Revised Foundation Investigation and Design Report

TEMPORARY PROTECTION SYSTEM, HIGHWAY 402 (EASTBOUND AND WESTBOUND) AND HOWARD WATSON NATURE TRAIL (FORMER CN) OVERHEAD STRUCTURES, CITY OF SARNIA, ONTARIO, MINISTRY OF TRANSPORTATION, ONTARIO
GWP 3105-18-00

SITE NO.: 14X-0337/B1 AND 14X-0337/B2

Site NO.	Latitude	Longitude
14X-0337/B1	42.987606°	-82.358487°
14X-0337/B2	42.987774°	-82.358483°

27 January 2023

GEOCRES NO.: 40J16-94

Distribution:

1 PDF & 1 Copy – Ministry of Transportation, Ontario (Central Region)

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→ The Power of Commitment

Contents

Table

Drawing

Appendices

Appendix A Site Photographs

Appendix B Previous Borehole Investigations Geocres 40J16-039

Appendix C Borehole Records

Appendix D Geotechnical Laboratory Test

Appendix E Non-Standard Special Provisions (NSSP)

PART A

FOUNDATION INVESTIGATION REPORT

TEMPORARY PROTECTION SYSTEM, HIGHWAY 402 (EASTBOUND AND WESTBOUND) AND HOWARD WATSON NATURE TRAIL (FORMER CNR) OVERHEAD STRUCTURES, CITY OF SARNIA, ONTARIO, MINISTRY OF TRANSPORTATION, ONTARIO, GWP 3105-18-00

1. Introduction

GHD Limited (GHD) was retained by the Ministry of Transportation, Ontario (MTO), to provide foundation investigation and engineering services for the temporary protection systems associated with the proposed rehabilitation and conversion to semi-integral abutments of two CNR overhead structures on Highway 402 (eastbound and westbound) at Howard Watson Nature Trail (former CNR), located in the City of Sarnia, Ontario (see the Key Plan on Drawing 1).

The purpose of this investigation is to establish the subsurface soil and groundwater conditions at the locations of proposed temporary protection system by means of borehole drilling and geotechnical laboratory testing on selected soil samples.

The Terms of Reference (TOR) and the scope of work for this project are identified within the agreement of services as amended between MTO and GHD for Consultant's Assignment Number 3020-E-0014. The work has been carried out in accordance with the requirements of *Guideline for Foundation Engineering Services, Version 3.0, April 2022*, prepared by the MTO.

2. Site Description

The CNR overhead structures are located along Highway 402, about 1.3 km west of Highway 402 and Highway 40 interchange, and 0.7 km east of Murphy Road, in the City of Sarnia, Ontario.

The existing three span CNR overhead structures were constructed in 1976. Howard Watson Nature Trail (former CNR) passes under the CNR overhead structures and is generally aligned in north-south direction. The eastbound and westbound CNR overhead structures of Highway 402 consist of two lanes each, separated by a grass median and noise barrier walls along the perimeter of the structures.

The CNR overhead structures are situated in an urban-setting environment with generally a flat landscape. The areas surrounding the CNR overhead structures are a mix of residential and commercial land uses with vacant farm fields mostly towards the northeast side of the CNR overhead structures. West of the existing east abutment there are two buried power utilities that are operated by Bluewater Power and there is also a buried cable operated by Eastlink.

The embankment slopes between the CNR overhead structures are covered by grass or other vegetation (a grass median) and observed to be stable, with no signs of erosion. General site conditions are shown in Photographs 1 to 4 presented in Appendix A.

3. Investigation Procedures

3.1 Previous Investigation

A geotechnical investigation was completed for the Highway 402 overhead structure at the former CNR tracks on July 17, 1970, during which time a total of fourteen boreholes were advanced near the overhead structure. The boreholes were advanced from the original ground surface and prior to construction of the overhead structure to depths of between 6.4 m and 35.3 m below ground surface and geotechnical laboratory testing was carried out on selected soil samples. The results of the investigation are contained in a report titled, "*Foundation Investigation Report for The Proposed C.N.R. Overhead of Highway 402, near Sarnia, District No. 1 (Chatham)"*, WP 346-65-01 & 02, prepared by the Department of Highways Ontario, dated July 17, 1970

(GEOCRES No. 40J16-039). The location of the boreholes are shown on Drawing 1 and on the borehole location drawing included in Appendix B.

3.2 Current Investigation

The geotechnical fieldwork for this investigation was carried out between September 6 and 12, 2022, during which time four boreholes designated as BH1-22 to BH4-22 (two boreholes at each structure) were advanced to a depth of about 12.8 m below ground surface (existing Highway 402 road level). The borehole depths were advanced to a minimum depth of 10 m below the base of the excavation for the proposed rehabilitation and in accordance with the MTO "*Guidelines for Foundation Engineering Services*", dated April 2022. The boreholes were advanced through the right lanes of eastbound and westbound as shown on Drawing 1.

Prior to the start of fieldwork, utility clearance procedures were carried out through Ontario One Call, and fieldwork notification was sent to MTO West Region. A project specific Health and Safety as well as Traffic Protection Plans were prepared before commencement of the fieldwork. In addition, the borehole locations were marked by GHD staff prior to drilling. All drilling activity, soil sampling and logging, and backfilling of boreholes were conducted under the full-time supervision of an experienced GHD geotechnical engineer.

The boreholes were advanced using a B57 track-mounted drill rig, equipped with continuous flight, hollow stem augers, supplied and operated by Landshark Drilling of Brantford, Ontario. The asphalt and underlying concrete were cored using concrete coring equipment and municipal water supplied by the drilling subcontractor. Soil samples were obtained at 0.75 m intervals of depth, using a 50 mm outer-diameter split-spoon sampler driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedures described in ASTM D1586[1]. Where firm to stiff cohesive deposits were encountered, in-situ field vane shear tests were carried out using an MTO 'N'-size vane to assess the strength characteristics of these soils in accordance with ASTM D2573[2]. Soil samples obtained from the boreholes were inspected in the field immediately upon retrieval for type, texture, and color. All retrieved samples from the investigation were sealed in clean plastic bags and transported to the GHD laboratory in Waterloo for further visual examination, and geotechnical laboratory tests.

No monitoring wells were installed in any of the boreholes; however, groundwater conditions and water levels were observed/measured in the open boreholes during drilling by visual examination of soil samples and drill rods as well as immediately following the drilling operations. The boreholes were backfilled with bentonite and sealed at the top with compacted auger cuttings, in accordance with Ontario Regulation 903, (as amended).

Surveying of the as-drilled borehole locations was conducted by Callon Dietz Inc. (Callon Dietz) of London, Ontario, subcontracted to GHD. Callon Dietz provided northing and easting in MTM NAD 83 (Zone 11) coordinates. The ground surface elevations are referenced to Geodetic datum. The coordinates and ground surface elevation are presented below, on the borehole records and on Drawing 1.

Structure Number	Borehole Number	Location	Location (MTM NAD 83, ZONE 11)		Borehole Depth (m)	Ground Surface Elevation (m)	End of Borehole Elevation (m)
			Northing (m) (Latitude, °)	Easting (m) (Longitude, °)			
14X-0337/B1 (Eastbound Lanes)	BH2-22	Right lane of EB of Highway 402	4,760,863.7 (42.987490)	316,314.3 (-82.358806)	12.8	189.9	177.1
	BH4-22	Right lane of EB of Highway 402	4,760,879.4 (42.987631)	316,364.0 (-82.358196)	12.8	190.1	177.3
14X-0337/B2	BH1-22	Right lane of WB of Highway 402	4,760,893.2 (42.987756)	316,314.3 (-82.358805)	12.8	190.0	177.2

[1] ASTM D1586-08a – Standard Test Method for Standard Penetration Tests and Split Barrel Sampling of the soil.
[2] ASTM D2573-15 Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils

Structure Number	Borehole Number	Location	Location (MTM NAD 83, ZONE 11)		Borehole Depth (m)	Ground Surface Elevation (m)	End of Borehole Elevation (m)
			Northing (m) (Latitude, °)	Easting (m) (Longitude, °)			
(Westboun d Lanes)	BH3-22	Right lane of WB of Highway 402	4,760,911.6 (42.987921)	316,369.7 (-82.358125)	12.8	189.9	177.1

Classification testing (i.e., water content, Atterberg limits and grain size distribution) was carried out on selected soil samples. All laboratory tests were conducted in accordance with MTO and/or American Society for Testing Materials (ASTM) standards, as appropriate.

4. Site Geology and Subsurface Conditions

4.1 Regional Geology

The CNR overhead structures are located within physiographic region known as Huron Fringe, which is a subdivision of the St. Clair Clay Plain, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)[3]. The surficial soils of the Huron Fringe region in proximity to the site generally consist of sand, gravel, silt and clay, and littoral deposits derived from coarse-textured lacustrine deposits. The majority of the region is characterized by Sand Plains and tributary valleys to Lake St. Clair. The depth to the bedrock in the area is in excess of 30 m below ground surface and consists of shale of the Kettle Point Formation.

4.2 Subsurface Conditions – Previous Investigation

As discussed in Section 3.1 previously a geotechnical investigation was carried out from the original ground surface prior to the construction of the overhead structure. The results of previous investigation from GEOCRES No. 40J16-039 are presented in Appendix B.

The subsurface conditions encountered in boreholes advanced from the original ground surface (approximately Elevation 180 m) consist of sandy silt to silty sand and organics that extended to a depth of between about 1.5 m and 3 m below the original ground surface. The SPT “N” values presented on the borehole records range from 2 blows to 7 blows per 0.3 m of penetration, suggesting a very loose to loose compactness condition.

The surficial deposit was underlain by a 32 m thick deposit of clayey silt to silty clay, with trace sand and gravel. Within the deposit the upper approximately 3 m can be characterized as an “upper weathered crust” encountered at depths of between 1.5 m and 3 m below the original ground surface (between Elevation 179.2 m and 177.0 m). The SPT “N” values within the upper weathered crust range from about 9 blows to 43 blows per 0.3 of penetration, suggesting a stiff to hard consistency. The upper weathered crust has slight plasticity with the plastic limit averaging about 16% and the liquid limits at about 30%.

Underlying the upper weathered crust the deposit consists of silty clay, with trace sand and gravel and extended to the bedrock surface at about a depth of 33.8 m below ground surface (approximate Elevation of 146.6 m). In-situ vane shear testing was carried out in the boreholes and the undrained shear strength of the silty clay deposit varied from about 38 kPa to greater than 105 kPa, indicating that the cohesive deposit has a firm to very stiff consistency. The silty clay deposit has medium plasticity with the plastic limit averaging about 19% and the liquid limits at about 38%.

Shale bedrock of the Kettle Point Formation was encountered at a depth of 33.5 m below the original ground surface (Elevation 246.6 m).

[3] Chapman, L.J. and Putman, D.F., 1984, The Physiography of Southern Ontario, Ontario Geological Society, Special Volume 2, Third Edition. Accompanied by Map p. 2715, Scale 1:600,000.)

The previous report indicates that the groundwater level measured in the completed boreholes was at depths of about 0.6 m below the original ground surface and that it was likely lower during drier seasons.

4.3 Subsurface Conditions

Details of the subsurface soil and groundwater conditions as encountered in the boreholes advanced during the geotechnical investigation and the results of the laboratory tests carried out on selected soil samples are presented on the borehole records provided in Appendix C. The *Notes on Borehole and Test Pit Reports* are also included in Appendix C to assist in the interpretation of the borehole records. The results of the geotechnical laboratory testing are contained in Appendix D. The results of in-situ field tests (i.e., SPT "N" values), as presented on the borehole records and in the sub-sections of Section 4 are uncorrected.

The stratigraphic boundaries shown on the borehole records are inferred from non-continuous sampling, observations of drilling progress, the results of the Standard Penetration Tests and in-situ vane shear tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations; however, the factual data presented in the borehole records governs any interpretation of the site conditions.

In summary, the subsurface conditions at boreholes completed in the vicinity of the existing CNR overhead structures consists of a layer of asphalt underlain by a layer of concrete. The concrete is further underlain by granular fill consisting of gravelly sand to sand and gravel, which in turn is underlain by fill material consisting of sandy clayey silt. In places beneath the cohesive fill material is a thin layer of fill material consisting of sand to gravelly sand. The fill material is underlain by a deposit consisting of sandy clayey silt. Detailed descriptions of subsurface conditions are provided in the following sections of this report. The subsurface conditions are described in accordance with the Ontario Ministry of Transportation (MTO) Guideline for Foundation Engineering Services Version 3.0 (April 2022).

4.3.1 Asphalt

Boreholes BH1-22 to BH4-22 were advanced through the eastbound and westbound lanes of Highway 402 and encountered an asphalt layer ranging in thickness from 150 mm to 310 mm.

4.3.2 Approach Slab Concrete

Underlying the asphalt in all four boreholes (BH1-22 to BH4-22), a layer of reinforced concrete was encountered, ranging is thickness from about 300 mm to 490 mm.

4.3.3 Fill

Underlying the concrete in all four boreholes (BH1-22 to BH4-22), fill material consisting of gravelly sand to sand and gravel with some fines was encountered and extended to depths of between about 1.2 m to 2.3 m below ground surface (Elevations 188.7 m and 187.8 m).

The Standard Penetration Test (SPT) "N" values recorded within the fill material range from 17 blows to 38 blows per 0.3 m of penetration, indicating a compact to dense compactness condition.

Grain size distribution testing was conducted on three representative samples of the granular fill and the results are presented on Figure D-1 in Appendix D). The water content measured on samples of the granular fill range from approximately 5% to 11%.

The granular fill is underlain by embankment fill consisting of sandy clayey silt, trace gravel. The cohesive fill extends to depths of between about 10.7 m and 11.3 m (Elevations 179.2 m and 178.6). In Borehole BH2-22 a 0.1 m thick layer of gravelly sand fill was encountered at 10.2 m depth (Elevation 179.7 m). Underlying the cohesive fill in Borehole BH2-22 at a depth of 10.7 m (Elevation 179.2 m) a 0.7 m thick layer of fill material consisting of sand, some silt, trace gravel and clay was encountered.

The Standard Penetration Test (SPT) “N” values recorded within the cohesive fill material range from 4 blows to 23 blows per 0.3 m of penetration. In-situ vane tests carried out within the cohesive fill material measured undrained shear strength of greater than 100 kPa. The in-situ field vane tests together with the SPT “N” values indicate that the cohesive encountered in the boreholes has a soft to very stiff consistency. The SPT “N” values recorded in the granular fill were 25 blows and 30 blows per 0.3 m of penetration, suggesting a compact compactness condition.

Grain size distribution testing was conducted on eight representative samples of the cohesive fill and the results are shown on Figure D-2 in Appendix D. Atterberg limits testing was carried out on fifteen samples of the cohesive fill and the results had liquid limits ranging from about 23% to 33%, plastic limits ranging from about 12% to 16%, and resulting plasticity indices of between about 9% to 17%. These results, which are plotted on a plasticity chart on Figures D-3A&B in Appendix D, indicate that the cohesive fill consist of sandy clayey silt of low to medium plasticity. Further, grain size distribution testing was conducted on two representative samples of the gravelly sand to sand fill material and the results are shown on Figure D-4 in Appendix D).

The water content measured on samples of the granular fill range from approximately 5% to 11% and water content measured on samples of the cohesive fill range from approximately 12% to 21%. The water content measured on a sample of the lower granular fill in Borehole BH2-22 was 17%.

4.3.4 Sandy Clayey Silt

A cohesive deposit consisting of sandy clayey silt with trace of gravel was encountered beneath the cohesive fill in Boreholes BH3-22 and 4-22 and below the granular fill in Boreholes BH1-22 and 2-22, at depths of about 11.3 m and 11.4 m below ground surface (Elevations 178.8 m and 178.5 m). All boreholes terminated within the sandy clayey silt at a depth of 12.8 m below ground surface (between Elevations 177.3 m and 177.1 m).

The SPT “N” values recorded within the sandy clayey silt deposit range from 11 blows to 18 blows per 0.3 m of penetration, suggesting a stiff to very stiff consistency.

The water content measured on samples of the sandy clayey silt deposit were 14% and 16%.

4.3.5 Groundwater

The groundwater level in the open boreholes was measure upon completion of drilling each borehole. The water levels measured in the open boreholes are summarized below.

Structure Number	Borehole Number	Water Level Depth (m)	Water Level Elevation (m)	Date of Observation (Measurement)	Remark
14X-0337/B1 (Eastbound Lanes)	BH2-22	12.7	177.2	September 08, 2022	Open boreholes upon completion of drilling
	BH4-22	Dry	--	September 07, 2022	
14X-0337/B2 (Westbound Lanes)	BH1-22	11.3	178.7	September 12, 2022	
	BH3-22	Dry	--	September 12, 2022	

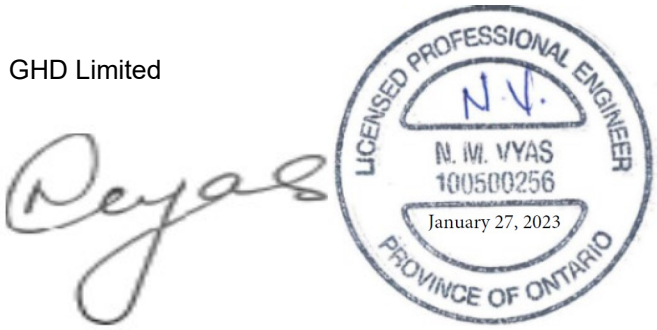
It should be noted that the groundwater level at the site will fluctuate with seasonal changes, periods of precipitation, and temperature and should be expected to be higher during wet periods of the year.

5. Closure

The fieldwork was supervised by Mr. Madlool Alsabak, E.I.T. under the direction of Mr. Nirjar Vyas, M.Eng., P.Eng., and Ms. Sandra McGaghran M.Eng., P.Eng. This report was prepared by Mr. Nirjar Vyas, M.Eng., P.Eng., a Geotechnical Engineer with GHD. Ms. Sandra McGaghran, M.Eng., P.Eng., a Senior Geotechnical Engineer with GHD and MTO Foundations Designated Contact conducted an independent review of the report.

Sincerely,

GHD Limited



Nirjar Vyas, M.Eng., P.Eng.
Geotechnical Engineer

Sandra McGaghran, M.Eng., P.Eng.
MTO Foundations Designated Contact, Senior Geotechnical Engineer

PART B

DISCUSSION AND ENGINEERING RECOMMENDATIONS

TEMPORARY PROTECTION SYSTEM, HIGHWAY 402 (EASTBOUND AND WESTBOUND) AND HOWARD WATSON NATURE TRAIL (FORMER CNR) OVERHEAD STRUCTURES, CITY OF SARNIA, ONTARIO, MINISTRY OF TRANSPORTATION, ONTARIO, GWP 3105-18-00

6. Discussion and Engineering Recommendations

This section of the report provides geotechnical design recommendations for the proposed temporary protection systems required for rehabilitation and conversion to semi-integral abutments of two CNR overhead structures on Highway 402 (eastbound and westbound) at Howard Watson Nature Trail (former CNR), located in the City of Sarnia, Ontario, under GWP 3105-18-00.

The discussion and engineering recommendations are based on the interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation. These recommendations presented are intended to provide the designers with sufficient information to assess the feasible foundation alternatives, and to develop approximate costs for the temporary protection systems. This report is intended for the use of the Ministry of Transportation, Ontario (MTO) for the purpose of designing temporary protection systems at above-mentioned CNR overhead structures. It shall not be relied upon for any other purpose or by any other parties, including construction or design-build contractor used for any other purposes or locations, or by any other parties including the construction or design-build contractor. The contractor must make their own interpretation based on the factual data in Part A (Foundation Investigation) of the report. Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project. Those requiring information on the aspects of construction must make their own interpretation of the factual information provided, as such interpretation may affect equipment selection, proposed construction methods, scheduling, and the like.

The proposed CNR overhead structures' rehabilitation will include conversion of the existing conventional abutments to semi-integral abutments, which will require removal of existing noise barrier walls and associated structural connections, along with the full depth removal of asphalt and reinforced concrete approach slab between Station 14+460 m and Station 14+533 m along the eastbound lanes, and between Station 14+468 m and Station 14+541 m along the westbound lanes. Protection systems are required to facilitate the excavations through asphalt, approach slab, granular fill, and upper portion of the sandy clayey silt deposit while maintaining traffic on Highway 402. Although the geometry and design of the protection system is the responsibility of the contractor, based on the 60% design drawings prepared by GHD's structural team, it is anticipated that the temporary protection systems will extend parallel to Highway 402 in stages for driving and overpassing lanes at the eastbound and westbound CNR overhead structures.

6.1 Excavation and Groundwater Control

It is understood that the excavations for the CNR overhead structures' rehabilitation works will extend below Highway 402 grade to approximate Elevations of 188 m and 187 m, approximate depths of about 2.0 m and 3.0 m, respectively. Proposed excavations will require removal of the asphalt, existing approach slab concrete, granular fill, and upper portion of the cohesive fill material. Excavations for the installation of temporary protection systems should be carried out in accordance with Ontario Regulation 213/91 and the Occupational Health and Safety Act and Regulations for Construction Projects (OHSA). According to OHSA, the soil classification and corresponding excavation side slopes for the existing fill and native soils to be removed are summarized below:

Soil Description	Above / Below Groundwater	OHSA Soil Type	Maximum Excavation Side Slopes
Fill - Granular	Above	Type 3	1H:1V
Fill - Sandy Clayey Silt	Above	Type 3	1H:1V

For excavations through multiple soil types, the side slope geometry is governed by the soil with the highest number Type designation.

During construction, stockpiles/equipment/materials should be located a minimum distance of 1.5 m from the top of the excavation or a distance equal to the depth of the excavation, whichever is greater; stockpile heights should be controlled to prevent surcharging the sides of the excavation and/or overall slope. Care must also be taken during excavation to ensure that adequate support is provided for any existing structures, roadways and underground services located adjacent to the excavations. Temporary excavations (i.e., those which are open for a relatively short time period) should be made with side slopes no steeper than 1 horizontal to 1 vertical (1H:1V) in Type 3 soil and 3H:1V in Type 4 soils. Depending upon the construction procedures adopted by the contractor and the weather conditions at the time of construction, some local flattening of the slopes could be required.

Groundwater observations and measurements were obtained from open boreholes during and upon completion of the drilling operations. Water levels upon completion of the drilling were measured at depths of about 11.3 m (Elevation 178.7 m) and 12.7 m (Elevation 177.2 m) below ground surface in Boreholes BH1-22 and BH2-22, respectively. Boreholes BH3-22 and BH4-22 were dry upon completion of drilling. Generally, groundwater levels are high during the time of snow melting in spring and heavy rains in summer. Based on the groundwater conditions observed, the anticipated excavation depths for the proposed construction and the properties of the soils encountered, significant groundwater seepage is not expected into open excavations during the construction. Depending on rainfall events immediately prior to construction there may be some perched water within the granular fill material above the cohesive fill. It is anticipated that any groundwater seepage into short-term excavations will be able to be handled using sumps and filtered pumps. Should any excavations require more intensive groundwater control, the use of filtered sumps, or other suitable method of dewatering and/or sheet piling is recommended.

6.2 Temporary Protection Systems

The protection systems should be designed and constructed in accordance with OPSS.PROV 539, as amended by SP 105S09 (Temporary Protection Systems). The lateral movement of the protection systems should meet Performance Level 2 as specified in OPSS.PROV 539, as amended by SP 105S09, provided that any utilities, if present can tolerate this magnitude of deformation.

It is anticipated that a driven interlocking sheet pile system would be suitable and constructible as the Standard Penetration Test (SPT) “N” values in the granular and cohesive fill are generally less than about 30 blows per 0.3 m of penetration, except at the location of Borehole BH3-22, where an SPT “N” value of 38 blows per 0.3 m of penetration was recorded in the granular fill material. Alternatively, a soldier pile and lagging system in conjunction with a sheet pile system is also feasible (i.e., in areas where adequate penetration can be achieved), but it would be necessary to include measures to control any seepage from behind the lagging boards if perched groundwater conditions are present at the time of construction and where the excavation extends below the water table or perched groundwater table.

The sheet piles or soldier piles will need to extend/be socketed to a sufficient depth below the soft to firm portion of cohesive fill to provide the necessary passive resistance for the retained soil height, plus any surcharge loads behind the protection system.

While the selection and design of the protection system will be the responsibility of the contractor, the following information is provided to MTO and its designers to aid in assessment of the approximate construction costs. Lateral support to the sheet pile wall or soldier pile wall could be provided in the form of rakers or temporary anchors, if and as required. The tiebacks or rakers/struts must be designed to accommodate the loads applied from the earth pressures, perched water pressure (if present) and surcharge pressures from area, line or point loads as well as the effects of sloping ground behind the protection system. Passive toes restraint to the soldier piles may be determined using conventional passive earth pressure distribution acting over an equivalent width equal to three times the soldier pile socket diameter provided that the soldier piles are separated by more than three times the socket diameter.

Materials/soils	Bulk Unit Weight (kN/m^3)	Angle of Internal Friction, θ	S_u (KPa)	Coefficient of Earth Pressure (2)		
				Active (Ka)	At-rest (Ko)	Passive (Kp)
Fill - Granular Gravelly Sand to Sand and Gravel (compact to dense)	20	32	--	0.31	0.47	3.25
Fill - Sandy Clayey Silt (Soft to Very Stiff)	19	28	75 - 100	0.36	0.53	3.0
Sandy Clayey Silt (Stiff to Very Stiff)	20	30	100	0.33	0.50	3.0

The total passive resistance below the base of the excavation (i.e., adjacent to the temporary protection system) may be calculated based on the values of Kp indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.27 of the Commentary to the CHBDC (2019), to account for the fact that a large strain would be required for mobilization of the full passive pressure. The earth pressure coefficients given above assume that the ground surface behind the roadway protection system is horizontal. If the retained ground is sloping, the lateral earth pressure coefficients must be adjusted to account for the slope based on the equations provided on Figures C6.28 and C6.29 in the Commentary to the CHBDC (2019). It should be noted that the pressure distributions given above are the minimum for the ultimate stress condition; a stiffer design may be required than predicted by these distributions in order to maintain displacements within an acceptable range.

Depending on the time of year, there may be perched water in the fill materials, above the cohesive fill. As noted above, if perched water is present and/or where the excavation extends below the groundwater level at the site, it would be necessary to control seepage or include measures to mitigate loss of soil particles through lagging boards if a soldier pile and lagging system is employed.

Consideration could be given to either partial or full removal of the protection system upon completion of construction or each stage of construction (as required). Where possible, full removal of the protection system should be considered to mitigate potential impediments to future rehabilitation/reconstruction work at the CNR overhead structures' site, or to the road structure above. It is recommended that a Non-Standard Special Provisions (NSSP) be included in the Contract Documents to alert the Contractor of this condition; such an NSSP is provided in Appendix E.

6.3 Obstructions During Installation of Temporary Protection Systems

It is anticipated that cobble and/or boulder size materials may be encountered within the granular and cohesive fill material and within the cohesive deposit underling the fill material while installing the temporary protection systems. The presence of these obstructions may affect the installation of protection system elements. It is recommended that a Notice to Contractor be included in the Contract Documents to warn the Contractor of the possible presence of cobbles and/or boulders within the overburden soils; a Notice to Contractor is provided in Appendix E.

7. Closure

This report was prepared by Mr. Nirjar Vyas, M.Eng., P.Eng., a Geotechnical Engineer with GHD. Ms. Sandra McGaghran, M.Eng., P.Eng., a Senior Geotechnical Engineer with GHD and MTO Foundations Designated Contact conducted an independent review of the report.

Sincerely,

GHD Limited

Nirjar Vyas, M.Eng., P.Eng.
Geotechnical Engineer

Sandra McGaghran, M.Eng., P.Eng.
MTO Foundations Designated Contact, Senior Geotechnical Engineer

References

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Kulhawy, F.H. and Mayne, P.W. 1990. Manual on Estimating Soil Properties for Foundation Design. EL6800, Research Project 14936. Prepared for Electric Power Research Institute, Palo Alto, California, U.S

ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
ASTM D2573-15	Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils

Ontario Provincial Standard Specification:

OPSS.PROV 539	Construction Specification for Temporary Protection Systems
SP 105S09	Special Provision – Amendment to OPSS 539, November 2014

Ontario Water Resources Act:

Ontario Regulation 903 Wells (as amended)

Ontario Occupational Health and Safety Act:

Ontario Regulation 213/91 Construction Projects (as amended)

Table 1: Comparison of Temporary Protection System Options

Options	Advantages	Disadvantages	Relative Cots	Risk / Consequences
Soldier Pile and Lagging	• Better able to penetrate cobbles, boulders or other potential obstructions • Relatively straightforward construction.	• Longer installation time compared to installation of sheet piles. • Additional measures required to control perched water / surface water seepage through lagging boards to avoid ground loss.	• Higher cost compared to sheet piles walls, especially if obstructions are encountered.	• Low risk that equipment won't penetrate obstructions in order to achieve required depth. • Risk of soil loss behind lagging if seepage not adequately / properly controlled.
Sheet Pile Wall	• Relatively straight forward installation provided that obstructions are not encountered. • Easier to remove compared to soldier pile and lagging. • Can also provide for seepage control from perched water conditions.	• Cannot penetrate cobbles and boulders, or obstructions.	• Typically less expensive than soldier pile and lagging.	• Risk of sheet piles encountering obstructions and not achieving required depth.

MINISTRY OF TRANSPORTATION, ONTARIO

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES

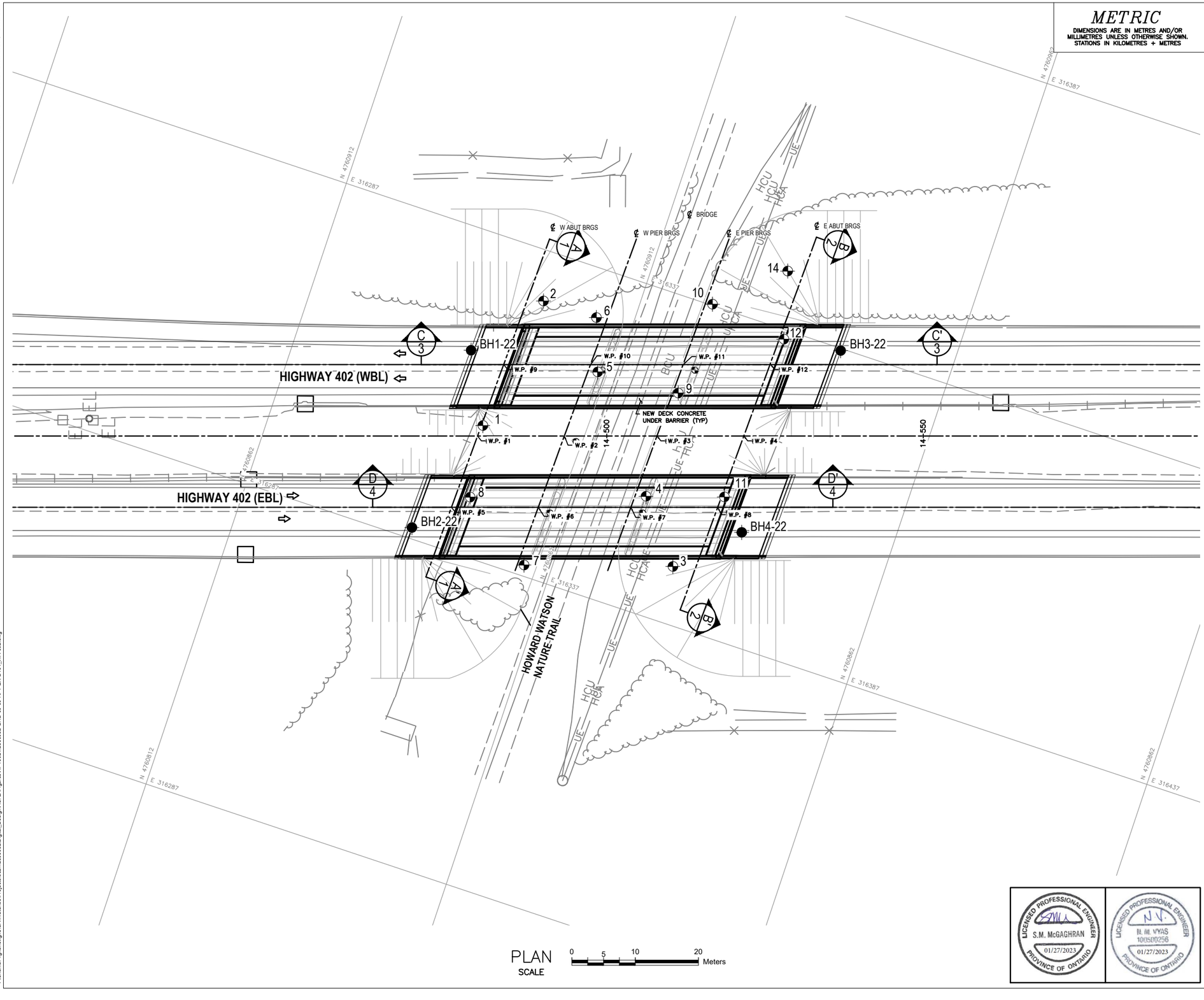
CONT No.
GWP No. 3105-18-00

SHEET

HWY 402/FORMER CN OVERHEAD
(RAPIDS PARKWAY) REHABILITATION

BOREHOLE LOCATIONS

GHD



PLAN
SCALE 0 5 10 20 Meters

KEY PLAN
SCALE 0 750 1500 3000 m

LEGEND

Borehole Location
Borehole Location
Geocres no. 40J16-039

BOREHOLE CO-ORDINATES (MTM ZONE 11)

NO	Elevation	Northing	Easting
BH1-22	190.0	4760893.2	316314.3
BH2-22	189.9	4760863.7	316314.3
BH3-22	189.9	4760911.6	316369.7
BH4-22	190.1	4760879.4	316364.0
1	180.6	4760882.5	316319.8
2	180.6	4760904.2	316322.7
3	180.4	4760870.9	316355.4
4	-	4760880.1	316347.8
5	-	4760896.3	316334.4
6	-	4760904.3	316331.5
7	-	4760863.7	316330.0
8	180.7	4760871.1	316321.5
9	180.4	4760897.1	316347.5
10	-	4760912.2	316348.2
11	-	4760883.9	316359.6
12	180.2	4760910.5	316360.6
14	180.3	4760920.9	316357.8

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boreholes shown in plan from GEOCRES 40J16-039 are approximate.

REFERENCE

Base plans provide in digital format by CALLON DIETZ, drawing file: 402SAR.dwg, received on October 31, 2022.

NO.	DATE	BY	REVISION

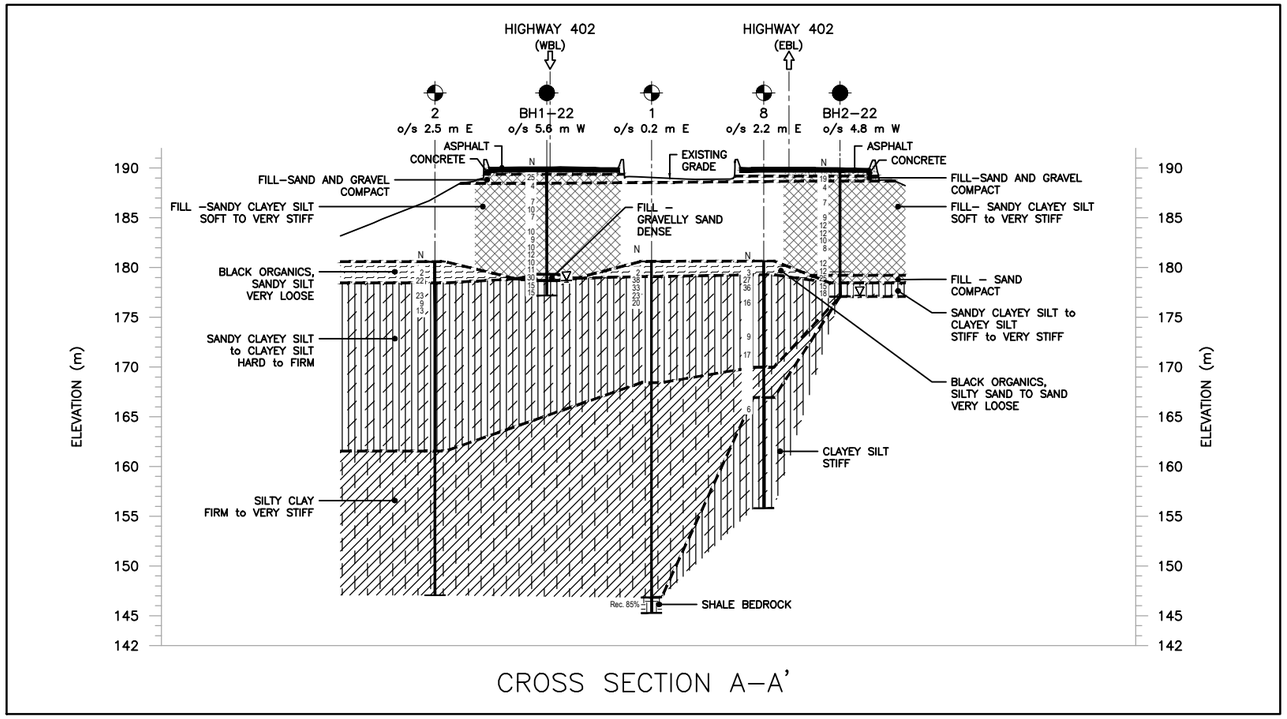
LICENSED PROFESSIONAL ENGINEER S.M. McGAGHRAN 01/27/2023 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N.M. VYAS 100500256 01/27/2023 PROVINCE OF ONTARIO

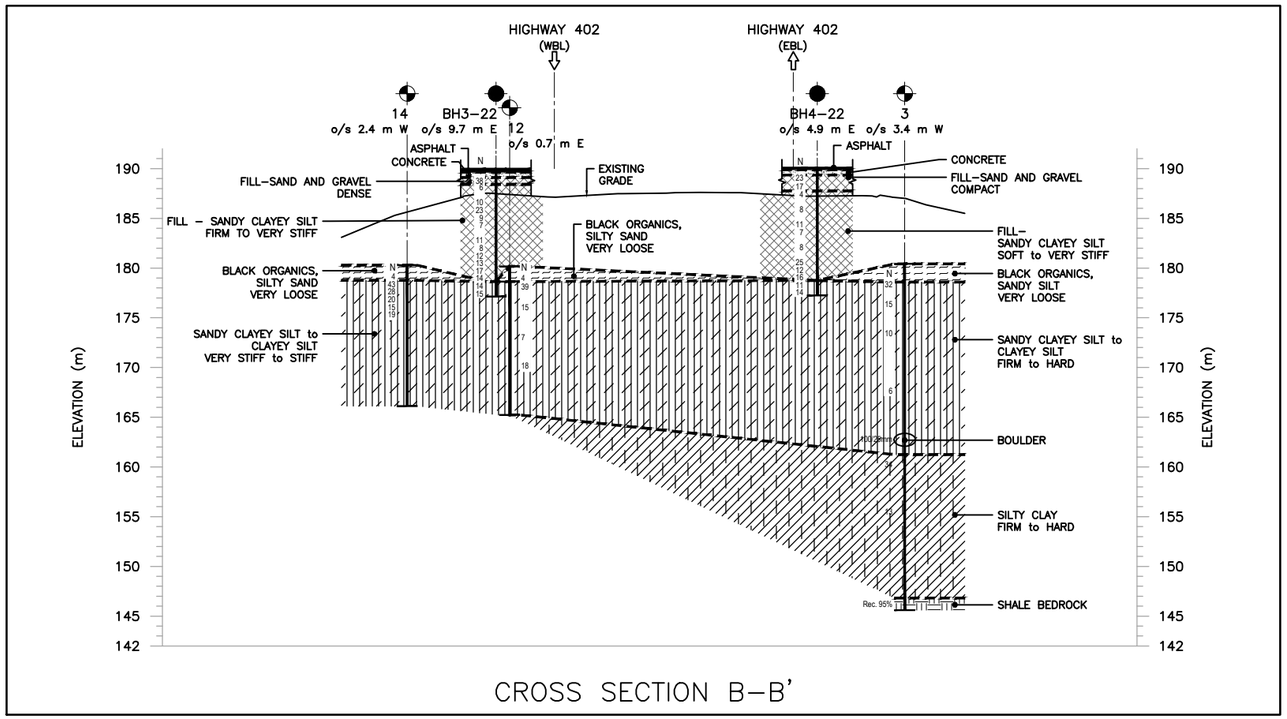
Geocres No.: 40J16-94

HWY. 402	PROJECT NO. 12566052		DIST. SOUTHWEST
SUBMTD. MA	CHKD. AC	DATE:1.23.2023	SITE: 14X-0337/B1 AND 14X-0337/B2
DRAWN: AW	CHKD. NV	APPD. SMM	DWG. 1

Plot Date: 23 January 2023 4:00 PM
Filename: \\ghdnet\ghd\CA\Waterloo\Projects\662\12566052\Digital_Design\ACAD\Figures\RPT\0021256605 2-GHD-00-00-RPT-EN-D101_WA-002.dwg



CROSS SECTION A-A'



CROSS SECTION B-B'

HORIZONTAL 0 5 10 20 Meters

VERTICAL 0 5 10 20 Meters

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES

CONT No.
GWP No. 3105-18-00

HWY 402/FORMER CN OVERHEAD (RAPIDS PARKWAY) REHABILITATION

SOIL STRATA

SHEET

GHD

KEY PLAN SCALE 0 750 1500 3000 m

LEGEND

●	Borehole Location
◐	Borehole Location Geocres no. 40J16-039
N	Standard Penetration Test Value
16	Blows/0.3 m unless otherwise stated (Std. Pen. Test, 475 j/blow)
▽	WL upon completion of drilling
REC/%	Recovery

BOREHOLE CO-ORDINATES (MTM ZONE 11)

NO	Elevation	Northing	Easting
BH1-22	190.0	4760893.2	316314.3
BH2-22	189.9	4760863.7	316314.3
BH3-22	189.9	4760911.6	316369.7
BH4-22	190.1	4760879.4	316364.0
1	180.6	4760882.5	316319.8
2	180.6	4760904.2	316322.7
3	180.4	4760870.9	316355.4
8	180.7	4760871.1	316321.5
12	180.2	4760910.5	316360.6
14	180.3	4760920.9	316357.8

NOTES

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The boreholes shown in profile from GEOCRES 40J16-039 are approximate.

The boundaries between soil strata has been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

Boreholes from GEOCRES 40J16-039 were advanced prior to construction of the overpass.

REFERENCE

Base plans provide in digital format by CALLON DIETZ, drawing file: 402SAR.dwg, received on October 31, 2022.

LICENSED PROFESSIONAL ENGINEER S.M. McGAGHRAN 01/27/2023 PROVINCE OF ONTARIO

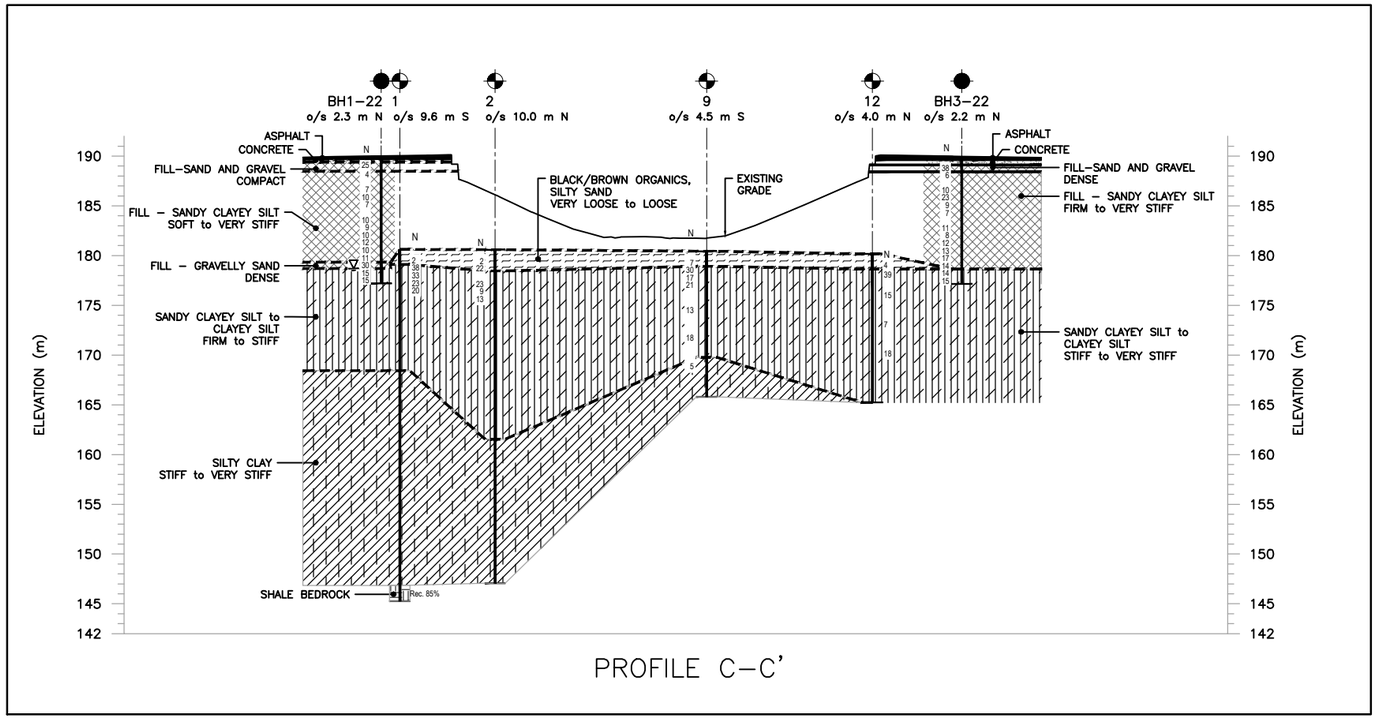
LICENSED PROFESSIONAL ENGINEER N. M. VYAS 100500256 01/27/2023 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

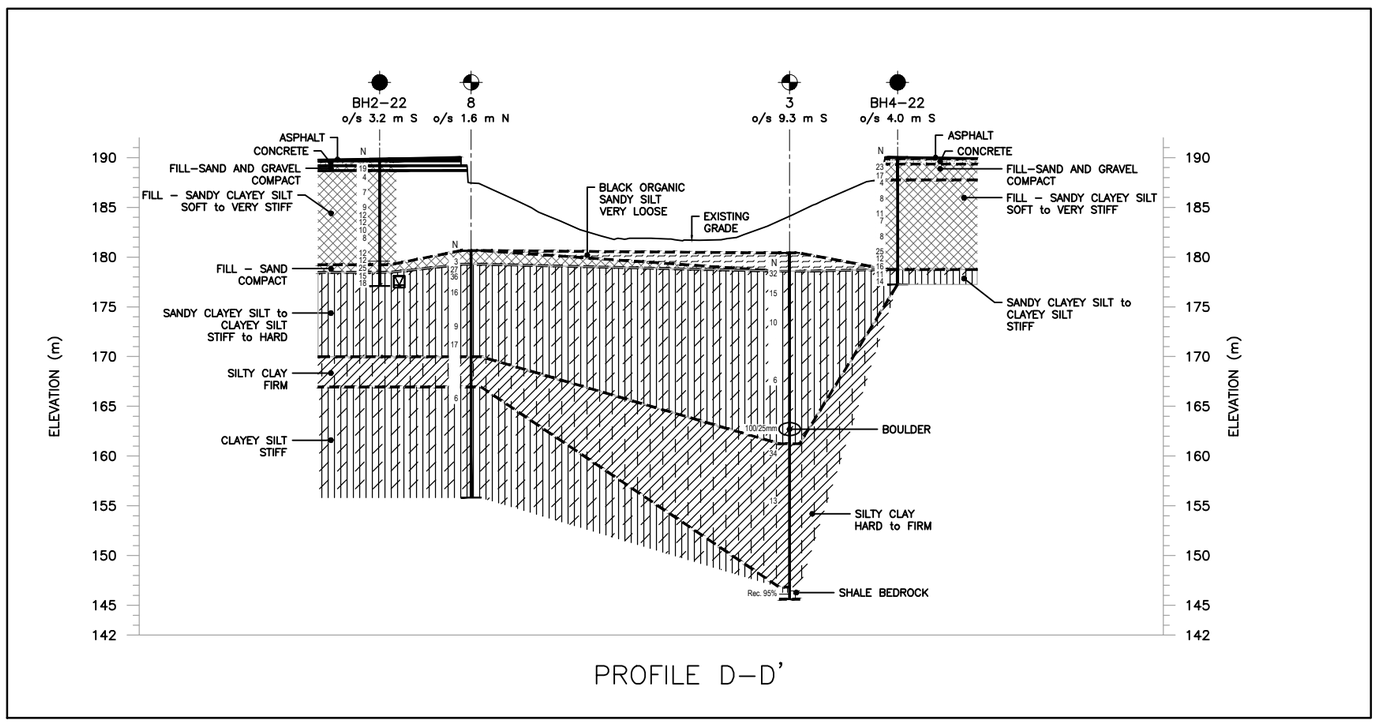
Geocres No.: 40J16-94

HWY. 402	PROJECT NO. 12566052		DIST. SOUTHWEST
SUBM'D. MA	CHK'D. AC	DATE:1.24.2023	SITE: 14X-0337/B1 AND 14X-0337/B2
DRAWN: AW	CHK'D. NV	APP'D. SMM	DWG. 2

MINISTRY OF TRANSPORTATION, ONTARIO



PROFILE C–C'



PROFILE D–D'

HORIZONTAL 0 5 10 20 Meters

VERTICAL 0 5 10 20 Meters

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.
STATIONS IN KILOMETRES + METRES

CONT No.
GWP No. 3105–18–00

HWY 402/FORMER CN OVERHEAD (RAPIDS PARKWAY) REHABILITATION

SOIL STRATA

SHEET

GHD

KEY PLAN
SCALE 0 750 1500 3000 m

LEGEND

●	Borehole Location
◐	Borehole Location Geocres no. 40J16–039
N	Standard Penetration Test Value
16	Blows/0.3 m unless otherwise stated (Std. Pen. Test, 475 j/blow)
▽	WL upon completion of drilling
REC/%	Recovery

BOREHOLE CO–ORDINATES (MTM ZONE 11)

NO	Elevation	Northing	Easting
BH1-22	190.0	4760893.2	316314.3
BH2-22	189.9	4760863.7	316314.3
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2	180.6	4760904.2	316322.7
3	180.4	4760870.9	316355.4
8	180.7	4760871.1	316321.5
9	180.4	4760897.1	316347.5
12	180.2	4760910.5	316360.6

NOTES

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The boreholes shown in profile from GEOCRES 40J16–039 are approximate.

The boundaries between soil strata has been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

Boreholes from GEOCRES 40J16–039 were advanced prior to construction of the overpass.

REFERENCE

Base plans provide in digital format by CALLON DIETZ, drawing file: 402SAR.dwg, received on October 31, 2022.

NO.	DATE	BY	REVISION

Geocres No.: 40J16–94

HWY. 402	PROJECT NO. 12566052		DIST. SOUTHWEST
SUBM'D. MA	CHK'D. AC	DATE:1.23.2023	SITE: 14X-0337/B1 AND 14X-0337/B2
DRAWN: AW	CHK'D. NV	APP'D. SMM	DWG. 3

LICENSED PROFESSIONAL ENGINEER S.M. McGAGHRAN 01/27/2023 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N.M. VYAS 100500256 01/27/2023 PROVINCE OF ONTARIO

Plot Date: 23 January 2023 5:20 PM
Filename: \\ghdnet\ghd\CA\Waterloo\Projects\66\21256605\2\Digital_Design\ACAD\Figures\RPT\00\21256605-GHD-00-00-RPT-EN-D101_WA-002.dwg

Appendices

Appendix A

Site Photographs

Photograph 1 – Drilling operations at Borehole, BH2-22 – Highway 402 Eastbound Lane

Photograph 2 – Highway 402 at CNR **overhead structure - Eastbound Lanes**

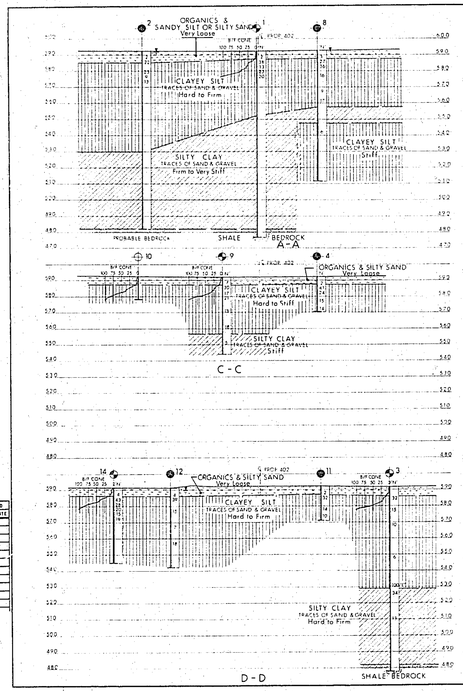
Photograph 3 – CNR **Overhead structures at Highway 402, westbound and eastbound lanes – Looking southeast**

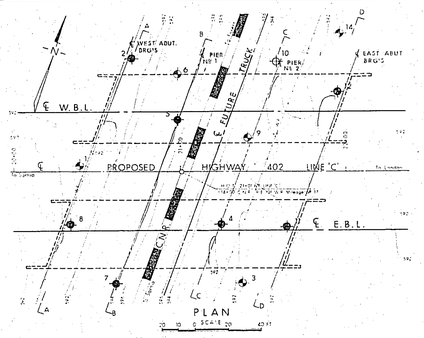
Photograph 4 – Drilling set up at Borehole, BH1-22 – Highway 402 Westbound Lane

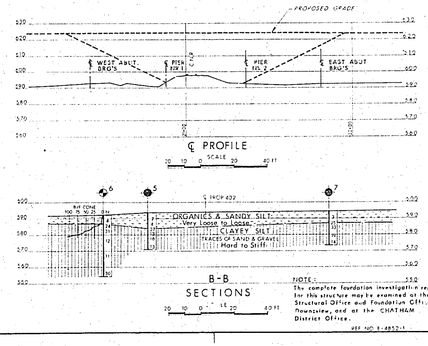
Appendix B

Previous Investigation

Geocres No. 40J16-039

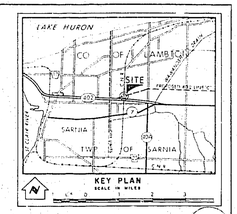






NOTE:
The complete foundation investigation report for this structure may be examined at the Structural Office and Foundation Office, Downsview, and at the CHATHAM District Office.

REF. NO. S-4852-1



141.

LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of Field Investigation, June 1970. Boreholes 2, 8 & 12 only.

NO.	ELEVATION	STATION	OFFSET
1	592.6	20+39	3' LT
2	592.5	20+71	69.5' LT
3	591.9	21+27	69.5' RT
4	592.5	21+24	32.5' RT
5	592.7	20+98	32.5' LT
6	592.0	20+98	60' LT
7	594.1	20+61	69.5' RT
8	592.7	20+36	32.5' RT
9	592.0	21+40	20' LT
10	592.1	21+57	69' LT
11	592.2	21+64	34' RT
12	591.1	21+90	52' LT
14	591.5	21+96	86' LT

– NOTE –

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISIONS		
DATE	NO.	DESCRIPTION

PRINT RECORD		
NO.	FOR	DATE

DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & TESTING OFFICE – FOUNDATION SECTION

CANADIAN NATIONAL RAILWAY

KING'S HIGHWAY NO. 402 LINE 'C' DIST. NO. 1
CO. LAMBTON
TWP. SARNIA LOT 17 & 18 CON. 7

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. A. S	DESIGNED	WP NO. 366-65-01602	MAT. DRAWING NO.
DRAWN S.O	CHECKED	JOB NO. 70-11045	70-11045A
DATE JULY 21, 1970		SITE NO. 14-337	BRIDGE DRAWING NO.
APPROVED		CONT NO. 75-11	D7099-2

Twp. 7 337 1-B

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL. THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

CONSISTENCY	'N' BLOWS / FT.	c LB. / SQ. FT.	DENSENESS	'N' BLOWS / FT.
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_P	PLASTIC LIMIT
I_P	PLASTICITY INDEX
s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta \sigma'}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma'}$
T_v	TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH

IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$

c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION

IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$

c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION

μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3·1416
e	BASE OF NATURAL LOGARITHMS 2·7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ε	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNGS MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_o	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY. DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

FORM OB-MT-126 (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 1

FOUNDATION SECTION

JOB 70-11045 LOCATION Sta. 20 + 39 Offset 3 Lt. ORIGINATED BY H.S.
W.P. 346-65-01802 BORING DATE Nov. 26,27, Dec. 1 & 2, 1969 COMPILED BY G.A.
DATUM Geodetic BOREHOLE TYPE Washboring, NX, BX casing, BXL core CHECKED BY

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT	BULK DENSITY γ P.C.F.	REMARKS
592.6	Ground Level					
0.0	Silty sand-- V. loose	1	SS	2		
587.6		2	SS	38		
5.0	Clayey silt with traces of sand & gravel firm to stiff grey	3	SS	33		
		4	SS	23		
		5	SS	20		
		6	TW	PH	130.5	
		7	TW	PH		
		8	TW	PH	130.0	
		9	TW	PH		
552.6		10	TW	PH	116.0	
40.0	Silty clay with traces of sand & gravel stiff to very stiff	11	TW	PH		
		12	TW	PH		2 8 44 46
		13	TW	PH	123.5	2 24 53 21
		14	TW	PH	122.0	
481.8						
110.8 / 476.6	Shale Bedrock	15	RC	Rec. 85%		
116.0	End of borehole					

ELEV. SCALE: 590, 580, 570, 560, 550, 540, 530, 520, 510, 490, 480

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT — 20 40 60 80 100

SHEAR STRENGTH P.S.F.
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000

LIQUID LIMIT — w_L
PLASTIC LIMIT — w_p
WATER CONTENT — w
WATER CONTENT % 10 20 30 40

End of cone test
+S 2.0
+S 2.4
+S 2.3
+S 2.2
+S 3.3
+S 1.8
+S 1.6
+S 1.9
Type "A"
Type "B"
Type "A"
Type "B"
Type "A"

20
15 ⟡ 5 % STRAIN AT FAILURE
10

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 2

FOUNDATION SECTION

JOB 70-11045 LOCATION STA. 20 + 71, 69.5 Ft. Lt. of ℄ ORIGINATED BY T.P.
W.P. 346-65-01 & 02 BORING DATE June 24, 1970 COMPILED BY A.K.B.
DATUM Geodetic BOREHOLE TYPE C.M.E. Auger CHECKED BY

ELEV. / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS / FOOT
592.5	Ground Level			
0.0	Black organics & sandy silt--V. loose	1	SS	2
585.5		2	SS	22
7.0	Clayey silt with traces of sand & gravel hard to firm	3	TW	PH
		4	SS	23
		5	SS	9
		6	SS	13
		7	TW	PH
		8	TW	PH
		9	TW	PH
		10	TW	PH
530.0				
62.5	Silty clay with traces of sand & gravel firm to stiff	11	TW	PH
		12	TW	PH
481.5	Probable Bedrock			
110.0	End of borehole			

ELEV. SCALE: 590, 580, 570, 560, 550, 540, 530, 520, 490

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT
SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000
○ 4000
+ < 2200

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w
w_P w w_L
WATER CONTENT % 10 20 30

BULK DENSITY γ P.C.F.: 136, 130, 134, 134.5, 120, 130, 120.5

REMARKS GR. SA. SI. CL.

20
15 ⊹ 5 % STRAIN AT FAILURE
10

FORM OB-MT-126 (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 3

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 21 + 37, 69.5 Ft. Rt. of ℄ ORIGINATED BY T.P.

W.P. 346-65-01 & 02 BORING DATE June 11-15, 1970 COMPILED BY A.K.B.

DATUM Geodetic BOREHOLE TYPE C.M.E. Auger & Wasboring, BX casing CHECKED BY

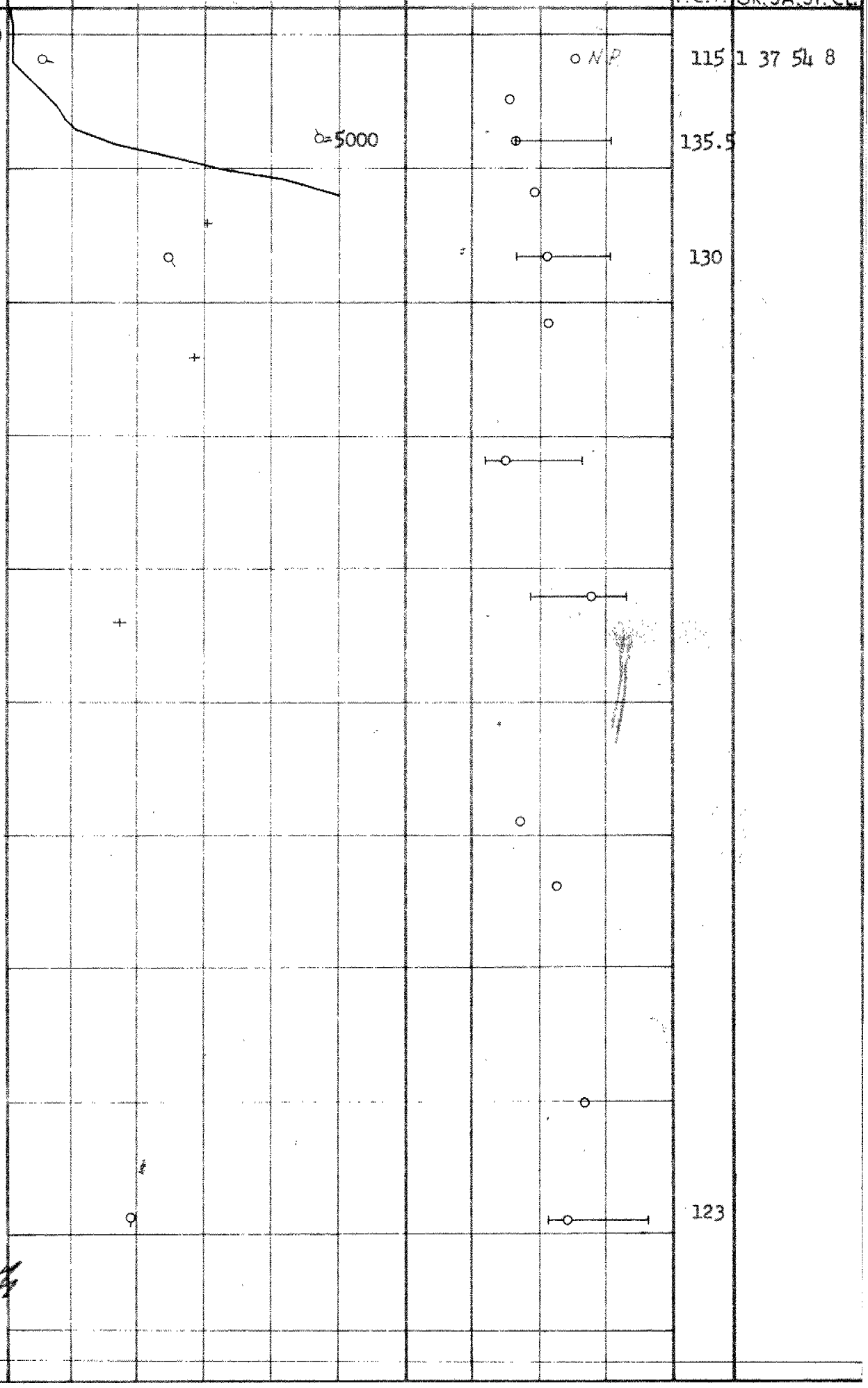
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE
591.9	Ground Level					
0.0	Black organics & sandy silt		1	TW	PM	590
585.9	V. Loose		2	SS	32	
6.0			3	TW	PH	
	Clayey silt with traces of sand & gravel		4	SS	15	580
			5	TW	PH	
	Hard to Firm		6	SS	10	570
			7	TW	PH	560
			8	SS	6	550
			9	TW	PH	540
	Boulder		10	SS	100/1"	530
529.0						
62.9	Silty clay with traces of sand & gravel		11	SS	34	
	Hard to firm		12	SS	13	510
			13	TW	PM	500
481.7						
110.2	Shale Bedrock		14	RC	Rec. 95%	480
477.7						
114.2	End of borehole					

DYNAMIC PENETRATION RESISTANCE
BLOWS / FOOT 20 40 60 80 100

SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_p
WATER CONTENT —— w
WATER CONTENT % 10 20 30

BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL.
115	1 37 54 8
135.5	
130	
123	



20
15 ✧ 5 % STRAIN AT FAILURE
10

FORM OB-MT-126 (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 4

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 21 + 24, 32.5 Ft. Rt. of ℄ ORIGINATED BY T.P.

W.P. 346-65-01 & 02 BORING DATE June 25/70 COMPILED BY A.K.B.

DATUM Geodetic BOREHOLE TYPE C.M.E. Auger CHECKED BY A.K.

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB. VANE	LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT					
592.5	Ground Level									
0.0	Black organics and very loose silty sand					590				
587.5			1	SS	2					
5.0	Clayey silt with traces of sand & gravel		2	SS	41					
			3	SS	24	580				
	Hard to stiff		4	SS	15					
570.5			5	SS	14					
22.0	End of borehole									

FORM OB-MT-126 (REV 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 5

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 20 + 98, 32.5 Ft. LT. of ℄ ORIGINATED BY T.P.
W.P. 346-65-01 & 02 BORING DATE June 25/70 COMPILED BY A.K.B.
DATUM Geodetic BOREHOLE TYPE C.M.E. Auger CHECKED BY

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB. VANE)	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
593.7	Ground Level						1000 2000	10 20 30		
0.0	Black organics & V. loose to loose sandy silt (railway base)		1	SS	2	590				0 40 52 8
			2	SS	4					
584.2			3	SS	27					
9.5	Clayey silt with traces of sand & gravel, V. Stiff to stiff		4	SS	13	580				
			5	SS	16					
570.7			6	SS	13					
23.0	End of borehole									

FORM OB-MT-126 (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 6

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 20 + 98 Offset 60 Lt. ORIGINATED BY G.A.
W.P. 346-65-01 & 02 BORING DATE Dec. 4/69 COMPILED BY
DATUM Geodetic BOREHOLE TYPE Washboring CHECKED BY

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT
592.0	ground level				
0.0	organics & silty sand loose		1	SS	4
587.0			2	SS	24
5.0			3	SS	31
	Clayey silt with		4	TW	PH
	traces of sand &		5	SS	12
	gravel		6	TW	PH
	very stiff to stiff		7	SS	11
			8		
554.0			9	SS	30
38.0	End of borehole				

ELEV. SCALE: 590, 580, 570, 560, 550

DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT: 20, 40, 60, 80, 100

SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000, 2000

End of cone test
+S 1.9
+S 2.9
+S. 2.4
+ S 1.8

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w
w_P w w_L
WATER CONTENT %: 10, 20, 30

BULK DENSITY γ P.C.F.

REMARKS	BULK DENSITY γ P.C.F.
GR.SA.SI.CL.	
	132.0
	228.0
	n.q.

FORM OB-MT-126 (REV 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 7

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 20 + 61, 69.5 Ft. Rt. of ℄ ORIGINATED BY T.P.
W.P. 346-65-01 & 02 BORING DATE June 25, 1970 COMPILED BY A.K.B.
DATUM Geodetic BOREHOLE TYPE C.M.E. Auger CHECKED BY

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB. VANE)	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w; WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL.
594.1	ground level						1000 2000	10 20 30		
0.0	Black organics & sandy silt		1	SS	3	590	○	○		1 27 64 8
587.6	V. loose		2	SS	25			○		
6.5	Clayey silt with traces of sand & gravel hard to stiff		3	SS	33			○		
			4	SS	19	580		○		
573.1			5	SS	14		+	○—○		
21.0	End of borehole									

FORM OB-MT-126 (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 8

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 20 + 34 32.5 Ft. Rt of ℄ ORIGINATED BY T.P.
W.P. 346-65-01 & 02 BORING DATE June 22-23, 1970 COMPILED BY A.K.B.
DATUM Geodetic BOREHOLE TYPE C.M.E. Auger CHECKED BY AK

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE
592.7	Ground Level					
0.0	Black organics & very					590
588.2	loose sand		1	SS	3	
4.5	Clayey silt with traces of sand and gravel ; Hard to stiff		2	SS	27	
			3	SS	36	
			4	TW	PH	580
			5	SS	16	
			6	TW	PH	
						570
			7	SS	9	
			8	SS	17	
557.7						560
35.0	Silty clay, traces of sand & gravel--firm		9	TW	PM	
547.7						550
45.0	Clayey silt with traces of sand & gravel stiff		10	SS	6	
			11	TW	PM	540
						530
						520
511.2			12	TW	PH	
81.5	End of boreholes					

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w
w_P w w_L
WATER CONTENT %
10 20 30

○ = 81

BULK DENSITY γ P.C.F.

135
130
116.5
124
121.5

REMARKS

GR.SA.SI.CL.

20
15 ⊹ 5 % STRAIN AT FAILURE
10

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 9

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 21 + 40 Offset 20'LT. ORIGINATED BY G.A.

W.P. 346-65-01 & 02 BORING DATE Dec. 2, 1969 COMPILED BY G.A.

DATUM Geodetic BOREHOLE TYPE Cont. Flt. Auger CHECKED BY [illegible]

ELEV. DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT
592.0	Ground Level				
0.0	Silty sand--firm		1	SS	7
587.0			2	SS	30
5.0			3	SS	17
	Clayey silt with traces of sand & gravel very stiff to stiff		4	SS	21
			5	TW	PH
			6	SS	13
			7	TW	PH
			8	SS	18
557.0			9	TW	PH
35.0	Silty clay with traces of sand & gravel stiff		10	SS	5
544.0			11	TW	PH
48.0	End of borehole				

ELEV. SCALE: 590, 580, 570, 560, 550

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT: 20, 40, 60, 80, 100

SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000

End of cone test

+S 2.0

+S 2.2

+S 2.7

+S 3.3

+S 3.5

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w

w_P w w_L

WATER CONTENT % 10 20 30

BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
	0 16 46 38
132.0	
129.0	
124.5	

FORM OB-MT-126 (REV. 1969)

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 10

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 21+57 OFFset 69' LT. ORIGINATED BY G.A.

W.P. 346-65-01 & 02 BORING DATE 1-6-70 COMPILED BY G.A.

DATUM Geodetic BOREHOLE TYPE Dynamic Cone Penetration CHECKED BY

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/FOOT	ELEV. SCALE
592.1	Ground Level					
0.0	Cone Penetration Only					590
578.1						580
14.0	End of cone test					570

DYNAMIC PENETRATION RESISTANCE
BLOWS / FOOT

SHEAR STRENGTH P.S.F.
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE

LIQUID LIMIT w_L
PLASTIC LIMIT w_P
WATER CONTENT w
w_P w w_L
WATER CONTENT %

BULK DENSITY γ P.C.F.

REMARKS
GR. SA. SI. CL.

End of cone test

FORM OB-MT-126 (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 11

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 21 + 64, 34 Ft. Rt. of ℄ ORIGINATED BY A.K.B.
W.P. 346-65-01-02 BORING DATE June 26, 1970 COMPILED BY A.K.B.
DATUM Geodetic BOREHOLE TYPE C.M.E. Auger CHECKED BY

SOIL PROFILE ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE
592.2	Ground Level					
0.0	Black organics & silty sand-V. loose		1	SS	2	
587.2						
5.0	Clayey silt with traces of sand & gravel hard to stiff		2	SS	32	
			3	SS	44	
			4	SS	10	
571.2						
21.0	End of borehole					

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w
WATER CONTENT % 10 20 30

BULK DENSITY γ P.C.F.

REMARKS

GR.SA.SI.CL.

DEPARTMENT OF HIGHWAYS- ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 12

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 21 + 95, 50 Ft. Lt. of ℄ ORIGINATED BY A.K.B.

W.P. 346-65-01-02 BORING DATE June 26, 1970 COMPILED BY A.K.B.

DATUM Geodetic BOREHOLE TYPE C.M.E. Auger CHECKED BY

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT — SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB. VANE	LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w — WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS GR. SA. SI. CL.
591.1	Ground Level						1000 2000	10 20 30		
0.0	Organics & brown silty sand									
586.1	V. loose		1	SS	4					
5.0			2	SS	39					
	Clayey silt with					580				
			3	SS	15					
	traces of sand &		4	TW	PH				130	
	gravel					570			131	
			5	SS	7					
	stiff to very stiff									
						560				
			6	SS	18		+ > 2000			
						550				
			7	TW	PH				121.5	
542.1										
49.0	End of borehole									

FORM OB-MT-126 (REV. 1969) OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & TESTING OFFICE

RECORD OF BOREHOLE No. 14

FOUNDATION SECTION

JOB 70-11045 LOCATION STA 21 + 96 Offset 86' LT. ORIGINATED BY P.P.

W.P. 346-65-01&02 BORING DATE Dec. 1 & 2, 1969 COMPILED BY G.A.

DATUM Geodetic BOREHOLE TYPE Cont. Flt. Auger CHECKED BY [illegible]

ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT
591.5	Ground Level				
0.0	Black organics & silty sand V. loose		1	SS	4
586.5			2	SS	43
5.0	Clayey silt with traces of sand & gravel very stiff to stiff		3	SS	28
			4	SS	20
			5	SS	15
			6	SS	19
			7	TW	PH
			8	TW	PH
			9	TW	PH
			10	TW	PH
545.0			11	TW	PM
46.5	End of borehole				

ELEV. SCALE: 590, 580, 570, 560, 550

DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT: 20, 40, 60, 80, 100

SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB. VANE
1000 2000

+S 1.6
+S 2.0
+S 2.0
+S 2.2

End of cone test

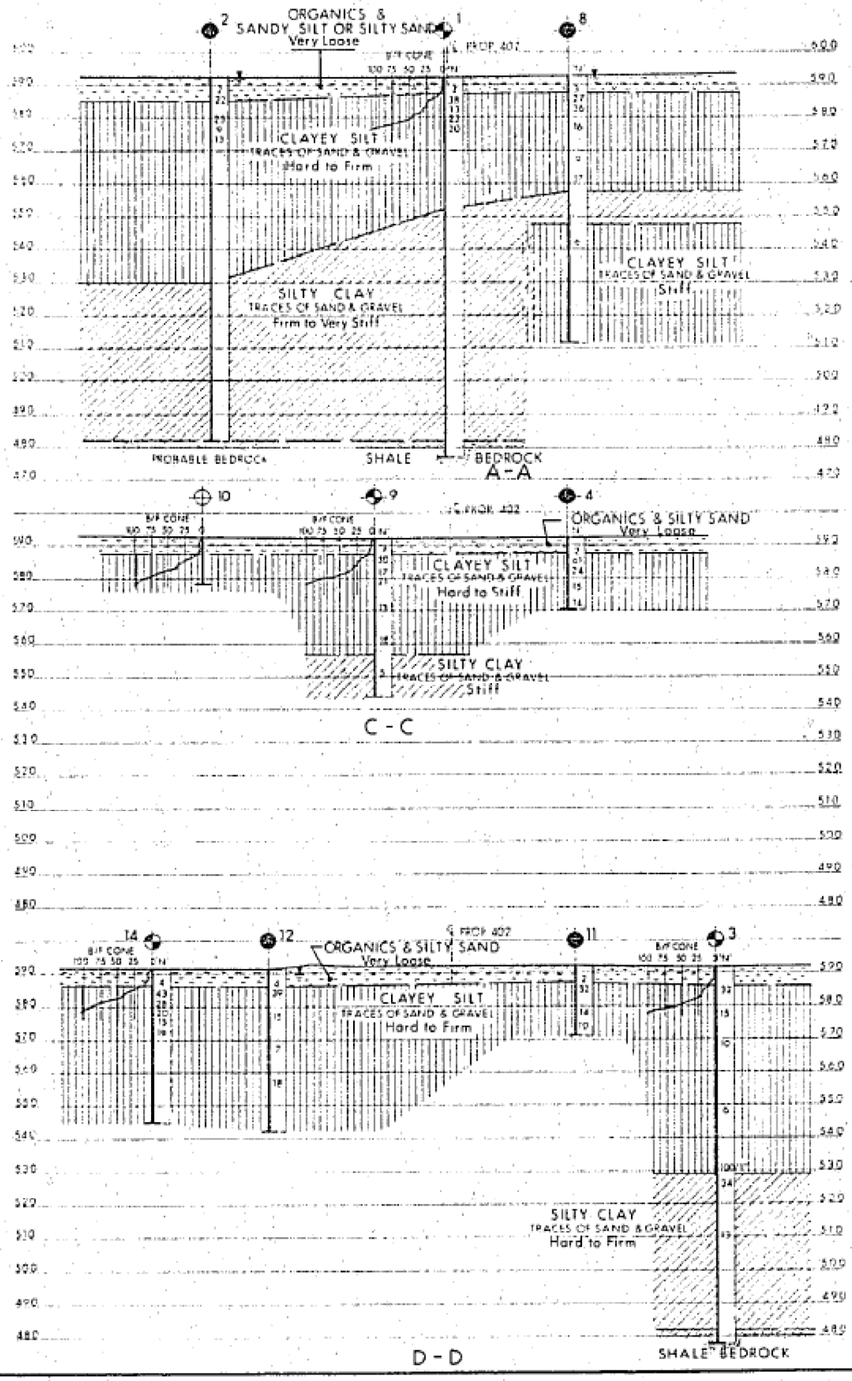
LIQUID LIMIT — w_L
PLASTIC LIMIT — w_P
WATER CONTENT — w

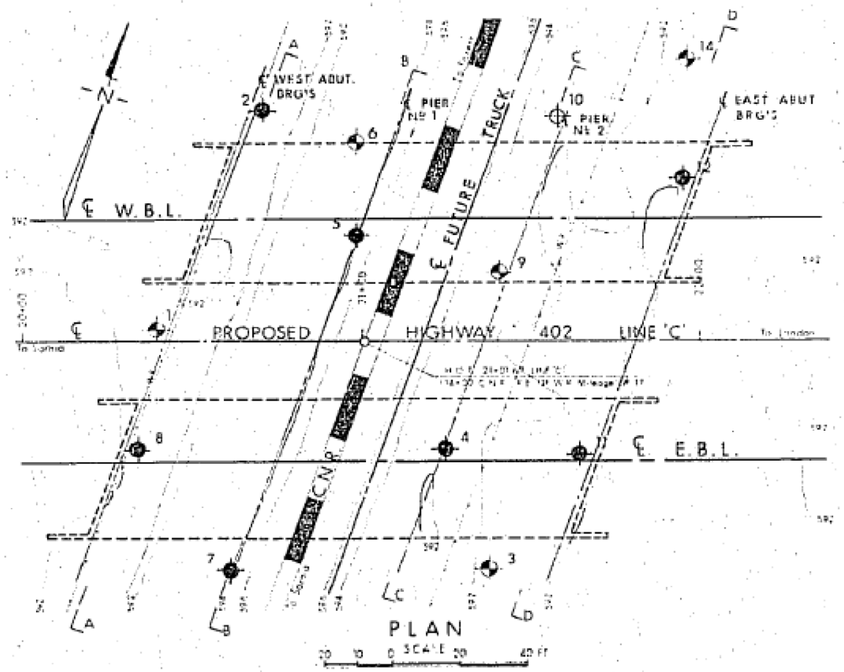
w_P w w_L

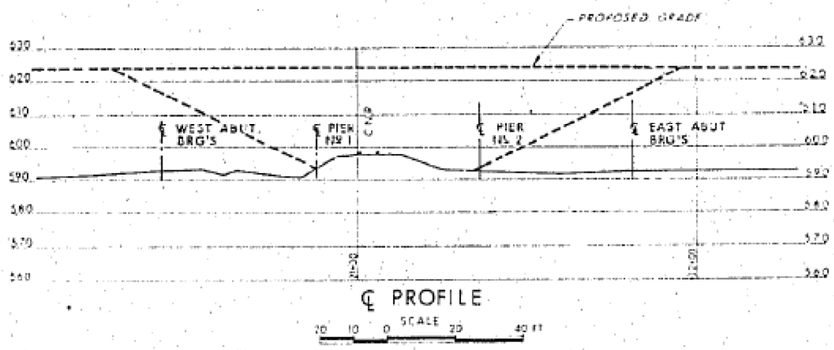
WATER CONTENT % 10 20 30

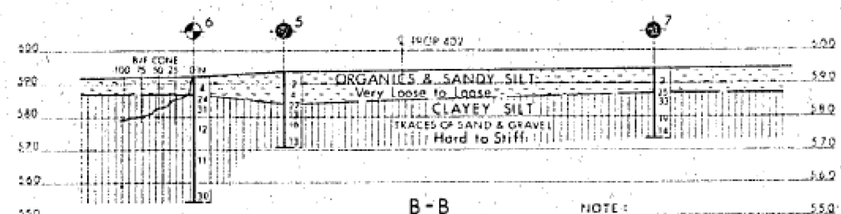
BULK DENSITY γ P.C.F.: 135, 126

REMARKS: GR. SA. SI. CL.









SECTIONS

SCALE

NOTE :
The complete foundation investigation report for this structure may be examined at the Structural Office and Foundation Office, Downsview, and at the CHATHAM District Office.

REF. NO. E-4852-1

141.

LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Water Levels established at time of field investigation, June 1970. Boreholes 2, 8 & 12 only

NO.	ELEVATION	STATION	OFFSET
1	592.6	20+39	1' LT
2	592.5	20+71	69.5' LT
3	591.9	21+37	69.5' RT
4	592.5	21+24	32.5' RT
5	593.7	20+98	32.5' LT
6	592.0	20+98	60' LT
7	594.1	20+61	69.5' RT
8	592.7	20+36	32.5' RT
9	592.0	21+40	20' LT
10	592.1	21+67	69' LT
11	592.2	21+64	34' RT
12	591.1	21+95	53' LT
14	591.5	21+96	86' LT

– NOTE –

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

REVISION		
DATE	BY	DESCRIPTION

DEPARTMENT OF HIGHWAYS – ONTARIO
MATERIALS & TESTING OFFICE – FOUNDATION SECTION

CANADIAN NATIONAL RAILWAY

KING'S HIGHWAY NO. 402 LINE 'C' DIST. NO. 1
CO. LAMBTON
TWP. SARNIA LOT 17&18 CON. 7

BORE HOLE LOCATIONS & SOIL STRATA

SUBMD. A.B.	CHECKED G.P.	W.P. NO. 346-65-01&02	M.B.T. DRAWING NO. 70-11045A
DRAWN S.D.	CHECKED G.P.	JOB NO. 70-11045	
DATE JULY 21, 1970		SITE NO. 14-337	BRIDGE DRAWING NO. D7099-2
APPROVED [signature]		CONT. NO. 75-89	

PRINT RECORD

NO.	FOR	DATE

Twp. 17 337 2.8

Appendix C

Borehole Records

Notes on Borehole and Test Pit Reports

Soil description :

Each subsurface stratum is described using the following terminology. The relative density of granular soils is determined by the Standard Penetration Index ("N" value), while the consistency ofclayey soils is measured by the value of undrained shear strength (Cu).

Classification (Unified system)

Clay	< 0.002 mm		
Silt	0.002 to 0.075 mm		
Sand	0.075 to 4.75 mm	fine	0.075 to 4.25 mm
		medium	0.425 to 2.0 mm
		coarse	2.0 to 4.75 mm
Gravel	4.75 to 75 mm	fine	4.75 to 19 mm
		coarse	19 to 75 mm
Cobbles	75 to 300 mm		
Boulders	>300 mm		

Terminology

"trace"	1-10%
"some"	10-20%
adjective (silty, sandy)	20-35%
"and"	35-50%

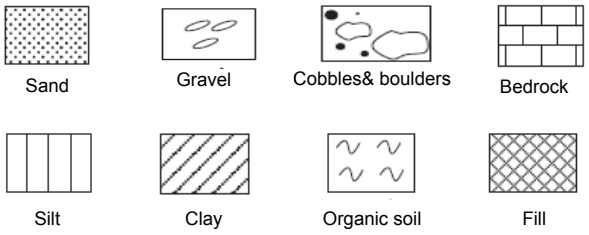
Relative density of granular soils	Standard penetration index "N" value (BLOWS/ft – 300 mm)
Very loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

Consistency of cohesive soils	Undrained shear strength (Cu) (P.S.F)	(kPa)
Very soft	<250	<12
Soft	250-500	12-25
Firm	500-1000	25-50
Stiff	1000-2000	50-100
Very stiff	2000-4000	100-200
Hard	>4000	>200

Rock quality designation

"RQD" (%) Value	Quality
<25	Very poor
25-50	Poor
50-75	Fair
75-90	Good
>90	Excellent

STRATIGRAPHIC LEGEND



Samples:

Type and Number

The type of sample recovered is shown on the log by the abbreviation listed hereafter. The numbering of samples is sequential for each type of sample.

SS: Split spoon
SSE, GSE, AGE: Environmental sampling
ST: Shelby tube
PS: Piston sample (Osterberg)
NR: No Recovery
AG: Auger
RC: Rock core
GS: Grab sample

Recovery

The recovery, shown as a percentage, is the ratio of length of the sample obtained to the distance the sampler was driven/pushed into the soil

RQD

The "Rock Quality Designation" or "RQD" value, expressed as percentage, is the ratio of the total length of all core fragments of 4 inches (10 cm) or more to the total length of the run.

IN-SITU TESTS:

N: Standard penetration index
R: Refusal to penetration
N_c: Dynamic cone penetration index
Cu: Undrained shear strength
Pr: Pressure meter
k: Permeability
ABS: Absorption (Packer test)

LABORATORY TESTS:

I_p: Plasticity index
W_l: Liquid limit
Wp: Plastic limit
H: Hydrometer analysis
GSA: Grain size analysis
NP: non-plastic
A: Atterberg limits
w: Water content
γ: Unit weight
C: Consolidation
CS: Swedish fall cone
CHEM: Chemical analysis
O.V.: Organic vapor

Ministry of Transportation Ontario

GHD

RECORD OF BOREHOLE No BH1-22

1 OF 2

METRIC

G.W.P. NO. 3105-18-00 LOCATION Hwy 402 / Former CNR (Northing: 4760893.2, Easting: 316314.3, MTM Zone 11) ORIGINATED BY M.A

DIST West HWY 402/CNR BOREHOLE TYPE Hollow Stem Auger DRILLING RIG TYPE Track Mounted Drill Rig COMPILED BY N.V

DATUM Geodetic DATE 2022.09.12 - 2022.09.12 LATITUDE 42.987756 LONGITUDE -82.358805 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
190.0											
0.0 / 189.7	ASPHALT (300 mm)										
0.3 / 189.4	CONCRETE (300 mm)										
0.6	FILL - SAND and GRAVEL, some fines Compact Brown Moist		1	SS	25		189				
188.5											
1.5	Fill - SANDY CLAYEY SILT, trace gravel Soft to stiff Brown to grey Moist		2	SS	4		188				5 26 49 20
				VANE				>100 kPa			
			3	SS	7		187		13		LL=25% PL=13% PI=12%
			4	SS	10		186		12		4 29 46 21
			5	SS	7		185				
				VANE				>100 kPa			
			6	SS	10		184		12		LL=23% PL=14% PI=9%
			7	SS	9		183				
			8	SS	10		182				
			9	SS	12		181				
	contrains trace rootlets below the depth of 9.1 m, up to the depth of 10.7 m		10	SS	10						
180.1											

Continued Next Page

+3 Numbers refer to Sensitivity

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RECORD OF BOREHOLE No BH1-22 2 OF 2 METRIC

G.W.P. NO. 3105-18-00 LOCATION Hwy 402 / Former CNR (Northing: 4760893.2, Easting: 316314.3, MTM Zone 11) ORIGINATED BY M.A

DIST West HWY 402/CNR BOREHOLE TYPE Hollow Stem Auger DRILLING RIG TYPE Track Mounted Drill Rig COMPILED BY N.V

DATUM Geodetic DATE 2022.09.12 - 2022.09.12 LATITUDE 42.987756 LONGITUDE -82.358805 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
9.9	FILL - SANDY CLAYEY SILT, trace gravel Stiff Brown to grey Moist		11	SS	11				19		LL=30% PL=15% PI=15%
179.3											
10.7	FILL - GRAVELLY SAND, some silt, trace clay Dense Brown		12	SS	30		179				22 61 12 5
178.7						▽					
11.3	Moist to wet SANDY CLAYEY SILT, trace gravel Stiff Grey Wet		13	SS	15		178				
			14	SS	15						
177.2											
12.8	END OF BOREHOLE										

NOTE:
1. Groundwater at a depth of 11.3 m (Elev. 178.7 m) upon completion of drilling.

+3 Numbers refer to Sensitivity

File: \\GHDNET\GHD\CA\WATERLOO\PROJECTS\66\12566052\TECH\12 FOUNDATIONS\04-FIELDWORK\06-FIELD NOTES AND LOGS\GINT LOGS\12566052 LOGS.GPJ
Library File: 12566052 MTO LIBRARY.GLB Report: 12566052 BOREHOLE LOG V01 Date: 23/1/23

Ministry of Transportation Ontario

GHD

RECORD OF BOREHOLE No BH2-22 1 OF 2 METRIC

G.W.P. NO. 3105-18-00 LOCATION Hwy 402 / Former CNR (Northing: 4760863.7, Easting: 316314.3, MTM Zone 11) ORIGINATED BY M.A

DIST West HWY 402/CNR BOREHOLE TYPE Hollow Stem Auger DRILLING RIG TYPE Track Mounted Drill Rig COMPILED BY N.V

DATUM Geodetic DATE 2022.09.08 - 2022.09.08 LATITUDE 42.987490 LONGITUDE -82.358806 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
189.9											
0.0 / 189.7	ASPHALT (220 mm)										
0.2 / 189.2	CONCRETE (480 mm)										
0.7 / 188.7	FILL - SAND and GRAVEL, some fines Compact Brown Moist		1A	SS	19		189	6			34 49 (17)
1.2			1B								
	FILL - SANDY CLAYEY SILT, trace clay Soft to very stiff Brown to grey Moist		2	SS	4		188	14			
				VANE				>100 kPa			
			3	SS	7		187	18			1 20 40 39 LL=33% PL=16% PI=17%
				VANE			186	>100 kPa			
			4	SS	9		185	13			LL=27% PL=15% PI=12%
			5	SS	12		184				
			6	SS	12			12			LL=24% PL=13% PI=11%
			7	SS	10		183				
			8	SS	8		182	14			LL=25% PL=14% PI=11%
				VANE				>100 kPa			
			9	SS	12		181				
							180				

Continued Next Page

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RECORD OF BOREHOLE No BH2-22 2 OF 2 METRIC

G.W.P. NO. 3105-18-00 LOCATION Hwy 402 / Former CNR (Northing: 4760863.7, Easting: 316314.3, MTM Zone 11) ORIGINATED BY M.A

DIST West HWY 402/CNR BOREHOLE TYPE Hollow Stem Auger DRILLING RIG TYPE Track Mounted Drill Rig COMPILED BY N.V

DATUM Geodetic DATE 2022.09.08 - 2022.09.08 LATITUDE 42.987490 LONGITUDE -82.358806 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	0.1 m gravelly sand layer at 10.2 m		10A 10B 10C	SS	12						
179.2											
10.7	FILL - SAND, some silt, trace gravel, trace clay Compact Brown Moist		11	SS	25		179		17		9 68 18 5
178.5											
11.4	SANDY CLAYEY SILT, trace gravel Stiff to very stiff Grey Moist to wet		12	SS	15		178				
			13	SS	18	▽			16		
177.1											
12.8	END OF BOREHOLE										

NOTE:
1. Groundwater at a depth of 12.7 m (Elev. 177.2 m) upon completion of drilling.

+3 Numbers refer to Sensitivity

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Library File: 12566052 MTO LIBRARY.GLB Report: 12566052 BOREHOLE LOG V01 Date: 23/1/23

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RECORD OF BOREHOLE No BH3-22 1 OF 2 METRIC

G.W.P. NO. 3105-18-00 LOCATION Hwy 402 / Former CNR (Northing: 4760911.6, Easting: 316369.7, MTM Zone 11) ORIGINATED BY M.A

DIST West HWY 402/CNR BOREHOLE TYPE Hollow Stem Auger DRILLING RIG TYPE Track Mounted Drill Rig COMPILED BY N.V

DATUM Geodetic DATE 2022.09.12 - 2022.09.12 LATITUDE 42.987921 LONGITUDE -82.358125 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
189.9											
0.0 / 189.6	ASPHALT (310 mm)										
0.3 / 189.1	CONCRETE (490 mm)										
0.8 / 188.4	FILL - SAND and GRAVEL, some fines Dense Brown Moist		1	SS	38		189		5		36 49 (16)
1.5	FILL - SANDY CLAYEY SILT, trace gravel, contains trace rootlets at the depth of 1.5 m below ground surface Firm to very stiff Brown to grey Moist		2	SS	6		188				
				VANE				>100 kPa			
			3	SS	10		187		13		LL=29% PL=14% PI=15%
			4	SS	23		186				
			5	SS	9		185		13		2 28 41 29 LL=28% PL=14% PI=14%
			6	SS	7						2 28 44 26 LL=28% PL=13% PI=15%
				VANE			184	>100 kPa			
			7	SS	11		183		13		
			8	SS	8		182				
			9	SS	12		181				
			10	SS	13		180		12		LL=26% PL=13% PI=13%

Continued Next Page

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RECORD OF BOREHOLE No BH3-22 2 OF 2 METRIC

G.W.P. NO. 3105-18-00 LOCATION Hwy 402 / Former CNR (Northing: 4760911.6, Easting: 316369.7, MTM Zone 11) ORIGINATED BY M.A

DIST West HWY 402/CNR BOREHOLE TYPE Hollow Stem Auger DRILLING RIG TYPE Track Mounted Drill Rig COMPILED BY N.V

DATUM Geodetic DATE 2022.09.12 - 2022.09.12 LATITUDE 42.987921 LONGITUDE -82.358125 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	contains trace rootlets, hydrocarbon odour at depths of 9.9 m and 12.0 m.		11	SS	17						
			12	SS	14		179				
178.6											
11.3	SANDY CLAYEY SILT, trace gravel Stiff Grey Moist		13	SS	14		178				
			14	SS	15						
177.1											
12.8	END OF BOREHOLE NOTE: 1. Borehole open and dry upon completion of drilling.										

+3 Numbers refer to Sensitivity

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RECORD OF BOREHOLE No BH4-22 1 OF 2 METRIC

G.W.P. NO. 3105-18-00 LOCATION Hwy 402 / Former CNR (Northing: 4760879.4, Easting: 316364.0, MTM Zone 11) ORIGINATED BY M.A

DIST West HWY 402/CNR BOREHOLE TYPE Hollow Stem Auger DRILLING RIG TYPE Track Mounted Drill Rig COMPILED BY N.V

DATUM Geodetic DATE 2022.09.06 - 2022.09.07 LATITUDE 42.987631 LONGITUDE -82.358196 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
190.1							
190.0 0.0	ASPHALT (150 mm)						
0.2	CONCRETE (350 mm)						
189.4							
0.7	FILL - SAND and GRAVEL, some fines Compact Brown Moist		1	SS	23		35 50 (15)
			2	SS	17		
187.8							
2.3	FILL - SANDY CLAYEY SILT, trace gravel Soft to very stiff Brown to grey Moist to wet		3	SS	4		6 26 43 25 LL=23% PL=12% PI=11%
				VANE			>100 kPa
			4	SS	8		LL=28% PL=14% PI=14%
				VANE			>100 kPa
			5	SS	11		3 26 44 28 LL=28% PL=15% PI=13%
			6	SS	7		
				VANE			>100 kPa
			7	SS	8		
				VANE			>100 kPa
			8	SS	25		2 27 (72)
180.2							

ELEVATION SCALE: 190, 189, 188, 187, 186, 185, 184, 183, 182, 181

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m^3

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Library File: 12566052 MTO LIBRARY.GLB Report: 12566052 BOREHOLE LOG V01 Date: 23/1/23

Ministry of Transportation Ontario

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RECORD OF BOREHOLE No BH4-22 2 OF 2 METRIC

G.W.P. NO. 3105-18-00 LOCATION Hwy 402 / Former CNR (Northing: 4760879.4, Easting: 316364.0, MTM Zone 11) ORIGINATED BY M.A

DIST West HWY 402/CNR BOREHOLE TYPE Hollow Stem Auger DRILLING RIG TYPE Track Mounted Drill Rig COMPILED BY N.V

DATUM Geodetic DATE 2022.09.06 - 2022.09.07 LATITUDE 42.987631 LONGITUDE -82.358196 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
9.9	FILL - SANDY CLAYEY SILT, trace gravel Stiff to very stiff Brown to grey Moist		9	SS	12		180				
			10	SS	16		179		21		LL=29% PL=13% PI=16%
178.8											
11.3	SANDY CLAYEY SILT, trace gravel Stiff Brown to grey Moist		11	SS	11		178				
			12	SS	14				14		
177.3											
12.8	END OF BOREHOLE NOTE: 1. Borehole open and dry upon completion of drilling.										

+3 Numbers refer to Sensitivity

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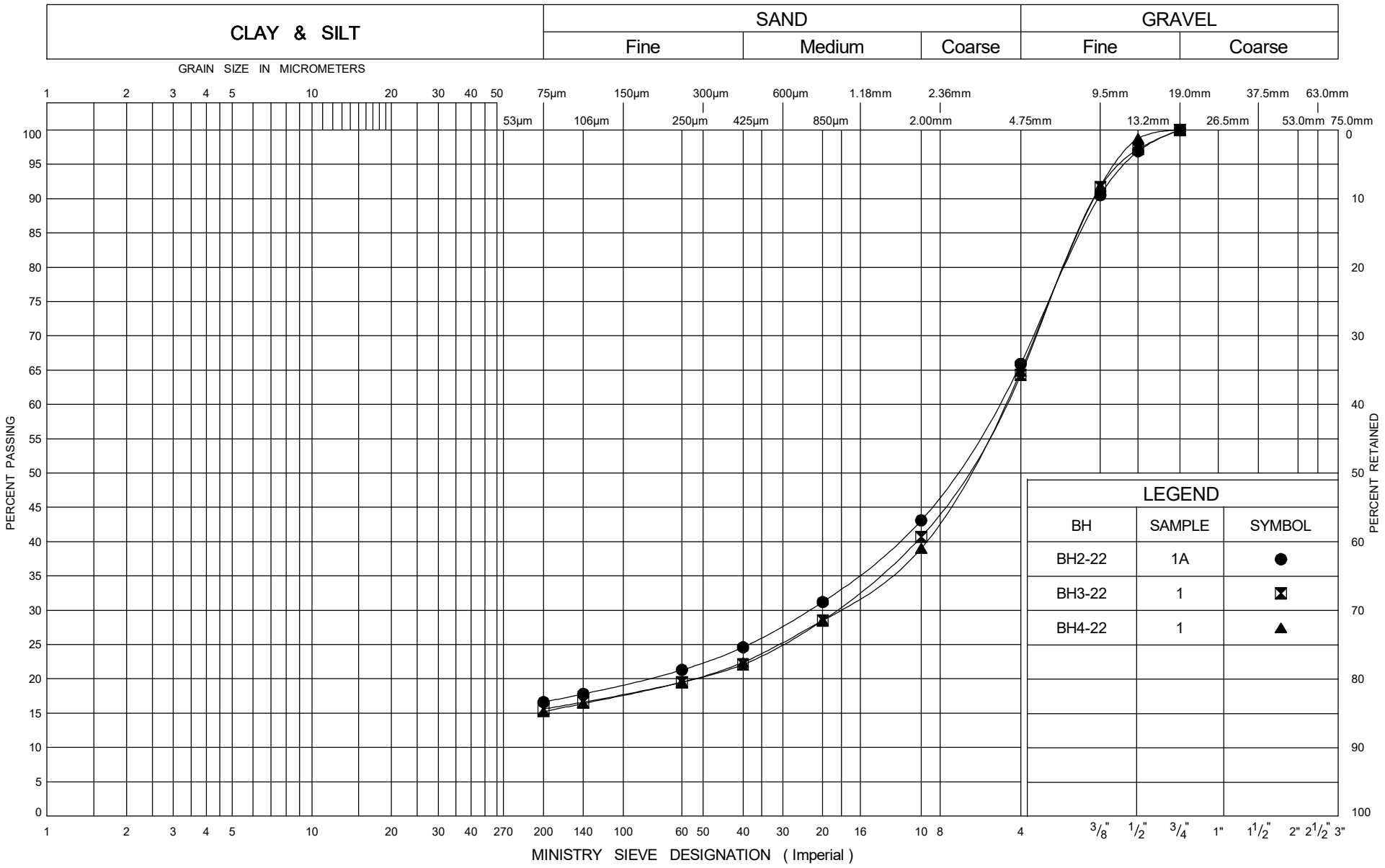
Appendix D

Geotechnical Laboratory Test

UNIFIED SOIL CLASSIFICATION SYSTEM



ONTARIO MOT GRAIN SIZE (TITLE) 12566052 LOGS.GPJ ONTARIO MOT.GDT 23/1/23

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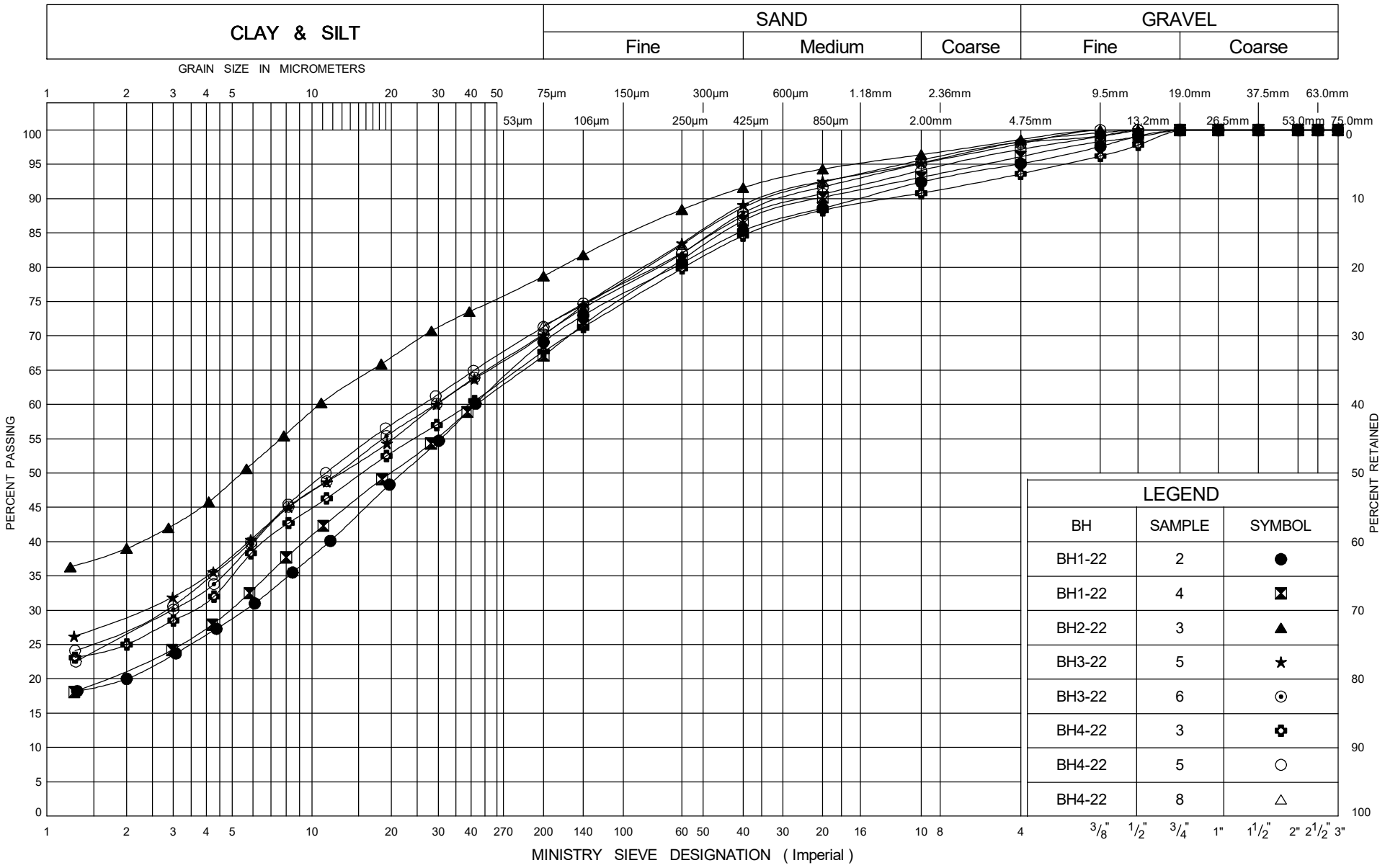
Ontario

GRAIN SIZE DISTRIBUTION

Granular Fill - Sand and Gravel

Figure:	D-1
Project Name:	Highway 402/CNR
G.W.P. No.:	3105-18-00
GHD Project No.:	12566052

UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of Transportation
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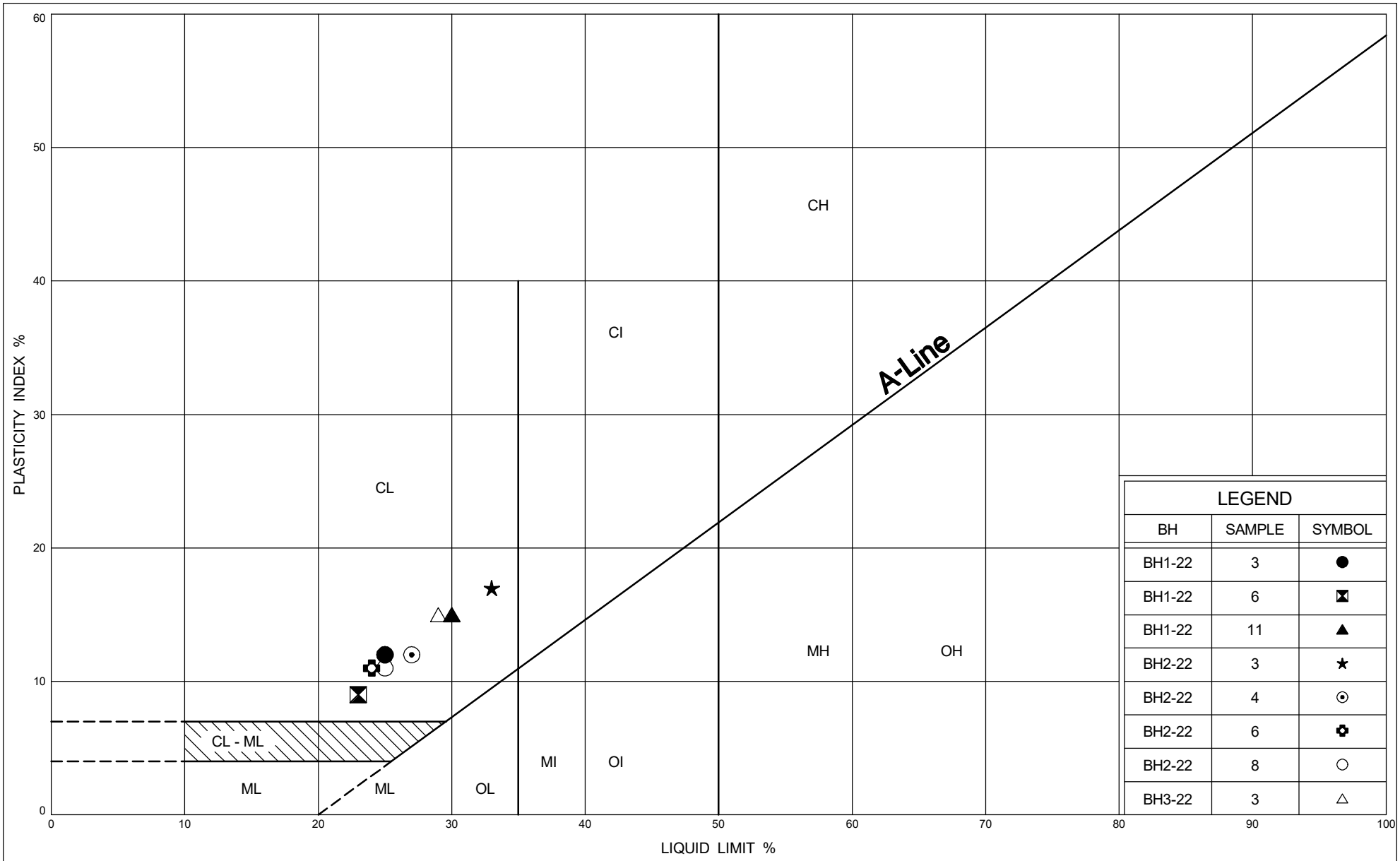
GRAIN SIZE DISTRIBUTION

FILL - Sandy Clayey Silt

Figure:	D-2
Project Name:	Highway 402/CNR
G.W.P. No.:	3105-18-00
GHD Project No.:	12566052

ONTARIO MOT GRAIN SIZE (TITLE) 12566052 LOGS.GPJ ONTARIO MOT.GDT 23/1/23



ONTARIO MOT PLASTICITY CHART 12566052 LOGS.GPJ ONTARIO MOT.GDT 23/1/23

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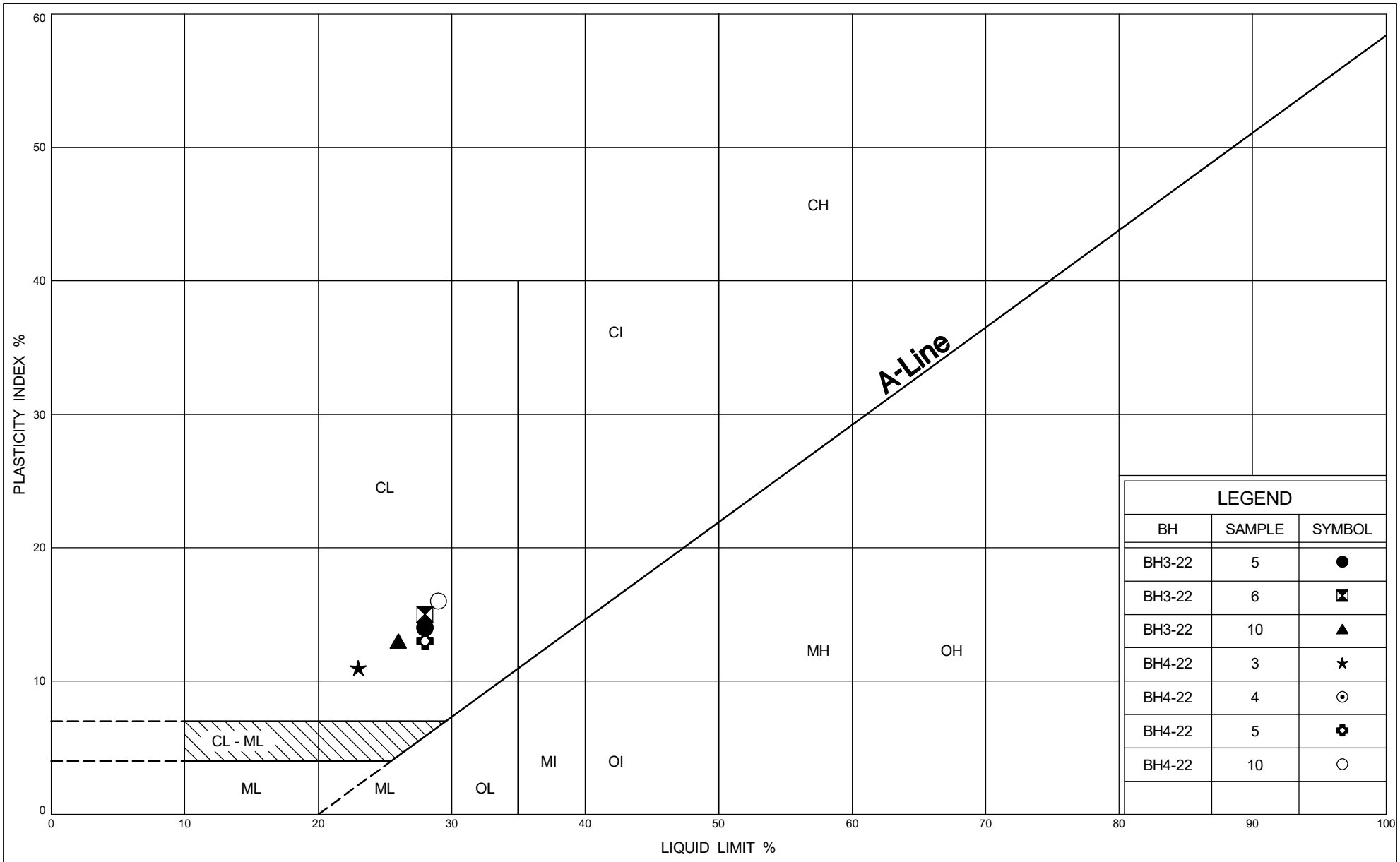
PLASTICITY CHART

FILL - Sandy Clayey Silt

Figure:	D-3A
Project Name:	Highway 402/CNR
G.W.P. No.:	3105-18-00
GHD Project No.:	12566052



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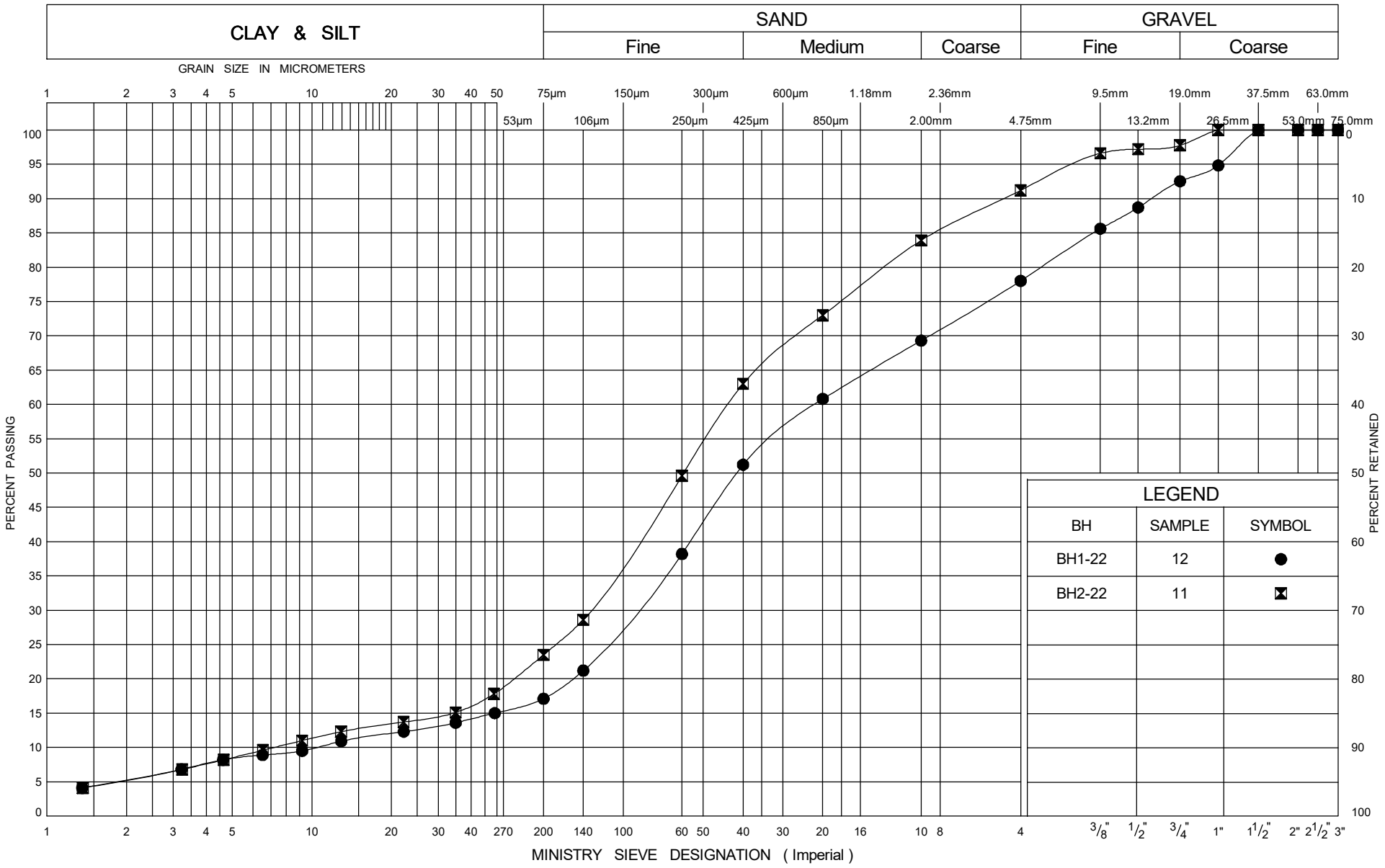
PLASTICITY CHART

FILL - Sandy Clayey Silt

Figure:	D-3B
Project Name:	Highway 402/CNR
G.W.P. No.:	3105-18-00
GHD Project No.:	12566052

ONTARIO MOT PLASTICITY CHART 12566052 LOGS.GPJ ONTARIO MOT.GDT 23/1/23

UNIFIED SOIL CLASSIFICATION SYSTEM



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Ontario

GRAIN SIZE DISTRIBUTION

FILL - Gravelly Sand to Sand

Figure:	D-4
Project Name:	Highway 402/CNR
G.W.P. No.:	3105-18-00
GHD Project No.:	12566052

ONTARIO MOT GRAIN SIZE (TITLE) 12566052 LOGS.GPJ ONTARIO MOT.GDT 23/1/23

Appendix E

Non-Standard Special Provisions (NSSP)

PROTECTION SYSTEM – Item No.

Special Provision

Amendment to OPSS 539, November 2014

593.07.02 Removal of Protection Systems

Subsection 539.07.02 of OPSS 539 is deleted in its entirety and replaced with the following:

Protection systems shall be removed from the right-of-way unless it is specified in the Contract Documents that the protection system may be left in place.

Where piles are left in place, the top(s) shall be removed to at least 1.0 m below the finished grade or ground level or ditch bottom.

The method and sequence of removal shall be such that there shall be no damage to the new work, and existing work being protected.

All disturbed areas shall be restored to an equivalent or better condition than existing prior to the commencement of construction.

Obstructions

Notice to Contractor

The Contactor shall be alerted to the potential presence of cobbles, boulders and/or obstructions within the fill material and native deposits.

Consideration of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for open cut excavations, and installation of temporary protection systems.