



**FOUNDATION INVESTIGATION AND DESIGN REPORT
IN SUPPORT OF DETAILED DESIGN FOR WATERMAIN
REPLACEMENT ON DIXIE ROAD
MISSISSAUGA, ONTARIO
PROJECT 20-1311**

for

**THE REGIONAL MUNICIPALITY OF PEEL
C/O COLE ENGINEERING LTD., PART OF IBI GROUP
LATITUDE AND LONGITUDE: 43.648059, -79.637868**

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PML Ref.: 20TF025A
GEOCRES No.: 30M12-516
November 3, 2021



**PART A – FOUNDATION INVESTIGATION REPORT
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PART A – FOUNDATION INVESTIGATION REPORT

for

In Support of Detailed Design for Watermain Replacement on Dixie Road
Mississauga, Ontario
Project 20-1311

1. INTRODUCTION

Peto MacCallum Ltd. (PML) was retained by The Regional Municipality of Peel (Peel Region) to conduct a foundation investigation and prepare a detailed Foundation Investigation Report (FIR) to facilitate detail design for construction of the watermain replacement on Dixie Road between Britannia Road East and south of the Highway 401 and Dixie Road Interchange in the City of Mississauga, Ontario.

As outlined in the Request for Proposal (RFP) Document 2020-339P, the new proposed watermain will consist of approximately 1,500 linear metres of 400mm diameter watermain along Dixie Road from Britannia Road East to South of the Highway 401 and Dixie Road Interchange. The assignment includes crossing the Ministry of Transportation of Ontario (MTO) Highway 401 by utilizing trenchless methodology.

A trenchless construction technique is to be considered crossing the MTO Highway 401 corridor, approximately 552.0 m in length. The installation of the proposed watermain north of Highway 401 corridor will be carried out with open-cut technique within the Region of Peel Right-of-Way.

2. OBJECTIVE

The objective of the subsurface investigation work was to obtain data to determine and evaluate the geotechnical engineering characteristics of soil overburden and bedrock along the proposed watermain replacement alignment. The majority of the field investigation activities involved drilling through overburden to specified depths at specific locations, in-situ testing, field classification of soil, and limited geophysical surveys. A limited geo-environmental chemical testing program of the soil was undertaken in conjunction with the foundation investigation. The results of the limited geoenvironmental chemical testing of soil samples are included in this report. The Hydrogeological Data Report and the associated Impact Assessment Report will be issued separately.



3. SITE DESCRIPTION

The topography of the project area terrain is flat to gently undulating. The proposed watermain tunnel alignment is approximately 22.0 m west of the existing Dixie Road underpass structure. The highway exit and entry ramps at this interchange are located at a higher elevation than the travelled portion of the highway. Highway 401 within the project limit is oriented in the east-west direction. The vicinities of the proposed watermain alignment range from industrial, commercial, to undeveloped lands.

4. BOREHOLE AND MONITORING WELL LOCATION PLANS

The proposed borehole locations and depths were provided in *Table 1 – Proposed Geotechnical Boreholes*, of the RFP and consisted of 14 boreholes, including one (1) provisional borehole P-1. The proposed monitoring well installation locations were provided in *Table 2 – Proposed Monitoring Wells*, of the RFP and consisted of four (4) monitoring well installations.

PML and Cole Engineering, part of IBI Group, (Cole) carried out a site visit on August 26, 2020. During the site visit, it was noted that Borehole BH4 required tree/shrub clearing in order to proceed with drilling. Upon further review and discussion, Borehole BH4 was relocated from the original staked location in order to eliminate the requirement for tree/shrub clearing. Similarly, Boreholes G-1 and G-2 were moved from their original staked location due to their proximity to existing underground utilities. The adjusted locations and coordinates of the boreholes were submitted for approval prior to carrying out the fieldwork investigation. Approval for the updated borehole locations were provided by Cole via e-mail dated December 14, 2020. Approval to proceed with Borehole P-1 investigation (provisional) was provided by Cole via e-mail dated December 16, 2020.

The borehole location plan of the as-drilled borehole locations and monitoring well installations are presented in Plan Nos. 74191-D, 74192-D, and 74193-D. The locations of previous boreholes completed by others, BH04A, BH 07, BH 08, BH08A, BH10A, and BH11B were already included in the CAD drawing received from Cole via email dated March 22, 2021. PML did not field verify the previous boreholes investigated by others.



During the preparation of the final report, the proposed location of Shaft No. 1 was relocated approximately 65.2 m north of the previous shaft location adjacent to Borehole BH1/MW1. The new shaft location was provided in plan and profile drawings to PML via emails dated October 6 and 25, 2021. The soil/rock stratigraphy is considered fairly consistent based on a review of the boreholes and it is assumed that the conditions are similar. However, the Contractor should verify the assumptions for ground conditions for Shaft 1 for their own purposes.

5. FIELD INVESTIGATION PROCEDURES

The borehole locations were laid out in the field by PML staff based on drawings and approvals provided by Cole, as per emails dated September 2, and 16, 2020.

Upon completion of the borehole layout work, underground utility locate clearances were processed via Ontario One Call and MTO AMC electrical utilities. Localized borehole location adjustments were made as necessary in some areas to avoid conflict with existing underground utility installations. In accordance with the RFP requirements, a road occupancy permit for Peel Region and Highway Corridor Management (HCM) Encroachment Permit (EC-2020-20T-00000433 V1) were obtained prior to carrying out field investigation.

The fieldwork for the foundation investigation for Boreholes G-1 to G-3, and BH1 to BH10 was carried out between December 3, 2020 and January 22, 2021. Upon approval and HCM Encroachment Permit issuance, fieldwork for Borehole P-1 was carried out on March 6 and 7, 2021. The depths of borehole explorations ranged from 4.0 m to 18.6 m below existing ground surface.

Following fieldwork completion of the boreholes, Cole provided updated plan and profile drawings of the proposed watermain via email dated May 28, 2021. Based on the updated invert levels of the watermain along the trenchless tunnelling section, Boreholes BH2 and BH7 required to be extended to meet the MTO exploration requirements in accordance with Guideline for MTO Foundation Engineering Services (V2, October 2020). Approval to extend the boreholes was provided by Cole on May 28, 2021. The fieldwork for the foundation investigation for the extended boreholes was carried out between June 2 and 7, 2021. Boreholes BH2A and BH7A were extended adjacent to the completed Boreholes BH2 and BH7 to depths of 19.1 m and 20.6 m, respectively. Boreholes BH2A and BH7A were augered down to BH2 and BH7 termination depths, respectively, without soil sampling. Rock core samples were obtained from 13.0 m to 19.1 m in



Borehole BH2A and from 16.0 m to 20.6 m in Borehole BH7A. An additional monitoring well was also installed in Borehole BH7A to measure subsequent groundwater levels.

The boreholes were advanced using a combination of track/truck mounted CME-75 drill rigs equipped with 200 mm diameter continuous hollow stem augers and rotary drilling. The drill rigs were supplied and operated by Drilltech Drilling Limited, based in Newmarket, Ontario, Walker Drilling Ltd. based in Utopia, Ontario, and Landshark Drilling, based on Brantford, Ontario. The specialist drilling contractors were subcontracted by PML to carry out the field investigation work. Packer testing equipment was provided by Walker Drilling Ltd. The testing and data collecting for the overcoring in-situ stress measurements were carried out by Golder Associates Ltd (Golder), subcontracted by PML. The overcoring testing equipment was provided by Golder and the specialized drilling equipment was provided by Walker Drilling Ltd. The fieldwork was supervised on a full-time basis by PML engineering staff.

Bedrock coring at the Borehole BH3-1 location was carried out in an adjacent borehole located 1.0 m east of Borehole BH3 location.

Traffic control services were provided by Geotech Support Services Inc. based in Markham, Ontario and Jackson Trademark Services based in Pefferlaw, Ontario, in accordance with Ontario Traffic Manual Book 7-Temporary Conditions (January 2014).

The thickness of the pavement components encountered in the Borehole P-1 was measured and samples of granular base/subbase materials were obtained.

Representative samples of the overburden were recovered typically at 0.75 m intervals using a conventional split spoon sampler. Standard penetration tests (SPT) were carried out simultaneously with the sampling operations to assess the compactness/consistency of the subsoil. HQ rock core samples were obtained from the bedrock using rotary drilling equipment.

Soils were identified in the field and in the laboratory in accordance with ASTM D2487, Unified Soil Classification System (USCS) by visual examination on recovered samples. The backfilling operation of the investigated boreholes was carried out in accordance with R.R.O. 1990, Reg. 903:Wells, as amended.

The groundwater conditions in the open boreholes were assessed during drilling by visual examination of soil, split spoon sampler, and drill rods as the samples were being retrieved and,



where encountered, by measuring the groundwater level in the open boreholes using a Solinst water level meter.

As part of the field investigation work, five (5) monitoring wells were installed in the overburden to facilitate subsequent monitoring of groundwater levels. The details of the monitoring well groundwater level are summarized in Table 18. The construction details of the monitoring wells are presented in the Record of Borehole Logs. Slug test was carried out in each monitoring well installed in the Boreholes BH1, BH4, BH7, and BH10 to determine the hydraulic conductivity. The wells were developed prior to carrying out the slug test by removing an equivalent 3 to 10 times the respective well volume. The monitoring wells were developed (purged) on February 9, 2021. In the test, a volume of water (the 'slug') was rapidly removed from the monitoring well using a bailer and periodic water level measurements were recorded manually and with an electronic transducer (a Solinst Levelogger), as the water level recovered inside the well. The test was carried out on February 26, 2021.

QRAE 3, a diffusion gas monitor from RAE Systems, was used to monitor/measure subsurface gases in the boreholes along the alignments for tunnelling/micro-tunnelling construction work. The QRAE 3 was used to detect the presence of methane, hydrogen sulphide, carbon monoxide and oxygen in the boreholes. UltraRAE 3000, a compound-specific monitor, was used to monitor/measure subsurface benzene gas along the alignment for tunnelling/micro-tunnelling construction work.

The recovered soil samples were delivered to PML's laboratory for detailed visual examination and testing. Moisture content testing was conducted on the retrieved soil samples. Grain size analyses and hydrometer testing were conducted on selected soil samples. The test results are included in the attached Record of Borehole Sheets. Compressive strength, point load index, splitting tensile strength, slake durability, and CERCHAR abrasivity tests on selected rock core samples were carried out.

PML staff used a portable GPS device to establish the location of boreholes in the field. Subsequently, PML carried out the survey of the as-drilled borehole locations and elevations using a Sokkia SHC5000 Differential GPS system, equipped with a GCX3 (Network RTK rover) GNSS Receiver. The vertical and horizontal accuracy of this equipment are within 0.1 m and 0.5 m, respectively.



The borehole coordinates, ground surface elevations, exploration depths are summarised in Table 1.

The elevations (EL.) in this report are expressed in meters and geodetic, unless otherwise noted.

TABLE 1
SUMMARY OF BOREHOLE LOCATION, GROUND ELEVATION AND
BOREHOLE DEPTH

BOREHOLE ID	UTM NAD 83 ZONE 17				GROUND ELEVATION (m)	BOREHOLE DEPTH (m)
	NORTHING	EASTING	LATITUDE	LONGITUDE		
G-1	4 833 991.672	609 526.262	43.650857	- 79.641840	162.1	4
G-2	4 833 922.466	609 604.518	43.650223	- 79.640884	161.4	4.4
G-3	4 833 872.035	609 650.806	43.649762	- 79.640321	160.4	5
BH1/MW-1	4 833 853.196	609 671.312	43.649590	- 79.640070	160.1	12.2
BH2	4 833 818.868	609 711.967	43.649275	- 79.639573	163.1	13.2
BH2A	4 833 818.198	609 712.194	43.651277	- 79.639374	163.0	19.1
BH3	4 833 788.818	609 744.756	43.648999	- 79.639173	163.5	12.3
BH3-1	4 833 788.818	609 745.756	43.648999	- 79.639160	163.5	15.9
BH4/MW-2	4 833 774.613	609 757.644	43.648869	- 79.639016	163.2	15.8
BH5	4 833 733.145	609 798.995	43.648490	- 79.638512	160.8	12.7
BH6	4 833 639.158	609 890.518	43.647631	- 79.637396	160.7	15.9
BH7/MW-3	4 833 607.425	609 930.584	43.647339	- 79.636906	165.1	15.3
BH7A	4 833 605.916	609 931.947	43.649325	- 79.636693	165.2	20.6
BH8	4 833 589.710	609 949.263	43.647177	- 79.636678	165.2	18.6
BH9	4 833 558.124	609 979.300	43.646888	- 79.636312	164.3	18.6
BH10/MW-4	4 833 517.316	610 011.247	43.646516	- 79.635925	159.6	13.7
P-1	4 833 686.098	609 851.700	43.648059	- 79.637868	160.9	17.8



The designer and the contractor should verify the elevations and coordinates for their own purposes.

6. LABORATORY TEST PROCEDURES

Laboratory tests on representative SPT samples recovered during the fieldwork were carried out by the certified laboratory owned by PML, located in Toronto. The routine index laboratory testing program included the following:

- Moisture content determination – 173 samples
- Sieve and Hydrometer test – 52 soil and weathered shale samples
- Sieve only test – 3 soil samples
- Atterberg limits test – 51 soil and weathered shale samples
- Standard Proctor Test – 5 soil samples

The laboratory tests to determine the index properties were performed in accordance with the MTO test procedures, which follow American Society for Testing Materials (ASTM) test procedures, with the exception of hydrometer test (LS-702). The results of the grain size distribution analyses are presented on the appended Figures GS-1A, GS-1B, GS-2, GS-3A to GS-3C, and GS-4 to GS-8. The Atterberg limit test results are presented in Figures PC-1, PC-2A to PC-2C, PC-3, PC-4, PC-5A and PC-5B. Standard Proctor test (Moisture Density Relationship test) was performed on six (6) samples in accordance with ASTM D698.

The complex laboratory testing program on rock samples included the following:

- Compressive Strength test was performed on 10 intact rock samples in accordance with ASTM D7012
- Elastic Moduli of Rock Core in Uniaxial Compression were determined on two (2) rock core samples in accordance with ASTM D7012
- Point Load Strength test was performed on 31 rock samples in accordance with ASTM D5731
- Splitting Tensile Strength test was performed on 10 rock samples in accordance with ASTM D3967
- Slake Durability Test was performed on 10 rock samples in accordance with ASTM D4644
- CERCHAR Abrasivity test was performed on 10 rock samples in accordance with ASTM D7625

The complex rock test results are appended in Appendix A.



7. SITE GEOLOGY AND SUBSURFACE CONDITIONS

7.1 Site Geology

In general, the project area is located within the southwest flange of the South Slope physiographic region. Within the project area, the South Slope consists of morainic topography, as outlined in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984).

The Quaternary Geology map published by the Ontario Ministry of Northern Development and Mines (MNDM) indicates that the sub-surface conditions in the vicinity of the project area predominantly consist of silt to silty clay Halton Till.

Based on the Bedrock Geology map (MRD126-REV1, 2011) published by the MNDM, the project area is within the boundary of the Georgian Bay formations of the Upper Ordovician rock formations, mainly consisting of shale, limestone, dolostone, and siltstone.

7.2 Subsurface Conditions

The subsurface conditions encountered during the course of the investigation, together with the field and laboratory test results are shown on the attached Record of Borehole Sheets. The borehole locations are presented in the attached drawings Plan Nos. 74191-D, 74192-D, 74193-D. This FIR presents factual information/data only. The boundaries between soil and rock strata have been established at the borehole locations only. The boundaries of soil and bedrock strata between and beyond the boreholes are assumed and may vary from location to location.

In general, the subsurface conditions consisted of 200 mm of topsoil over 0.8 m to 6.1 m thick fill, which consisted of sandy silt/silty sand and clayey silt. Clayey silt fill was encountered in most boreholes. Pavement structure was encountered only in Borehole P-1, which was investigated in the median of Highway 401. The fill was underlain by 1.5 m to 1.6 m compact to very dense silty sand/sandy silt in Boreholes G-1, BH2 and BH3. Borehole G-1 was terminated in this layer. Sandy Clayey Silt Till, very stiff to hard consistency, was the predominant overburden soil and was encountered in all boreholes, excluding Borehole G-1, below the topsoil or fill. Within this till layer, intercepts of clayey sand, silty sand and silty gravel was encountered. Boreholes G-2, G-3, BH2, and BH7 were terminated in this layer. Very dense Clayey Sand Till was encountered immediately below sandy clayey silt till in Boreholes BH3, BH4, BH6 and P-1. Borehole BH3 was terminated in this layer. In Boreholes BH4, BH6 and P-1 extended to shale bedrock. Rock core



lengths of 2.0 m to 7.3 m were obtained from Boreholes BH1, BH2A, BH3-1, BH4, BH5, BH6, BH7A, BH8, BH9, BH10 and P-1. For classification purposes, the soils encountered at this site can be divided into seven (7) distinct zones:

- a. Pavement Structure
- b. Topsoil
- c. Fill
- d. Sandy Silt/Silty Sand
- e. Sandy Clayey Silt Till
- f. Clayey Sand Till
- g. Shale Bedrock

7.2.1 Pavement Structure

Pavement structure was encountered immediately at the existing surface at Borehole P-1 location. The pavement structure consisted of 130 mm asphaltic concrete over 500 mm crusher-run-limestone (CRL) fill. The CRL was underlain by sand with gravel fill. One N value recorded in the pavement fill is 25 blows for 300 mm penetration (blows). Moisture content determination of one sample is 4.1%.

7.2.2 Topsoil

A 200 mm thick topsoil was encountered immediately at the ground surface in Boreholes G-1 to G-3, BH2, BH4, BH6 to BH8, and BH10, extending to EL. 159.4 to EL. 165. The boreholes were located off-road, away from sidewalk, in the boulevards.

7.2.3 Fill

Fill materials comprising of silty sand/sandy silt, and clayey silt were encountered in all investigated boreholes. The thickness of the fill layer ranged from 0.8 m to 6.1 m. The fill layers extended to depths ranging from 1.8 m to 6.1 m (EL. 157.0 to EL. 162.0) below existing ground surface. The SPT 'N'-values in the non-cohesive fill ranged from 4 to 44, indicating compactness ranging from loose to very dense. The SPT 'N'-values in the cohesive fill ranged from 5 to 27, indicating firm to very stiff consistency. The results of moisture content tests performed on recovered samples of the non-cohesive fill material ranged from 7.1% to 24.1%, with an average



value of 14.6%. The results of moisture content tests performed on recovered samples of the cohesive fill material ranged from 6.8% to 25.1%, with an average value of 15.5%.

Grain size distribution and Atterberg limit tests were conducted on two (2) representative split spoon samples obtained from this layer. Based on the grain size distribution results, the non-cohesive fill tested sample comprised of 37% gravel, 44% sand, 15% silt, and 4% clay sized particles, and the cohesive tested sample comprised of 0% gravel, 24% sand, 51% silt, and 25% clay sized particles. Based on the Atterberg limits test results, the liquid limit (LL) of the cohesive fill sample was 30, plastic limit (PL) was 17, and plasticity index (PI) was 13, indicating low to medium plasticity. The sieve analysis test results are presented in Figure GS-1A and GS-1B, and the Atterberg limit test results are presented in Figure PC-1, in Appendix A. The sieve analysis and Atterberg limit test results are summarized in Table 2.

TABLE 2
SUMMARY OF ATTERBERG LIMITS AND GRAIN SIZE DISTRIBUTION

BOREHOLE ID	SAMPLE NO	ATTERBERG LIMITS			GRAIN SIZE DISTRIBUTION (%)			
		LL	PL	PI	GRAVEL	SAND	SILT	CLAY
G-3	3	-	-	-	37	44	15	4
BH2	5	30	17	13	0	24	51	25

LL – Liquid Limit (%); PL – Plastic Limit (%); PI – Plasticity Index (%)

7.2.4 Sandy Silt/Silty Sand

In Boreholes G-1, BH2 and BH3, the fill is underlain by 1.5 m to 1.6 m of sandy silt/silty sand, where fully penetrated. This layer was not fully penetrated in Borehole G-1, and extended to the termination depth of 4.0 m (EL. 158.1) below the existing ground surface. Shale fragments were encountered within this layer in Borehole G1 at 3.8 m (EL. 158.3). In BH2 and BH3, the silty sand/sandy silt layer extended to 6.1 m (EL. 157.0) and 7.6 m (EL. 155.9), respectively, below existing ground surface. The SPT 'N'-values in these deposits ranged from 17 to 100 blows, indicating compactness ranging from compact to very dense. The results of moisture content testing conducted on samples from these deposits ranged from 15.3% to 19.6%, with an average of 17.1%.



Grain size distribution tests were conducted on four (4) representative split spoon sample obtained from sandy silt/silty sand layer. Based on the grain size distribution result, the tested sample comprised of 0% to 3% gravel, 21% to 62% sand, 30% to 71% silt, and 8% to 19% clay sized particles. The sieve analysis test results are presented in Figure GS- 2, and are summarized in Table 3.

TABLE 3
SUMMARY OF GRAIN SIZE DISTRIBUTION

BOREHOLE ID	SAMPLE NO	GRAIN SIZE DISTRIBUTION (%)			
		GRAVEL	SAND	SILT	CLAY
BH2	6	0	21	71	8
BH3	9	3	32	46	19
G-1	4	0	62	30	8
	5	0	25	66	9

7.2.5 Sandy Clayey Silt Till

This sandy clayey silt till deposit was encountered below the fill in Boreholes G2, G3, BH1, BH4 to BH10 and P1 at depths ranging from 1.8 m to 6.1m (EL. 157.8 to EL. 159.1) below existing ground surface. This till was also encountered below the silty sand/sandy silt deposit in Boreholes BH2 and BH3 at 6.1 m and 7.6 m (EL. 157.0 and EL. 155.9), respectively, below existing ground surface. This layer extended to depths ranging from 4.4 m to 16.0 m (EL. 149.2 to EL. 157.0) below existing ground surface. This deposit was not fully penetrated in Boreholes G-2, G-3, BH2 and BH7. Where this layer was fully penetrated, shale bedrock of Georgian Bay Formation was encountered. Thinly laminated shale layers were encountered within this till deposit in Boreholes G-3, BH1, BH2, BH3, BH5, BH7, BH8, BH9 and BH10 from elevations ranging from EL. 150.6 to EL. 157.0 to the termination depth of borehole or to the bedrock surface. The presence of cobbles was inferred in Boreholes BH3 and BH5 by auger grinding observed during drilling. Presence of cobbles was confirmed during bedrock coring in Borehole BH3 and BH5. The SPT-'N' values in this deposit typically ranged from 21 blows to more than 100 blows, indicating very stiff to hard consistency. Two SPT 'N'-values of 4 and 8 were recorded in Borehole BH8 from 6.1 m to 7.5 m (EL. 159.1 to EL. 157.7) below existing ground surface, indicating firm consistency. In Boreholes BH1 and BH7



and P-1, SPT 'N' values of 12 to 15 blows were recorded at the upper zone of this layer, indicating stiff consistency. The results of moisture content testing conducted on samples from these deposits ranged from 2.6% to 20.2%, with an average of 10.6%.

Grain size distribution and Atterberg limit tests were conducted on selected split spoon samples obtained from this deposit. Based on the grain size distribution results, the tested samples comprised of 0% to 21% gravel, 17% to 55% sand, 22% to 56% silt, and 4% to 29% clay sized particles. Based on the Atterberg limits test results, the liquid limits (LL) of the samples ranged from 16 to 35, plastic limits (PL) ranged from 12 to 19, and plasticity indices (PI) ranged from 4 to 17, indicating low to medium plasticity. The sieve analysis test results are presented in Figure GS-3A to GS-3D and the Atterberg limit test results are included in Figure PC-2A and PC-2D, in Appendix A. The sieve analysis and Atterberg limit test results are summarized in Table 4.

TABLE 4
SUMMARY OF ATTERBERG LIMITS AND GRAIN SIZE DISTRIBUTION

BOREHOLE ID	SAMPLE NO.	ATTERBERG LIMITS			GRAIN SIZE DISTRIBUTION (%)			
		LL	PL	PI	GRAVEL	SAND	SILT	CLAY
G-2	5	-	-	-	15	37	43	5
G-2	6	25	17	8	16	32	35	17
G-3	5	18	14	4	10	37	41	12
G-3	6	27	17	10	17	51	22	10
BH1	6	26	19	7	7	37	41	15
BH1	7	28	19	9	16	32	37	15
BH1	9*	-	-	-	21	35	24	22
BH1	10*	29	19	10	-	-	-	-
BH2	8	-	-	-	7	42	39	12
BH2	11*	33	17	16	6	29	36	29
BH2	12*	30	18	12	-	-	-	-
BH2	13*	35	18	17	5	35	33	27
BH3	11	-	-	-	13	32	44	11
BH3	12*	27	16	11	-	-	-	-
BH3	13*	27	18	9	6	17	43	34
BH3	15*	27	18	9	16	33	29	22
BH4	6	23	16	7	6	30	45	19
BH4	7	-	-	-	0	40	56	4



TABLE 4
SUMMARY OF ATTERBERG LIMITS AND GRAIN SIZE DISTRIBUTION

BOREHOLE ID	SAMPLE NO.	ATTERBERG LIMITS			GRAIN SIZE DISTRIBUTION (%)			
		LL	PL	PI	GRAVEL	SAND	SILT	CLAY
BH5	5	-	-	-	3	28	44	25
BH5	6	-	-	-	10	28	41	21
BH5	7	-	-	-	8	32	36	24
BH5	8*	29	16	5	12	28	41	21
BH5	9*	26	16	10	-	-	-	-
BH6	4	-	-	-	2	29	44	25
BH6	6	-	-	-	7	29	45	19
BH6	8	22	14	8	3	31	46	20
BH6	9	-	-	-	6	38	41	15
BH7	9	26	15	11	2	31	46	21
BH7	10	25	14	11	7	31	41	21
BH7	13	16	12	4	5	34	40	21
BH7	14	16	12	4	-	-	-	-
BH8	7	25	17	8	5	28	48	19
BH8	9	21	14	7	-	-	-	-
BH8	12	18	13	5	11	38	37	14
BH8	14	17	13	4	-	-	-	-
BH8	16	19	13	6	9	39	40	12
BH8	17*	19	14	5	-	-	-	-
BH9	7	25	15	10	4	30	42	24
BH9	8	28	16	12	4	30	43	23
BH9	9	-	-	-	6	34	48	12
BH9	12	20	13	7	2	34	50	14
BH9	15	18	14	4	11	39	38	12
BH10	5	-	-	-	1	24	49	26
BH10	7	-	-	-	4	55	41	
BH10	9	21	14	7	-	-	-	-
P-1	7	24	15	9	14	31	35	20
P-1	9	26	17	9	10	39	30	21

Note: * - Thinly laminated shale layers within sandy clayey silt till.
 LL – Liquid Limit (%); PL – Plastic Limit (%); PI – Plasticity Index (%)



A 0.8 m thick clayey sand deposit intercepted this till layer in Borehole BH1 at 6.1 (EL. 154.0), extending to 6.9 m (EL. 153.2) below existing ground surface. A SPT-'N' value recorded was 90, indicating a very dense compactness condition. Moisture content determination of the sample was 6.8%.

Grain size distribution tests were conducted on one (1) representative split spoon sample obtained from this clayey sand deposit. Based on the grain size distribution result, the tested sample comprised of 20% gravel, 44% sand, 22% silt, and 14% clay sized particles. The sieve analysis test results are presented in Figure GS-4, and are summarized in Table 5.

TABLE 5
SUMMARY OF GRAIN SIZE DISTRIBUTION

BOREHOLE ID	SAMPLE NO	GRAIN SIZE DISTRIBUTION (%)			
		GRAVEL	SAND	SILT	CLAY
BH1	8	20	44	22	14

In Boreholes BH7, BH8 and BH10, this till layer was intercepted by 0.8 to 1.5 m thick silty sand deposits at 9.9 m (EL. 155.2), 8.4 m (EL. 156.8) and 6.9 m (EL. 152.7), respectively, below existing ground surface. The SPT-'N' values ranged from 23 blows to 73 blows, indicating compactness ranging from compact to very dense. Moisture content determinations ranged from 9.1% to 15.9%, with an average of 11.5%.

Grain size distribution and Atterberg limit tests were conducted on selected split spoon samples obtained from this deposit. Based on the grain size distribution results, the tested samples comprised of 1% to 13% gravel, 41% to 62% sand, 37% to 52% silt and clay sized particles. Based on the Atterberg limits test results, the liquid limits (LL) of the samples are 15 and 16, plastic limits (PL) are 13, and plasticity indices (PI) are 2 and 3, indicating none to low plasticity. The sieve analysis test results are presented in Figure GS-5 and the Atterberg limit test results are included in Figure PC-3, in Appendix A. The sieve analysis and Atterberg limit test results are summarized in Table 6.



TABLE 6
SUMMARY OF ATTERBERG LIMITS AND GRAIN SIZE DISTRIBUTION

BOREHOLE ID	SAMPLE NO.	ATTERBERG LIMITS			GRAIN SIZE DISTRIBUTION (%)			
		LL	PL	PI	GRAVEL	SAND	SILT	CLAY
BH8	10	-	-	-	1	62	37	
BH10	10	15	13	2	13	41	38	8
BH10	11	16	13	3	7	41	41	11
LL – Liquid Limit (%); PL – Plastic Limit (%); PI – Plasticity Index (%)								

A 1.8 m thick deposit of silty gravel with sand was intercepted in the sandy clayey silt till layer in Borehole BH7 at 12.2 m (EL. 152.9), extending to 14.0 m (EL. 151.1) below existing ground surface. The SPT-'N' values in this deposit ranged from 109 blows for 20 cm penetration to 172 blows for 20 cm penetration. Moisture content determinations of silty gravel with sand samples ranged from 12.4% to 13.4%, with an average of 12.8%.

Grain size distribution tests were conducted on one (1) representative split spoon sample obtained from this silty gravel with sand deposit. Based on the grain size distribution result, the tested sample comprised of 36% gravel, 29% sand, 25% silt, and 10% clay sized particles. The sieve analysis test results are presented in Figure GS-6, and are summarized in Table 7.

TABLE 7
SUMMARY OF GRAIN SIZE DISTRIBUTION

BOREHOLE ID	SAMPLE NO	GRAIN SIZE DISTRIBUTION (%)			
		GRAVEL	SAND	SILT	CLAY
BH7	17	36	29	25	10

Standard Proctor test was carried out on five (5) auger samples. Table 8 summarizes the results. The complete results, Proc-1 to Proc-5, are appended in Appendix A.



TABLE 8
Summary of Standard Proctor Test

BOREHOLE ID	DEPTH (m)	MAXIMUM DRY DENSITY (kg/m ³)	CORRECTED MAXIMUM DRY DENSITY (kg/m ³)	OPTIMUM MOISTURE CONTENT (%)	CORRECTED OPTIMUM MOISTURE CONTENT (%)
BH2	6.1-7.6	1880	1907	14.1	13.6
BH5	6.1-7.6	1925	1941	12.0	11.7
BH7	8.4-9.0	1870	1908	15.0	14.2
BH9	7.6-8.2	1885	1922	13.5	12.8
BH10	6.1-7.6	2015	2048	10.9	10.4

7.2.6 Clayey Sand Till

Clayey sand till was encountered immediately below the sandy clayey silt till in Boreholes BH4, BH6 and P-1 at 6.9 m to 8.4 m (EL. 152.5 to EL. 156.0), extending to 10.5 m to 11.1 m (EL. 149.6 to EL. 152.5) below existing ground surface. Thinly laminated shale layers were encountered within this deposit in all three boreholes from elevations ranging from EL. 151.0 to EL. 154.8 to the bedrock surface. The SPT-'N' values ranged from 50 blows to more than 100 blows, indicating very dense in compactness. A SPT-'N' value of 15 blows was recorded in Borehole BH6 at 6.9 m (EL. 153.8), indicating compact in compactness. The results of moisture content testing conducted on samples from clayey sand till ranged from 5.8% to 10.2%, with an average of 8.1%.

Grain size distribution and Atterberg limit tests were conducted on selected split spoon samples obtained from this deposit. Based on the grain size distribution results, the tested samples comprised of 5% to 20% gravel, 36% to 58% sand, 22% to 38% silt and 13% to 16% clay sized particles. Based on the Atterberg limits test results, the liquid limits (LL) of the samples ranged from 18 to 28, plastic limits (PL) ranges from 13 to 19, and plasticity indices (PI) ranges from 5 to 9, indicating low plasticity. The sieve analysis test results are presented in Figure GS-7 and the Atterberg limit test results are included in Figure PC-4, in Appendix A. The sieve analysis and Atterberg limit test results are summarized in Table 9.



TABLE 9
SUMMARY OF ATTERBERG LIMITS AND GRAIN SIZE DISTRIBUTION

BOREHOLE ID	SAMPLE NO.	ATTERBERG LIMITS			GRAIN SIZE DISTRIBUTION (%)			
		LL	PL	PI	GRAVEL	SAND	SILT	CLAY
BH1	8	-	-	-	20	44	22	14
BH4	8	-	-	-	18	58	24	
BH4	10*	22	14	8	-	-	-	-
BH4	11*	28	19	9	26	36	24	14
BH6	11	19	13	6	17	37	30	16
BH6	12	18	13	5	5	43	38	14
BH6	13*	24	18	6	-	-	-	-
BH6	14*	-	-	-	15	49	25	11
P-1	11	26	18	8	13	51	23	13

Note: * - Thinly laminated shale layers within clayey sand till.
 LL – Liquid Limit (%); PL – Plastic Limit (%); PI – Plasticity Index (%)

Based on the grain size distribution and Atterberg limits, this soil may be classified as clayey sand (SC) in USCS.

Standard Proctor test was carried out on one (1) auger sample. Table 10 summarizes the results. The complete results, Proc-6, are appended in Appendix A.

TABLE 10
SUMMARY OF STANDARD PROCTOR TEST

BOREHOLE ID	DEPTH (m)	MAXIMUM DRY DENSITY (kg/m ³)	CORRECTED MAXIMUM DRY DENSITY (kg/m ³)	OPTIMUM MOISTURE CONTENT (%)	CORRECTED OPTIMUM MOISTURE CONTENT (%)
BH1	6.1-7.6	1945	1984	12.2	11.5



7.2.7 Shale Bedrock

Bedrock was encountered in Boreholes BH1, BH2A, BH3, BH4, BH5, BH6, BH7A, BH8, BH9, BH10, and P-1, below the existing ground surface at elevations varying from EL. 152.9 to EL. 148.6. The presence of bedrock was confirmed by obtaining 2.0 m to 7.3 m of rock cores from the boreholes. In Borehole BH3-1, BH4 and BH5, clay and cobbles were recovered in Run 1. These boreholes were advanced using an HQ sized core barrel. The rock core recovery ranged from 80% to 100%. The Rock Quality Designation (RQD) of the rock cores generally ranged from 54% to 100%, indicating fair to excellent quality, with the exception of RQD values of 0% in Run 2 of Borehole BH5, 15% in Run 1 of Borehole BH7A, 17% in Run 3 of Borehole BH3-1, 20% in Run 1 of Borehole BH2A, and 31% in Run 3 of Borehole BH5 and in Run 1 of Borehole BH6, indicating very poor to poor quality. Unconfined compressive strength (UCS) of rock cores obtained from Boreholes BH6, BH9, BH10 and P-1 typically ranged from 15.4 MPa to 24.5 MPa, which may be classified as Type R2 (weak) with respect to strength. UCS of rock cores of 32.2 MPa (Borehole P-1, depth 13.0 m) and 58.0 MPa (Borehole BH2A, depth 16.7 m) may be classified as Type R3 (medium strong) and Type R4 (Strong) with respect to strength, respectively. An exception UCS of rock core obtained was 217.9 MPa (Borehole BH3-1, depth 13.4 m) may be classified as Type R5 (very strong) with respect to strength. The bedrock was identified as weathered to unweathered shale bedrock. For complete description of the bedrock, refer to the Rock Core Description logs provided in Appendix A.

7.2.8 Laboratory Testing of Representative Rock Core Samples

7.2.8.1 Unconfined Compressive Strength (UCS) Testing

A total of 10 unconfined compression strength tests were performed on selected rock core samples from tunnelling/micro-tunnelling boreholes (BH3, BH6, BH9, BH10 and BH P1). Testing was carried out in accordance with ASTM D7012. The test results are included in Appendix A and summarized in Table 11A.



TABLE 11A
SUMMARY OF UCS TEST RESULTS FOR ROCK CORE SAMPLES

BOREHOLE NO.	ROCK CORE DEPTH (m)	UCS (MPa)	DENSITY (g/cm ³)	RANGE (g/cm ³)	AVERAGE (g/cm ³)	NO. TESTS
BH2A	16.7	58	2.630	-	2.630	1
BH3	13.4	217.9	2.668	-	2.668	1
BH6	14.5	23.7	2.653	-	2.653	1
BH9	15.5	24.2	2.682	-	2.682	1
BH10	12.8	16.5	2.334	2.334-2.528	2.431	2
	11.8	16.6	2.528			
P-1	12.1	24.5	2.598	2.598-2.651	2.619	3
	12.4	20.1	2.651			
	13.0	32.2	2.607			
P-1	10.7	15.4	2.524	-	2.524	1

Elastic moduli (E) of rock core in uniaxial compression were determined for two rock core samples. The test results are included in Appendix A and Table 11B summarizes the elastic moduli of the rock core samples.

TABLE 11B
SUMMARY OF ELASTIC MODULI OF ROCK CORES

BOREHOLE NO. (RUN NO.)	ROCK CORE DEPTH (m)	YOUNG'S MODULUS, E _{tan} (GPa)	YOUNG'S MODULUS, E _{sec} (GPa)	YOUNG'S MODULUS, E _{ave.} (GPa)
BH3 (Run 3)	13.4	62.48	47.91	55.20
BH9 (Run 1)	15.5	37.33	2.59	19.96

7.2.8.2 Point Load Index (PLI) Testing

Point load testing was conducted on 31 rock core samples selected from borehole locations along the proposed watermain alignment to be constructed using tunnelling/micro-tunnelling methods. Both diametrical and axial tests were conducted in accordance with ASTM D5731. PLI values ($I_{s(50)}$) were calculated using the following equations from ASTM D5731 as follows:



$$I_{s(50)} = F \times I_s$$

where: F = Size correction factor = $(D_e/50)^{0.45}$

I_s = Uncorrected point load strength = P/D_e^2 , MPa

P = failure load, N

D_e = equivalent core diameter in mm, and is given by:

$D_e^2 = D^2$ for diametrical core tests without penetration, mm² and

$D_e^2 = 4A/\pi$ for axial, mm²;

where:

A = WD = minimum cross-sectional area of a plane through the platen contact points

The Point Load Index, $I_{s(50)}$ test results are included in Appendix A and summarized in Table 12.

TABLE 12
SUMMARY OF POINT LOAD INDEX TEST RESULTS

BOREHOLE NO.	DEPTH (m)	RUN	ORIENTATION	AVERAGE $I_{s(50)}$ (MPa)	RANGE (MPa)	NO. OF TEST
BH1	9.9	Run 2	Diametrical	0.34	0.05–0.75	3
	10.8	Run 3				
	11.4	Run 3				
BH2A	14.0	Run 1	Axial	0.74	0.53–1.10	3
	15.3	Run 2				
	16.7	Run 3				
	18.0	Run 1	Diametrical	0.67	0.10-1.23	2
	18.6	Run 4				
BH3	12.4	Run 2	Axial	0.42	-	1
	13.5	Run 3	Diametrical	6.14	-	1
BH4	10.8	Run 1	Axial	0.55	-	1
	10.9	Run 1	Diametrical	0.08	0.07–0.09	2
	13.2	Run 2				
BH5	10.9	Run 4	Axial	0.61	-	1
	11.4	Run 4	Diametrical	0.04	-	1



TABLE 12
SUMMARY OF POINT LOAD INDEX TEST RESULTS

BOREHOLE NO.	DEPTH (m)	RUN	ORIENTATION	AVERAGE $I_{S(50)}$ (MPa)	RANGE (MPa)	NO. OF TEST
BH6	12.0	Run 1	Diametrical	0.1	0.03–0.17	2
	14.8	Run 4				
	11.8	Run 1	Axial	0.71	-	1
BH7A	17.4	Run 1	Diametrical	0.29	1.09	3
	18.3	Run 2		2.89		
	19.8	Run 3		0.08		
	17.8	Run 2	Axial	0.67	0.63	2
	20.5	Run 3		0.59		
BH8	17.5	Run 2	Diametrical	0.08	-	1
	16.4	Run 1	Axial	1.13	1.13	2
	16.5	Run 1		1.13		
BH9	16.1	Run 2	Diametrical	0.1	-	1
	15.3	Run 1	Axial	3.1	0.48–5.72	2
	15.6	Run 1				
BH10	12.6	Run 2	Axial	0.64	0.33–0.96	2
	13.4	Run 2				



7.2.8.3 Splitting Tensile Strength Testing

Splitting tensile strength testing was carried out on 10 rock core samples in accordance with ASTM D3967. Splitting tensile strength was calculated using the following formula:

$$\sigma_t = 2P/\pi LD$$

where:

σ_t = splitting tensile strength, MPa,

P = maximum applied load indicated by the testing machine, N

L = thickness of the specimen, mm, and

D = diameter of the specimen, mm.

The splitting tensile strength test results are included in Appendix A and summarized in Table 13.

TABLE 13
SUMMARY OF TENSILE STRENGTH TEST RESULTS

BOREHOLE NO.	DEPTH (m)	RANGE (MPa)	AVERAGE (MPa)	MEDIAN (MPa)
BH3	12.5	1.9	-	-
BH4	12.4	1.1-1.8	1.5	1.7
BH4	13.3	1.7		
BH5	10.3	8.3-10.5	9.4	-
BH6	11.9	1.7-2.3	2.0	-
BH8	16.2	5.0	-	-
BH9	15.8	3.9	4.4	3.9
BH9	16.2	3.9 – 5.4		
BH10	11.3	1.6	3.1	-
BH10	12.4	4.5		-



7.2.8.4 Slake Durability Testing

Slake durability testing was conducted on 10 shale samples taken at or near trenchless crossing elevation in accordance with ASTM D4644.

The slake durability index (second cycle), was determined using the following formula:

$$I_d (2) = [(WF - C) / (B - C)] \times 100$$

where: $I_d (2)$ = slake durability index (second cycle),

B = mass of drum plus oven-dried specimen before the first cycle, g

WF = mass of drum plus oven-dried specimen retained after the second cycle, g, and

C = mass of drum, g.

The slake durability test results are included in Appendix A and summarized in Table 14.

TABLE 14
SUMMARY OF SLAKE DURABILITY TEST RESULTS

BOREHOLE NO.	SAMPLE FORMATION	SAMPLE DEPTH (m)	SLAKE DURABILITY INDEX
BH1	Georgian Bay Formation	9.3	68.8
BH1		10.6	72.8
BH3		11.9	71.7
BH4		12.0	70.0
BH5		10.7	70.8
BH6		11.9	73.3
BH8		16.2	78.0
BH9		15.1	69.0
BH10		11.5	74.3
BH10		12.1	75.8

7.2.8.5 CERCHAR Abrasivity Index (CAI) Testing

A total of 10 rock core samples were selected for CERCHAR Abrasivity Index (CAI) testing. The CAI test was conducted in accordance with ASTM D7625. The test results are included in Appendix A and summarized in Table 15.



TABLE 15
SUMMARY OF CERCHAR ABRASIVITY TEST RESULTS

BOREHOLE NO.	CORE ID	SAMPLE DEPTH (m)	ROCK TYPE	CERCHAR ABRASIVE INDEX RESULTS		CERCHAR ABRASIVE INDEX CLASSIFICATION
				CAI _s	CAI	
BH1	Run 1	9.3	Shale	-	1.40	Medium
BH3	Run 3	13.3	Shale	-	1.50	Medium
BH3	Run 4	14.5	Shale	2.00	2.46	High
BH4	Run 2	13.0	Shale	3.50	3.95	High
BH4	Run 2	13.4	Shale	-	1.30	Medium
BH5	Run 5	11.5	Shale	-	1.20	Medium
BH6	Run 2	12.1	Shale	-	1.10	Medium
BH6	Run 2	12.5	Shale	-	1.60	Medium
BH8	Run 2	17.4	Shale	-	1.00	Medium
BH9	Run 1	15.7	Shale	-	1.00	Medium

7.2.8.6 Atterberg Limits

Atterberg limit tests were conducted on selected shale crushed samples in accordance with ASTM D4318. The Atterberg limit test results are included in Figure PC-5, which are included in Appendix A. The Atterberg test results are summarized in Table 16.

TABLE 16
SUMMARY OF ATTERBERG LIMITS RESULTS

BOREHOLE NO.	RUN # / SAMPLE ID	LL	PL	PI
BH2A	Run 2	20	16	4
	Run 3	20	16	4
BH5	Run 2	29	19	10
	Run 2	26	18	8
BH7A	Run 1	22	16	6
BH7A	Run 3	22	16	6
BH9	Run 1	22	17	5
BH10	Run 1	22	17	5
P-1	Run 1	22	17	5

LL – Liquid Limit (%); PL – Plastic Limit (%); PI – Plasticity Index (%)



7.2.8.7 Null Swell Testing

Null swell test was performed on six (6) shale samples in accordance with ISRM (1977) procedure using a Durham Geo Terraload S450 consolidometer by Mirarco Mining Innovation. The test results are summarized in Table 17A. The complete test results are provided in Appendix A.

TABLE 17A
SUMMARY OF NULL SWELL TEST

BY MIRARCO MINING INNOVATION				
BOREHOLE NO.	DEPTH (m)	WATER CONTENT (%)	MAXIMUM APPLIED FORCE (kN)	SWELL INDEX (kPa)
BH1	10.9	2.95	1.290	418
BH1	11.3	4.27	1.150	372
BH4	12.8	3.64	0.630	202
BH-5	12.9	4.03	0.578	186
BH-6	13.5	3.26	0.307	98
BH-10	12.6	3.83	0.568	181

In addition, four (4) null swell tests were performed on shale samples by Western University, Geotechnical Research Centre. The procedure and method of interpretation was carried out as discussed in Lo (1989), and Lo and Lee (1990) to determine the water content, salinity and calcite content. The test results are summarized in Table 17B. The complete test results are provided in Appendix A.

TABLE 17B
SUMMARY OF NULL SWELL TEST

By Western University, Geotechnical Research Centre							
BOREHOLE NO., RUN NO.	ORIENTATION	ROCK SAMPLE DEPTH (m)	WATER CONTENT (%)		SALINITY (g/L)		CALCITE CONTENT (%)
			INITIAL	FINAL	INITIAL	FINAL	
BH5, Run 5	Vertical	11.84 - 11.94	3.2	3.6	35.8	23.9	2.2
BH6, Run 4		14.40 - 14.50	3.7	4.4	35.7	19.7	1.0
BH4, Run 2	Horizontal	12.42 - 12.55	4.5	5.0	27.7	10.0	3.8
BH9, Run 2		15.95 - 16.07	4.4	4.7	19.4	13.1	1.7



7.2.9 Groundwater

Groundwater levels were measured in all boreholes at the time of drilling (when first encountered during the advancement of the drilling) and upon completion of borehole drilling. First strike of groundwater was encountered during drilling operations in Boreholes G-1, G-2, BH-2, BH-3, BH-6, BH-10 and P-1 at depths ranging from 3.1 m to 7.6 m (EL. 155.0 to EL. 159.0) below the ground surface. In the remaining boreholes, groundwater was not encountered during drilling operation. Upon completion of drilling, groundwater was encountered in Boreholes G-1, G-2, BH-2, BH-7, BH-8 and BH-9 at depths ranging from 1.5 m to 12.7 m (EL. 150.4 to EL. 159.9) below the ground surface. In the remaining boreholes, except Borehole P-1, groundwater was not encountered upon completion of drilling. Boreholes P-1, BH2A and BH7A were charged with coring water/mud and thus, groundwater level could not be established upon completion of drilling. Groundwater levels may fluctuate due to the influence of precipitation and seasonal changes.

Monitoring wells were installed in Boreholes BH1, BH4, BH7, BH7A, and BH10. Subsequent water level readings were periodically taken up to June 25, 2021. The groundwater level measurements were recorded in the Records of Borehole Sheets provided in Appendix A and are summarized in Table 18.

TABLE 18
GROUND WATER LEVEL READINGS

MONITORING WELL (MW) No. ⁽¹⁾	GROUND SURFACE ELEVATION (m) ⁽²⁾	MID-SCREEN DEPTH (m) ⁽¹⁾ (ELEVATION, m)	HYDROSTATIC GROUND WATER LEVEL DEPTH (m) ⁽³⁾ (ELEVATION, m)					
			FEBRUARY 9, 2021	FEBRUARY 26, 2021	MARCH 10, 2021	APRIL 9, 2021	MAY 11, 2021	JUNE 25, 2021
BH1/MW1	160.1	7.6 (152.5)	2.62 (157.48)	2.80 (157.3)	2.78 (157.32)	2.72 (157.38)	2.70 (157.40)	2.55 (157.52)
BH4/MW2	163.2	11.2 (152.0)	Dry to the bottom of the screen	6.12 (157.08)	6.24 (156.96)	5.95 (157.25)	6.00 (157.20)	5.82 (157.38)
BH7/MW3	165.1	13.7 (151.4)	5.95 (159.15)	6.05 (159.05)	5.98 (159.12)	5.38 (159.72)	5.50 (159.60)	5.56 (159.54)



TABLE 18
GROUND WATER LEVEL READINGS

MONITORING WELL (MW) No. ⁽¹⁾	GROUND SURFACE ELEVATION (m) ⁽²⁾	MID-SCREEN DEPTH (m) ⁽¹⁾ (ELEVATION, m)	HYDROSTATIC GROUND WATER LEVEL DEPTH (m) ⁽³⁾ (ELEVATION, m)					
			FEBRUARY 9, 2021	FEBRUARY 26, 2021	MARCH 10, 2021	APRIL 9, 2021	MAY 11, 2021	JUNE 25, 2021
BH7A	165.2	18.0 (147.2)	-	-	-	-	-	6.94 (158.21)
BH10/MW4	159.6	9.2 (150.4)	1.10 (158.5)	1.21 (158.39)	1.19 (158.41)	0.82 (158.78)	0.84 (158.76)	0.72 (158.88)

Note(s):

- (1) See Log of Borehole sheets for details of monitoring wells.
- (2) Ground surface elevations at the monitoring well locations were surveyed by PML and are geodetic.
- (3) Water levels measured using a Solinst flat tape water level reader.

8. OVERCORING IN-SITU STRESS MEASUREMENTS

Overcoring in-situ stress testing data was collected at Boreholes BH-3, BH4, BH5, BH6, BH8 and BH9. The testing and data collecting was carried out by Golder Associates Ltd (Golder), subcontracted by PML. The testing method is slightly modified from the procedure described in ASTM D4626-16 to make use of HQ drilling equipment.

Based on the results, the maximum horizontal stresses measured ranged from 0.73 MPa to 5.02 MPa and the minimum horizontal stresses measured ranged from 0.31 MPa to 2.73 MPa. The horizontal deformation modulus determined ranged from 6.80 GPa to 12.6 GPa. The orientations of the maximum horizontal stresses are typically within $\pm 55^\circ$ of the East-West direction. The Technical Memorandum prepared by Golder is included in Appendix B.

9. PACKER TEST

Packer testing was conducted in Borehole BH1 between 10.4 m and 12.2 m depth and in Borehole BH10 between 12.2 m and 13.7 m depth. The hydraulic conductivity obtained from the packer tests were 1.34×10^{-5} cm/s in Borehole BH1 and 3.31×10^{-4} cm/s in Borehole BH10. The packer test results are presented in Appendix C.



10. SLUG TEST

Slug test was conducted in the monitoring wells installed in Boreholes BH1, BH4, BH7 and BH10 to determine the hydraulic conductivity. Table 19 summarizes the hydraulic conductivity results.

TABLE 19
SUMMARY OF HYDRAULIC CONDUCTIVITY RESULTS

MONITORING WELL (MW) No.⁽¹⁾	MID-SCREEN DEPTH (m)⁽¹⁾ (ELEVATION, m)	SOIL TYPE WITHIN SCREEN DEPTH⁽¹⁾	ESTIMATED HYDRAULIC CONDUCTIVITY VALUE FROM SLUG TEST (cm/s)
BH1/MW1	7.6 (152.5)	Clayey Sand (EL. 154.0 to 153.3) followed by Sandy Clayey Silt Till (thinly laminated Shale layers within till - EL.153.3 to EL.151.0)	8×10^{-5}
BH4/MW2	11.2 (152.0)	Clayey Sand Till (with thinly laminated Shale layers – EL. 153.5 to EL. 152.5) followed by Clay and Cobbles (EL. 152.5 to EL. 151.0) over Shale Bedrock (EL. 151.0 to EL. 150.5)	5×10^{-5}
BH7/MW3	13.7 (151.4)	Silty Gravel (EL. 152.9 to EL. 151.1) followed by Sandy Clayey Silt Till (thinly laminated Shale layers within till – EL. 151.1 to EL. 149.8)	2×10^{-6}
BH10/MW4	9.2 (150.4)	Silty Sand (EL. 151.9 to EL. 151.3) followed by Sandy Clayey Silt Till (thinly laminated Shale layers within till – EL.151.3 to EL. 148.9)	2×10^{-4}

Note:

(1) Refer to Record of Borehole Log Sheets for soil type description.



11. GAS MONITORING

The QRAE 3 was used to detect the presence of methane, hydrogen sulphide, carbon monoxide and oxygen in Boreholes BH1, BH3, BH4, BH5, BH9 and BH10. Carbon dioxide (CO₂) was detected only in Borehole BH9, which ranged from 7 ppm to 45 ppm from 7.6 m to 12.0 m depth below ground surface. One CO gas reading measured was 490 ppm at 13.0 m depth in Borehole BH9. Oxygen ranged from 20.6% to 20.9% in all measured boreholes. The monitor did not detect/register presence of methane or hydrogen sulphide in the six (6) boreholes. UltraRAE 3000 was used to detect benzene. Benzene was detected in Boreholes BH3 (from 9.1 m to 11.9 m) and BH4 (from 4.6 m to 11.6 m) and ranged from 0.03 ppm to 0.66 ppm.

12. CHEMICAL ANALYSIS

SGS Canada Inc. (SGS) carried out the chemical analyses. SGS is accredited by The Standards Council of Canada (SCC) and The Canadian Association for Laboratory Accreditation (CALA).

A total of 12 samples were tested to determine the soil corrosivity. A summary of the results are presented in Table 20. Details of the chemical test results are presented in the SGS Environment Final Report (CA CA15910-MAR21 R1), which is appended in Appendix D.



TABLE 20
SUMMARY OF CHEMICAL TEST RESULTS

BOREHOLE NO.	SAMPLE DEPTH (m)		CORROSIVITY INDEX	REDOX POTENTIAL (mV)	SULFIDE (%)	pH	RESISTIVITY (ohm.cm)	SULPHATE (µg/g)	CHLORIDE (µg/g)
	FROM	TO							
G-1	2.3	2.9	6	369	0.10	8.36	2610	74	30
G-2	2.3	2.9	8	263	0.09	8.82	4810	34	82
G-3	2.3	2.9	4	265	0.02	8.50	5680	130	32
G-3	4.6	5.2	4	223	<0.04	9.29	5030	99	84
BH1	3.0	3.7	12	243	0.05	8.50	1720	280	440
BH2	10.7	11.3	5	270	<0.04	8.77	2600	110	90
BH3	8.4	9.0	8	199	0.08	9.17	3600	110	180
BH5	8.4	9.0	8	260	0.06	9.27	3610	130	110
BH6	8.4	9.0	8	155	0.22	9.28	6670	81	38
BH7	13.0	13.6	8	137	0.09	9.31	4500	84	45
BH8	8.4	9.0	10	91	0.22	8.88	5210	84	43
BH9	10.7	11.3	8	138	0.15	8.99	4830	31	71



13. CLOSURE

The field work was carried out under the supervision of Mr. Akbar Hossain, P.Eng., and Mr. Mahad Mohamed working under the direction of Mr. Mohammed Zamshad, P.Eng. The geotechnical laboratory work was carried out by PML (Toronto laboratory) and the geo-environmental testing was carried out by SGS Canada Inc., Toronto, Ontario.

The FIR was prepared by Mr. Nazibur Rahman, P.Eng. with the assistance of Mr. Mahad Mohamed, EIT, in accordance with the RFP requirements. Mr. Robert Ng, PhD, MBA, P.Eng., MTO Designated Principal Contact, conducted an independent review of the report.

We trust this report has been completed within the terms of reference and is sufficient for your current needs. Should you require additional information and/or clarification, please contact our office.

Sincerely

Peto MacCallum Ltd.



Nazibur Rahman, P.Eng.
Senior Engineer
Geotechnical Engineering Services



Robert Ng, PhD, MBA, P.Eng.
MTO Designated Principal Contact

NR/RN:nr-ap-nk



APPENDIX A

Plan Nos. 74191-D, 74192-D, 74193-D

Explanations of Terms Used in Report

Record of Borehole Sheets G-1 to G-3, BH1 to BH10, BH2A, BH3-1, BH7A, and P-1

Figures GS-1A, 1B, 2, 3A to 3D, and 4 to 7 – Grain Size Distribution Charts

Figures PC-1, 2A to 2D, 3, 4, 5 – Plasticity Charts

Rock Core Description Logs and Photographs

Unconfined Compressive Strength Test Results

Elastic Moduli of Rock Core in Uniaxial Compression

Point Load Index Test Results

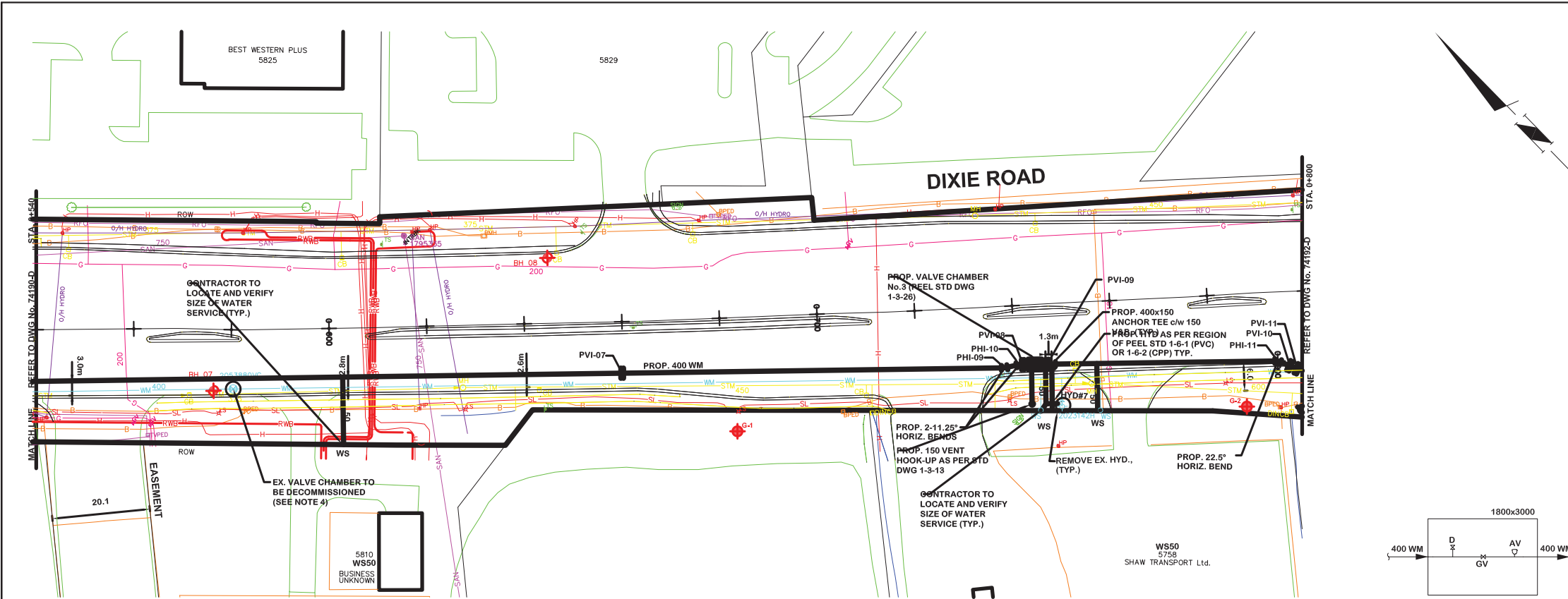
Splitting Tensile Strength Test Results

Slake Durability Test Results

CERCHAR Abrasivity Test Results

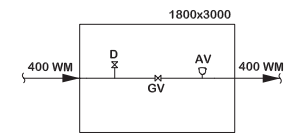
Null Swell Test Results

Proctor Test Results



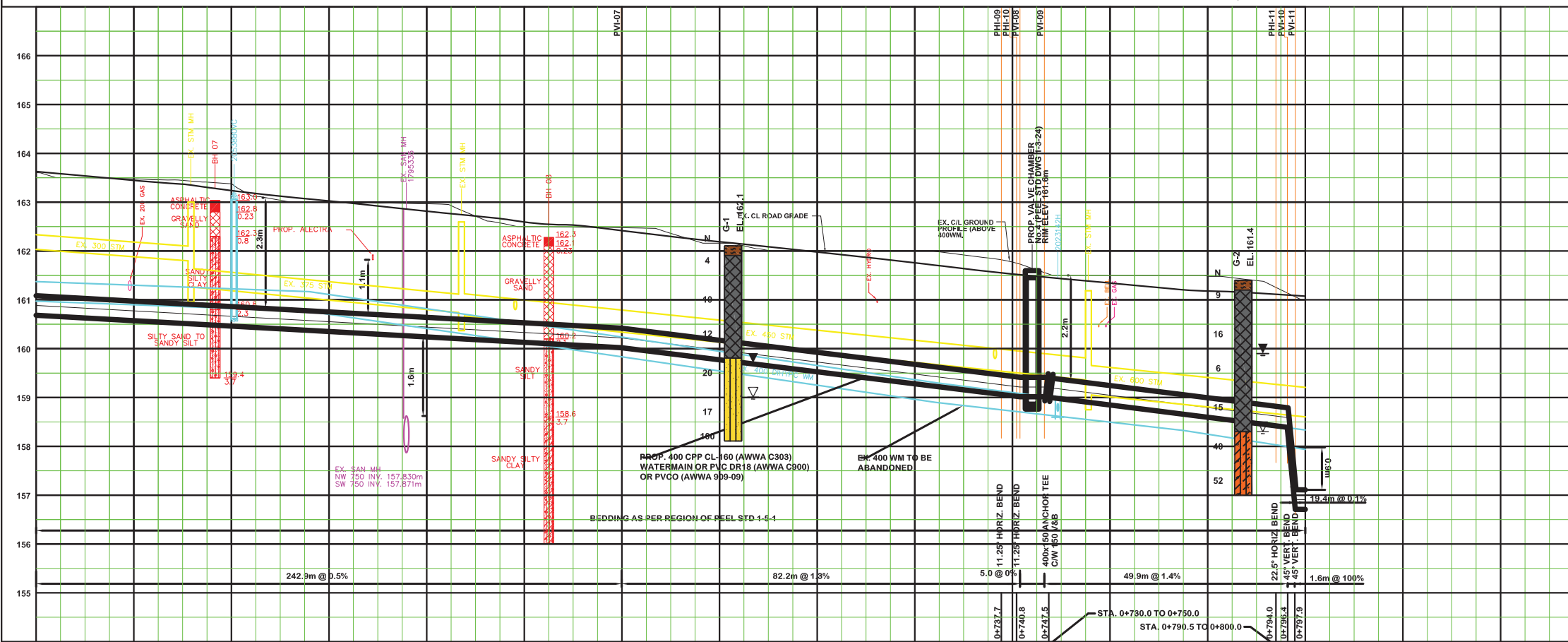
NOTES:

- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE FIR/GDR AND RECORD OF BOREHOLE LOGS.
- THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
- THE SOIL AND BEDROCK STRATA HAVE BEEN ESTABLISHED AT THE BOREHOLE LOCATIONS ONLY.



VALVE CHAMBER VC-3 - SCHEMATIC
SEE STD DWG 1-3-26 ON DWG 74205-D FOR DETAILS

	Water Level Observed During Drilling		PML Borehole		Topsoil		Sandy Silt		Clayey Sand Till
	Water Level Measured After Drilling		Previous Borehole		Fill		Silty Sand		Clay and Cobbles
	Asphalt		Sandy Clayey Silt Till		Bedrock				



160.68	160.57	160.46	160.35	160.24	160.13	160.02	159.77	159.53	159.28	159.03	158.91	158.59	158.39	158.15	157.71
163.63	163.45	163.26	163.02	162.81	162.62	162.52	162.19	161.98	161.76	161.51	161.34	161.17	161.08		
0+540	0+560	0+580	0+600	0+620	0+640	0+660	0+680	0+700	0+720	0+740	0+760	0+780	0+800		

SERVICE DATA

SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS	NOV 2019	S.M.	GAS MAINS	JAN 2021	S.M.
STORM SEWERS	NOV 2019	S.M.	BELL U/G CABLE	MAR 2021	S.M.
WATERMANS	NOV 2019	S.M.	HYDRO U/G CABLE	DEC 2020	S.M.
TRANSIT	-	-	HYDRO ONE	DEC 2020	S.M.
PARKS & REC.	-	-	CTV	JAN 2021	S.M.
ONT. CLEAN WATER	-	-	COMMUNIC. CABLES	DEC 2020	S.M.

REVISIONS

DATE	DETAILS	INIT.
NOV. 2021	ISSUED FOR TENDER	S.M.

KEY PLAN (N.T.S.)

NOTES:

- FOR GENERAL NOTES AND DETAILS SEE DWG 74185-D.
- TEMPORARILY SUPPORT EXISTING UTILITIES DURING CONSTRUCTION.
- DEFLECT PROPOSED WATERMAIN/WATER SERVICE AS NECESSARY TO PASS OVER OR UNDER EXISTING UNDERGROUND INFRASTRUCTURE UTILITIES (IE WATERMAIN, STORM AND SANITARY SEWERS, GAS, BELL ETC.).
- DECOMMISSION EXISTING VALVE CHAMBER. REMOVE ALL PIPES AND VALVES. FILL EXISTING 300mm WM WITH GROUT. REMOVE CHAMBER 1m BELOW EXISTING GROUND AND FILL CHAMBER WITH UNSHRINKABLE FILL. RESTORE SURFACE AREA TO PRE-CONSTRUCTION CONDITION.
- FOR WATERMAIN DATA SEE DWG 74195-D.

LEGEND:

- REPLACE EX. W/S, SIZE AS INDICATED.
- EX. HYD. V. & B. TO BE REMOVED AND HYDRANT TO BE RETURNED TO REGION YARD IN MISSISSAUGA 3515 WOLFDALE RD. VALVES TO BE DISPOSED OF OFF SITE

THIS DRAWING TO BE USED FOR WATERMAIN CONSTRUCTION ONLY

General Notes

All Driveways Are ASPHALT Unless Otherwise Noted
All Water And Sanitary Service Locations Are Approximate And Must Be Located Accurately In The Field
All Horizontal And Vertical Bends Are In Degrees
All Pipes Size In mm
200 Existing Water Service, Size In mm
WS25 Proposed Water Service, Size In mm
S.M. No. Elev.
Description Location
The Contractor Is Responsible For Locating And Protecting All Existing Utilities Prior To And During Construction. Location Of Existing Utilities Approximate Only, To Be Verified In Field By Contractor.

Designed by: Chkd. Approved by:

NOTICE TO CONTRACTOR

48 HOURS PRIOR TO COMMENCING WORK NOTIFY THE FOLLOWING

THE REGIONAL MUNICIPALITY OF PEEL
CITY OF MISSISSAUGA WORKS DEPT.
BELL CANADA
EMBRIDGE INCORPORATED-GAS DISTRIBUTION
ONTARIO MINISTRY OF TRANSPORTATION
HYDRO ONE NETWORKS
ENERSOURCE, HYDRO MISSISSAUGA
HYDRO ONE BRAMPTON

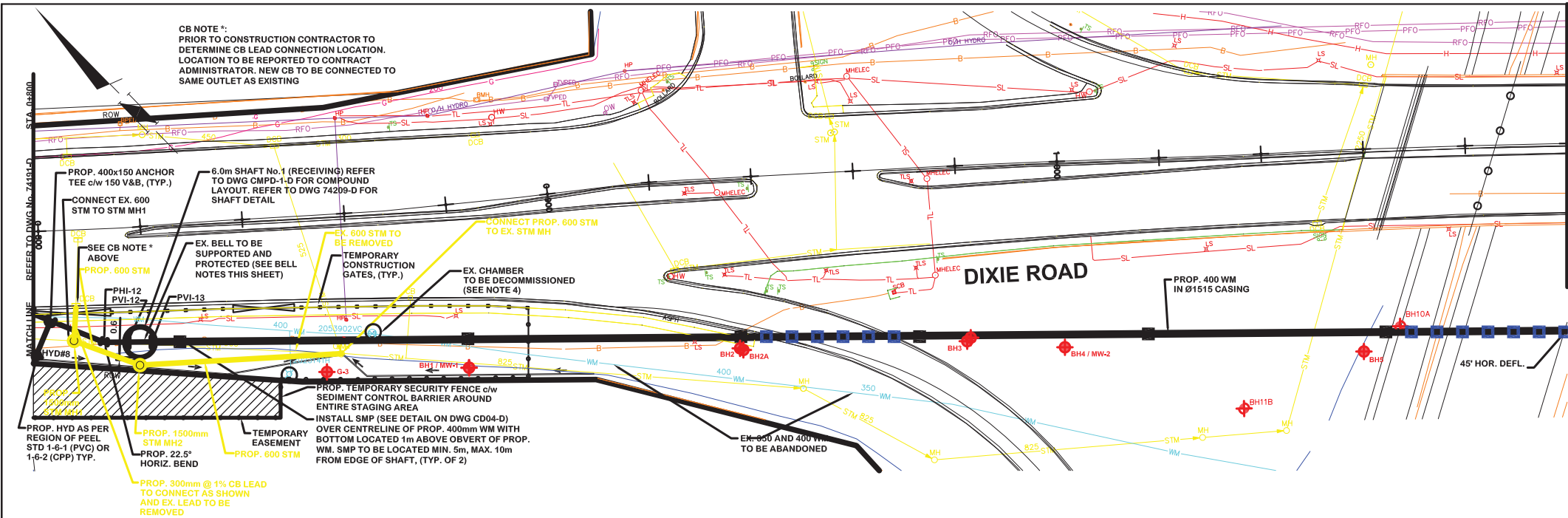
CABLE TELEVISION/BROADBAND PROVIDERS:
BELL CANADA
ENERSOURCE TELECOM
HYDRO ONE TELECOM
ROGERS CABLE
ALLSTREAM
PSN (PUBLIC SECTOR NETWORK)
FUTUREWAY (FCI BROADBAND)

Region of Peel
working with you

DIXIE ROAD
(FROM BRITANNIA ROAD TO HIGHWAY 401 CROSSING)
PROP. 400mm WATERMAIN REPLACEMENT

STA. 0+540 TO STA. 0+800

CAD Area	-	Area	Z-35	Project No.	20-1311
Checked by	-	Drawn by	-		
Date	OCT. 2021	Sheet	7 of 44	Pbin No.	74191-D



BELL NOTES:

1. THE CONTRACTOR TO LOCATE THE 11 PAIR DIRECT BURIED COPPER CABLE. THE CABLE IS TO BE SUPPORTED AND PROTECTED DURING THE CONSTRUCTION. IF TEMPORARY DIVERSION OF THE CABLE IS REQUIRED, THE CONTRACTOR TO BE COORDINATED WITH BELL.
2. PRIOR TO COMMENCING SHAFT CONSTRUCTION 2 TEST PITS (STA. 0+817 & STA. 0+822) WILL BE REQUIRED TO IDENTIFY THE 11 PAIR DIRECT BURIED COPPER CABLE.
3. PLEASE NOTIFY BELL IMPLEMENTATION MANAGER (AJMAL SAIRALLY, AT 905-614-3066, ajmal.sairally@bell.ca) 48 HOURS PRIOR TO COMMENCING CONSTRUCTION.

SERVICE DATA					
SERVICE	DATE	INIT.	SERVICE	DATE	INIT.
SAN SEWERS	NOV 2019	S.M.	GAS MAINS	JAN 2021	S.M.
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WATER MAINS	NOV 2019	S.M.	HYDRO U/G CABLE	DEC 2020	S.M.
TRANSIT	-	-	HYDRO ONE	DEC 2020	S.M.
PARKS & REC.	-	-	CTV	JAN 2021	S.M.
ONT. CLEAN WATER	-	-	COMMUNIC. CABLES	DEC 2020	S.M.

REVISIONS		
DATE	DETAILS	INIT.
NOV. 2021	ISSUED FOR TENDER	S.M.

KEY PLAN (N.T.S.)

- NOTES:
1. FOR GENERAL NOTES AND DETAILS SEE DWG 74185-D.
 2. TEMPORARILY SUPPORT EXISTING UTILITIES DURING CONSTRUCTION.
 3. DEFLECT PROPOSED WATERMAIN/WATER SERVICE AS NECESSARY TO PASS OVER OR UNDER EXISTING UNDERGROUND INFRASTRUCTURE UTILITIES (IE WATERMAIN, STORM AND SANITARY SEWERS, GAS, BELL ETC.).
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 5. FOR WATERMAIN DATA SEE DWG 74195-D.

LEGEND:

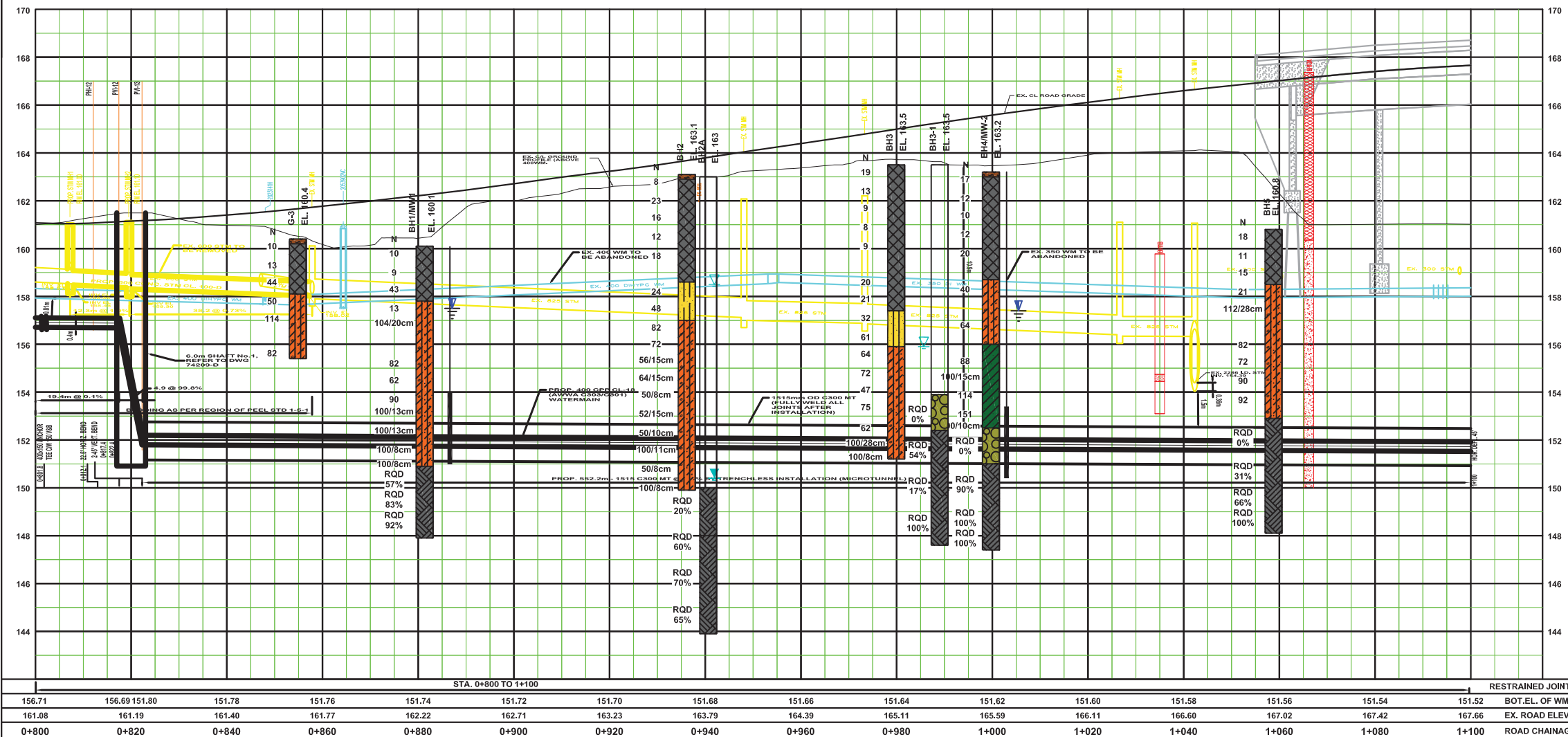
- REPLACE EX. W/S, SIZE AS INDICATED.
- EX. HYD. V. & B. TO BE REMOVED AND HYDRANT TO BE RETURNED TO REGION YARD IN MISSISSAUGA 3515 WOLFDALE RD. VALVES TO BE DISPOSED OF OFF SITE

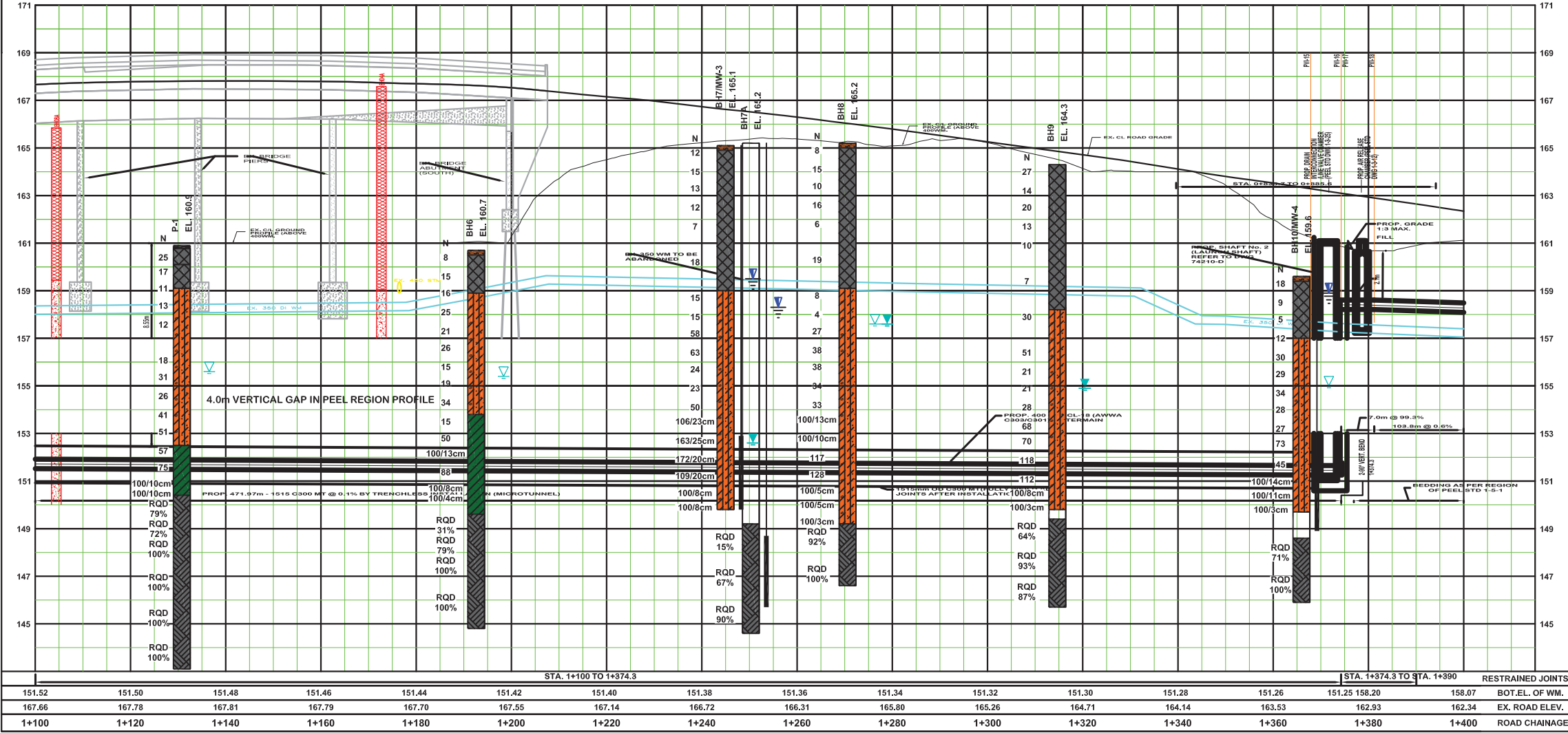
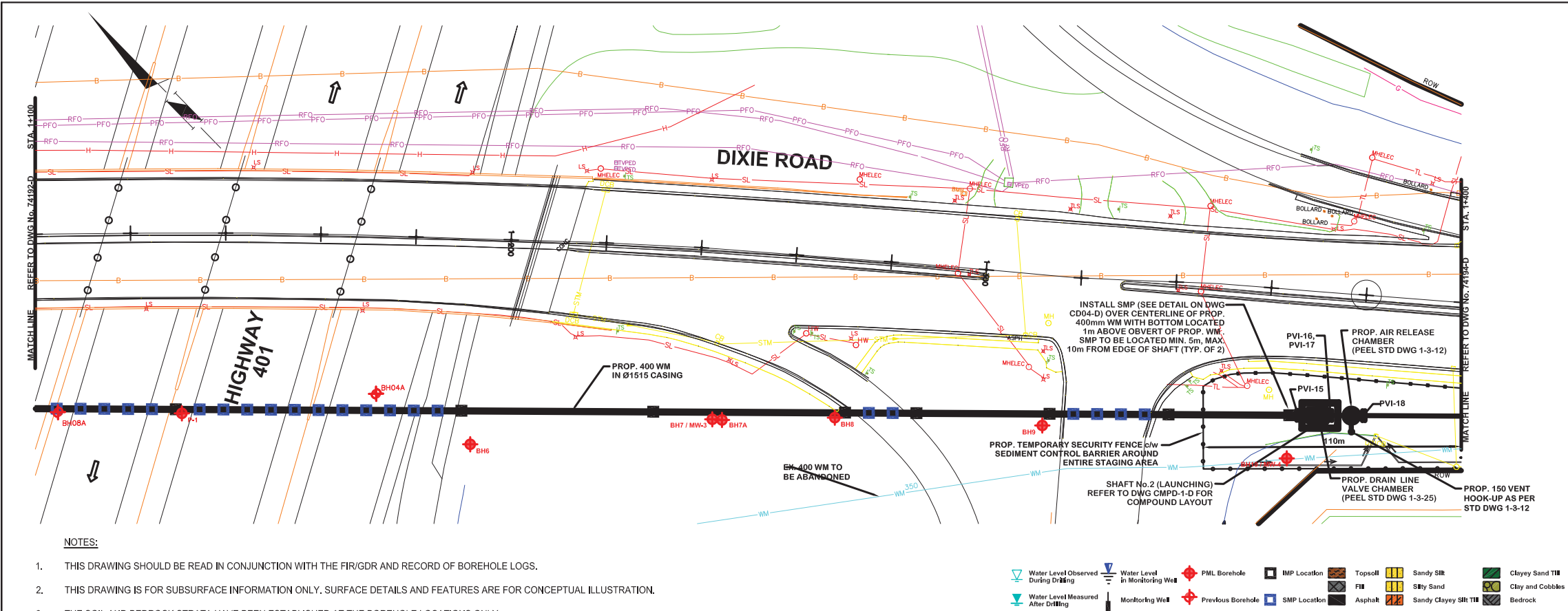
CONTRACTOR TO DETERMINE SHAFT DIMENSIONS BASED ON THEIR PROPOSED TUNNELING EQUIPMENT AND PIPE DIAMETER AND LENGTH. CONTRACTOR TO DESIGN ALL SHAFT ELEMENTS, STAMPED BY P.ENG. IN ONTARIO

THIS DRAWING TO BE USED FOR WATERMAIN CONSTRUCTION ONLY

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- Water Level in Monitoring Well
- PML Borehole
- IMP Location
- Topsoil
- Sandy Silt
- Clayey Sand Till
- Water Level Measured After Drilling
- Monitoring Well
- Previous Borehole
- SMP Location
- Fill
- Silty Sand
- Clay and Cobbles
- Bedrock
- Asphalt
- Sandy Clayey Silt Till





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REVISIONS		
DATE	DETAILS	INIT.
NOV. 2021	ISSUED FOR TENDER	S.M.

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S.M. No. Description Location
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HYDRO ONE TELECOM
ROGERS CABLE
ALLSTREAM
PSN (PUBLIC SECTOR NETWORK)
FUTUREWAY (FCI BROADBAND)

10m 0 10 20 30m HORIZONTAL SCALE
2m 0 2 4 6m VERTICAL SCALE

Region of Peel
working with you

DIXIE ROAD
(FROM BRITANNIA ROAD TO HIGHWAY 401 CROSSING)
PROP. 400mm WATERMAIN REPLACEMENT

STA. 1+100				TO STA. 1+440			
CAD Area	-	Area	Z-35	Project No.	20-1311		
Checked by	-	Drawn by	-	Pbin No.	74193-D		
Date	OCT. 2021	Sheet	9 of 44				

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

COMPOSITION: SECONDARY SOIL COMPONENTS ARE DESCRIBED ON THE BASIS OF PERCENTAGE BY MASS OF THE WHOLE SAMPLE AS FOLLOWS:

PERCENT BY MASS	0-10	10-20	20-30	30-40	>40
	TRACE	SOME	WITH	ADJECTIVE (SILTY)	AND (AND SILT)

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0-12	12-25	25-50	50-100	100-200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0-5	5-10	10-30	30-50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm* IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0-25	25-50	50-75	75-90	90-100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50-300mm	0.3m-1m	1m-3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING			MECHANICAL PROPERTIES OF SOIL		
S S	SPLIT SPOON	T P	THINWALL PISTON	m_v	kPa^{-1} COEFFICIENT OF VOLUME CHANGE
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE	c_c	1 COMPRESSION INDEX
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE	c_s	1 SWELLING INDEX
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY	c_a	1 RATE OF SECONDARY CONSOLIDATION
C S	CHUNK SAMPLE	F M	T W ADVANCED MANUALLY	c_v	m^2/s COEFFICIENT OF CONSOLIDATION
T W	THINWALL OPEN	F S	FOIL SAMPLE	H	m DRAINAGE PATH
F V	FIELD VANE			t_v	1 TIME FACTOR
STRESS AND STRAIN			U	%	DEGREE OF CONSOLIDATION
u_w	kPa		σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
u	1		σ'_p	kPa	PRECONSOLIDATION PRESSURE
σ	kPa		τ_f	kPa	SHEAR STRENGTH
σ'	kPa		c'	kPa	EFFECTIVE COHESION INTERCEPT
τ	kPa		ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$\sigma_1, \sigma_2, \sigma_3$	kPa		c_u	kPa	APPARENT COHESION INTERCEPT
ϵ	%		ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\epsilon_1, \epsilon_2, \epsilon_3$	%		τ_R	kPa	RESIDUAL SHEAR STRENGTH
E	kPa		τ_r	kPa	REMOULDED SHEAR STRENGTH
G	kPa		S_i	1	SENSITIVITY = $\frac{c_u}{\tau_r}$
μ	1				

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	n	1, %	POROSITY	e_{max}	1, %	VOID RATIO IN LOOSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	w	1, %	WATER CONTENT	e_{min}	1, %	VOID RATIO IN DENSEST STATE
ρ_w	kg/m ³	DENSITY OF WATER	S_r	%	DEGREE OF SATURATION	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
γ_w	kN/m ³	UNIT WEIGHT OF WATER	w_L	%	LIQUID LIMIT	D	mm	GRAIN DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_p	%	PLASTIC LIMIT	D_n	mm	n PERCENT - DIAMETER
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_s	%	SHRINKAGE LIMIT	C_u	1	UNIFORMITY COEFFICIENT
ρ_d	kg/m ³	DENSITY OF DRY SOIL	I_p	%	PLASTICITY INDEX = $w_L - w_p$	h	m	HYDRAULIC HEAD OR POTENTIAL
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_L	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	q	m ³ /s	RATE OF DISCHARGE
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	v	m/s	DISCHARGE VELOCITY
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	DTPL		DRIER THAN PLASTIC LIMIT	i	1	HYDRAULIC GRADIENT
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	APL		ABOUT PLASTIC LIMIT	k	m/s	HYDRAULIC CONDUCTIVITY
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL	WTP		WETTER THAN PLASTIC LIMIT	j	kN/m ²	SEEPAGE FORCE
e	1, %	VOID RATIO						

RECORD OF BOREHOLE No G-1

1 OF 1

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 991.672 N; 609 526.262 E ORIGINATED BY A.H.
 DIST Central HWY 401 BOREHOLE TYPE CFHSA COMPILED BY N.L.
 DATUM Geodetic DATE 2021.01.22 LATITUDE 43.650857 LONGITUDE -79.64184 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								WATER CONTENT (%)	
162.1	Ground Surface							20	40	60	80	100					
161.9	TOPSOIL																
0.2	SILTY SAND Loose, Brown, Moist		1	SS	4												
	CLAYEY SILT, trace sand Stiff, Brown, Moist		2	SS	10												
	SANDY SILT/SILTY SAND Compact, Grey, Wet to moist (FILL)		3	SS	12												
159.8	SANDY SILT/SILTY SAND																
2.3	Compact to very dense, Grey, Wet to moist		4	SS	20												0 62 30 8
			5	SS	17												0 25 66 9
158.1	shale fragments		6	SS	100												
4.0	End of borehole																Upon completion, no cave-in, free water at 2.4 m
	<div><div>▽</div>Groundwater level observed during drilling</div> <div><div>▼</div>Groundwater level measured upon completion of drilling</div>																

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-6-18

RECORD OF BOREHOLE No G-2

1 OF 1

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 922.466 N; 609 604.518 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA COMPILED BY N.L.
DATUM Geodetic DATE 2021.01.22 LATITUDE 43.650223 LONGITUDE -79.640884 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE								● QUICK TRIAXIAL		× LAB VANE
161.4	Ground Surface							20	40	60	80	100								
161.2	TOPSOIL																			
0.2	SILTY SAND Loose, Brown, Moist		1	SS	9		161							○						
															○					
															○					
	CLAYEY SILT, trace sand Very stiff, Brown, Moist		2	SS	16		160							○						
	SILTY SAND/SANDY SILT, trace gravel Loose to compact, Brown to grey, Moist to wet (FILL)		3	SS	6		159							○						
			4	SS	15									○						
158.3	Sandy CLAYEY SILT, trace gravel, shale fragments Hard, Grey, Moist (TILL)		5	SS	40		158							○			15 37 43 5			
				6	SS		52								○	H	16 32 35 17			
157.0	End of borehole						157										Upon completion, no cave-in, free water at 1.5 m			
4.4	Groundwater level observed during drilling Groundwater level measured upon completion of drilling																			

RECORD OF BOREHOLE No G-3

1 OF 1

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 872.035 N; 609 650.806 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA COMPILED BY N.L.
DATUM Geodetic DATE 2020.12.07 LATITUDE 43.649762 LONGITUDE -79.640321 CHECKED BY M.Z.


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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									WATER CONTENT (%)
160.4	Ground Surface							20	40	60	80	100					
160.2	TOPSOIL																
0.2	CLAYEY SILT, trace sand, trace gravel		1	SS	10		160						○				
	Stiff, Brown, Moist																
	SANDY SILT, trace gravel		2	SS	13								○				
	Compact to very dense, Brown, Moist (FILL)		3	SS	44		159						○		non-plastic		-37 44 15 4
158.1	Sandy CLAYEY SILT, some gravel																
2.3	Hard, Grey, Moist (TILL) shale fragments		4	SS	50		158						○				
			5	SS	114		157						○				10 37 41 12
							156						○	H			17 51 22 10
155.4	End of borehole		6	SS	82												Upon completion, no cave-in, no free water
5.0																	

RECORD OF BOREHOLE No BH1/MW1

1 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 853.196 N; 609 671.312 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2020.12.07 LATITUDE 43.64959 LONGITUDE -79.64007 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE								WATER CONTENT (%)				
160.1	Ground Surface						20	40	60	80	100					GR	SA	SI	CL	
0.0	CLAYEY SILT, some sand, some gravel Stiff, Brown, Moist		1	SS	10								○							
			2	SS	9								○							
	SANDY SILT, trace gravel Dense, Brown, Moist (FILL)		3	SS	43								○							
157.8																				
2.3	Sandy CLAYEY SILT, trace/some gravel Stiff to hard, Brown to grey, Moist (TILL)		4	SS	13								○			O ₂ =20.9%				
			5	SS	104/20cm								○							
			6	SS	82								○	H			7	37	41	15
			7	SS	62								○	H			16	32	37	15
	Clayey Sand, very dense		8	SS	90								○			O ₂ =20.9%	20	44	22	14
	shale fragments		9	SS	100/13cm								○			O ₂ =20.9%	21	35	24	20
			10	SS	100/13cm								○	H						
			11	SS	100/8cm								○			O ₂ =20.9%				
150.9			12	SS	100/8cm								○			O ₂ =20.9%				
9.2	Unweathered, laminated, slightly calcareous SHALE Soft, Dark grey		RUN 1	RC	RQD 57%								○			O ₂ =20.9%				REC 80%
			RUN 2	RC	RQD 83%															REC 90%
			RUN 3	RC	RQD 92%															REC 100%
147.9																				
12.2	End of borehole																			
	 Groundwater level measured in monitoring well NOTE: Bedrock coring conducted on Jan 22 & 25, 2021 GAS READING NOTES: 1. CH ₄ , CO, and H ₂ S readings were zero in all samples. Monitoring Well Readings: Date Depth Elev. (m) Feb.09/21 2.6 157.5 Feb.26/21 2.8 157.3																			Upon completion, no cave-in, no free water on Dec 7, 2020

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-7-5

METRIC

+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2

1 OF 1

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 818.868 N; 609 711.967 E ORIGINATED BY A.H.
 DIST Central HWY 401 BOREHOLE TYPE CFHSA COMPILED BY N.L.
 DATUM Geodetic DATE 2020.12.03 LATITUDE 43.649275 LONGITUDE -79.639573 CHECKED BY M.Z.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa									
163.1	Ground Surface						20	40	60	80	100					
162.9	TOPSOIL						○ UNCONFINED	+	FIELD VANE							
0.2	CLAYEY SILT, some sand, trace gravel		1	SS	8		● QUICK TRIAXIAL	×	LAB VANE							
	Firm to very stiff, Brown, Moist															
	(FILL)		2	SS	23											
			3	SS	16											
			4	SS	12											
	_____ sandy		5	SS	18											
158.6	SILTY SAND, some gravel		6	SS	24											
4.5	Compact to dense, Brown, Moist		7	SS	48											
157.0	Sandy CLAYEY SILT, trace gravel		8	SS	82											
6.1	Hard, Grey, Moist		9	SS	72											
	(TILL)		10	SS	56/15cm											
	_____ shale fragments		11	SS	64/15cm											
			12	SS	50/8cm											
			13	SS	52/15cm											
			14	AS	50/10cm											
			15	AS	100/11cm											
			16	AS	50/8cm											
149.9	End of borehole		17	SS	100/8cm											
13.2																



Groundwater level observed during drilling



Groundwater level measured upon completion of drilling

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

METRIC


+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH2A

2 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 818.198 N; 609 712.194 E ORIGINATED BY M.M.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2021.06.02 - 2021.06.03 LATITUDE 43.651277 LONGITUDE -79.639374 CHECKED BY M.Z.


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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)																	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa																								
148.0	Uneathered, thinly laminated, dark grey, soft, slightly calcareous. SHALE with minor, unweathered, grey, moderately hard, calcareous CARBONATE interbeds		RUN 2	RC	RQD 60%	147	20	40	60	80	100	20	40	60	GR	SA	SI	CL														
15.0																																
			RUN 3	RC	RQD 70%	146													REC 95% UCS = 58,0 MPa													
			RUN 4	RC	RQD 65%	145													REC 87%													
143.9	End of borehole					144													Upon completion, no cave-in, no free water													
19.1																																

RECORD OF BOREHOLE No BH3

1 OF 1

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 788.818 N; 609 744.756 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA COMPILED BY N.L.
DATUM Geodetic DATE 2020.12.08 LATITUDE 43.648999 LONGITUDE -79.639173 CHECKED BY M.Z.

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/ GAS READING γ _k N/m ³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
163.5	Ground Surface																
0.0	CLAYEY SILT, some sand, trace gravel		1	SS	19		163						○			O ₂ =20.9%	
	Stiff to very stiff, Brown, Moist (FILL)		2	SS	13		162						○			O ₂ =20.9%	
			3	SS	9		161						○				
			4	SS	8		160						○				
			5	SS	9		159						○			O ₂ =20.9%	
			6	SS	20		158						○				
			7	SS	21		157						○			O ₂ =20.9%	
157.4	SANDY SILT, trace gravel		8	SS	32		156						○				
6.1	Dense to very dense, Brown, Moist		9	SS	61		155						○			3 32 46 19	
155.9	Sandy CLAYEY SILT, trace/some gravel		10	SS	64		154						○			13 32 44 11	
7.6	Hard, Grey, Moist (TILL) shale fragments, cobbles		11	SS	72		153						○			C ₆ H ₆ =0.03 ppm	
			12	SS	47		152						○			C ₆ H ₆ =0.03 ppm	17 43 34
			13	SS	75								○				
			14	SS	62								○			C ₆ H ₆ =0.06 ppm	16 33 29 22
			15	SS	100/28cm								○				
			16	AS	100/8cm								○				
151.2	End of borehole												○				Upon completion, no cave-in, no free water
12.3																	
	<div>  Groundwater level observed during drilling </div> <div> GAS READING NOTES: 1. CH₄, CO, and H₂S readings were zero in all samples. NOTE: The presence of cobbles was inferred by auger grinding observed during drilling and is not indicative of quantity. </div>																

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-6-18

METRIC

+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH3-1

2 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 788.818 N; 609 745.756 E ORIGINATED BY A.H.
 DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
 DATUM Geodetic DATE 2020.12.21 - 2020.12.23 LATITUDE 43.648999 LONGITUDE -79.63916 CHECKED BY M.Z.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT/ GAS READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						W _p
148.5	Unweathered, thinly laminated, dark grey, soft, slightly calcareous SHALE (Cont'd)						148							GR SA SI CL
			OC 3	CORE										
147.6	End of borehole													
15.9	CORE Denotes over-coring													

RECORD OF BOREHOLE No BH4/MW-2

1 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 774.613 N; 609 757.644 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2021.01.06 - 2021.01.07 LATITUDE 43.648869 LONGITUDE -79.639016 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
163.2	Ground Surface							20 40 60 80 100		20 40 60					
163.0	TOPSOIL														
0.2	CLAYEY SILT, trace sand, trace gravel		1	SS	17		163				○				
	Stiff to very stiff, Brown, Moist														
	(FILL)		2	SS	12		162				○				
			3	SS	10										
			4	SS	12		161				○				
			5	SS	20		160				○				Tri-cone mud drilling begins
158.7	Sandy CLAYEY SILT, trace gravel						159								
4.5	Hard, Brown, Moist		6	SS	40		158				⊕			C _e H _b = 0.09 ppm	6 30 45 19
	(TILL)														
			7	SS	64		157				○			C _e H _b = 0.03 ppm	0 40 56 4
156.0	CLAYEY SAND, some gravel						156								
7.2	Very dense, Grey, Moist		8	SS	88		155				○			C _e H _b = 0.08 ppm	18 58 (24)
	(TILL)		9	SS	100/15cm		154				○			C _e H _b = 0.09 ppm	
	shale fragments		10	SS	114		153				○	⊕		C _e H _b = 0.1 ppm	26 36 24 14
			11	SS	151		152				○	⊕		C _e H _b = 0.1 ppm	
152.5	Clay and cobbles		12	SS	100/10cm		151							C _e H _b = 0.11 ppm	
10.7	Dark grey		RUN 1	RC	RQD 0%		150							C _e H _b = 0.66 ppm	
151.0	Unweathered, thinly laminated, soft, dark grey, slightly calcareous SHALE		RUN 2	RC	RQD 90%		149								REC 100%
12.2			OC 1 CORE												EX-coring failed
			RUN 3	RC	RQD 100%										REC 100%
			OC 2 CORE												EX-core recovered

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-7-5

RECORD OF BOREHOLE No BH4/MW-2

2 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 774.613 N; 609 757.644 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2021.01.06 - 2021.01.07 LATITUDE 43.648869 LONGITUDE -79.639016 CHECKED BY M.Z.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT/ GAS READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)																		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L																				
148.2	Unweathered, thinly laminated, soft, dark grey, slightly calcareous SHALE (Cont'd)		RUN 4	RC	RQD 100%		148										REC 100%																		
147.4			OC 3	CORE																								Biaxial test successful							
15.8	End of borehole Groundwater level measured in monitoring well CORE Denotes over-coring NOTE: Bedrock coring conducted on Jan 7, 2021 GAS READING NOTES: 1. CH ₄ , O ₂ , CO, and H ₂ S readings were zero in all samples. Monitoring Well Readings: <table border="1"> <thead> <tr> <th>Date</th> <th>Depth (m)</th> <th>Elev.</th> </tr> </thead> <tbody> <tr> <td>Feb.09/21</td> <td>DRY</td> <td>---</td> </tr> <tr> <td>Feb.26/21</td> <td>6.1</td> <td>157.1</td> </tr> <tr> <td>Mar.10/21</td> <td>6.2</td> <td>157.0</td> </tr> <tr> <td>Apr.09/21</td> <td>6.0</td> <td>157.2</td> </tr> <tr> <td>May.11/21</td> <td>6.0</td> <td>157.2</td> </tr> <tr> <td>Jun.09/21</td> <td>5.8</td> <td>157.4</td> </tr> </tbody> </table> Monitoring Well Legend: Bentonite Seal Filter Sand Screen	Date	Depth (m)	Elev.	Feb.09/21	DRY	---	Feb.26/21	6.1	157.1	Mar.10/21	6.2	157.0	Apr.09/21	6.0	157.2	May.11/21	6.0	157.2	Jun.09/21	5.8	157.4													Upon completion, no cave-in, no free water on Jan 6, 2021
Date	Depth (m)	Elev.																																	
Feb.09/21	DRY	---																																	
Feb.26/21	6.1	157.1																																	
Mar.10/21	6.2	157.0																																	
Apr.09/21	6.0	157.2																																	
May.11/21	6.0	157.2																																	
Jun.09/21	5.8	157.4																																	

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-7-5

RECORD OF BOREHOLE No BH5

1 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 733.145 N; 609 798.995 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2020.12.09 LATITUDE 43.64849 LONGITUDE -79.638512 CHECKED BY M.Z.

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/7 GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	● QUICK TRIAXIAL	+ FIELD VANE	× LAB VANE	20						40	60	80
160.8	Ground Surface																			
0.0	CLAYEY SILT, trace sand, trace gravel		1	AS	18															
	Very stiff to stiff, Brown, Moist (FILL)		2	SS	11															
			3	SS	15															
158.5	Sandy CLAYEY SILT, trace gravel		4	SS	21															
2.3	Very stiff to hard, Brown to grey, moist (TILL)		5	SS	112/28cm															
			6	SS	82															
			7	SS	72															
	clay and cobbles, shale fragments		8*	SS	90															
			9*	SS	92															
152.9	Unweathered, thinly laminated, dark grey, soft, slightly calcareous, SHALE		RUN 2	RC	RQD 0%															
7.9	minor, unweathered, grey, moderately hard, calcareous CARBONATE interbeds		OC 1	CORE																
			RUN 3	RC	RQD 31%															
			OC 2	CORE																
			RUN 4	RC	RQD 66%															
			RUN 5	RC	RQD 100%															
			OC 3	CORE																
148.1	End of borehole																			
12.7	CORE Denotes over-coring																			
	* Split spoon samples and SPT were conducted in a separate borehole 2.0 m west of BH5 location subsequent to rock coring (Run 1) indicated clay and cobbles																			

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-6-18

RECORD OF BOREHOLE No BH5

2 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 733.145 N; 609 798.995 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2020.12.09 LATITUDE 43.64849 LONGITUDE -79.638512 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
145.8						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20	40	60	80	100	20	40	60				
	NOTES: 1. Bedrock coring conducted on Jan 4 & 5, 2021 2. The presence of cobbles was inferred by auger grinding observed during drilling and is not indicative of quantity. GAS READING NOTES: 1. CH ₄ , CO, and H ₂ S readings were zero in all samples.																

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-6-18

METRIC



+³, ×³: Numbers refer to Sensitivity ○^{3%} STRAIN AT FAILURE

RECORD OF BOREHOLE No P-1

2 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 686.098 N; 609 851.700 E ORIGINATED BY F.M.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2021.03.06 - 2021.03.07 LATITUDE 43.648059 LONGITUDE -79.637868 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
145.9	Unweathered, thinly laminated, dark grey, soft, slightly calcareous, SHALE (Cont.d)		RUN 5	RC	RQD 100%		145										REC 100%
			RUN 6	RC	RQD 100%			144									
143.1 17.8	End of borehole  Groundwater level observed during drilling																Upon completion, no cave-in. Borehole was charged with coring water/mud, thus groundwater level could not be established upon completion of drilling.

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-6-18

RECORD OF BOREHOLE No BH6

1 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 639.158 N; 609 890.518 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2020.12.14 LATITUDE 43.647631 LONGITUDE -79.637396 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
160.7	Ground Surface					▽		20	40	60	80	100					GR SA SI CL
160.5	TOPSOIL						○ UNCONFINED	+	FIELD VANE								
0.2	CLAYEY SILT, some sand, trace gravel		1	SS	8		● QUICK TRIAXIAL	×	LAB VANE								
	Stiff to very stiff, Brown, Moist (FILL)		2	SS	15												
158.9	Sandy CLAYEY SILT, trace/some gravel		3	SS	16												
1.8	Very stiff to hard, Brown to grey, Moist (TILL)		4	SS	25												
			5	SS	21												
			6	SS	26												
			7	SS	15												
			8	SS	19												
			9	SS	34												
153.8	CLAYEY SAND, trace/some gravel		10	SS	15												
6.9	Compact to very dense, Grey, Moist (TILL)		11	SS	50												
			12	SS	100/13cm												
	shale fragments		13	SS	88												
			14	SS	100/8cm												
			15	SS	100/4cm												
149.6	Unweathered, thinly laminated, dark grey, soft, slightly calcareous, SHALE		RUN 1	RC	RQD 31%												
11.1			RUN 2	RC	RQD 79%												
			RUN 3	RC	RQD 100%												
			OC 1	CORE													
	minor, unweathered, grey, moderately hard, calcareous CARBONATE interbeds		RUN 4	RC	RQD 100%												

Continued Next Page

+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-6-18

RECORD OF BOREHOLE No BH6

2 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 639.158 N; 609 890.518 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2020.12.14 LATITUDE 43.647631 LONGITUDE -79.637396 CHECKED BY M.Z.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT	UNIT WEIGHT/ GAS READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						W _p	W	W _L	γ _{kN/m³} / ppm/%
145.7	Unweathered, thinly laminated, dark grey, soft, slightly calcareous, SHALE (Cont'd)		OC 2	CORE			145	20	40	60	80	100	20	40	60		GR SA SI CL
144.8																	
15.9	End of borehole																Upon completion, no cave-in, no free water on Dec 14, 2020
	 Groundwater level observed during drilling																
	CORE Denoted over-coring																
	NOTE: Bedrock coring conducted on Jan 13 & 14, 2021																

RECORD OF BOREHOLE No BH7/MW-3

1 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 607.425 N; 609 930.584 E ORIGINATED BY A.H.
 DIST Central HWY 401 BOREHOLE TYPE CFHSA COMPILED BY N.L.
 DATUM Geodetic DATE 2020.12.10 LATITUDE 43.647339 LONGITUDE -79.636906 CHECKED BY M.Z.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT/ GAS READING γ kN/m ³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						PLASTIC LIMIT w _p NATURAL MOISTURE CONTENT w LIQUID LIMIT w _L WATER CONTENT (%)				
165.1	Ground Surface							20	40	60	80	100						
164.9	TOPSOIL							20	40	60	80	100						
0.2	CLAYEY SILT, some sand, trace gravel Stiff to very stiff, Brown, Moist (FILL)		1	SS	12		165							○				
			2	SS	15		164							○				
			3	SS	13		163							○				
			4	SS	12		162							○				
			5	SS	7		161							○				
			6	SS	18		160							○				
159.0	Sandy CLAYEY SILT, trace gravel Very stiff to hard, Grey, Moist (TILL)		7	SS	15		159							○				
6.1	Silty Sand, compact		8	SS	15		158							○				
			9	SS	58		157							○	—			2 31 46 21
			10	SS	63		156							○	—			7 31 41 21
			11	SS	24		155							○				
			12	SS	23		154							○				
			13	SS	50		153							○				
			14	SS	106/23cm		152							○				
			15	SS	163/25cm		151							○				
			16	SS	172/20cm									○				
			17	SS	109/20cm									○				
			18	SS	100/8cm									○				
			Silty Gravel, with sand, very dense															
	shale fragments																36 29 25 10	

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+ ³, X ³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE






ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-7-5

RECORD OF BOREHOLE No BH7/MW-3

2 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 607.425 N; 609 930.584 E ORIGINATED BY A.H.
 DIST Central HWY 401 BOREHOLE TYPE CFHSA COMPILED BY N.L.
 DATUM Geodetic DATE 2020.12.10 LATITUDE 43.647339 LONGITUDE -79.636906 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL																				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100																									
150.1																																					
149.8			19	SS	100/8cm																																
15.3	End of borehole																																				
	 Groundwater level measured upon completion of drilling  Groundwater level measured in monitoring well <u>Monitoring Well Readings:</u> <table border="1"> <thead> <tr> <th>Date</th> <th>Depth (m)</th> <th>Elev.</th> </tr> </thead> <tbody> <tr> <td>Feb.09/21</td> <td>6.0</td> <td>159.1</td> </tr> <tr> <td>Feb.26/21</td> <td>6.1</td> <td>159.0</td> </tr> <tr> <td>Mar.10/21</td> <td>6.0</td> <td>159.1</td> </tr> <tr> <td>Apr.09/21</td> <td>5.4</td> <td>159.7</td> </tr> <tr> <td>May.11/21</td> <td>5.5</td> <td>159.6</td> </tr> <tr> <td>Jun.25/21</td> <td>5.6</td> <td>159.5</td> </tr> </tbody> </table> <u>Monitoring Well Legend:</u>  Bentonite Seal  Filter Sand  Screen	Date	Depth (m)	Elev.	Feb.09/21	6.0	159.1	Feb.26/21	6.1	159.0	Mar.10/21	6.0	159.1	Apr.09/21	5.4	159.7	May.11/21	5.5	159.6	Jun.25/21	5.6	159.5															Upon completion, no cave-in, free water at 12.5 m
Date	Depth (m)	Elev.																																			
Feb.09/21	6.0	159.1																																			
Feb.26/21	6.1	159.0																																			
Mar.10/21	6.0	159.1																																			
Apr.09/21	5.4	159.7																																			
May.11/21	5.5	159.6																																			
Jun.25/21	5.6	159.5																																			

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-7-5

METRIC

+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH7A

2 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 605.916 N; 609 931.947 E ORIGINATED BY M.M.
 DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
 DATUM Geodetic DATE 2021.06.03 - 2021.06.07 LATITUDE 43.649325 LONGITUDE -79.636693 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa			WATER CONTENT (%)								
150.2									20	40	60	80	100				
149.9	Augered to 15.3 m (<i>Cont.d</i>)																
15.3	Weathered SHALE																
149.2	Weathered, thinly laminated, dark grey, soft, slightly calcareous, SHALE																
16.0																	
	unweathered, with minor, unweathered, grey, moderately hard, calcareous CARBONATE interbeds																

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-7-5

RECORD OF BOREHOLE No BH8

1 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 589.710 N; 609 949.263 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2020.12.11 LATITUDE 43.647177 LONGITUDE -79.636678 CHECKED BY M.Z.

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/ GAS READING γ kN/m ³ / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
165.2	Ground Surface						20	40	60	80	100					
165.0	TOPSOIL						20	40	60	80	100					
0.2	CLAYEY SILT, trace sand, trace gravel		1	SS	8											
	Stiff to very stiff, Brown, Moist															
	(FILL)		2	SS	15											
			3	SS	10											
			4	SS	16											
			5	SS	6											
			6	SS	19											
159.1	Sandy CLAYEY SILT, trace/some gravel		7	SS	8											
6.1	Stiff to very stiff, Grey, Moist															
	(TILL)		8	SS	4											
			9	SS	27											
			10	SS	38											
			11	SS	38											
			12	SS	34											
			13	SS	33											
			14	SS	100/13cm											
			15	SS	100/10cm											
			16	SS	117											
			17	SS	128											
			18	SS	100/5cm											

Continued Next Page

+³, X³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH8

2 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 589.710 N; 609 949.263 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2020.12.11 LATITUDE 43.647177 LONGITUDE -79.636678 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
150.2								20	40	60	80	100					
	Sandy CLAYEY SILT, trace/some gravel		19	SS	100/5cm		150										
	Stiff to very stiff, Grey, Moist																
	(TILL) (Cont'd)																
149.2			20	SS	100/3cm												
16.0	Unweathered, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, grey, moderately hard, calcareous CARBONATE interbeds		RUN 1	RC	RQD 92%		149										REC 100%
			OC 1	CORE			148										Over-coring failed
			RUN 2	RC	RQD 100%		147										REC 100%
146.6			OC 2	CORE													USBM & biaxial test successful
18.6	End of borehole																Upon completion, no cave-in, no free water on Dec 11, 2020
	<div><div>▽</div>Groundwater level observed during drilling</div> <div><div>▼</div>Groundwater level measured upon completion of drilling</div> <div>CORE Denotes over-coring</div> <div>NOTE: Bedrock coring conducted on Jan 12, 2021</div>																

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-6-18

RECORD OF BOREHOLE No BH9

1 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 558.124 N; 609 979.300 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2020.12.15 LATITUDE 43.646888 LONGITUDE -79.636312 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)		
								○ UNCONFINED		+ FIELD VANE							○		
								● QUICK TRIAXIAL		× LAB VANE							○		
164.3	Ground Surface						20	40	60	80	100								
0.0	CLAYEY SILT, some sand, some gravel Very stiff to stiff, Brown, Moist		1	SS	27		164								O ₂ =20.9%	4 30 42 24			
			2	SS	14		163								O ₂ =20.9%				
	SILTY SAND, some gravel Compact, Brown, Moist		3	SS	20		162								O ₂ =20.9%				
	CLAYEY SILT/SILTY CLAY, some sand, trace gravel Stiff, Brown, Moist (FILL)		4	SS	13		161								O ₂ =20.9%				
			5	SS	10		160								O ₂ =20.9%				
			6	SS	7		159								O ₂ =20.9%				
			7	SS	30		158								O ₂ =20.9% CO = 7 ppm				
			8	SS	51		156								O ₂ =20.9% CO = 9 ppm				
			9	SS	21		155								O ₂ =20.9% 21.16 kN/m ³				
			10	SS	21		154								O ₂ =20.7%				
			11	SS	28		153								O ₂ =20.9%	2 34 50 14			
			12	SS	68		152								O ₂ =20.6% CO = 45 ppm				
			13	SS	70		151								20.60 kN/m ³				
			14	SS	118		150								O ₂ =20.9% CO = 490 ppm	11 39 38 12			
			15	SS	112														
			16	SS	100/8cm														
149.8	Augered to 14.9 m		17	SS	100/3cm														
14.5																			
149.4																			

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH9

2 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 558.124 N; 609 979.300 E ORIGINATED BY A.H.
DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
DATUM Geodetic DATE 2020.12.15 LATITUDE 43.646888 LONGITUDE -79.636312 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								WATER CONTENT (%)			
149.3	Unweathered, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, grey, moderately hard, calcareous CARBONATE interbeds (<i>Cont'd</i>)		RUN 1	RC	RQD 64%	149								H	REC 100% UCS = 24 MPa				
14.9			RUN 2	RC	RQD 93%		148												
			OC 1	CORE				147											
			RUN 3	RC	RQD 87%				146										
			OC 2	CORE															
145.7	End of borehole															Upon completion, no cave-in, free water at 9.4 m on Dec 15, 2020			
18.6																			
	Groundwater level measured upon completion of drilling																		
	CORE Denotes over-coring																		
	NOTE: Bedrock coring conducted on Jan 18 & 19, 2021																		
	<u>GAS READING NOTES:</u> 1. CH ₄ , and H ₂ S readings were zero in all samples.																		

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-6-18

RECORD OF BOREHOLE No BH10/MW-4

1 OF 2

METRIC

PROJECT Dixie Road Watermain LOCATION COORDS: 4 833 517.316 N; 610 011.247 E ORIGINATED BY A.H.
 DIST Central HWY 401 BOREHOLE TYPE CFHSA and Rotary Drilling COMPILED BY N.L.
 DATUM Geodetic DATE 2020.12.16 LATITUDE 43.646516 LONGITUDE -79.635925 CHECKED BY M.Z.

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/ GAS READING γ _{kN/m³} / ppm/%	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								WATER CONTENT (%)	
159.6	Ground Surface							20	40	60	80	100					
159.4	TOPSOIL							20	40	60	80	100					
0.2	CLAYEY SILT, trace/some sand, trace gravel		1	SS	18								○				
	Very stiff to firm, Brown, Moist (FILL)		2	SS	9								○				
			3	SS	5								○				
157.0	Sandy CLAYEY SILT, trace/some gravel		4	SS	12								○				
2.6	Hard, Grey, Moist (TILL)		5	SS	30								○				
			6	SS	29								○				
			7	SS	34								○				
			8	SS	28								○				
			9	SS	27								○				
			10	SS	73								○				
	Silty Sand, very dense to dense		11	SS	45								○				
	shale fragments		12	SS	100/14cm								○				
			13	SS	100/11cm												
			14	SS	100/3cm												
149.7	Augered to 11.0 m																
148.6	Unweathered, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, grey, moderately hard, calcareous CARBONATE interbeds		RUN 1	RC	RQD 71%								○				
11.0			RUN 2	RC	RQD 100%												
145.9	End of borehole																
13.7	Groundwater level observed during drilling																
	Groundwater level measured in monitoring well																

Continued Next Page

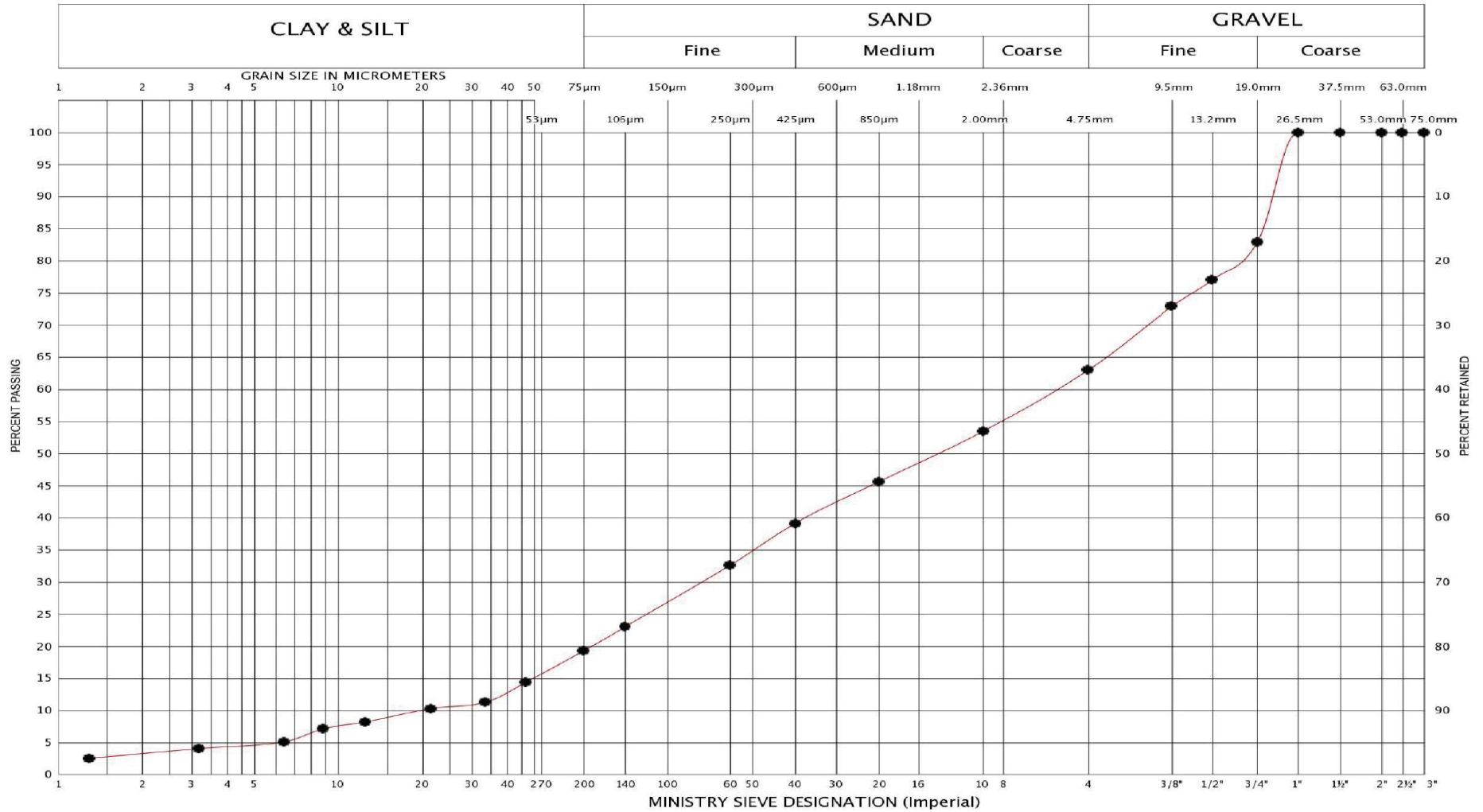
+ 3, X 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO - W/GAS READING 20TF025.GPJ ONTARIO MTO.GDT 21-7-5

METRIC

[illegible]

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	G-3
	SAMPLE	3
	SYMBOL	•



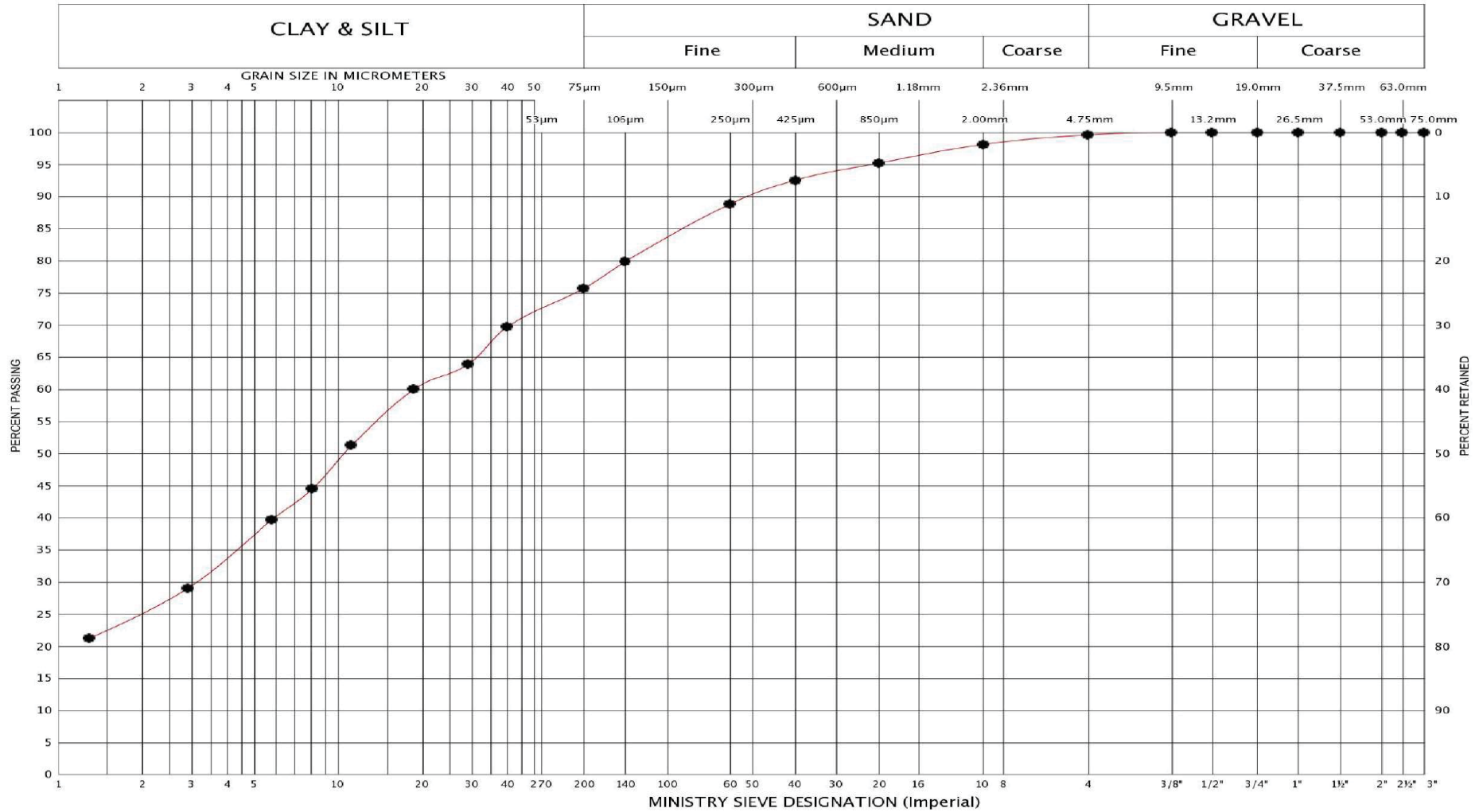
GRAIN SIZE DISTRIBUTION
SILTY SAND, with Gravel (FILL)

FIG No.: GS-1A

HWY : 401

Project No.: 20TF025A

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	BH2
	SAMPLE	5
	SYMBOL	•



GRAIN SIZE DISTRIBUTION

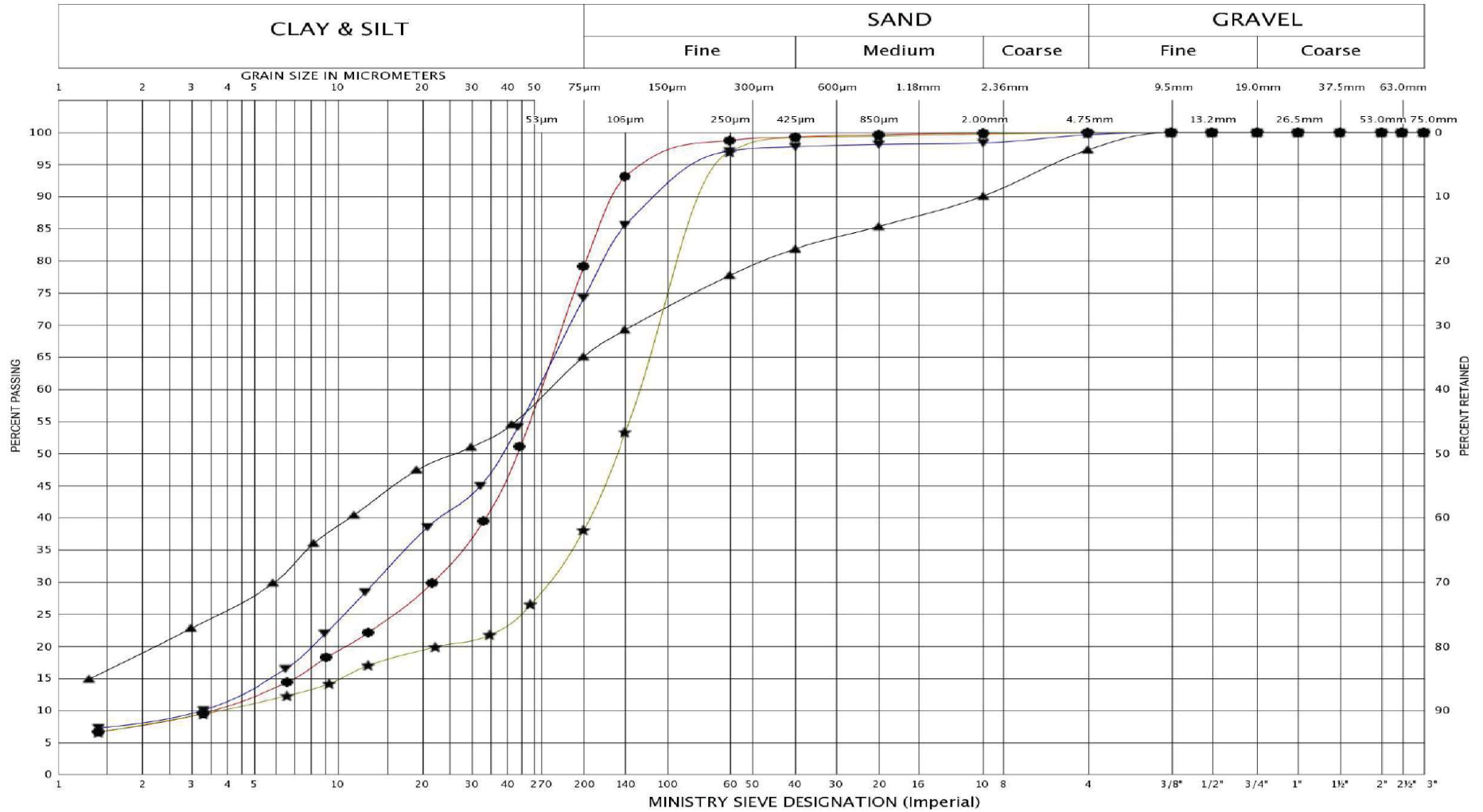
CLAYEY SILT, sandy (FILL)

FIG No.: GS-1B

HWY : 401

Project No.: 20TF025A

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	BH2	BH3	G-1	G-1
	SAMPLE	6	9	4	5
	SYMBOL	●	▲	★	▼



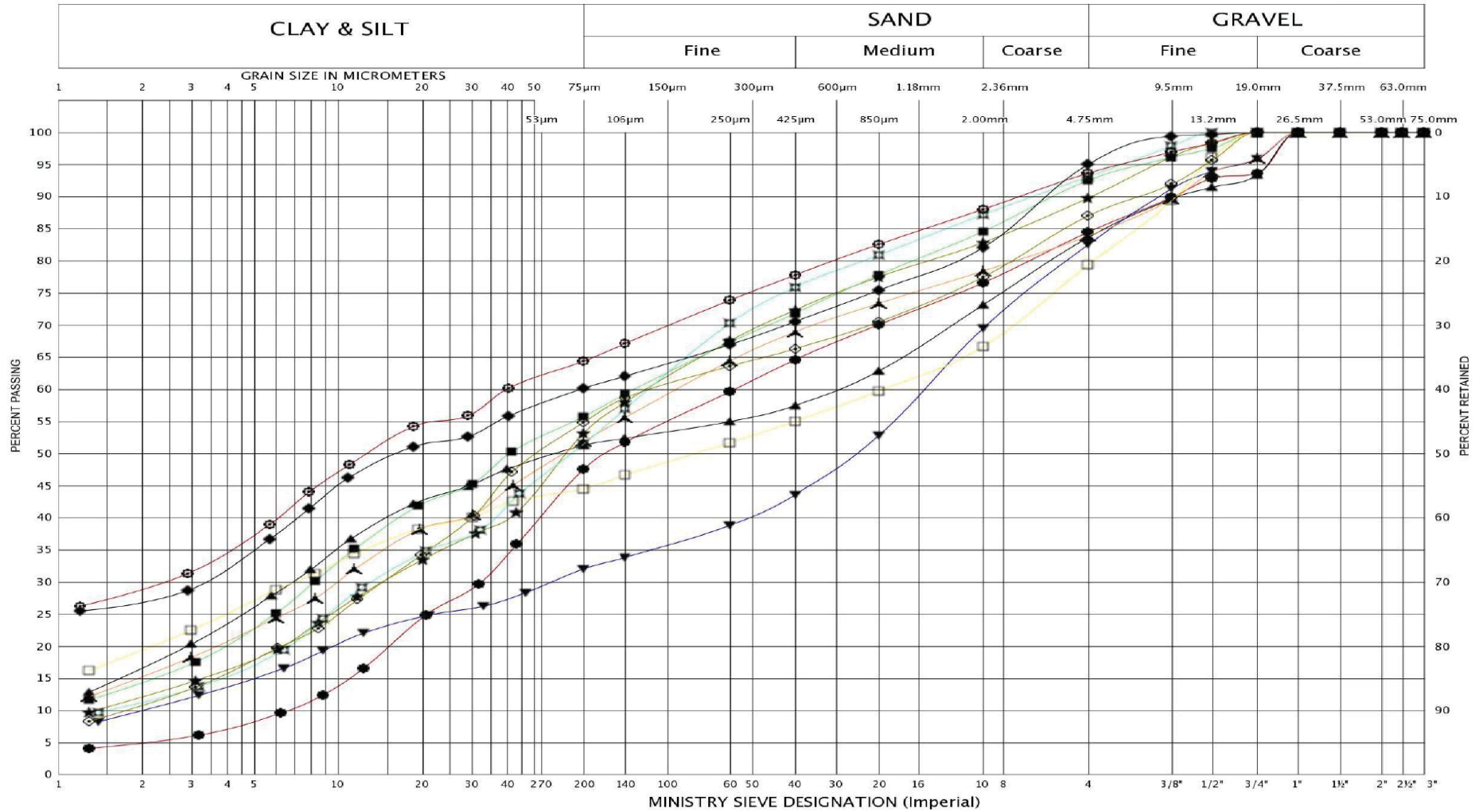
GRAIN SIZE DISTRIBUTION
Sandy Silt/Silty Sand, trace gravel

FIG No.: GS-2

HWY : 401

Project No.: 20TF025A

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	G-2	G-2	G-3	G-3	BH1	BH1	BH1	BH2	BH2	BH2	BH3
	SAMPLE	5	6	5	6	6	7	9	8	11	13	11
	SYMBOL	●	▲	★	▼	■	▲	□	■	⊕	◆	◇



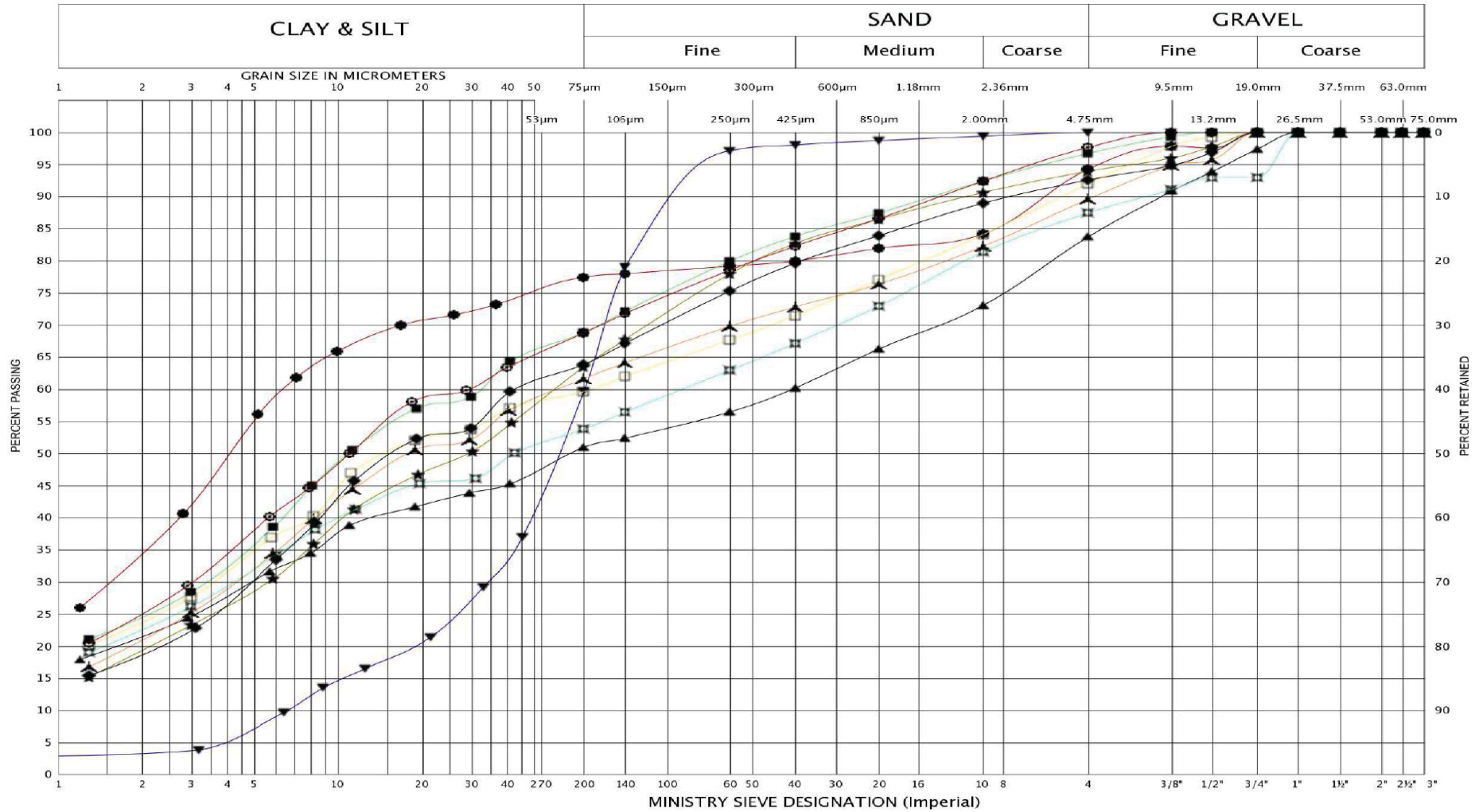
GRAIN SIZE DISTRIBUTION
Sandy Clayey Silt, trace/some gravel (Till)

FIG No.: GS-3A

HWY : 401

Project No.: 20TF025A

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	BH3	BH3	BH4	BH4	BH5	BH5	BH5	BH5	BH6	BH6
	SAMPLE	13	15	6	7	5	6	7	8	4	6
	SYMBOL	●	▲	★	▼	■	▲	□	■	●	◆



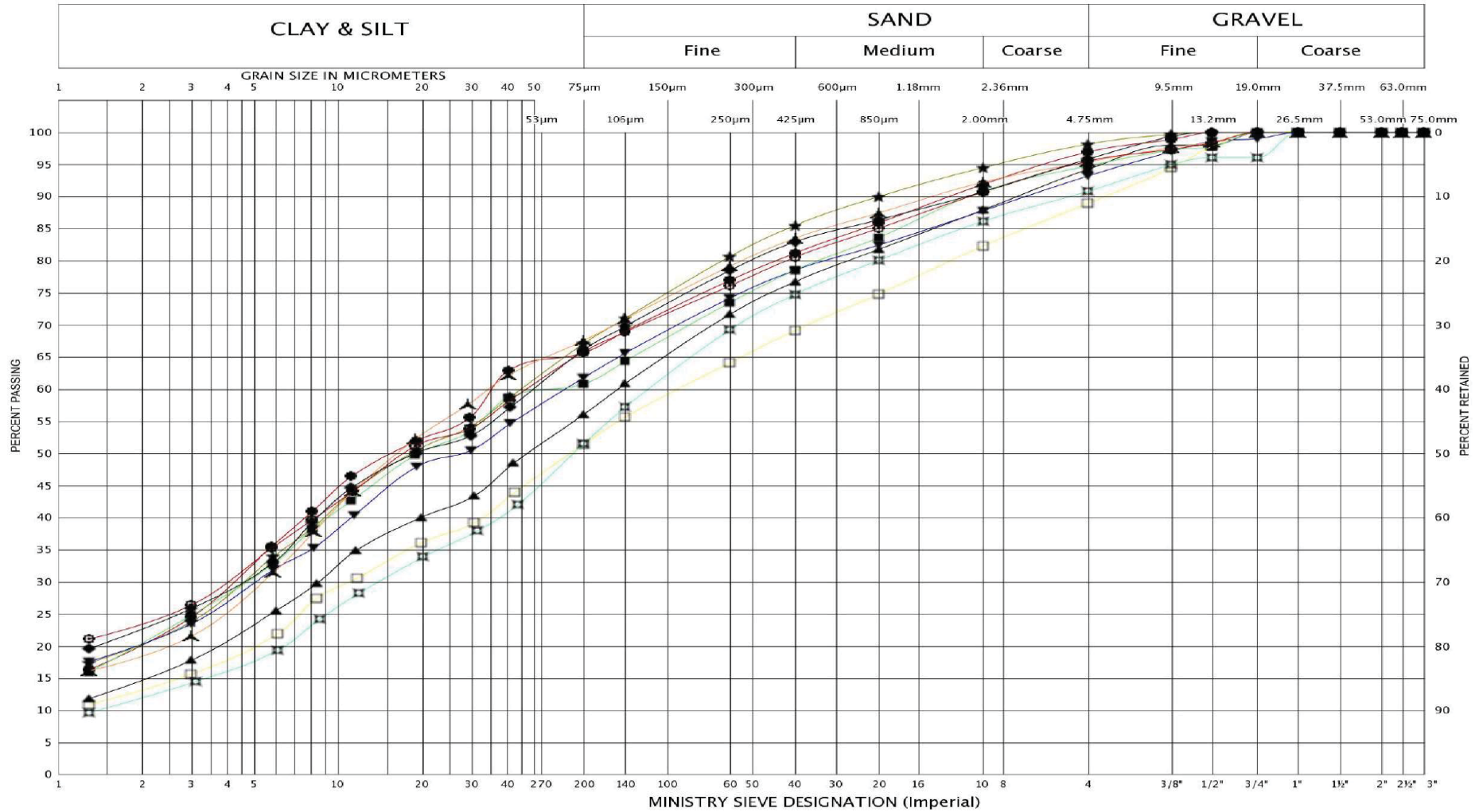
GRAIN SIZE DISTRIBUTION
Sandy Clayey Silt, trace/some gravel (Till)

FIG No.: GS-3B

HWY : 401

Project No.: 20TF025A

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	BH6	BH6	BH7	BH7	BH7	BH8	BH8	BH8	BH9	BH9
	SAMPLE	8	9	9	10	13	7	12	16	7	8
	SYMBOL	●	▲	★	▼	■	▲	□	■	⊗	◆



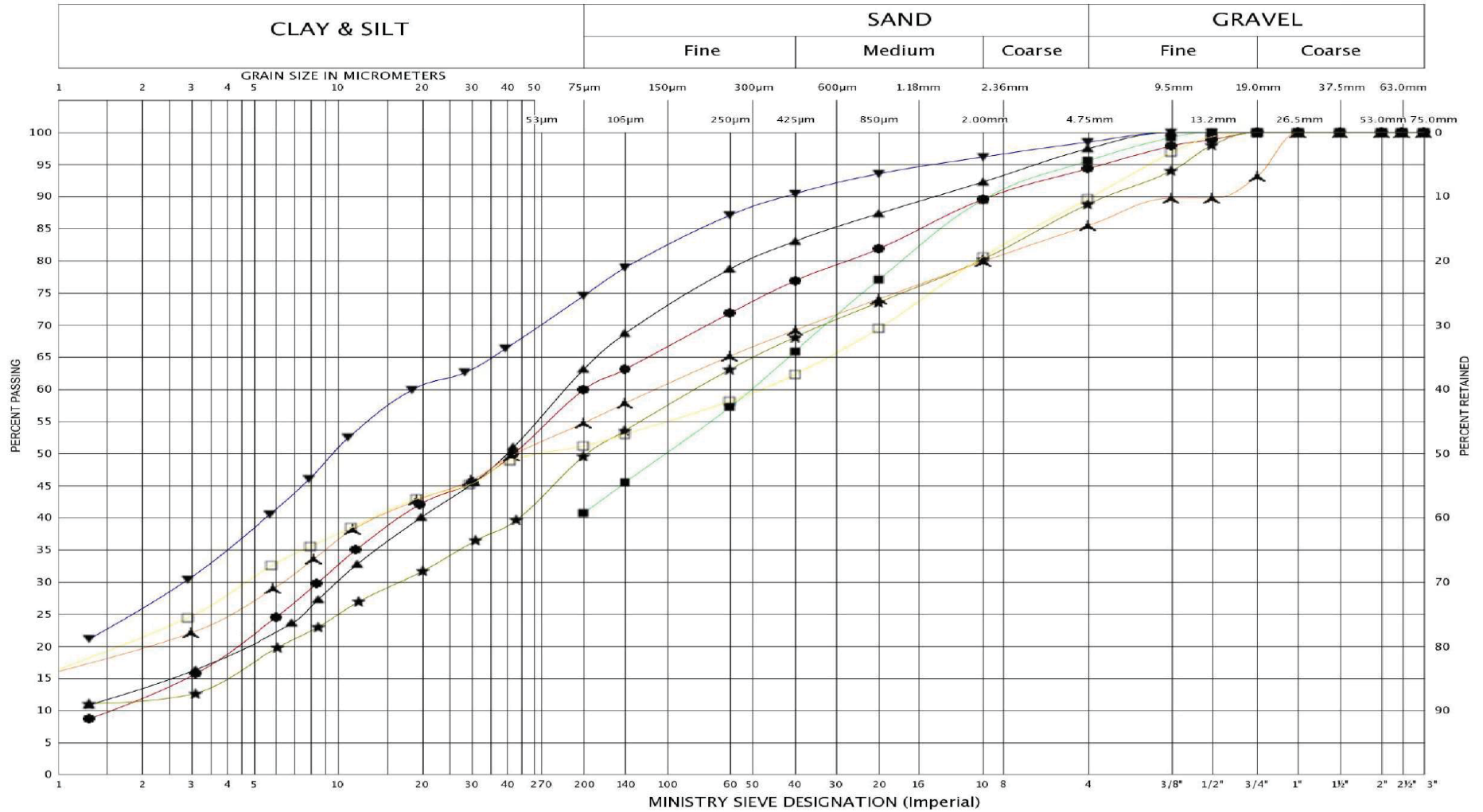
GRAIN SIZE DISTRIBUTION
Sandy Clayey Silt, trace/some gravel (Till)

FIG No.: GS-3C

HWY : 401

Project No.: 20TF025A

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	BH9	BH9	BH9	BH10	BH10	P-1	P-1
	SAMPLE	9	12	15	5	7	7	9
	SYMBOL	●	▲	★	▼	■	▲	□



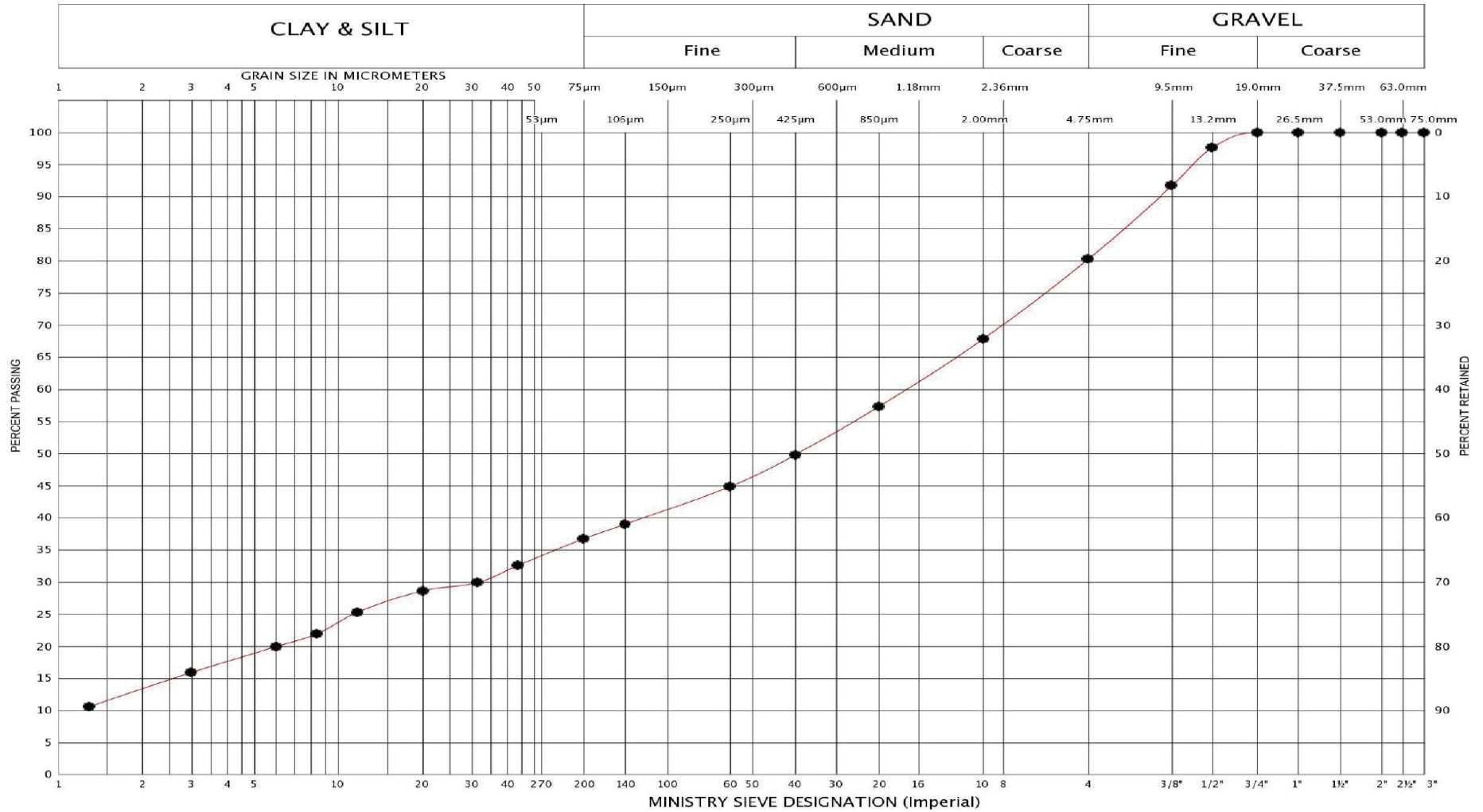
GRAIN SIZE DISTRIBUTION
Sandy Clayey Silt, trace/some gravel (Till)

FIG No.: GS-3D

HWY : 401

Project No.: 20TF025A

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	BH1
	SAMPLE	8
	SYMBOL	•



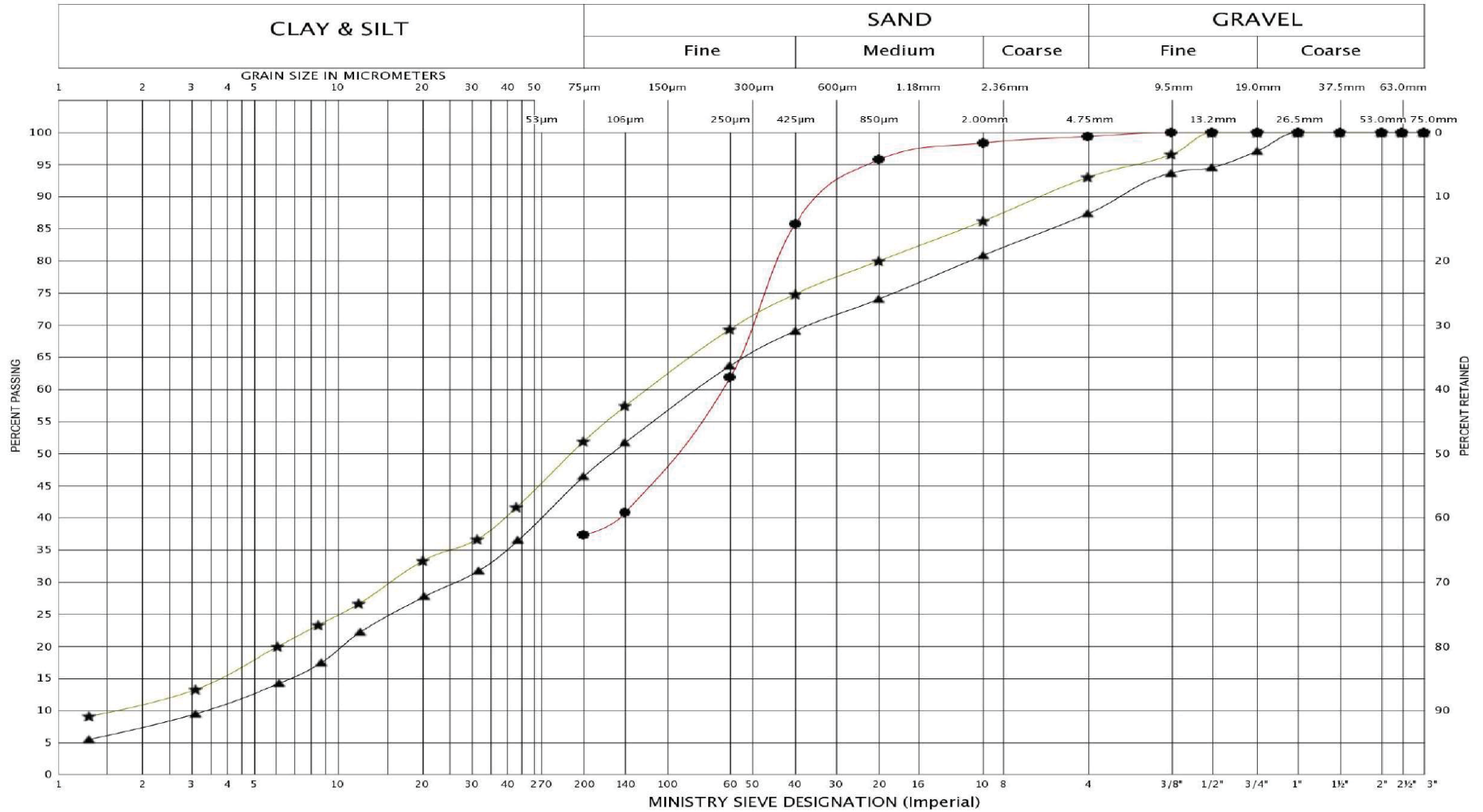
GRAIN SIZE DISTRIBUTION
CLAYEY SAND, silty, some gravel (within Till)

FIG No.: GS-4

HWY : 401

Project No.: 20TF025A

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	BH8	BH10	BH10
	SAMPLE	10	10	11
	SYMBOL	●	▲	★



GRAIN SIZE DISTRIBUTION

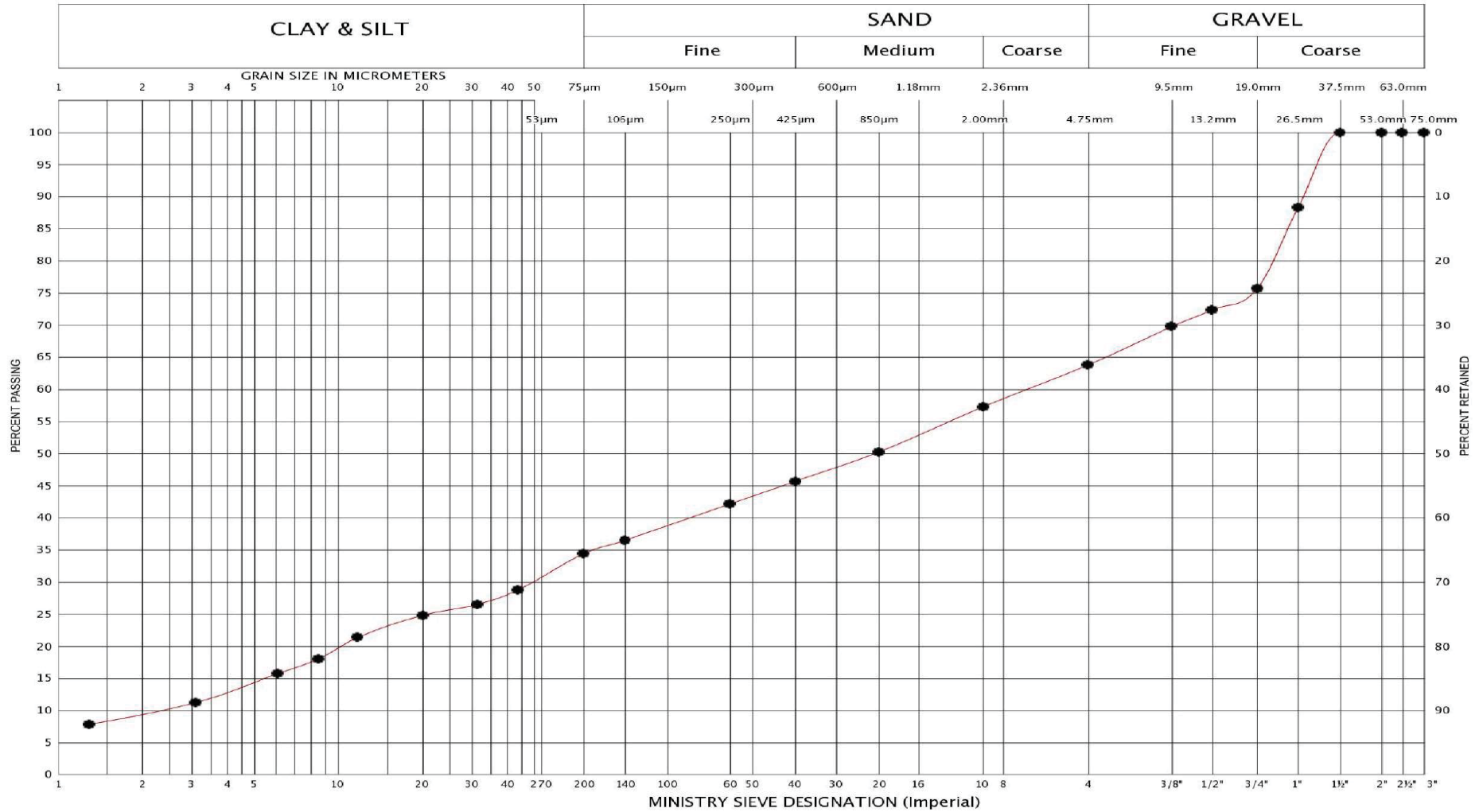
SILTY SAND, trace/some clay, trace/some gravel (within Till)

FIG No.: GS-5

HWY : 401

Project No.: 20TF025A

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	BH7
	SAMPLE	17
	SYMBOL	•



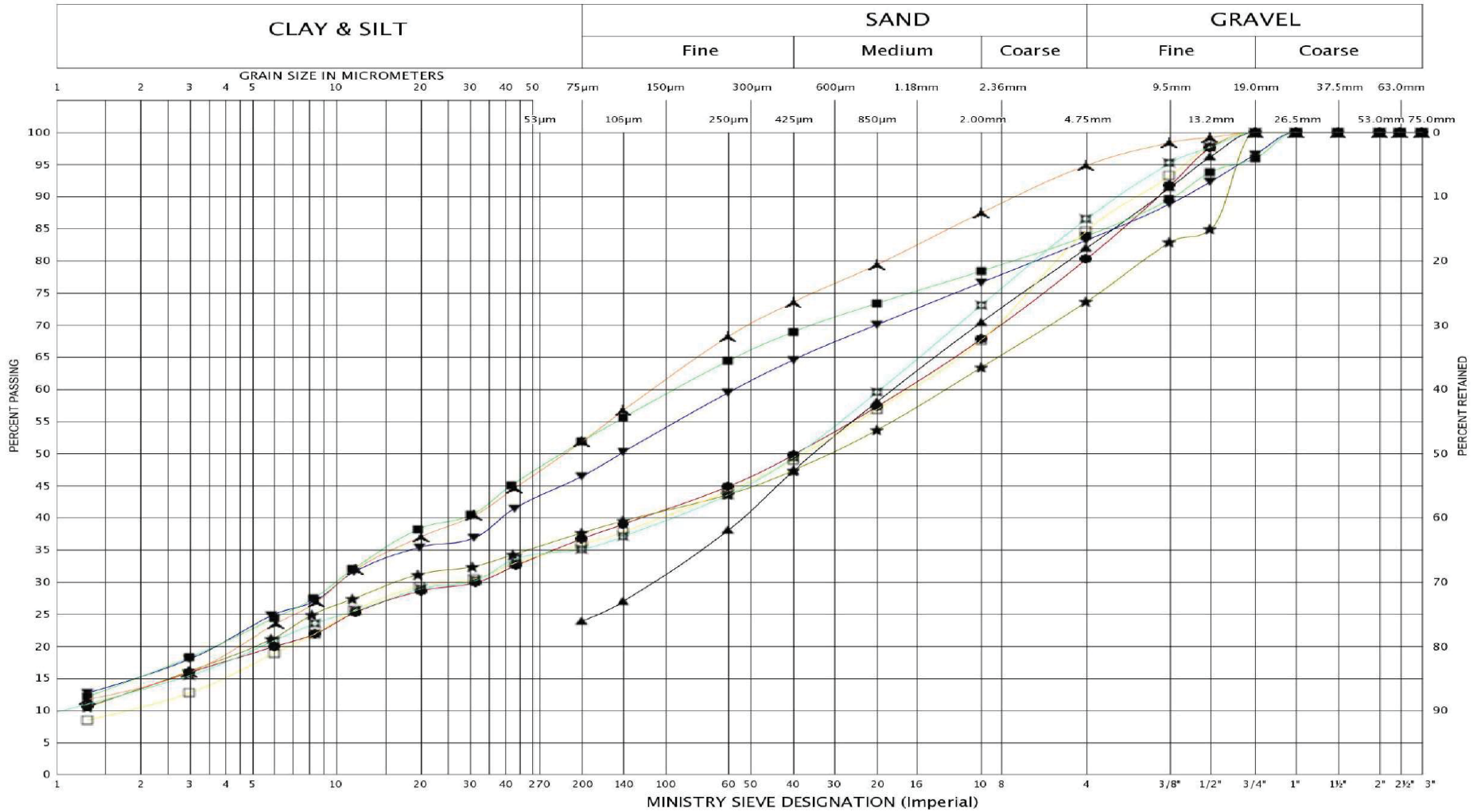
GRAIN SIZE DISTRIBUTION
 SILTY GRAVEL, with Sand, trace clay (within Till)









FIG No.: GS-6

HWY : 401

Project No.: 20TF025A

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND	BH	BH1	BH4	BH4	BH6	BH1	BH6	BH6	P-1
	SAMPLE	8	8	11	11	7	12	14	11
	SYMBOL								



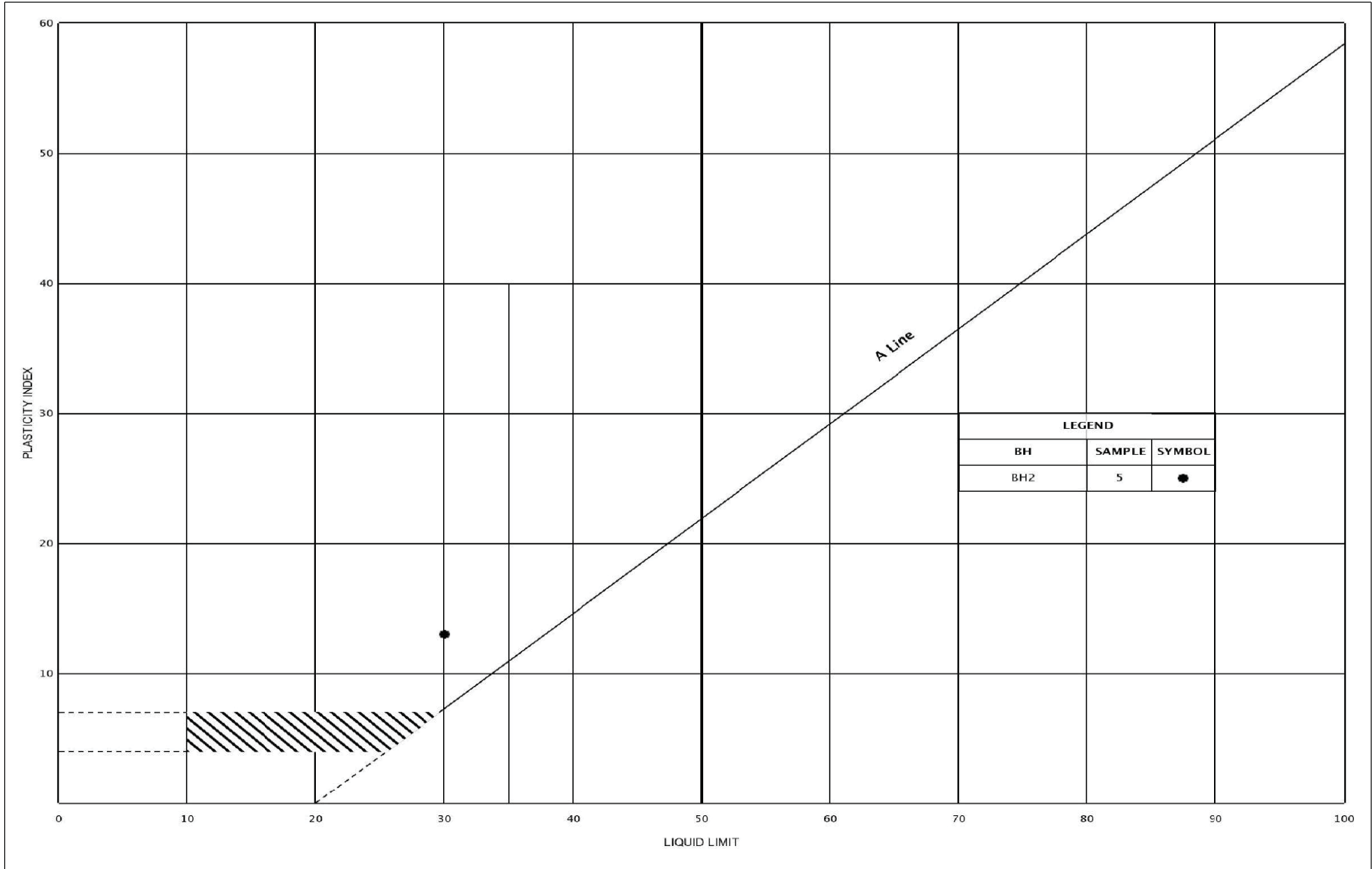
GRAIN SIZE DISTRIBUTION

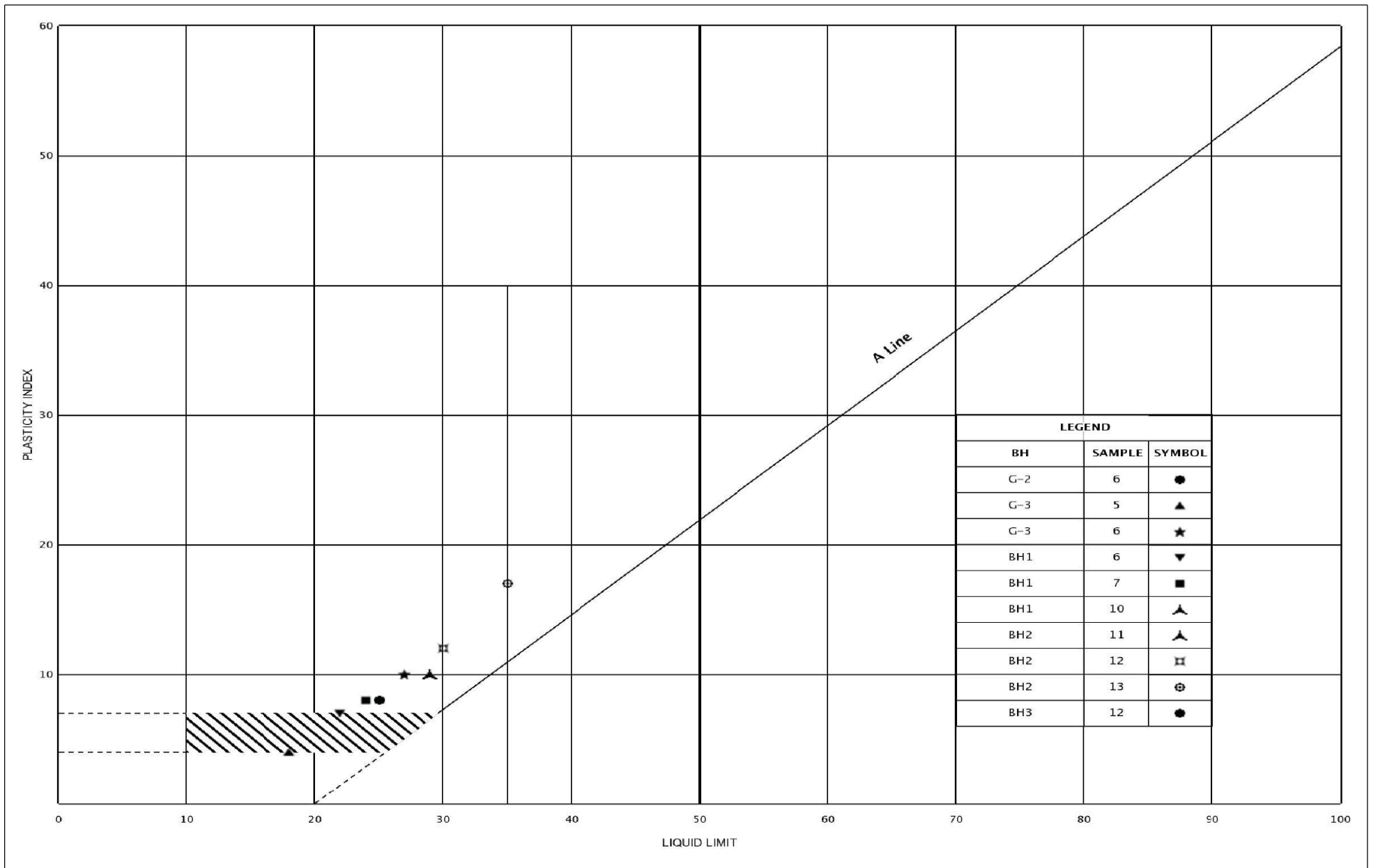
CLAYEY SAND, silty, some gravel (Till)

FIG No.: GS-7

HWY : 401

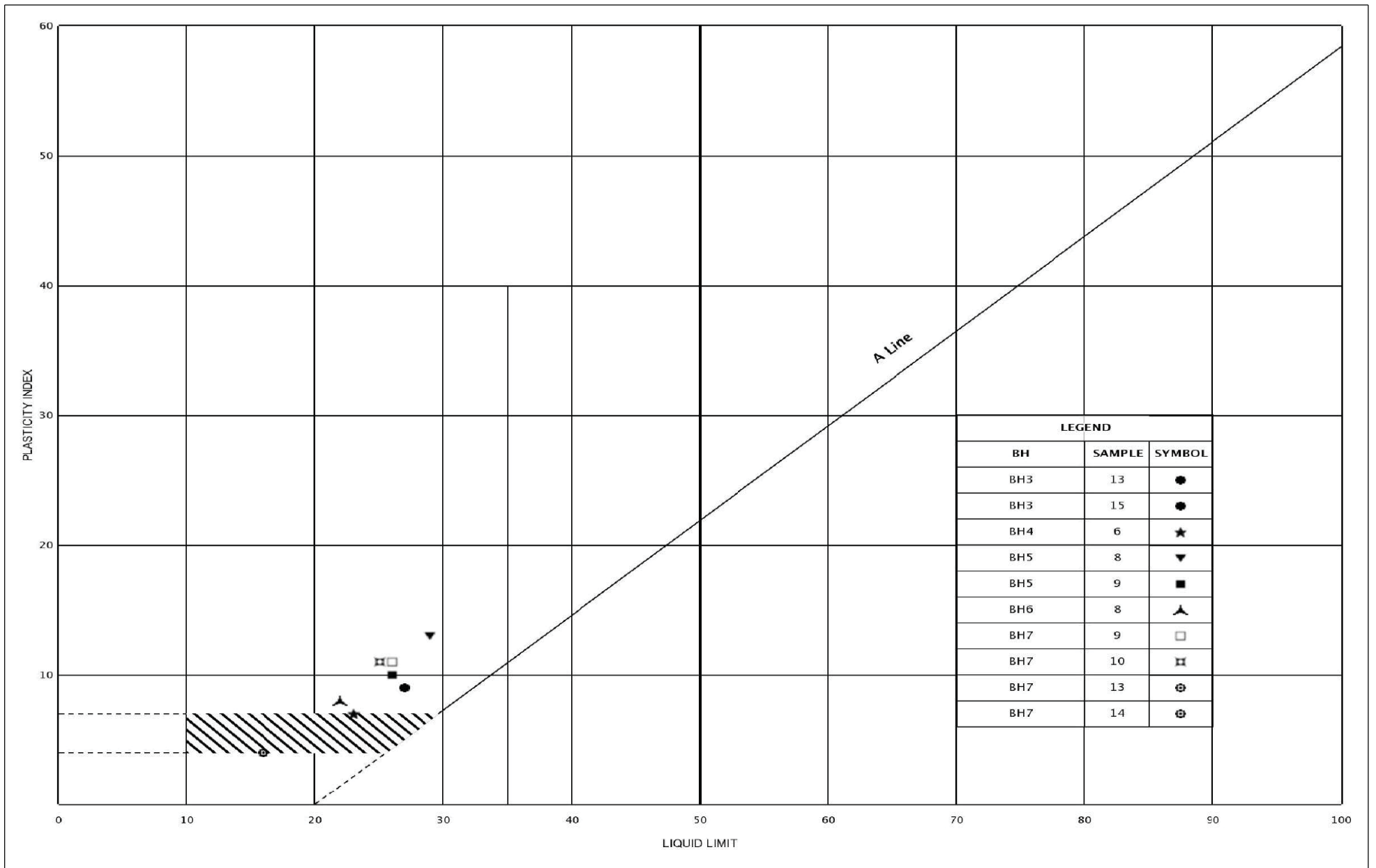
Project No.: 20TF025A





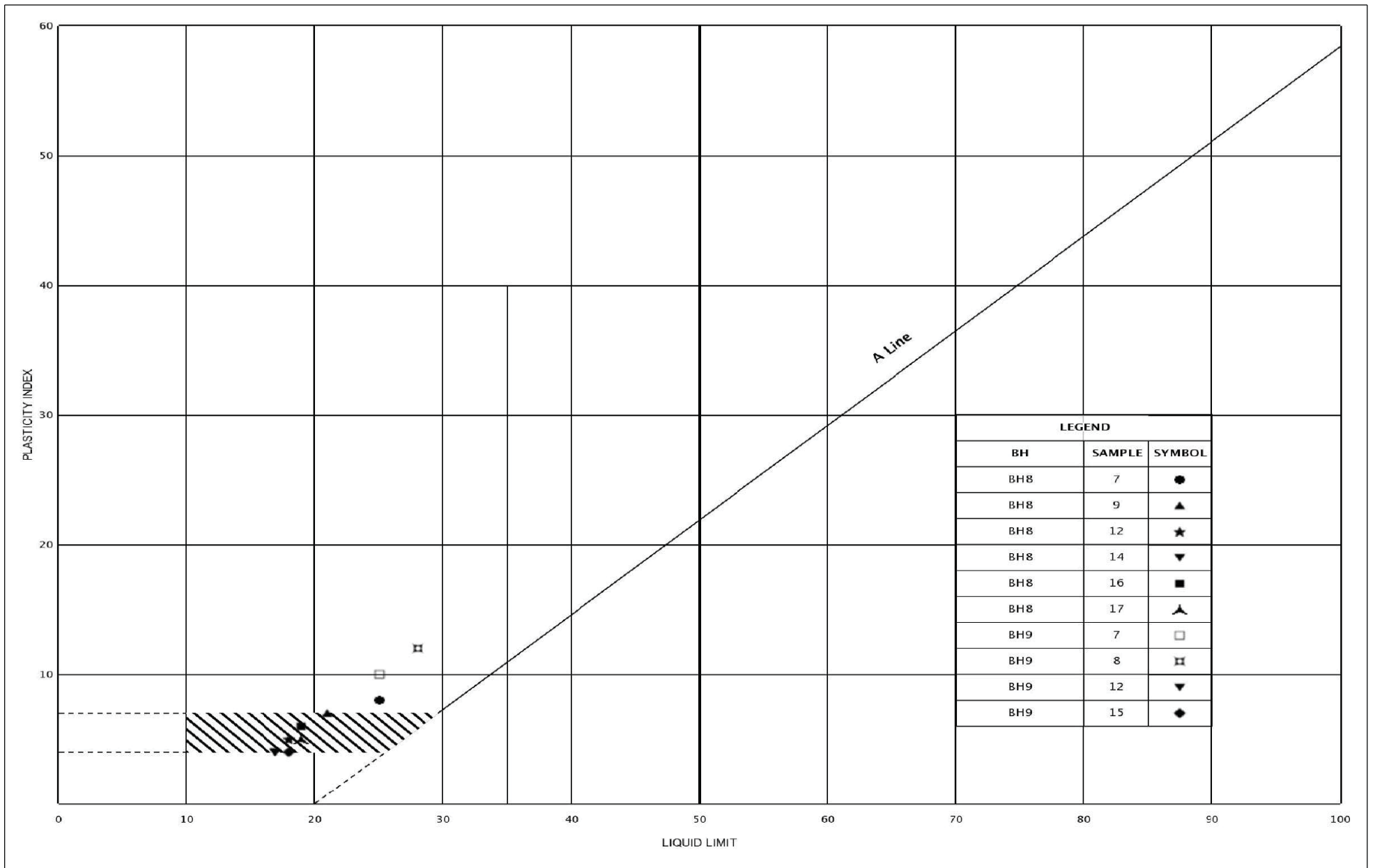
PLASTICITY CHART
Sandy Clayey Silt, trace/some gravel (Till)

FIG No.: PC-2A
HWY.: 401
Proj No. 20TF025A



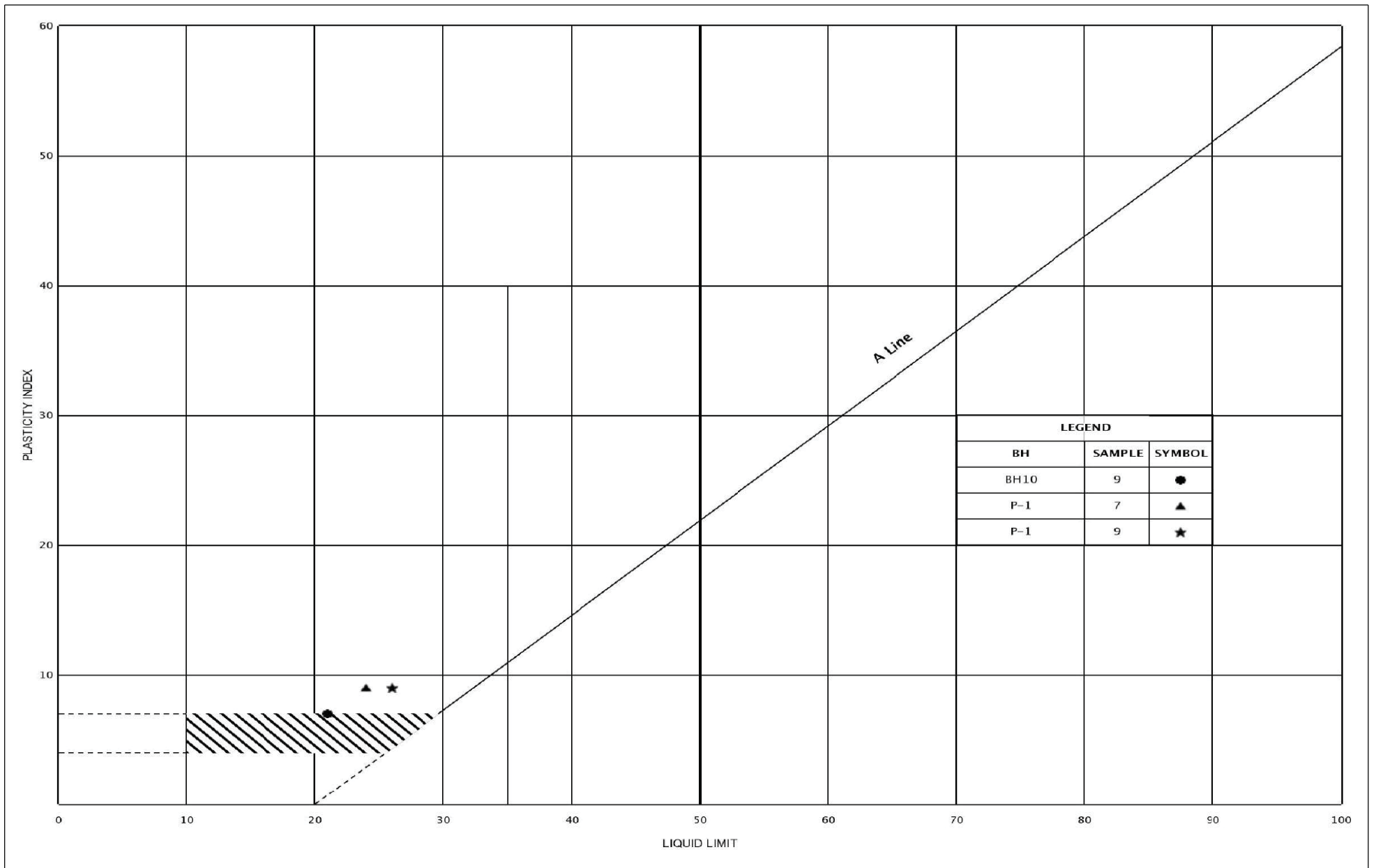
PLASTICITY CHART
Sandy Clayey Silt, trace/some gravel (Till)

FIG No.: PC-2B
HWY.: 401
Proj No. 20TF025A



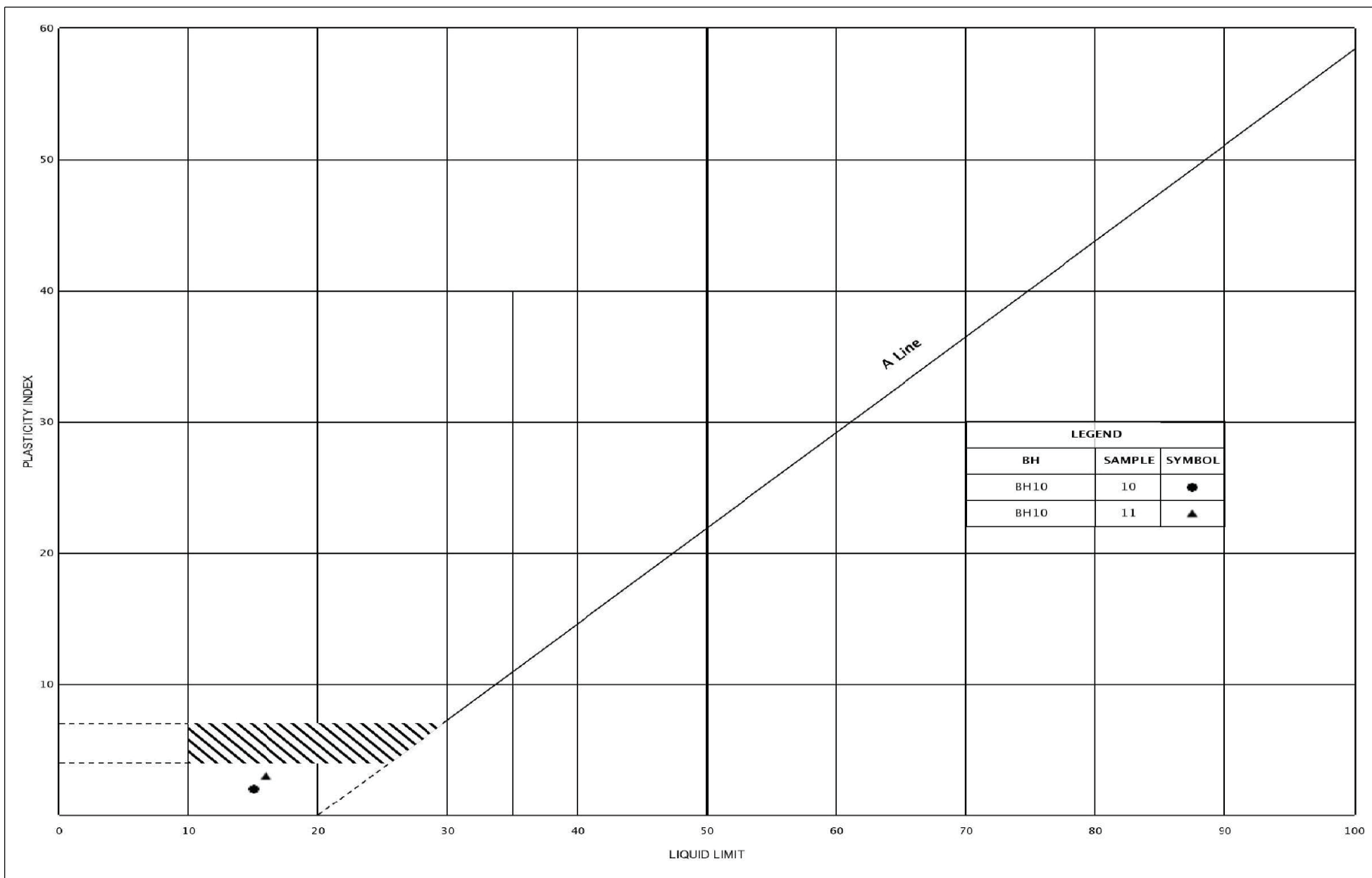
PLASTICITY CHART
Sandy Clayey Silt, trace/some gravel (Till)

FIG No.: PC-2C
HWY.: 401
Proj No. 20TF025A



PLASTICITY CHART
Sandy Clayey Silt, trace/some gravel (Till)

FIG No.: PC-2D
HWY.: 401
Proj No. 20TF025A



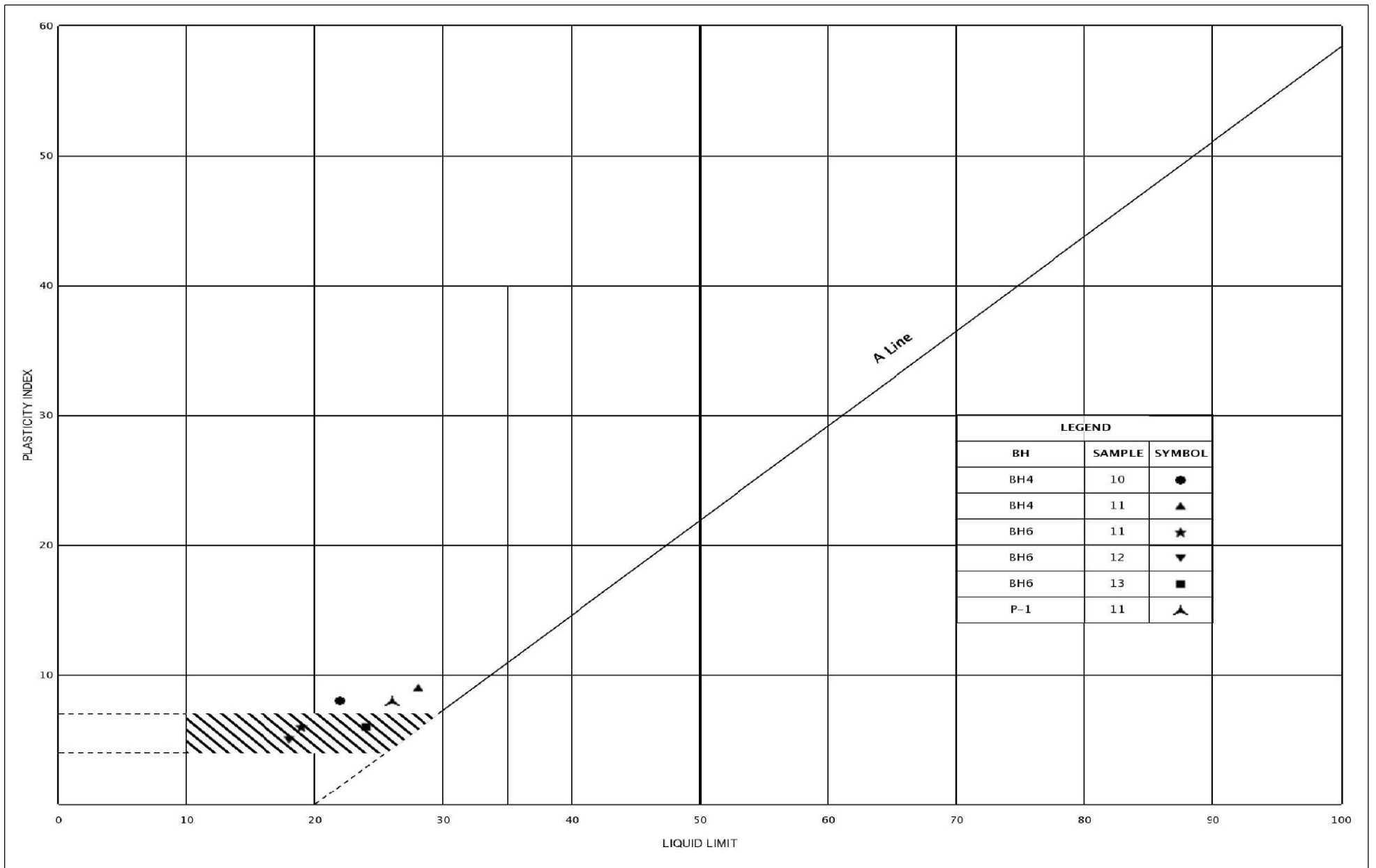
PLASTICITY CHART

SILTY SAND, trace/some clay, trace/some gravel (within Till)

FIG No.: PC-3

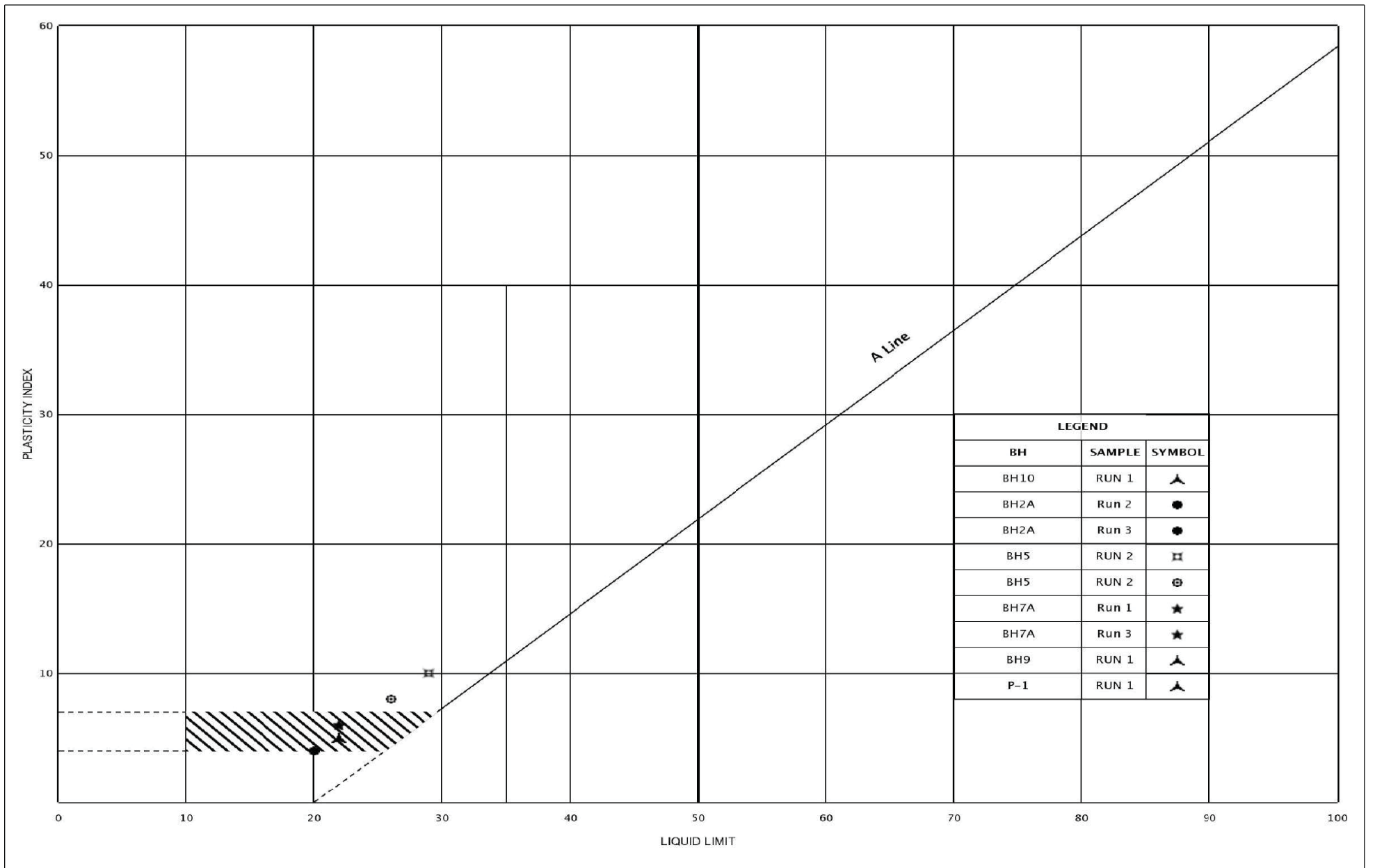
HWY.: 401

Proj No. 20TF025A



PLASTICITY CHART
CLAYEY SAND, silty, some gravel (Till)

FIG No.: PC-4
HWY.: 401
Proj No. 20TF025A



STRENGTH

VH = Very High = >200 MPa
H = High = 50-200 MPa

M = Medium = 15-50 MPa

L = Low = 4-15 MPa

VL = Very Low = 1-4 MPa

WEATHERING

U = Unweathered = No signs

S = Slightly = Oxidized

M = Moderately = Discoloured

H = Highly = Friable

C = Completely = Soil-Like

DISCONTINUITY TYPE

B = Bedding Joint

J = Cross Joint

F = Fault

S = Shear Plane

BR = Broken Rock

ORIENTATION

F = Flat = 0-20°

D = Dipping = 20-50°

V = Vertical >50°

SPACING

VW = Very Wide = >3 m

W = Wide = 1-3 m

M = Moderate = 0.3-1 m

C = Close = 5-30 cm

VC = Very Close = <5 cm

ROUGHNESS

RU = Rough Undulating

RP = Rough Planar

SU = Smooth Undulating

SP = Smooth Planar

LU = Slickensided Undulating

LP = Slickensided Planar

FILLING

T = Tight, Hard

O = Oxidized

SA = Slightly Altered, Clay Free

S = Sandy, Clay Free

Si = Sandy, Silty, Minor Clay

NC = Non-softening Clay

SC = Swelling, Soft Clay

CORE LOG IDENTIFICATION

BOREHOLE #: BH 1

PML REF.: 20TF025

PROJECT: Detailed Design of Watermain Replacement on Dixie Road

LOCATION: Mississauga, ON.

DATE: February 3, 2021

LOGGED BY: H. Racher, P.Geo./ A.Hossain, P.Eng.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								# OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
1	9.20	80 (0.55 m)	57 (0.40m)	9.91	GEORGIAN BAY FORMATION	L	U	-	-	-	-	-	-	-		
					Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous											
					CARBONATE interbeds.											
					GEORGIAN BAY FORMATION											
					Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous											
2	9.91	90 (0.69 m)	83 (0.64m)	10.67	GEORGIAN BAY FORMATION	M/L	U	-	-	-	-	-	-	-		
					Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous											
					CARBONATE interbeds.											
					GEORGIAN BAY FORMATION											
					Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous											
3	10.67	100 (1.52 m)	92 (1.40 m)	12.19	GEORGIAN BAY FORMATION	M/L	U	-	-	-	-	-	-	-	End of Borehole.	
					Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous											
					CARBONATE interbeds.											
					GEORGIAN BAY FORMATION											
					Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous											

STRENGTH

VH = Very High = >200 MPa
H = High = 50-200 MPa

M = Medium = 15-50 MPa

L = Low = 4-15 MPa
VL = Very Low = 1-4 MPa

WEATHERING

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M = Moderately = Discoloured
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DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint

F = Fault

S = Shear Plane
BR = Broken Rock

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = Vertical >50°

SPACING

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W = Wide = 1-3 m

M = Moderate = 0.3-1 m

C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS

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RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING

T = Tight, Hard
O = Oxidized

SA = Slightly Altered, Clay Free

S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

CORE LOG IDENTIFICATION

BOREHOLE #: BH 2A
PML REF.: 20TF025

PROJECT: Detailed Design of Watermain Replacement on Dixie Road

LOCATION: Mississauga, ON.

DATE: June 8, 2021

LOGGED BY: H. Racher, P.Geo.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes
MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								# OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
1	12.96	87 (1.32 m)	20 (0.30 m)	14.48	GEORGIAN BAY FORMATION Weathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	VL	H/U	7	J	F	C	SP/RP	-	-	Weathered shale/clay at 13.11-13.67m; clay at 12.96-13.11 m.	
2	14.48	100 (1.52 m)	60 (0.91 m)	16.00	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	12	J	F	VC/C	SP/RP	-	-	Broken rock at 14.59-14.63 m & 15.90-15.98 m; vertical fracture at 15.77-15.85 m.	
								2	BR	-	C	-	-	-		
								1	J	V	-	-	-	-		
3	16.00	95 (1.45 m)	70 (1.07 m)	17.52	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	11	J	F	VC/C	SP/RP	-	-	Broken rock at 16.00-16.03 m.	
								1	J	D	-	SP	-	-		
								1	BR	-	-	-	-	-		
4	17.52	87 (1.32 m)	65 (0.99 m)	19.04	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	10	J	F	VC/C	SP/RP	-	-	Broken rock at 17.52-17.65 m; clay seam at 18.54-18.59 m. End of Borehole.	
								1	BR	-	-	-	-	-		

STRENGTH

VH = Very High = >200 MPa
H = High = 50-200 MPa

M = Medium = 15-50 MPa

L = Low = 4-15 MPa

VL = Very Low = 1-4 MPa

WEATHERING

U = Unweathered = No signs

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DISCONTINUITY TYPE

B = Bedding Joint

J = Cross Joint

F = Fault

S = Shear Plane

BR = Broken Rock

ORIENTATION

F = Flat = 0-20°

D = Dipping = 20-50°

V = Vertical >50°

SPACING

VW = Very Wide = >3 m

W = Wide = 1-3 m

M = Moderate = 0.3-1 m

C = Close = 5-30 cm

VC = Very Close = <5 cm

ROUGHNESS

RU = Rough Undulating

RP = Rough Planar

SU = Smooth Undulating

SP = Smooth Planar

LU = Slickensided Undulating

LP = Slickensided Planar

FILLING

T = Tight, Hard

O = Oxidized

SA = Slightly Altered, Clay Free

S = Sandy, Clay Free

Si = Sandy, Silty, Minor Clay

NC = Non-softening Clay

SC = Swelling, Soft Clay

CORE LOG IDENTIFICATION

BOREHOLE #: BH 3-1

PML REF.: 20TF025

PROJECT: Detailed Design of Watermain Replacement on Dixie Road

LOCATION: Mississauga, ON.

DATE: January 18, 2021

LOGGED BY: H. Racher, P.Geo./ A.Hossain, P.Eng.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								# OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
1	9.60	-	-	11.13	Dark gray clay and cobbles.	-	U	-	-	-	-	-	-	-	Entire run dark gray clay and cobbles with recovery of 1.42 m.	
2	11.13	81 (1.17m)	54 (0.78m)	12.57	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	L	U	5	J	F	C	SP	-	-	Dark gray clay and cobbles from 11.13-11.79 m; rock core from 11.79-12.55 m; total recovery including clay/cobbles/rock is 1.42 m; broken rock at 11.79-11.94 m.	
3	13.03	100 (0.61 m)	17 (0.10 m)	13.64	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	5	J	F/D	VC/C	SP	-	-	Broken rock at 13.03-13.64 m; clay seam at 14.05-14.12 m.	Run #3 started 0.46 m deeper than Run #2 end depth following overcoring test attempt
4	14.20	100 '(0.45 m)	100 (0.45 m)	14.65	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	L	U	7	J	F	VC/C	SP	2.0 cm	NC		Run #4 started 0.56 m deeper than Run #3 end depth following overcoring test attempt

STRENGTH

VH = Very High = >200 MPa
H = High = 50-200 MPa

M = Medium = 15-50 MPa

L = Low = 4-15 MPa
VL = Very Low = 1-4 MPa

WEATHERING

U = Unweathered = No signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-Like

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint

F = Fault

S = Shear Plane
BR = Broken Rock

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = Vertical >50°

SPACING

VW = Very Wide = >3 m
W = Wide = 1-3 m

M = Moderate = 0.3-1 m

C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING

T = Tight, Hard
O = Oxidized

SA = Slightly Altered, Clay Free

S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

CORE LOG IDENTIFICATION

BOREHOLE #: BH 4
PML REF.: 20TF025
PROJECT: Detailed Design of Watermain Replacement on Dixie Road
LOCATION: Mississauga, ON.
DATE: January 18, 2021
LOGGED BY: H. Racher, P.Geo. / A.Hossain, P.Eng.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								# OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
1	10.67	-	-	12.19	Dark gray clay and cobbles.	-	U	-	-	-	-	-	-	-	Dark gray clay and cobbles from 10.67-11.84 m; rock core from 11.84-12.17 m; total recovery including clay/cobbles/rock is 1.50 m; broken rock at 11.84-11.89 m.	
2	12.19	100 (1.52 m)	90 (1.37 m)	13.72	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	L	U	15	J	F	C	SP	3.0 mm	NC		
3	14.32	100 (0.3 m)	100 (0.3 m)	14.62	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	L	U	4	J	F	VC/C	SP	-	-		Run #3 started 0..6 m deeper than Run #2 end depth following overcoring test
4	15.10	100 (0.2 m)	100 (0.2 m)	15.30	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	L	U	2	J	F	C	SP	-	-		Run #4 started 0..48 m deeper than Run #3 end depth following overcoring test

STRENGTH

VH = Very High = >200 MPa
H = High = 50-200 MPa

M = Medium = 15-50 MPa

L = Low = 4-15 MPa
VL = Very Low = 1-4 MPa

WEATHERING

U = Unweathered = No signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-Like

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint

F = Fault

S = Shear Plane
BR = Broken Rock

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = Vertical >50°

SPACING

VW = Very Wide = >3 m
W = Wide = 1-3 m

M = Moderate = 0.3-1 m

C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slicksided Undulating
LP = Slicksided Planar

FILLING

T = Tight, Hard
O = Oxidized

SA = Slightly Altered, Clay Free

S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

CORE LOG IDENTIFICATION

BOREHOLE #: BH 5
PML REF.: 20TF025
PROJECT: Detailed Design of Watermain Replacement on Dixie Road
LOCATION: Mississauga, ON.
DATE: January 18, 2021
LOGGED BY: H. Racher, P.Geo./ A.Hossain, P.Eng.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								# OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
1	6.40	-	-	7.92	Dark gray clay and cobbles.	-	U	-	-	-	-	-	-	-	Entire run dark gray clay and cobbles with recovery of 1.32 m.	
2	7.92	93 (1.42 m)	0	9.45	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	L	U	1	J	D	-	SP	6.0 cm	NC	From 7.62-9.09 m is dark gray clay with cobbles; rock core from 9.09-9.31 m; total recovery including clay/cobbles/rock is 1.69 m.	
3	9.75	94 (0.57 m)	31 (0.19 m)	10.36	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	2	J	F	C	SP	8.0 cm	NC	Cobbles at 9.45-9.55 m; clay seam at 9.25-9.32 m & 9.38-9.40 m.	Run #3 started 0.31 m lower than Run #2 bottom depth following EX-coring and overcoring test attempt
4	10.76	100 (1.17 m)	66 (0.53 m)	11.57	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	L	U	11	J	F	VC	SP	-	-	Broken rock at 11.06-11.11 m, 11.60-11.67 m & 11.75-11.80 m; clay seam at 11.67-11.75 m.	Run #4 started 0.4m deeper than Run #3 end depth following following EX-coring and overcoring test attempt

STRENGTH

VH = Very High = >200 MPa
H = High = 50-200 MPa

M = Medium = 15-50 MPa

L = Low = 4-15 MPa
VL = Very Low = 1-4 MPa

WEATHERING

U = Unweathered = No signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-Like

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint

F = Fault

S = Shear Plane
BR = Broken Rock

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = Vertical >50°

SPACING

VW = Very Wide = >3 m
W = Wide = 1-3 m

M = Moderate = 0.3-1 m

C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING

T = Tight, Hard
O = Oxidized

SA = Slightly Altered, Clay Free

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Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

CORE LOG IDENTIFICATION

BOREHOLE #: BH 5
PML REF.: 20TF025
PROJECT: Detailed Design of Watermain Replacement on Dixie Road
LOCATION: Mississauga, ON.
DATE: January 18, 2021
LOGGED BY: H. Racher, P.Geo./ A.Hossain, P.Eng.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCONTINUITIES						OCCASIONAL FEATURES	DRILLING OBSERVATIONS	
								# OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE			FILLING
5	11.57	100 (0.68 m)	100 (0.68 m)	12.25	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	L	U	4	J	F	C	SP	-	-		

STRENGTH

VH = Very High = >200 MPa
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M = Medium = 15-50 MPa

L = Low = 4-15 MPa
VL = Very Low = 1-4 MPa

WEATHERING

U = Unweathered = No signs
S = Slightly = Oxidized
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DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint

F = Fault

S = Shear Plane
BR = Broken Rock

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = Vertical >50°

SPACING

VW = Very Wide = >3 m
W = Wide = 1-3 m

M = Moderate = 0.3-1 m

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VC = Very Close = <5 cm

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
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FILLING

T = Tight, Hard
O = Oxidized

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NC = Non-softening Clay
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CORE LOG IDENTIFICATION

BOREHOLE #: BH 6
PML REF.: 20TF025
PROJECT: Detailed Design of Watermain Replacement on Dixie Road
LOCATION: Mississauga, ON.
DATE: January 18, 2021
LOGGED BY: H. Racher, P.Geo./ A.Hossain, P.Eng.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								# OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
1	11.12	83 (0.76 m)	31 (0.28 m)	12.04	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	L	U	2	J	F	C	SP	-	-	Broken rock at 10.97-11.10 m.	
2	12.04	100 (0.51 m)	79 (0.48 m)	12.65	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	L	U	4	J	F	VC	SP	-	-		
3	12.65	100 (1.22 m)	100 (1.22 m)	13.87	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	L	U	13	J	F	VC/C	SP	-	-	Broken rock at 12.65-12.70 m & 12.93-12.97 m.	
4	14.35	100 (0.81 m)	100 (0.81 m)	15.16	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	1	J	F	-	SP	-	-	Broken rock at 14.35-5.71 m.	Run #4 started 0.48 m deeper than Run #3 end depth following following EX-coring and overcoring test attempt

STRENGTH

VH = Very High = >200 MPa
H = High = 50-200 MPa

M = Medium = 15-50 MPa

L = Low = 4-15 MPa
VL = Very Low = 1-4 MPa

WEATHERING

U = Unweathered = No signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-Like

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint

F = Fault

S = Shear Plane
BR = Broken Rock

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = Vertical >50°

SPACING

VW = Very Wide = >3 m
W = Wide = 1-3 m

M = Moderate = 0.3-1 m

C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING

T = Tight, Hard
O = Oxidized

SA = Slightly Altered, Clay Free

S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

CORE LOG IDENTIFICATION

BOREHOLE #: BH 7A
PML REF.: 20TF025
Detailed Design of
PROJECT: Watermain Replacement on
Dixie Road
LOCATION: Mississauga, ON.
DATE: June 8, 2021
LOGGED BY: H. Racher, P.Geo.

Provincial Highways: A Guide to the
Description of Rock for Engineering
Purposes MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								# OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
1	16.00	80 (1.22 m)	15 (0.23 m)	17.52	GEORGIAN BAY FORMATION Weathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE.	VL	H/U	2	J	F	C	SP	-	-	Weathered shale/clay at 16.23-16.33 m; clay at 16.00-16.23 m; broken rock at 16.69-16.76 m.	
								1	BR	-	-	-	-	-		
2	17.52	93 (1.42 m)	67 (1.02 m)	19.04	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	10	J	F	VC/C	SP/RP	-	-	Large carbonate interbed at 18.34-18.44 m.	
3	19.04	+100 (1.55 m)	90 (1.37 m)	20.56	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	8	J	F	VC/C	SP/RP	-	-	Vertical fracture at 19.96-20.07 m. End of Borehole.	
								1	J	V	-	RP	-	-		

STRENGTH

VH = Very High = >200 MPa
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M = Medium = 15-50 MPa

L = Low = 4-15 MPa
VL = Very Low = 1-4 MPa

WEATHERING

U = Unweathered = No signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-Like

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint

F = Fault

S = Shear Plane
BR = Broken Rock

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = Vertical >50°

SPACING

VW = Very Wide = >3 m
W = Wide = 1-3 m

M = Moderate = 0.3-1 m

C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING

T = Tight, Hard
O = Oxidized

SA = Slightly Altered, Clay Free

S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

CORE LOG IDENTIFICATION

BOREHOLE #: BH 8
PML REF.: 20TF025
PROJECT: Detailed Design of Watermain Replacement on Dixie Road
LOCATION: Mississauga, ON.
DATE: January 18, 2021
LOGGED BY: H. Racher, P.Geo./ A.Hossain, P.Eng.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								# OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
1	16.00	100 (0.61 m)	92 (0.56 m)	16.61	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	5	J	F	VC/C	SP	-	-	Broken rock at 16.18-16.21 m.	
2	17.27	100 (0.79 m)	100 (0.79 m)	18.06	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	9	J	F	VC/C	SP	-	-		Run #2 started 0.66 m deeper than Run #1 end depth following EX-coring and overcoring test attempt

STRENGTH

VH = Very High = >200 MPa
H = High = 50-200 MPa

M = Medium = 15-50 MPa

L = Low = 4-15 MPa
VL = Very Low = 1-4 MPa

WEATHERING

U = Unweathered = No signs
S = Slightly = Oxidized
M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-Like

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint

F = Fault

S = Shear Plane
BR = Broken Rock

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = Vertical >50°

SPACING

VW = Very Wide = >3 m
W = Wide = 1-3 m

M = Moderate = 0.3-1 m

C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING

T = Tight, Hard
O = Oxidized

SA = Slightly Altered, Clay Free

S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

CORE LOG IDENTIFICATION

BOREHOLE #: BH 9
PML REF.: 20TF025
PROJECT: Detailed Design of Watermain Replacement on Dixie Road
LOCATION: Mississauga, ON.
DATE: February 3, 2021
LOGGED BY: H. Racher, P.Geo./ A.Hossain, P.Eng.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								# OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
1	14.94	100 (0.91 m)	64 (0.58 m)	15.85	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous	M/L	U	-	-	-	-	-	-	-	Broken rock 5.0 cm in length.	Samples taken prior to rock core analysis - could not obtain depth of broken rock.
2	15.85	100 (1.52 m)	93 (1.42 m)	17.37	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous	M/L	U	-	-	-	-	-	-	-		
3	17.75	100 (0.41 m)	87 (0.36 m)	18.16	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous	M/L	U	-	-	-	-	-	-	-	Broken rock at 17.37-17.42m.	Run #3 started 0.38 m deeper than Run #2 end depth following following EX-coring and overcoring test attempt

STRENGTH

VH = Very High = >200 MPa
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M = Medium = 15-50 MPa

L = Low = 4-15 MPa
VL = Very Low = 1-4 MPa

WEATHERING

U = Unweathered = No signs
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H = Highly = Friable
C = Completely = Soil-Like

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint

F = Fault

S = Shear Plane
BR = Broken Rock

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = Vertical >50°

SPACING

VW = Very Wide = >3 m
W = Wide = 1-3 m

M = Moderate = 0.3-1 m

C = Close = 5-30 cm
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ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
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FILLING

T = Tight, Hard
O = Oxidized

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S = Sandy, Clay Free
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NC = Non-softening Clay
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CORE LOG IDENTIFICATION

BOREHOLE #: BH 10
PML REF.: 20TF025
PROJECT: Detailed Design of Watermain Replacement on Dixie Road
LOCATION: Mississauga, ON.
DATE: February 3, 2021
LOGGED BY: H. Racher, P.Geo./ A.Hossain, P.Eng.

Provincial Highways: A Guide to the Description of Rock for Engineering Purposes M1-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	ROD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								# OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
1	10.97	100 (1.22 m)	71 (0.86 m)	12.19	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	-	-	-	-	-	-	-	Broken rock at 11.00-11.13 m.	
2	12.19	100 (1.52 m)	100 (1.52 m)	13.72	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	-	-	-	-	-	-	-	End of Borehole.	Samples taken prior to rock core analysis - could not obtain Discontinuities.

STRENGTH

VH = Very High = >200 MPa
H = High = 50-200 MPa

M = Medium = 15-50 MPa

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WEATHERING

U = Unweathered = No signs
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DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint

F = Fault

S = Shear Plane
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ORIENTATION

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V = Vertical >50°

SPACING

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FILLING

T = Tight, Hard
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CORE LOG IDENTIFICATION

BOREHOLE #: BH P-1
PML REF.: 20TF025
PROJECT: Detailed Design of
Watermain Replacement on
Dixie Road
LOCATION: Mississauga, ON.
DATE: February 3, 2021
LOGGED BY: H. Racher, P.Geo.

Provincial Highways: A Guide to the
Description of Rock for Engineering
Purposes MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERING	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								# OF SETS	TYPE	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING		
1	10.46	100 (0.51 m)	94 (0.48 m)	10.97	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE	L	U	4	J	F	VC/C	SP	-	-		
2	10.97	100 (0.99 m)	80 (0.74 m)	11.89	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds	M/L	U	8	J	F	C	SP	-	-	Minor bioturbation.	
3	11.89	100 (1.52 m)	87 (1.32 m)	13.41	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	6	J	F	C/M	SP	-	-	Minor bioturbation.	
4	13.41	100 (1.52 m)	97 (1.47 m)	14.93	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	1	J	F	-	SP	-	-	Minor bioturbation.	

STRENGTH

VH = Very High = >200 MPa
H = High = 50-200 MPa

M = Medium = 15-50 MPa

L = Low = 4-15 MPa
VL = Very Low = 1-4 MPa

WEATHERING

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M = Moderately = Discoloured
H = Highly = Friable
C = Completely = Soil-Like

DISCONTINUITY TYPE

B = Bedding Joint
J = Cross Joint

F = Fault

S = Shear Plane
BR = Broken Rock

ORIENTATION

F = Flat = 0-20°
D = Dipping = 20-50°
V = Vertical >50°

SPACING

VW = Very Wide = >3 m
W = Wide = 1-3 m

M = Moderate = 0.3-1 m

C = Close = 5-30 cm
VC = Very Close = <5 cm

ROUGHNESS

RU = Rough Undulating
RP = Rough Planar
SU = Smooth Undulating
SP = Smooth Planar
LU = Slickensided Undulating
LP = Slickensided Planar

FILLING

T = Tight, Hard
O = Oxidized

SA = Slightly Altered, Clay Free

S = Sandy, Clay Free
Si = Sandy, Silty, Minor Clay
NC = Non-softening Clay
SC = Swelling, Soft Clay

CORE LOG IDENTIFICATION

BOREHOLE #: BH P-1
PML REF.: 20TF025
PROJECT: Watermain Replacement on
Dixie Road
LOCATION: Mississauga, ON.
DATE: February 3, 2021
LOGGED BY: H. Racher, P.Geo.

Provincial Highways: A Guide to the
Description of Rock for Engineering
Purposes MI-47

RUN #	DEPTH TO (m)	CORE RECOVERY (%)	RQD (%)	DEPTH TO (m)	GENERAL DESCRIPTION	STRENGTH	WEATHERIN G	DISCONTINUITIES							OCCASIONAL FEATURES	DRILLING OBSERVATIONS
								# OF SETS	TYPE	ORIENTATIO N	SPACING	ROUGHNES S	APERTURE	FILLING		
5	14.93	100 (1.45 m)	98 (1.42 m)	16.38	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	4	J	F	C/M	SP	-	-	Minor bioturbation.	
6	16.38	99 (1.37 m)	90 (1.24 m)	17.76	GEORGIAN BAY FORMATION Unweathered, very fine grained to fissile, thinly laminated, dark grey, soft, slightly calcareous, SHALE with minor, unweathered, fine to medium grained, thin bedded, grey, moderately hard, calcareous CARBONATE interbeds.	M/L	U	5	J	F	VC/M	SP	-	-	End of Borehole	

Core Photographs

Borehole 2A



RC1



RC2 and RC3



RC4

Borehole BH3-1



RC1 and RC2



RC3 and RC4

Borehole BH4



RC1 and RC2



RC3 and RC4

Borehole BH5



RC1 and RC2



RC3, RC4 and RC5

Borehole BH6



RC1, RC2 and RC3



RC4

Borehole BH7A



RC1 and RC2



RC3

Borehole BH8



RC1 and RC2

Borehole P-1



RC1, RC2 and RC3



RC4 and RC5



RC 6

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK CORE
ASTM D7012

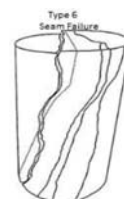
CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2103378 H
SAMPLE IDENTIFICATION	BH-2A, Run3, 54'9"-55'1"	DATE SAMPLED	2021-06-10
		DATE TESTED	2021-06-14
		TESTED BY	L. Gowry

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.3937	TEST TIME (min) (spec. 2 to 15)	3:12
SPECIMEN LENGTH (in.)	4.008	MAXIMUM LOAD APPLIED (kN)	168.30
	4.007		
	4.002	COMPRESSIVE STRENGTH (MPa)	58.0
AVE.	4.005	TYPE OF FAILURE	2
SURFACE AREA (sq mm)	2903	LENGTH TO DIAMETER RATIO (spec 2-2.5)	1.67

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	867.47	WEIGHT OF DRY SAMPLE IN AIR (g)	776.80
WEIGHT OF DRY SAMPLE + TARE (g)	859.23	VOLUME OF SAMPLE (cu m)	0.000295
WEIGHT OF WATER (g)	8.24	Density (kg/cu m)	2630
WEIGHT OF TARE (g)	133.80	UNIT WEIGHT (γ)	25.78
WEIGHT OF DRY SAMPLE (g)	725.43		
MOISTURE CONTENT (%)	1.1		
REMARKS Length to Diameter ratio is less than two.			



REVIEWED BY

J. Noor

DATE

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK CORE
ASTM D7012

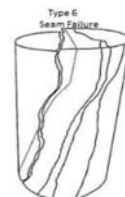
CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2100524 P
SAMPLE IDENTIFICATION	BH3, Run3, 44'	DATE SAMPLED	2021-02-10
		DATE TESTED	2021-03-08
		TESTED BY	Azar/Gowry

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.4725	TEST TIME (min) (spec. 2 to 15)	9:36
SPECIMEN LENGTH (in.)	4.567	MAXIMUM LOAD APPLIED (kN)	674.90
	4.567		
	4.568	COMPRESSIVE STRENGTH (MPa)	217.9
AVE.	4.567	TYPE OF FAILURE	4
SURFACE AREA (sq mm)	3098	LENGTH TO DIAMETER RATIO (spec 2-2.5)	1.85

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	692.53	WEIGHT OF DRY SAMPLE IN AIR (g)	958.73
WEIGHT OF DRY SAMPLE + TARE (g)	690.81	VOLUME OF SAMPLE (cu m)	0.000359
WEIGHT OF WATER (g)	1.72	UNIT WEIGHT (kg/cu m)	2668
WEIGHT OF TARE (g)	117.82		
WEIGHT OF DRY SAMPLE (g)	572.99		
MOISTURE CONTENT (%)	0.3		
REMARKS	Length to Diameter ratio is less than 2.		



REVIEWED BY

J.Noor

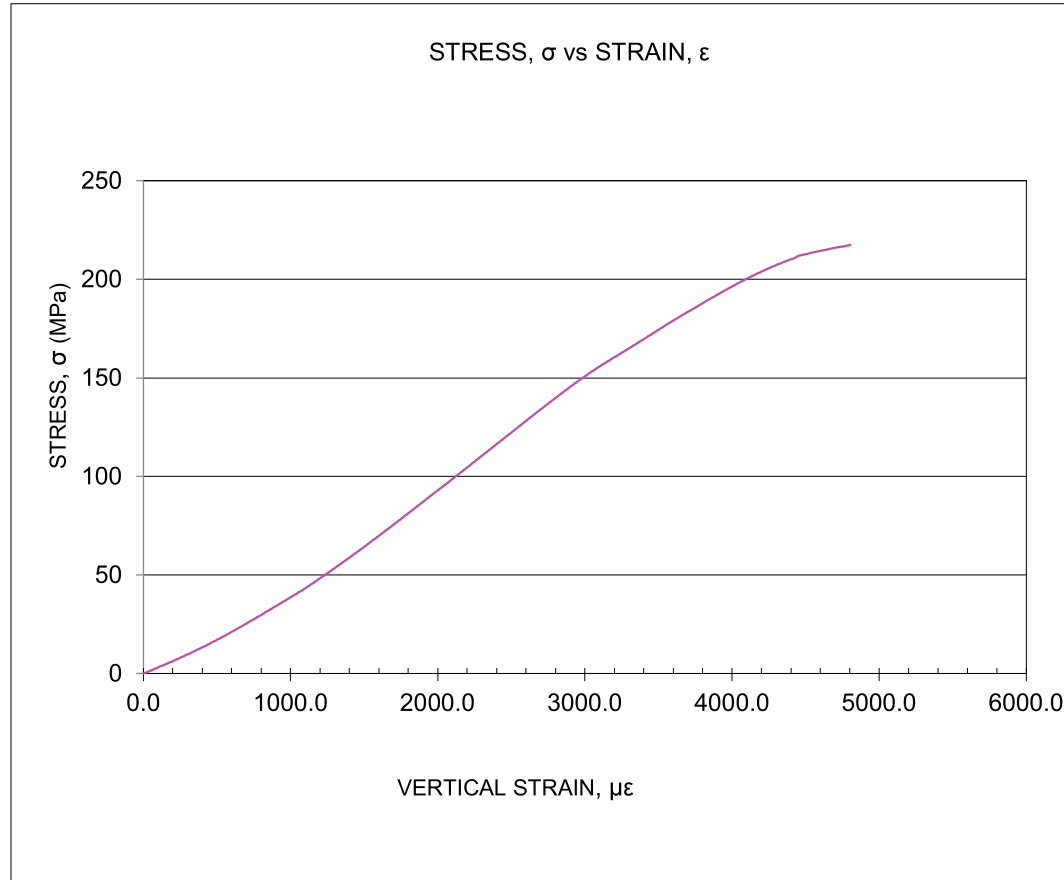
DATE

2021-03-09

ELASTIC MODULI OF ROCK CORE IN UNIAXIAL COMPRESSION

ASTM D7012

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2100524 P
SAMPLE IDENTIFICATION	BH3, Run3, 44'	DATE SAMPLED	2021-02-10
YOUNG'S MODULUS, E_{tan} (at 50% σ)	62.48 GPa	DATE TESTED	2021-03-08
YOUNG'S MODULUS, E_{sec} (at 50% σ)	47.91 GPa	TESTED BY	Azar/Gowry
YOUNG'S MODULUS, $E_{ave.}$ (at 50% σ)	55.20 GPa	POISSON'S RATIO	0.189



REVIEWED BY

J.Noor

DATE 2021-03-09

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK CORE
ASTM D7012

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2100524 B
SAMPLE IDENTIFICATION	BH6, Run4, 47' 5"	DATE SAMPLED	2021-02-10
		DATE TESTED	2021-03-08
		TESTED BY	Azar/Gowry

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.4478	TEST TIME (min) (spec. 2 to 15)	9:36
SPECIMEN LENGTH (in.)	4.397	MAXIMUM LOAD APPLIED (kN)	72.10
	4.395		
	4.390	COMPRESSIVE STRENGTH (MPa)	23.7
AVE.	4.394	TYPE OF FAILURE	2
SURFACE AREA (sq mm)	3036	LENGTH TO DIAMETER RATIO (spec 2-2.5)	1.8

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	1016.48	WEIGHT OF DRY SAMPLE IN AIR (g)	899.00
WEIGHT OF DRY SAMPLE + TARE (g)	992.22	VOLUME OF SAMPLE (cu m)	0.000339
WEIGHT OF WATER (g)	24.26	UNIT WEIGHT (kg/cu m)	2653
WEIGHT OF TARE (g)	133.85		
WEIGHT OF DRY SAMPLE (g)	858.37		
MOISTURE CONTENT (%)	2.8		

REMARKS Length to Diameter ratio is less than 2.



REVIEWED BY

J.Noor

DATE

2021-03-09

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK CORE
ASTM D7012

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2100566 I
SAMPLE IDENTIFICATION	BH9, Run1, 50' 10"	DATE SAMPLED	2021-02-10
		DATE TESTED	2021-03-08
		TESTED BY	Azar/ Gowry

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.4237	TEST TIME (min) (spec. 2 to 15)	9:36
SPECIMEN LENGTH (in.)	4.280	MAXIMUM LOAD APPLIED (kN)	72.10
	4.273		
	4.290	COMPRESSIVE STRENGTH (MPa)	24.2
AVE.	4.281	TYPE OF FAILURE	1
SURFACE AREA (sq mm)	2977	LENGTH TO DIAMETER RATIO (spec 2-2.5)	1.77

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	867.75	WEIGHT OF DRY SAMPLE IN AIR (g)	868.20
WEIGHT OF DRY SAMPLE + TARE (g)	844.67	VOLUME OF SAMPLE (cu m)	0.000324
WEIGHT OF WATER (g)	23.08	UNIT WEIGHT (kg/cu m)	2682
WEIGHT OF TARE (g)	108.28		
WEIGHT OF DRY SAMPLE (g)	736.39		
MOISTURE CONTENT (%)	3.1		

REMARKS Length to Diameter ratio is less than 2.



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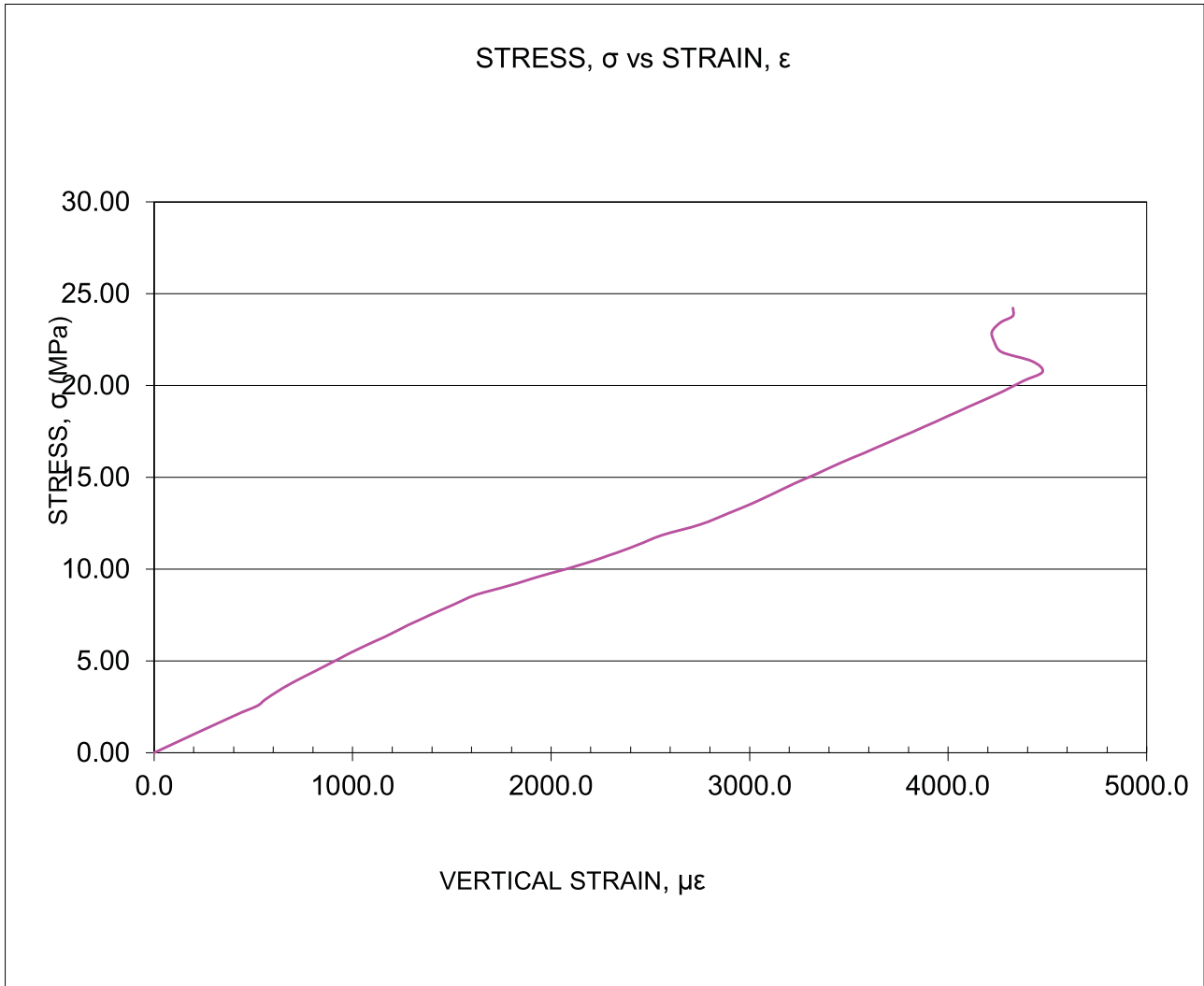
J.Noor

DATE

2021-03-09

ELASTIC MODULI OF ROCK CORE IN UNIAXIAL COMPRESSION
ASTM D7012

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2100566 I
SAMPLE IDENTIFICATION	BH9, Run1, 50' 10"	DATE SAMPLED	2021-02-10
YOUNG'S MODULUS, E_{tan} (at 50% σ)	37.33 GPa	DATE TESTED	2021-03-08
YOUNG'S MODULUS, E_{sec} (at 50% σ)	2.59 GPa	TESTED BY	Azar/ Gowry
YOUNG'S MODULUS, $E_{ave.}$ (at 50% σ)	19.96 GPa	POISSON'S RATIO	0.020



REVIEWED BY

J.Noor

DATE 2021-03-09

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK CORE
ASTM D7012

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2100568A
SAMPLE IDENTIFICATION	BH10, Run2, 41'10"	DATE SAMPLED	2021-02-10
		DATE TESTED	2021-03-03
		TESTED BY	Azar

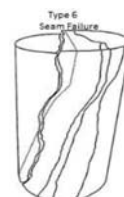
CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.4945	TEST TIME (min) (spec. 2 to 15)	3:12
SPECIMEN LENGTH (in.)	4.152	MAXIMUM LOAD APPLIED (kN)	51.90
	4.080		
	4.075	COMPRESSIVE STRENGTH (MPa)	16.5
AVE.	4.102	TYPE OF FAILURE	2
SURFACE AREA (sq mm)	3153	LENGTH TO DIAMETER RATIO (spec 2-2.5)	1.64

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	905.76	WEIGHT OF DRY SAMPLE IN AIR (g)	769.91
WEIGHT OF DRY SAMPLE + TARE (g)	893.11	VOLUME OF SAMPLE (cu m)	0.000329
WEIGHT OF WATER (g)	12.65	UNIT WEIGHT (kg/cu m)	2344
WEIGHT OF TARE (g)	133.79		
WEIGHT OF DRY SAMPLE (g)	759.32		
MOISTURE CONTENT (%)	1.7		

REMARKS Lenth to Diameter ratio of the specimen is less than 2.



REVIEWED BY

J.Noor

DATE

2021-03-03

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK CORE
ASTM D7012

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2100568B
SAMPLE IDENTIFICATION	BH10, Run1, 38' 10"	DATE SAMPLED	2021-02-10
		DATE TESTED	2021-03-03
		TESTED BY	Azar

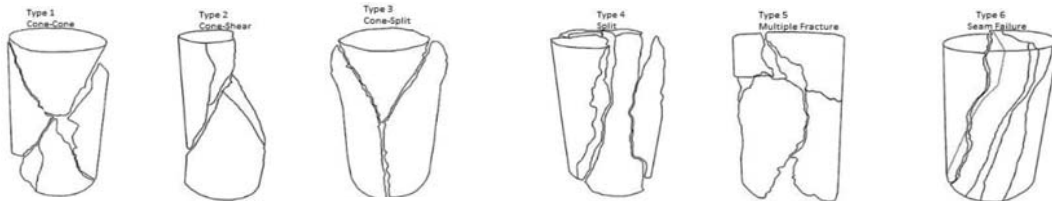
CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.5085	TEST TIME (min) (spec. 2 to 15)	7:12
SPECIMEN LENGTH (in.)	2.860	MAXIMUM LOAD APPLIED (kN)	52.90
	2.870		
	2.861	COMPRESSIVE STRENGTH (MPa)	16.6
AVE.	2.864	TYPE OF FAILURE	1
SURFACE AREA (sq mm)	3188	LENGTH TO DIAMETER RATIO (spec 2-2.5)	1.14

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	697.45	WEIGHT OF DRY SAMPLE IN AIR (g)	586.32
WEIGHT OF DRY SAMPLE + TARE (g)	686.75	VOLUME OF SAMPLE (cu m)	0.000232
WEIGHT OF WATER (g)	10.70	UNIT WEIGHT (kg/cu m)	2528
WEIGHT OF TARE (g)	108.25		
WEIGHT OF DRY SAMPLE (g)	578.50		
MOISTURE CONTENT (%)	1.8		

REMARKS Lenth to Diameter ratio of the specimen is less than 2.

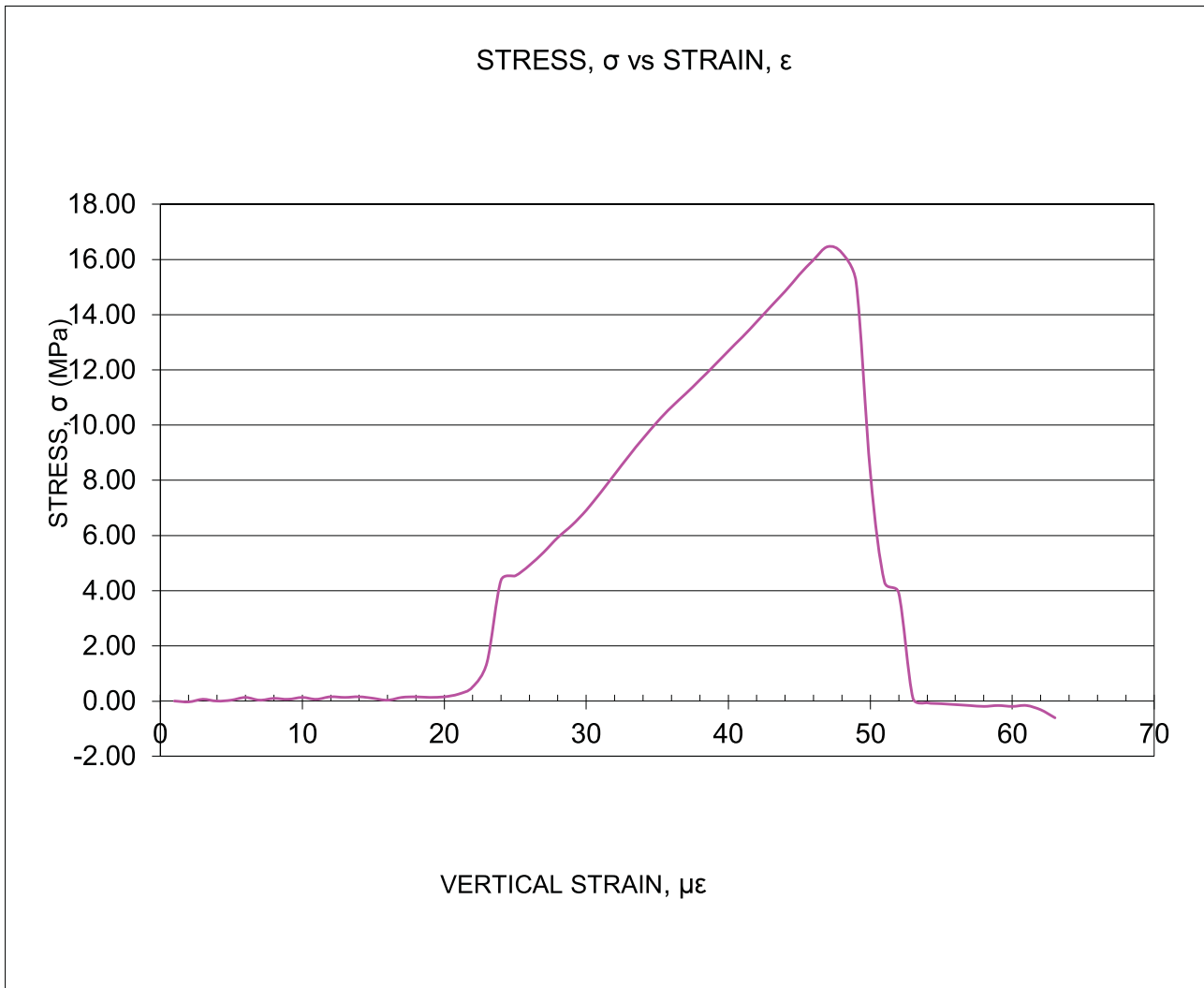


REVIEWED BY J.Noor

DATE 2021-03-03

ELASTIC MODULI OF ROCK CORE IN UNIAXIAL COMPRESSION
ASTM D7012

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2100568A
SAMPLE IDENTIFICATION	BH10, Run2, 41'10"	DATE SAMPLED	2021-02-10
YOUNG'S MODULUS, E_{tan} (at 50% σ)	GPa	DATE TESTED	2021-03-03
YOUNG'S MODULUS, E_{sec} (at 50% σ)	GPa	TESTED BY	Azar
YOUNG'S MODULUS, $E_{ave.}$ (at 50% σ)	GPa	POISSON'S RATIO	



REVIEWED BY

J.Noor

DATE 2021-03-03

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK CORE
ASTM D7012

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2101295D
SAMPLE IDENTIFICATION	P1, Run3, 39' 7"	DATE SAMPLED	2021-03-09
		DATE TESTED	2021-03-10
		TESTED BY	Azar

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.4908	TEST TIME (min) (spec. 2 to 15)	9:36
SPECIMEN LENGTH (in.)	4.799	MAXIMUM LOAD APPLIED (kN)	77.10
	4.798		
	4.792	COMPRESSIVE STRENGTH (MPa)	24.5
AVE.	4.796	TYPE OF FAILURE	2
SURFACE AREA (sq mm)	3144	LENGTH TO DIAMETER RATIO (spec 2-2.5)	1.93

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	1100.99	WEIGHT OF DRY SAMPLE IN AIR (g)	994.98
WEIGHT OF DRY SAMPLE + TARE (g)	1073.64	VOLUME OF SAMPLE (cu m)	0.000383
WEIGHT OF WATER (g)	27.35	UNIT WEIGHT (kg/cu m)	2598
WEIGHT OF TARE (g)	108.26		
WEIGHT OF DRY SAMPLE (g)	965.38		
MOISTURE CONTENT (%)	2.8		

REMARKS Lenth to Diameter ratio of the specimen is less than 2.



REVIEWED BY

J.Noor

DATE

2021-03-11

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK CORE
ASTM D7012

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2101295B
SAMPLE IDENTIFICATION	P1, Run3, 40' 10"	DATE SAMPLED	2021-03-09
		DATE TESTED	2021-03-11
		TESTED BY	Azar

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.4600	TEST TIME (min) (spec. 2 to 15)	9:36
SPECIMEN LENGTH (in.)	4.929	MAXIMUM LOAD APPLIED (kN)	61.50
	4.928		
	4.934	COMPRESSIVE STRENGTH (MPa)	20.1
AVE.	4.93	TYPE OF FAILURE	2
SURFACE AREA (sq mm)	3066	LENGTH TO DIAMETER RATIO (spec 2-2.5)	2

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	1125.77	WEIGHT OF DRY SAMPLE IN AIR (g)	1018.00
WEIGHT OF DRY SAMPLE + TARE (g)	1090.19	VOLUME OF SAMPLE (cu m)	0.000384
WEIGHT OF WATER (g)	35.58	UNIT WEIGHT (kg/cu m)	2651
WEIGHT OF TARE (g)	117.83		
WEIGHT OF DRY SAMPLE (g)	972.36		
MOISTURE CONTENT (%)	3.7		
REMARKS			



REVIEWED BY

J.Noor

DATE

2021-03-11

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK CORE
ASTM D7012

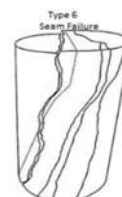
CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2101295C
SAMPLE IDENTIFICATION	BH-P1, Run3, 42' 8"	DATE SAMPLED	2021-03-09
		DATE TESTED	2021-03-15
		TESTED BY	Azar

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.4902	TEST TIME (min) (spec. 2 to 15)	9:36
SPECIMEN LENGTH (in.)	5.468	MAXIMUM LOAD APPLIED (kN)	101.30
	5.467		
	5.470	COMPRESSIVE STRENGTH (MPa)	32.2
AVE.	5.468	TYPE OF FAILURE	1
SURFACE AREA (sq mm)	3142	LENGTH TO DIAMETER RATIO (spec 2-2.5)	2.2

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	1307.03	WEIGHT OF DRY SAMPLE IN AIR (g)	1137.66
WEIGHT OF DRY SAMPLE + TARE (g)	1271.00	VOLUME OF SAMPLE (cu m)	0.000436
WEIGHT OF WATER (g)	36.03	UNIT WEIGHT (kg/cu m)	2607
WEIGHT OF TARE (g)	174.26		
WEIGHT OF DRY SAMPLE (g)	1096.74		
MOISTURE CONTENT (%)	3.3		
REMARKS			



REVIEWED BY

J.Noor

DATE

2021-03-16

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK CORE
ASTM D7012

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road	LAB NO.	2101295A
SAMPLE IDENTIFICATION	P1, Run1, 35' 1"	DATE SAMPLED	2021-03-09
		DATE TESTED	2021-03-10
		TESTED BY	Azar

CORE DIMENSIONS		COMPRESSIVE STRENGTH	
SPECIMEN DIAMETER (in.)	2.5077	TEST TIME (min) (spec. 2 to 15)	9:36
SPECIMEN LENGTH (in.)	3.839	MAXIMUM LOAD APPLIED (kN)	49.10
	3.861		
	3.844	COMPRESSIVE STRENGTH (MPa)	15.4
AVE.	3.848	TYPE OF FAILURE	1
SURFACE AREA (sq mm)	3186	LENGTH TO DIAMETER RATIO (spec 2-2.5)	1.53

MOISTURE CONTENT

UNIT WEIGHT

WEIGHT OF WET SAMPLE + TARE (g)	917.32	WEIGHT OF DRY SAMPLE IN AIR (g)	785.95
WEIGHT OF DRY SAMPLE + TARE (g)	886.77	VOLUME OF SAMPLE (cu m)	0.000311
WEIGHT OF WATER (g)	30.55	UNIT WEIGHT (kg/cu m)	2524
WEIGHT OF TARE (g)	133.86		
WEIGHT OF DRY SAMPLE (g)	752.91		
MOISTURE CONTENT (%)	4.1		
REMARKS	Lenth to Diameter ratio of the specimen is less than 2.		



REVIEWED BY

J.Noor

DATE

20201-03-11

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

CLIENT	The Regional Municipality of Peel
PROJECT	Detailed Design of Watermain Replacement on Dixie Road
LOCATION	Dixie Road; City of Mississauga, Ontario

PML REF	20TF025A
REPORT NO	
ENCLOSURE	
LAB NUMBER	2100566
DATE TESTED	2021-02-04

POINT LOAD TESTER												
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305	CALIBRATION FACTOR			0.006632			
SAMPLE DETAILS												
BH	1						SAMPLE TYPE		Core			
DESCRIPTION												
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa
Diametrical		Run3/2100566 D	37' 6"	45.00	63.50	122.00	0.809	4032.3	63.5	0.20	1.11	0.22
Diametrical		Run2/2100566 E	32' 6"	32.00	63.00	403.00	2.673	3969.0	63.0	0.67	1.11	0.75
AVERAGE OF DIAMETRIC TESTS												0.49
AVERAGE OF AXIAL TESTS												

\perp = Perpendicular to plane of weakness

= Parallel to plane of weakness

[illegible]

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

CLIENT	The Regional Municipality of Peel
PROJECT	Detailed Design of Watermain Replacement on Dixie Road
LOCATION	Dixie Road; City of Mississauga, Ontario

PML REF	20TF025A
REPORT NO	
ENCLOSURE	
LAB NUMBER	2100568 K
DATE TESTED	2021-02-05

POINT LOAD TESTER												
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305			CALIBRATION FACTOR	0.006632			
SAMPLE DETAILS												
BH	1							SAMPLE TYPE		Core		
DESCRIPTION												
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa
Diametrical		2100568 K/ Run3	35' 5"	32.72	64.50	26.00	0.172	4160.3	64.5	0.04	1.12	0.05
AVERAGE OF DIAMETRIC TESTS												0.05
AVERAGE OF AXIAL TESTS												

\perp = Perpendicular to plane of weakness

= Parallel to plane of weakness

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POINT LOAD STRENGTH INDEX OF ROCK

ASTM D5731

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2103378
DATE TESTED 2021-06-10

POINT LOAD TESTER												
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305	CALIBRATION FACTOR	0.006632					
SAMPLE DETAILS												
BH	2A						SAMPLE TYPE		Core			
DESCRIPTION	Shale											
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa
Diametrical		2103378 A/ Run1	59'-59'3"	44.08	62.50	52.00	0.345	3906.3	62.5	0.09	1.11	0.10
Diametrical				45.33	62.50	657.00	4.357	3906.3	62.5	1.12	1.11	1.23
		2103378 D/ Run4	61'1"-61'4"									
Axial	⊥	2103378 F/ Run2	50'2"-50'5"	60.64	37.50	252.00	1.671	2895.3	53.8	0.58	1.03	0.60
Axial	⊥	2103378 E/ Run3	54'9"-55'2"	60.65	45.50	261.00	1.731	3513.6	59.3	0.49	1.08	0.53
Axial	⊥	2103378 C/ Run1	46'-46'2"	60.63	34.50	435.00	2.885	2663.3	51.6	1.08	1.01	1.10
AVERAGE OF DIAMETRIC TESTS												0.67
AVERAGE OF AXIAL TESTS												0.74
<div style="display: flex; justify-content: space-between;"> ⊥ = Perpendicular to plane of weakness = Parallel to plane of weakness </div>												
MOISTURE CONTENT												
SAMPLE NO	DEPTH	TARE NUMBER	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)				
2103378 A/ Run1	59'-59'3"	GEO400	641.61	630.27	11.34	121.58	508.69	2.23				
2103378 D/ Run4	61'1"-61'4"	GEO30	631.52	627.99	3.53	88.42	539.57	0.65				
2103378 F/ Run2	50'2"-50'5"	N11	384.89	377.45	7.44	117.84	259.61	2.87				
2103378 E/ Run3	54'9"-55'2"	F1	433.56	425.93	7.63	111.56	314.37	2.43				
2103378 C/ Run1	46'-46'2"	GEO52	356.66	352.79	3.87	108.03	244.76	1.58				

REVIEWED BY

J. Noor

DATE

2021-06-11

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100524 E
DATE TESTED 2021-02-03

POINT LOAD TESTER													
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305	CALIBRATION FACTOR	0.006632						
SAMPLE DETAILS													
BH	3						SAMPLE TYPE		Core				
DESCRIPTION													
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa	
Axial	⊥	Run2	40' 10"	63.48	58.00	258.00	1.711	4687.9	68.5	0.36	1.15	0.42	
AVERAGE OF DIAMETRIC TESTS													
AVERAGE OF AXIAL TESTS												0.42	

⊥ = Perpendicular to plane of weakness

|| = Parallel to plane of weakness

MOISTURE CONTENT								
SAMPLE NO	DEPTH	TARE NUMBER	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)
Run2	40' 10"	FN	90.19	87.80	2.39	27.02	60.78	3.93

REVIEWED BY

J. Noor

DATE

2021-02-12

PML REF	20TF025A
REPORT NO	
ENCLOSURE	
LAB NUMBER	2100526 G
DATE TESTED	2021-02-05

[illegible]

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100524 I
DATE TESTED 2021-02-03

POINT LOAD TESTER													
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305	CALIBRATION FACTOR	0.006632						
SAMPLE DETAILS													
BH	4						SAMPLE TYPE		Core				
DESCRIPTION													
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa	
Axial	⊥	Run1	35' 6"	62.78	56.00	325.00	2.155	4476.3	66.9	0.48	1.14	0.55	
AVERAGE OF DIAMETRIC TESTS													
AVERAGE OF AXIAL TESTS												0.55	

⊥ = Perpendicular to plane of weakness

|| = Parallel to plane of weakness

MOISTURE CONTENT								
SAMPLE NO	DEPTH	TARE NUMBER	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)
Run1	35' 6"	F4	67.42	65.39	2.03	16.07	49.32	4.12

REVIEWED BY

J. Noor

DATE

2021-02-12

PML REF	20TF025A
REPORT NO	
ENCLOSURE	
LAB NUMBER	2100568 J
DATE TESTED	2021-02-05

[illegible]

PML REF	20TF025A
REPORT NO	
ENCLOSURE	
LAB NUMBER	2100526 A
DATE TESTED	2021-02-05

[illegible]

POINT LOAD STRENGTH INDEX OF ROCK

ASTM D5731

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2103378
DATE TESTED 2021-06-10

POINT LOAD TESTER												
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305	CALIBRATION FACTOR	0.006632					
SAMPLE DETAILS												
BH	7A						SAMPLE TYPE		Core			
DESCRIPTION	Shale											
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa
Diametrical		2103378 I/ Run1	57'	38.94	62.40	154.00	1.021	3893.8	62.4	0.26	1.10	0.29
Diametrical				39.75	63.50	41.00	0.272	4032.3	63.5	0.07	1.11	0.08
Diametrical		2103378 L/ Run3	64'11"-65'2"	48.15	62.50	1540.00	10.213	3906.3	62.5	2.61	1.11	2.89
		2103378 M / Run2	60'-60'6"									
Axial	⊥	2103378 N/ Run3	67'3"-67'5"	60.67	56.45	345.00	2.288	4360.6	66.0	0.52	1.13	0.59
Axial	⊥	2103378 K/ Run2	58'3"-58'6"	60.71	39.50	296.00	1.963	3053.3	55.3	0.64	1.05	0.67
AVERAGE OF DIAMETRIC TESTS												1.09
AVERAGE OF AXIAL TESTS												0.63
<div style="display: flex; justify-content: space-between;"> ⊥ = Perpendicular to plane of weakness = Parallel to plane of weakness </div>												
MOISTURE CONTENT												
SAMPLE NO	DEPTH	TARE NUMBER	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)				
2103378 I/ Run1	57'	GEO41	703.66	692.46	11.20	145.17	547.29	2.05				
2103378 L/ Run3	64'11"-65'2"	17.00	675.06	662.10	12.96	120.40	541.70	2.39				
2103378 M / Run2	60'-60'6"	GEO10	918.72	915.49	3.23	105.62	809.87	0.40				
2103378 N/ Run3	67'3"-67'5"	A2	522.86	514.59	8.27	121.05	393.54	2.10				
2103378 K/ Run2	58'3"-58'6"	GEO20	411.73	403.52	8.21	128.12	275.40	2.98				

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J. Noor

DATE

2021-06-11

POINT LOAD STRENGTH INDEX OF ROCK

ASTM D5731

CLIENT	The Regional Municipality of Peel
PROJECT	Detailed Design of Watermain Replacement on Dixie Road
LOCATION	Dixie Road; City of Mississauga, Ontario

PML REF	20TF025A
REPORT NO	
ENCLOSURE	
LAB NUMBER	2100566
DATE TESTED	2021-02-05

POINT LOAD TESTER												
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305	CALIBRATION FACTOR			0.006632			
SAMPLE DETAILS												
BH	9						SAMPLE TYPE		Core			
DESCRIPTION												
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa
Diametrical	⊥	Run2/ 2100566 J	52' 9"	31.40	65.00	58.00	0.385	4225.0	65.0	0.09	1.13	0.10
Axial				62.45	40.00	218.00	1.446	3180.6	56.4	0.45	1.06	0.48
	⊥	Run1/2100566 K	51' 2"									
Axial				62.94	51.50	3182.00	21.103	4127.1	64.2	5.11	1.12	5.72
		Run1/2100566 L	50' 3"									
AVERAGE OF DIAMETRIC TESTS												0.10
AVERAGE OF AXIAL TESTS												3.10

\perp = Perpendicular to plane of weakness

= Parallel to plane of weakness

[illegible]

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

CLIENT	The Regional Municipality of Peel
PROJECT	Detailed Design of Watermain Replacement on Dixie Road
LOCATION	Dixie Road; City of Mississauga, Ontario

PML REF	20TF025A
REPORT NO	
ENCLOSURE	
LAB NUMBER	2100568
DATE TESTED	2021-02-05

POINT LOAD TESTER												
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305			CALIBRATION FACTOR		0.006632		
SAMPLE DETAILS												
BH	10							SAMPLE TYPE		Core		
DESCRIPTION												
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa
Axial	⊥	2100568 E/ Run2	43' 10"	63.37	44.00	473.00	3.137	3550.1	59.6	0.88	1.08	0.96
Axial	⊥			2100568 H/ Run2	41' 3"	63.53	41.00	154.00	1.021	3316.4	57.6	0.31
AVERAGE OF DIAMETRIC TESTS												
AVERAGE OF AXIAL TESTS												0.64

\perp = Perpendicular to plane of weakness

= Parallel to plane of weakness

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POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100568 I
DATE TESTED 2021-02-05

POINT LOAD TESTER													
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305	CALIBRATION FACTOR	0.006632						
SAMPLE DETAILS													
BH	5						SAMPLE TYPE		Core				
DESCRIPTION													
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa	
Axial	⊥	2100568 I/ Run4	35' 9"	62.74	52.50	342.00	2.268	4193.9	64.8	0.54	1.12	0.61	
AVERAGE OF DIAMETRIC TESTS													
AVERAGE OF AXIAL TESTS												0.61	
⊥ = Perpendicular to plane of weakness = Parallel to plane of weakness													
MOISTURE CONTENT													
SAMPLE NO	DEPTH	TARE NUMBER	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)					
2100568 I/ Run4	35' 9"	h18	58.77	57.37	1.40	19.86	37.51	3.73					

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

CLIENT	The Regional Municipality of Peel
PROJECT	Detailed Design of Watermain Replacement on Dixie Road
LOCATION	Dixie Road; City of Mississauga, Ontario

PML REF	20TF025A
REPORT NO	
ENCLOSURE	
LAB NUMBER	2100526 E
DATE TESTED	2021-02-05

POINT LOAD TESTER												
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305	CALIBRATION FACTOR	0.006632					
SAMPLE DETAILS												
BH	5					SAMPLE TYPE			Core			
DESCRIPTION												
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa
Diametrical		Run4	37' 4'	43.72	63.00	20.00	0.133	3969.0	63.0	0.03	1.11	0.04
AVERAGE OF DIAMETRIC TESTS												0.04
AVERAGE OF AXIAL TESTS												

\perp = Perpendicular to plane of weakness

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[illegible]

POINT LOAD STRENGTH INDEX OF ROCK

ASTM D5731

CLIENT	The Regional Municipality of Peel
PROJECT	Detailed Design of Watermain Replacement on Dixie Road
LOCATION	Dixie Road; City of Mississauga, Ontario

PML REF	20TF025A
REPORT NO	
ENCLOSURE	
LAB NUMBER	2100524
DATE TESTED	2021-02-03

POINT LOAD TESTER												
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305			CALIBRATION FACTOR		0.006632		
SAMPLE DETAILS												
BH	6							SAMPLE TYPE		Core		
DESCRIPTION												
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa
Axial	⊥	Run1/ 2100524 A	38' 10"	61.71	42.00	334.00	2.215	3300.0	57.4	0.67	1.06	0.71
Diametrical	∥	Run1/ 2100524 M	39' 3"	42.79	64.50	15.00	0.099	4160.3	64.5	0.02	1.12	0.03
Diametrical	∥	Run4/ 2100524 N	48' 7"	36.35	64.50	93.00	0.617	4160.3	64.5	0.15	1.12	0.17
AVERAGE OF DIAMETRIC TESTS												0.10
AVERAGE OF AXIAL TESTS												0.71

\perp = Perpendicular to plane of weakness

= Parallel to plane of weakness

[illegible]

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

CLIENT	The Regional Municipality of Peel
PROJECT	Detailed Design of Watermain Replacement on Dixie Road
LOCATION	Dixie Road; City of Mississauga, Ontario

PML REF	20TF025A
REPORT NO	
ENCLOSURE	
LAB NUMBER	2100524
DATE TESTED	2021-02-03

POINT LOAD TESTER												
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305	CALIBRATION FACTOR	0.006632					
SAMPLE DETAILS												
BH	8						SAMPLE TYPE		Core			
DESCRIPTION												
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa
Axial	⊥	Run1/ 2100524 G	54'	62.87	52.00	635.00	4.211	4162.5	64.5	1.01	1.12	1.13
Diametrical	∥	Run2/ 2100524 O	57' 6"	30.27	64.00	44.00	0.292	4096.0	64.0	0.07	1.12	0.08
AVERAGE OF DIAMETRIC TESTS												0.08
AVERAGE OF AXIAL TESTS												1.13

\perp = Perpendicular to plane of weakness

= Parallel to plane of weakness

[illegible]

POINT LOAD STRENGTH INDEX OF ROCK
ASTM D5731

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100526 D
DATE TESTED 2021-02-05

POINT LOAD TESTER													
MODEL	JHP73	DATE CALIBRATED	2019-05-27	SERIAL NO	048A1305	CALIBRATION FACTOR	0.006632						
SAMPLE DETAILS													
BH	8						SAMPLE TYPE		Core				
DESCRIPTION													
TEST TYPE	ORIENTATION	SAMPLE NO	DEPTH	W (mm)	POINT GAP D (mm)	GUAGE READING (PSI)	LOAD (P) kN	D _e ²	D _e	I _s MPa	F	I _{s(50)} MPa	
Axial	⊥	Run1	53' 9"	62.82	57.50	682.00	4.523	4599.1	67.8	0.98	1.15	1.13	
AVERAGE OF DIAMETRIC TESTS													
AVERAGE OF AXIAL TESTS												1.13	

⊥ = Perpendicular to plane of weakness

|| = Parallel to plane of weakness

MOISTURE CONTENT								
SAMPLE NO	DEPTH	TARE NUMBER	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)
Run1	53' 9"	35	91.72	89.38	2.34	16.52	72.86	3.21

REVIEWED BY

J. Noor

DATE

2021-02-16

SPLITTING TENSILE STRENGTH OF ROCK

ASTM D3967

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario
SAMPLE IDENTIFICATION BH3, Run2, 41' 2"
SAMPLE DESCRIPTION Shale

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100522 C
DATE TESTED 2021-02-19

DIAMETER (mm)	HEIGHT (mm)	MAXIMUM LOAD APPLIED (kN)	TEST TIME (spec 1 to 10 min) (min)	SPLITTING TENSILE STRENGTH (MPa)
63.18	25.83	4.85	2:04	1.9
AVERAGE				1.9

MOISTURE CONTENT						
TARE NO.	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)
124.00	285.16	279.98	5.18	82.64	197.34	2.62

REMARKS This test does not meet procedure requirement for minimum of 10 specimens.

REVIEWED BY J. Noor

DATE 2021-02-22

SPLITTING TENSILE STRENGTH OF ROCK

ASTM D3967

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario
SAMPLE IDENTIFICATION BH4, Run2, 40' 9"
SAMPLE DESCRIPTION Shale

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100522 E
DATE TESTED 2021-02-19

DIAMETER (mm)	HEIGHT (mm)	MAXIMUM LOAD APPLIED (kN)	TEST TIME (spec 1 to 10 min) (min)	SPLITTING TENSILE STRENGTH (MPa)
62.64	23.33	4.12	2:15	1.8
62.91	19.79	2.11	2:00	1.1
AVERAGE				1.4

MOISTURE CONTENT						
TARE NO.	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)
A6	351.26	346.66	4.60	173.58	173.08	2.66
Geo52	258.08	253.75	4.33	107.94	145.81	2.97

REMARKS This test does not meet procedure requirement for minimum of 10 specimens.

REVIEWED BY J. Noor

DATE 2021-02-22

SPLITTING TENSILE STRENGTH OF ROCK

ASTM D3967

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario
SAMPLE IDENTIFICATION BH4, Run2, 43' 6"
SAMPLE DESCRIPTION Shale

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100522 H
DATE TESTED 2021-02-19

DIAMETER (mm)	HEIGHT (mm)	MAXIMUM LOAD APPLIED (kN)	TEST TIME (spec 1 to 10 min) (min)	SPLITTING TENSILE STRENGTH (MPa)
63.12	27.74	4.62	2.23	1.7
AVERAGE				1.7

MOISTURE CONTENT						
TARE NO.	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)
17.00	320.20	314.05	6.15	120.40	193.65	3.18

REMARKS This test does not meet procedure requirement for minimum of 10 specimens.

REVIEWED BY J. Noor

DATE 2021-02-22

SPLITTING TENSILE STRENGTH OF ROCK

ASTM D3967

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario
SAMPLE IDENTIFICATION BH5, Run3, 33' 8"
SAMPLE DESCRIPTION

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100522 J
DATE TESTED 2021-02-19

DIAMETER (mm)	HEIGHT (mm)	MAXIMUM LOAD APPLIED (kN)	TEST TIME (spec 1 to 10 min) (min)	SPLITTING TENSILE STRENGTH (MPa)
63.13	33.21	34.71	2:57	10.5
62.23	21.76	17.70	2:42	8.3
AVERAGE				9.4

MOISTURE CONTENT						
TARE NO.	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)
A5	450.92	449.86	1.06	186.89	262.97	0.40
AS	246.09	245.58	0.51	79.84	165.74	0.31

REMARKS This test does not meet procedure requirement for minimum of 10 specimens.

REVIEWED BY J. Noor

DATE 2021-02-22

SPLITTING TENSILE STRENGTH OF ROCK

ASTM D3967

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario
SAMPLE IDENTIFICATION BH6, Run2, 39' 2"
SAMPLE DESCRIPTION Shale

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100522 G
DATE TESTED 2021-02-19

DIAMETER (mm)	HEIGHT (mm)	MAXIMUM LOAD APPLIED (kN)	TEST TIME (spec 1 to 10 min) (min)	SPLITTING TENSILE STRENGTH (MPa)
62.75	15.81	3.58	2:00	2.3
62.72	14.82	2.51	2:23	1.7
AVERAGE				2.0

MOISTURE CONTENT						
TARE NO.	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)
B	236.19	233.46	2.73	117.87	115.59	2.36
A7	267.73	265.22	2.51	148.52	116.70	2.15

REMARKS This test does not meet procedure requirement for minimum of 10 specimens.

REVIEWED BY J. Noor

DATE 2021-02-22

SPLITTING TENSILE STRENGTH OF ROCK

ASTM D3967

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario
SAMPLE IDENTIFICATION BH8, Run1, 53'
SAMPLE DESCRIPTION Shale

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100522 D
DATE TESTED 2021-02-18

DIAMETER (mm)	HEIGHT (mm)	MAXIMUM LOAD APPLIED (kN)	TEST TIME (spec 1 to 10 min) (min)	SPLITTING TENSILE STRENGTH (MPa)
61.86	31.16	15.14	3:57	5.0
AVERAGE				5.0

MOISTURE CONTENT						
TARE NO.	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)
Geo400	354.26	349.93	4.33	121.58	228.35	1.90

REMARKS This test does not meet procedure requirement for minimum of 10 specimens.

REVIEWED BY J. Noor DATE 2021-02-22

SPLITTING TENSILE STRENGTH OF ROCK

ASTM D3967

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario
SAMPLE IDENTIFICATION BH9, Run1, 51' 11"
SAMPLE DESCRIPTION Shale

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100566 O
DATE TESTED 2021-02-18

DIAMETER (mm)	HEIGHT (mm)	MAXIMUM LOAD APPLIED (kN)	TEST TIME (spec 1 to 10 min) (min)	SPLITTING TENSILE STRENGTH (MPa)
62.53	42.37	16.19	2:28	3.9
AVERAGE				3.9

MOISTURE CONTENT						
TARE NO.	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)
Geo2	447.95	438.55	9.40	112.84	325.71	2.89

REMARKS This test does not meet procedure requirement for minimum of 10 specimens.

REVIEWED BY J. Noor

DATE 2021-02-22

SPLITTING TENSILE STRENGTH OF ROCK

ASTM D3967

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario
SAMPLE IDENTIFICATION BH10, Run1, 36' 11"
SAMPLE DESCRIPTION Shale

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100568 C
DATE TESTED 2021-02-18

DIAMETER (mm)	HEIGHT (mm)	MAXIMUM LOAD APPLIED (kN)	TEST TIME (spec 1 to 10 min) (min)	SPLITTING TENSILE STRENGTH (MPa)
63.31	24.16	3.89	2:21	1.6
AVERAGE				1.6

MOISTURE CONTENT						
TARE NO.	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)
F11	285.11	279.78	5.33	111.55	168.23	3.17

REMARKS This test does not meet procedure requirement for minimum of 10 specimens.

REVIEWED BY J. Noor

DATE 2021-02-22

SPLITTING TENSILE STRENGTH OF ROCK

ASTM D3967

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario
SAMPLE IDENTIFICATION BH10, Run2, 40' 7"
SAMPLE DESCRIPTION Shale

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100568 D
DATE TESTED 2021-02-19

DIAMETER (mm)	HEIGHT (mm)	MAXIMUM LOAD APPLIED (kN)	TEST TIME (spec 1 to 10 min) (min)	SPLITTING TENSILE STRENGTH (MPa)
63.48	29.83	13.52	2:51	4.5
AVERAGE				4.5

MOISTURE CONTENT						
TARE NO.	WET SAMPLE WITH TARE (g)	DRY SAMPLE WITH TARE (g)	WATER (g)	TARE (g)	DRY SAMPLE (g)	WATER CONTENT (%)
No	347.18	342.57	4.61	117.83	224.74	2.05

REMARKS This test does not meet procedure requirement for minimum of 10 specimens.

REVIEWED BY J. Noor



DATE 2021-02-22

SLAKE DURABILITY OF ROCK

ASTM D4644

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100566 G
DATE TESTED 2021-02-09

SAMPLE DETAILS							
BH	1	SAMPLE NO	1	DEPTH	30' 6"	TYPE	Core
DESCRIPTION	Shale						
INITIAL MOISTURE CONTENT							
TARE + WET SAMPLE (g)	637.67						
TARE + DRY SAMPLE (g)	623.04						
WATER (g)	14.63						
TARE (g)	128.09						
DRY SAMPLE (g)	494.95						
MOISTURE CONTENT (%)	2.96						
INITIAL SLAKE CONDITION							
DRUM + DRY SAMPLE (g)	1731.00						
SLAKE CYCLE 1							
DRUM + WET SAMPLE (g)	1689.50						
DRUM + DRY SAMPLE (g)	1666.90						
WATER (g)	22.60						
DRUM (g)	1234.80						
DRY SAMPLE (g)	432.10						
MOISTURE CONTENT (%)	5.23						
SLAKE CYCLE 2							
DRUM + WET SAMPLE (g)	1605.20						
DRUM + DRY SAMPLE (g)	1576.20						
WATER (g)	29.00						
DRUM (g)	1234.80						
DRY SAMPLE (g)	341.40						
MOISTURE CONTENT (%)	8.49						
FINAL SLAKE CONDITION							
RETAINED SPECIMEN TYPE	TYPE II						
SLAKE DURABILITY INDEX	68.8						

REVIEWED BY

J. Noor

DATE

2021-02-17

SLAKE DURABILITY OF ROCK

ASTM D4644

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100566 H
DATE TESTED 2021-02-11

SAMPLE DETAILS							
BH	1	SAMPLE NO	2	DEPTH	34' 8"	TYPE	Core
DESCRIPTION	Shale						
INITIAL MOISTURE CONTENT							
TARE + WET SAMPLE (g)	550.94						
TARE + DRY SAMPLE (g)	543.92						
WATER (g)	7.02						
TARE (g)	88.40						
DRY SAMPLE (g)	455.52						
MOISTURE CONTENT (%)	1.54						
INITIAL SLAKE CONDITION							
DRUM + DRY SAMPLE (g)	1691.50						
SLAKE CYCLE 1							
DRUM + WET SAMPLE (g)	1664.10						
DRUM + DRY SAMPLE (g)	1638.50						
WATER (g)	25.60						
DRUM (g)	1237.10						
DRY SAMPLE (g)	401.40						
MOISTURE CONTENT (%)	6.38						
SLAKE CYCLE 2							
DRUM + WET SAMPLE (g)	1598.90						
DRUM + DRY SAMPLE (g)	1567.70						
WATER (g)	31.20						
DRUM (g)	1237.10						
DRY SAMPLE (g)	330.60						
MOISTURE CONTENT (%)	9.44						
FINAL SLAKE CONDITION							
RETAINED SPECIMEN TYPE	TYPE II						
SLAKE DURABILITY INDEX	72.8						

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DATE

2021-02-17

SLAKE DURABILITY OF ROCK

ASTM D4644

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100522 B
DATE TESTED 2021-02-09

SAMPLE DETAILS							
BH	3	SAMPLE NO	2	DEPTH	39'	TYPE	Core
DESCRIPTION	Shale						
INITIAL MOISTURE CONTENT							
TARE + WET SAMPLE (g)	633.19						
TARE + DRY SAMPLE (g)	622.19						
WATER (g)	11.00						
TARE (g)	133.69						
DRY SAMPLE (g)	488.50						
MOISTURE CONTENT (%)	2.25						
INITIAL SLAKE CONDITION							
DRUM + DRY SAMPLE (g)	1723.40						
SLAKE CYCLE 1							
DRUM + WET SAMPLE (g)	1686.40						
DRUM + DRY SAMPLE (g)	1669.20						
WATER (g)	17.20						
DRUM (g)	1234.80						
DRY SAMPLE (g)	434.40						
MOISTURE CONTENT (%)	3.96						
SLAKE CYCLE 2							
DRUM + WET SAMPLE (g)	1603.10						
DRUM + DRY SAMPLE (g)	1584.90						
WATER (g)	18.20						
DRUM (g)	1234.80						
DRY SAMPLE (g)	350.10						
MOISTURE CONTENT (%)	5.20						
FINAL SLAKE CONDITION							
RETAINED SPECIMEN TYPE	TYPE II						
SLAKE DURABILITY INDEX	71.7	Final					

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DATE

2021-02-17

SLAKE DURABILITY OF ROCK

ASTM D4644

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100522 I
DATE TESTED 2021-02-11

SAMPLE DETAILS							
BH	4	SAMPLE NO	1	DEPTH	39' 6"	TYPE	Core
DESCRIPTION	Shale						
INITIAL MOISTURE CONTENT							
TARE + WET SAMPLE (g)	602.21						
TARE + DRY SAMPLE (g)	589.99						
WATER (g)	12.22						
TARE (g)	105.96						
DRY SAMPLE (g)	484.03						
MOISTURE CONTENT (%)	2.52						
INITIAL SLAKE CONDITION							
DRUM + DRY SAMPLE (g)	1718.50						
SLAKE CYCLE 1							
DRUM + WET SAMPLE (g)	1679.30						
DRUM + DRY SAMPLE (g)	1642.90						
WATER (g)	36.40						
DRUM (g)	1237.10						
DRY SAMPLE (g)	405.80						
MOISTURE CONTENT (%)	8.97						
SLAKE CYCLE 2							
DRUM + WET SAMPLE (g)	1613.90						
DRUM + DRY SAMPLE (g)	1574.00						
WATER (g)	39.90						
DRUM (g)	1237.10						
DRY SAMPLE (g)	336.90						
MOISTURE CONTENT (%)	11.84						
FINAL SLAKE CONDITION							
RETAINED SPECIMEN TYPE	TYPE II						
SLAKE DURABILITY INDEX	70.0						

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J. Noor

DATE

2021-02-17

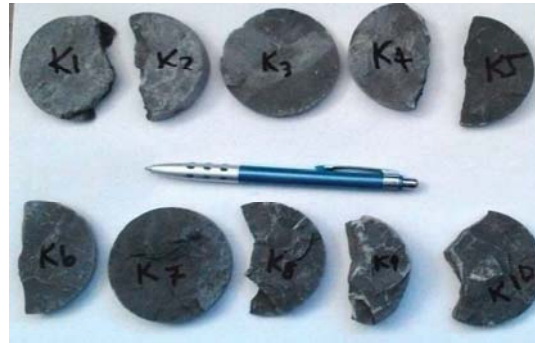
SLAKE DURABILITY OF ROCK

ASTM D4644

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100522 K
DATE TESTED 2021-02-11

SAMPLE DETAILS							
BH	5	SAMPLE NO	4	DEPTH	35'	TYPE	Core
DESCRIPTION	Shale						
INITIAL MOISTURE CONTENT							
TARE + WET SAMPLE (g)	632.83						
TARE + DRY SAMPLE (g)	624.52						
WATER (g)	8.31						
TARE (g)	133.67						
DRY SAMPLE (g)	490.85						
MOISTURE CONTENT (%)	1.69						
INITIAL SLAKE CONDITION							
DRUM + DRY SAMPLE (g)	1724.50						
SLAKE CYCLE 1							
DRUM + WET SAMPLE (g)	1683.40						
DRUM + DRY SAMPLE (g)	1655.30						
WATER (g)	28.10						
DRUM (g)	1234.80						
DRY SAMPLE (g)	420.50						
MOISTURE CONTENT (%)	6.68						
SLAKE CYCLE 2							
DRUM + WET SAMPLE (g)	1610.90						
DRUM + DRY SAMPLE (g)	1581.70						
WATER (g)	29.20						
DRUM (g)	1234.80						
DRY SAMPLE (g)	346.90						
MOISTURE CONTENT (%)	8.42						
FINAL SLAKE CONDITION							
RETAINED SPECIMEN TYPE	TYPE II						
SLAKE DURABILITY INDEX	70.8						



Initial



Final

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J. Noor

DATE



2021-02-17

SLAKE DURABILITY OF ROCK

ASTM D4644

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100522 F
DATE TESTED 2021-02-09

SAMPLE DETAILS							
BH	6	SAMPLE NO	1	DEPTH	39'	TYPE	Core
DESCRIPTION	Shale						
INITIAL MOISTURE CONTENT							
TARE + WET SAMPLE (g)	631.79						
TARE + DRY SAMPLE (g)	612.32						
WATER (g)	19.47						
TARE (g)	121.05						
DRY SAMPLE (g)	491.27			Initial			
MOISTURE CONTENT (%)	3.96						
INITIAL SLAKE CONDITION							
DRUM + DRY SAMPLE (g)	1727.00						
SLAKE CYCLE 1							
DRUM + WET SAMPLE (g)	1695.40						
DRUM + DRY SAMPLE (g)	1660.40						
WATER (g)	35.00						
DRUM (g)	1234.80						
DRY SAMPLE (g)	425.60						
MOISTURE CONTENT (%)	8.22			Final			
SLAKE CYCLE 2							
DRUM + WET SAMPLE (g)	1637.40						
DRUM + DRY SAMPLE (g)	1595.60						
WATER (g)	41.80						
DRUM (g)	1234.80						
DRY SAMPLE (g)	360.80						
MOISTURE CONTENT (%)	11.59						
FINAL SLAKE CONDITION							
RETAINED SPECIMEN TYPE	TYPE II						
SLAKE DURABILITY INDEX	73.3						



Initial



Final

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J. Noor

DATE

2021-02-17

SLAKE DURABILITY OF ROCK

ASTM D4644

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100522 A
DATE TESTED 2021-02-11

SAMPLE DETAILS							
BH	8	SAMPLE NO	1	DEPTH	53' 3"	TYPE	Rock Core
DESCRIPTION	Shale						
INITIAL MOISTURE CONTENT							
TARE + WET SAMPLE (g)	641.18						
TARE + DRY SAMPLE (g)	632.90						
WATER (g)	8.28						
TARE (g)	112.75						
DRY SAMPLE (g)	520.15						
MOISTURE CONTENT (%)	1.59						
INITIAL SLAKE CONDITION							
DRUM + DRY SAMPLE (g)	1753.10						
SLAKE CYCLE 1							
DRUM + WET SAMPLE (g)	1731.60						
DRUM + DRY SAMPLE (g)	1706.80						
WATER (g)	24.80						
DRUM (g)	1234.80						
DRY SAMPLE (g)	472.00						
MOISTURE CONTENT (%)	5.25						
SLAKE CYCLE 2							
DRUM + WET SAMPLE (g)	1664.60						
DRUM + DRY SAMPLE (g)	1639.00						
WATER (g)	25.60						
DRUM (g)	1234.80						
DRY SAMPLE (g)	404.20						
MOISTURE CONTENT (%)	6.33						
FINAL SLAKE CONDITION							
RETAINED SPECIMEN TYPE	TYPE II						
SLAKE DURABILITY INDEX	78.0						

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J. Noor

DATE

2021-02-17

SLAKE DURABILITY OF ROCK

ASTM D4644

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100566 N
DATE TESTED 2021-02-09

SAMPLE DETAILS							
BH	9	SAMPLE NO	1	DEPTH	49' 5"	TYPE	Core
DESCRIPTION	Shale						
INITIAL MOISTURE CONTENT							
TARE + WET SAMPLE (g)	579.53						
TARE + DRY SAMPLE (g)	562.36						
WATER (g)	17.17						
TARE (g)	128.09						
DRY SAMPLE (g)	434.27						
MOISTURE CONTENT (%)	3.95						
INITIAL SLAKE CONDITION							
DRUM + DRY SAMPLE (g)	1672.20						
SLAKE CYCLE 1							
DRUM + WET SAMPLE (g)	1642.20						
DRUM + DRY SAMPLE (g)	1603.40						
WATER (g)	38.80						
DRUM (g)	1237.10						
DRY SAMPLE (g)	366.30						
MOISTURE CONTENT (%)	10.59						
SLAKE CYCLE 2							
DRUM + WET SAMPLE (g)	1575.50						
DRUM + DRY SAMPLE (g)	1537.40						
WATER (g)	38.10						
DRUM (g)	1237.10						
DRY SAMPLE (g)	300.30						
MOISTURE CONTENT (%)	12.69						
FINAL SLAKE CONDITION							
RETAINED SPECIMEN TYPE	TYPE II						
SLAKE DURABILITY INDEX	69.0						

REVIEWED BY

J. Noor

DATE

2021-02-17

SLAKE DURABILITY OF ROCK

ASTM D4644

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100568 F
DATE TESTED 2021-02-11

SAMPLE DETAILS							
BH	10	SAMPLE NO	1	DEPTH	37' 10"	TYPE	Core
DESCRIPTION	Shale						
INITIAL MOISTURE CONTENT							
TARE + WET SAMPLE (g)	622.83						
TARE + DRY SAMPLE (g)	611.95						
WATER (g)	10.88						
TARE (g)	105.63						
DRY SAMPLE (g)	506.32						
MOISTURE CONTENT (%)	2.15						
INITIAL SLAKE CONDITION		Initial					
DRUM + DRY SAMPLE (g)	1743.42						
SLAKE CYCLE 1							
DRUM + WET SAMPLE (g)	1714.30						
DRUM + DRY SAMPLE (g)	1678.10						
WATER (g)	36.20						
DRUM (g)	1237.10						
DRY SAMPLE (g)	441.00						
MOISTURE CONTENT (%)	8.21						
SLAKE CYCLE 2		Final					
DRUM + WET SAMPLE (g)	1659.50						
DRUM + DRY SAMPLE (g)	1613.30						
WATER (g)	46.20						
DRUM (g)	1237.10						
DRY SAMPLE (g)	376.20						
MOISTURE CONTENT (%)	12.28						
FINAL SLAKE CONDITION							
RETAINED SPECIMEN TYPE	TYPE II						
SLAKE DURABILITY INDEX	74.3						

REVIEWED BY

J. Noor

DATE


2021-02-17

SLAKE DURABILITY OF ROCK

ASTM D4644

CLIENT The Regional Municipality of Peel
PROJECT Detailed Design of Watermain Replacement on Dixie Road
LOCATION Dixie Road; City of Mississauga, Ontario

PML REF 20TF025A
REPORT NO
ENCLOSURE
LAB NUMBER 2100568 G
DATE TESTED 2021-02-09

SAMPLE DETAILS							
BH	10	SAMPLE NO	1	DEPTH	39' 10"	TYPE	Core
DESCRIPTION	Shale						
INITIAL MOISTURE CONTENT							
TARE + WET SAMPLE (g)	541.88						
TARE + DRY SAMPLE (g)	528.52						
WATER (g)	13.36						
TARE (g)	88.40						
DRY SAMPLE (g)	440.12						
MOISTURE CONTENT (%)	3.04						
INITIAL SLAKE CONDITION							
DRUM + DRY SAMPLE (g)	1677.00						
SLAKE CYCLE 1							
DRUM + WET SAMPLE (g)	1667.50						
DRUM + DRY SAMPLE (g)	1638.40						
WATER (g)	29.10						
DRUM (g)	1237.10						
DRY SAMPLE (g)	401.30						
MOISTURE CONTENT (%)	7.25						
SLAKE CYCLE 2							
DRUM + WET SAMPLE (g)	1602.70						
DRUM + DRY SAMPLE (g)	1570.40						
WATER (g)	32.30						
DRUM (g)	1237.10						
DRY SAMPLE (g)	333.30						
MOISTURE CONTENT (%)	9.69						
FINAL SLAKE CONDITION							
RETAINED SPECIMEN TYPE	TYPE II						
SLAKE DURABILITY INDEX	75.8						

REVIEWED BY

J. Noor

DATE

2021-02-17

ABRASIVENESS OF ROCK USING CERCHAR METHOD
ASTM D7625

ABRASIVENESS OF ROCK USING CERCHAR METHOD
ASTM D7625

*ABRASIVENESS OF ROCK USING CERCHAR METHOD
ASTM D7625*



Western
Geotechnical
Research Centre

FACTUAL REPORT

Factual Results of Laboratory Swell Tests on Rock Samples

Dixie Road Watermain, Mississauga

(Peto MacCallum Project No.: 20TF025A)

Prepared for:
Peto MacCallum Ltd.
126 Cartwright Avenue
Toronto, ON
M6A 1V5

Geotechnical Research Centre,
Western University
June 18, 2021

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1. Introduction

Geotechnical Research Centre, Western University was retained by Peto MacCallum Ltd. (The Client) to test the swelling characteristics of shale cores of Georgian Bay Formation from boreholes BH04, BH05, BH06, and BH09 drilled for the Dixie Road Watermain Project in Mississauga, Ontario. The following swell tests were requested by the Client to be performed on the received rock cores from:

- Two (2) null swell test – vertical direction (NSTV)
- Two (2) null swell test – horizontal direction (NSTH)

This report presents factual laboratory results of swell tests completed on the received rock samples. The results of water content tests, pore water salinity tests and calcite content tests done on the same rock samples are also included.

2. Received Rock Samples

The rock samples received from the Client are listed in Table 1 attached in Appendix A. Table 1 includes the borehole ID, the date of rock core received, the depth and the length of cores. The table also includes information about conditions of samples upon their opening as well as information for which swell test they are used.

A total of four (4) HQ3 rock cores (i.e. diameter ~ 61 mm) recovered from boreholes BH04, BH05, BH06, and BH09 (one from each borehole) were received on February 5, 2021. All of the cores received were wrapped by electrical tape and bubble wrap and then placed in a plastic tube. The cores recovered were sedimentary rocks of Georgian Bay Formation (see Figure 2 and 3, Appendix B).

3. Laboratory Testing Program

The laboratory testing program requested by the Client included: two (2) NSTV, and two (2) NSTH, totalling four (4) swell tests. Swell tests were obtained from all received rock cores. A summary of swell tests performed on received rock cores is presented in Table 1 in Appendix A.

The specimen for the horizontal NST was obtained by coring perpendicularly available vertical cores using a laboratory coring machine. The laboratory cored specimens were approximately 31.5 mm in diameter. For vertical NSTs, measurements were taken perpendicular to rock beddings, while for horizontal NSTs, measurements were taken parallel to rock beddings.

4. Methodology of Testing

4.1 Null Swell Tests

Null swell tests were included in the testing program to measure the critical pressure required to completely suppress swelling in the vertical or horizontal direction. A typical setup is shown in Figure 1 in Appendix B. This test arrangement consists of the loading support frame, the load cell and loading–cap assembly, deformation monitoring system and container where sample is submerged in tap water. The procedure and method of interpretation for null swell tests have been discussed in Lo (1989) and Lo and Lee (1990).

4.2 Water Content, Salinity and Calcite Content Tests

The gravimetric method was used to measure water content of the rock sample. In this method the measurement of water content is direct, being simply the mass of water lost on drying in a convection oven at a temperature of 105°C until the mass remains constant. It was experimentally established that shales need four (4) days of drying to reach constant dry mass.

The salinity of rock pore fluid was determined by adding distilled water to the powdered rock sample and then centrifuging the mixture. The electrical conductivity of the supernatant of the centrifuged solution was measured using a conductivity meter (WTW TetraCon 325), and then converted to the salinity (salt concentration) expressed in grams per litre of pore water, NaCl equivalent.

Water content and salinity of each swell test specimen were measured before and after the test (after 100 days of swelling). Before a swell test, water content and salinity were measured on rock pieces adjacent to the swell test specimen. After swell test, water content and salinity tests were performed on the actual swell test specimen.

The gasometric method using the Chittick apparatus (Dreimanis, 1962) was used to estimate the amount of calcite in the rock samples after swell test. The calcite content was measured on the actual specimen upon the swell test was terminated.

5. Results of Laboratory Testing

The results of null swell tests are presented on the attached graphs in Appendix C. The results of calcite content, water content and salinity tests performed before and after swell tests are presented on the insert in each graph. These results are also summarized in Table 2 in Appendix A.

We appreciate opportunity to work with you on this project.

A handwritten signature in cursive script, appearing to read "Silvana Micic".

Prepared by

Silvana Micic, Ph.D., P.Eng.

A handwritten signature in cursive script, appearing to read "Kwan Yee Lo".

Reviewed by

Kwan Yee Lo, Ph.D., P.Eng., FEIC

6. References

Dreimanis, A. 1962. Quantitative Gasometric Determination of Calcite and Dolomite Using Chittick Apparatus. *Journal of Sedimentary Petrology*, Vol. 32, pp. 520-529.

Lo, K.Y. 1989. Recent Advances in Design and Evaluation of Performance of Underground Structures in Rocks. *Tunneling and Underground Space Technology*, Vol. 4, No. 2, pp. 171-183.

Lo, K.Y. and Lee, Y.N. 1990. Time-dependent Deformation Behaviour of Queenston Shale. *Canadian Geotechnical Journal*, Vol. 27, No. 3, pp. 461-471.

Appendix A - Tables

Table 1 - Summary of received rock cores and obtained swell test specimens as per the laboratory testing program

Received Rock Samples						Swell Test Specimens		Remarks
Borehole ID	Received at UWO	Run No.	Depth (ft)	Depth (m)	Length (m)	Specimen ID	Specimen Depth (m)	
BH04	5-Feb-21	2	40'9" - 41'2"	12.42 - 12.55	0.13	NSTH-4-2-1	11.87 - 11.91	Intact GB Shale with limestone interbeds
BH05	5-Feb-21	5	38'10" - 39'2"	11.84 - 11.94	0.10	NSTV-5-5-1	14.42 - 14.45	GB Shale broken into many pieces
BH06	5-Feb-21	4	47'3" - 47'7"	14.40 - 14.50	0.10	NSTV-6-4-2	12.51 - 12.54	Intact GB Shale with limestone interbeds and at bottom 0.06 m of sample, sample was dry and cracking upon opening
BH09	5-Feb-21	2	52'4" - 52'9"	15.95 - 16.07	0.12	NSTH-9-2-2	16.03 - 16.06	Intact GB shale with limestone at middle of sample

Table 2 - Summary of water content, salinity, and calcite content tests performed on rock samples

Test	Depth (m)		Water Content (%)		Salinity (g/L)		Calcite Content (%)
	From	To	Initial	Final	Initial	Final	
NSTV-5-5-1	11.87	11.91	3.2	3.6	35.8	23.9	2.2
NSTV-6-4-2	14.42	14.45	3.7	4.4	35.7	19.7	1.0
NSTH-4-2-1	12.51	12.54	4.5	5.0	27.7	10.0	3.8
NSTH-9-2-2	16.03	16.06	4.4	4.7	19.4	13.1	1.7

Appendix B - Figures

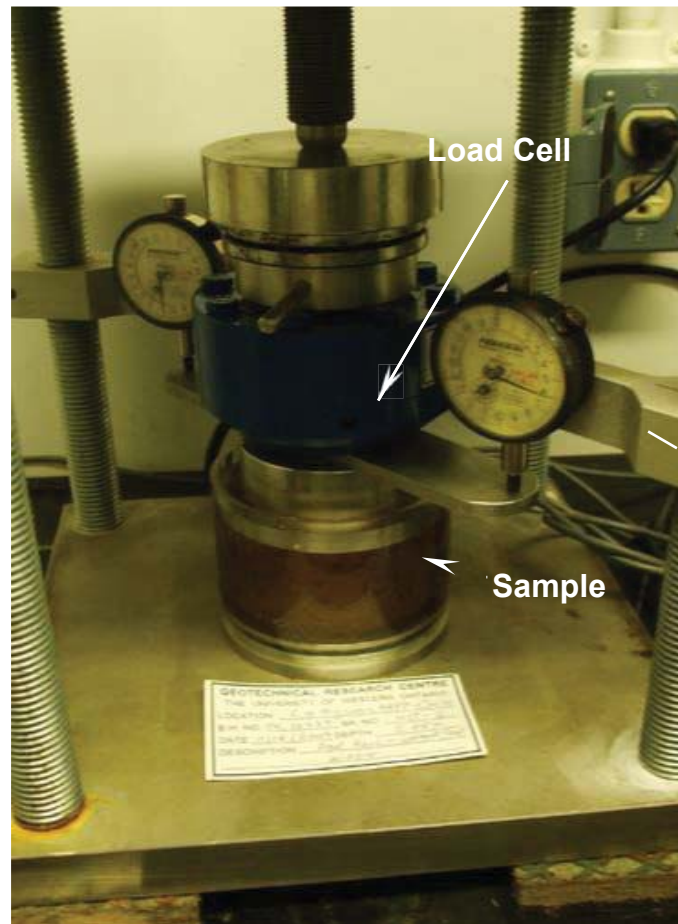


Figure 1 - Typical set up for null swell test

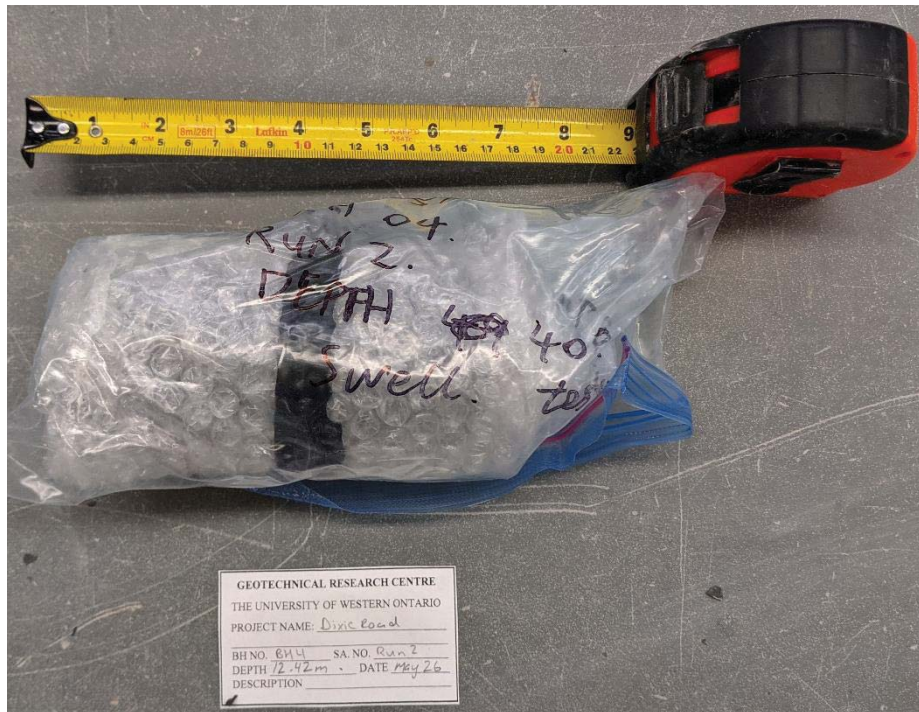


Figure 2 – Rock core prior to opening (BH04)



Figure 3 – Rock core upon opening (BH04)

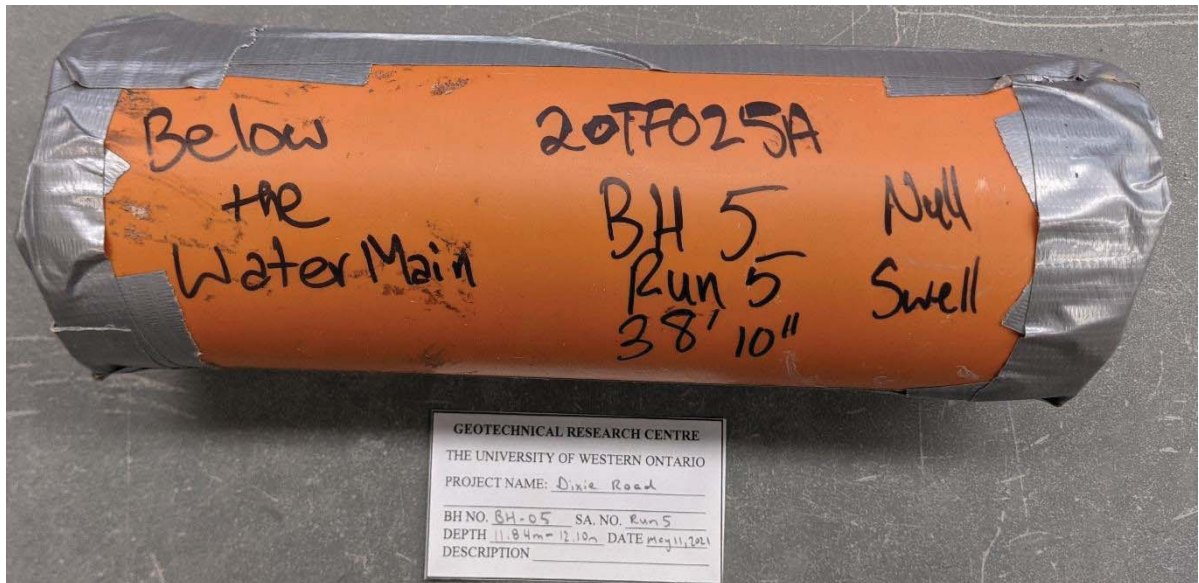


Figure 4 – Rock core prior to opening (BH05)



Figure 5 – Rock core upon opening (BH05)

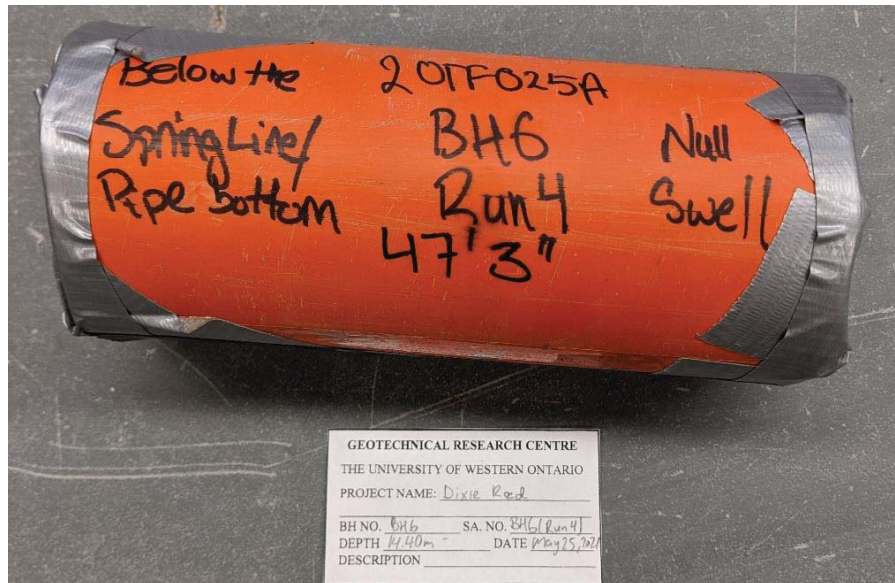


Figure 5 – Rock core prior to opening (BH06)

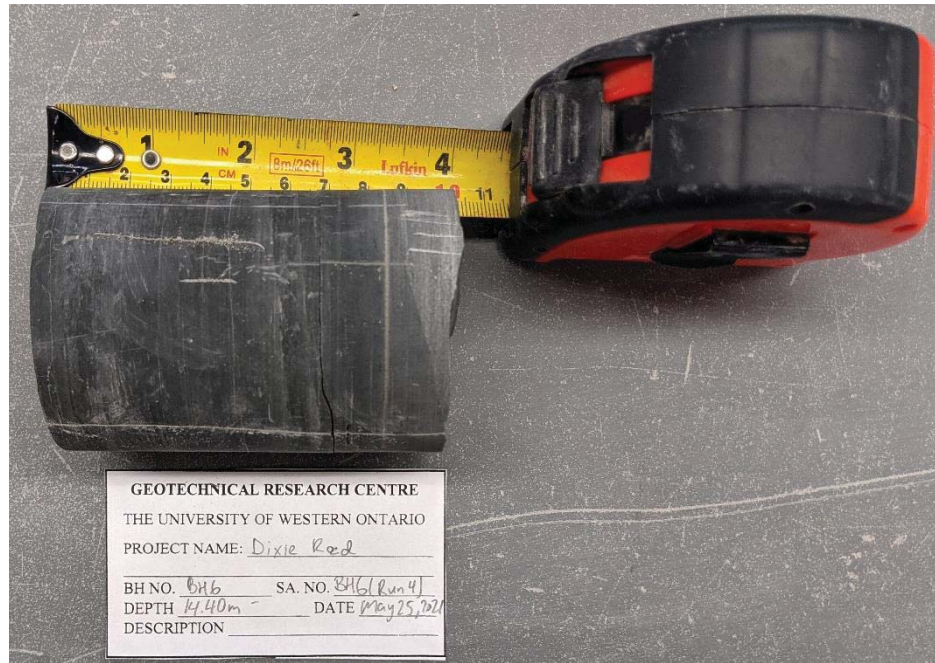


Figure 6 – Rock core upon opening (BH06)

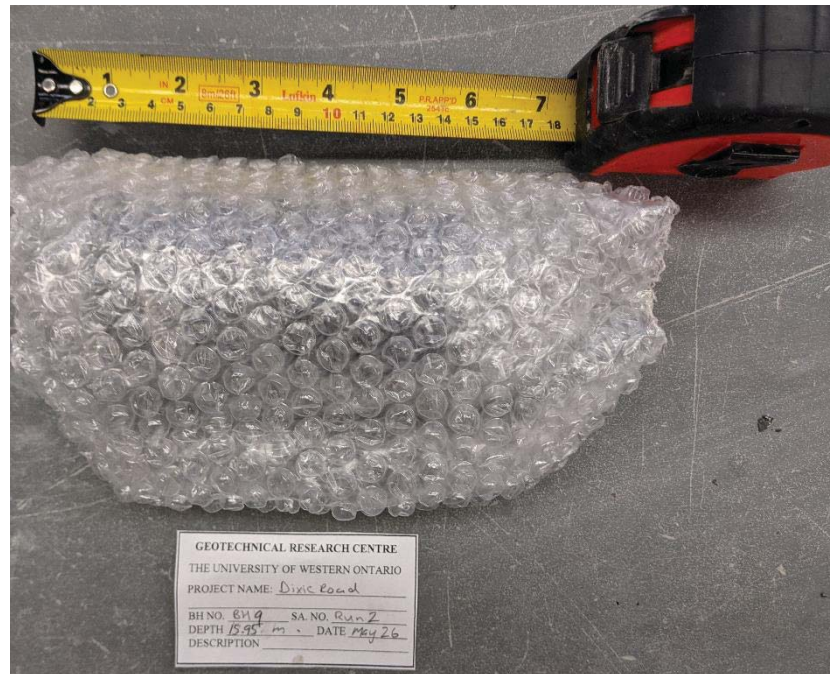


Figure 7 – Rock core prior to opening (BH09)



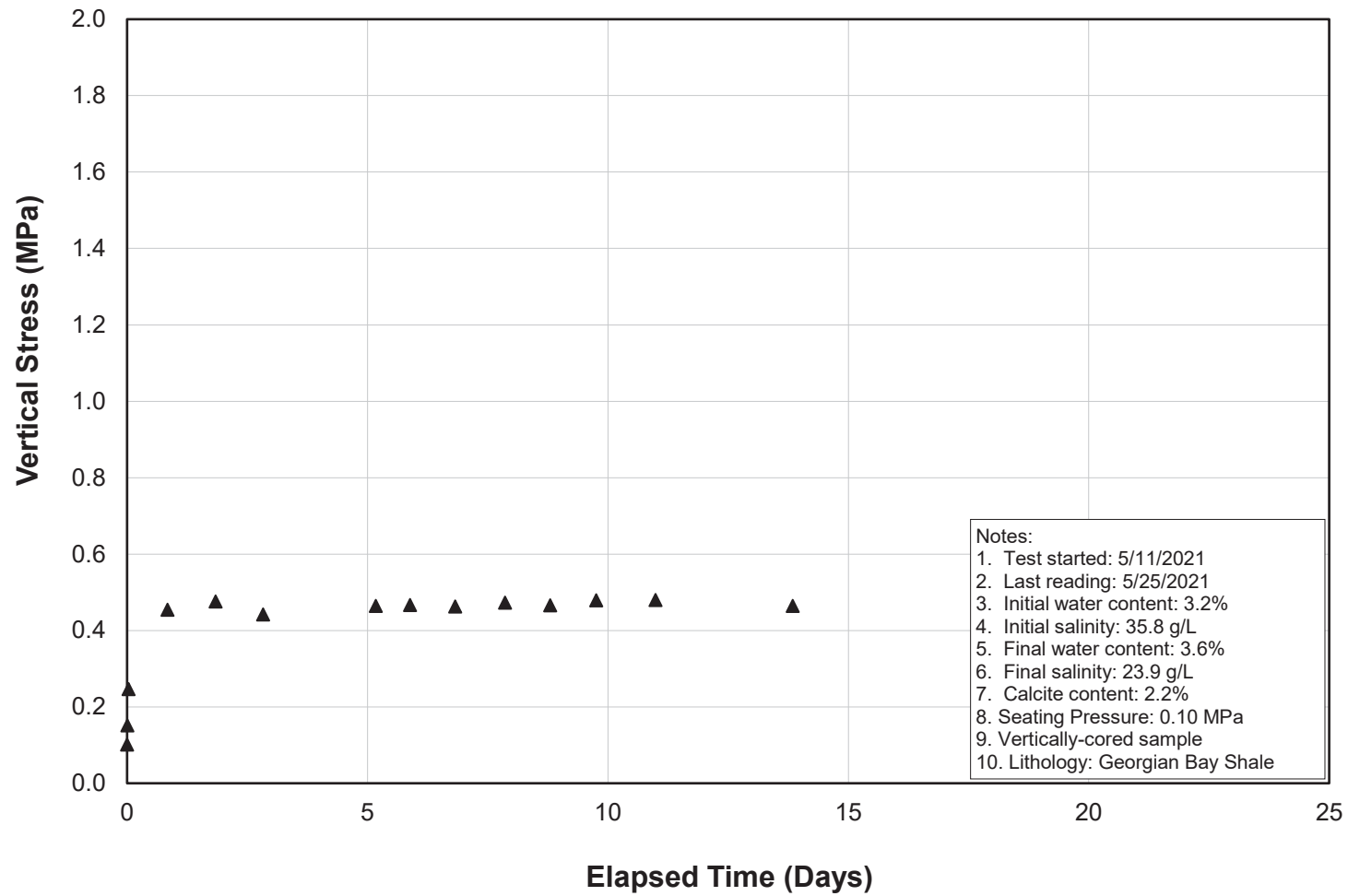
Figure 8 – Rock core upon opening (BH09)

Appendix C - Results of Null Swell Tests

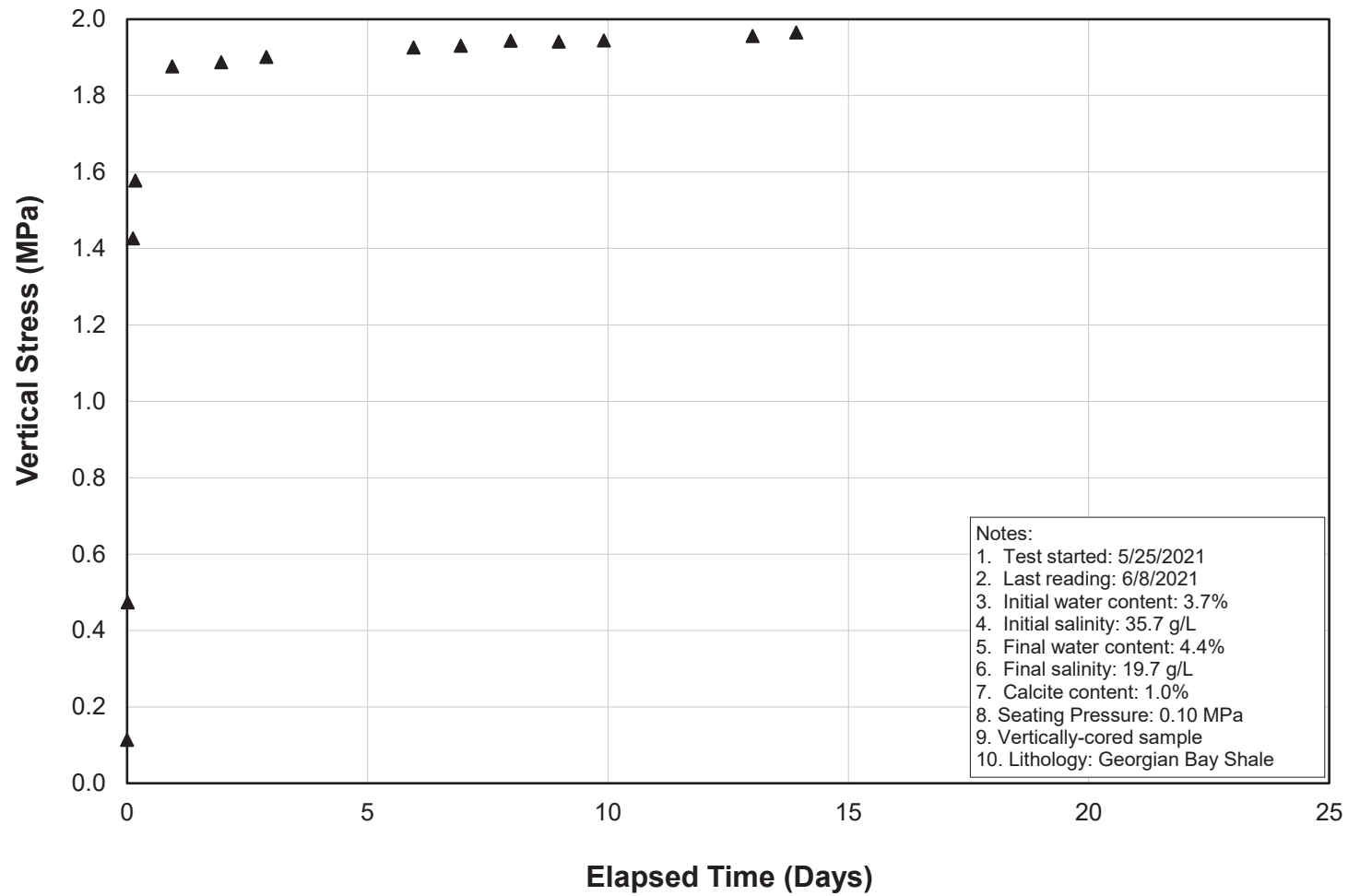
Null Swell Test - Vertical
Dixie Road Watermain, Mississauga

NSTV-5-5-1

BH: BH05; Run: 5; Depth: 11.87m - 11.91m



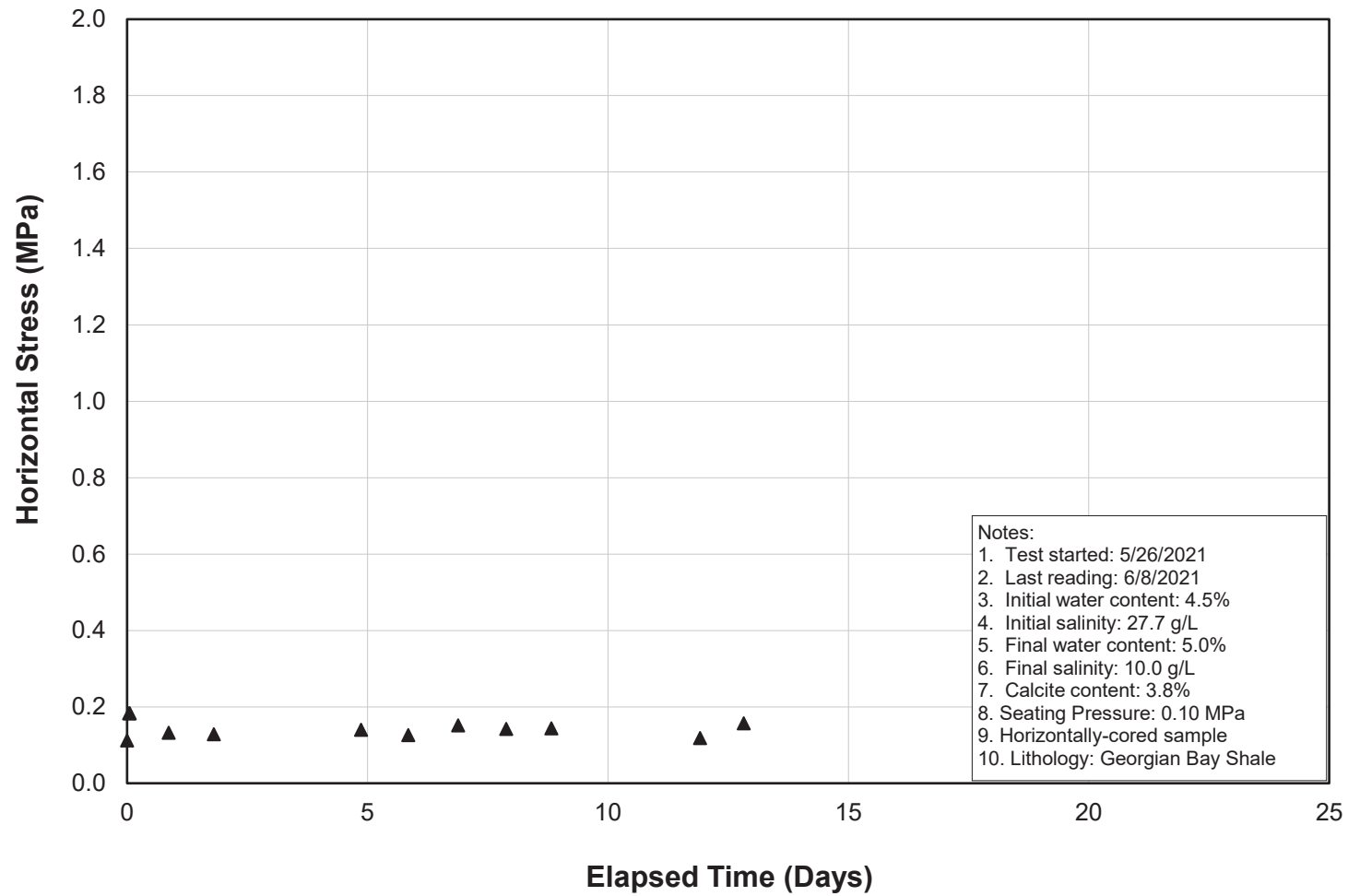
Null Swell Test - Vertical
Dixie Road Watermain, Mississauga
NSTV-6-4-2
BH: BH06; Run: 4; Depth: 14.42m - 14.45m



Null Swell Test - Horizontal
Dixie Road Watermain, Mississauga

NSTH-4-2-1

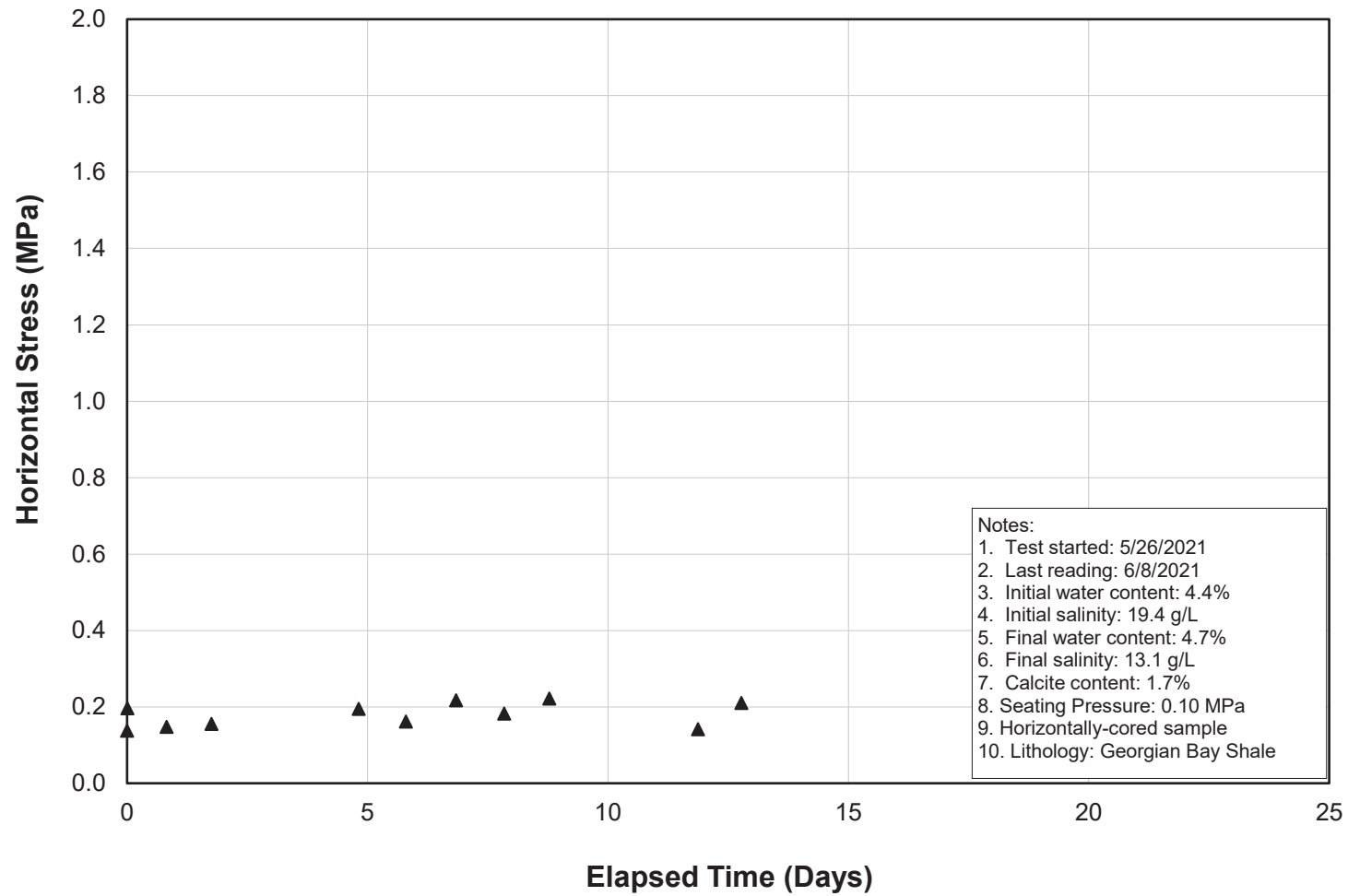
BH: BH04; Run: 2; Depth: 12.51m - 12.54m



Null Swell Test - Horizontal
Dixie Road Watermain, Mississauga

NSTH-9-2-2

BH: BH09; Run: 2; Depth: 16.03m - 16.06m



MEMO

TO: MOHAMMED ZAMSHAD, M.ENG, P.ENG

CC:

FROM: SEAN MALONEY

CENTRE: GEOMECHANICS RESEARCH

DATE: APRIL 19, 2021

RE: NULL SWELL TEST RESULTS

The Geomechanics Research Centre was contracted by Mohammed Zamshad, Senior Geotechnical/Materials Engineer at Peto MacCallum Ltd. to perform null swell tests on six (6) shale samples. Testing was performed in accordance with ISRM (1977) procedures using a Durham Geo Terraload S450 consolidometer; applied load and deformation were digitally monitored/recorded with an Omega DAQ-3000 logger sampling at a frequency of 10Hz. Post test data processing and analysis were performed in Excel®. The results of the tests are presented in Table 1 below. Plots of the individual tests showing the development of the resisting force (device air pressure) are presented in Figures 1 through 6.

Table 1: Results of Null Swell Tests

Sample	Diameter (mm)	Height (mm)	Weight (g)	Water Content (%)	Maximum Applied Force (kN)	Swell Index (kPa)
BH01 35'-8"	62.7	23.7	189.8	2.95	1.290	418
BH01 37'-2"	62.7	19.4	147.1	4.27	1.150	372
BH04 41'-10"	63.0	15.7	122.0	3.64	0.630	202
BH04 42'-4"	63.0	23.1	191.9	4.03	0.578	186
BH06 44'-2"	63.0	21.5	161.7	3.26	0.307	98
BH10 41'-6"	63.2	11.8	90.8	3.83	0.568	181

References

ISRM 1977 Suggested Method for Determining Water Content, Porosity, Density, Absorption and Related Properties and Swelling and Slake-Durability Index Properties. Int'l J. Rock Mechanics Mining Sciences & Geomechanics Abstracts 16: 141–156

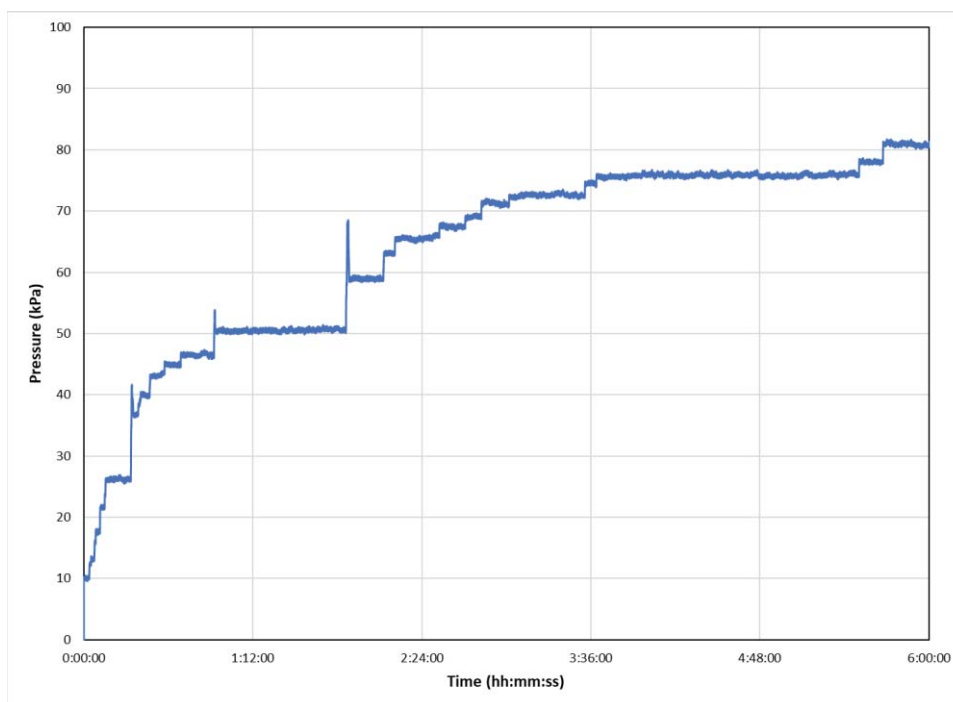


Figure 1: Null Swell Pressure Curve - Sample BH01 35'8"

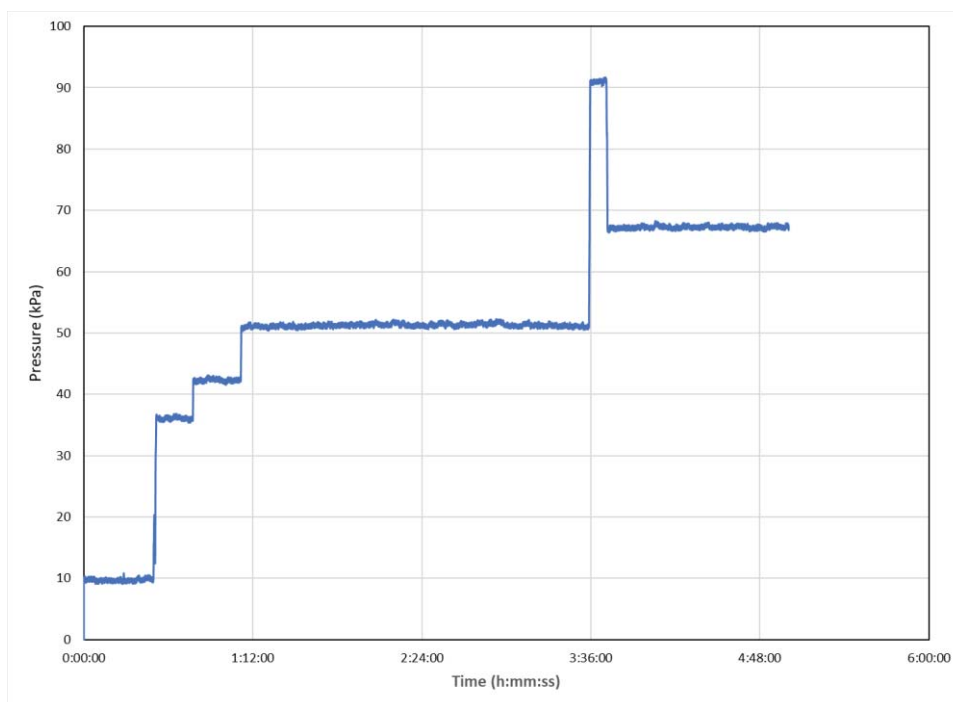


Figure 2: Null Swell Pressure Curve - Sample BH01 37'2"

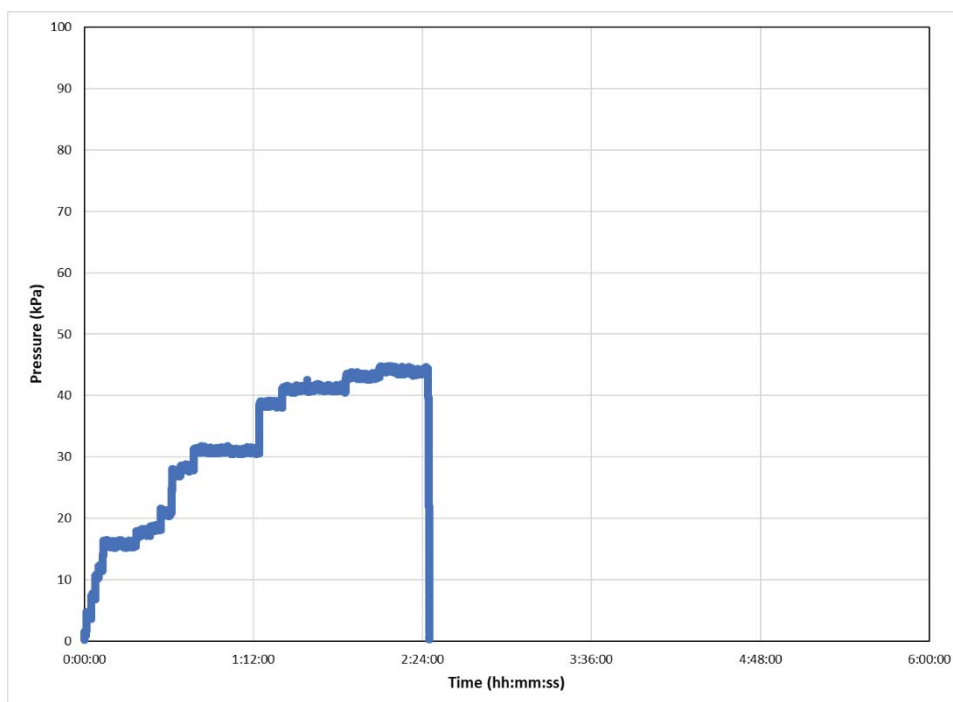


Figure 3: Null Swell Pressure Curve - Sample BH04 41'10"

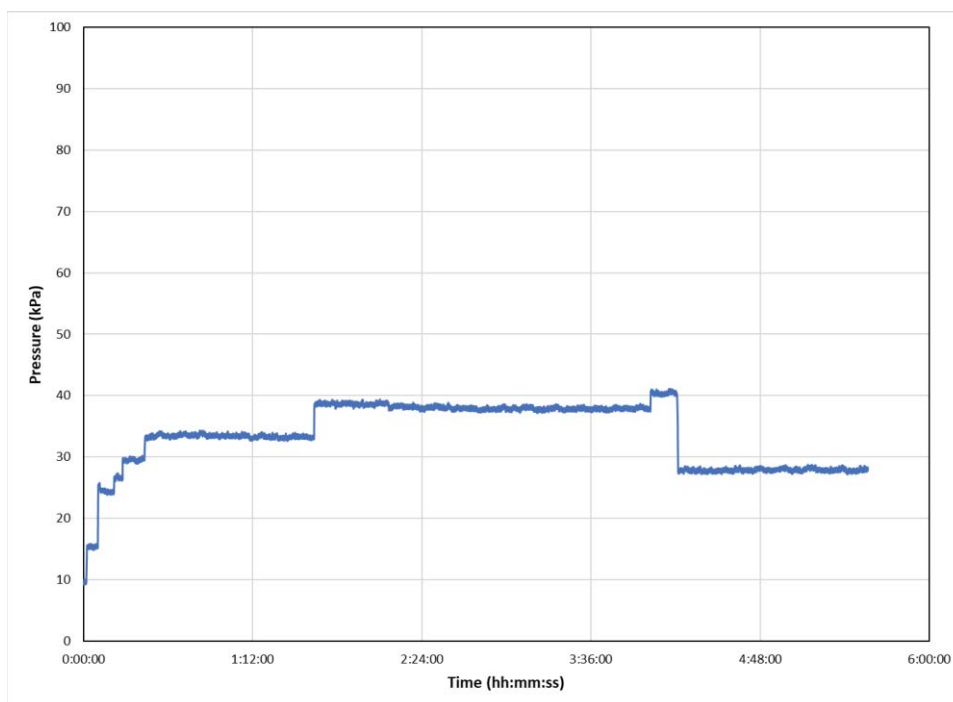


Figure 4: Null Swell Pressure Curve - Sample BH04 42'4"

MEMO CONT'D

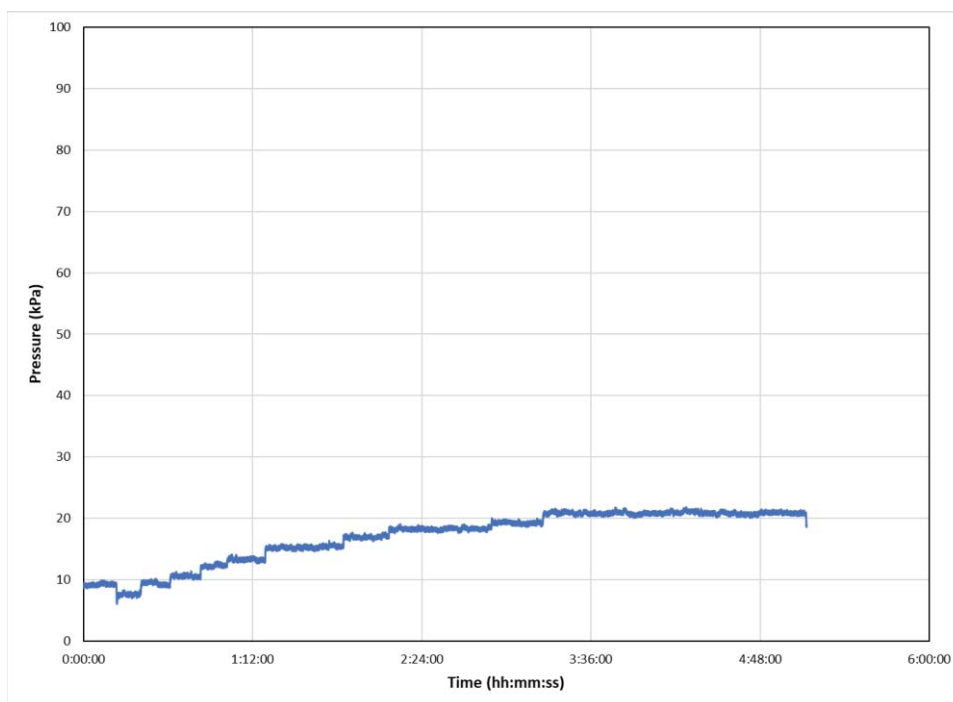


Figure 5: Null Swell Pressure Curve - Sample BH06 44'2"

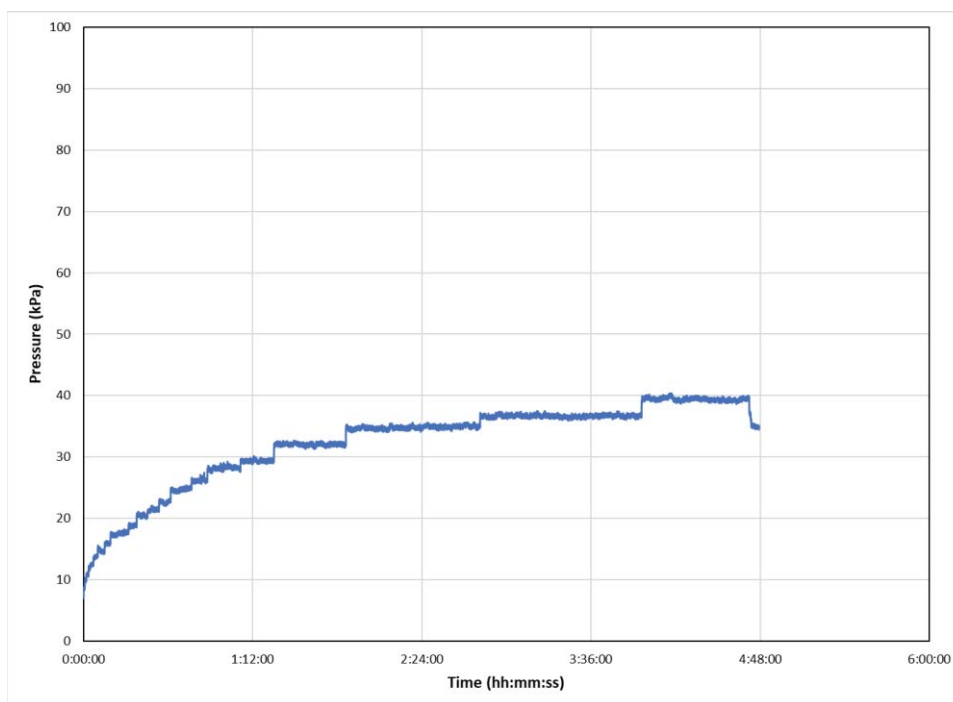


Figure 6: Null Swell Pressure Curve - Sample BH10 41'2"

MOISTURE DENSITY RELATIONSHIP TEST REPORT

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road (Project 20-1311)	REPORT NO	Proc-1
LOCATION	Dixie Road; City of Mississauga, Ontario	ENCLOSURE	

SAMPLE TYPE	Brown Sandy Clayey Silt, trace gravel	SAMPLE NO	2008196
SOURCE	Auger Cuttings	DATE SAMPLED	December 03, 2020
SAMPLED FROM	BH2, from 6.1 m to 7.6 m	SAMPLED BY	Akbar Hossain
DATE TESTED	December 07, 2020	DATE RECEIVED	December 04, 2020

PROCTOR TEST RESULTS

TEST METHOD	<div style="display: flex; justify-content: space-between;"> ASTM D698 METHOD <input checked="" type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C </div> <div style="display: flex; justify-content: space-between;"> ASTM D1557 METHOD <input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C </div> <div style="display: flex; justify-content: space-between;"> MTO LS-706 PROCEDURE <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 </div> <div style="display: flex; justify-content: space-between;"> MTO LS-707 PROCEDURE <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 </div> <div style="display: flex; justify-content: space-between;"> AIRPORT <input type="checkbox"/> </div>
MATERIAL RETAINED ON 4.75 mm SIEVE (%)	4.7
MATERIAL RETAINED ON 9.5 mm SIEVE (%)	
MATERIAL RETAINED ON 19 mm SIEVE (%)	
MATERIAL RETAINED ON 26.5 mm SIEVE (%)	
MOISTURE CONTENT, AS RECEIVED (%)	8.2
MAXIMUM DRY DENSITY (kg/m ³)	1880
OPTIMUM MOISTURE CONTENT(%)	14.1
CORRECTED MAXIMUM DRY DENSITY (kg/m ³)	1907
CORRECTED OPTIMUM MOISTURE CONTENT (%)	13.6

REMARKS	Corrected Max. Dry Density=1907Kg/m ³ at 13.6% Moisture
---------	--

REVIEWED BY: Jalil A. Noor, B.Sc.

DATE ISSUED: December 07, 2020

MOISTURE DENSITY RELATIONSHIP TEST REPORT

CLIENT The Regional Municipality of Peel

PML REF 20TF025A

PROJECT Detailed Design of Watermain Replacement on Dixie Road (Project 20-1311)

REPORT NO Proc-1

LOCATION Dixie Road; City of Mississauga, Ontario

ENCLOSURE

SAMPLE TYPE Brown Sandy Clayey Silt, trace gravel

SAMPLE NO 2008196

SOURCE Auger Cuttings

DATE SAMPLED December 03, 2020

SAMPLED FROM BH2, from 6.1 m to 7.6 m

SAMPLED BY Akbar Hossain

DATE TESTED December 07, 2020

DATE RECEIVED December 04, 2020

MOISTURE CONTENT AS RECEIVED 8.2

ASTM D698 METHOD

☒ A ☐ B ☐ C

MAX.DRY DENSITY (kg/m³) 1880

ASTM D1557 METHOD

☐ A ☐ B ☐ C

OPTIMUM MOISTURE (%) 14.1

MTO LS-706 PROCEDURE

☐ 1 ☐ 2 ☐ 3

MTO LS-707 PROCEDURE

☐ 1 ☐ 2 ☐ 3

AIRPORT

☐

REMARKS:

Corrected Max. Dry Density=1907Kg/m³ at 13.6% Moisture



MOISTURE DENSITY RELATIONSHIP TEST REPORT

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road (Project 20-1311)	REPORT NO	Proc-2
LOCATION	Dixie Road; City of Mississauga, Ontario	ENCLOSURE	

SAMPLE TYPE	Brown Sandy Clayey Silt, trace gravel	SAMPLE NO	2008521
SOURCE	Auger Cuttings	DATE SAMPLED	December 17, 2020
SAMPLED FROM	BH7, From 8.4 m to 9.0 m	SAMPLED BY	Akbar Hossain
DATE TESTED	December 24, 2020	DATE RECEIVED	December 17, 2020

PROCTOR TEST RESULTS

TEST METHOD	<div style="display: flex; justify-content: space-between;"> ASTM D698 METHOD <input checked="" type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C </div> <div style="display: flex; justify-content: space-between;"> ASTM D1557 METHOD <input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C </div> <div style="display: flex; justify-content: space-between;"> MTO LS-706 PROCEDURE <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 </div> <div style="display: flex; justify-content: space-between;"> MTO LS-707 PROCEDURE <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 </div> <div style="display: flex; justify-content: space-between;"> AIRPORT <input type="checkbox"/> </div>
MATERIAL RETAINED ON 4.75 mm SIEVE (%)	6.5
MATERIAL RETAINED ON 9.5 mm SIEVE (%)	
MATERIAL RETAINED ON 19 mm SIEVE (%)	
MATERIAL RETAINED ON 26.5 mm SIEVE (%)	
MOISTURE CONTENT, AS RECEIVED (%)	10.1
MAXIMUM DRY DENSITY (kg/m ³)	1870
OPTIMUM MOISTURE CONTENT(%)	15.0
CORRECTED MAXIMUM DRY DENSITY (kg/m ³)	1908
CORRECTED OPTIMUM MOISTURE CONTENT (%)	14.2

REMARKS	Corrected Max. Dry Density=1908Kg/m ³ at 14.2% Moisture
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REVIEWED BY: Jalil A. Noor, B.Sc.

DATE ISSUED: December 24, 2020

MOISTURE DENSITY RELATIONSHIP TEST REPORT

CLIENT The Regional Municipality of Peel

PML REF 20TF025A

PROJECT Detailed Design of Watermain Replacement on Dixie Road (Project 20-1311)

REPORT NO Proc-2

LOCATION Dixie Road; City of Mississauga, Ontario

ENCLOSURE

SAMPLE TYPE Brown Sandy Clayey Silt, trace gravel

SAMPLE NO 2008521

SOURCE Auger Cuttings

DATE SAMPLED December 17, 2020

SAMPLED FROM BH7, from 8.4 m to 9.0 m

SAMPLED BY Akbar Hossain

DATE TESTED December 24, 2020

DATE RECEIVED December 17, 2020

MOISTURE CONTENT AS RECEIVED 10.1

ASTM D698 METHOD

☒ A ☐ B ☐ C

MAX.DRY DENSITY (kg/m³) 1870

ASTM D1557 METHOD

☐ A ☐ B ☐ C

OPTIMUM MOISTURE (%) 15.0

MTO LS-706 PROCEDURE

☐ 1 ☐ 2 ☐ 3

MTO LS-707 PROCEDURE

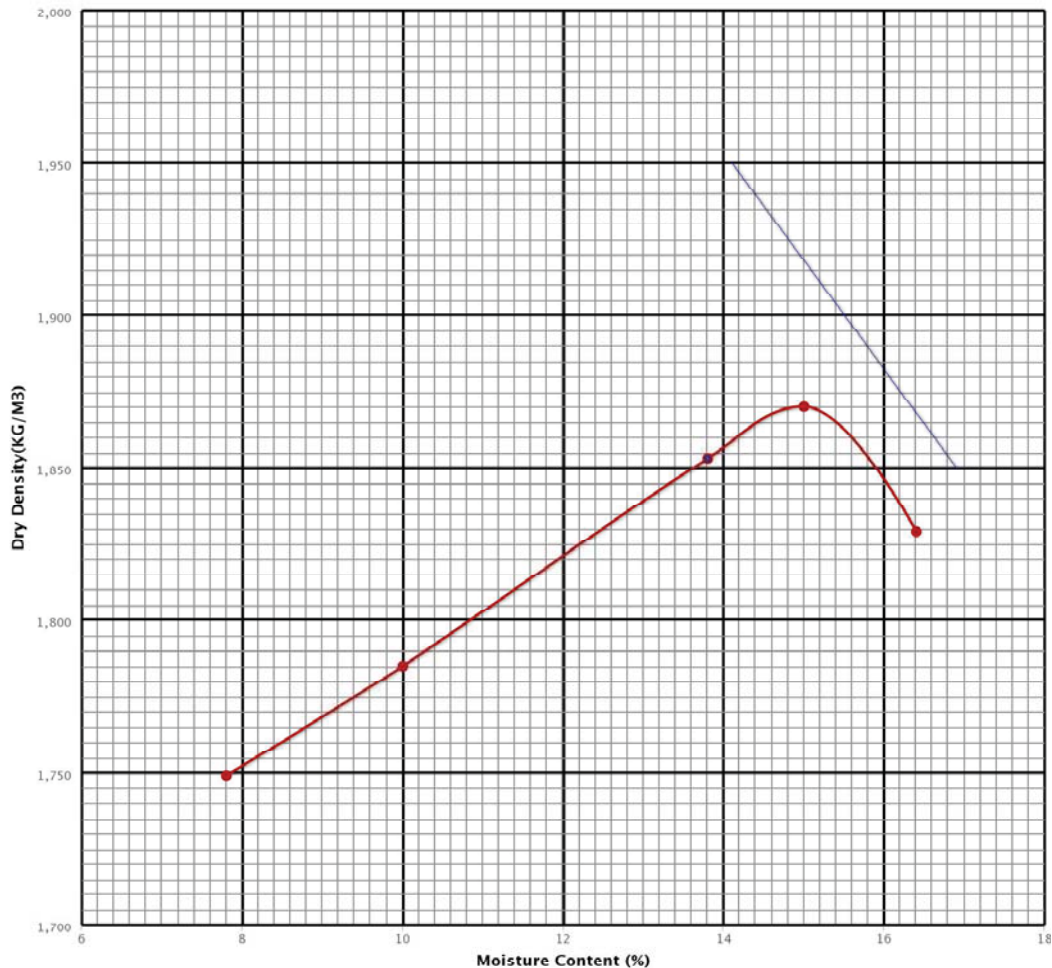
☐ 1 ☐ 2 ☐ 3

AIRPORT

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REMARKS:

Corrected Max. Dry Density=1908Kg/m³ at 14.2% Moisture



MOISTURE DENSITY RELATIONSHIP TEST REPORT

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road (Project 20-1311)	REPORT NO	Proc-3
LOCATION	Dixie Road; City of Mississauga, Ontario	ENCLOSURE	

SAMPLE TYPE	Brown Clayey Silt, trace Sand and Gravel	SAMPLE NO	2008515
SOURCE	Auger Cuttings	DATE SAMPLED	December 17, 2020
SAMPLED FROM	BH9, from 7.6 m to 8.2 m	SAMPLED BY	Akbar Hossain
DATE TESTED	December 19, 2020	DATE RECEIVED	December 17, 2020

PROCTOR TEST RESULTS

TEST METHOD	<div style="display: flex; justify-content: space-between;"> ASTM D698 METHOD <input checked="" type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C </div> <div style="display: flex; justify-content: space-between;"> ASTM D1557 METHOD <input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C </div> <div style="display: flex; justify-content: space-between;"> MTO LS-706 PROCEDURE <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 </div> <div style="display: flex; justify-content: space-between;"> MTO LS-707 PROCEDURE <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 </div> <div style="display: flex; justify-content: space-between;"> AIRPORT <input type="checkbox"/> </div>
MATERIAL RETAINED ON 4.75 mm SIEVE (%)	6.5
MATERIAL RETAINED ON 9.5 mm SIEVE (%)	
MATERIAL RETAINED ON 19 mm SIEVE (%)	
MATERIAL RETAINED ON 26.5 mm SIEVE (%)	
MOISTURE CONTENT, AS RECEIVED (%)	14.3
MAXIMUM DRY DENSITY (kg/m ³)	1885
OPTIMUM MOISTURE CONTENT(%)	13.5
CORRECTED MAXIMUM DRY DENSITY (kg/m ³)	1922
CORRECTED OPTIMUM MOISTURE CONTENT (%)	12.8

REMARKS Corrected Max. Dry Density=1922Kg/m³ at 12.8% Moisture

REVIEWED BY: Jalil A. Noor, B.Sc.

DATE ISSUED: December 21, 2020

MOISTURE DENSITY RELATIONSHIP TEST REPORT

CLIENT The Regional Municipality of Peel

PML REF 20TF025A

PROJECT Detailed Design of Watermain Replacement on Dixie Road (Project 20-1311)

REPORT NO Proc-3

LOCATION Dixie Road; City of Mississauga, Ontario

ENCLOSURE

SAMPLE TYPE Brown Clayey Silt, trace Sand and Gravel

SAMPLE NO 2008515

SOURCE Auger Cuttings

DATE SAMPLED December 17, 2020

SAMPLED FROM BH9, from 7.6 m to 8.2 m

SAMPLED BY Akbar Hossain

DATE TESTED December 19, 2020

DATE RECEIVED December 17, 2020

MOISTURE CONTENT AS RECEIVED 14.3

ASTM D698 METHOD

☒ A ☐ B ☐ C

MAX.DRY DENSITY (kg/m³) 1885

ASTM D1557 METHOD

☐ A ☐ B ☐ C

OPTIMUM MOISTURE (%) 13.5

MTD LS-706 PROCEDURE

☐ 1 ☐ 2 ☐ 3

MTD LS-707 PROCEDURE

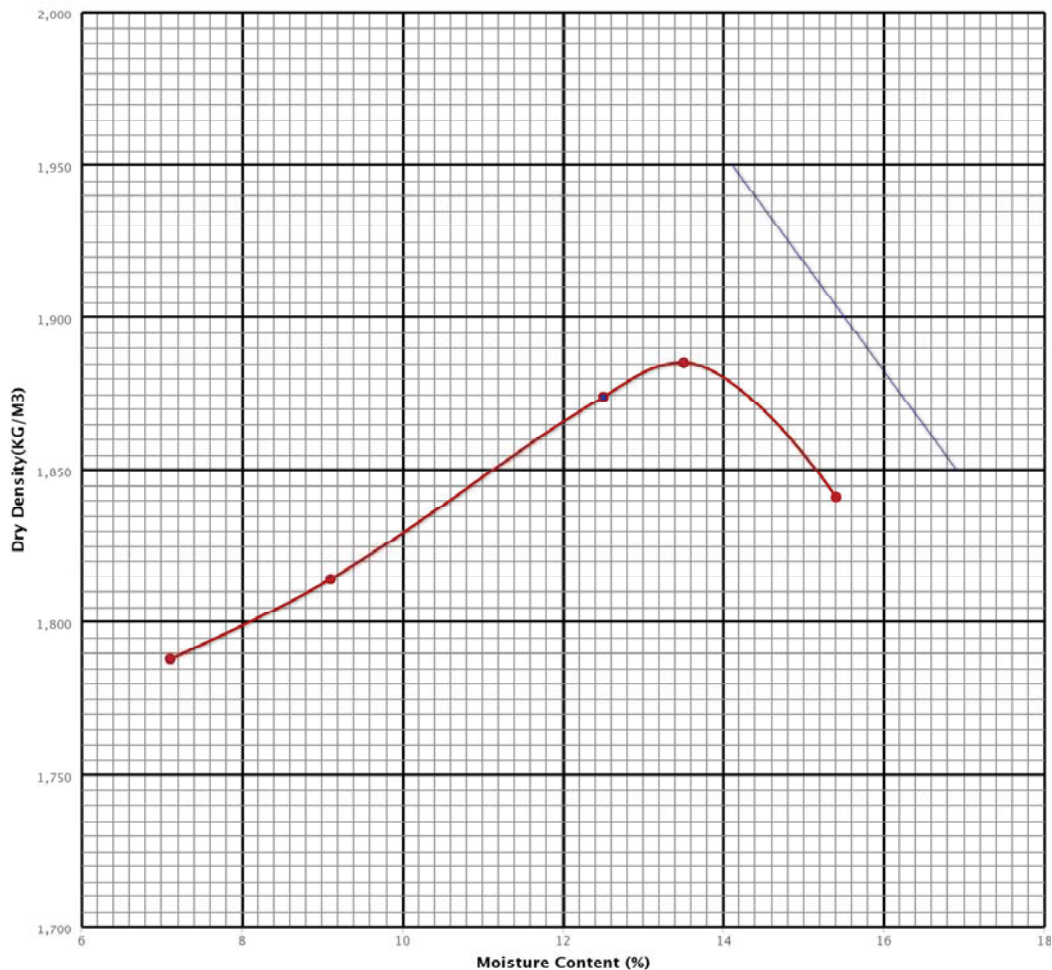
☐ 1 ☐ 2 ☐ 3

AIRPORT

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REMARKS:

Corrected Max. Dry Density=1922Kg/m³ at 12.8% Moisture



MOISTURE DENSITY RELATIONSHIP TEST REPORT

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road (Project 20-1311)	REPORT NO	Proc-4
LOCATION	Dixie Road; City of Mississauga, Ontario	ENCLOSURE	

SAMPLE TYPE	Brown Sandy Clayey Silt, trace gravel	SAMPLE NO	2008558
SOURCE	Auger Cuttings	DATE SAMPLED	December 18, 2020
SAMPLED FROM	BH10, from 6.1 m to 7.6 m	SAMPLED BY	Akbar Hossain
DATE TESTED	December 19, 2020	DATE RECEIVED	December 18, 2020

PROCTOR TEST RESULTS

TEST METHOD	ASTM D698 METHOD	<input checked="" type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C
	ASTM D1557 METHOD	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C
	MTO LS-706 PROCEDURE	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3
	MTO LS-707 PROCEDURE	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3
	AIRPORT	<input type="checkbox"/>
MATERIAL RETAINED ON 4.75 mm SIEVE (%)	6.5	
MATERIAL RETAINED ON 9.5 mm SIEVE (%)		
MATERIAL RETAINED ON 19 mm SIEVE (%)		
MATERIAL RETAINED ON 26.5 mm SIEVE (%)		
MOISTURE CONTENT, AS RECEIVED (%)	14.7	
MAXIMUM DRY DENSITY (kg/m³)	2015	
OPTIMUM MOISTURE CONTENT(%)	10.9	
CORRECTED MAXIMUM DRY DENSITY (kg/m³)	2048	
CORRECTED OPTIMUM MOISTURE CONTENT (%)	10.4	

REMARKS	Corrected Max. Dry Density=2048Kg/m3 at 10.4% Moisture
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REVIEWED BY: Jalil A. Noor, B.Sc.

DATE ISSUED: December 21, 2020

MOISTURE DENSITY RELATIONSHIP TEST REPORT

CLIENT The Regional Municipality of Peel

PML REF 20TF025A

PROJECT Detailed Design of Watermain Replacement on Dixie Road (Project 20-1311)

REPORT NO Proc-4

LOCATION Dixie Road; City of Mississauga, Ontario

ENCLOSURE

SAMPLE TYPE Brown Sandy Clayey Silt, trace gravel

SAMPLE NO 2008558

SOURCE Auger Cuttings

DATE SAMPLED December 18, 2020

SAMPLED FROM BH10, from 6.1 m to 7.6 m

SAMPLED BY Akbar Hossain

DATE TESTED December 19, 2020

DATE RECEIVED December 18, 2020

MOISTURE CONTENT AS RECEIVED 14.7

ASTM D698 METHOD

☒ A ☐ B ☐ C

MAX.DRY DENSITY (kg/m³) 2015

ASTM D1557 METHOD

☐ A ☐ B ☐ C

OPTIMUM MOISTURE (%) 10.9

MTO LS-706 PROCEDURE

☐ 1 ☐ 2 ☐ 3

MTO LS-707 PROCEDURE

☐ 1 ☐ 2 ☐ 3

AIRPORT

☐

REMARKS:

Corrected Max. Dry Density=2048Kg/m³ at 10.4% Moisture



MOISTURE DENSITY RELATIONSHIP TEST REPORT

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road (Project 20-1311)	REPORT NO	Proc-5
LOCATION	Dixie Road; City of Mississauga, Ontario	ENCLOSURE	

SAMPLE TYPE	Brown to grey Sandy Clayey Silt, trace gravel	SAMPLE NO	2008317
SOURCE	Onsite Native	DATE SAMPLED	December 10, 2020
SAMPLED FROM	BH5, SAMPLE NO. 8	SAMPLED BY	Akbar Hossain
DATE TESTED	December 12, 2020	DATE RECEIVED	December 10, 2020

PROCTOR TEST RESULTS

TEST METHOD	ASTM D698 METHOD	<input checked="" type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C
	ASTM D1557 METHOD	<input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C
	MTO LS-706 PROCEDURE	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3
	MTO LS-707 PROCEDURE	<input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3
	AIRPORT	<input type="checkbox"/>
MATERIAL RETAINED ON 4.75 mm SIEVE (%)	3.0	
MATERIAL RETAINED ON 9.5 mm SIEVE (%)		
MATERIAL RETAINED ON 19 mm SIEVE (%)		
MATERIAL RETAINED ON 26.5 mm SIEVE (%)		
MOISTURE CONTENT, AS RECEIVED (%)	8.5	
MAXIMUM DRY DENSITY (kg/m³)	1925	
OPTIMUM MOISTURE CONTENT(%)	12.0	
CORRECTED MAXIMUM DRY DENSITY (kg/m³)	1941	
CORRECTED OPTIMUM MOISTURE CONTENT (%)	11.7	

REMARKS Corrected Max. Dry Density=1941Kg/m³ at 11.7% Moisture

REVIEWED BY: Jalil A. Noor, B.Sc.

DATE ISSUED: December 14, 2020

MOISTURE DENSITY RELATIONSHIP TEST REPORT

CLIENT The Regional Municipality of Peel

PML REF 20TF025A

PROJECT Detailed Design of Watermain Replacement on Dixie Road (Project 20-1311)

REPORT NO Proc-5

LOCATION Dixie Road; City of Mississauga, Ontario

ENCLOSURE

SAMPLE TYPE Brown to grey Sandy Clayey Silt, trace gravel

SAMPLE NO 2008317

SOURCE Onsite Native

DATE SAMPLED December 10, 2020

SAMPLED FROM BH5, SAMPLE NO. 8

SAMPLED BY Akbar Hossain

DATE TESTED December 12, 2020

DATE RECEIVED December 10, 2020

MOISTURE CONTENT AS RECEIVED 8.5

ASTM D698 METHOD

☒ A ☐ B ☐ C

MAX.DRY DENSITY (kg/m³) 1925

ASTM D1557 METHOD

☐ A ☐ B ☐ C

OPTIMUM MOISTURE (%) 12.0

MTO LS-706 PROCEDURE

☐ 1 ☐ 2 ☐ 3

MTO LS-707 PROCEDURE

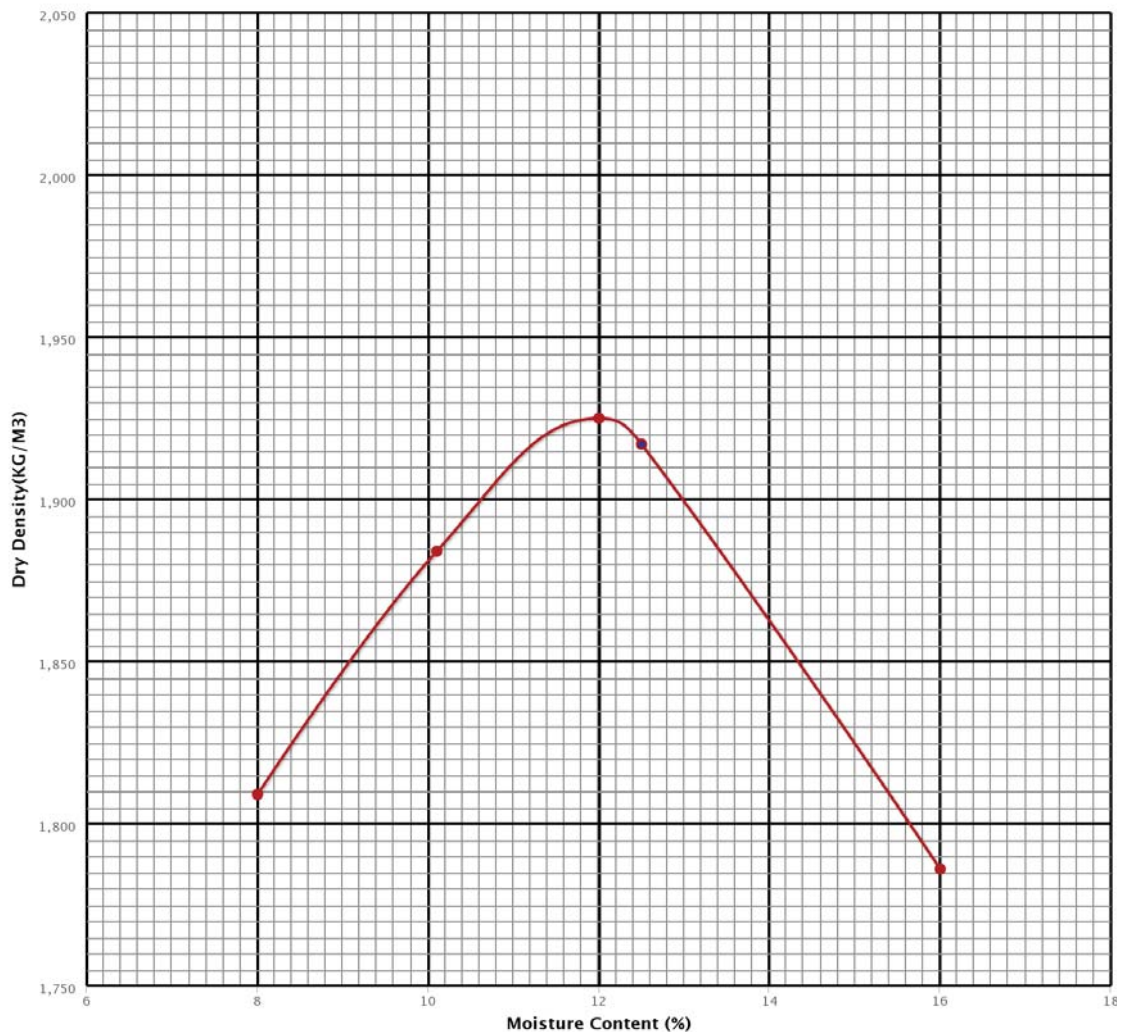
☐ 1 ☐ 2 ☐ 3

AIRPORT

☐

REMARKS:

Corrected Max. Dry Density=1941Kg/m³ at 11.7% Moisture



MOISTURE DENSITY RELATIONSHIP TEST REPORT

CLIENT	The Regional Municipality of Peel	PML REF	20TF025A
PROJECT	Detailed Design of Watermain Replacement on Dixie Road (Project 20-1311)	REPORT NO	Proc-6
LOCATION	Dixie Road; City of Mississauga, Ontario	ENCLOSURE	

SAMPLE TYPE	Brown/Grey Clayey Sand, some gravel	SAMPLE NO	2008559
SOURCE	Auger Cuttings	DATE SAMPLED	December 18, 2020
SAMPLED FROM	BH1, from 6.1 m to 7.6 m	SAMPLED BY	Akbar Hossain
DATE TESTED	December 19, 2020	DATE RECEIVED	December 18, 2020

PROCTOR TEST RESULTS

TEST METHOD	<div style="display: flex; justify-content: space-between;"> ASTM D698 METHOD <input checked="" type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C </div> <div style="display: flex; justify-content: space-between;"> ASTM D1557 METHOD <input type="checkbox"/> A <input type="checkbox"/> B <input type="checkbox"/> C </div> <div style="display: flex; justify-content: space-between;"> MTO LS-706 PROCEDURE <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 </div> <div style="display: flex; justify-content: space-between;"> MTO LS-707 PROCEDURE <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 </div> <div style="display: flex; justify-content: space-between;"> AIRPORT <input type="checkbox"/> </div>
MATERIAL RETAINED ON 4.75 mm SIEVE (%)	7.1
MATERIAL RETAINED ON 9.5 mm SIEVE (%)	
MATERIAL RETAINED ON 19 mm SIEVE (%)	
MATERIAL RETAINED ON 26.5 mm SIEVE (%)	
MOISTURE CONTENT, AS RECEIVED (%)	8.3
MAXIMUM DRY DENSITY (kg/m ³)	1945
OPTIMUM MOISTURE CONTENT(%)	12.2
CORRECTED MAXIMUM DRY DENSITY (kg/m ³)	1984
CORRECTED OPTIMUM MOISTURE CONTENT (%)	11.5

REMARKS

REVIEWED BY: Jalil A. Noor, B.Sc.

DATE ISSUED: December 21, 2020

MOISTURE DENSITY RELATIONSHIP TEST REPORT

CLIENT The Regional Municipality of Peel

PML REF 20TF025A

PROJECT Detailed Design of Watermain Replacement on Dixie Road (Project 20-1311)

REPORT NO Proc-6

LOCATION Dixie Road; City of Mississauga, Ontario

ENCLOSURE

SAMPLE TYPE Brown/Grey Clayey Sand, some gravel

SAMPLE NO 2008559

SOURCE Auger Cuttings

DATE SAMPLED December 18, 2020

SAMPLED FROM BH1, from 6.1 m to 7.6 m

SAMPLED BY Akbar Hossain

DATE TESTED December 19, 2020

DATE RECEIVED December 18, 2020

MOISTURE CONTENT AS RECEIVED 8.3

ASTM D698 METHOD

☒ A ☐ B ☐ C

MAX.DRY DENSITY (kg/m³) 1945

ASTM D1557 METHOD

☐ A ☐ B ☐ C

OPTIMUM MOISTURE (%) 12.2

MTO LS-706 PROCEDURE

☐ 1 ☐ 2 ☐ 3

MTO LS-707 PROCEDURE

☐ 1 ☐ 2 ☐ 3

AIRPORT

☐

REMARKS:





APPENDIX B

Overcoring In-Situ Stress Technical Memorandum Prepared by
Golder Associates Ltd.

TECHNICAL MEMORANDUM

DATE October 15, 2021 **Project No.** 20446253

TO Mohammed Zamshad, MEng, P.Eng.
Peto MacCallum Ltd.

CC File

FROM Sarah Pidgen/Joe Carvalho/Michael Harris **EMAIL** sarah_pidgen@golder.com

IN SITU STRESS MEASUREMENTS ALONG DIXIE ROAD, BETWEEN BRITANNIA ROAD AND HWY 401, MISSISSAUGA, ONTARIO

1.0 INTRODUCTION

The following document provides a summary of the in situ stress measurement data collected at boreholes BH-03, BH-04, BH-05, BH-06, BH-08 and BH-09 as part of the geotechnical investigation for the 400 mm watermain replacement, which will be micro-tunnelled. The stress measurements targeted the section along Dixie Road, between Britannia Road and Hwy 401, Mississauga, Ontario.

2.0 IN SITU STRESS TESTING

2.1 Testing Approach

In situ stress tests were undertaken to investigate horizontal stresses in the rock mass. The testing was conducted using the United States Bureau of Mines (USBM) borehole deformation gauge overcoring method. This method is slightly modified from the procedure described in ASTM D4623-16 to make use of standard HQ drilling equipment (96 mm diameter).

Overcoring is a common method of in situ stress measurement, whereby the USBM borehole deformation gauge is installed in an EX hole (38 mm diameter) within a volume of rock that is subject to in situ stresses. The gauge is then monitored as the EX hole is overcored and isolated from the in situ stresses. The diametral deformations of the EX hole across three axes (spaced 120 degrees apart) are recorded during the overcoring process. The steps involved in overcoring stress measurements in a vertical drillhole are described below and illustrated graphically in Figure 1.

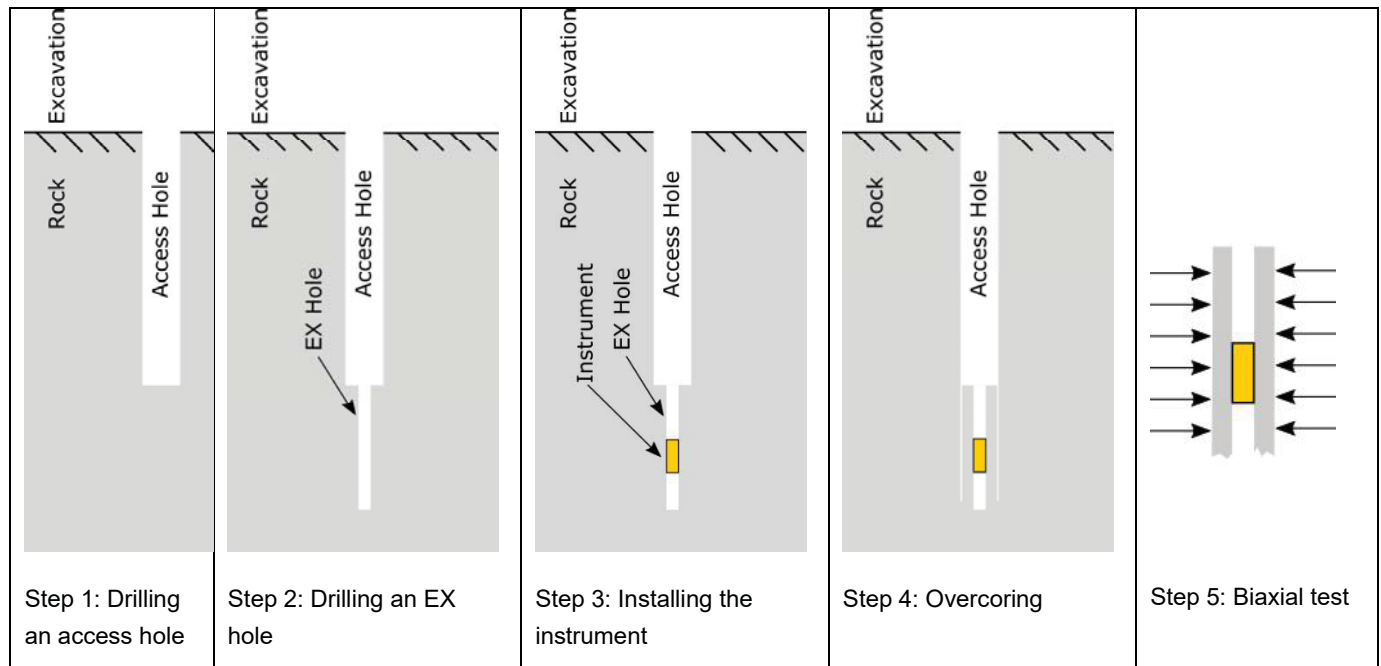


Figure 1: Generic overcoring stress measurement steps

Step 1: An access hole (96 mm diameter) is advanced to the target testing depth with standard HQ triple tube drill string and bit, with core recovery. If necessary, the bottom of the borehole is ground flat.

Step 2: A 38 mm diameter (EX size) pilot hole (approximately 600 mm in length) concentric with the 96 mm diameter hole is drilled through the desired test interval, and the core is examined for natural discontinuities.

Step 3: If a suitably long interval of the EX hole is found to be free of natural discontinuities the deformation gauge may be installed. The USBM deformation gauge (photograph shown in Figure 2 below) is then installed in the pilot hole, normally about 200 mm to 300 mm into the pilot hole (i.e., from the end of the 96 mm diameter hole). The USBM deformation gauge is designed to measure the changes in the deformation of the bedrock across three axes (spaced 120 degrees apart). The gauge has three pairs of buttons which provide contact between the surface of the 38 mm diameter pilot hole and the sensing element of the gauge.



Figure 2: Photograph of a USBM borehole deformation gauge.

Step 4: The pilot hole (with USBM gauge in position) is then overcored using a 96 mm diameter thin wall coring bit to relieve the in situ stresses around the pilot hole. The corresponding changes in diametral deformation of the pilot hole are monitored during overcoring using the USBM deformation gauge connected by a cable through the drill string to a digital strain indicator / recorder, allowing continuous observation of the borehole deformation changes during overcoring. The overcore, or sample of bedrock that was in place between the pilot hole and the thin wall coring bit during the overcore test is recovered, intact if possible.

Step 5: The elastic deformation modulus (Young's Modulus) of the bedrock overcore sample is determined by testing the recovered overcored rock sample in a biaxial chamber (cell). The cell consists of a cylindrical steel jacket, membrane and seals. The overcored rock sample, recovered from the test position, is placed in the biaxial chamber with the USBM gauge installed in the same configuration as it was during the overcore test, where possible. Hydraulic oil is pumped into the space between the steel jacket and the sealed membrane which is in contact with the overcore. The outer surface of the overcore is therefore subjected to a uniformly distributed radial (biaxial) pressure. During modulus testing, the deformation of the inner pilot hole of the overcore sample is monitored using the USBM gauge as described above at various pressure increments and decrements. A photograph of a typical biaxial test setup in the field is shown in Figure 3.

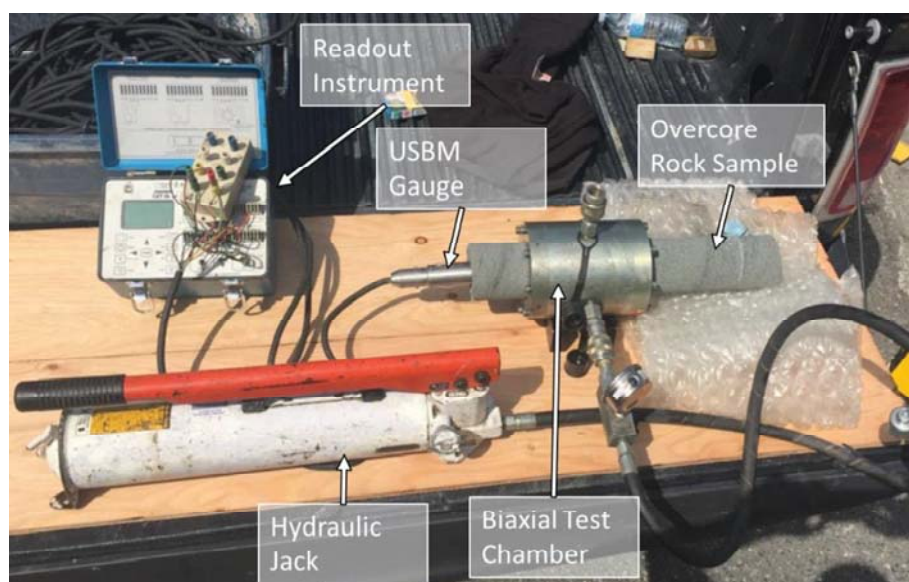


Figure 3: Typical biaxial test setup in the field

2.2 Field Activities

In situ stress testing was carried out in borehole BH-03 from December 21 to 23, 2020. On December 21, the borehole was not yet cased when Golder arrived on site and there was no opportunity for testing. On December 22, two attempts were made, one at 12.57 m depth and another at 13.64 m depth. It was not possible to seat the USBM gauge at the shallower location due to the rock quality. A successful test was completed at the deeper location. The borehole was advanced to a depth of 15.24 m and on December 23, a test was successfully attempted but damaged the instrument.

In situ stress testing resumed on January 5, 2021, at borehole BH-05. The first test was attempted at a depth of 9.67 m. Drilling the EX hole was not successful due to the poor quality of the rock in the weathered zone. A second attempt was made at a depth of 10.35 m but after recovering the core from the EX hole, it was decided that it was still too risky to test at this depth. However, the borehole was overcored to obtain a sample for a biaxial test. The borehole was advanced to a depth of 12.25 m and another attempt was made but was not successful. The rock steered the core barrel out of straight alignment and veered off until the barrel sheared. The lack of success in this borehole was due to the poor quality of the rock at the targeted depths.

Testing on borehole BH-04 started on January 7, at a depth of 13.86 m. The EX hole was drilled and upon inspection of the core it was decided that it was too risky to attempt the test. The borehole was overcored to retrieve a sample for biaxial testing but could not recover a sample large enough for the biaxial cell. The borehole was advanced to a depth of 14.62 m and the EX core was drilled and recovered. The location was still deemed too risky for a test. The borehole was overcored and a sample was successfully retrieved for a biaxial test. On January 8, the borehole was advanced to a depth of 15.32 m and a stress measurement was attempted. The USBM gauge readings recorded a very large jump as the drilling went by the gauge buttons and it is not clear whether it was because of the core splitting or due to the very low temperatures that day affecting the signal. No successful stress measurements were obtained from this hole, only one biaxial test.

Testing on borehole BH-08 started on January 12. The borehole was advanced to a depth of 16.61 m for a test. The EX hole was drilled and the gauge seated in the hole. Overcoring was stopped after advancing 2 inches. The readings during testing were erratic, which usually indicates the gauge may not be seated correctly, or there is an electrical signal issue. After recovering the core sample, it was found that the EX core barrel had deviated. The EX hole was not straight and true. The borehole was advanced to a depth of 18.06 m and a stress measurement was completed successfully. The core was recovered, and a biaxial test was also completed successfully.

Testing on borehole BH-06 started on January 14. The borehole was advanced to a depth of 12.56 m and the EX hole was drilled and the core recovered. The quality of the EX core was too poor and testing was deemed too risky. The borehole was overcored for a biaxial sample, but it was too small for the biaxial cell. The borehole was advanced to a depth of 13.90 m and the EX hole was drilled and the core recovered. There was rock stuck in the EX hole blocking the USBM gauge and the gauge could not be seated. The borehole was overcored for a biaxial sample but could not recover a sample large enough for the biaxial cell. The borehole was advanced to a depth of 15.17 m and the EX hole was drilled and the core recovered. The EX core barrel deviated and the USBM tool could only be seated 3" into EX which is not enough for testing. The borehole was overcored for a biaxial sample, but could not recover a sample large enough for the biaxial cell. No successful stress measurements or biaxial cell measurements were obtained from this hole.

Testing on borehole BH-09 started on January 18. The borehole was advanced to a depth of 17.37 m and a stress test was completed successfully. Upon retrieval of the core, a successful biaxial test was completed. The borehole was advanced to a depth of 18.16 m and a stress test was completed successfully. Upon retrieval of the core, a successful biaxial test was completed.

All boreholes were drilled into the Georgian Bay Formation. Peto MacCallum was provided daily updates on the testing progress. The boreholes were cored vertically by Walker Drilling, using an Atlas Copco CS-1000 diamond drill equipped with HQ triple-tube (HQ3) drill string. Detailed borehole information is presented below in Table 1.

Table 1: Test Borehole Details

Borehole ID	Easting (m)	Northing (m)	Ground Elevation (m.a.s.l.)	Top of Bedrock Depth (ft/m)
BH-03	609744.756	4833788.818	163.480	31.5 / 9.6
BH-04	609757.644	4833774.613	163.208	35.0 / 10.7
BH-05	609798.995	4833733.145	160.787	21.0 / 6.4
BH-06	609890.518	4833639.158	160.691	36.0 / 11.0
BH-08	609949.263	4833589.710	165.167	52.5 / 16
BH-09	609979.300	4833558.124	164.334	49 / 14.9

Notes:

ft/m = feet/metres; m.a.s.l. = metres above sea level

2.3 Evaluation of Stresses from Overcoring Stress Data

Based on the deformations measured across the three pairs of buttons of the USBM borehole deformation gauge described in Steps 3 to 4 above, the stresses on the plane perpendicular to the axis of the borehole are given by the following expressions (Obert and Duval, 1967).

$$P = \frac{E}{6d(1-\nu^2)} \left(U_1 + U_2 + U_3 + \frac{1}{\sqrt{2}} [(U_1 - U_2)^2 + (U_2 - U_3)^2 + (U_3 - U_1)^2]^{1/2} \right)$$

$$Q = \frac{E}{6d(1-\nu^2)} \left(U_1 + U_2 + U_3 - \frac{1}{\sqrt{2}} [(U_1 - U_2)^2 + (U_2 - U_3)^2 + (U_3 - U_1)^2]^{1/2} \right)$$

where,

E is the average deformation modulus

ν is the Poisson's ratio

d is the diameter of the pilot hole

U_1, U_2, U_3 are the measured changes in borehole diameter across three diameters at 60° rotation (i.e. the 3 sets of buttons on the USBM deformation gauge).

U is positive for an increasing diameter

P is the maximum stress perpendicular to borehole axis

Q is the minimum stress perpendicular to borehole axis

The direction of P is given by:

$$\theta = \frac{1}{2} \tan^{-1} \left[\frac{\sqrt{3}(U_2 - U_3)}{2U_1 - U_2 - U_3} \right]$$

where,

θ is the angle to P measured counterclockwise from the direction of the U_1 diameter.

The quadrant of θ may be determined as follows:

If	$U_2 > U_3$ and $U_2 + U_3 < 2U_1$	then θ is between 0° and 45°
	$U_2 > U_3$ and $U_2 + U_3 > 2U_1$	then θ is between 45° and 90°
	$U_2 < U_3$ and $U_2 + U_3 > 2U_1$	then θ is between 90° and 135°
	$U_2 < U_3$ and $U_2 + U_3 < 2U_1$	then θ is between 135° and 180°

The above equations are derived for plane strain conditions with zero axial strain ($\varepsilon_2 = 0$) along the borehole. If the effect of axial strain is to be taken into account, an estimate of the axial stress along the borehole is required.

The deformation modulus of the rock is evaluated from the results of the biaxial tests using the following expression and assuming isotropic elasticity:

$$E = \frac{4ab^2P_o}{(b^2 - a^2)U}$$

where,

E	is the deformation modulus
a	is the inner radius of the overcore
b	is the outer radius of the overcore
P_o	is the radial pressure on the outer surface of the overcore
U	is the average diametral deformation of pilot hole in the overcore

2.4 Results

All the in situ stress measurements were carried out within the Georgian Bay Formation which is composed of predominantly shale with occasional siltstone and limestone layers. The tests were selected in the shale portion of the formation. Due to the bedded and especially fissile nature of the shale, there is a tendency for the shale to split along the bedding planes and/or fissilities during overcoring, thus affecting the success rate in achieving interpretable tests.

Figure 4 shows the plot of the maximum (P) and minimum horizontal stresses (Q) for the interpretable tests achieved in Boreholes BH-03, BH-04, BH-08 and BH-09. The horizontal elastic modulus (E) of the rock measured from the biaxial tests on the overcore samples recovered are shown in Figure 5. The maximum horizontal

stresses range from 0.73 to 5.02 MPa whereas the minimum horizontal stresses range from 0.31 to 2.73 MPa. The ratio of the maximum to minimum horizontal stress is between 1.3 to 2.35, which is well within the expected range. The range of stress magnitudes is relatively high; however, the more reliable tests (best strain signatures) yielded maximum horizontal stresses of 2.08 and 2.24 MPa and minimum horizontal stresses of 1.42 and 1.59 MPa. The orientations of the maximum horizontal stresses are generally within $\pm 55^\circ$ of the East-West direction. In general, the magnitudes of the horizontal in situ stresses measured in the boreholes at this site are within those measured in the Greater Toronto Area (GTA). APPENDIX A presents the overcoring and biaxial test data from the interpretable tests.

Table 2: Summary of In Situ Stress Measurement Test Results

Borehole	Test No.	Depth (mbgs)	U ₁		U ₂		U ₃		P	Q	E	Azimuth of P	Remarks
		Elev.(m)	(μin)	(μm)	(μin)	(μm)	(μin)	(μm)	(MPa)	(MPa)	(GPa)	(°)	
BH-03	1	13.64 (149.84)	675	17	1017	26	728	18	2.08	1.59	6.80	60	
	2	15.24 (148.24)	1613	41	697	18	2237	57	5.02	2.73	7.65	134	
BH-04	1	15.32 (147.89)	-	-	-	-	-	-	-	-	8.16	-	Biaxial only
BH-08	1	18.06 (147.11)	283	7	453	12	408	10	1.00	0.77	6.94	68	
BH-09	1	17.37 (146.96)	313	8	672	17	360	9	2.24	1.34	11.95	144	
	2	18.16 (146.17)	137	3	31	1	200	5	0.73	0.31	12.6	40	

Notes:

Only results of interpretable tests shown

U₁, U₂, and U₃ are measured diametral deformations (in microinches and in micrometer) of the EX pilot hole during overcoring. These values are interpreted from the recorded USBM gauge readings.

P = Maximum Horizontal Stress (Major Principal Horizontal Stress).

Q = Minimum Horizontal Stress (Minor Principal Horizontal Stress).

E = Horizontal Deformation Modulus determined from biaxial tests on overcore samples unless otherwise stated

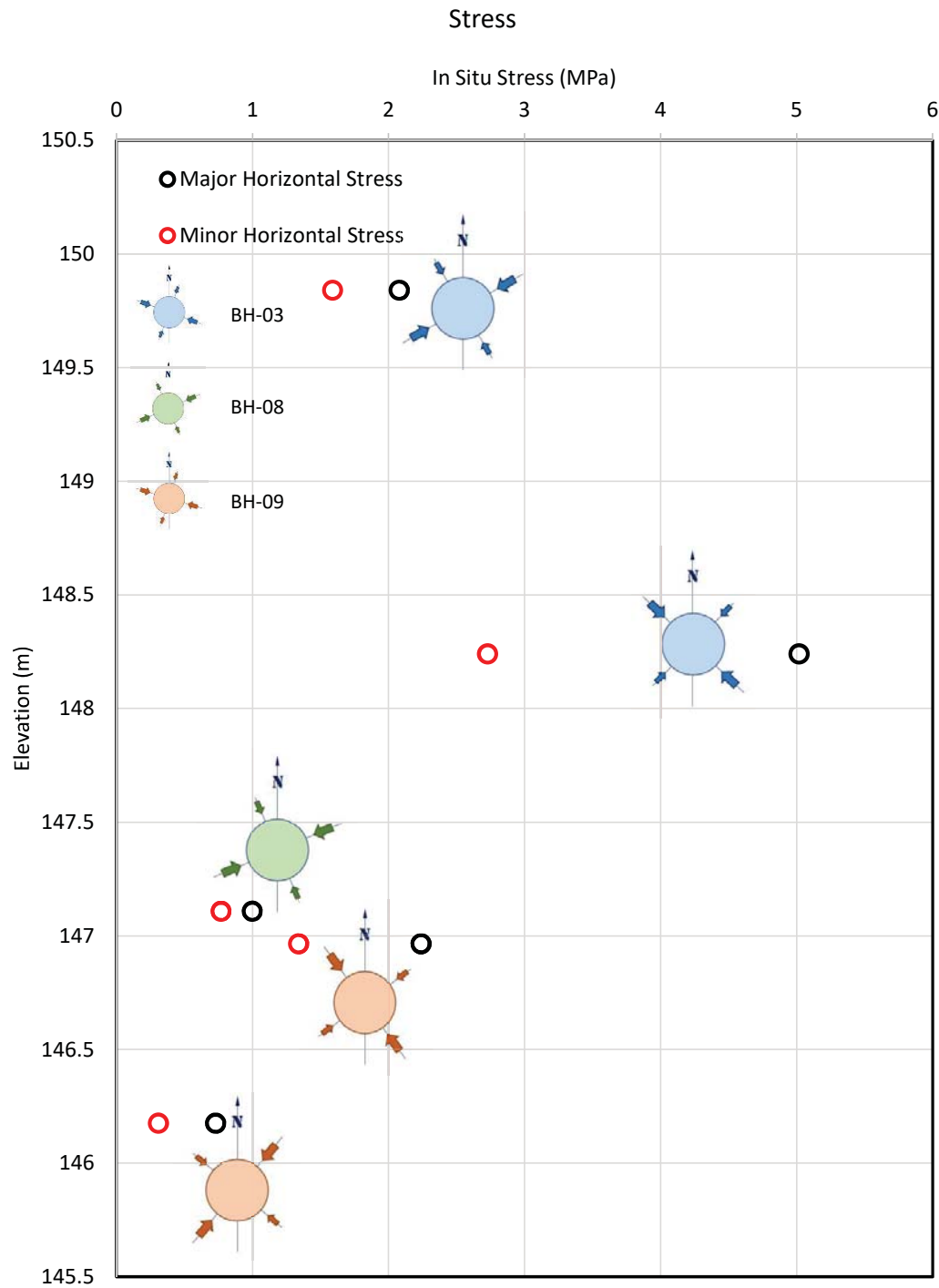


Figure 4: Maximum (P) and minimum horizontal stresses (Q) for the interpretable tests

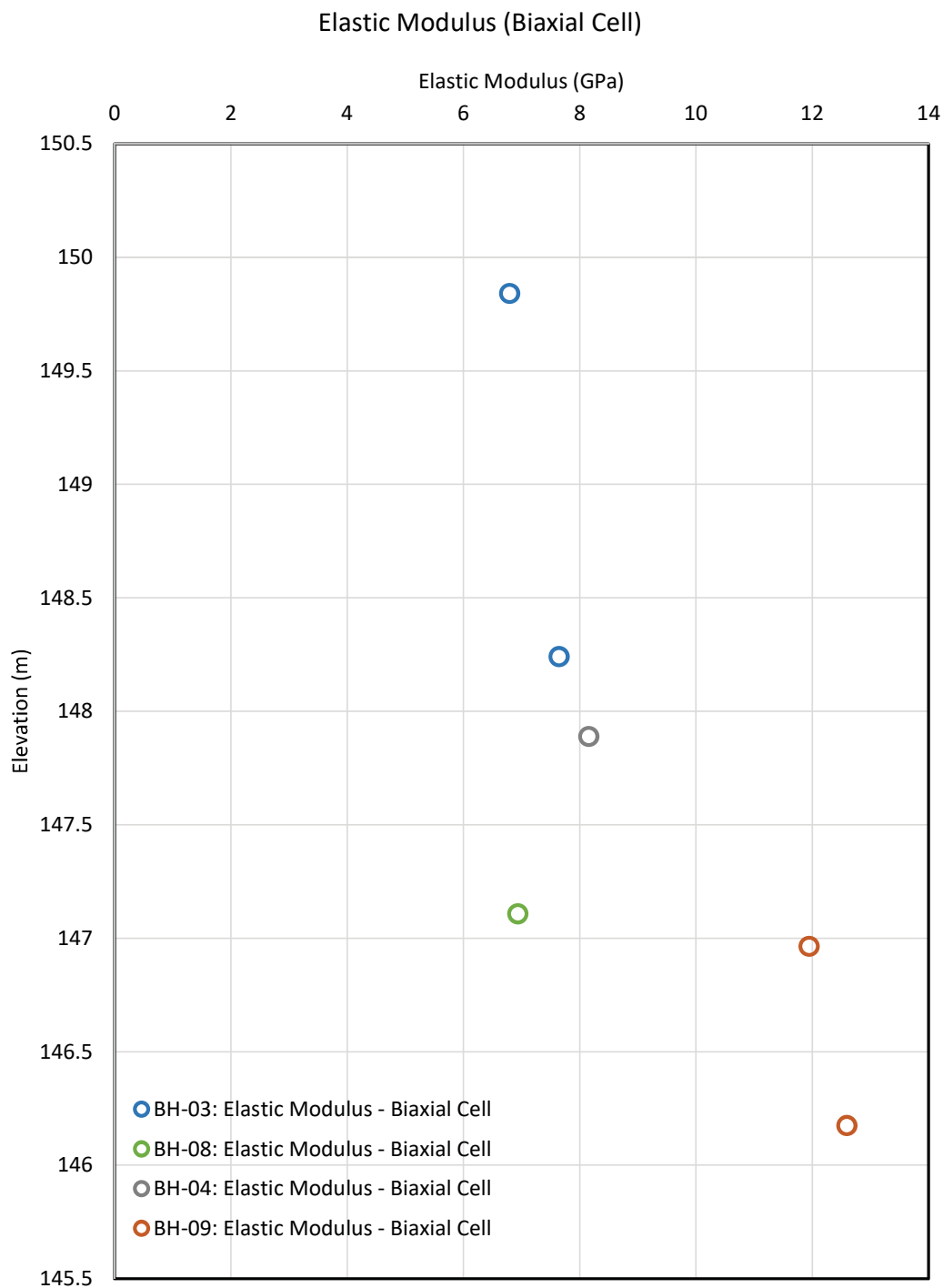
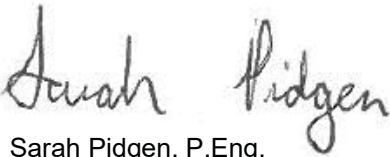


Figure 5: Horizontal elastic modulus (E) of the rock measured from the biaxial tests

3.0 CLOSURE

We trust the above meets your requirements. If you have any questions or requirements, please don't hesitate to contact the undersigned.



Sarah Pidgen, P.Eng.
Mining & Rock Engineering



Joe Carvalho, Ph.D., P.Eng.
Principal, Mining & Rock Engineering



Michael Harris,
Rock Mechanics Technician

SP/JLC/MH/jlc/jp/jl

[https://golderassociates.sharepoint.com/sites/138651/project files/6 deliverables/final/20446253 final memo insitu stress testing 2021-10-15.docx](https://golderassociates.sharepoint.com/sites/138651/project%20files/6%20deliverables/final/20446253%20final%20memo%20insitu%20stress%20testing%202021-10-15.docx)

Attachment: APPENDIX A

References

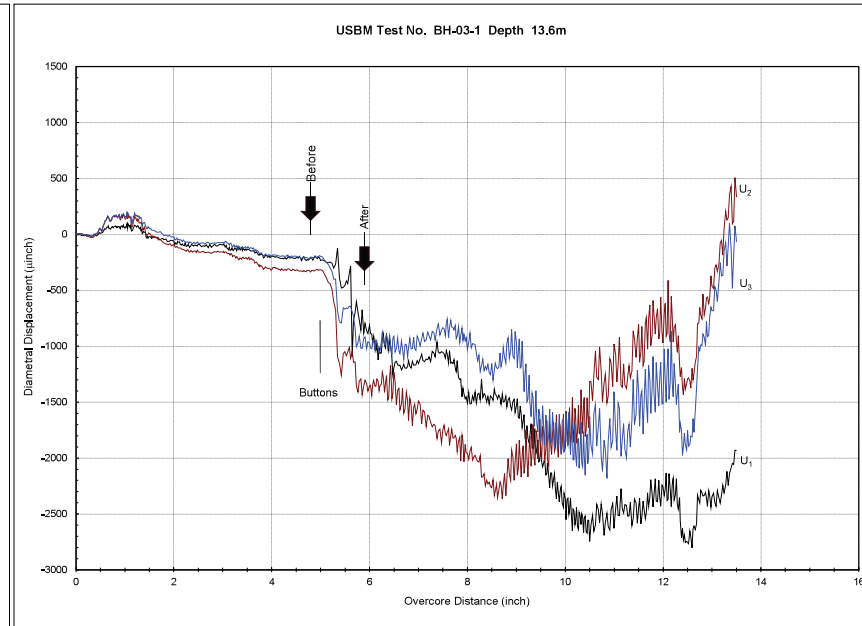
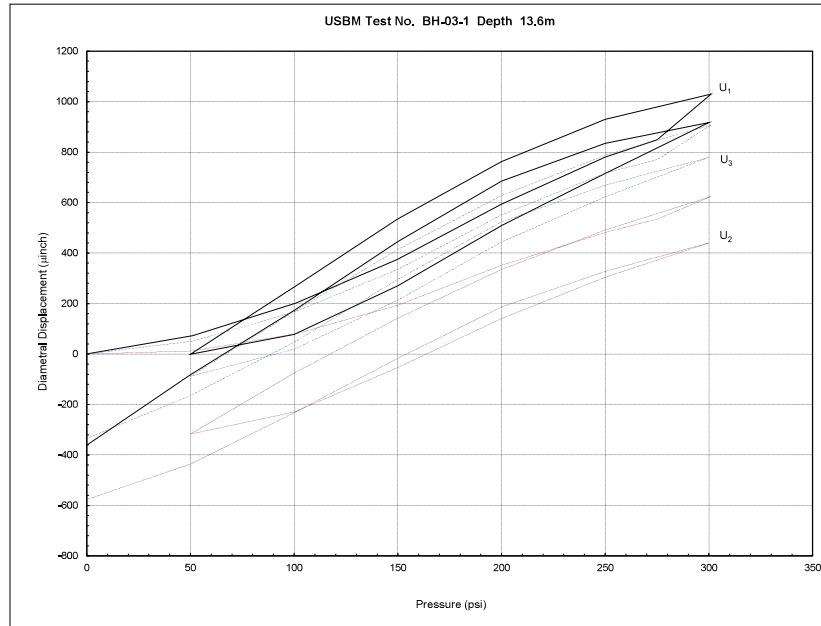
ASTM. 2008. D4623-16 Standard Test Method for Determination of In Situ Stress in Rock Mass by Overcoring Method – Three Component Borehole Deformation Gauge. ASTM International.

Brown, E.T. (ed.) 1981. Suggested Methods for Rock Characterization Testing and Monitoring, International Society for Rock Mechanics. Oxford : Pergamon.

Obert, L., and Duvall, W.I. 1967. Rock Mechanics and the Design of Structures in Rocks. New York, NY: Wiley.

APPENDIX A

Overcoring and Biaxial Test Data
Interpretation and Core
Photographs



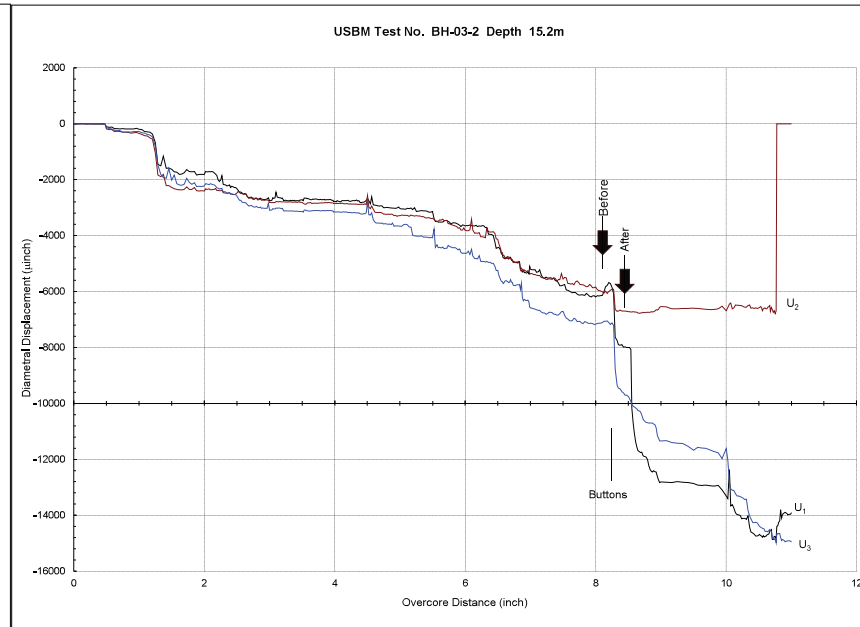
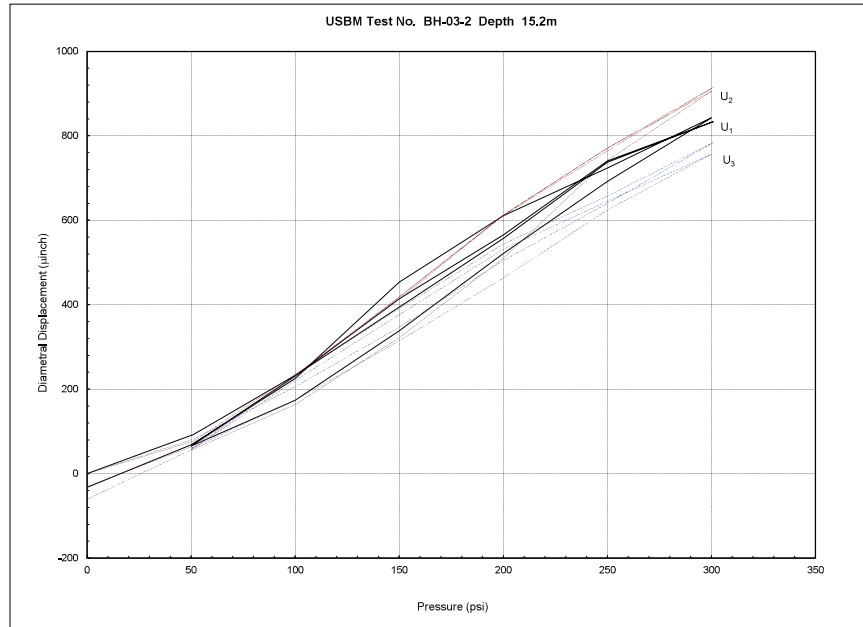
Biaxial Reduction			Radius (inches)	Measured Diam (in)
E Hole Diameter (mm)	38.00		0.748	1.496
HQ Hole Diameter (mm)	87.30		1.719	3.437
	Pressure (psi)	Displacement (μinch)	Modulus (psi)	Modulus (GPa)
U ₁	200	826.98	8.12E+05	5.60
U ₂	200	543.66	1.24E+06	8.52
U ₃	200	738.296	9.10E+05	6.27
Average Modulus			9.86E+05	6.80

USBM Reduction	Test:	BH-03-1	
			inches
Modulus (GPa)	6.80	Before USBM Gauge	4.8
Poissons ratio	0.30	After USBM Gauge	5.9
Borehole diameter (mm)	38.00	1.496063	
Displacement 1 (μinch)	675		
Displacement 2 (μinch)	1017		
Displacement 3 (μinch)	728		
P (MPa)	2.08		
Q (MPa)	1.59		
θ (deg)	64.12		
Angle U ₁ from 0 (clockwise = +ve)	356.00		
Corrected θ (deg)	60.12		

Figure A-1: USBM Results for test BH-03-1 (13.6 m)



Figure A-2: Photograph of retrieved core for test BH-03-1 (13.6 m)



Biaxial Reduction			Radius (inches)	Measured Diam (in)
E Hole Diameter (mm)	38.00		0.748	1.496
HQ Hole Diameter (mm)	87.30		1.719	3.437
	Pressure (psi)	Displacement (μinch)	Modulus (psi)	Modulus (GPa)
U ₁	250	741.376	1.13E+06	7.81
U ₂	250	837.936	1.00E+06	6.91
U ₃	250	702.792	1.19E+06	8.24
Average Modulus			1.11E+06	7.65

USBM Reduction	Test:	BH-03-2	
			inches
Modulus (GPa)	7.65	Before USBM Gauge	8.1
Poissons ratio	0.30	After USBM Gauge	8.325
Borehole diameter (mm)	38.00	1.496063	
Displacement 1 (μinch)	1613		
Displacement 2 (μinch)	697		
Displacement 3 (μinch)	2237		
P (MPa)	5.02		
Q (MPa)	2.73		
θ (deg)	138.14		
Angle U ₁ from 0 (clockwise = +ve)	356.00		
Corrected θ (deg)	134.14		

Figure A-3: USBM Results for test BH-03-2 (15.2 m)

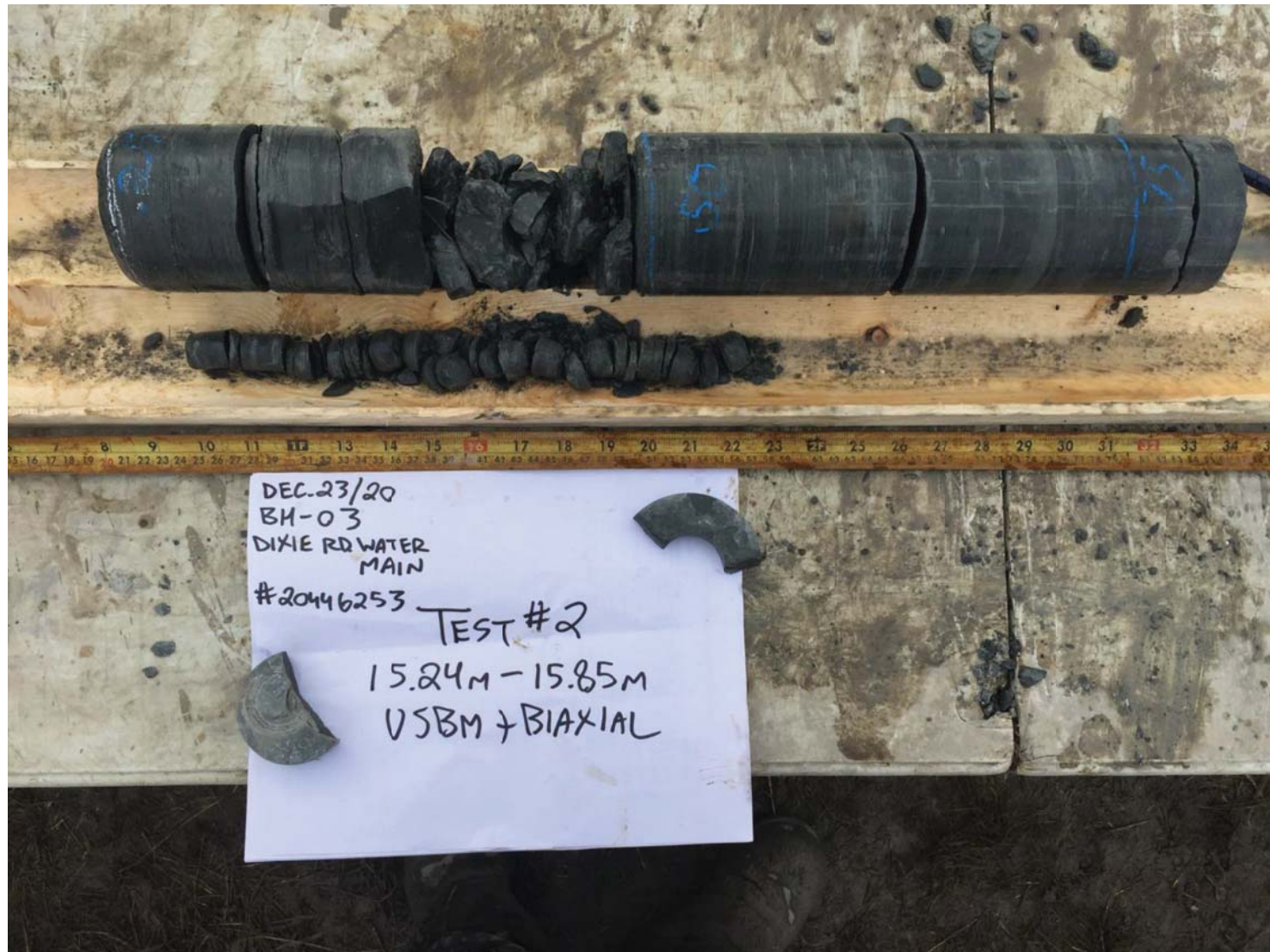


Figure A-4: Photograph of retrieved core for test BH-03-2 (15.2 m)

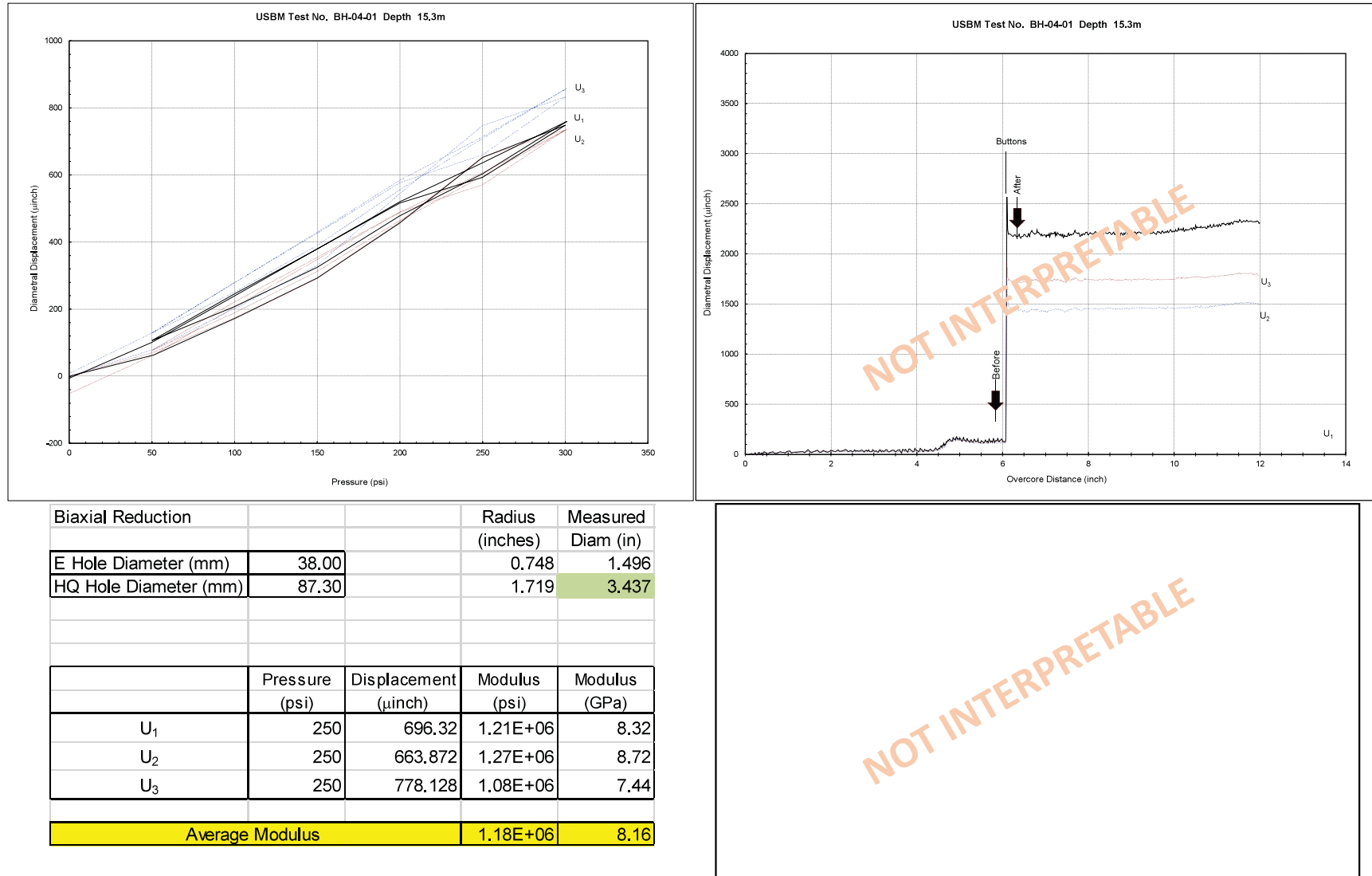


Figure A-5: USBM Results for test BH-04-1 (15.3 m)

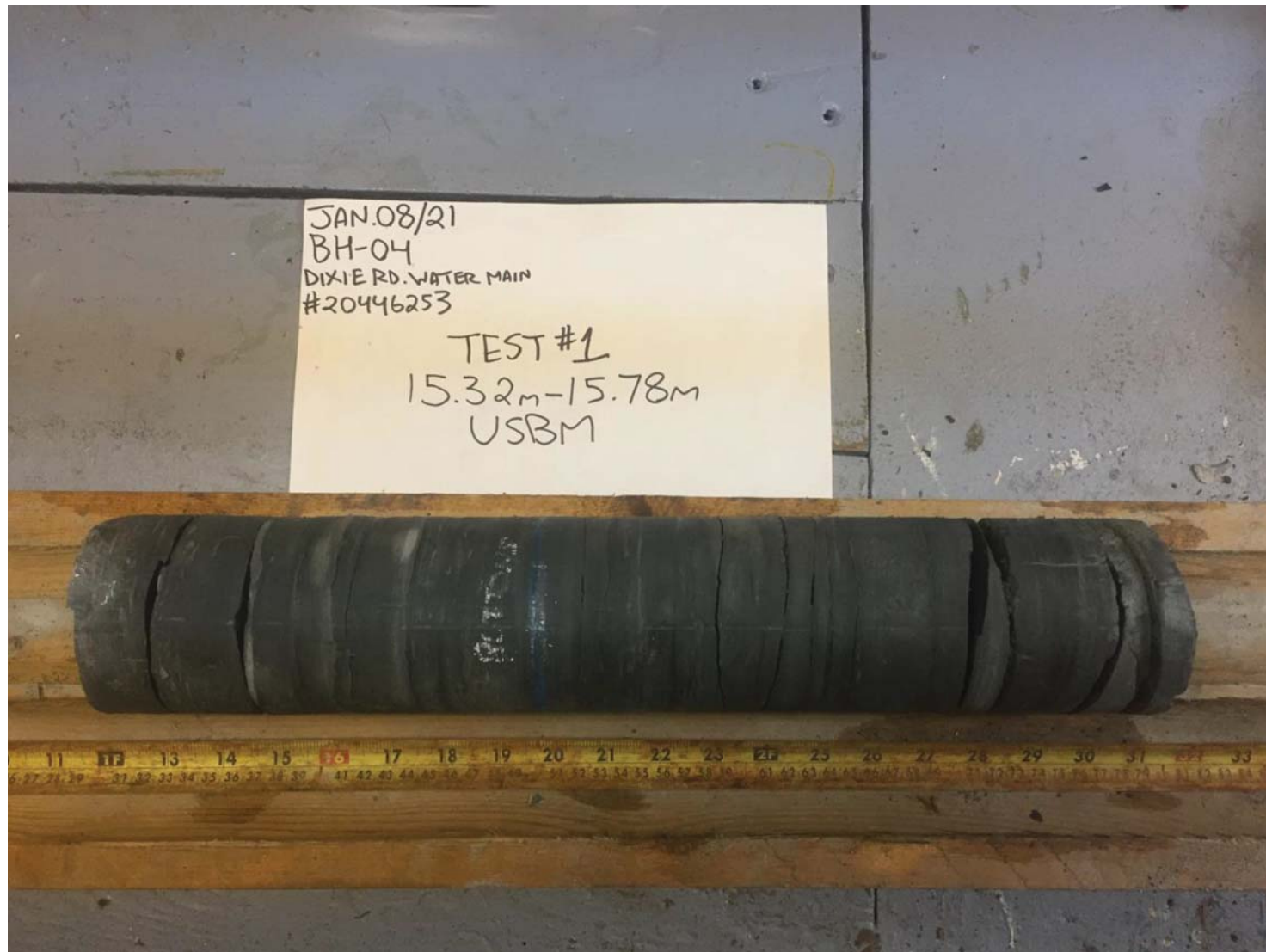
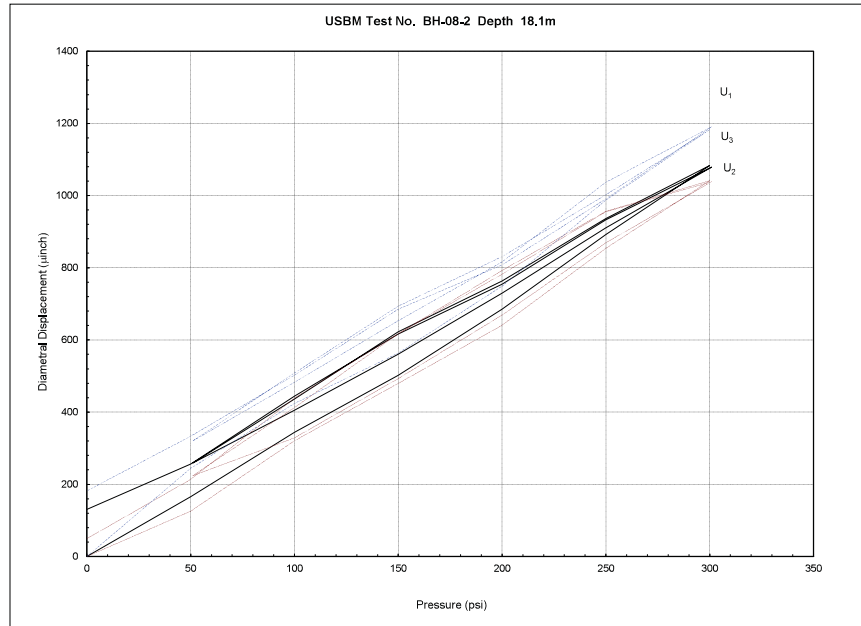


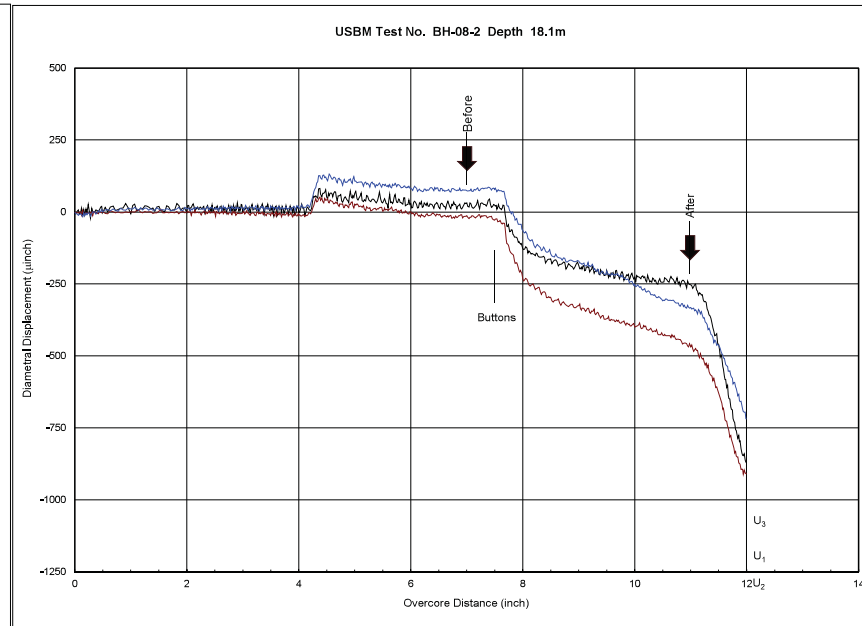
Figure A-6: Photograph of retrieved core for USBM test BH-03-2 (15.2 m)



Figure A-7: Photograph of retrieved core for biaxial test BH-03-2 (15.2 m)



Biaxial Reduction			Radius (inches)	Measured Diam (in)
E Hole Diameter (mm)	38.00		0.748	1.496
HQ Hole Diameter (mm)	87.30		1.719	3.437
	Pressure (psi)	Displacement (μinch)	Modulus (psi)	Modulus (GPa)
U ₁	250	820.224	1.02E+06	7.06
U ₂	250	814.66	1.03E+06	7.11
U ₃	250	871.008	9.64E+05	6.65
Average Modulus			1.01E+06	6.94



USBM Reduction	Test:	BH-08-2	
			inches
Modulus (GPa)	6.94	Before USBM Gauge	7
Poissons ratio	0.30	After USBM Gauge	11
Borehole diameter (mm)	38.00	1.496063	
Displacement 1 (μinch)	283		
Displacement 2 (μinch)	453		
Displacement 3 (μinch)	408		
P (MPa)	1.00		
Q (MPa)	0.77		
θ (deg)	82.50		
Angle U ₁ from 0 (clockwise = +ve)	345.00		
Corrected θ (deg)	67.50		

Figure A-8: USBM Results for test BH-08-2 (18.1 m)

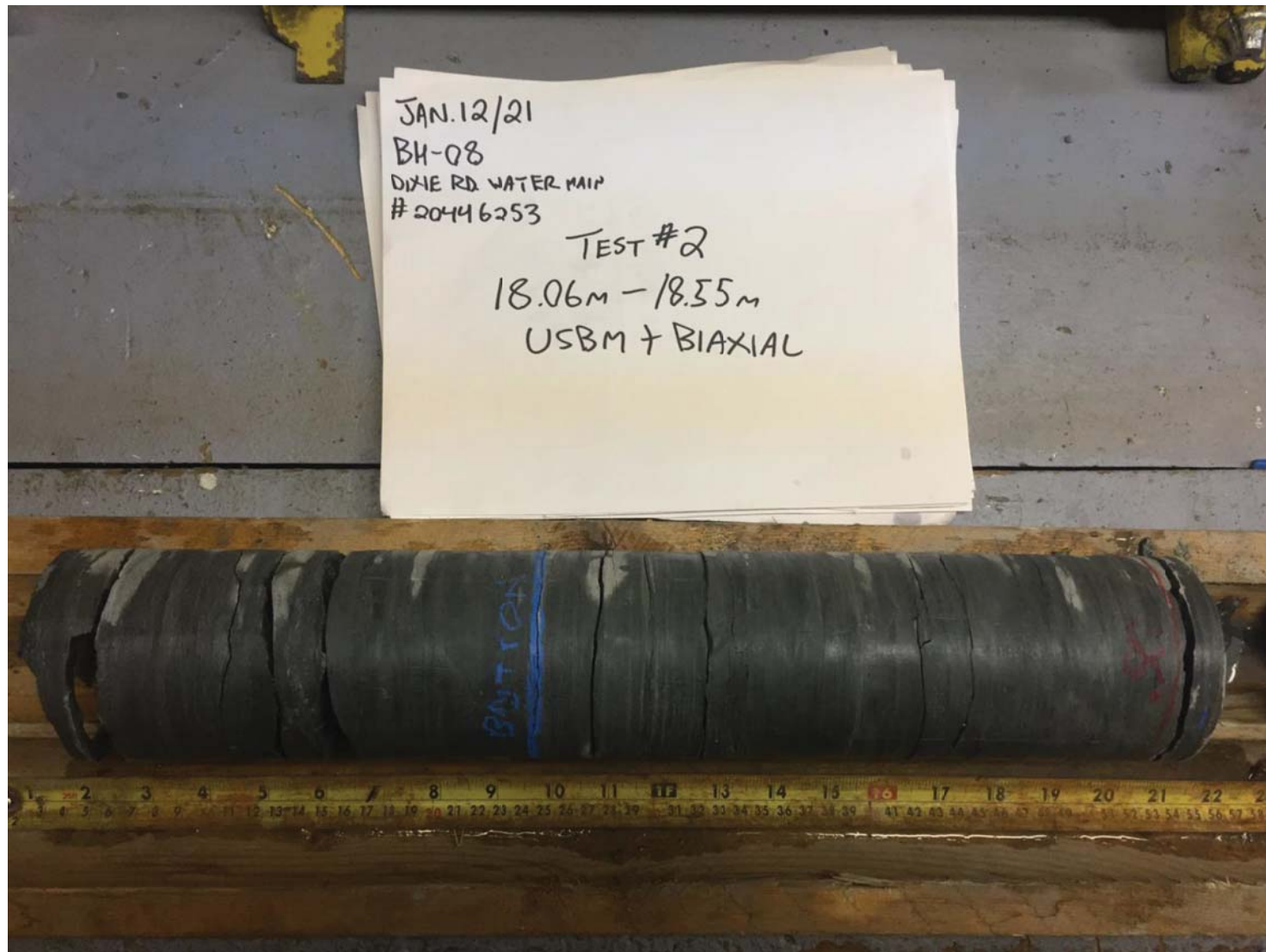


Figure A-9: Photograph of retrieved core for test BH-08-2 (18.1 m)

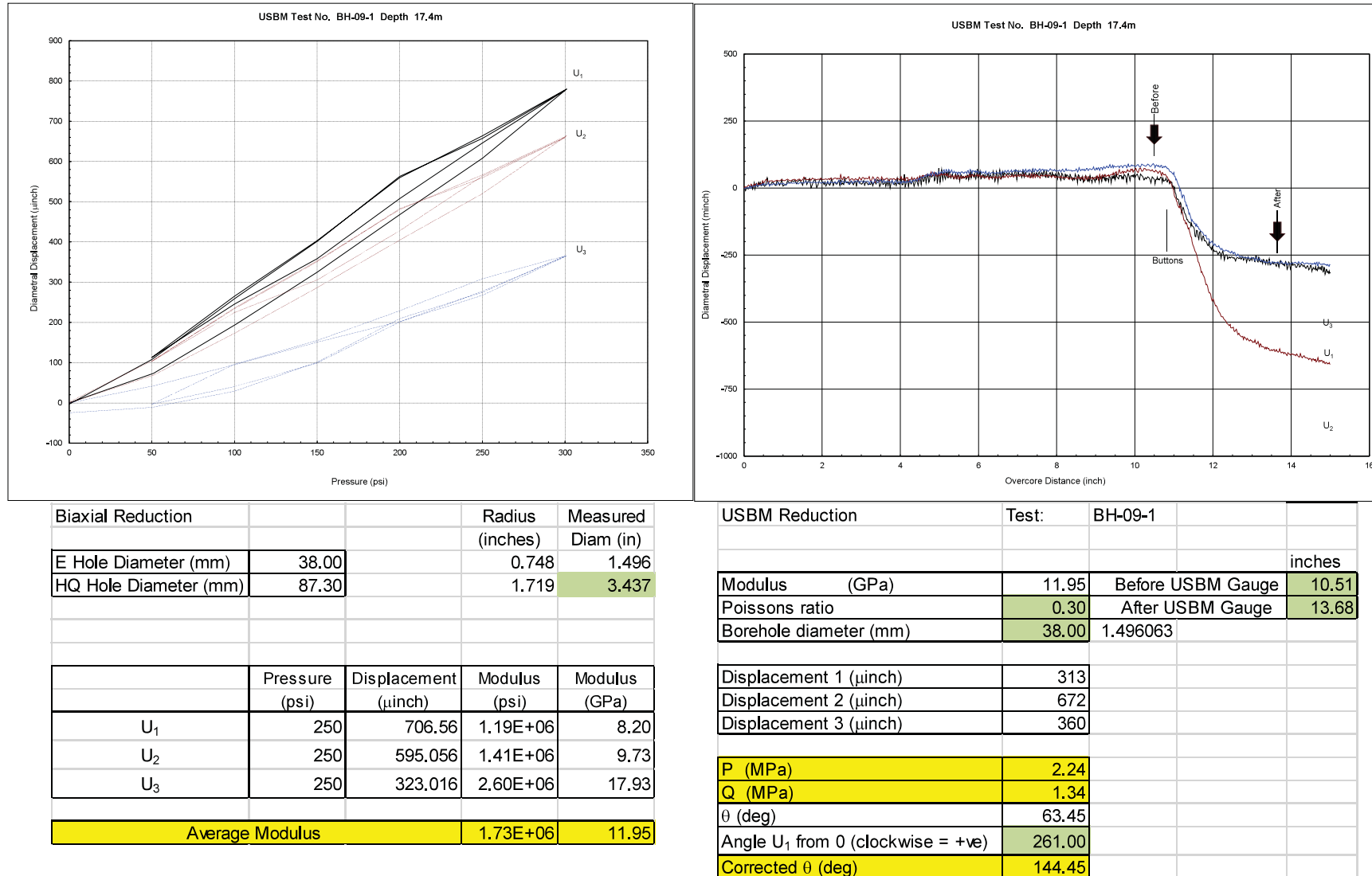


Figure A-10: USBM Results for test BH-09-1 (17.4 m)

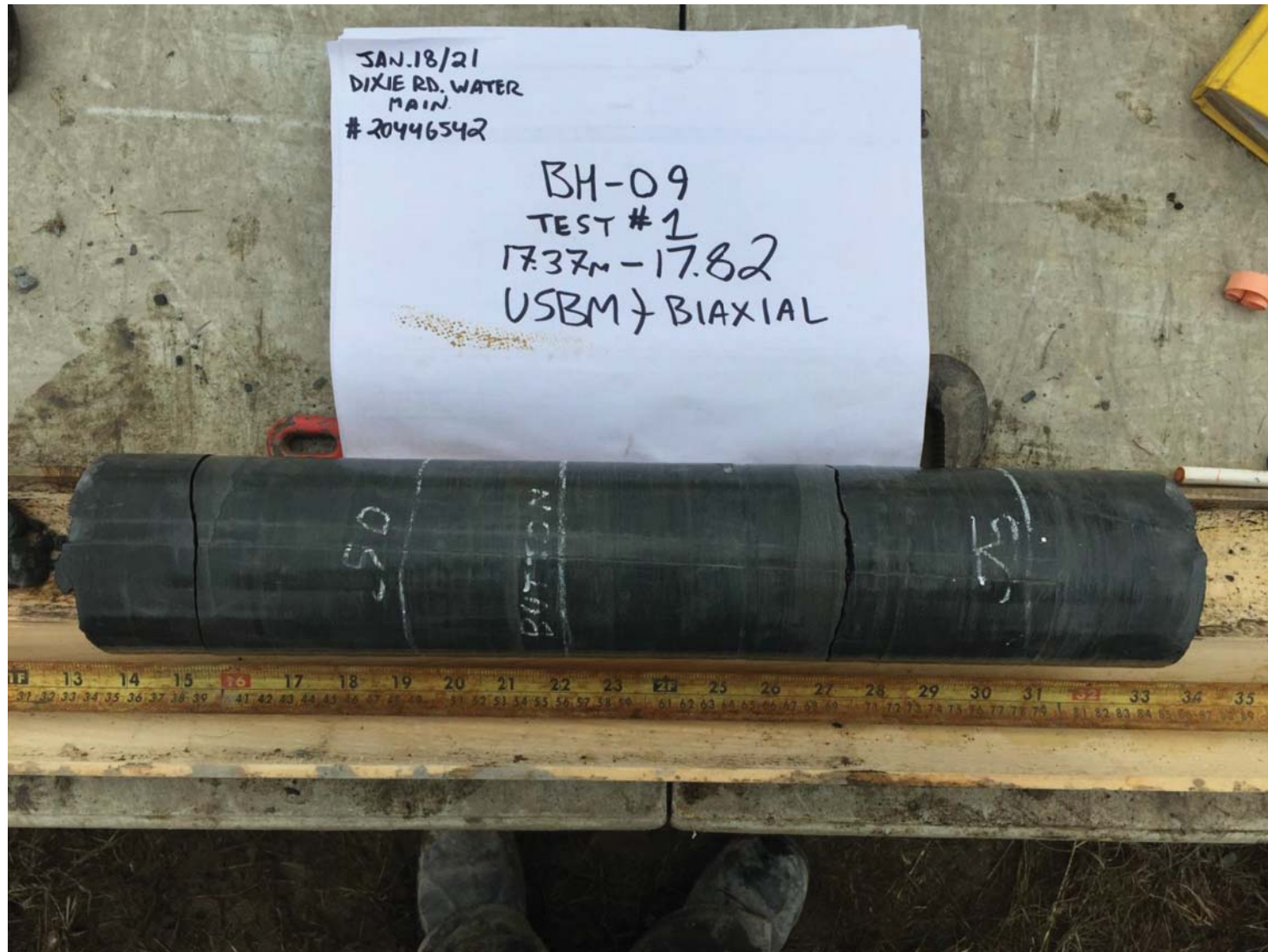


Figure A-11: Photograph of retrieved core for test BH-09-1 (17.4 m)

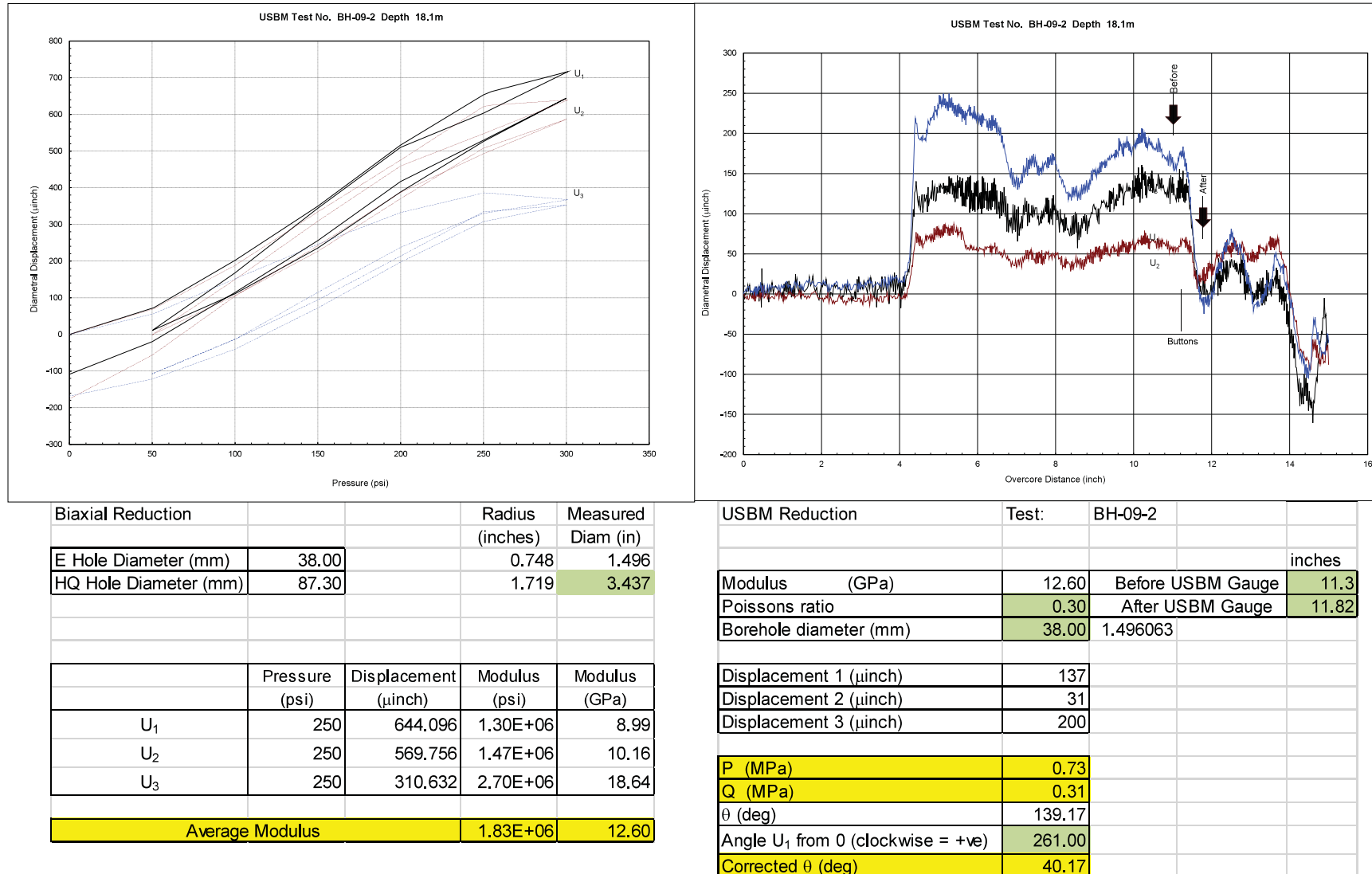


Figure A-12: USBM Results for test BH-09-2 (18.1 m)

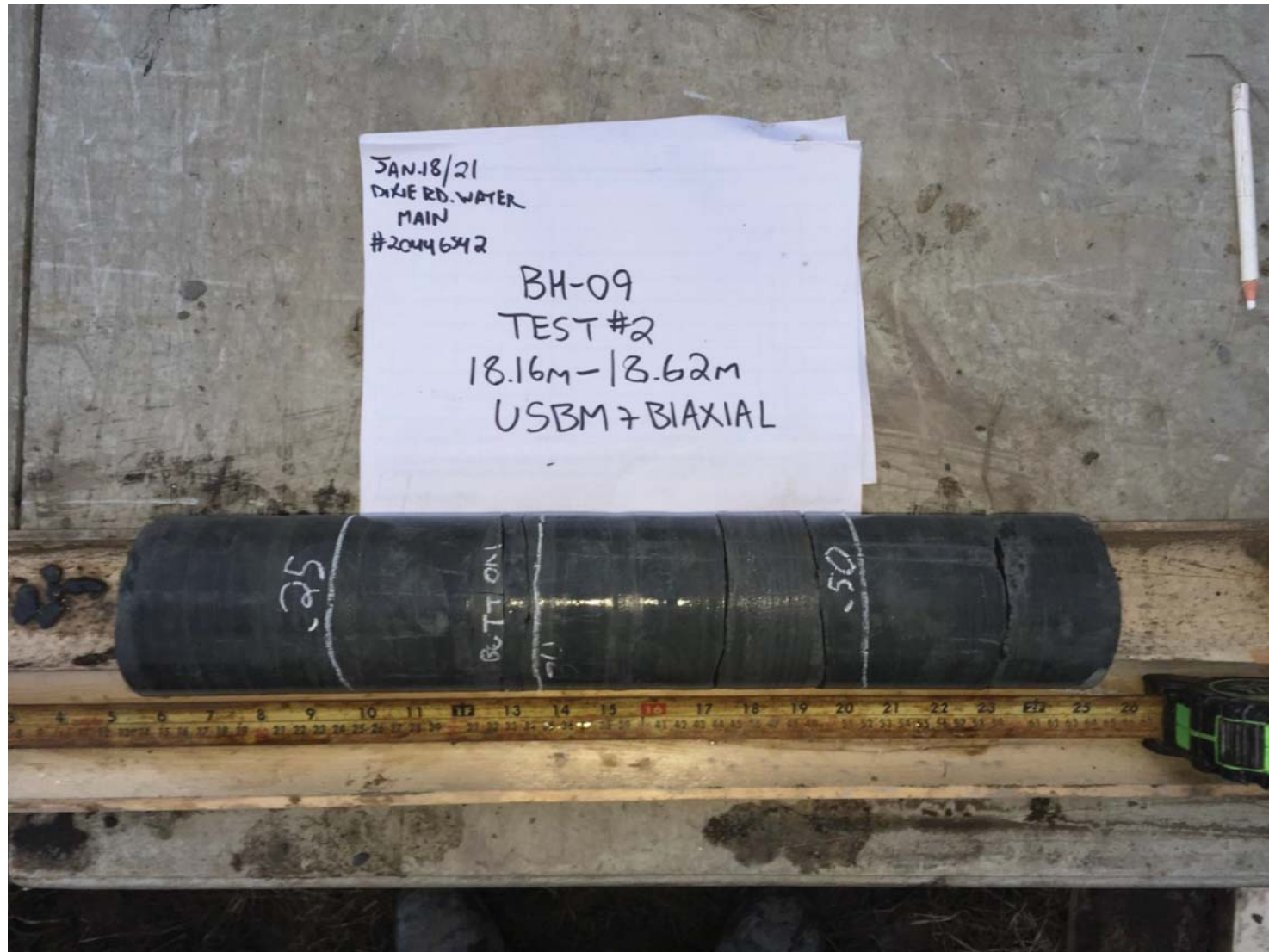


Figure A-13: Photograph of retrieved core for test BH-09-2 (18.1 m)



golder.com



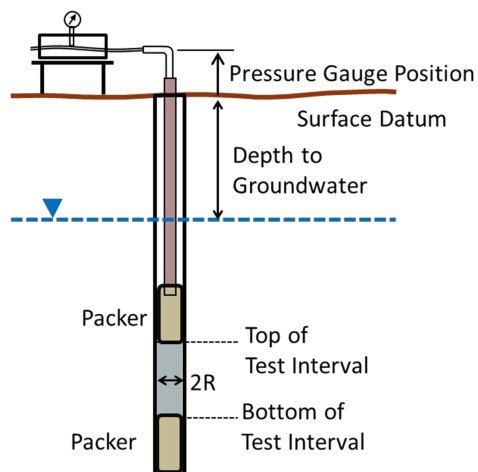
APPENDIX C

Packer Test Results

			Lugeon Test Analysis Report
			Project: Watermain Replacement on Dixie Road
			Number: 20TF025
			Client: The Regional Municipality of Peel

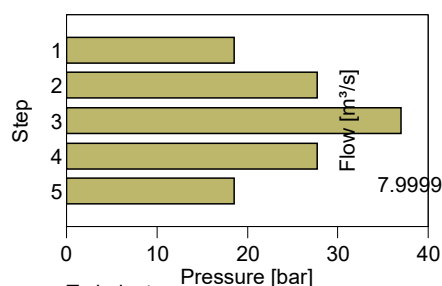
Location: Dixie Road at Highway 401	Lugeon Test: Packer Test 1	Tested bore: Borehole BH 1
Test Conducted by: Drilltech Drilling Limited/A.Hossain		Test Date: 2021-01-25
Analysis Performed by: A. Hossain/M.Zamshad		Analysis Date: 2021-03-25

Lithology:

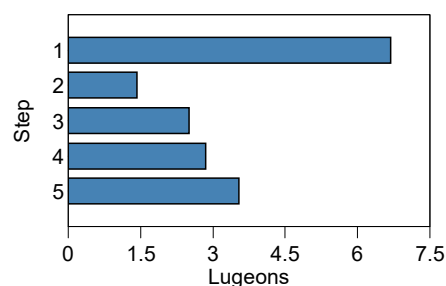
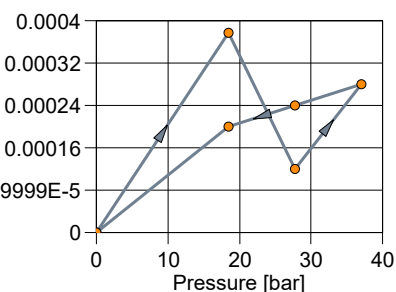


Top of Test Interval: 10.40 m
Bottom of Test Interval: 12.20 m
Length of Test Interval: 1.80 m
Gauge Position: 0.60 m
Depth to Groundwater: 2.60 m
Radius of Test Section: 0.05 m

Step	Pressure [bar]	Flow Meter Readings [m³/s]										Average Flow Rate [m³/s]	Hydraulic Conductivity		
		1	2	3	4	5	6	7	8	9	10		[m/s]	[m/d]	Lugeon
1	18.50	0.0024	0.0002	0.0003	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0004	6.298×10^{-7}	0.054	6.7
2	27.75	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0001	1.344×10^{-7}	0.012	1.4
3	37.00	0.0004	0.0004	0.0004	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0001	0.0003	2.358×10^{-7}	0.020	2.5
4	27.75	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	2.688×10^{-7}	0.023	2.9
5	18.50	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0002	3.341×10^{-7}	0.029	3.5
Average													3.206×10^{-7}	0.028	3.4



Turbulent
Lugeon: 1.4
Hydraulic Conductivity: 1.344×10^{-7} m/s
Hydraulic Conductivity: 0.012 m/d



		Lugeon Test Summary - Borehole BH 1		
		Project: Watermain Replacement on Dixie Road		
		Number: 20TF025		
		Client: The Regional Municipality of Peel		
Test Interval Top Bottom	Graphs		Result	
10.40 m 12.20 m	<div><div><div><div>Step</div><div><div>1</div><div>2</div><div>3</div><div>4</div><div>5</div></div><div><div>0</div><div>10</div><div>20</div><div>30</div><div>40</div></div></div><div><div>Flow [m³/s]</div><div>7.999999999999999E-5</div></div></div><div><div><div>0.0004</div><div>0.00032</div><div>0.00024</div><div>0.00016</div><div>0</div></div><div><div>0</div><div>10</div><div>20</div><div>30</div><div>40</div></div></div><div><div>Pressure [bar]</div><div>Pressure [bar]</div></div></div>		<div><div><div>Step</div><div><div>1</div><div>2</div><div>3</div><div>4</div><div>5</div></div><div><div>0</div><div>1.5</div><div>3</div><div>4.5</div><div>6</div><div>7.5</div></div></div><div><div>Lugeons</div></div></div>	Turbulent Lugeon: 1.4 Hydraulic Conductivity: 1.344E-7 m/s Hydraulic Conductivity: 0.012 m/d

Step

1

2

3

4

5

0

1.5

3

4.5

6

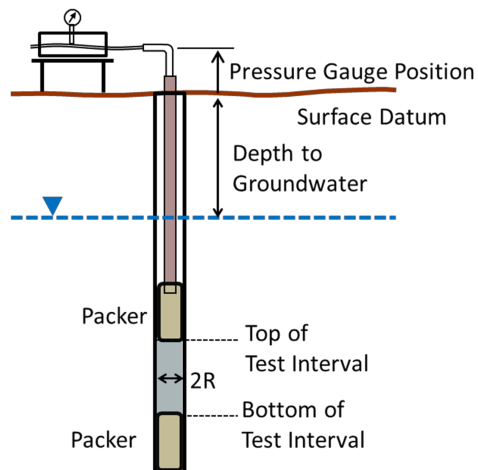
7.5

Lugeons

			Lugeon Test Analysis Report
			Project: Watermain Replacement on Dixie Road
			Number: 20TF025
			Client: The Regional Municipality of Peel

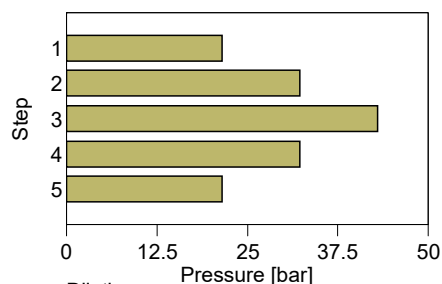
Location: Dixie Road at Highway 401	Lugeon Test: Packer Test 2	Tested bore: Borehole BH 10
Test Conducted by: Drilltech Drilling Limited/A.Hossain	Test Date: 2021-01-21	
Analysis Performed by: A. Hossain/M.Zamshad	Analysis Date: 2021-03-25	

Lithology:

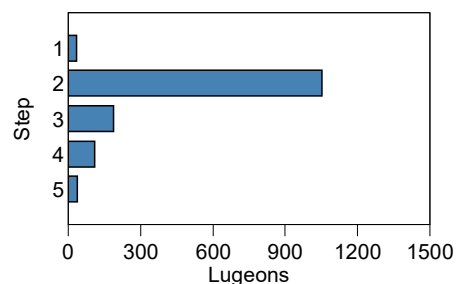
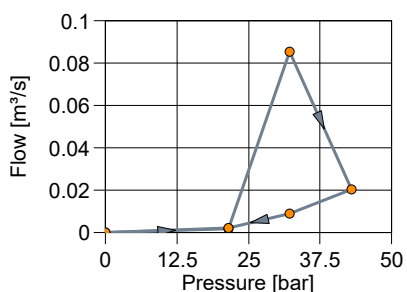


Top of Test Interval: 12.20 m
Bottom of Test Interval: 13.70 m
Length of Test Interval: 1.50 m
Gauge Position: 0.60 m
Depth to Groundwater: 1.10 m
Radius of Test Section: 0.05 m

Step	Pressure [bar]	Flow Meter Readings [m³/s]										Average Flow Rate [m³/s]	Hydraulic Conductivity		
		1	2	3	4	5	6	7	8	9	10		[m/s]	[m/d]	Lugeon
1	21.50	0.0026	0.0018	0.0020	0.0020	0.0020	0.0010	0.0015	0.0020	0.0020	0.0010	0.0018	2.959×10^{-6}	0.256	33.0
2	32.25	0.0200	0.1800	0.0200	0.0190	0.0230	0.0200	0.1800	0.1900	0.1800	0.0200	0.0852	9.414×10^{-5}	8.133	1051.3
3	43.00	0.0200	0.0250	0.0190	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0204	1.693×10^{-5}	1.462	189.0
4	32.25	0.0150	0.0100	0.0100	0.0080	0.0070	0.0080	0.0070	0.0080	0.0070	0.0080	0.0088	9.723×10^{-6}	0.840	108.6
5	21.50	0.0030	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0010	0.0020	3.306×10^{-6}	0.286	36.9
Average													2.541×10^{-5}	2.195	283.8



Dilation
Lugeon: 36.9
Hydraulic Conductivity: 3.306×10^{-6} m/s
Hydraulic Conductivity: 0.286 m/d



		Lugeon Test Summary - Borehole BH 10	
		Project: Watermain Replacement on Dixie Road	
		Number: 20TF025	
		Client: The Regional Municipality of Peel	
Test Interval Top Bottom	Graphs		Result
12.20 m 13.70 m	<div><div><div><div>Step</div><div><div>1</div><div>2</div><div>3</div><div>4</div><div>5</div></div><div><div>0</div><div>12.5</div><div>25</div><div>37.5</div><div>50</div></div><div>Pressure [bar]</div></div><div><div>Flow [m³/s]</div><div><div>0</div><div>0.02</div><div>0.04</div><div>0.06</div><div>0.08</div><div>0.1</div></div><div><div>0</div><div>12.5</div><div>25</div><div>37.5</div><div>50</div></div><div>Pressure [bar]</div></div><div><div>Step</div><div><div>1</div><div>2</div><div>3</div><div>4</div><div>5</div></div><div><div>0</div><div>300</div><div>600</div><div>900</div><div>1200</div><div>1500</div></div><div>Lugeons</div></div></div></div>		Dilation Lugeon: 36.9 Hydraulic Conductivity: 3.306E-6 m/s Hydraulic Conductivity: 0.286 m/d



APPENDIX D

Soil Chemical Analyses Results by SGS Environment



FINAL REPORT

CA15910-MAR21 R1

20TF025A, Dixie+ Hwy 401

Prepared for

Peto MacCallum Ltd

First Page

CLIENT DETAILS

Client Peto MacCallum Ltd

Address 165 Cartwright Ave
Toronto, ON
M6A 1V5, Canada

Contact Mohammad Zamshad

Telephone 416-785-5110

Facsimile 416-785-5120

Email mzamshad@petomacallum.com

Project 20TF025A, Dixie+ Hwy 401

Order Number

Samples Soil (4)

LABORATORY DETAILS

Project Specialist Jill Campbell, B.Sc.,GISAS

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 2165

Facsimile 705-652-6365

Email jill.campbell@sgs.com

SGS Reference CA15910-MAR21

Received 03/16/2021

Approved 03/19/2021

Report Number CA15910-MAR21 R1

Date Reported 03/19/2021

COMMENTS

Temperature of Sample upon Receipt: 9 degrees C

Cooling Agent Present:Yes

Custody Seal Present:Yes

Chain of Custody Number:019785

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

SIGNATORIES

Jill Campbell, B.Sc.,GISAS





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FINAL REPORT

CA15910-MAR21 R1

Client: Peto MacCallum Ltd

Project: 20TF025A, Dixie+ Hwy 401

Project Manager: Mohammad Zamshad

Samplers: Akbai Hossain

PACKAGE: - Corrosivity Index (SOIL)

Sample Number	5	6	7	8
Sample Name	BH-G1 SS4 7.5-9.5'	BH-G2 SS4 7.5-9.5'	BH-G3 SS4 7.5-9.5'	BH SS5 10-12'
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	15/03/2021	15/03/2021	15/03/2021	15/03/2021

Parameter	Units	RL		Result	Result	Result	Result
Corrosivity Index							
Corrosivity Index	none	1		6	8	4	12
Soil Redox Potential	mV	-		369	263	265	243
Sulphide (Na ₂ CO ₃)	%	0.04		0.10	0.09	0.02	0.05
pH	pH Units	0.05		8.36	8.82	8.50	8.50
Resistivity (calculated)	ohms.cm	-9999		2610	4810	5680	1720

PACKAGE: - General Chemistry (SOIL)

Sample Number	5	6	7	8
Sample Name	BH-G1 SS4 7.5-9.5'	BH-G2 SS4 7.5-9.5'	BH-G3 SS4 7.5-9.5'	BH SS5 10-12'
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	15/03/2021	15/03/2021	15/03/2021	15/03/2021

Parameter	Units	RL		Result	Result	Result	Result
General Chemistry							
Conductivity	uS/cm	2		383	208	176	580

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6	7	8
Sample Name	BH-G1 SS4 7.5-9.5'	BH-G2 SS4 7.5-9.5'	BH-G3 SS4 7.5-9.5'	BH SS5 10-12'
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	15/03/2021	15/03/2021	15/03/2021	15/03/2021

Parameter	Units	RL		Result	Result	Result	Result
Metals and Inorganics							
Moisture Content	%	0.1		14.0	16.1	6.4	5.9



FINAL REPORT

CA15910-MAR21 R1

Client: Peto MacCallum Ltd

Project: 20TF025A, Dixie+ Hwy 401

Project Manager: Mohammad Zamshad

Samplers: Akbai Hossain

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6	7	8
Sample Name	BH-G1 SS4 7.5-9.5'	BH-G2 SS4 7.5-9.5'	BH-G3 SS4 7.5-9.5'	BH SS5 10-12'
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	15/03/2021	15/03/2021	15/03/2021	15/03/2021

Parameter	Units	RL		Result	Result	Result	Result
Metals and Inorganics (continued)							
Sulphate	µg/g	0.4		74	34	130	280

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6	7	8
Sample Name	BH-G1 SS4 7.5-9.5'	BH-G2 SS4 7.5-9.5'	BH-G3 SS4 7.5-9.5'	BH SS5 10-12'
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	15/03/2021	15/03/2021	15/03/2021	15/03/2021

Parameter	Units	RL		Result	Result	Result	Result
Other (ORP)							
Chloride	µg/g	0.4		30	82	32	440



FINAL REPORT

CA15910-MAR21 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0284-MAR21	µg/g	0.4	<0.4	2	20	97	80	120	121	75	125
Sulphate	DIO0284-MAR21	µg/g	0.4	<0.4	3	20	96	80	120	93	75	125

Carbon/Sulphur
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0041-MAR21	%	0.04	< 0.04	NV	20	106	80	120			

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0292-MAR21	uS/cm	2	< 2	0	20	98	90	110	NA		



QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0292-MAR21	pH Units	0.05	NA	0		100			NA		

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

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

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

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

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

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

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

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

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

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

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

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

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-- End of Analytical Report --



FINAL REPORT

CA15900-DEC20 R1

20TF025A,

Prepared for

Peto MacCallum Ltd

First Page

CLIENT DETAILS

Client Peto MacCallum Ltd

Address 165 Cartwright Ave
Toronto, ON
M6A 1V5, Canada

Contact Mohammad Zamshad

Telephone 416-785-5110

Facsimile 416-785-5120

Email mzamshad@petomacallum.com

Project 20TF025A,

Order Number

Samples Soil (8)

LABORATORY DETAILS

Project Specialist Brad Moore Hon. B.Sc

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 705-652-2143

Facsimile 705-652-6365

Email brad.moore@sgs.com

SGS Reference CA15900-DEC20

Received 12/21/2020

Approved 12/24/2020

Report Number CA15900-DEC20 R1

Date Reported 12/24/2020

COMMENTS

Temperature of Sample upon Receipt: 5 degrees C

Cooling Agent Present:Yes

Custody Seal Present:Yes

Chain of Custody Number:017684

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

SIGNATORIES

Brad Moore Hon. B.Sc

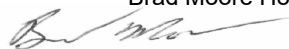




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FINAL REPORT

CA15900-DEC20 R1

Client: Peto MacCallum Ltd

Project: 20TF025A,

Project Manager: Mohammad Zamshad

Samplers: Akbar Hossain

PACKAGE: - Corrosivity Index (SOIL)

Sample Number	5	6	7	8	9	10	11	12
Sample Name	BH G3, SS6, 15'-17'	BH2, SS14, 35'-37'	BH3, SS11, 27.5'-29.5'	BH5, SS11, 27.5'-29.5'	BH6, SS9, 22.5'-24.5'	BH7, SS17, 42.5'-44.5'	BH8, SS10, 27.5'-29.5'	BH9, SS14, 35'-37'
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020

Parameter	Units	RL		Result	Result	Result	Result	Result	Result	Result	Result
Corrosivity Index											
Corrosivity Index	none	1		4	5	8	8	8	8	10	8
Soil Redox Potential	mV	-		223	270	199	260	155	137	91	138
Sulphide (Na2CO3)	%	0.04		< 0.04	< 0.04	0.08	0.06	0.22	0.09	0.22	0.15
pH	pH Units	0.05		9.29	8.77	9.17	9.27	9.28	9.31	8.88	8.99
Resistivity (calculated)	ohms.cm	-9999		5030	2600	3600	3610	6670	4500	5210	4830

PACKAGE: - General Chemistry (SOIL)

Sample Number	5	6	7	8	9	10	11	12
Sample Name	BH G3, SS6, 15'-17'	BH2, SS14, 35'-37'	BH3, SS11, 27.5'-29.5'	BH5, SS11, 27.5'-29.5'	BH6, SS9, 22.5'-24.5'	BH7, SS17, 42.5'-44.5'	BH8, SS10, 27.5'-29.5'	BH9, SS14, 35'-37'
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020

Parameter	Units	RL		Result	Result	Result	Result	Result	Result	Result	
General Chemistry											
Conductivity	uS/cm	2		199	384	278	277	150	222	192	207

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6	7	8	9	10	11	12
Sample Name	BH G3, SS6, 15'-17'	BH2, SS14, 35'-37'	BH3, SS11, 27.5'-29.5'	BH5, SS11, 27.5'-29.5'	BH6, SS9, 22.5'-24.5'	BH7, SS17, 42.5'-44.5'	BH8, SS10, 27.5'-29.5'	BH9, SS14, 35'-37'
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020

Parameter	Units	RL		Result	Result	Result	Result	Result	Result	Result	
Metals and Inorganics											
Moisture Content	%	0.1		6.3	8.1	10.1	7.7	9.3	12.7	11.3	12.2



FINAL REPORT

CA15900-DEC20 R1

Client: Peto MacCallum Ltd

Project: 20TF025A,

Project Manager: Mohammad Zamshad

Samplers: Akbar Hossain

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number	5	6	7	8	9	10	11	12
Sample Name	BH G3, SS6, 15'-17'	BH2, SS14, 35'-37'	BH3, SS11, 27.5'-29.5'	BH5, SS11, 27.5'-29.5'	BH6, SS9, 22.5'-24.5'	BH7, SS17, 42.5'-44.5'	BH8, SS10, 27.5'-29.5'	BH9, SS14, 35'-37'
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020

Parameter	Units	RL		Result	Result	Result	Result	Result	Result	Result
-----------	-------	----	--	--------	--------	--------	--------	--------	--------	--------

Metals and Inorganics (continued)

Sulphate	µg/g	0.4		99	110	110	130	81	84	84	31
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PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6	7	8	9	10	11	12
Sample Name	BH G3, SS6, 15'-17'	BH2, SS14, 35'-37'	BH3, SS11, 27.5'-29.5'	BH5, SS11, 27.5'-29.5'	BH6, SS9, 22.5'-24.5'	BH7, SS17, 42.5'-44.5'	BH8, SS10, 27.5'-29.5'	BH9, SS14, 35'-37'
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020	18/12/2020

Parameter	Units	RL		Result	Result	Result	Result	Result	Result	Result
-----------	-------	----	--	--------	--------	--------	--------	--------	--------	--------

Other (ORP)

Chloride	µg/g	0.4		84	90	180	110	38	45	43	71
----------	------	-----	--	----	----	-----	-----	----	----	----	----



FINAL REPORT

CA15900-DEC20 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0384-DEC20	µg/g	0.4	<0.4	2	20	99	80	120	105	75	125
Sulphate	DIO0384-DEC20	µg/g	0.4	<0.4	5	20	98	80	120	91	75	125

Carbon/Sulphur
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0055-DEC20	%	0.04	< 0.04	ND	20	102	80	120			

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0353-DEC20	uS/cm	2	< 2	0	20	100	90	110	NA		



FINAL REPORT

CA15900-DEC20 R1

QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-1ENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0353-DEC20	pH Units	0.05	NA	0		101			NA		

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

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

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

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

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

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

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

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

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

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

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

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

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-- End of Analytical Report --



**PART B – FOUNDATION DESIGN REPORT
IN SUPPORT OF DETAILED DESIGN FOR WATERMAIN
REPLACEMENT ON DIXIE ROAD
MISSISSAUGA, ONTARIO
PROJECT 20-1311
for
THE REGIONAL MUNICIPALITY OF PEEL
C/O COLE ENGINEERING LTD., PART OF IBI Group
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FIG. 1 – Settlement Instrumentation

List of Standard Specifications Relevant to Report

Appendix E - Copy of Ministry of Transportation's "Guidelines for Foundation Engineering –
Tunnelling Specialty for Corridor Encroachment Permit Application"

PART B – FOUNDATION DESIGN REPORT

for

In Support of Detailed Design for Watermain Replacement on Dixie Road
Mississauga, Ontario
Project 20-1311

14. INTRODUCTION

This foundation design report with the interpretations and recommendations are intended for the use of Regional Municipality of Peel and Cole Engineering, part of IBI Group, (Cole), and shall not be used or relied upon for any other purposes or by any other parties including the bidders and contractor. Contractors must make their own interpretation of the factual data provided in the foundation investigation report (Part A), as it may affect equipment selection, proposed construction methods and scheduling. Where comments are made on construction, they are provided only to highlight aspects, which could affect the design of the structure.

The scope of foundation investigation does not include assessing the impact on the pavement and utilities that may be in the vicinity of the alignment.

15. DISCUSSION AND RECOMMENDATIONS

15.1 Proposed Installation

The proposed plan and profile drawings for the watermain replacement were provided by Cole, via email dated May 28, 2021. A proposed 400 mm diameter Concrete Pressure Pipe (CPP) or Polyvinyl Chloride (PVC) watermain is contemplated to be installed by open-cut method and trenchless method. The open-cut method of installation was initially planned to be approximately from Station 0+675 to Station 0+888 (approximately 213 m linear length) and the trenchless installation, including entry and exit shafts, will be approximately from Station 0+885 to Station 1+377 (approximately 492 m linear length). Subsequently, the location for shaft location of Shaft No. 1 was relocated approximately 65.2 m north of the previous shaft location based on updated plan and profile drawings, provided by Cole via emails dated October 6 and 25, 2021. Accordingly, the open-cut method of installation will be approximately from Station 0+675 to Station 0+817 (approximately 142 m linear length) and the trenchless installation, including entry and exit shafts, will be approximately from Station 0+817 to Station 1+377 (approximately 560 m linear length).



15.2 Frost Penetration Depth

In accordance with Ontario Provincial Standard Drawing (OPSD) 3090.101, the frost penetration depth for design purposes in the area where the site is located is 1.2 m.

15.3 Seismic Zone and Site Response

The site specific spectral and Peak Ground Acceleration numbers for the project site, for the 2% in 50 year probability of exceedance, are $S_a(0.2)=0.200$, $S_a(0.5)=0.108$, $S_a(1.0)=0.056$, $S_a(2.0)=0.027$ and $PGA=0.128$ (National Building Code of Canada, 2015 website).

For seismic design purposes, the site may be classified as Site Class C in accordance with Clause 4.4.3.2 (Table 4.1) of the Canadian Highway Bridge Design Code, 2019.

16. OPEN CUT METHOD

16.1 General

The proposed 400 mm diameter watermain will be installed by open cut or trenching method approximately from Station 0+675 to Station 0+817 (approximately 142 m linear length). Boreholes G-1 to G-3 were investigated within the portion of the watermain by open cut or trenching method. The proposed invert of the watermain will be from EL. 159.8 to EL. 156.7 from north to south along Dixie Road. The open cut or trenching method will be carried out within the Region of Peel Right-of-Way.

16.2 Subsurface Conditions

In summary, the subsoil conditions encountered in Boreholes G-1 and G-2 within the open-cut or trench section consist of 0.2 m of topsoil immediately below the ground surface in the two boreholes. Fill was encountered below the topsoil in the boreholes, which extended to depths of 2.3 m (EL. 159.8) and 3.1 m (EL. 158.3) in Boreholes G-1 and G-2, respectively. The fill is immediately followed by sandy silt/silty sand in Borehole G-1, and sandy clayey silt till in Borehole G-2, which extended to termination depths of 4.0 m (EL. 158.1) and 4.4 m (EL. 157.0), respectively. Groundwater level was measured upon completion of drilling in Boreholes G-1 and G-2 at 2.4 m (EL. 159.7) and at 1.5 m (EL. 159.9) below ground surface, respectively.



16.3 Excavation and Temporary Protection System

General Reference is given to Ontario Provincial Standard Specifications (OPSS).MUNI 201, 490 and 801 for specifications associated with site preparation.

Prior to excavation, the locations and depths of existing underground utilities should be verified by the Contractor. All underground utilities that might be exposed and become unsupported as a result of the excavation should be properly supported to avoid potential damage. If there may be conflicts it may be necessary to consider relocation of the existing underground utilities.

For the open cut or trenching method section, excavation is anticipated to extend through the topsoil, fill and native overburden consisting of silty sand/sandy silt to about 2.3 to 2.8 m below ground surface at Boreholes G-1 and G-2 locations. Because the boreholes were relocated from the original locations due to conflict with existing underground utilities during field investigation, it is anticipated that the excavation may extend through the existing pavement structure along the proposed alignment along Dixie Road. Table 21 summarizes the borehole locations, ground surface elevation, proposed invert depth, anticipated excavation depth, and anticipating bearing soils at the invert level. It should be noted that the final base of excavation will be lower than the pipe invert to allow for pipe bedding materials and any subgrade excavation due to local poor soils as approved by the Engineer.

TABLE 21		
SUMMARY OF INVERT, EXCAVATION DEPTH AND SOIL		
	BOREHOLE ID	
	G-1	G-2
Ground Surface Elevation (m)	162.1	161.4
Proposed Watermain Invert Elevation (m)	159.8	158.6
Anticipated Excavation Depth to invert level, (m)	2.3	2.8
Anticipated Bearing Subgrade Soils	Sandy Silt/Silty Sand	Silty Sand / Sandy Silt Fill



Any fill, spongy or soft area observed within the base of the excavation should be removed and replaced with suitable fill material and compacted in accordance with OPSS.MUNI 401.

All work should be carried out in accordance with the Occupational Health and Safety Act (Ontario Regulation 213/91) and with Region of Peel/City of Mississauga regulations.

Excavated material shall not be stockpiled in the areas immediately adjacent to the top of the excavation slopes. All excavated surfaces should be kept free of frost and water during the period of construction. Runoff shall be directed away from open excavations and should not be allowed to flow into the excavation.

According to the Ontario's Occupational Health and Safety Act, Ontario Regulation 213/91 amended to regulation 628/05, the existing fill and compact sandy silt/silty sand can be classified as Type 3 soils. Hard sandy clayey silt till deposit can be classified as Type 2 soil. Soils below the groundwater level which may generally take on the characteristics of a Type 4 soil should be classified as Type 4 soils. Open cut excavations are governed by soils with the highest soil type number. For excavations through multiple soil types, the side slope geometry is governed by the soil with the highest number designation. The slope of excavation walls should conform to as described in Ont. Reg. 213/92, S. 234. Temporary shoring systems may be required if slopes as described in Ont. Reg. 213/92, S. 234 cannot be provided.

If excavations steeper than approximately 1H:1V are required and open excavation is restricted such that a road protection system is required, it should be designed to meet minimum Performance Level 2 in accordance with OPSS.MUNI 539 and SSP 105S09. It should be noted that the use of shoring may conflict with existing utilities in some locations. The Contractor is responsible for the selection, design, construction, and performance of the temporary protection systems.

Geotechnical parameters provided in Table 22 may be used for the temporary protection systems.



TABLE 22
SOIL PARAMETERS

ELEVATION (m)		SOIL TYPE	SOIL PARAMETERS *		
FROM	TO		FRICTION ANGLE (Ø')	UNIT WEIGHT (γ) kN/m³	Cu, (kPa)
Borehole G-1					
161.9	161.3	Silty Sand (Fill)	28	19	-
161.3	160.6	Clayey Silt (Fill)	20	18	50
160.6	159.8	Sandy Silt/Silty Sand (Fill)	28	19	-
159.8	158.1	Sandy Silt/Silty Sand	32	19	-
Borehole G-2					
161.2	160.6	Silty Sand (Fill)	28	19	-
160.6	159.9	Clayey Silt (Fill)	20	18	50
159.9	158.3	Sandy Silt/Silty Sand (Fill)	28	19	-
158.3	157.0	Hard Sandy Clayey Silt (Till)	20	20	100

Note: Submerged unit weight should be used below the water level.

If the shoring system does not provide for drainage, the groundwater pressure should be added to the lateral earth pressure for design.

16.4 Installation of Watermain

Based on the plan drawings provided by Cole via emails dated October 6 and 25, 2021, it is anticipated that the proposed watermain will be installed approximately from Station 0+675 to Station 0+817.

The installation of the 400 mm diameter watermain shall be in accordance with OPSS.MUNI 410. Watermain bedding should be in accordance with Region of Peel Standard Drawing Number 1-5-1 based on drawing provided by Cole. The native soils consisting of compact to very dense silty sand/sandy silt and stiff sandy clayey silt are considered adequate for support of the watermain. Where fill is encountered at the proposed invert level, the fill should be removed completely and replaced with granular material. The bedding material should be Granular A meeting the requirement of OPSS.MUNI 1010. Reference to OPSDs 802.030, 802.031, 802.032 should be



made for rigid pipe and reference to OPSDs 802.010 should be made for flexible pipe with regards to embedment, bedding, cover and backfill.

Trenching, backfilling and compacting shall be in accordance with OPSS.MUNI 401. The backfill material may be Granular A or Granular B Type II meeting the requirements of OPSS.MUNI 1010.

The sandy clayey silt till/silty sand/sandy silt layer at the bedding level may be susceptible to disturbance due to construction activity and any ponded water. In order to limit the degradation, it is recommended that the granular bedding be placed on the subgrade within four hours after preparation, inspection and approval of the subgrade.

16.5 Groundwater Control

Groundwater was encountered during drilling in Boreholes G-1 and G-2 at 3.1 m depth below ground surface, EL. 159.0 and EL. 158.3, respectively. Upon completion of drilling, groundwater was encountered in Boreholes G-1 and G-2 at 2.4 m (EL. 159.7) and 1.5 m (EL. 159.9) below ground surface, respectively. Groundwater was not encountered in Borehole G-3 during and upon completion of drilling.

Surface water flow or seepage from perched water should be directed away from the excavation areas to mitigate disturbance and weakening of the native soil. Conventional sump pumping techniques are considered to be adequate to mitigate any surface runoff and seepage from localized soil fissures at the excavation depth. The groundwater control or dewatering scheme is required to lower the water level a minimum of 0.5 m below the base of excavation to allow all the work to be carried out in a dry condition. The contractor should be responsible for the selection, performance and detailed design of the dewatering system. The dewatering system should be designed to conform to the requirements of OPSS.MUNI 517 and SP 517F01.

A preconstruction survey is not required due to the relatively shallow depth of dewatering and the relatively large distances to critical private properties. However, monitoring of the vertical and horizontal movement of the exposed utilities during the duration of the open cut method installation should be considered.



17. INSTALLATION USING TRENCHLESS TECHNOLOGY

17.1 MTO Requirements and Policy for Encroachments and Utilities

As the project involves the crossing of Highway 401, the investigation must comply with the Ministry of Transportation (MTO) "Guidelines for Foundation Engineering - Tunnelling Specialty for Corridor Encroachment Permit Application" dated February 2021, a copy of which has been provided in Appendix E. This foundation design report has been prepared as per the project requirements and the above noted MTO guidelines.

Reference is also given to the Transportation Association of Canada (TAC) Guidelines for Underground Utility Installations Crossing Highway Rights-of-Way, dated March 2013.

MTO does not generally permit open cut or trenching for installation of utility pipe or casing across the 400 series highway corridor, except where in the opinion of the Field Service Engineer other methods are not possible because of the size of the pipe or the nature of the subsoil conditions. Entry and receiving pits are required to be located at the bottom of the ditch line and back slope of the ditch. In a fill area, pits should be located beyond the toe of the road embankment slope. Open cut and entry or exit pit are prohibited within 3.0 m of the travelled portion of the highway or within the shoulder area of the highway.

The standard depth of cover for buried utility pipes under the travelled portion of the highway should not be less than 1.2 m. In Southern Ontario, the depth of cover for buried pipes should not be less than 0.75 m below the bottom of highway ditch. However, TAC requires 1.8 m of cover below the paved area, 1.5 m of cover below the ground area, and 1.2 m of cover in the ditch area. The proposed depth of cover along the casing alignment provided above meets the MTO and TAC requirements for encroachments and utilities below the travelled lanes.

17.2 Selection of Installation Method

There are number of trenchless technologies employed in the industry, depending on the site conditions and the size of the casing to be installed. The installation of steel casing liner at this site requires boring through very dense/hard clayey sand/sandy clayey silt till and weathered bedrock and not all of the trenchless methods are considered feasible through the subsoil and



groundwater conditions encountered. The steel liner to be installed will be 1515 mm outside diameter C300 MT.

Three trenchless methods, namely Jack and Bore, Horizontal Directional Drilling (HDD), and Micro-tunnelling, are considered to employ at this site to install the casing. Jack and bore is not considered feasible at this site. To install the casing across the full tunnelling length by jack and bore method will require intermediate shafts, which may not be feasible due to site constraints. HDD cannot be used in deep shaft setting. At this site location, the shafts are anticipated to be 10.0 m deep from the existing ground surface. In addition, compared to micro-tunnelling, over cut may cause higher ground loss and potential settlement along the tunnelling length. The discussions and recommendations below are limited only to micro-tunnelling trenchless method that Cole is proposing on behalf of the Region of Peel. The general requirements and specifications for the installation by micro-tunnelling may reference MTO NSSP "Pipe installation by Trenchless methods".

17.3 Recommended Trenchless Method

Micro-tunnelling method is recommended for the installation of the steel liner at this project site. Alternative liner configurations and installation methods may also be considered, provided that they meet the needs of the project and the MTO policy for encroachment.

The recommendations presented are based on the boreholes drilled along the currently proposed alignment. Additional subsurface investigation will be required if the crossing alignment is altered or shifted. Regardless of the method used, the Contractor shall prepare a plan in advance of construction outlining the details of the installation to provide instructions for the construction crews and provide a possible contingency action plan should difficulties occur during the tunnelling operations. The tunnelling plan, H & S plan, and shop drawings should be reviewed and approved by the Client's Project design team prior to construction. Upon request, PML can assist in reviewing the plan to check that the assumptions regarding the interpretation of soil and bedrock conditions are appropriate.



18. MICRO-TUNNELLING

18.1 General

This section of the report provides recommendations for the design of the proposed installation of a 1515 mm outside diameter C300 MT steel liner by trenchless method to carry a 400 mm diameter watermain across Highway 401, approximately 21.4 to 23.9 m west of the existing south abutment to north abutment of the Dixie Road Underpass in Mississauga, Ontario. The recommendations are based on interpretation of the factual information obtained from the boreholes drilled during the site investigation and the details of the proposed tunnel provided by Cole. The discussions and recommendations presented are intended to provide information to the Designer of the proposed installation of the casing by micro-tunnelling trenchless method, which has been proposed by Cole. This report should not be used for other trenchless technologies, which may require additional subsurface data and geotechnical analysis.

Existing underground services may impose potential conflict with the proposed alignment of the casing and precautionary measures to prevent damage must be arranged with the respective utility owners. The scope of foundation investigation work carried out by PML does not cover or include accessing beyond location of boreholes and easement requirements. Therefore, the specialty contractor and owner of the watermain should confirm the existence of any utility or obstructions that may impose potential conflict with the proposed alignment and to obtain necessary permits/permissions prior to the commencement of construction.

18.2 Subsoil Conditions

In summary, the subsurface stratigraphy encountered in the boreholes along the alignment comprised of pavement structure/topsoil overlying fill. Generally, the fill is underlain by generally a generally dense / hard glacial till deposit, which is underlain by generally fair to excellent quality, locally very poor to poor quality, shale bedrock. The glacial till deposit within the depth of boring consists of sandy clayey silt/clayey sand. Within the till deposit, thinly laminated shale layers and cobbles were encountered in the boreholes. Shale bedrock is encountered below the till deposits at elevations varying from EL. 152.9 to EL. 148.6.



Groundwater was encountered during drilling operations in Boreholes BH-2, BH-3, BH-6, BH-10 and P-1 at depths ranging from 4.6 m to 7.6 m (EL. 155.0 to EL. 158.5) below ground surface. In the remaining boreholes, groundwater was not encountered during drilling operation. Upon completion of drilling, groundwater was encountered in Boreholes BH-2, BH-7, BH-8 and BH-9 at depths ranging from 7.6 m to 12.7 m (EL. 150.4 to EL. 157.6) below ground surface. In the remaining boreholes, except Borehole P-1, groundwater was not encountered upon completion of drilling. Borehole P-1 was charged with coring water/mud and thus, groundwater level could not be established upon completion of drilling. Groundwater levels may fluctuate due to the influence of precipitation and seasonal changes.

Shaft No.1 is relocated approximately 65.2 m north of the initial proposed location which was adjacent to Borehole BH1. The ground conditions are assumed similar based on a review of the available boreholes in the vicinity and are deemed sufficient for design purpose. The Contractor should verify the subsurface soil and groundwater conditions.

The nature of the glacial till deposit is that occasional cobbles or boulders may be expected. The presence of cobbles was confirmed during bedrock coring in Boreholes BH3 and BH5 at the level of the tunnel alignment. A special provision should be provided in the contract package to alert the Contractor the presence of cobbles or boulders within the glacial till soils.

18.3 Tunnel Alignment

The trenchless installation, including entry and exit shafts, will be approximately from Station 0+817 to Station 1+377 based on the drawings provided by Cole. The 400 mm diameter watermain is proposed to be carried within a 1515 mm outside diameter (OD) C300 MT steel liner, which is to be installed by micro-tunnelling trenchless method. The length of the proposed tunnel section will be approximately 552.2 m across MTO ROW approximately from Station 0+822.8 to Station 1+375. The proposed invert level of the steel liner will be approximately from EL. 151.2, at Station 0+822.8, to EL. 150.7, at Station 1+375. Table 23 summarizes the approximate stations for the proposed tunnel alignment.



TABLE 23
SUMMARY OF TUNNEL SECTION

SECTION	FROM STATION (APPROXIMATE)	TO STATION (APPROXIMATE)	APPROXIMATE LENGTH (m)
Shaft No. 1	0+817	0+823	6.0
Tunnel Section	0+822.8	1+375	552.2
Shaft No. 2	1+369	1+377	8.0

Refer to Table 24 for the details of cover depth, obvert/invert elevations and groundwater levels along the tunnel section.

18.4 Installation of 1515 mm OD C300 MT Steel Liner

Micro-tunnelling involves the advancement of a tunnel boring machine from the jacking pit to the receiving pit. The Micro-Tunnel Boring Machine (MTBM) and the tunnel segments are pushed from the jacking pit while line and grade are controlled by the tunnel boring machine as it advances. These machines typically utilize pressurized bentonite slurry to counterbalance the earth and water pressures acting at the tunnel face. The excavated soil slurry is withdrawn in a controlled manner to prevent loss of ground during tunnel advance. The slurry is circulated back through the tunnel to transport cuttings to a settling tank. Given the machines ability to control soil and water pressures at the face, dewatering prior to advancing the tunnel would not be necessary with this tunnelling method. However, dewatering of the staging and receiving pits will still be required and reference is given to the excavation and ground water control section. The size of drive and receiving pits required may vary in length.

Based on the subsurface conditions encountered, it is considered that the risk is low for the MTBM advancement to be halted and stuck (unable for further advancement).



To manage potential obstruction resulting from cobbles, boulders and Shale bedrock during tunnelling operation, the TBM can be equipped with suitable combination heads, scraper and disc cutters, to bore through the glacial till deposit, cobbles and boulders, and shale bedrock at this site. The Contractor must be prepared to deal with encountered cobbles, boulders and bedrock during tunnelling operations.

If MTBM advancement has been halted under the Highway 401, and the obstruction cannot be removed, the tunnel has to be abandoned by removing the MTBM and accessories, and to fill in the abandoned tunnel by effective means such as cement grout. An adjacent tunnel may be advanced for the installation of the watermain. Use of a rescue shaft from the surface of Highway 401 is considered not practical and not feasible due to traffic on the highway, safety of the public, and the massive disruption that this may cause to the traffic network throughout the City and the Greater Toronto Area.

Table 24 summarizes the cover depth, tunnel invert depth and the anticipated soil/bedrock to be encountered at each borehole location investigated within the micro-tunnelling trenchless section.



TABLE 24
SUMMARY OF MICRO-TUNNELLING TRENCHLESS SECTION

BOREHOLE NO.	GROUND ELEVATION (m)	COVER DEPTH (m) AND OBVERT ELEVATION (m)	APPROXIMATE INVERT ELEVATION (m)	GROUNDWATER LEVEL DISTANCE FROM INVERT ELEVATION (m) (GROUNDWATER ELEVATION, m)	ANTICIPATED SOIL/ROCK TYPE ALONG TUNNELLING DIAMETER
G-3	160.2	7.5 (152.7)	151.1	N.E.	Borehole not extended to the tunnel depth. Possibly Sandy Clayey Silt Till (based on extrapolation from BH1)
BH1	160.1	7.4 (152.7)	151.1	+6.4 ⁽¹⁾ (157.5)	Sandy Clayey Silt Till (thinly laminated shale layers within till from EL. 153.3).
BH2	163.1	10.4 (152.7)	151.1	-0.7 ⁽²⁾ (150.4)	Sandy Clayey Silt Till (thinly laminated shale layers within till from EL. 155.5).
BH3/3-1	163.5	10.8 (152.7)	151.0	+4.9 ⁽³⁾ (155.9)	Sandy Clayey Silt Till (thinly laminated shale layers and cobbles within till from EL. 154.4) to Shale Bedrock (EL. 152.4 to EL. 151.0, RQD 54%).
BH-4	163.2	10.6 (152.6)	151.0	+6.4 ⁽¹⁾ (157.4)	Clay and Cobbles (EL. 152.5 to EL. 151.0)
BH-5	160.8	8.2 (152.6)	151.0	N.E.	Clay and Cobbles (EL. 152.6 to EL. 152.9) followed by Shale Bedrock (Run 2, RQD 0%)
P-1	160.9	8.3 (152.6)	151.0	+4.7 ⁽³⁾ (155.7)	Clayey Sand Till (thinly laminated shale layers within till from EL. 151.0).



TABLE 24
SUMMARY OF MICRO-TUNNELLING TRENCHLESS SECTION

BOREHOLE NO.	GROUND ELEVATION (m)	COVER DEPTH (m) AND OBVERT ELEVATION (m)	APPROXIMATE INVERT ELEVATION (m)	GROUNDWATER LEVEL DISTANCE FROM INVERT ELEVATION (m) (GROUNDWATER ELEVATION, m)	ANTICIPATED SOIL/ROCK TYPE ALONG TUNNELLING DIAMETER
BH-6	160.7	8.3 (152.4)	150.8	+4.6 ⁽³⁾ (155.4)	Clayey Sand Till (thinly laminated shale layers within till from EL. 151.7).
BH7/7A	165.1	12.7 (152.4)	150.8	+8.7 ⁽¹⁾ (159.5)	Silty Gravel, with sand (thinly laminated shale layers within till from EL. 151.0).
BH8	165.2	12.8 (152.4)	150.8	+6.8 ⁽²⁾ (157.6)	Sandy Clayey Silt Till (thinly laminated shale layers within till from EL. 151.5).
BH9	164.3	12.0 (152.3)	150.7	+4.2 ⁽²⁾ (154.9)	Sandy Clayey Silt Till (thinly laminated shale layers within till from EL. 150.7).
BH10 (Close to Shaft 2)	159.6	7.3 (152.3)	150.7	+8.2 ⁽¹⁾ (158.9)	Silty Sand to Sandy Clayey Silt Till (thinly laminated shale layers within till from EL. 151.2)

Note(s): N.E. – Groundwater was not encountered during and upon completion of drilling.
 (1) – Groundwater level measured (latest) in monitoring well was considered.
 (2) – Groundwater level measured upon completion of drilling was considered.
 (3) – Groundwater level (first strike) observed during drilling was considered.
 + – Groundwater distance above tunnel invert elevation.
 – Groundwater distance below tunnel invert elevation.



The tunnel invert will be ranging from EL. 151.2 to EL. 150.7, from north to south along the tunnel alignment. It is anticipated that the proposed tunnelling will be mostly carried out within the very dense/hard glacial till deposit. Cobbles and boulders are anticipated to be encountered within the glacial till. In Boreholes BH3/3-1 and BH5, it is anticipated that bedrock will be encountered at the tunnel invert level. It is anticipated that the Shale is interbedded with limestone and siltstone layers that are stronger and more abrasive than the shale beds, and will tend to slow penetration rates and cause increased plucking and overbreak above the cutterhead, increase tool wear and impact steering of the machine.

The proposed tunnel path is generally above the bedrock surface and hence, the in-situ stresses may not be a major concern. Nonetheless, the Contractor/ Designer should examine whether the steel liner is sufficient for potential rock stresses. The tunnel bore is partly in overburden and only partly in the rock in the area of Boreholes BH3/3-1 and BH5. The Contractor should be prepared to handle mixed face conditions. There may also be variability in the bedrock surface, and in case the tunnel excavation encounters higher rock surface at or above the obvert level, the contractor should have the provision of an oversized cutter head or a larger bore of the MTBM to facilitate the tunnel advance, and a gap to accommodate the rock displacement and stress relief prior to contacting the liner. All voids or gap between the wall of the excavated tunnel/bore and the liner/casing shall be filled with suitable compressible material with appropriate strengthening agents or equivalent materials by the tunnelling Contractor.

The Contractor should anticipate that penetration rates, cutter tool wear, cutter tool replacement downtime and overall excavation progress will be impacted by the interbeds and suitably account for these factors. Alignment control of the tunnelling equipment may also be impacted by interbeds depending on their alignment and thickness around the excavation perimeter.

It is expected a slurry shield micro-tunnelling machine with face support will be utilized to carry out the installation. In general, the stability of the tunnel face is not anticipated to be an issue within the hard/very dense glacial till overburden. As a result, there is a relatively low risk for collapse and loss of ground under the highway during construction. The above is based on providing appropriate method of installation and good workmanship. However, the presence of cobbles, boulders and bedrock along the tunnelling path may hamper the progress of the tunnelling operation.



After the permanent watermain pipe is placed within the installed steel casing, post grouting to fill the annular space between the pipes by a suitable grout/ cement foam or equivalent materials should be carried out by the tunnelling Contractor.

18.5 Ground Classification Discussions

The trenchless operation will advance mostly through the native glacial till as indicated in Table 24. Shale bedrock will be encountered locally in the vicinity of Boreholes BH3 and BH5. It is anticipated that the glacial till will contain cobbles and boulders. It is expected that the till will exhibit different resistances across the tunnel diameter along the tunnel length, and advancement of the steel liner may be often difficult.

The Tunnelman's Ground Classification System (Heuer, 1974, Terzaghi, 1950) has been used as a basis to describe the anticipated behaviour of the ground. Considering the encountered subsurface soil and groundwater conditions, the native sandy clayey silt till and clayey sand till may be classified as 'firm', 'slow ravelling' and 'bouldery'. The initially "slow ravelling" ground may change into "fast ravelling" ground where less cohesive or fissured zones are encountered, requiring the excavation to be supported at the crown, perimeter and face.

The stand-up time for these soils is shown in Table 25. The stand-up time is based on the behavioristic classification of various soils by Deere et. al. (1969).

TABLE 25
STAND-UP TIME FOR SOIL TYPE

TUNNELMAN'S SOIL TYPE	STAND-UP TIME RANGE
Firm	>30 hours
Slow Ravelling	100 min to 30 hours
Fast Ravelling	7 min to 100 min

Clean gravel and sands have practically no stand-up time.



The RQD of the Shale bedrock through the tunnel alignment in Boreholes BH3/3-1 and BH5 are 54% and 0%, respectively. Based on the RQD values, the bedrock may be classified as Class E (very broken rock) to Class C (unstable rock after a long time) in accordance with Lauffer's (1958) classification. The approximate stand-up time for these rock types is shown in Table 26 for an unsupported width of 1.5 m span. The stand-up time is based on the Deere et. al. (1969) classification.

TABLE 26
STAND-UP TIME FOR ROCK TYPE

TUNNELMAN'S SOIL TYPE	APPROXIMATE STAND-UP TIME
Class C	1 day
Class E	1 min

It should be noted that unsupported vertical side walls cannot be maintained in the firm to slow ravelling cohesive soils and the completely to highly weathered shale bedrock.

18.6 Predicted Settlement and Horizontal Displacement

Attewell et. al., 1986, method was used to estimate the settlement and horizontal displacement along the tunnel alignment. The following equations, as proposed by Attewell et. al., 1986, were used to estimate the settlement and horizontal displacement along the tunnel length.

$$i = R_o (Z_o / 2R_o)^n$$

$$S_{\max} = \frac{V_{\text{tunnel}} \times V_s}{2i} \times 1000$$

$$\delta_y(x) = S_{\max} e^{-x^2/2i^2}$$

$$\delta_x(x) = -\frac{n\delta_y(x)}{Z_o} x$$



Where,

- i is horizontal distance between inflection point and tunnel axis on the $\delta_y(x)$ curve in [m]
- R_o is tunnel radius in [m]
- z_o is depth to tunnel axis below ground surface in [m]
- n is depth coefficient (between 0.8 and 1.0)
- V_{tunnel} is the tunnel cross-sectional area in [mm²]
- V_s is the ground loss percentage in [%]
- S_{max} is maximum surface settlement above tunnel ($x=0$) in [mm]
- $\delta_y(x)$ is the estimated settlement in [mm]
- $\delta_x(x)$ is the estimated horizontal displacement in [mm]

A 3.0% volume loss and a depth coefficient (n) of 1.0 were assumed for the settlement calculation. Table 27 summarizes the estimated settlement and horizontal displacement along the tunnel length.

TABLE 27
SUMMARY OF SETTLEMENT AND HORIZONTAL DISPLACEMENT

BOREHOLE NO.	APPROXIMATE COVER DEPTH (m)	HORIZONTAL DISTANCE i (m)	APPROXIMATE MAXIMUM SETTLEMENT (mm)	APPROXIMATE SETTLEMENT AT DISTANCE i (mm)	APPROXIMATE HORIZONTAL DISPLACEMENT AT DISTANCE i (mm)
G-3	7.5	4.1	5.2	3.2	1.6
BH1	7.4	4.1	5.3	3.2	1.6
BH2	10.4	5.6	3.9	2.4	1.2
BH3/3-1	10.8	5.8	3.7	2.3	1.1
BH-4	10.6	5.7	3.8	2.3	1.2
BH-5	8.2	4.5	4.8	2.9	1.5
P-1	8.3	4.5	4.8	2.9	1.4
BH-6	8.3	4.5	4.8	2.9	1.4
BH7/7A	12.7	6.7	3.2	2.0	1.0
BH8	12.8	6.8	3.2	1.9	1.0
BH9	12.0	6.4	3.4	2.1	1.0
BH10	7.3	4.0	5.4	3.3	1.6



The theoretical calculations based on the assumptions made in this section and couples with experiences and case records of tunnelling indicate that the settlements could be controlled to within acceptable tolerance provided that the suitable and proper equipment and workmanship has been used. The Designer and Contractor should carry out their own settlement and horizontal displacement calculations based on their own purposes.

The scope of foundation investigation does not include assessing the impact on the pavement and utilities that may be in the vicinity of the alignment. Cole will be responsible for any associated impact on the existing structures and underground utilities in the vicinity due to settlement and horizontal displacement along the tunnel length.

18.7 Entry and Exit Shafts

Based on the drawing provided by Cole, PML understand that the staging pits (Shaft 1 and Shaft 2) will be located at approximate stations as shown in Table 23.

18.7.1 Excavation for Entry and Exit Shafts

Prior to excavation, the locations and depths of existing underground utilities should be verified. All underground utilities that might be exposed and become unsupported as a result of the excavation should be properly supported to avoid potential damage. In detail design, it may be necessary to consider relocation of the existing underground utilities if the conflicts cannot be resolved.

Based on the updated plan and profile drawings, excavation at Shaft No. 1 is expected to extend to an approximate depth of 10.6 m (EL. 150.9) below the existing grade, and at Shaft No. 2, it is expected to extend to an approximate depth of 10.4 m (EL. 150.6) below the existing grade. The excavations to the depths indicated require a drill shaft or a properly designed protection system.

General Reference is given to OPSS.PROV 201, 490 and 801 for specifications associated with site preparation.

As noted above, the excavations will be advanced through surficial topsoil, fill, stiff to hard sandy clayey silt glacial till and shale bedrock. Cobbles and boulders are anticipated to be encountered within the glacial till. The hydrostatic pressure at the base of the pits, based on ground water levels measured at the nearest monitoring wells in Boreholes BH1 and BH10, is expected to be about 70 kPa at the Shaft 1 location, and 90 kPa at the Shaft 2 location. Considering the stiff to



very stiff sandy clayey silt till and shale bedrock below the base of the pits, basal instability or heave at the pits is not anticipated. Nonetheless, it is imperative that the Contractor should check the stability based on their own shoring design and dewatering methods.

Provided adequate groundwater control is achieved, the onsite soils are classified as Type 3 material as defined in the Occupational Health and Safety Act (OHSA). Excavations within Type 3 soil that are to be entered by workers may not be steeper than one horizontal to one vertical (1H:1V) from the base. Workers should not enter an unprotected excavation if there is evidence of ongoing ground water seepage in the pits. Temporary protection system will be required where temporary excavation slopes cannot be provided or maintained.

18.7.2 Temporary Protection System

The soil parameters provided in Table 28 may be used to for the design of the temporary protection system at the exit/entry pits. The protection system for excavations should follow OPSS.PROV 539, amended by SSP 105S09, and OPSS.PROV 902. It should be noted that the use of shoring may conflict with existing utilities. The Contractor is responsible for the selection, design, construction, and performance of the temporary protection systems. The protection systems should be designed to meet the appropriate Performance Level 2 as specified in OPSS 539 and SSP 105S09.

TABLE 28
SOIL PARAMETERS

APPROXIMATE SHAFT STATION (BOREHOLE No.)	ELEVATION (m)		SOIL TYPE	SOIL PARAMETERS		
	FROM	TO		FRICTION ANGLE (ϕ°)	UNIT WEIGHT ² (γ) kN/m ³	C _u , (kPa)
0+817 to 0+823 (nearest borehole to bedrock, BH1) ¹	160.1	158.9	Clayey Silt (Fill)	20	18	50
	158.9	157.8	Sandy Silt/Silty Sand (Fill)	28	19	-
	157.8	150.9	Hard Sandy Clayey Silt (Till)	20	20	100
	150.9	150.1	Shale Bedrock	24	22	7500 (UCS ~15 MPa)
1+369 to 1+377 (BH10)	159.4	157.0	Clayey Silt (Fill)	20	18	50
	157.0	149.7	Very Stiff Clayey Silt (Till)	20	20	100

Note 1: The soil and rock parameters are based on close by boreholes to the shaft and geological inference only.

Note 2: Submerged unit weight for soils should be used below the water level.



If the shoring system does not provide for drainage or is a watertight system, the groundwater pressure should be added to the lateral earth pressures for design.

18.7.3 Groundwater Control

The actual groundwater control methods should be established at the contractor's discretion within the context of a performance specification for the project. Regardless of the method chosen, the hydraulic head and ground water inflow must be properly controlled to ensure a stable and safe excavation and to facilitate construction. The design of the groundwater control system should be carried out by specialists in the field and specified to maintain and control ground water at least 0.5 m below the base of the excavation, in order to provide a stable base throughout the construction.

Groundwater control will be required to lower the ground water table in both (entry/exit) pits. The groundwater level may have to be lowered by at least 7.1 m (Shaft No. 1) to 8.8 m (Shaft No. 2) to maintain the base of the pits in dry conditions. Considering the hydraulic conductivity ($K \approx 4.0 \times 10^{-7}$ cm/s to 1.0×10^{-6} cm/s) of glacial till measured in the monitoring wells installed in Boreholes BH1 and BH10, and hydraulic conductivity (1×10^{-5} cm/s to 8×10^{-5} cm/s) of bedrock in Borehole BH1, dewatering scheme together with shoring system design is required to lower the water level a minimum of 0.5 m below the base of excavation. Alternatively, water-tight shaft construction could be employed at the entry and exit shafts. Construction during the dry time of the year is also recommended in order to reduce the ground water control requirements.

The contractor should be responsible for the selection, performance and detailed design of the dewatering system. The dewatering system should be designed to conform to the requirements of OPSS.PROV 517 and SSP 517F01.

The lowering of water level by about 7.1 m to 8.8 m may increase the effective stress at the base by about 70 to 90 kPa, which will be a temporary loading, and expected to last until the installation of watermain. The settlement resulting from lowering of groundwater level is not expected to exceed 5.0 mm around the pit.

In accordance with SSP 517F01, the dewatering system should be designed by a designer with a minimum 5 years of experience in the field. A preconstruction survey of 40 m radius from the exit and entry pits should be considered due to relatively deeper depth of dewatering required.



18.7.4 Backfill of Entry and Exit Shafts

Ontario Provincial Standard Specifications (OPSS.PROV 1010) Granular 'A' or 'B Type II' should be used as backfill material and compacted in accordance with the requirements specified in the OPSS.PROV 902 (Excavation and Backfilling of Structures). The backfill material should be placed in layers not exceeding 200 mm (8 in.) in thickness before compaction.

Heavy vibratory compaction equipment near entry/exit pit drill shafts should be restricted to limit the compaction pressure described in Clause 6.12.3 of the CHBDC, 2019. Restrictions on compaction near the drill shafts shall be as specified in OPSS.PROV 902. The type of compaction equipment and the compaction procedure that can be used for this purpose should be in accordance with OPSS.PROV 501 (Construction Specification for Compacting). Table 29 provides the recommended preliminary earth pressure coefficients for granular backfill.

TABLE 29
PRELIMINARY EARTH PRESSURE COEFFICIENTS

PARAMETERS	OPSS GRANULAR 'A'	OPSS GRANULAR 'B' TYPE II
Internal Friction Angle, (degrees)	35	30
Unit weight, γ (kN/m ³)	22.5	21.5
Coefficient of Active Earth Pressure, K_a	0.27	0.33
Coefficient of Earth Pressure At Rest, K_o	0.43	0.5
Coefficient of Passive Earth Pressure, K_p	3.69	3

19. CONSTRUCTION CONSIDERATIONS

It is the responsibility of the Contractor to assure that potential loss of ground is minimized and any excessive movements and settlements resulting from the trenchless operations are to be dealt with immediately at no additional cost to the owner. If adverse conditions are met, depending on the severity of the suspected ground loss, a contingency investigation program may be required to identify potential repair methods and extent of damage. Investigation techniques may include boreholes, or test pits and geophysical methods such as ground penetrating radar (GPR). It is suggested that the specifications should require the contractor to provide contingency



plan for adverse and excessive ground loss events to be implemented upon observations of large voids or excessive settlements. A program of repair including grouting and regrading /paving may be required.

19.1 Settlement Monitoring

The ground surface over the tunnel route may become distorted and distressed by tunnelling. The most common type of distress is settlement caused by loss of ground around the tunnel. Heave of the ground surface and or inadvertent drilling fluid returns are also possible depending on the type of installation. Mitigation of the distress or distortion on the travelled lanes of Highway 401 is required for safety of the highway users.

Distress at the ground surface is generally prevented or minimized by good construction practices and proper planning. In this regard, preparation of an installation plan as noted above is recommended.

The tunnelling process should be continuous, such that a stoppage in the advancement of the tunnel is not programmed when the end of the tunnel is under the travelled lanes of Highway 401. Such a stoppage would provide greater potential for loss of ground/settlement around the tunnel.

Monitoring during tunnelling will provide feedback to the Engineer and Contractor to adjust the construction procedures to control ground movements. Accordingly, changes to the progress and procedures can be made before the construction reaches locations where ground movements could be potentially damaging to the highway. The proposed locations of the in-ground monitoring points (IMPs) and surface monitoring point (SMPs) are shown in Plan Nos. 74191-D, 74192-D and 74193-D. Within the travelled lanes of Highway 401 and associated ramps, the settlement points are shown at a maximum interval of 5.0 m. Where feasible, an array of three SMPs, with one at the centerline and two SMPs at distance of 5 m apart are to be installed at the road shoulder and the medians.

It is recommended that the project proponent implement a monitoring program to check the condition of the ground over the tunnel before, during and upon completion of construction. The monitoring program should be carried out by a qualified geotechnical consulting firm that is MTO RAQS approved and should conform to the MTO Settlement Monitoring Guidelines for Tunnelling (MTO Tunnelling Guidelines provided in Appendix E). Monitoring points should be



installed over the proposed tunnelling route at a maximum interval of 5 m. Monitoring period should begin prior to tunnelling, extend throughout the duration and continue at least 2 weeks after completion of tunnelling. Measurement of the monitoring points should be done at least 3 times a day for everyday in the monitoring period. Monitoring of settlement points by remote methods (off-road) such as the use of total stations is suggested for the travelled portions of the Highway 401 and associated ramps.

Settlement or heave of the roadway from a micro-tunnelling method carried out in accordance with the recommendations provided in this report should be less than 10 mm. If settlement or heave of the ground surface exceeds 10 mm, the construction process should be reviewed and adjusted to mitigate further disturbances for the remainder of the tunnelling work.

If total settlement or heave exceeds 15 mm, tunnelling operations should be terminated, the site secured against further deterioration and mitigation action should be undertaken immediately to reinstate the roadway, ditches and/or the existing storm sewer.

If distress is observed during construction, the contractor should be informed and corrective action should be undertaken immediately. Specific corrective action will be dependent on the nature of the distress and type of installation. Regardless, the process should be outlined in the monitoring program and be part of the contingency actions in the contractor's installation plan. It should be noted that the ground movement monitoring does not relieve the Contractor's responsibility to undertake the necessary action and additional instrumentation and independent reading of the instrumentation to ensure that work is carried out in a safe and acceptable manner.

Monitoring points should be marked using a method approved by MTO. Monitoring points should also be functional throughout the monitoring period and should not deteriorate because of highway traffic, maintenance activities, and weather conditions. IMP and SMP, as shown in FIG. 1, Settlement Instrumentation, may be used for marking monitoring points.

A pavement condition survey of the pavement directly above the pipe alignment should be carried out before, during and after the installation.

All actions to prevent, secure, or mitigate destruction or damage to the highway and associated features should be done in accordance with and approved by MTO.



19.2 In-Construction Water Taking Permit

In-construction and post-construction dewatering, like other water takings in Ontario, is governed by the Ontario Water Resources Act (OWRA) and the Water Taking and Transfer Regulation 387/04, a regulation under the OWRA.

In accordance with the above-noted regulatory requirements and in compliance with the MECP's Permit-To-Take-Water Manual (April 2005), an application for a Permit-To-Take-Water (PTTW) should be filed with the MECP if the construction dewatering discharge rate is expected to be greater than 400,000 L/day or about 4.6 L/s. If the dewatering discharge is expected to be greater than 50,000 L/d and less than 400,000 L/d, the water taking will not require the MECP PTTW approval process and can instead be registered with the Environmental Activity and Sector Registry (EASR). Water takings of less than 50,000 L/d do not require a permit with the MECP.

The estimated construction dewatering discharge rates range from 10,200 L/d to 22,600 L/d, and with a factor of safety of 2.0, the discharge rates range from 20,400 L/d to 45,200 L/d. Note that the latter rate is for a length of 260 m, and is not likely to be dewatered at one time. The estimated dewatering zone of influence radii ranged from about 3 to 39 m.

Since the construction dewatering discharge rate is estimated to be less than 50,000 L/d if the watermain and associated structures (shafts, drain interconnection, air release chamber etc.) are not dewatered simultaneously, neither a PTTW nor an EASR is required for the site.

Please note that due to the inherent uncertainties of the limited findings and analyses, there is a potential for the actual dewatering pump rates to exceed 50,000 L/d, necessitating an EASR. Thus, it is advised that all practical methods be used to ensure that this limit is not exceeded; for example, since ground water levels vary over time, it is best to schedule excavation for periods of low ground water level. The dewatering system (or excavation) footprint should be minimal and dewatering wells or sumps installed no deeper than is required to achieve the desired drawdown. Surface water intrusion should be minimized. Also, the dewatering requirements should be reassessed if the design footprint or depths of excavation are changed, or if additional underground services (not assumed in this evaluation) are to be installed and dewatered simultaneously.



19.3 Discussion on Swelling Potential

Null swell tests were conducted on selected samples of slightly weathered to unweathered Georgian Bay Shale by K.Y. Lo Inc., University of Western Ontario, London, Ontario and Mirarco Mining Innovation, at Sudbury, Ontario. A total of ten null swell testing were conducted on selected shale bedrock samples.

Based on the interpretation of the null swell test results on 6 rock samples by Mirarco Mining Innovation, the swelling index ranged between 98 and 418 kPa, and the maximum pressure ranged approximately from 40 kPa to 90 kPa. Based on the test results, the classification of the swelling pressure index of the rock samples may be classified as 'Low'.

The test results provided by the University of Western Ontario indicate that Calcite content ranged from 1.0 to 3.8% and Salinity content 19.4 to 35.8 g/L. Calcite and salt concentrations are included in the test program as it is known that higher calcite concentrations in the shale matrix inhibit swelling of the rock while higher salt concentrations increase swelling.

For tunnelling in shale with swelling potential, the results of the laboratory tests may be used for the design using the suppression pressures presented in the FIR of the report. The lining should be checked for all combined loading cases for the worse scenario. The design of the watermain and casing may be based on bedrock/pipe interaction analysis considering the excavation size, controlled overcut gap filling materials, and the rock swell characteristics. Because the tunnel alignment is generally proposed above the bedrock surface, the in-situ bedrock stresses are not a concern.

Generally, there is relatively little time between the MTBM tunnel excavation advance and the installation of the casing pipe, which is generally placed immediately following the MTBM by "pipe jacking" methods. It is assumed that the tunnel contractor will provide for an oversized cut so as to allow for advancing the MTBM without being trapped in the squeezing rock, where encountered. The casing and potentially the watermain pipe will need to be designed for the loads induced by swelling of the shale formation in the vicinity of BH3/3-1 and BH5 locations. In practice, generally compressible grout/cement foam or equivalent materials would need to be considered in the design between the overburden soil/bedrock and casing pipe, and between the casing pipe and the watermain pipe. This action is to attenuate the pressure. The final pressures will be



dependent on the tunnel contractor's design of the dimension of the controlled overcut and viscosity of the slurry between the casing and the shale, assuming a Slurry MTBM is used in the construction.

19.4 Toxic and Explosive Gases

Methane and hydrogen sulphide gas are known to occur in pockets of deep soil and shale bedrock of Southern Ontario. Methane can form an explosive mixture with air, while hydrogen sulphide has toxic effects.

The QRAE 3 was used to detect the presence of methane and hydrogen sulphide, with other gases, in Boreholes BH1, BH3, BH4, BH5, BH9 and BH10. The monitor did not detect/register presence of methane or hydrogen sulphide in the six (6) boreholes.

However, the presence of methane and hydrogen sulphide should not be overlooked along the full tunnel length. Based on the known association of methane with the Georgian Bay Formation, as a baseline condition, a designation of "potentially gassy" may be applied to the shale bedrock. The project specifications may include provisions for gas monitoring and requirements for selected underground equipment (such as ventilation systems). The Contractor should prepare and implement protocols to address all hazards from subsurface gases that are expected to be encountered during tunnelling and excavation activities in accordance with the Contract Specifications and the Occupational Health and Safety Act.

19.5 Soil Corrosivity

A total of 12 samples were tested for soil corrosivity and potential exposure of concrete to sulphate attack. A summary of the results of chemical analyses are provided in Section 12 of Part A of this report. The sulphate concentration varied from 31.0 µg/g to as high as 280 µg/g (0.0031% to 0.0280%), which is less than 0.1% (1000 µg/g) generally indicates a low degree of sulphate attack. Compared to the values suggested in Canadian Standard A23.1-14, the effect of soils on buried concrete structures may be negligible. The chloride contents of the samples from the fill ranged from as low as 30 µg/g to 440 µg/g (0.0030% to 0.044%). Generally, the concentration value in excess of 250 ppm (0.025%) leads to corrosive environment for buried metals or reinforcing steel. The potential for corrosive environment is assessed to be high at



Borehole BH1 location. The other borehole locations for corrosive environment are assessed to be low.

Electrical resistivity less than 2000 ohm-cm generally leads to highly corrosive environment for steel elements in contact with soil. The resistivity values typically ranged from 2600 ohm-cm to 6670 ohm-cm, indicating negligible to low corrosive environment for steel elements in contact with soils, with the exception of a resistivity value of 1720 ohm-cm obtained in Borehole BH1 sample depth 3.0 m to 3.7 m indicating high corrosive environment for steel elements. The pH values of soil samples ranged from 8.36 to 9.31 compared to the value of 5.5 that generally lead to corrosion.

Based on the results, imported granular material in accordance with OPSS.PROV 1010 should be used to mitigate corrosive effect of native soil on steel elements, if required.



20. CLOSURE

This report was prepared by Mr. N. Rahman, P.Eng. and Mr. S. Tarafder, PhD, P.Geo. Mr. Robert Ng, PhD, MBA, P.Eng., MTO Designated Principal Contact, conducted an independent review of the report.

We trust this report has been completed within the terms of reference and is sufficient for your current needs. Should you have further questions, do not hesitate to contact our office.

Sincerely

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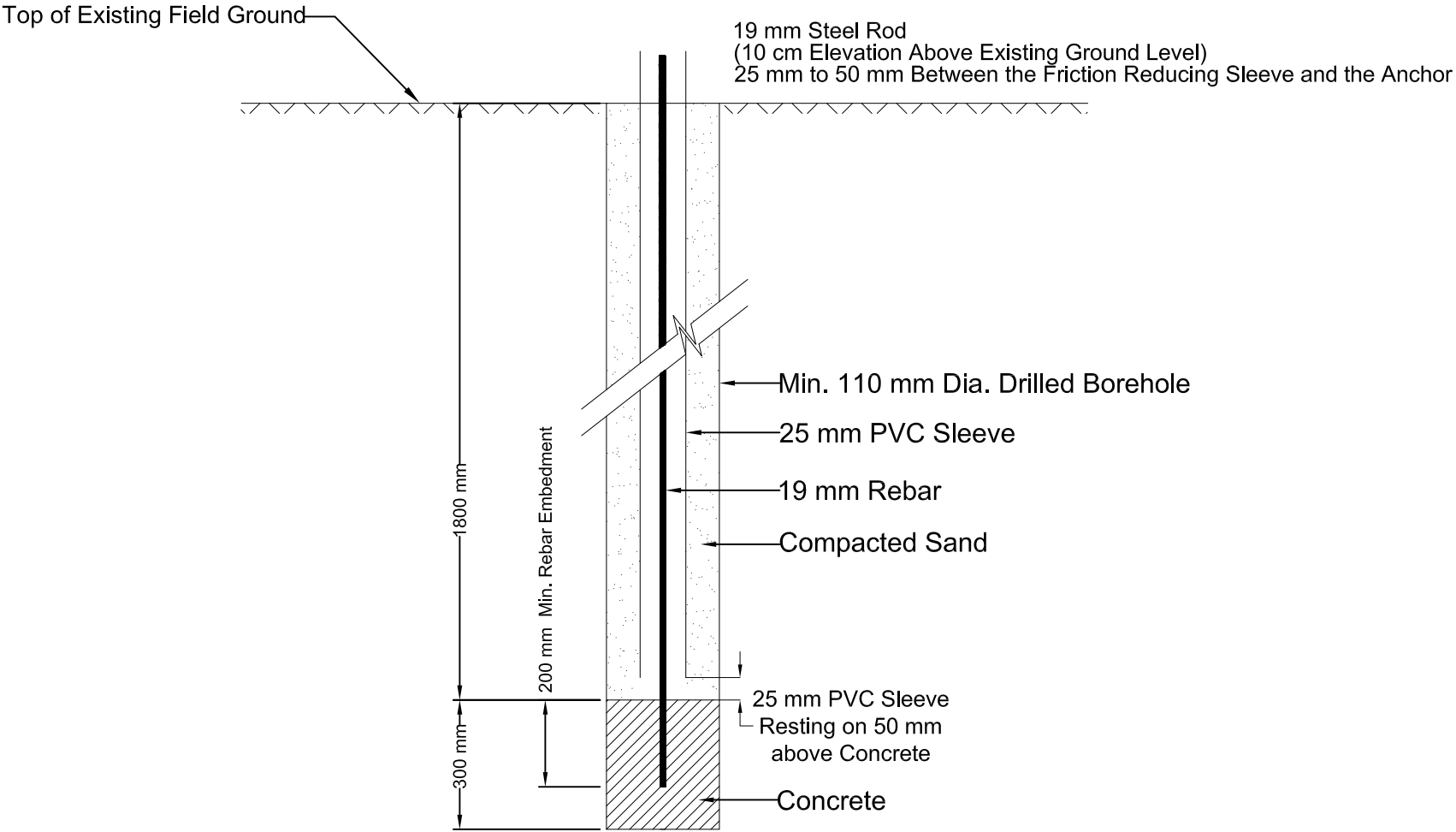
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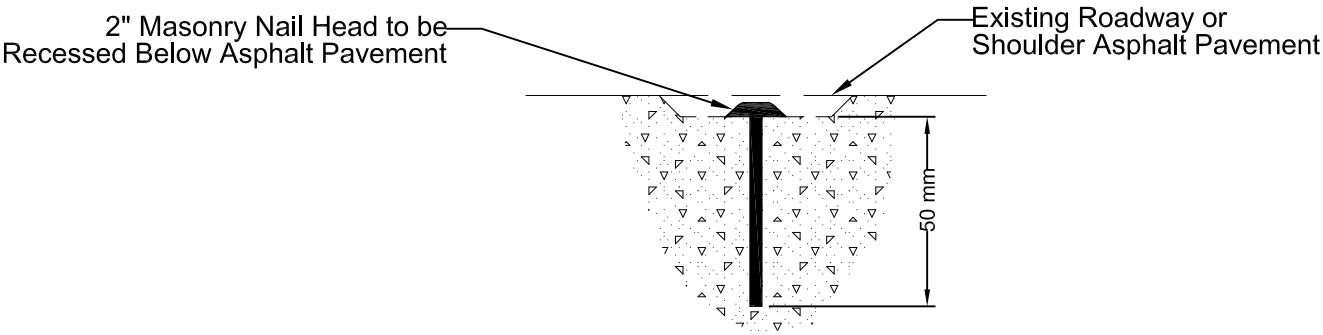
LIST OF STANDARD SPECIFICATIONS RELEVANT TO REPORT

DOCUMENT	TITLE
OPSS.PROV 201	Cleaning, Close Cut Clearing, Grubbing and Removal of Surface and Piled Boulder
OPSS.PROV 490	Site Preparation for Pipelines, Utilities and Associated Structures
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 801	Construction Specification for Protection of Trees
OPSS.PROV 902	Construction Specification for Excavating and Backfilling -Structures
OPSS.PROV 1010	Material Specification for Aggregates, Base, Subbase, Select Subgrade and Backfill Material
OPSS.MUNI 201	Cleaning, Close Cut Clearing, Grubbing and Removal of Surface and Piled Boulder (Municipal)
OPSS.MUNI 410	Construction Specification for Pipe Sewer Installation in Open Cut (Municipal)
OPSS.MUNI 490	Site Preparation for Pipelines, Utilities and Associated Structures (Municipal)
OPSS.MUNI 517	Construction Specification for Dewatering (Municipal)
OPSS.MUNI 801	Construction Specification for Protection of Trees (Municipal)
OPSS.MUNI 1010	Material Specification for Aggregates, Base, Subbase, Select Subgrade and Backfill Material (Municipal)
SSP 517F01	Amendment to OPSS 517
SSP 105S09	Amendment to OPSS 539
OPSD 802.010	Flexible Pipe Embedment and Backfill Earth Excavation
OPSD 803.030	Rigid Pile Bedding, Cover, and Backfill, Type 1 or 2 Soil, Earth Excavation
OPSD 803.031	Rigid Pile Bedding, Cover, and Backfill, Type 3 Soil, Earth Excavation
OPSD 803.032	Rigid Pile Bedding, Cover, and Backfill, Type 4 Soil, Earth Excavation
OPSD 3090.101	Foundation, Frost Penetration depths for Southern Ontario

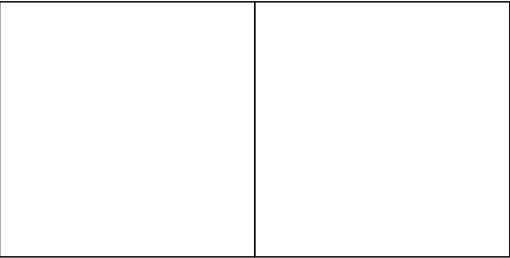
CONT No	
GWP No	
WP No	
DIXIE ROAD	SHEET
WATERMAIN REPLACEMENT	
SETTLEMENT INSTRUMENTATION	



IN-GROUND MONITORING POINT (IMP) (TYP.)
(NTS)



SURFACE MONITORING POINT(SMP) (TYP.)
(NTS)



REVISIONS			
DATE	BY		DESCRIPTION

HWY No	401			DIST	Central
SUBMD	NL	CHECKED	NR	DATE	OCT, 2021
DRAWN	NL	CHECKED	MZ	APPROVED	RN
				FIG.	1



APPENDIX E

MINISTRY OF TRANSPORTATION'S
"GUIDELINES FOR FOUNDATION ENGINEERING – TUNNELLING SPECIALTY
FOR CORRIDOR ENCROACHMENT PERMIT APPLICATION"

Guidelines for Foundation Engineering – Tunnelling Specialty For Corridor Encroachment Permit Application

General

These guidelines specify MTO requirements for the Foundation Engineering – Tunnelling Specialty component of submissions from proponents of development within the Ministry of Transportation's (MTO) corridor permit control area. The Foundation Engineering – Tunnelling Specialty component of submissions is a requirement for the permit application only and does not cover all the design requirements.

All applications containing tunnelling proposals shall be forwarded to the regional Geotechnical Section for review. Applications containing Low Complexity tunnelling proposals will typically be reviewed by the regional Geotechnical Section. The Geotechnical Section will forward applications involving Medium and High Complexity tunnelling proposals to the Foundation Section of the Structures Office for review.

Foundations Engineering consultants that are registered in the MTO consultant acquisition system (RAQS) at complexity ratings identified in Table 1 are eligible to provide Foundations Engineering services for this project. Alternatively, the proponents may propose a Foundations Engineering consultant that is not registered in RAQS, in which case, the proponent must submit sufficient documentation to demonstrate that the consultant's qualifications meet or exceed the RAQS complexity requirements. The submission for RAQS exemption shall demonstrate that the proponent has successfully completed tunnelling/trenchless projects on projects of similar scope and complexity. The proponent shall submit a minimum of three (3) Foundation Investigation and Design Reports on projects of similar scope and complexity produced in the last five (5) years. The proponent shall submit any supplementary engineering and construction experience to demonstrate their qualifications.

For Engineering Materials Testing and Evaluation, the consultant shall be qualified for Soil and Rock testing of complexity level at least equal to that identified for this project.

Please refer to Table 1 on Page 2 for the Foundation Engineering Complexity of Work guideline.

Table 1: Complexity ratings for tunnelling specialty services

Excavation Diameter (Ø)	≤ 300 mm		1 m ≥ Ø > 300 mm		2 m ≥ Ø > 1 m		Ø > 2 m
Design Cover* (m)	≥ 1.5 m	< 1.5 m	≥ 3 Ø and > 1.5 m	< 3 Ø or < 1.5 m	≥ 3 Ø	< 3 Ø	N/A
King's Highway	Low	Medium	Low	Medium	Medium	High	High
400 Series Freeway	Low	High	Medium	High	High	High	High

* Design cover is the proposed vertical distance measured from the lowest ground elevation to the crown of the tunnel

Site Investigation, Field Testing and Monitoring

General

This section describes requirements for site investigation, field/laboratory testing and monitoring programs for a proposed tunnelling projects. For low complexity projects, some or all of these requirements may not be necessary. Foundation field investigation, laboratory analyses and monitoring for low complexity projects with an excavation diameter of 300 mm or less will generally only be required on an exception basis. The applicant's Foundation Engineering service can contact MTO Geotechnical staff for clarification regarding appropriate levels of investigation, testing and monitoring.

Field Testing

A minimum of one borehole is required at each end of tunnel crossing. The boreholes shall be located outside but within two metres of the tunnel's excavated footprint.

Spacing between the boreholes shall not exceed 50 m. In case of larger spacing between the boreholes, additional boreholes shall be advanced except where significant traffic disruptions might occur and where consistent conditions are evident.

Boreholes shall be advanced to 3 tunnel diameters (excavated diameters) below invert. If bedrock is encountered earlier, the borehole shall advance to at least 3 m below the invert of tunnel into the bedrock.

The investigations, if required, shall be supplemented with additional and deeper boreholes to verify consistent conditions and existence of boulders within critical foundation zones.

Sampling and testing, consisting of Standard Penetration Test, thin wall tube sample, rock cores, and MTO Field Vane Test where appropriate, shall be conducted to develop a comprehensive subsurface model. Semi-continuous sampling at 0.75m (2.5ft) intervals is required within overburden; whereas, sampling interval of 1.5m (5.0ft) is required below the tunnel invert.

Where encountered, the bedrock-soil interface shall be determined by geological definition and not by the material properties.

All aspects of implementation of means of subsurface investigations including, but not limited to, planning, licensing, construction, maintenance, abandonment, and reporting, shall be in accordance with Ministry of the Environment Regulation 903 and its amendments (the water well regulation under the OWRA).

Boreholes and piezometer tubes shall be backfilled with a suitable bentonite/cement mixture. Test pits shall be backfilled with suitable material and either re-vegetated or otherwise protected from erosion. Temporary open holes shall be adequately covered. Holes in roads shall be backfilled as required to prevent future settlement and acceptably patched where pavement surfaces have been damaged. Backfilling requirements shall be described in the Foundation Investigation and Design Report.

Where encountered, artesian groundwater conditions shall be sealed. Details of the artesian condition and the sealing operation shall be included in the Foundation Investigation Report.

Fieldwork, including any Traffic Protection Plans required, shall be carried out in accordance with the Occupational Health and Safety Act.

Traffic Control in accordance with Ontario Traffic Manual Book 7 shall be provided during the course of any field investigations. However, where significant traffic disruptions might occur, boreholes may be relocated or numbers reduced with MTO's approval.

The locations and ground surface elevations of all boreholes, test pits and soundings shall be surveyed and referred to fixed reference points and data. Locations are to be identified by co-ordinates (Northing and Easting). The vertical accuracy of survey readings shall be within 0.1m; whereas, horizontal accuracy shall be within 0.5m.

The site investigation shall be of sufficient scope to verify design assumptions and to provide the contractor with adequate subsurface information for design and construction planning.

Sufficient subsurface (factual) information is required to determine the vertical and horizontal extent of subsurface materials (including both soil and rock) and their pertinent engineering properties and groundwater conditions.

Subsurface information is usually acquired by advancing boreholes, laboratory testing of soil samples and rock core samples, performing in-situ tests such as standard penetration tests, dynamic cone tests, and piezocone tests (CPTU) and test pits.

Minimum Laboratory Testing Requirements

Laboratory testing shall consist of routine testing of 25% of samples. One routine lab test is defined as natural water content plus Atterberg Limits plus grain size distribution tests. Complex laboratory testing is defined by all other tests including compressive strength, shear strength, consolidation, permeability and triaxial testing. Laboratory testing requirements shall be supplemented with additional routine and complex tests if required to verify strata boundaries and properties and behaviour of critical subsurface zones.

A minimum of one (1) soil chemical test shall be conducted at maximum of 100 m spacing. A soil chemical test includes pH, water soluble sulphate, sulphide, chloride, resistivity and electrical conductivity analyses.

Borehole Log Preparation and Foundation Drawing

Borehole log sheets, figures and drawings shall be prepared in accordance with MTO standards. The Foundation Drawing shall consist of a plan showing the locations of all borings, test pits and soundings and various stratigraphical longitudinal profiles and stratigraphical cross-sections at each tunnel structure foundation element and groundwater levels.

Requirements for the Foundation Investigation and Design Report

A Foundation Investigation and Design Report shall consist of the factual subsurface information (including the field and laboratory test information) and the recommendations required for foundation design.

Service Provider services shall be in accordance with the most recent editions of the Canadian Highway Bridge Design Code (CHBDC), and the 'Guideline for Professional Engineers Providing Geotechnical Engineering Services' published by the Professional Engineers of Ontario.

The designated principal contact identified for Foundations Engineering services by MTO shall sign, and where required, seal, all submissions and correspondence that are submitted to MTO.

The report shall be signed and sealed by two professional engineers, registered with the Professional Engineers of Ontario, representing the consulting firm; one of them shall be the firm's designated principal contact for MTO's Foundations Engineering projects.

The Foundation Investigation component of the report shall contain:

- Site Description - including topography, vegetation, drainage, existing land use, and structures.
- Investigation Procedures - including site investigation and lab testing procedures.
- Description of Subsurface Conditions - including soil, boulders, rock and groundwater conditions.
- Miscellaneous Section - that identifies the name of the drilling company, the laboratory where testing was performed, the persons who carried out the field supervision, and those who wrote and reviewed the report.

The Foundation Design component of the report shall present discussion and recommendations for design. The Service Provider shall analyse field data and test results and make comprehensive and practical recommendations pertaining to temporary, interim and permanent conditions at the Project.

The Service Provider shall identify and evaluate all reasonable and appropriate alternatives for the proposed tunnel crossing. Alternatives may include, but not limited to, jack & bore, pipe jacking using TBM, pipe ramming, micro-tunnelling, utility tunnelling using TBM (two pass system), Horizontal Directional Drilling (HDD) and cut and cover methods.

The Service Provider shall identify and present overview assessments of the advantages, disadvantages, relative costs and risks/consequences of alternative tunnelling methods in a table. The report should conclude a preferred alternative from foundation engineering and cost effectiveness perspective.

In the development and design of the preferred alternative, the Service Provider shall, as applicable, address:

- impacts on the land use and property, traffic and transportation, and environment,
- length and diameter constraints
- control of face stability
- capability of boulder excavation
- evaluation of temporary and permanent support
- alignment control
- estimated settlements and heave and management of these deformations

- special access and egress requirements for TBM's and other similar equipment such as those used for the Jack & Bore method including recommendations for vertical shafts and jacking pits;
- shored and un-shored alternatives for open-cut excavation;
- groundwater control & dewatering;
- the long-term stability of the tunnel;
- relative costs; and
- traffic management and contractor access for each alternative.

If borehole logs available from previous projects are included to meet the requirements of field investigations then the accuracy of subsurface information from these boreholes remains the responsibility of Service Provider except in situations where MTO specify the use of previous boreholes. Borehole logs from previous studies that are appended to the report shall be reformatted to meet the MTO's requirements.

The final foundation recommendations shall detail the geometric, material and strength properties of the new tunnel crossing plus the liner, bedding and backfill requirements, and slope and embankment restoration requirements. The invert elevation should be assessed in view of the subsurface conditions and the anticipated open face stability control.

The Service Provider is responsible for developing contract documents sufficient to implement the design. This typically includes:

- Contract specifications for materials and specialized construction activities, and
- Recommendations for methods of overcoming anticipated construction problems, in particular, those relating to dewatering, boulder excavation, alignment control and the stability of excavations and embankments.

The Service Provider shall develop a detailed instrumentation and monitoring program that meets the requirements of these guidelines. (see Appendix for typical settlement monitoring guidelines).

The Service Provider is responsible for preparing Traffic Control Plans, Traffic Protection Plans and to obtain approvals and an Encroachment Permit from the Ministry, which are required for lane closures necessary to install the settlement monitoring points.

The tunnelling Service Provider shall ensure that the foundations engineering component of the project is adequately reflected in the design drawings, specifications and related contract documents.

Written confirmation is required from the Proponent and the tunnelling Service Provider that the design package submitted to MTO have been reviewed by the tunnelling Service Provider and that all recommendations have been satisfactorily incorporated in the contract package.

APPENDIX: SETTLEMENT MONITORING GUIDELINES - TUNNELING

The purpose of settlement monitoring is to prevent damage to existing utilities and highway structures along the tunnel alignment. Ground settlement include settlement due to lost ground and dewatering/drainage.

Daily visual monitoring of the road surface and shoulders shall be carried out for any evidence of movements (e.g. cracks, bulges, heaves, depressions, ponding, etc.)

Instrumentation Arrays

All measurement points shall be installed and surveyed before the start of excavation to establish benchmarks/baseline.

Surface Monitoring Points

Surface monitoring points will be installed to cover the whole length of the tunnel with in the right of way under the jurisdiction of MTO (Figure 1).

Surface monitoring points will be located at not greater than 5m intervals along the tunnel alignment. The surface monitoring will be identified using paint marks on the pavement. Surface monitoring points installed on the unpaved right of way shall be founded below frost penetration depths. The interval and/or marking of the points should be changed with MTO's approval where traffic disruptions might occur.

The final instrumentation plan should be finalised when Contractor's proposed construction method is available.

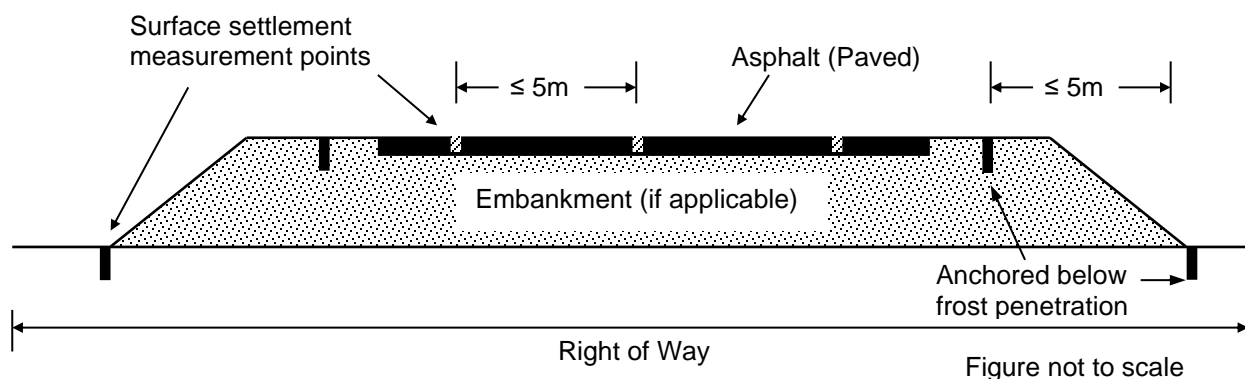


Figure 1: Typical configuration of surface settlement monitoring points along the tunnel alignment.

Condition Survey

A condition survey for the pavement will be carried out prior to commencement of construction and documented for the purpose of requirement of restoration. The condition survey shall document visible flaws such as cracks, distortions and deviations, heaves, and depressions. This surface survey will be completed during the installation of the monitors and again once the tunnel has been completed.

Reading Frequency

An average of at least two readings shall be taken to establish the initial conditions.

The reading and collection of data from the surface monitoring points shall be read and recorded by the Contractor during the construction period and after construction for period of at least 2 weeks provided that further settlement has stopped.

A minimum of three (3) sets of reading be taken daily, provided that movements are within anticipated limits. Otherwise, the frequencies should increase according to a pre-planned interval.

Monitoring of movements is required during work stoppages, such as during non-operation period (off-shifts) or weekends. A minimum of three (3) sets of readings should be taken daily.

Measurements of the monitoring points shall be reported promptly to MTO for review.

Data Collection and Data Transfer

A procedure is required to be established in consultation with MTO so that the monitoring data and the interpreted data will reach all parties as soon as necessary. The contract administrator/Service Provider and the Contractor should interpret monitoring data as needed for the purpose of on-going construction. The Foundation Engineer should be contacted for technical support to the prime Service Provider in the interpretation of ground movements and review of the Contractor's response when Review and Alert Levels are reached.

Criteria for Assessment

The acceptable surface settlement (or heave) will be according to criteria as specified below.

Baseline Reading – A baseline reading of the instrumentation shall be taken prior to commencement of the work. An average of at least two initial readings shall be recorded as baseline reading.

Review Level – A maximum value of 10 mm relative to the baseline readings is suggested for this project. If this level is reached, the method, rate or sequence of construction, or ground stabilization measures should be reviewed or modified to mitigate further ground displacements.

Alert Level – A maximum value of 15mm relative to the baseline readings is suggested for this project. If this level is reached, the Contractor shall cease construction operations and to execute pre-planned measures to secure the site, to mitigate further movements and to assure safety of public and maintain traffic.

Review of Contractor's Proposed Method

MTO, the Proponent's prime Service Provider and Foundation Engineer should review the Contractor's proposed method of construction. The proposed method should include a description of the potential loss of ground, and calculation of the maximum settlement in relation to the Contractor's procedure and equipment, alternative/remedial measures when review level of measurement is reached; and contingency/remedial measures when alert level of measurement is reached.

Contractor's Responsibility for Restoration and Warranty Provision

In addition to the monitoring program to assess the adequacy of the construction method to control potential ground movements and groundwater, the Contractor is responsible for reinstatement (such as surface paving) should movements or other surface distress occur, and provide a reasonable warranty period acceptable to MTO. Remedial measures shall be approved by MTO; however, MTO maintains the right to perform the maintenance at the proponent's expense.

Construction Monitoring

The Proponent shall retain a RAQS qualified Geotechnical Service Provider – Medium Complexity to supervise the installation of surface settlement points on site and to provide direction, technical input and field inspection on this project.