (Elev. 261.3 m) in Boreholes GRB-01 and GRB-02, respectively. In Borehole GRB-01, the base of the cohesive deposit transitions into a sandy silt clay.

SPT 'N' values recorded in the silty clay to clay ranged from 0 blows (i.e., weight of rod) to 9 blows per 0.3 m of penetration. In general, shear vane testing carried out within silty clay to clay recorded undrained shear strengths ranging from 38 kPa to 94 kPa; however, an undrained shear strength of 150 kPa was also recorded albeit within the sandy silty clay portion of the deposit. The sensitivity of silty clay to clay was typically between 1.3 and 4.0; however, a sensitivity of 10.9 was calculated at Elev. 265.9 m in Borehole GRB-02. Based on the recorded SPT 'N' values and

undrained shear strength recorded, the silty clay to clay is considered to have a very soft to stiff consistency.

The measured moisture contents were between 23 per cent and 63 per cent.

The result of grain size analysis carried out on a sample of the sandy silty clay is shown on the Record of Borehole sheets in Appendix B and presented in Figures C2 of Appendix C. The result is summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	25
Silt	40
Clay	35

The results of the Atterberg Limits test carried out on samples of cohesive deposit are shown on the Record of Borehole logs in Appendix B and presented in Figure C3 of Appendix C. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	28 to 73
Plastic Limit	18 to 25
Plastic Index	10 to 48

Except for one test result indicating the material is a silty clay of low plasticity (CL), the results of the Atterberg Limits testing indicate the material is typically silty clay of medium plasticity (CI) to a clay of high plasticity (CH). It should be noted that the liquidity indices of the silty clay to clay were greater than 1.0 in Borehole GRB-02 while the liquidity indices of the silty clay to clay in Borehole GRB-01 were generally less than 1.0. In addition, the liquid limit and plasticity index of the material were observed to decrease with depth in both boreholes.

4.6 Silt

A deposit of silt, some sand was encountered below the silty clay to clay deposit at a depth of 10.8 m (Elev. 261.7 m) and 11.7 m (Elev. 261.3 m) below ground surface in Boreholes GRB-01 and GRB-02, respectively. The silt was at least 2.6 m and 1.7 m in Boreholes GRB-01 and GRB-02, respectively, prior to reaching borehole termination depth.

SPT 'N' values recorded in the silt ranged from 0 blows (i.e., weight of rod) to 8 blows per 0.3 m of penetration, indicating a very loose to loose condition. The measured moisture contents were between 24 per cent and 31 per cent.

The results of grain size analyses carried out on samples of the silt are shown on the Record of Borehole sheets in Appendix B and presented in Figure C4 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0
Sand	17 to 18
Silt	79 to 80
Clay	3

Atterberg Limits testing was attempted on a sample of the silt from Borehole GRB-01 but was determined to be non-plastic. The sample that was determined to be non-plastic is noted on the Record of Borehole sheet for GRB-01.

4.7 Dynamic Cone Penetration Tests

Dynamic Cone Penetration Testing (DCPT) was carried out through the base of each abutment upon reaching the target depth of investigation. The results of DCPTs are summarized below:

Borehole	Starting and End Depth (m)	Starting and End Elevation (m)	Remark
GRB-01	13.4 / 15.1	259.1 / 257.4	A blow count of 100 blows per 0.2 m was recorded at a depth of 15.1 m below ground surface
GRB-02	13.4 / 22.6	259.7 / 250.2	Test was terminated at a depth of 22.6 m below ground surface

When compared to the available subsurface information from GEOCRE Report No. 32D-004, the end of DCPTs were consistent with the base of the silt deposit.

4.8 Groundwater Conditions

Details of the water level observed in the boreholes upon completion of drilling are presented on the record of boreholes and summarized below.

Borehole	Date of Measurement	Groundwater Level (m)		Remark
		Depth	Elevation	
GRB-01	November 29, 2023	5.3	267.2	Water level measured in hollow stem augers upon completion of drilling.
GRB-02	December 1, 2023	3.4	269.7	Water level measured in hollow stem augers upon completion of drilling.

The water levels measured in the borehole upon completion of drilling are short-term observations and subject to seasonal fluctuations. In particular, the water levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

5. MISCELLANEOUS

Walker Drilling Ltd. of Utopia, Ontario supplied and operated the drilling, sampling, and in-situ testing equipment for the foundation investigation. The investigation was supervised on a full-time basis by Mr. Ian Ross, B.A.Sc. The overall management of the field program was conducted by Mr. Christopher Ng, P.Eng.

Geotechnical laboratory testing on soil samples was carried out in Thurber's geotechnical laboratory.

Interpretation of the field data and preparation of this report was carried out by Mr. Christopher Ng, P.Eng., and was reviewed by Mr. Jason Lee, P.Eng.



THURBER ENGINEERING LTD.

Thurber Engineering Ltd.



Christopher Ng, P. Eng.
Associate, Senior Geotechnical Engineer

Date: **February 23, 2024**

File: **33730-GRB**



Jason Lee, P. Eng., M.Sc.
Partner, Senior Geotechnical Engineer
Designated MTO Contact

PART B: ENGINEERING DISCUSSION AND RECOMMENDATIONS

6. GENERAL

This report provides an interpretation of the geotechnical data in the foundation investigation report and presents foundation design recommendations to assist the design team in selecting and designing a suitable Temporary Protection Systems (TPS) for the rehabilitation of Ghost River Bridge on Highway 101. It is understood that the rehabilitation will include reconstruction of wing walls, ballast walls, and deck ends, installation of new approach slabs and sleeper slabs, and the replacement of bearings at the abutments and piers. Temporary Protection Systems will be required to maintain the stability of the approach embankment and two-way traffic on Highway 101. Based on the General Arrangement (GA) Drawing dated September 2023, it is understood that up to about 2 m of excavation below highway grade will be required to facilitate the rehabilitation at the abutments.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, Ontario, and the designer to carry out the bridge rehabilitation and shall not be used or relied upon for any other purposes or by any other parties including the constructor or design-build contractor. The constructor or contractor must make their own interpretation based on the data provided in factual portion of the report (Part A).

Where comments are made on construction, they are provided to highlight those aspects which could affect the design of the project. The constructor or contractor must make their own interpretation of the factual data as such interpretation may affect equipment selection, proposed construction methods, scheduling, and the like.

7. TEMPORARY EXCAVATIONS AND PROTECTION SYSTEMS

The proposed rehabilitation work will require the removal of the pavement structure and excavation into the existing embankment fill material.

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). The silty sand to sand embankment fills above the groundwater level are classified as a Type 3. Below the groundwater level, the embankment fills, and all native soils are classified as Type 4 soil. For Type 3 soils, temporary cut slopes should have a gradient of 1H:1V or flatter and while Type 4 soils should have a gradient of 3H:1V or flatter. Where required, excavations could be supported with temporary protection systems.

Consideration should be given to protecting the temporary cut slopes from precipitation and runoffs during construction to avoid erosion and surficial instability. Stability of the highway embankment and temporary cut slopes during construction are the responsibility of the contractor.

Excavated material must be stockpiled at a distance away from the excavation equal to or greater than the depth of the open cut excavation. The selection and operation of heavy construction equipment near the open cut excavation are the contractor's responsibility. Stockpiling of excavated material and the operation of construction equipment must not destabilize the embankment.

Temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539, as amended by Special Provision 105S09. The lateral movement of the temporary protection systems shall meet Performance Level 2 as specified in OPSS.PROV 539, provided that any existing adjacent utilities (where present) can tolerate the associated magnitude of deformation. Consideration could be given to the use of sheet pile or soldier pile and lagging system; however, the selection, design, installation, and inspection of temporary protection systems are the responsibility of the contractor.

The soil parameters presented below may apply for the design of temporary roadway protection systems with horizontal backfill.



Stratigraphic Unit	Unit Weight of Material, γ' (kN/m ³)	Angle of Internal Friction, ϕ (kN/m ³)	Undrained Shear Strength, s_u (kPa)	Coefficient of Static Lateral Earth Pressure	
				Active, K_a	Passive, K_p
East Approach Embankment (Borehole GRB-01)					
Sand to Silty Sand Fill	21	32	--	0.31	3.3
Silty Clay to Clay (CI to CH) (Elev. 268.8 m to 265 m)	18	22	90	0.45	2.2
Silty Clay (CI) (Elev. 265 m to 261.7m)	18	25	95	0.40	2.5
Silt	19	29	--	0.35	2.9
West Approach Embankment (Borehole GRB-02)					
Sand to Silty Sand Fill	21	32	--	0.31	3.3
Clay (CH) (Elev. 269.4 m to 265.5 m)	18	22	35	0.45	2.2
Silty Clay (CL to CI) (Elev. 265.5 m to 261.3m)	18	25	35 (top) to 60 (bottom)	0.40	2.5
Silt	19	27	--	0.38	2.7

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 to account for the slope.
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 (CHBDC, 2019) to account for the fact that a large strain would be required for mobilization of the full passive resistance.

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

8. CONTROL OF GROUNDWATER AND SURFACE WATER

For design purposes, the groundwater level should be assumed to be at Elev. 270 m; however, it may be higher during/following periods of heavy/sustained precipitation or snowmelt and would be influenced by the water level in surrounding ditches and depressions. It is anticipated that the base of the excavation during construction will likely be above the groundwater level.

Seepage or perched water from the embankment fill is to be expected. The volume of perched water within the embankment fill is expected to be limited. Surface runoffs should be diverted away from the excavation precipitation should be prevented from entering the excavation. It is anticipated that a pumping from a properly filtered sump would be sufficient to remove water from within the excavation.

9. CONSTRUCTION CONCERNS

During construction, the excavation cut slopes and/or temporary protection systems should be inspected regularly for evidence of instability if the excavation have been left for a prolonged period and following periods of heavy precipitation.

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

- Seasonal fluctuations of the groundwater level are to be expected. Snowmelt and/or heavy precipitation may impact the stability of the temporary cut slopes and/or temporary protection systems.
- Excavations and construction of temporary protection systems should be carried out in a manner as to not disturb or undermine the soils supporting the travelled lane that will be required to maintain traffic on the highway.



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10. CLOSURE

Preparation of the design report was carried out by Mr. Christopher Ng, P.Eng., which was reviewed by Mr. Jason Lee, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



Christopher Ng, P. Eng.
Associate, Senior Geotechnical Engineer



Jason Lee, P. Eng., M.Sc.,
Partner, Senior Geotechnical Engineer
Designated MTO Contact

Date: **February 23, 2024**

File: **33730-GRB**

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

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

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 SITE PHOTOGRAPHS



Photograph #1 – Highway 11 Ghost River bridge looking east. (November 2023)



Photograph #2 – Highway 11 Ghost River bridge look west. (November 2023)



Photograph #3 – Underside of Highway 11 Ghost River bridge, looking northeast. (November 2023)



Photograph #4 – Ghost River, looking north. (November 2023)

APPENDIX B
RECORD OF BOREHOLE SHEETS

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level
 Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

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

RECORD OF BOREHOLE No GRB-01

1 OF 2

METRIC

WP# 5343-19-01 LOCATION MTM 83-12: N 5 377 138.3 E 388 172.6 ORIGINATED BY IR
DIST HWY 17 BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers COMPILED BY AR
DATUM Geodetic DATE 2023.11.29 - 2023.11.29 LATITUDE 48.527297 LONGITUDE -79.871113 CHECKED BY CN

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	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
272.5	GROUND SURFACE											
0.0	ASPHALT: (125 mm)											
0.1	SAND, trace to some silt, trace gravel, containing cobbles Very Dense Brown Moist (FILL)		1	GS	-		272					
			1	SS	60							4 84 11 1
			2	SS	50/ 0.125		271					
			3	SS	56		270					
	Containing wood fragments from a depth of 3.0 m to 3.7 m		4	SS	49		269					
268.8	Silty CLAY (CI) to CLAY (CH) Firm to Very Stiff Grey Moist		5	SS	8		268					
3.7							267					
	Containing organics from a depth of 7.6 m to 8.7 m		6	SS	9		266					
			7	SS	5		265					
263.8	Sandy, silty CLAY (CI), containing organics Soft to Very Stiff Dark Grey Wet		8	SS	3		264					0 25 40 35
8.7							263					

Continued Next Page

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

RECORD OF BOREHOLE No GRB-01

2 OF 2

METRIC

WP# 5343-19-01 LOCATION MTM 83-12: N 5 377 138.3 E 388 172.6 ORIGINATED BY IR
DIST HWY 17 BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers COMPILED BY AR
DATUM Geodetic DATE 2023.11.29 - 2023.11.29 LATITUDE 48.527297 LONGITUDE -79.871113 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				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					
	Continued From Previous Page							20 40 60 80 100					
								○ UNCONFINED + FIELD VANE					
								● QUICK TRIAXIAL × LAB VANE					
								WATER CONTENT (%)					
								20 40 60					
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT					
								W P W W L					
261.7	Sandy, silty CLAY (CI), containing organics Soft to Very Stiff Dark Grey Wet						262						
10.8	SILT , some sand Loose Grey Wet		9	SS	8								
							261						
			10	SS	8		260						
259.1													
13.4	End of Borehole and Soil Sampling. Start of DCPT a depth of 13.4 m						259						
							258						
257.4													
15.1	END OF DCPT AT A DEPTH OF 15.1 m. ON ENCOUNTERING REFUSAL CONDITION. BOREHOLE WATER LEVEL OBSERVED AT 5.3 m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE AND CUTTINGS, SAND AND GRAVEL, THEN CONCRETE AND ASPHALT PATCH AT SURFACE.												

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RECORD OF BOREHOLE No GRB-02

1 OF 3

METRIC

WP# 5343-19-01 LOCATION MTM 83-12: N 5 377 120.4 E 388 094.1 ORIGINATED BY IR
DIST HWY 17 BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers COMPILED BY AR
DATUM Geodetic DATE 2023.12.01 - 2023.12.01 LATITUDE 48.527146 LONGITUDE -79.872178 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		<div><div>PLASTIC LIMIT</div><div>NATURAL MOISTURE CONTENT</div><div>LIQUID LIMIT</div></div> <div><div>W P</div><div>W</div><div>W L</div></div> <div>WATER CONTENT (%)</div>	UNIT WEIGHT <div>γ</div> kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				
273.1	GROUND SURFACE							20 40 60 80 100				
0.0	ASPHALT: (200 mm)						273	20 40 60 80 100				
0.2	SAND, trace to some silt, trace gravel Compact to Very Dense Brown Moist (FILL)		1	GS	-			20 40 60 80 100				
			1	SS	55		272	20 40 60 80 100				
			2	SS	35		271	20 40 60 80 100				
			3	SS	13			20 40 60 80 100				
270.0							270	20 40 60 80 100				
3.0	Silty SAND, trace gravel Compact Brown Wet (FILL)		4	SS	22			20 40 60 80 100				3 76 18 3
269.4							269	20 40 60 80 100				
3.7	Silty CLAY (CL) to CLAY (CH) Very Soft to Stiff Grey Wet		5	SS	WH			20 40 60 80 100				
			6	SS	1		268	20 40 60 80 100				
			7	SS	1		267	20 40 60 80 100				
			8	SS	1		266	20 40 60 80 100				
							265	20 40 60 80 100				
							264	20 40 60 80 100				

Continued Next Page

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

RECORD OF BOREHOLE No GRB-02

2 OF 3

METRIC

WP# 5343-19-01 LOCATION MTM 83-12: N 5 377 120.4 E 388 094.1 ORIGINATED BY IR
DIST HWY 17 BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers COMPILED BY AR
DATUM Geodetic DATE 2023.12.01 - 2023.12.01 LATITUDE 48.527146 LONGITUDE -79.872178 CHECKED BY CN

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
261.3	Continued From Previous Page Silty CLAY (CL) to CLAY (CH) Very Soft to Stiff Grey Wet		9	SS	WR		263								
11.7	SILT , some sand Very Loose Grey Wet		10	SS	WR		262								
259.7	End of Borehole and Soil Sampling. Start of DCPT a depth of 13.4 m						261								
13.4							260								
							259								
							258								
							257								
							256								
							255								
							254								

Continued Next Page

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

RECORD OF BOREHOLE No GRB-02

3 OF 3

METRIC

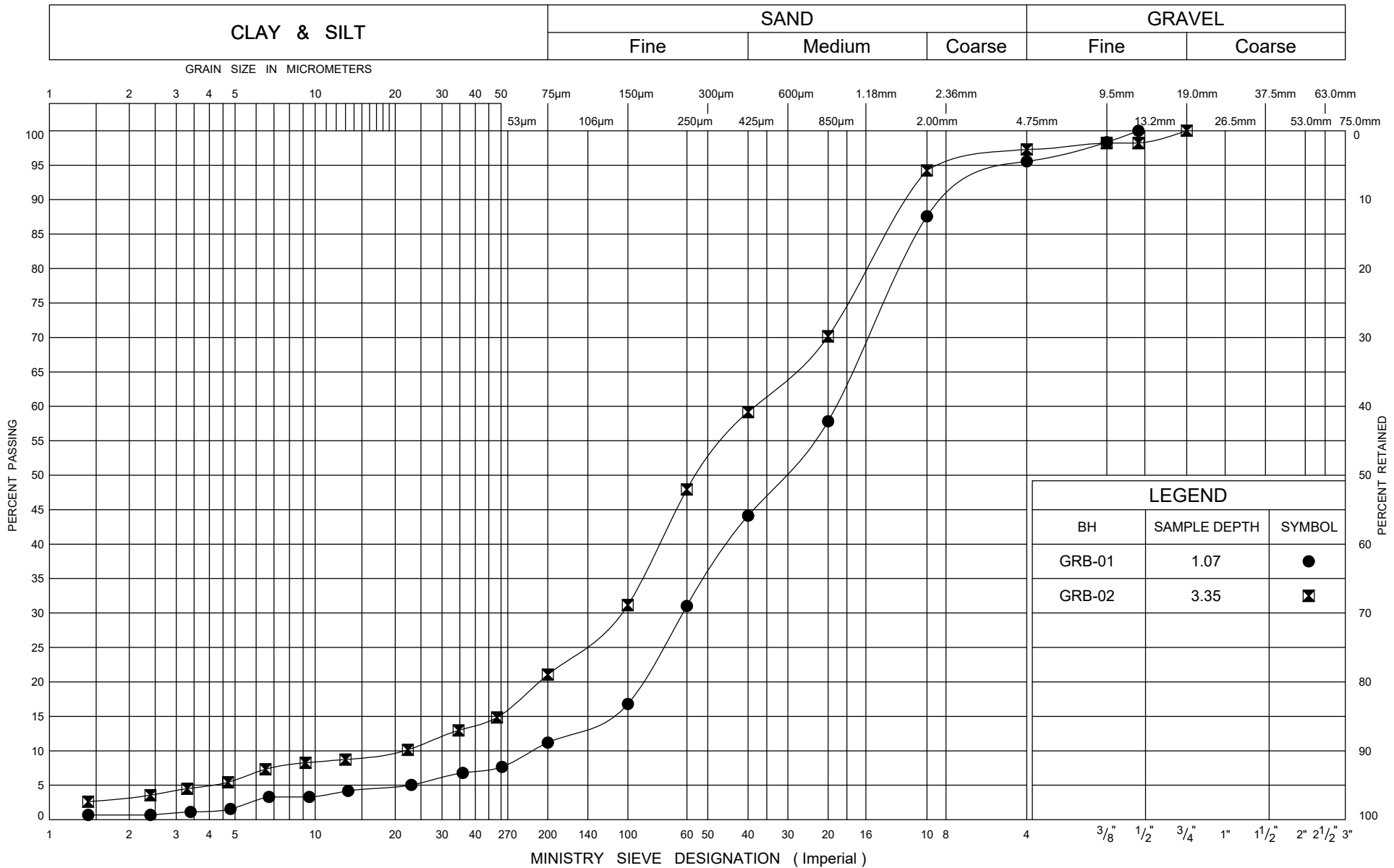
WP# 5343-19-01 LOCATION MTM 83-12: N 5 377 120.4 E 388 094.1 ORIGINATED BY IR
DIST HWY 17 BOREHOLE TYPE 205 mm O.D. Hollow Stem Augers COMPILED BY AR
DATUM Geodetic DATE 2023.12.01 - 2023.12.01 LATITUDE 48.527146 LONGITUDE -79.872178 CHECKED BY CN

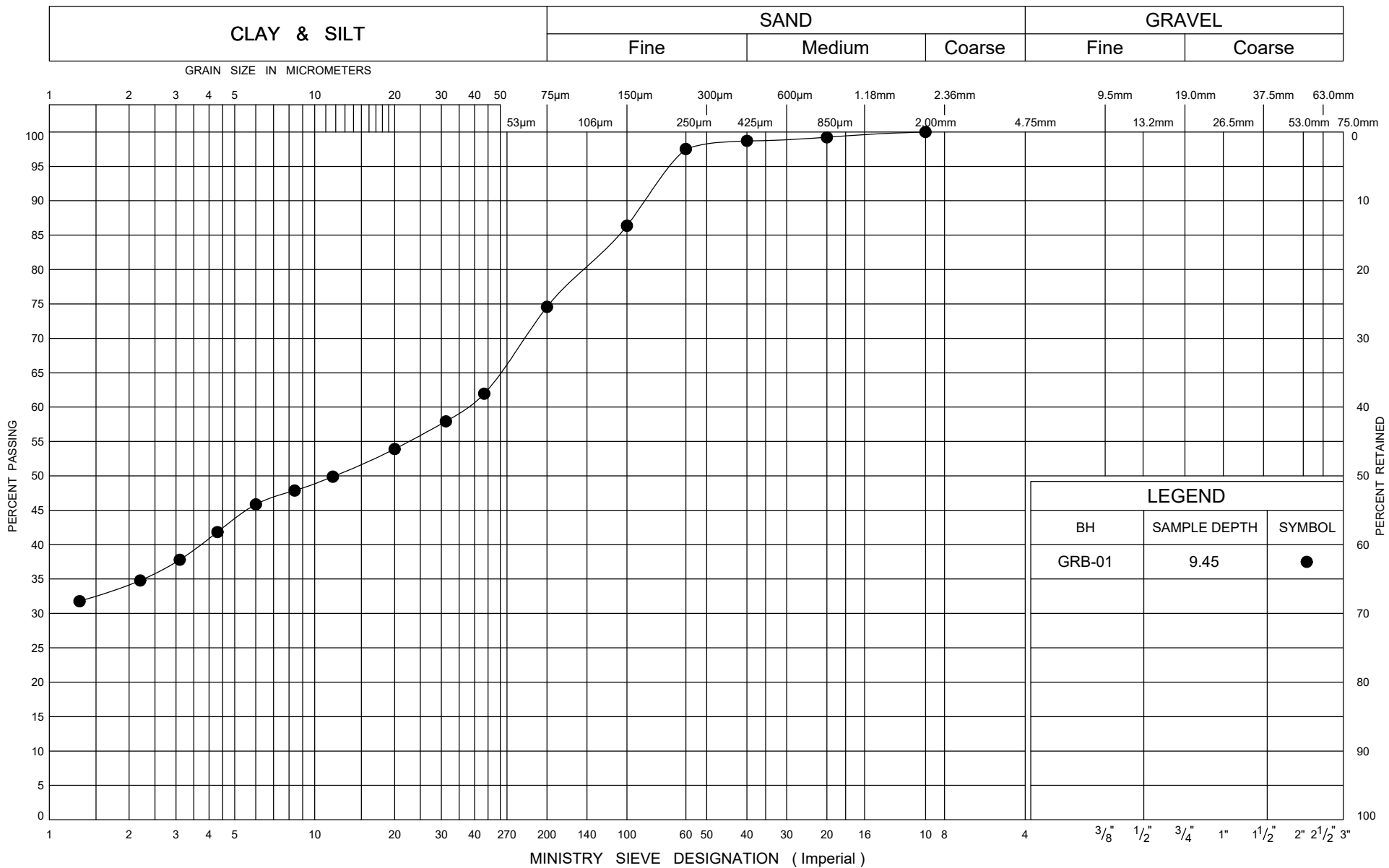
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
	Continued From Previous Page							20 40 60 80 100							
250.5							253								
22.6	END OF DCPT AT A DEPTH OF 22.6 m. BOREHOLE WATER LEVEL OBSERVED AT 3.4 m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE AND CUTTINGS, SAND AND GRAVEL, THEN CONCRETE AND ASPHALT PATCH AT SURFACE.														

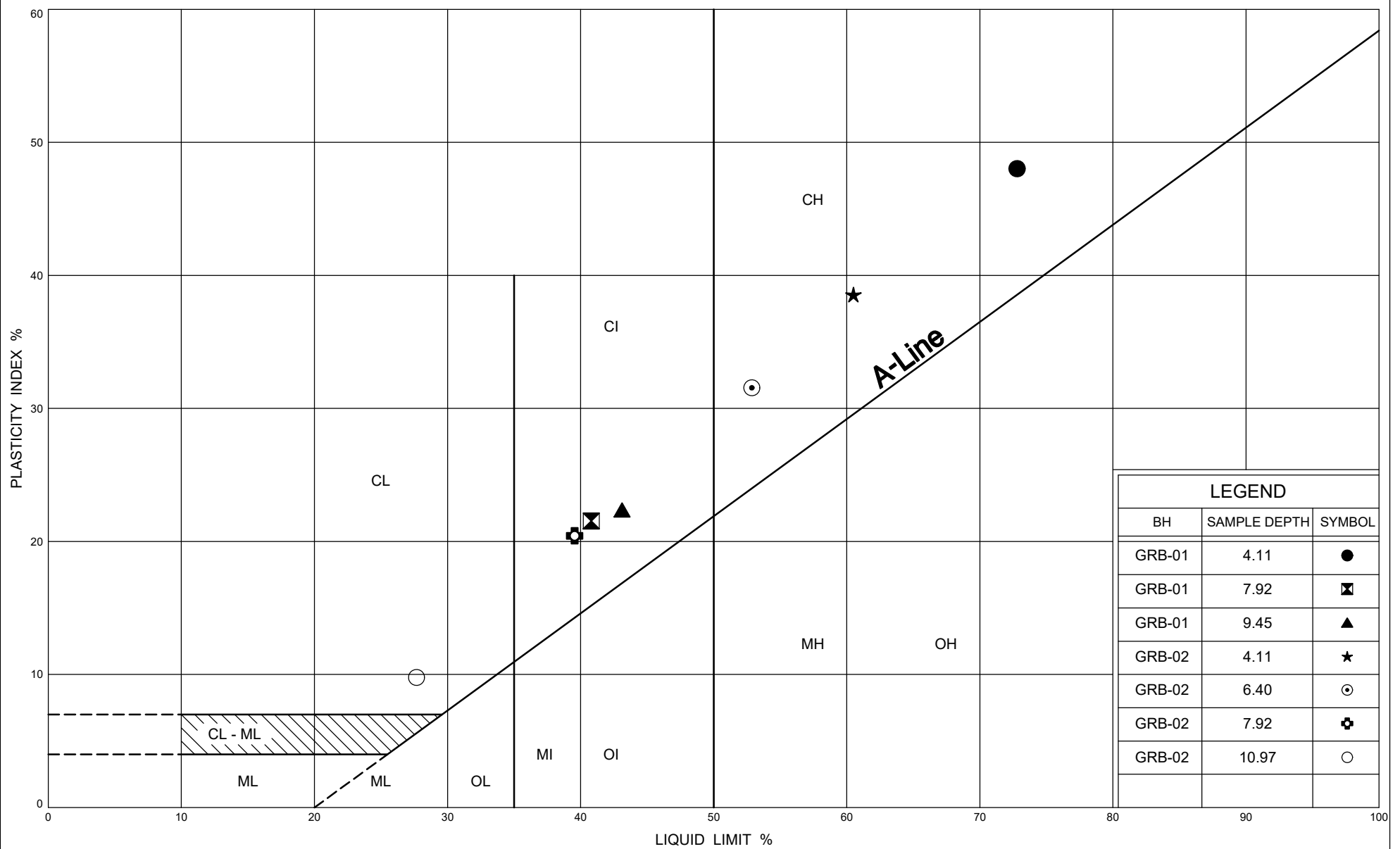
+³, ×³: Numbers refer to Sensitivity
20
15 10 5 0
(%) STRAIN AT FAILURE

APPENDIX C

GEOTECHNICAL AND ANALYTICAL LABORATORY TEST RESULTS







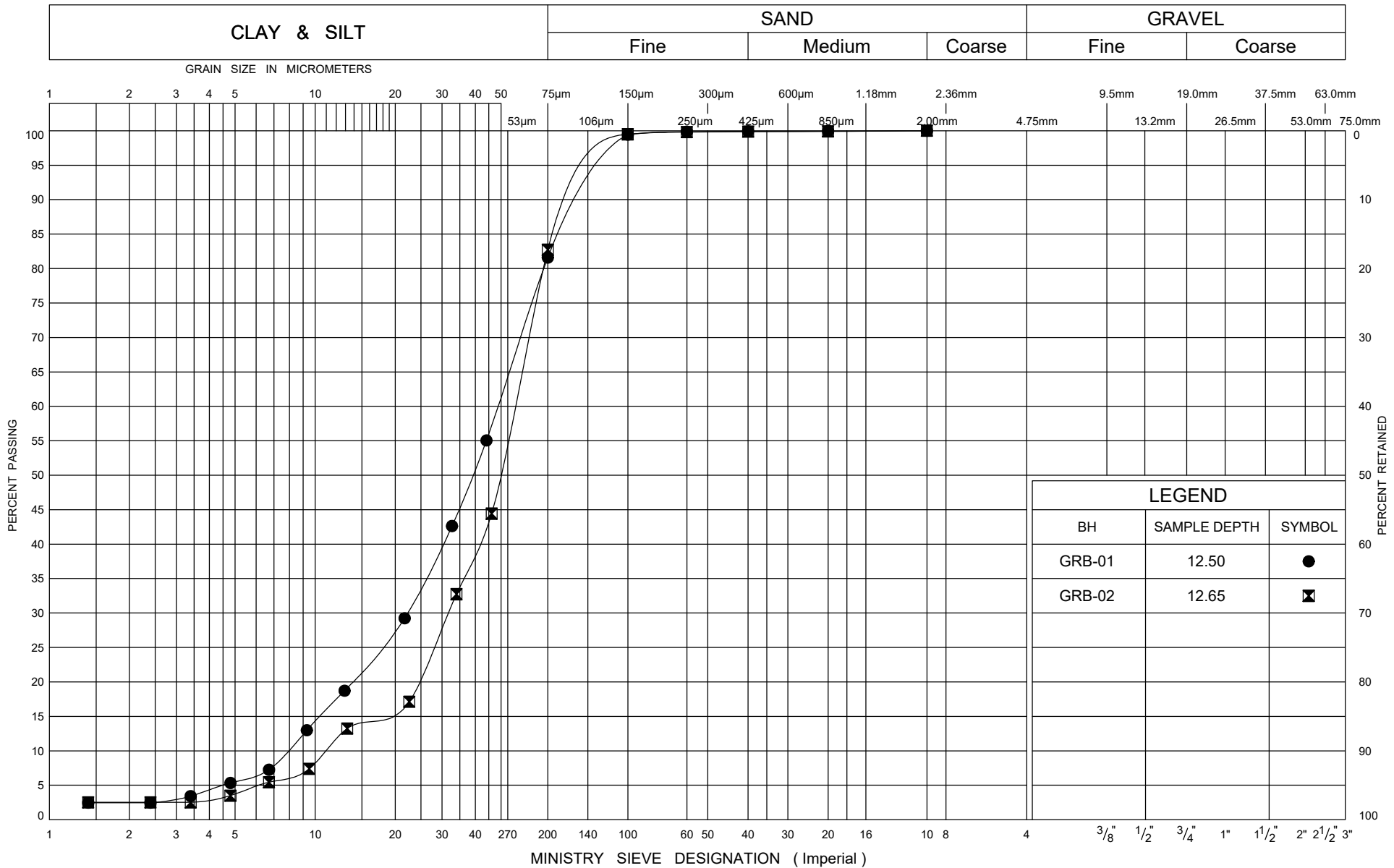
Ministry of
Transportation

PLASTICITY CHART

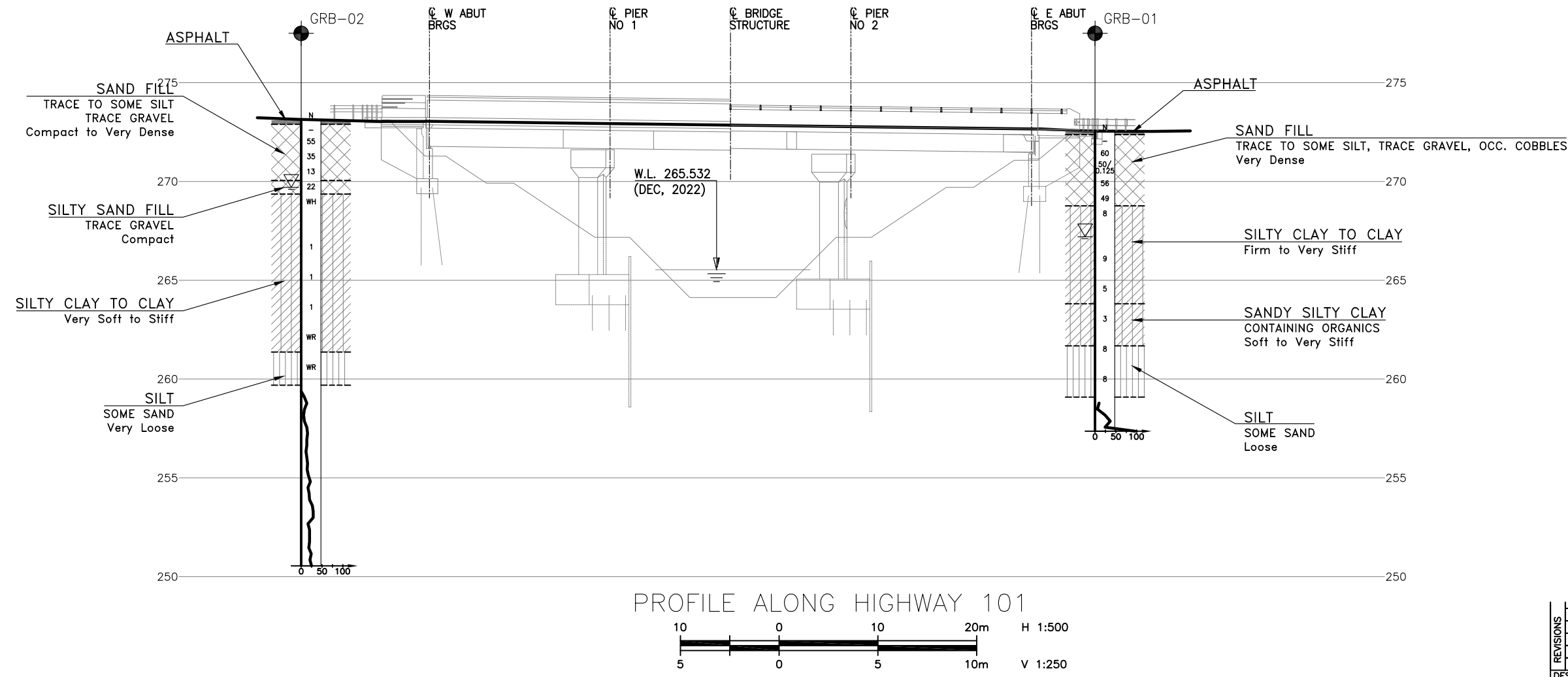
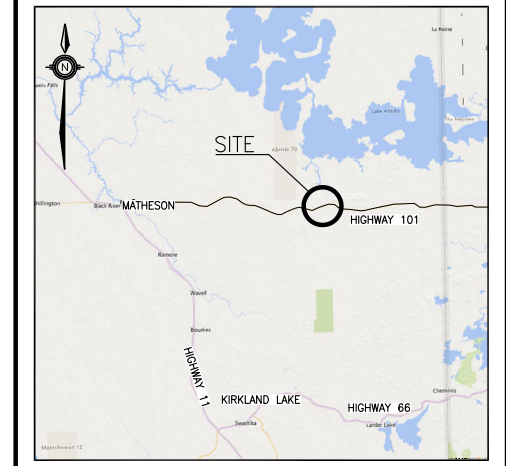
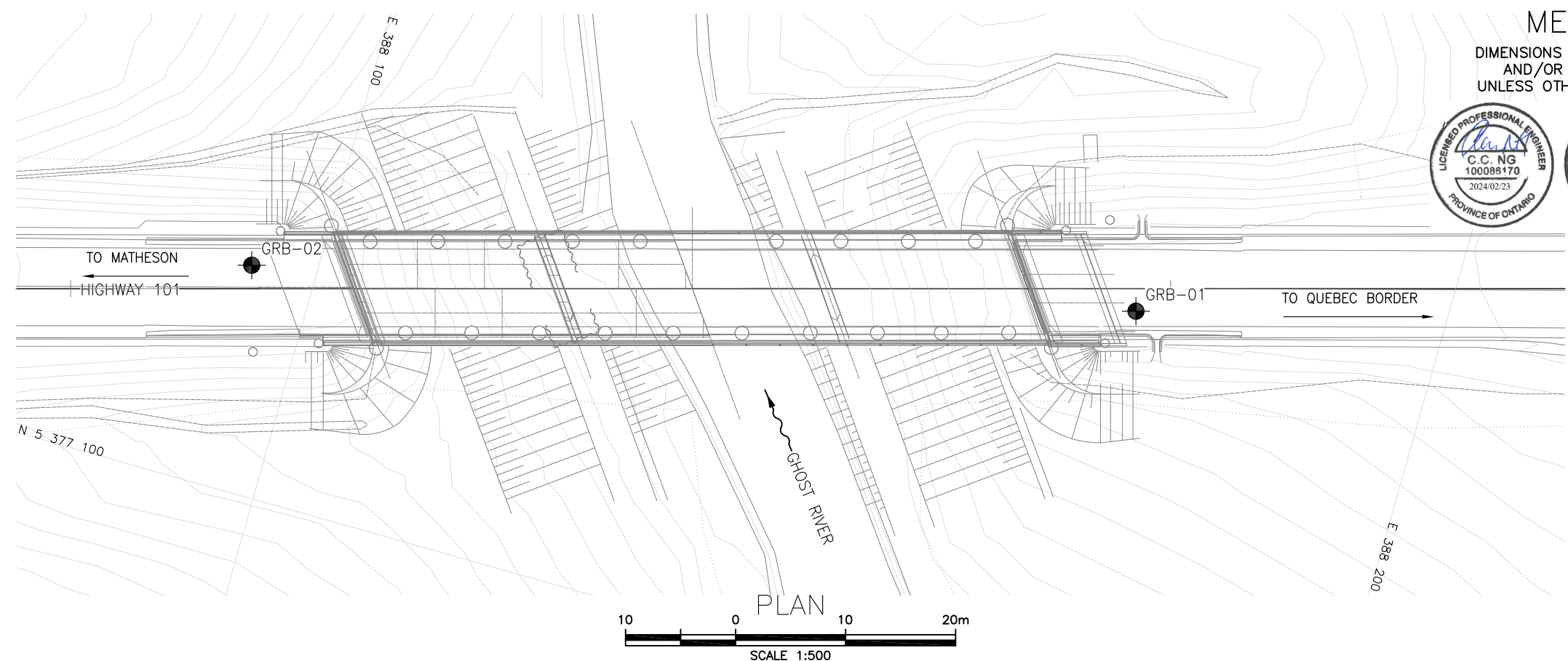
Sandy Silty CLAY to CLAY






FIG No C3

WP# 5343-19-01



APPENDIX D
BOREHOLE LOCATION PLAN AND SOIL STRATA DRAWINGS



L E G E N D	
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	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

[illegible]

- ## -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 12.

GEOCRES No. 32D12-001

REVISIONS								
	DATE	BY	DESCRIPTION					
DESIGN	—	CHK CN	CODE	LOAD	DATE	FEB 2024		
DRAWN	MC	CHK JPL	SITE	STRUCT	DWG	1		