THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
SOUTH GEORGETOWN WASTEWATER SERVICING
WASTEWATER MAIN
TRENCHLESS CROSSING UNDER HIGHWAY 401 AT EIGHTH LINE SOUTH
MILTON & HALTON HILLS, ONTARIO

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Report to

HATCH

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PART 1: FACTUAL INFORMATION

1.0 INTRODUCTION

This report presents the factual findings obtained from of a foundation investigation carried out by Thurber Engineering Ltd. for the design and construction of a wastewater main (WWM) crossing under Highway 401 at Eighth Line South, east of the Trafalgar Road interchange, in Milton and Halton Hills, Ontario.

This report pertains to an approximately 350 m long trenchless highway crossing, which is a section of a WWM with an overall design length of approximately 15 km in the Town of Halton Hills.

It is understood the WWM will be installed using trenchless construction methods. A review of the 90% design drawings titled “Contract No. S-3126A-19, Construction of 1200mm Dia. South Georgetown Servicing Wastewater Main on Eighth Line and Trafalgar Road (Reg. Rd. 3) from No. 10 Side Road (Reg. Rd. 10) to Britannia Road (Reg. Rd. 6) in the Town of Milton and Town of Halton Hills” prepared by Hatch for Halton Region and dated May 20, 2020 was consulted in preparation for this investigation.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide borehole location drawings, record of borehole sheets, laboratory test results and a written description of the subsurface conditions.

A hydrogeological assessment was completed concurrently for this project. This report includes the assessment regarding groundwater conditions and dewatering for the Highway 401 crossing.

Thurber completed this assignment as a sub-consultant to Hatch, who are preparing the detailed design of the WWM for The Regional Municipality of Halton.

2.0 SITE DESCRIPTION

The topography at the Highway 401 crossing is relatively flat, ranging from near elevation 206 to 210 m AMSL. The Highway 401 roadway is near elevation 208.5 m AMSL. In general, the land use surrounding the site is rural residential and/or agricultural.

Based on the information in *The Physiography of Southern Ontario*[1] by Chapman and Putnam (1984), the site is located within the Peel Plain physiographic region. The Peel Plain is characterized by a level to undulating topography gradually sloping towards Lake Ontario with surficial soil comprising a thin lacustrine clay underlain by till. Based on *Quaternary Geology Map M2509*[2] and *Pleistocene Geology Map M2033*[3], the surficial deposits in the vicinity of the site are generally Halton clay or silt till with localized overlays of shallow lacustrine sediments of Lake Peel. Within the creek valleys, stream deposits of stratified gravel, sand, silt and clay are noted. According to *Paleozoic Geology Map M2336*[4], the underlying bedrock geology consists of red shale of the Queenston Formation.

3.0 INVESTIGATION PROCEDURES

The field investigation for the Highway 401 crossing was carried out on between the periods of July 30 to August 2, 2019, September 3 to 9, 2019 and November 17 to 20, 2019 and comprised a total of six boreholes drilled for the WWM (Boreholes 19-41, 19-42A, 19-42B, 19-43A, 19-43B and 19-44). Borehole details are provided in the Record of Borehole sheets included in Appendix B. The approximate locations of the boreholes and stratigraphic profiles are shown on Drawing 25063-1 in Appendix A. A summary of the borehole details is provided on Table 3.1 below.

[1] Chapman, L.J. and Putnam, D.F. 1984. The Physiography of Southern Ontario, Ontario Geological Survey Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.
[2] Karrow, P.F., 1986: Quaternary Geology of the Hamilton Area, Southern Ontario; Ontario Geological Survey, Map 2509, Quaternary Geology Series, scale 1:50,000.
[3] Karrow, P.F., 1963: Pleistocene Geology of the Hamilton Area, Southern Ontario; Ontario Geological Survey, Map M2033, Scale: 1:63,360.
[4] B.A. Liberty, I.J. Bond and P. G. Telford, 1972 & 1973; Paleozoic Geology, Hamilton, Southern Ontario; Ontario Geological Survey, Map M2336, Scale: 1:50 000.

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Table 3.1 – Summary of Borehole Details

BH No.	Northing (m)	Easting (m)	Ground Surface Elev. (m)	Term. Depth (m)	Term. Elev. (m)	Monitoring Well	Shaft /Manhole (SM) or Tunnel (T)
19-41	4825879.3	595478.5	206.6	22.4	184.2	☒	SM
19-42B	4825946.5	595417.1	208.0	23.1	184.9	☒	T
19-42A	4825972.6	595386.4	208.6	21.4	187.2	☐	T
19-43A	4825998.2	595357.4	208.5	21.3	187.1	☐	T
19-43B	4826022.6	595327.8	209.0	22.9	186.2	☒	T
19-44	4826128.5	595227.1	210.1	23.0	187.1	☒	SM

The borehole locations were established in the field by Thurber using a portable GPS receiver and verified relative to existing site features. All borehole locations were cleared of utilities prior to commencement of drilling. The boreholes were repositioned as necessary in consideration of surface features, underground utilities, and restricted site access.

The drilled borehole locations and ground surface elevations were subsequently recorded by MacKay, Mackay & Peters Limited (MMP), a registered Ontario Land Surveyor (OLS) using survey equipment capable of providing an accuracy of 0.3 m for horizontal locations and 0.01 m for ground surface elevations. The ground surface elevations are orthometric (CGVD-1928:1978). Borehole location coordinates are presented in the Universal Transverse Mercator (UTM) system (NAD83, CSRS 2010.0).

The boreholes were advanced using hollow stem augers and mud rotary/tricone advancement methodologies powered by a track mounted Diedrich D120 and truck mounted D90 drill rigs supplied and operated by Walker Drilling Ltd. Soil samples were obtained at selected intervals using a 50 mm outside diameter split-spoon sampler driven in conjunction with the Standard Penetration Test (SPT). Bedrock core samples were recovered using HQ size diamond drill core barrels.

The field investigation was carried out under the full-time supervision of Thurber technical staff. All boreholes were logged in the field. Soil samples were identified, placed in labelled containers and transported back to Thurber's laboratory in Oakville for further examination and testing. Particular attention was applied to visual and olfactory evidence of potential contamination such as odours and staining during the course of the field work. The recovered rock core samples were described and photographed in the field, packaged in core boxes with moist paper towel and parafilm wrap, and transported back to our laboratory for further examination and testing.

Monitoring wells were installed in selected boreholes to permit monitoring of the groundwater levels at the site. The monitoring wells consisted of 50 mm diameter PVC pipe with a slotted screen sealed at a selected depth within the borehole. The installation details are summarized in Table 3.2 below.

Table 3.2 – Monitoring Well Details

Borehole/Monitoring Well No.	Ground Surface Elev. (m)	Monitoring Well Tip		Slotted Screen Length (m)
		Depth (m)	Elevation (m)	
19-41	206.6	15.8	190.8	3.0
19-42B	208.0	18.0	190.0	3.0
19-43B	209.0	19.1	190.0	3.0
19-44	210.1	22.7	187.4	3.0

The remaining boreholes were backfilled with bentonite to the ground surface in general accordance with MOE Regulation 903.

The groundwater conditions at the borehole locations were assessed during drilling by visual examination of the soil, the sampler and the drill rods as the samples were retrieved and when appropriate by measurement of the water level in the open borehole.

Water levels were measured in the monitoring wells using a groundwater level meter. The water level meter was cleaned between uses at each monitoring well location.

The hydraulic conductivity of the screened geologic media was estimated through Single Well Response Tests (rising head "slug tests") in selected boreholes. A volume of water was removed to initiate the test, in accordance with ASTM procedure D4044 "Standard Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers".

Groundwater levels were monitored before testing and during water level recovery using both manual readings with a groundwater level reader and using a water level datalogger.

The monitoring wells were developed prior to testing to remove excess sediment that may have entered the well during installation, to increase the representativeness of the natural groundwater in the well and to improve the transmissivity of the sand pack and well screen. Prior to any sampling or in-situ testing, the wells were purged dry, or until at least three well volumes had been removed. Prior to sampling, general chemistry parameters (pH, temperature and conductivity) were monitored with a hand-held meter to ensure consistency in addition to visual observations of turbidity.

Groundwater quality samples were collected from selected monitoring wells installed using low flow sampling techniques. The groundwater samples were collected using a peristaltic pump and dedicated Waterra® tubing and, where required, a dedicated inline disposable 0.45 µm metals filter. The samples were collected into prepared laboratory sample bottles, stored in an insulated cooler on ice for transportation to Thurber's laboratory and subsequent submission to an independent analytical laboratory.

4.0 LABORATORY TESTING

Geotechnical laboratory testing of soil samples was carried out at Thurber's laboratory. All recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to grain size distribution analysis (hydrometer and/or sieve) and Atterberg Limits testing, where appropriate.

Geotechnical laboratory testing of rock core samples consisted of point load strength and unconfined compressive strength testing.

Results of the geotechnical soil and rock laboratory testing are presented on the Record of Borehole sheets in Appendix B and in detail in Appendices C and D, respectively.

A limited analytical testing program was completed concurrently on selected soil samples. The results of the testing and preliminary management options for excess excavated soils that may be generated during the proposed construction works are reported under separate cover.

Groundwater quality samples were collected from selected monitoring wells installed in the boreholes. The samples were submitted to SGS Canada Inc., for analysis of metals and inorganics (M&I), major anions and cations, general chemistry (GC) parameters, petroleum hydrocarbons (PHCs), benzene, toluene, ethylbenzene and xylene (BTEX) and parameters required for the Halton Use Sewer By-Law. The samples were analyzed and compared to Provincial Water Quality Objectives (PWQO), Halton Sewer Use By-Law (No.2-03), and O. Reg. 153/04 Table 1: Full Depth Background Site Condition Standards (Table 1) and Table 2: Full Depth Generic Site Condition Standards in a Potable Ground Water Condition (Table 2).

In addition, a blind duplicate and trip blank were submitted for QA/QC purposes. Samples were collected following the procedures outlined in Section 3.4.

A summary of the groundwater samples collected and submitted for chemical analysis is presented in Table 4.1 below.

Table 4.1 – Groundwater Samples Submitted for Analytical Testing

Borehole/ Monitoring Well	Sample ID(s)	Mid-Screen Depth (m)	Screened Material	Analytical Analysis						
				O. Reg. 153/04						
				M & I	PHCs	BTEX	General Chemistry	Major Cations and Anions	PWQO	Halton Sewer
19-41	19-41	14.3	Silty Sand	☒	☒	☒	☒	☒	☒	☒
19-42B	19-42B	16.5	Silty Sand & Clayey Silt Till	☒	☒	☒	☒	☒	☒	☒
19-43B	19-43B	17.6	Silty Sand & Silt and Sand Till	☒	☒	☒	☒	☒	☒	☒
19-44	19-44	21.2	Shale	☒	☒	☒	☒	☒	☒	☒

The results of the analytical testing are summarized in Section 6 and laboratory Certificates of Analysis are included in Appendix G.

5.0 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B. A general summary of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs and on the Borehole Location and Stratigraphic Profiles drawings in Appendix A. However, the factual data presented on the Record of Borehole sheets takes precedence over this summary and must be used for interpretation of the site conditions. It should be recognized and expected that soil conditions will vary between and beyond borehole locations.

The subsurface stratigraphy encountered in the boreholes typically consisted of surficial materials overlying glacial till interspersed with sand and silt layers overlying till/shale complex grading to shale bedrock. More detailed summaries of the individual strata encountered during the investigation are presented below.

5.1 Pavement Structure

An existing pavement structure consisting of 75 mm of asphalt over 225 to 535 mm of sand and granular fill base was encountered at the ground surface of Boreholes 19-41 and 19-42B drilled on the existing roadway of Auburn Road. In Borehole 19-42A drilled on the paved shoulder of Highway 401, the pavement structure consisted of 125 mm of asphalt over 565 mm of sand and gravel granular base. Locally, a 75 mm thick layer of granular fill was contacted at the ground surface of Borehole 19-44 drilled on the shoulder of Eighth Line South.

Standard Penetration Test N-values recorded in the granular fill material varied from 18 to 46 blows/0.3 m of penetration a compact to dense condition. Moisture contents ranged from 5% to 10%.

5.2 Topsoil

A 50 mm thick layer of topsoil was encountered at the ground surface in Boreholes 14-43A and 19-43B. The topsoil thicknesses will vary between and beyond the borehole locations and the reported thicknesses are not meant to be used for estimating quantities.

5.3 Fill

A layer of clay fill was encountered below the topsoil or granular material in all the boreholes. The clay fill was contacted at depths of 0.1 to 0.7 m (Elev. 206.3 to 210.0) and was penetrated at 0.7 to 1.5 m (Elev. 205.2 to 209.4). Locally, in Borehole 19-42A, a layer of sand fill was contacted below the clay fill at a depth of 1.5 m (Elev. 207.2) and extended to a depth of 2.3 m (Elev. 206.3).

SPT N-values recorded in fill typically ranged from 5 to 30 blows to per 0.3 m of penetration indicating a firm to compact/very stiff consistency. Moisture contents ranged from 8% to 21%.

5.4 Silty Clay Till to Clayey Silt Till

A plastic till deposit described as silty clay to clayey silt was encountered below the fill and/or clay in all the boreholes. This till contained some sand to sandy and trace gravel. The colour of this till ranged from brown changing to grey with depth. The plastic till deposit was contacted at depths of 0.7 to 2.3 m (Elev. 205.2 to 209.4) and penetrated at depths of 6.8 to 9.8 m (Elev. 196.9 to 203.3). Locally, in Borehole 19-42B, a lower layer of silty clay till was encountered below the sand and silt layers at a depth of 16.2 m (Elev. 191.8) and extended to 18.0 m (Elev. 190.0).

SPT N-values recorded in the plastic till ranged from 16 blows per 0.3 m of penetration to 50 blows for only 100 mm of penetration, indicating a very stiff to hard consistency. Moisture contents ranged from 8% to 18%, typically 10% to 15%.

The results of grain size distribution analyses carried out on selected samples of the silty clay till to clayey silt till are presented on Figures C1 to C3 in Appendix C. The results of the grain size distribution analyses are summarized in Table 5.1 below.

Table 5.1 – Grain Size Distribution Silty Clay Till to Clayey Silt Till

Soil Particle	Percentage (%)
Gravel	2 to 13
Sand	24 to 41
Silt	33 to 55
Clay	11 to 25

The results of Atterberg Limits testing carried out on this material indicate that the layer is low plastic silty clay (CL) and clayey silt (CL-ML). The results of the testing are presented on Figures C10 and C11 in Appendix C and are summarized in Table 5.2 below.

Table 5.2 – Atterberg Limits Silty Clay Till to Clayey Silt Till

Index Property	Percentage (%)
Liquid Limit	17 to 31
Plastic Limit	10 to 18
Plasticity Index	5 to 14

The till soils contain cobbles and boulders, and these should be anticipated when excavating during construction.

5.5 Sand Till to Silt Till

Non-plastic till ranging in composition from silty sand to sandy silt was found below the plastic till in the boreholes. It generally contained trace to some clay and gravel with localized clayey zones within the non-plastic till. The non-plastic till deposit was contacted at depths of 6.8 to 9.8 m (Elev. 196.9 to 203.3) and penetrated at depths of 8.8 to 14.0 m (Elev. 194.4 to 201.3). In Boreholes 19-41, 19-42A, 19-43A and 19-44, a lower layer of non-plastic till was encountered below sand and/or silt layers at depths of 15.9 to 16.7 m (Elev. 190.7 to 193.5) and penetrated at 17.3 to 18.2 m (Elev. 189.3 to 192.0).

SPT N-values in this material ranged from 59 blows per 0.3 m of penetration to 100 blows for only 75 mm of penetration, indicating a very dense state. Approximately 80% of the SPTs carried out reached refusal (less than 150 mm of penetration achieved after 50 or 100 blows) indicating that this material is typically very dense. Moisture contents in the non-plastic till ranged from 7% to 19%.

The results of grain size distribution analyses carried out on selected samples of the sand and silt till are presented on Figure C4 in Appendix C. The results of the grain size distribution analyses are summarized in Table 5.3 below.

Table 5.3 – Grain Size Distribution Sand Till to Silt Till

Soil Particle	Percentage (%)
Gravel	4 to 14
Sand	31 to 49
Silt	32 to 56
Clay	4 to 10

Atterberg limits testing carried out on samples of this material generally indicated this stratum is non-plastic. Inherent to the heterogenous nature of glacial till, localized pockets of low plastic clayey material (CL-ML) were observed within the non-plastic till.

The significant number of very high blow counts and the observations of grinding augers and slow advancement made during drilling indicate that the till contains numerous cobbles and boulders.

5.6 Clayey Silt to Silty Clay

A layer of clayey silt to silty clay was encountered below the silt and sand till at depths of 11.7 and 8.8 m (Elev. 197.3 and 201.3) and was penetrated at depths of 14.3 and 10.3 m (Elev. 194.7 and 199.8) in Boreholes 19-43B and 19-44, respectively. Localized partings, seams and layers of silty clay were encountered within the clayey silt and sandy silt deposits.

SPT N-values in this material ranged from 48 blows per 0.3 m of penetration to 97 blows for only 250 mm of penetration, indicating a hard consistency. Moisture contents ranged from 11% to 20%.

The results of grain size distribution analyses carried out on selected samples of the clayey silt to silty clay are presented on Figures C5 in Appendix C. The results of the grain size distribution analyses are summarized in Table 5.4 below.

Table 5.4 – Grain Size Distribution Silty Clay to Clayey Silt

Soil Particle	Percentage (%)
Gravel	0 to 4
Sand	4 to 20
Silt	41 to 87
Clay	9 to 38

The results of Atterberg Limits testing carried out on this material indicate that the layer is low plastic silty clay (CL) and clayey silt (CL-ML). The results of the testing are presented on Figure C12 in Appendix C and are summarized in Table 5.5 below.

Table 5.5 – Atterberg Limits Silty Clay to Clayey Silt

Index Property	Percentage (%)
Liquid Limit	22 to 27
Plastic Limit	11 to 19
Plasticity Index	5 to 15

5.7 Sand to Silt

Units consisting primarily of sand and silt size particles were found below the till and/or clayey silt deposits in all the boreholes. The deposits, ranging in thickness from 2.6 to 6.3 m, were encountered at depths of 10.3 to 14.0 m (Elev. 194.4 to 199.8) and penetrated at depths of 15.9 to 17.9 m (Elev. 190.7 to 193.5). As noted previously, layers of clayey silt and/or silty clay were encountered locally within the silt deposits. Gravelly layers were observed in the sand deposits.

SPT N-values in this material ranged from 36 blows per 0.3 m of penetration to 50 blows for only 125 mm of penetration, indicating a dense to very dense state. Typically the N-values ranged were greater than 50 blows per 0.3 m of penetration indicating a very dense state. Moisture contents ranged from 7% to 24%, typically about 10% to 20%.

The results of grain size distribution analyses conducted on samples of this material are presented on Figures C6 and C7 in Appendix C for materials consisting primarily of sand and Figure C8 in Appendix C for materials consisting primarily of silt. The results of the grain size distribution analyses are summarized in Table 5.6 below.

Table 5.6 – Grain Size Distribution Sand to Silt

Soil Particle	Percentage (%)	
	Sand	Silt
Gravel	0 to 3	0 to 9
Sand	43 to 77	4 to 16
Silt	21 to 53	74 to 88
Clay	0 to 4	6 to 9

As noted previously, localized partings, seams and layers of silty clay were encountered within the silt deposits.

5.8 Till/Shale Complex

A 0.7 to 0.8 m thick layer of till/shale complex was generally encountered above the bedrock. This material generally consists of silty clay till, clayey silt till or silt and sand till, with highly variable amounts of sand, gravel, and shale fragments (to cobble and/or boulder size) and represents the transition between the overlying till deposits and the underlying weathered shale bedrock. It is noted that this material is highly variable and ranges from non-plastic to plastic.

SPT N-values recorded in this layer ranged from 50 to 100 blows for 75 to 225 mm of penetration, indicating a very dense/hard consistency. Natural moisture contents ranged from 7 to 13%.

The results of grain size distribution analyses carried out on selected samples of the till/shale complex are presented on Figure C9 in Appendix C. The results of the grain size distribution analyses are summarized in Table 5.7 below.

Table 5.7 – Grain Size Distribution Till/Shale Complex

Soil Particle	Percentage (%)
Gravel	4 to 28
Sand	26 to 44
Silt	29 to 57
Clay	4 to 13

Atterberg limits testing was carried out on one sample of the till/shale complex. The measured plastic limit, liquid limit and plasticity index were 21, 13 and 8, respectively. These results, which are plotted on Figure C13 in Appendix C, indicate that the sample tested consists of low plastic silty clay (CL).

Observations of grinding augers and slow advancement made during drilling indicate that the till/shale complex contains cobbles and boulders.

5.9 Shale Bedrock

Shale bedrock was encountered underlying the overburden soils in all the boreholes. The depths and elevations at which bedrock was encountered are summarized in Table 5.8 below.

Table 5.8 – Shale Bedrock Contact Depths and Elevations

Borehole	Ground Surface Elev. (m)	Bedrock Surface	
		Depth (m)	Elevation
19-41	206.6	18.0	188.7
19-42B	208.0	18.8	189.2
19-42A	208.6	19.0	189.6
19-43A	208.5	18.1	190.4
19-43B	209.0	18.7	190.3
19-44	210.1	18.8	191.4

The shale bedrock was visually identified as red shale of the Queenston Formation interbedded with limestone, siltstone and/or sandstone layers referred to as “hard layers”. Augering and SPT sampling were typically continued in the upper 0.2 to 0.3 m of highly weathered shale with penetrations of 50 to 100 mm achieved for 50 to 100 blows; local, in Borehole 19-42A, SPT augering and sampling continued over a length of 2.4 m to the termination depth of 21.4 m (Elev. 187.2). HQ size core samples were recovered below this depth in all the boreholes with the exception of Borehole 19-42A. Photographs of the retrieved rock core are provided in Appendix E.

5.9.1 Physical Properties

5.9.1.1 Total Core Recovery

Total Core Recovery (TCR) is the total cumulative length of all core recovered in the core barrel expressed as a percentage of the length of the core run and is recorded on a per run basis. Prior to measuring the recovered length, the core was assembled to align joints and rubble zones were reassembled to the extent practicable. The TCR of the rock cores was typically 95 to 100%.

5.9.1.2 Solid Core Recovery

Solid Core Recovery (SCR) is the total cumulative length of all solid, cylindrical pieces of core recovered in the core barrel expressed as a percentage of the length of the core run and is recorded on a per run basis. The SCR of the rock cores recovered typically ranged from 70 to 100%; localized values of 43 and 60% were encountered in Boreholes 19-41 and 19-44, respectively.

5.9.1.3 Rock Quality Designation

Rock Quality Designation (RQD) is the total cumulative length of intact core recovered in the core barrel expressed as a percentage of the length of the core run and is recorded on a per run basis. Intact core was measured along the centreline and a 100 mm requisite length was used for the purposes of standardization and comparison. It is considered that with good drilling techniques, the lengths of the core pieces, measured along the centerline, will generally be the same regardless of core diameter since the spacing of natural unbonded joints does not change. The RQD of the rock cores ranged typically from 40 to 90% and was determined to be poor to excellent quality. In general, RQD was determined to be very poor to poor quality (<50%) in the upper 1.5 to 3.0 m, generally becoming fair to excellent (>50%) with depth.

5.9.1.4 Hard Layers

The Queenston Formation consists mainly of red shale. Minor amounts of grey shale interbedded with siltstone, limestone and occasionally sandstone layers (Armstrong, 2001)[5], herein referred to as “hard layers”, are noted throughout the formation. It is noted that petrography was not completed to determine the mineral content and/or crystalline structure of each hard layer. The measured thickness of the hard layers was generally less than 50 mm, with those layers greater than 50 mm indicated on the borehole logs. It is noted that the maximum thickness of the hard layers measured in the cores for this project was 400 mm.

5.9.1.5 Fracture Index

The fracture index records the number of natural fractures per 0.3 m length of core run. The index fracture of the shale bedrock typically ranged from 0 to 5, with localized zones of greater than 25 in more weathered and/or highly fractured zones.

[5] Armstrong, D.K. 2001. A regional evaluation of the shale resource potential of the Upper Ordovician Queenston Formation, southern Ontario; Ontario Geological Survey, Open File Report 6058, 148p.

5.9.1.6 Weathering

In general, the shale was judged to be moderately to slightly weathered near the contact surface of the bedrock, locally completely to highly weathered. The shale weathering generally decreased with depth, becoming slightly weathered to fresh. The hard layers were generally slightly weathered to fresh. It is noted that localized highly fractured zones ranging in thickness from 25 to 325 mm, locally up to 600 mm, and clay seams ranging in thickness from 10 to 225 mm were observed within the cores.

5.9.2 Index Properties

5.9.2.1 Point Load Testing

Point load index strength tests were carried out on selected intact rock core samples. The test results are presented in Appendix D. Determination of the unconfined compressive strength was based on the empirical relationship between unconfined compressive strength and point load index strength as follows:

$$\text{Unconfined compressive strength (MPa)} = 24\ I_{S(50)}$$

Where $I_{S(50)}$ is the point load index strength in MPa for a 50 mm equivalent diameter core. The correlation value of 24 is site specific and was developed based on a comparison of the UCS tests and the point load index tests.

The unconfined compressive strength (UCS) of the rock, estimated from the results of point load tests, typically varied from 10 to 70 MPa, indicating a weak to strong rock strength classification. In general, the strength of the shale typically ranged from 15 to 40 MPa and the hard layers ranged from about 40 to 70 MPa. Locally, and typically in the upper 1.5 m, the point load tests resulted in UCS less than 5 MPa, indicating a very weak rock strength classification. Locally, UCS values above 70 MPa and up to 130 MPa occurred infrequently and without any apparent pattern with respect to depth or elevation. The results are summarized on the Record of Borehole sheets included in Appendix B and on the Point Load Test Sheets in Appendix D.

5.9.2.2 Unconfined Compressive Strength

Unconfined compressive strength (UCS) testing was completed on a total of seven shale samples. The results of the UCS testing are summarized in Table 5.9 below; the test results are shown on the Borehole Logs and provided in Appendix D.

Table 5.9 – UCS Test Results on Shale Bedrock

BH No.	Run No.	Sample Depth (m)	Bulk Density (g/cm^3)	UCS (MPa)	Young's Modulus (GPa)
19-41	1	19.05 - 19.18	2.570	8.6	-
19-41	3	20.96 - 21.13	2.618	32.1	5.6
19-42B	1	19.23 - 19.38	2.590	9.4	-
19-42B	3	22.15 - 22.30	2.589	16.7	-
19-43A	1	19.41 - 19.56	2.714	7.2	-
19-43B	2	20.04 - 20.19	2.585	2.3	-
19-44	1	19.38 - 19.51	2.595	14.5	-

5.10 Groundwater Conditions and Hydraulic Conductivity Testing

5.10.1 Water Levels

As they were completed with hollow stem augers and mud rotary drilling methodologies and/or water or mud was introduced during the drilling or coring operation, the groundwater conditions were not able to be observed in the open boreholes during drilling operations.

Monitoring wells were installed in selected boreholes to monitor groundwater levels. The groundwater levels measured in the monitoring wells are summarized in Table 5.10 below.

The groundwater levels above are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

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Table 5.10 – Groundwater Levels and Observations

Borehole/ Monitoring Well	Mid-Screen Depth (m)	Mid-Screen Elev. (m)	Screened Material	Date	Water Level (m)	
					Depth	Elevation
19-41	14.3	192.3	Silty Sand	Oct. 16, 2019	-0.7	207.3
				Oct. 25, 2019	-0.9	207.5
				Nov. 19, 2019	-0.4	207.0
				Mar. 19, 2020	-1.5	208.1
				Jun. 08, 2020	<-1.52	>208.1
				Oct. 19, 2020	-0.7	207.4
19-42B	16.5	191.5	Silty Sand & Clayey Silt Till	Aug. 1, 2019	-0.8	208.8
				Oct. 2, 2019	0.2	207.8
				Oct. 25, 2019	0.3	207.7
				Nov. 19, 2019	0.5	207.4
				Jun. 08, 2020	-0.7	208.6
				Oct. 19, 2020	Buried	
19-43B	17.6	191.5	Silty Sand & Silt and Sand Till	Oct. 2, 2019	1.0	208.0
				Nov. 4, 2019	0.7	208.4
				Nov. 28, 2019	-0.1	209.1
				Dec. 18, 2019	0.0	209.0
				Jun. 04, 2020	Buried	
				Oct. 19, 2020	Buried	
19-44	21.2	188.9	Shale	Oct. 2, 2019	2.2	207.9
				Nov. 4, 2019	1.9	208.2
				Nov. 28, 2019	1.6	208.5
				Dec. 18, 2019	1.1	209.0
				Jun. 04, 2020	Buried	
				Oct. 19, 2020	Buried	

Notes:

1. Negative values indicate water levels above ground surface or artesian condition

5.10.2 Single Well Response Tests

The single well response tests were analyzed using the Hvorslev method. The test results indicated that the hydraulic conductivity of the screened formations ranged from 1.0 x 10^{-3} cm/s to 1.4 x 10^{-4} cm/s. Plots of the slug test results are included in Appendix F. The hydraulic conductivity values calculated from the in-situ slug tests are summarized in Table 5.11 below.

Table 5.11 – Summary of Single Well Response Test Results

Monitoring Well	Hydraulic Conductivity (cm/s)	Screened Formation
19-41	5.8 x 10^{-4}	Silty Sand
19-42B	1.0 x 10^{-3}	Silty Sand & Clayey Silt Till
19-43B	6.7 x 10^{-4}	Silty Sand & Silt and Sand Till
19-44	1.4 x 10^{-4}	Shale

6.0 RESULTS OF ANALYTICALTESTING

6.1 Groundwater

Groundwater quality samples were collected from selected wells for the purpose of considering disposal options and potential treatment needs at a preliminary level. The results obtained herein were representative of the water sampled from the selected wells at the time of sampling and provide a general understanding of groundwater quality under those conditions; however, the water quality may vary significantly from the results obtained based on location, time, meteorological conditions, and in particular based on construction and dewatering methods. The concentration of suspended solids in the groundwater or in water that is collected during construction dewatering (e.g., from a sump in an open excavation) will significantly affect the concentrations of many regulated parameters.

Groundwater samples were submitted to SGS for analysis of metals and inorganics (M&I), major anions and cations, general chemistry (GC) parameters, petroleum hydrocarbons (PHCs), benzene, toluene, ethylbenzene and xylene (BTEX) and parameters required for Halton Sewer Use By-Law. The samples were analyzed and compared to Provincial Water Quality Objectives (PWQO), Halton Sewer By-Law (No.2-03), and O. Reg. 153/04 Table 1: Full Depth Background Site Condition Standards (Table 1) and Table 2: Full Depth Generic Site Condition Standards in a Potable Ground Water Condition (Table 2).

The results and corresponding Certificates of Analysis are provided in Appendix G. Exceedances of the above standards within the groundwater analytical results are presented in a summary table, Table G1 in Appendix G.

6.1.1 O. Reg. 153/04

Testing of groundwater samples for comparison to O. Reg. 153/04, as amended, comprised analysis of selected M&I, PHCs and BTEX.

Comparison to the standards provided in O. Reg. 153/04 are provided for informational purposes only and do not directly affect discharge options. O. Reg. 153/04 Table 1 reflects natural background concentrations and exceedances of Table 1 indicate that the measured parameters exceed those nominal background levels. O. Reg. 153/04 Table 2 reflects the concentrations of the parameters in groundwater that are acceptable at properties in a potable groundwater condition, which are less stringent than Table 1 Standards.

Concentrations of the tested parameters were below the Table 1 and 2 standards.

6.1.2 PWQO and Interim PWQO

Testing of groundwater samples for comparison to the PWQO and Interim PWQO comprised analysis of general chemistry and selected metals and inorganic parameters. PWQO metals testing was carried out on an unfiltered groundwater sample.

Multiple parameters exceeded the PWQO limits in the samples, including the following: aluminum, arsenic, boron, iron, phosphorous, and 4AAP-phenolics.

6.1.3 Halton Sanitary and Combined Sewer Use By-Law

Concentrations of the tested parameters complied with the Sanitary and Combined Sewer limits in the Region of Halton Sewer Use By-Law.

7.0 MISCELLANEOUS

The borehole locations were established in the field by Thurber using a portable GPS receiver, with consideration of site features and access limitations. The drilled borehole locations and ground surface elevations were subsequently recorded by MacKay, Mackay & Peters Limited (MMP), a registered Ontario Land Surveyor (OLS). Walker Drilling of Utopia, Ontario supplied and operated the drilling and sampling equipment for the field program.

Full time supervision of the field activities was carried out by Mr. Omar Ali of Thurber Engineering. Overall supervision of the field program was performed by Mr. Karel Furbacher, P.Eng. of Thurber. Interpretation of the field data and preparation of the report was performed by Mr. Karel Furbacher, P.Eng. The report was reviewed by Mr. Renato Pasqualoni, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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THURBER

FOUNDATION INVESTIGATION AND DESIGN REPORT
SOUTH GEORGETOWN WASTEWATER SERVICING
WASTEWATER MAIN
TRENCHLESS CROSSING UNDER HIGHWAY 401 AT EIGHTH LINE SOUTH
MILTON & HALTON HILLS, ONTARIO

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8.0 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical recommendations for the design and construction of a wastewater main (WWM) crossing under Highway 401 at Eighth Line South, east of the Trafalgar Road interchange, in Milton and Halton Hills, Ontario.

For the purposes of this report, Highway 401 is considered to run in an east-west orientation, and the WWM alignment in a north-south orientation, at approximately right angle to the highway.

It is understood the WWM will be installed using trenchless construction methods. The 50% design drawings titled “Contract No. S-3126A-19, Construction of 1200mm Dia. South Georgetown Servicing Wastewater Main on Eighth Line and Trafalgar Road (Reg. Rd. 3) from No. 10 Side Road (Reg. Rd. 10) to Britannia Road (Reg. Rd. 6) in the Town of Milton and Town of Halton Hills” prepared by Hatch for Halton Region and dated January 11, 2019 was consulted in preparation for this investigation.

These drawings indicate that the current plans call for the trenchless construction of a 1200 mm diameter wastewater gravity sewer main to depths ranging from about 16 to 20 m below ground surface (mbgs) at the Highway 401 crossing. It is understood that the proposed method of trenchless construction is pressurized face MTBM. The current design calls for the installation of two shaft/manholes, located approximately 150 and 100 m from the north and south limits of the MTO right-of-way (ROW), respectively, to be used for launching and receiving the MTBM.

The subsurface stratigraphy encountered in the boreholes typically consisted of surficial materials overlying glacial till interspersed with sand and silt layers overlying till/shale complex grading to shale bedrock.

The discussion and recommendations presented in this report are based on the information provided by Hatch and on the factual data obtained in the course of the investigation. The interpretation and recommendations are intended for the use of the design consultant and shall not be relied upon by any other parties including the construction contractor, or used for any purposes other than development of the project design. Comments on construction methodology and equipment, where presented, are provided only to highlight those aspects that could affect the design of the project. Contractors must make their own assessment of the factual information presented in previous sections of the report, and the implications on equipment selection, construction methodology, and scheduling.

8.1 Trenchless Crossing

8.1.1 Tunnelling Method

It is understood microtunnelling is specified as the trenchless installation methodology. Microtunnelling is the geotechnically preferred method of trenchless installation at this site. It is recommended that the Contractor be alerted to the high groundwater conditions at the site, the need to maintain stability of the tunnel face, the settlement tolerances and the likelihood of encountering cobbles, boulders and/or rock slabs within the till and till/shale complex deposits. The Contractor should be equipped to handle the presence of cobbles and boulders. The advancement of the MTBM should be continuous and uninterrupted below the highway ROW.

The experience of the Contractor is of primary importance for trenchless installation. Selection of an appropriate methodology should be the responsibility of the Contractor and will depend upon the relative costs and risks associated with each method. The Contractor must submit a detailed work plan, including the proposed methodology for boring, maintenance of alignment, dewatering and disposal of cuttings.

Monitoring of the highway as well as any nearby underground utility and structures must be carried out during construction to identify any areas of settlement. Additional information regarding settlement monitoring is provided below. A pre-construction survey should be carried out to document the condition of and assess the potential for damage to all facilities near the alignment of the trenchless installation.

8.1.2 Expected Ground Conditions

The stratigraphic profile presented in Appendix A shows the expected soil and groundwater conditions along the alignment of the tunnel. The tunnel will be primarily installed at depths of about 18 to 20 mgs, at invert elevations of 190.6 to 191.0, through a mixed face soil condition consisting of very dense silt and sand, very dense non-plastic sand and silt till and very dense/hard plastic and non-plastic till/shale complex. The tunnel will be installed below the groundwater level. Cobbles, boulders and/or rock slabs should be anticipated within the till soils and the till/shale complex.

It is understood that the South Georgetown Wastewater Servicing Wastewater Main is a gravity-flow trunk sanitary sewer that is constrained at the upstream and downstream ends. It is further understood that lowering the sewer depth at the MTO crossing into the underlying bedrock would negatively impact the sewer hydraulics performance and reliability of the entire wastewater conveyance system.

8.1.3 Ground Behaviour

8.1.3.1 Behaviour Classification

The Tunnelman's Ground Classification System is a framework for describing soil behaviour in an unsupported tunnel heading under atmospheric conditions. It was initially developed by Terzaghi in 1950 and later modified by Heuer in 1974. A summary of the Tunnelman's Ground Classification System according to Heuer, 1974, is presented in Appendix H.

Table 8.1 below presents a classification of the soils expected to be encountered within the tunnel excavations both without and with advance dewatering. Based on this classification, the non-plastic till, silt and sand may cause instability at the tunnel face without advance dewatering or supporting pressure from the tunneling machine.

Table 8.1 – Soil Classification

Soil Class	Tunnelman's Classification	
	With Dewatering	**Without Dewatering**
Plastic Till	Firm	Slow Raveling
Non-Plastic Till	Firm to Slow Raveling	Fast Raveling
Silt	Slow Raveling to Fast Raveling	Flowing
Sand	Slow Raveling to Fast Raveling	Flowing

8.1.3.2 Clogging Potential

The clogging potential, also known as stickiness potential, for plastic soils was investigated by analyzing the plastic soils as described in Thewes and Burger[6] (2004). The clogging problem results from the material's tendency to adhere to steel surfaces.

The results of tests conducted on the current and other sections of this project, indicate that the clayey pockets of non-plastic till and plastic till deposits will demonstrate low to medium clogging potential at their in situ moisture content. It is important to note that the clogging potential is evaluated on the basis of the material's in situ moisture content. In the excavation process, as a result of mixing soils with water or conditioning agents, the moisture content may be increased resulting in a change in the clogging potential.

8.1.3.3 Cobbles, Boulders and Rock Slabs

Cobbles, boulders and/or rock slabs should be anticipated along the entire alignment of the tunnel. The contractor should be prepared to deal with these obstructions.

8.2 Shaft/Manholes

The expected soil and groundwater conditions at the shaft excavations are shown on the interpreted stratigraphic profile included in Appendix A. The shafts are expected to extend through the surficial pavement structure, topsoil, and sand fill and clay fill and into the underlying stiff to hard silty clay till, very dense silt and sand till, silt and sand layers, till/shale complex and underlying shale bedrock. A summary of the shaft details, anticipated soil and groundwater conditions, and anticipated basal stability conditions (for excavation without dewatering) is provided in Table 8.2. The diameters of the shafts are not known at the time of this report.

Table 8.2 – Shaft Details

MH No.	Approx. Shaft Depth (mbgs)	Approx. Shaft Base Elev.	BH No.	Anticipated Ground Conditions at Base of Shaft	Ground Water Depth (mbgs)	Ground Water Elev.	Basal Stability Issues
MH17	17.4	189.2	19-41	Till/Shale Complex	-0.9[1]	207.5	Piping
MH18	19.7	190.4	19-44	Shale Bedrock	1.1	209.0	None

Note:
1. Negative value indicates water level above ground surface or artesian condition

[6] Thewes and Burger, 2004: Clogging risks for TBM drives in clay. Tunnels & Tunnelling International, pp.28-31.

8.2.1 Excavation and Engineered Support System

All excavations must be carried out in accordance with the current Occupational Health and Safety Act (OHSA) of Ontario and local regulations. The surficial fill materials are classified as a Type 3 soil under OHSA; the silty clay till is classified as a Type 2 soil under OHSA; the dense to very dense silt and sand till and dense silt and sand are classified as Type 1 soils where dewatering is provided.

Given the depth of excavation a temporary support system will likely be required for shaft excavation. The selection and design of the shoring system is the responsibility of the Contractor, however suitable systems may include soldier pile and lagging or secant pile walls. The shoring system must be provided in accordance with OPSS.PROV 539 and designed for Performance Level 2. All shoring systems must be designed by a Professional Engineer experienced in such designs.

The engineering support system employed for the conditions at the site may be designed using the lateral pressure distribution shown on Figure I1 in Appendix I for plastic soils (clay and clay till) and on Figure I2 in Appendix I for non-plastic soils (sand, silt, and sand and silt till).

The following parameters can be used with Figures I1 and I2:

K	=	0.33 for very stiff to hard silty clay till
	=	0.35 for stiff clay till
K_a	=	0.30 for dense to very dense silt and sand till
	=	0.35 for compact sand, silt and, sand and silt till
	=	0.54 for sloping backfill (2H:1V)
γ	=	20 kN/m^3 for fill
	=	21 kN/m^3 for native soils
h_w	=	height of water above the base of excavation for watertight shoring system (assume at ground surface for design purposes)
	=	0 for non-watertight shoring systems (with dewatering)

Hydrostatic seepage pressures added to the apparent earth pressures may be assessed using the appropriate method outlined in Section 26.10.7 of the Canadian Foundation Engineering Manual.

Soldier piles or secant piles should extend below the base of the excavation to satisfy horizontal equilibrium.

Use of a hydraulic excavator should be suitable for excavation in the fill and native overburden soils. Difficulties in excavating possible debris within the fill should be anticipated. Provision should be made for handling of the existing pavement structure, as well as cobbles, boulders and rock fragments in the till soils during excavation.

Difficulties with respect to the excavation of buried construction rubble, such as a pavement structure and/or concrete slabs that may be reinforced, as well as underground services left in place should be anticipated.

Excavation of the highly to moderately weathered shale should be possible using heavy excavation equipment and rippers, supplemented by pneumatic rock breakers where thick layers of hard material are encountered. The shale typically becomes stronger and less weathered with depth, and intensive use of pneumatic/hydraulic breakers, line drilling or other methods of loosening the bedrock may be required with increasing depth.

There must be close coordination of the shoring design installation with the design of tunnel eyes at launch and receiving shafts. Extra care needs to be taken during shaft installation to avoid loosening of the soils near the tunnel eyes. The design of tunnel eyes should provide provision for ground improvement (i.e. grouting) of any soils weakened as a result of shaft installation.

8.2.2 Groundwater

Seepage into excavations should be anticipated where excavations extend below the water level. As noted previously, it is anticipated the excavation for the shaft will have to be undertaken within the confines of an engineered support system (soldier pile and lagging or secant pile walls).

If the contractor selects a watertight engineered support system, such as secant pile walls, the Contractor must extend the watertight engineered support system to sufficient depth below the base of the excavation to cut off groundwater inflow. The water tight support system should be keyed into the underlying shale bedrock a minimum of 3 m. In this case, dewatering using sumps and pumps from within the excavation should be sufficient to maintain a dry excavation.

If a watertight engineered support system is not employed, dewatering will be required to lower the ground water at least 1.0 m below the lowest base of excavation. The dewatering system must prevent disturbance of the foundation subgrade. Additional measures such as heavy duty pumping and/or perimeter wells to maintain a dry excavation may be required.

Surface water runoff must be diverted away from the excavations at all times during construction.

The contractor must ensure the dewatering remains fully operational and effective until the shaft is constructed and backfilling operations are completed. There must be adequate provisions for backup power for standby conditions to ensure the continuous operation of the dewatering system.

Effective dewatering operations rely on the Contractor's experience, construction techniques, sequencing, and work force efficiency.

Groundwater control must be the responsibility of the contractor. The contractor must retain a dewatering specialist to design the dewatering system and identify effective measures for the conditions encountered. The dewatering plan should be submitted for information purposes before the start of excavation. The impact of the dewatering on local water wells or other groundwater resources in the area would need to be assessed prior to adopting this method of construction. Dewatering should be in accordance with OPSS.PROV 517 and SP 517F01.

A hydrogeological assessment to provide recommendations for groundwater control during construction and determine the need for EASR registration or PTTW application was completed concurrently with the geotechnical investigation. Further comments and recommendations regarding dewatering are discussed in Section 9 of this report.

8.2.3 Permanent Structures Lateral Earth Pressure

Drawings indicate that a manhole structure will be installed in each of the shafts. The structure should be designed to withstand hydrostatic pressure, hydrostatic uplift and effective stresses in accordance with the following equation:

$$p = K(\gamma h_1 + \gamma' h_2 + q) + \gamma_w h_2$$

where

K	=	lateral earth pressure coefficient
	=	0.5
γ	=	unit weight of soil above the design water level
	=	21.5 kN/m^3
γ'	=	buoyant unit weight of soil below design water level
	=	11.7 kN/m^3
h_1	=	depth below final grade (m), above design water level
h_2	=	depth below design water level (m)
q	=	any surcharge load (kN/m^2)
γ_w	=	unit weight of water
	=	9.8 kN/m^3

The ground water level should be assumed to occur at the ground surface for design purposes.

The above parameters are based on the assumption that the space between the permanent structure and the temporary shoring will be backfilled with compacted granular fill.

Due to observed artesian groundwater conditions at the shaft locations, it is recommended that unshrinkable fill is used as backfill. Where unshrinkable fill (lean concrete) is used for backfilling to the top of the manhole, the chamber structure should be designed for hydrostatic pressure applied by the fill in its fluid state. Fill placement must be carried out in stages in order to avoid imposing hydrostatic pressure on the structure larger than those assumed in the design, prior to setting and hardening of the concrete.

It is understood that the manhole will be designed as a watertight structure and, as the base of the structure is below the groundwater table, the structure should be designed to resist hydrostatic forces, including uplift. The ground water level should be assumed to occur at the ground surface for design purposes.

8.3 Instrumentation and Monitoring Plan

The trenchless crossing construction methodology must consider the need to minimize settlement and loss of ground below the highway. The magnitude of potential settlement will be based on the contractor's experience, construction techniques, sequencing and efficiency of work force.

Potential ground loss should be monitored by the contractor by reviewing mass/volume of the quantity of tunnelled spoils in comparison to advancement methodology, rate and anticipated ground mass/volume.

Provided appropriate tunneling methods are implemented and good construction practices are followed to limit loss of ground, settlement due to tunneling is not expected to exceed 10 mm. The settlement pattern that typically develops over a tunnel excavated through soil is a trough-shaped depression with the maximum settlement occurring above the middle of the tunnel.

Monitoring of the MTO right-of-way should be carried out during the trenchless installation. The settlement monitoring program, including layout of instrumentation and monitoring frequency, should be in accordance with the MTO Document 'Guidelines for Foundation Engineering – Tunnelling Specialty for Corridor Encroachment Permit Application' and the MTO Non-Standard Special Provision (NSSP) "Pipe Installation by Trenchless Method". A copy of the NSSP is provided in Appendix L.

Layout of instrumentation and monitoring should be in accordance with the NSSP. A preliminary monitoring plan and schematic of instrumentation for the monitoring program is provided in Drawing J1 in Appendix J. The Contractor is required to select a suitable method for the installation of pipe such that the ground settlement review and alert levels of 10 mm and 15 mm, respectively, stipulated in the instrumentation and monitoring program in Appendix J, can be satisfied.

The impact of the proposed installation on existing nearby structures and underground utilities should be assessed. A pre-construction condition survey should be carried out to document the existing condition of the highway pavement and assess the potential for damage to all facilities and underground services along the alignments of the trenchless crossings.

9.0 HYDROGEOLOGICAL ASSESSMENT

9.1 Dewatering Assessment and Construction Considerations

Groundwater taking for construction dewatering is governed by the Ontario Water Resources Act (OWRA), Environmental Protection Act (EPA) and the Water Taking and Transfer Regulation 387/04, a regulation under the OWRA.

If the water taking rate will be greater than 50,000 L/day and less than 400,000 L/day then registration on the Environmental Activity and Sector Registry (EASR) will be required. If the water taking rate will be greater than 400,000 L/day, then a Category 3 Permit To Take Water (PTTW) will be required.

For the purposes of estimating water taking, the estimated withdrawal rates are conservatively assessed in order to reduce the likelihood that actual pumping rates might exceed the permit allowance thereby stopping work and delaying the Project. It is noted that dewatering for the portion of wastewater main in the vicinity of Highway 401 represents only a portion of the overall Project, and that water taking needs for the Project as a whole are considered under separate cover.

Based on design information available to date, it is understood that dewatering will not be required in advance of the trenchless installation of the wastewater main under Highway 401 because microtunnelling was selected for the construction method. Thus, the nearest water takings that will occur near the highway are at the shafts closest to the Highway 401 ROW. The shaft details as assumed or understood were provided in Table 8.2 previously. Based on Drawing '1200 mm Wastewater Main Microtunnel Shaft, Detail Sheet', the excavation limit for each shaft was assumed to have a horizontal length and width of approximately 8 m. The shaft for MH17 is located approximately 100 m south of the south ROW and the shaft for MH18 is located approximately 160 m north of the north ROW.

For the purpose of estimating water taking flow rates it was assumed that support of excavation structures would not be watertight. The use of watertight support of excavation would greatly reduce the required water taking rates.

The following approach was used to estimate the budgeted peak water taking rate:

- A base groundwater extraction flow rate was estimated, and a factor of safety of three was applied to this flow rate to provide an allowance for removal of water from soil storage, variation in hydraulic conductivity, actual excavation dimensions and geometry, and ground water levels due to seasonality or other factors;
- An allowance for removal of rainfall into the excavation was included, assuming 24 hours are used to remove 50 mm of rainfall; and
- Lowering of groundwater to about 1 m below the base of the excavation when terminating in soil, or to the base of the excavation when terminating in shale, to facilitate a dry, stable work area was assumed.

The water taking will be temporary in nature for the purpose of construction dewatering for installation of the infrastructure. We understand that the shafts will be backfilled following construction and that permanent drainage of the wastewater main is not anticipated.

As part of the investigation for the wastewater main, many single well response tests in addition to those presented herein were conducted. A geologic model was developed and the hydraulic conductivities assigned to the geologic units that are applicable to dewatering for the shafts north and south of the Highway 401 ROW are presented in Table 9.1 below. The rationale for the choice of assigned values for construction dewatering estimates is to establish a hydraulic conductivity that is towards the upper end or at the upper end of the range of tested values for similar screened geologies such that any water taking permits are unlikely to limit construction, and conservative radii of influence can be used to assess potential impacts.

Table 9.1 – Summary of Assigned Hydraulic Conductivities (cm/s) for Dewatering Estimates

Geologic Unit	Minimum	Maximum	Geometric Mean	90th Percentile	Assigned Value	Notes
Silty Clay Till (Si-Cl Till)	9.5×10^{-7}	7.0×10^{-4}	2.6×10^{-5}	-	7.0×10^{-4}	Two tests. Assigned maximum value.
Silt and Sand Till (Si-Sa Till)	2.9×10^{-6}	8.8×10^{-4}	4.0×10^{-5}	4.0×10^{-4}	4.0×10^{-4}	Assigned 90th Percentile
Sand	1.4×10^{-4}	5.5×10^{-3}	1.2×10^{-3}	3.9×10^{-3}	3.9×10^{-3}	Assigned 90th Percentile
Shale	1.8×10^{-7}	5.9×10^{-3}	6.9×10^{-5}	2.1×10^{-3}	2.1×10^{-3}	Assigned 90th Percentile

The assumptions pertaining to groundwater levels, dewatering targets, geology and geologic unit elevations used for the dewatering scenario for each shaft are provided in Table 9.2 below. The arithmetic weighted average of the hydraulic conductivities assigned to each of the units was calculated as presented in Appendix K based on the relative saturated horizontal flow-through thicknesses.

Table 9.2 – Assumed Elevations for Dewatering Scenarios

Shaft for MH#	Initial GWL	Unit 1	Bottom Unit 1	Unit 2	Bottom Unit 2	Unit 3	Bottom Unit 3	Unit 4	Bottom Unit 4	Unit 5	Bottom Unit 5	Target GWL
MH17	207.5	Si-Cl Till	196.9	Si-Sa Till	194.4	Sand	190.7	Si-Sa Till	189.3	Shale	>184.2	187.7
MH18	209.0	Si-Cl Till	203.3	Si-Sa Till	199.8	Sand	193.5	Si-Sa Till	192.0	Shale	>187.1	190.4

Note: GWL indicates groundwater level elevation in m AMSL.

Dewatering rates were estimated using the Dupuit analytical solution. The base groundwater flow to lower the groundwater level to the target elevation was estimated. A safety factor of 3 was applied to the base groundwater flow and a rainfall removal allowance of 50 mm in 24 hours was added, to estimate the peak budgeted flow rate.

Two methods of estimating the radius of influence were evaluated. The first was calculated using the Sichardt equation using the mean hydraulic conductivity and is used in the Dupuit analytical solution. In comparison, the radius of influence based on the geologic unit with the largest hydraulic conductivity was used for the purpose of potential impact assessment.

The calculations and equations for the peak flow rate and radius of influence are provided in Appendix K. A summary of the dewatering estimates and radius of influence are provided in Table 9.3, below.

Table 9.3 – Estimated Construction Dewatering Rates and Radius of Influence

Shaft for MH#	Base Groundwater Flow (L/day)	Groundwater Flow with Safety Factor of 3 (L/day)	Stormwater Allowance (L/day)	Estimated Peak Flow Rate (L/day)	Approx. Radius of Influence (m)
MH17	398,000	1,194,000	3,000	1,197,000	390
MH18	458,000	1,374,000	3,000	1,377,000	370

However, it is understood that watertight shoring walls will be specified. A further estimation of water taking was conducted assuming watertight shoring in the soil and accounting for flow through a 3-m minimum vertical interval below the shaft, which was increased where greater shale thickness is exposed. The estimate was calculated as a ratio of extraction depth over total saturated depth with respect to the fully dewatered scenario. To be conservative, the radius of influence was estimated on the same basis as the fully dewatered scenario.

Table 9.4 – Estimated Construction Dewatering Rates Assuming Base Dewatering Only

Shaft for MH#	Base Groundwater Flow (L/day)	Groundwater Flow with Safety Factor of 3 (L/day)	Stormwater Allowance (L/day)	Estimated Peak Flow Rate (L/day)	Approx. Radius of Influence (m)
MH17	63,000	189,000	3,000	192,000	390
MH18	74,000	222,000	3,000	225,000	370

As discussed previously, construction of these shafts is only a portion of the work that will include dewatering for the overall wastewater main construction, and water taking permitting for the overall Project is addressed under separate cover. A Category 3 Permit To Take Water will

be required given that the estimated peak flow rate for each shaft herein exceeds 400,000 litres per day.

An experienced dewatering specialist is recommended to design the dewatering system, as multiple dewatering approaches may be required.

9.2 Hydrogeological Impact Assessment

9.2.1 Geotechnical Impacts

The potential for settlement is most likely to occur where the estimated drawdown is significant, where structures are located within close proximity to the dewatering, and where soils within the drawdown depths are compressible. The potential settlement at the highway ROW as a result of drawdown from the nearest shafts, was analyzed assuming the general stratigraphy is consistent with the closest boreholes. Given the specified use of watertight shoring walls in soil, and the estimated groundwater flow rates being more than five times smaller than the non-watertight scenario, the drawdown in the soil adjacent to the shafts is anticipated to be less than 5 m. The magnitude of the drawdown is moderate at the shaft and decreases with distance, the highway structure is located more than 100 m from the shafts, and the drawdown occurs in very stiff to hard/very dense glacial till and compact to very dense silt and sand overburden. Under these conditions the estimated settlement from dewatering is less than 5 mm and can be considered negligible.

A preconstruction survey of all structures and utilities within the radius of influence should be considered prior to dewatering activities, and a survey should be considered during dewatering to assess if any undesirable deformation has occurred. Additional comments and recommendations for instrumentation and monitoring are provided in Section 7.3.

If significant sediment and fines are removed during the dewatering due to improperly filtered extraction wells then ground loss and settlement beyond that described above could occur.

As the bottom of shaft excavation will extend below the groundwater table into the silt and sand till and till/shale complex at MH17, an effective dewatering system will be required to lower the ground water at least 1.0 m below the lowest base of excavation or to the top of shale prior to the start of excavation to maintain basal stability for non-watertight shoring systems. Basal stability is not expected to be an issue for watertight shoring systems extended to sufficient depth below the base of the excavation to cut off groundwater inflow.

9.2.2 Impact to Surface Water and Natural Environment

No surface water bodies or areas of natural and scientific interest were identified within the radii of influence of construction dewatering from the shaft locations. The closest water body is Sixteen Mile Creek, located approximately 700 m west of the shafts. No reduction in water flow to a surface water body is anticipated as a result of construction dewatering for these shafts.

Groundwater of the quality that was observed herein should not be discharged to the natural environment without pre-treatment due to exceedances of the PWQO limits. An experienced water treatment specialist is recommended to assess needs and design an effective treatment system.

9.2.3 Impacts to Water Well Users

Several well records were identified within the radius of influence of each of the shafts. A private well survey was conducted. Residences and/or businesses are located at 7524 and 7594 Auburn Road and at 7851 and 7729 Eighth Line, which are within the ROI of the shafts for MH17 and/or MH18. There may be additional wells and properties located within the ROI as well. Details on the well survey are provided in the report for the larger wastewater main project.

The potential to impact wells due to construction dewatering exists, and monitoring is recommended where permission has been granted. Mitigation measures that the Region may consider for affected well users include the provision of potable water or assistance with well productivity until the effects have been remedied.

Permanent drainage is not anticipated and thus permanent impact to existing water well users is not anticipated.

9.2.4 Other Potential Impacts

With prolonged dewatering activities there can be potential for inorganic or organic chemical compounds present within the radius of influence to migrate and to enter open excavations where sufficient flow rate and time permit. A printing service is located at 7729 Eighth Line, a pet care service is located at 7594 Auburn Road, and a telecommunications business is located at 7524 Auburn Road. The printing service and the telecommunications business have the potential to have groundwater quality impacted, albeit the risk is low given the assumed nature of these operations. A Contaminant Overview Study was not conducted and there may currently be, or historically have been, other activities with the potential to have impaired groundwater quality.

Given the proximity of these services that have the potential to have impacted groundwater quality, visual, olfactory, and testing of the water from dewatering operations is required. If any contaminated groundwater is collected from the dewatering operations it must be treated to meet any discharge criteria or disposed of at a facility licensed to handle such materials. However, the likelihood of impacted groundwater from these properties reaching the shaft locations is low due to the distance and relatively low hydraulic conductivity of shallow soils.

10.0 CONSTRUCTION CONCERNS

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

- Shaft excavation, at both shafts, will take place in sands and silts below the water table. Basal instability and sloughing will occur if appropriate precautions are not put in place. The methodology selected for excavation must anticipate these conditions.

- Selection of the trenchless technique employed for installing the sewer must take into account the need to avoid settlement and loss of ground below Highway 401. Confirmatory monitoring of the roadway surface should be carried out during construction, and contingency plans should be prepared to manage any adverse impacts that may arise.

- Cobbles, boulders, rock slabs or other obstructions may be present within the existing highway embankment fill, native tills and till/shale complex. The Contractor's equipment and methodology must be able to safely handle and remove such obstructions.

- The Contractor must accurately establish the locations and depths of all buried utilities in the vicinity of the excavations and tunnelling.

11.0 CLOSURE

Full time supervision of the field activities was carried out by Mr. Omar Ali of Thurber Engineering. Overall supervision of the field program was performed by Mr. Karel Furbacher, P.Eng. of Thurber. Interpretation of the field data and preparation of the report was performed by Mr. Karel Furbacher, P.Eng. The report was reviewed by Mr. Renato Pasqualoni, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Karel Furbacher, P.Eng.
Geotechnical Engineer

Renato Pasqualoni, P.Eng.
Review Principal

P.K. Chatterji, P.Eng., Ph.D.
Review Principal, Designated MTO Contact

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

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

2. COMPLETE REPORT

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

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

3. BASIS OF REPORT

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

4. USE OF THE REPORT

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

5. INTERPRETATION OF THE REPORT

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

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

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

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

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

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

7. INDEPENDENT JUDGEMENTS OF CLIENT

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

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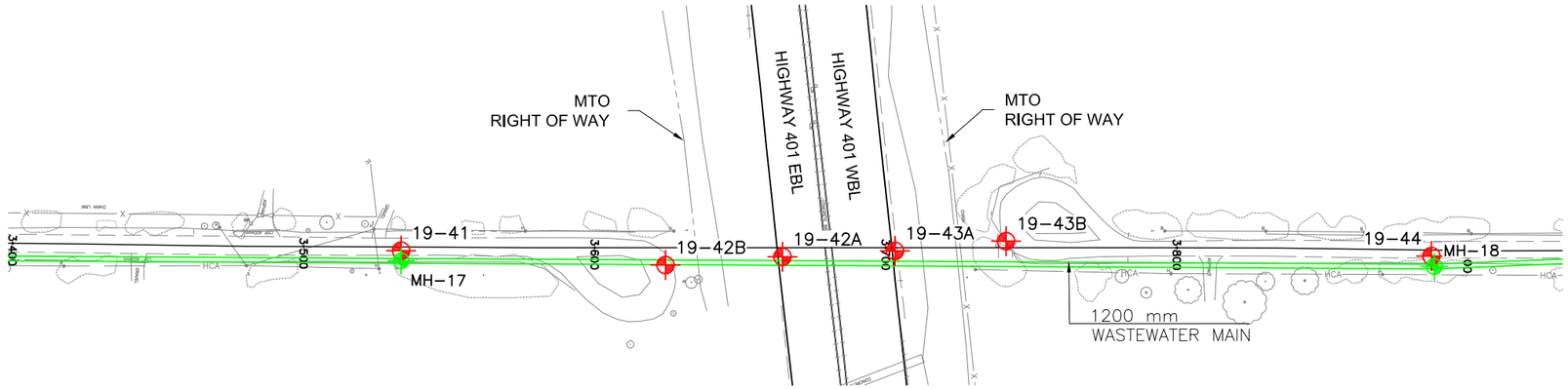
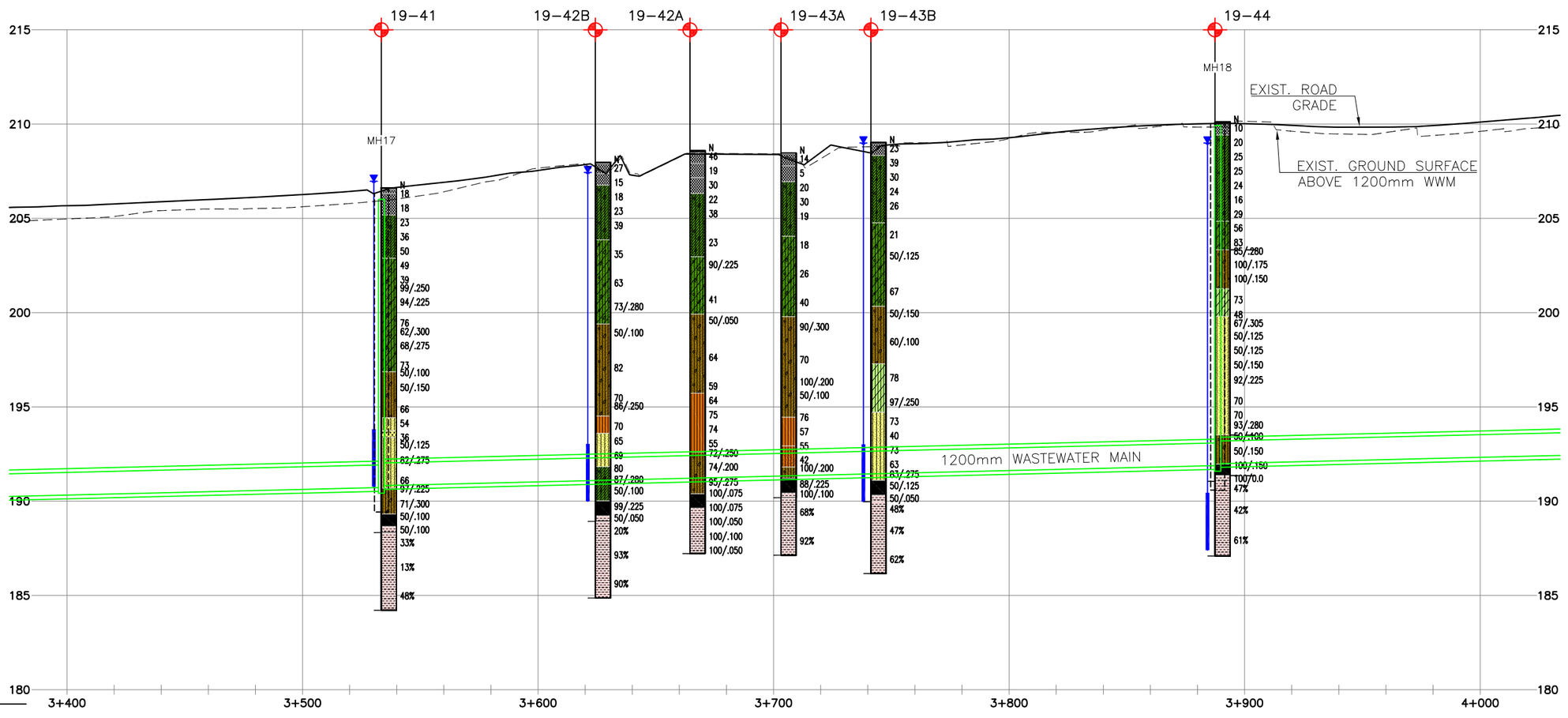
Appendix A

Borehole Location Plan and Stratigraphic Profile





LEGEND:

- CURRENT BOREHOLE LOCATION
- PREVIOUS BOREHOLE LOCATION
- WATER LEVEL MEASURED IN MONITORING WELL
- WATER LEVEL UPON COMPLETION
- INTERPRETED OVERBURDEN AND SHALLOW BEDROCK GROUNDWATER LEVEL
- INTERPRETED LOWER BEDROCK GROUNDWATER LEVEL, WHERE IDENTIFIED
- N 'N' SPT VALUE
- #% BEDROCK RQD MEASUREMENTS

CLASS A - FILL
- FILL
- TOPSOIL/ORGANICS

CLASS B - SAND
- SAND
- SILTY SAND
- SAND AND SILT

CLASS C - SILT
- SILT
- SANDY SILT

CLASS D - NON-PLASTIC TILL
- SAND TILL
- SANDY GRAVEL/ SAND & GRAVEL
- GRAVELLY SAND

- SANDY SILT TILL/ SAND & SILT TILL
- SILT TILL
- SILTY SAND TILL

CLASS E - CLAY
- CLAYEY SILT
- CLAY
- SILTY CLAY

CLASS F - PLASTIC TILL
- SILTY CLAY TILL
- CLAYEY SILT TILL

CLASS G - TILL/SHALE COMPLEX
- TILL/SHALE COMPLEX

CLASS H - BEDROCK
- SHALE

NOTE:

BOREHOLE STRATIGRAPHY IS APPROXIMATED. REFER TO GDR BOREHOLE LOGS FOR DETAILED CONDITIONS.

20 0 20 40 H 1:2000
2.5 0 2.5 5 V 1:250

HATCH

SOUTH GEORGETOWN WASTEWATER SERVICING
WASTEWATER MAIN
HIGHWAY 401 CROSSING
MILTON & HALTON HILLS, ONTARIO

BOREHOLE LOCATIONS AND STRATIGRAPHIC PROFILE

JOB# 25063 GEOCRES No. 30M12-497

THURBER ENGINEERING LTD.

ENGINEER:	DRAWN:	APPROVED:
KF	AN	RP
DATE:	SCALE:	DRAWING No.
DECEMBER 2020	AS SHOWN	25063-1

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PLOTDATE: Dec 9, 2020 - 10:45 AM

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Appendix B

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

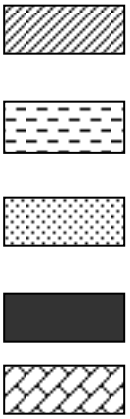
(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

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

TERMS

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

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	(psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

THURBER

RECORD OF BOREHOLE 19-41

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Auburn Road, Milton, ON
STARTED : August 1, 2019 — SHEET 1 OF 2
COMPLETED : August 2, 2019 — N 4 825 879.3 E 595 478.5 — DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	SHEAR STRENGTH: Cu, KPa (nat V - ✤, rem V - ●, Q - ✖, Cpen ▲; 40 80 120 160) / WATER CONTENT, PERCENT (wp w wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		206.62							
		ASPHALT: (75mm)		0.08							Flushmount Well Protector Set In Concrete
		SAND and **GRAVEL**: (FILL)			1	SS	18				
		CLAY, silty, trace sand, trace gravel, stiff, grey: (FILL)		0.30							
1	Hollow Stem Augers				2	SS	18				
				205.17							
		CLAY, silty, some sand to sandy, trace to some gravel, very stiff to hard, brown: (TILL)		1.45	3	SS	23				
2					4	SS	36				
3					5	SS	50	Grain Size Analysis: Gr 12%/Sa 41%/Si 33%/ Cl 14%			
				202.88							
		SILT, clayey, sandy, trace to some gravel, hard, grey, occasional cobbles and boulders: (TILL)		3.73	6	SS	49				
4					7	SS	39				
5					8	SS	99/ 0.250				
6	Mud Rotary/Tricone				9	SS	94/ 0.225				Bentonite
7					10	SS	76				
					11	SS	62/ 0.300				
8					12	SS	68/ 0.275				
9					13	SS	73	Grain Size Analysis: Gr 4%/ Sa 38%/Si 45%/ Cl 13%			
				196.86							
		SILT and **SAND**, some clay, trace to some gravel, very dense, grey: (TILL)		9.75	14	SS	50/				

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION — ▼ WATER LEVEL IN WELL/PIEZOMETER

November 19, 2019

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 2/25/20

RECORD OF BOREHOLE 19-41

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Auburn Road, Milton, ON
STARTED : August 1, 2019 — SHEET 2 OF 2
COMPLETED : August 2, 2019 — N 4 825 879.3 E 595 478.5 — DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160 / WATER CONTENT, PERCENT (wp, w, wl) 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		SILT and **SAND**, some clay, trace to some gravel, very dense, grey, moist, occasional cobbles and bouldetrs: (TILL)					0.100				
11					15	SS	50/ 0.150				
					16	SS	66				
12				194.43							
		SAND, silty, trace gravel, very dense, grey, wet		12.19	17	SS	54				Sand
				193.74							
13		becoming gravelly, trace silt, occasional cobbles and boulders		12.88							
		becoming silty, trace gravel		193.37 13.25	18	SS	36				
					19	SS	50/ 0.125				
14											
					20	SS	82/ 0.275				Slotted Screen
15											
					21	SS	66	Grain Size Analysis: Gr 3%/ Sa 73%/ Si 24%/ Cl 0%			
				190.69							
16		**SILT** and **SAND**, trace gravel, trace clay, very dense, reddish brown, moist, occasional shale fragments: (TILL)		15.93	22	SS	97/ 0.225	Grain Size Analysis: Gr 7%/ Sa 37%/ Si 48%/ Cl 8%			
					23	SS	71/ 0.300				
17				189.32							
		CLAY, silty, some sand, trace gravel, hard, reddish brown, occasional to numerous shale fragments: (TILL/SHALE COMPLEX)		17.30	24	SS	50/ 0.100				
				188.66							
18		**SHALE**, highly weathered, with grey hard layers		17.96							
				188.33	25	SS	50/ 0.100				
		END OF SAMPLING AT 18.29m AND START CORING. FOR ROCK CORE REFER TO BOREHOLE 19-41R.		18.29							
19		Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.									

WATER LEVEL READINGS:

DATE	DEPTH(m)	ELEV.(m)
Oct 16/19	-0.65	207.27
Oct 25/19	-0.89	207.51
Nov 19/19	-0.35	206.97

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER November 19, 2019

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 2/25/20

RECORD OF BOREHOLE 19-41R

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063

LOCATION : — INCLINATION: Vertical

STARTED : August 1, 2019 — AZIMUTH: Vertical

COMPLETED : August 2, 2019 — N 4 825 879.3 E 595 478.5

SHEET 1 OF 1

DATUM Geodetic

FR-FRACTURE, CL-CLEAVAGE, J-JOINT, B-BEDDING; RU-ROUGH UNDULATING, RP-ROUGH PLANAR, SU-SMOOTH UNDULATING, SP-SMOOTH PLANAR; T-TIGHT, HARD, SA-SLIGHTLY ALTERED, CLAY FREE, SC-SWELLING, SOFT CLAY; HOR-HORIZONTAL, D-DIPPING, V-VERTICAL

FIELD/LABORATORY TESTING RESULTS: ● Point Load Test Diametral; ▲ Point Load Test Axial; ⊠ Laboratory UCS Test

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min)	FLUSH / COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER .3 m	DISCONTINUITY DATA: DIP wrt Core Axis	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	Unconfined Compressive Strength (MPa)
				188.33											
19	HQ Coring	**SHALE**, slightly weathered to fresh, laminated, red, very poor to poor quality, very weak to medium strong, very thinly to thickly bedded with slightly weathered to fresh, grey, weak to strong, slightly calcareous hard layers (<50mm except noted) highly fractured zones (200mm) at 18.6m and (100mm) at 18.9m hard layer (100mm) at 19.5m		18.29	1										
20		highly fractured zones (75mm) at 19.6m, (100mm) at 20.0m and (75mm) at 20.7m clay seam (100mm) at 20.0m and (150mm) at 20.4m			2										
21		occasional vugs			3										
22		hard layers (75mm) at 21.9m and 22.2m clay seam at 22.1m and 22.3m		184.22											
		END OF BOREHOLE AT 22.40m.		22.40											
23															
24															
25															
26															
27															
28															

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER

LOGGED : OA

CHECKED : KF

THURBER

ROCKM4 TEL-25063.GPJ 2/27/20

RECORD OF BOREHOLE 19-42B

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Auburn Road, Milton, ON
STARTED : July 30, 2019 — SHEET 1 OF 3
COMPLETED : July 31, 2019 — N 4 825 946.5 E 595 417.1 — DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	COMMENTS	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) / WATER CONTENT, PERCENT (wp, w, wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		207.98				DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	40 80 120 160 / wp w wl 10 20 30 40		
		ASPHALT: (75mm)		0.08							Flushmount Well Protector Set in Concrete
		SAND and **GRAVEL**: (FILL)		207.37	1	SS	27				
		CLAY, silty, some sand, some gravel, stiff, greyish brown: (FILL)		0.61	2	SS	15				
1	Hollow Stem Augers	**CLAY**, silty, some sand, trace to some gravel, stiff to very stiff, brown: (TILL)		206.76 1.22	3	SS	18	Grain Size Analysis: Gr 5%/ Sa 24%/ Si 46%/ Cl 25%			
2					4	SS	23				
3					5	SS	39				
4		**SILT**, clayey, sandy, trace gravel, hard, grey, moist: (TILL)		203.86 4.11	6	SS	35	Grain Size Analysis: Gr 6%/ Sa 36%/ Si 46%/ Cl 12%			
5											
6					7	SS	63				
7	Mud Rotary/Tricone										Bentonite
8					8	SS	73/ 0.280	Grain Size Analysis: Gr 13%/Sa 37%/ Si 37%/ Cl 13%			
9		**SILT** and **SAND**, some clay, trace to some gravel, dense, grey, moist, occasional cobbles and boulders: (TILL)		199.40 8.57	9	SS	50/ 0.100				

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER November 19, 2019

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 2/25/20

RECORD OF BOREHOLE 19-42B

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Auburn Road, Milton, ON
STARTED : July 30, 2019 — SHEET 2 OF 3
COMPLETED : July 31, 2019 — N 4 825 946.5 E 595 417.1 — DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160 / WATER CONTENT, PERCENT (wp, w, wl) 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
11	Mud Rotary/Tricone				10	SS	82				
12					11	SS	70	Grain Size Analysis: Gr 14%/Sa 49%/Si 32%/Cl 5%			
13					12	SS	86/0.250				
		SILT, trace to some sand, trace gravel, with occasional clay seams		194.52 13.46							
14					13	SS	70	Grain Size Analysis: Gr 3%/Sa 16%/Si 75%/Cl 6%			Filter Sand
		SAND, some silt to silty, trace gravel, very dense, grey, wet, with occasional silt seams		193.60 14.37							
15					14	SS	65				
					15	SS	69	Grain Size Analysis: Gr 0%/Sa 55%/Si 43%/Cl 2%			
16											
		CLAY, silty, sandy, trace gravel, hard, reddish brown, moist, occasional shale fragments: (TILL)		191.83 16.15	16	SS	80				Slotted Screen
17					17	SS	87/0.280	Grain Size Analysis: Gr 4%/Sa 26%/Si 57%/Cl 13%			
					18	SS	50/0.100				
18		**CLAY**, silty, some sand to sandy, trace to some gravel, hard, reddish brown, moist, occasional to numerous shale fragments: (TILL/SHALE COMPLEX)		190.02 17.96	19	SS	99/0.225				
		SHALE, highly weathered, red, with grey hard layers		189.22 18.76							
19		END OF SAMPLING AT 19.05m AND START CORING. FOR ROCK CORE REFER TO BOREHOLE 19-42BR.		188.93 19.05	20	SS	50/0.050				
		Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.									

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER November 19, 2019

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 2/25/20

RECORD OF BOREHOLE 19-42B

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station
Project No. 25063

LOCATION : Auburn Road, Milton, ON

STARTED : July 30, 2019
SHEET 3 OF 3

COMPLETED : July 31, 2019
N 4 825 946.5 E 595 417.1
DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	SHEAR STRENGTH: Cu, KPa (nat V - ✤, rem V - ●, Q - ✖, Cpen ▲; 40 80 120 160) / WATER CONTENT, PERCENT (wp, w, wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL READINGS:

DATE	DEPTH(m)	ELEV.(m)
Aug 01/19	-0.80	208.77
Oct 02/19	0.18	207.80
Oct 25/19	0.27	207.70
Nov 19/19	0.54	207.44

21
22
23
24
25
26
27
28
29

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION

▼ WATER LEVEL IN WELL/PIEZOMETER
November 19, 2019

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 2/25/20

RECORD OF BOREHOLE 19-42BR

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Auburn Road, Milton, ON — INCLINATION: Vertical
STARTED : July 30, 2019 — AZIMUTH: Vertical
COMPLETED : July 31, 2019 — N 4 825 946.5 E 595 417.1
SHEET 1 OF 1
DATUM Geodetic

FR-FRACTURE, CL-CLEAVAGE, J-JOINT, B-BEDDING; RU-ROUGH UNDULATING, RP-ROUGH PLANAR, SU-SMOOTH UNDULATING, SP-SMOOTH PLANAR; T-TIGHT, HARD, SA-SLIGHTLY ALTERED, CLAY FREE, SC-SWELLING, SOFT CLAY; HOR-HORIZONTAL, D-DIPPING, V-VERTICAL

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min)	FLUSH / COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER .3 m	DISCONTINUITY DATA: DIP wrt Core Axis	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	Unconfined Compressive Strength (MPa)	FIELD/LABORATORY TESTING RESULTS
				188.93												
	HQ Coring	**SHALE**, slightly weathered to fresh, laminated, red, very poor quality, very weak to medium strong, very thinly to thickly bedded with slightly weathered to fresh, grey, weak to strong, slightly calcareous hard layers (<50mm except noted)		19.05	1											
20		becoming excellent quality			2											
21																
22		hard layer (75mm) at 22.0m clay seam at 22.5m			3											
23				184.86												
		END OF BOREHOLE AT 23.11m.		23.11												
24																
25																
26																
27																
28																

RECOVERY, R.Q.D. and FRACT. INDEX scales: 80 60 40 20 (5 10 15 20 for FRACT. INDEX PER .3 m)
DISCONTINUITY DATA: DIP wrt Core Axis: 0 30 60 90
HYDRAULIC CONDUCTIVITY k, cm/sec: 10^-6 10^-5 10^-4 10^-3
Unconfined Compressive Strength (MPa): 25 50 75

FIELD/LABORATORY TESTING RESULTS
- Point Load Test Diametral
- Point Load Test Axial
- Laboratory UCS Test

GROUNDWATER ELEVATIONS

WATER LEVEL UPON COMPLETION — WATER LEVEL IN WELL/PIEZOMETER

LOGGED : OA
CHECKED : KF

THURBER

ROCKM4 TEL-25063.GPJ 2/27/20

RECORD OF BOREHOLE 19-42A

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Highway 401, Milton, ON
STARTED : November 19, 2019 — SHEET 1 OF 3
COMPLETED : November 20, 2019 — N 4 825 972.6 E 595 386.4 — DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	COMMENTS
		GROUND SURFACE		208.60				
		ASPHALT: (125mm)						
		SAND and **GRAVEL**: (FILL)		0.13	1	SS	46	
				207.92				
		CLAY, silty, some sand, some gravel, very stiff, brown: (FILL)		0.69	2	SS	19	
1				207.16				
		SAND, gravelly, some clay, compact, grey, moist: (FILL)		1.45	3	SS	30	
2				206.32				
		CLAY, silty, some sand, trace gravel, very stiff to hard, brown: (TILL)		2.29	4	SS	22	Grain Size Analysis: Gr 10%/Sa 24%/Si 45%/Cl 21%
3					5	SS	38	
4								
	Hollow Stem Augers				6	SS	23	
5								
				202.96				
		SILT, clayey, sandy, trace gravel, hard, grey, moist: (TILL)		5.64	7	SS	90/0.225	
6								
7								
					8	SS	41	Grain Size Analysis: Gr 5%/Sa 37%/Si 44%/Cl 14%
8								
				199.92				
		SILT and **SAND**, trace clay, trace gravel, very dense, grey, moist, occaisonal cobbles and boulders: (TILL)		8.69				
9					9	SS	50/0.050	

SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160
DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
WATER CONTENT, PERCENT wp w wl 10 20 30 40

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 3/2/20

RECORD OF BOREHOLE 19-42A

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station
Project No. 25063
LOCATION : Highway 401, Milton, ON
STARTED : November 19, 2019
SHEET 2 OF 3
COMPLETED : November 20, 2019
N 4 825 972.6 E 595 386.4
DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) (40 80 120 160) / WATER CONTENT, PERCENT (wp w wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
11	Hollow Stem Augers				10	SS	64	Grain Size Analysis: Gr 5%/ Sa 35%/ Si 56%/ Cl 4% Non-Plastic			
12					11	SS	59				
13		**SILT**, some clay to clayey, trace to some sand, trace gravel, very dense, grey, wet, with occasional partings of silty clay		195.73 12.88	12	SS	64				
14					13	SS	75	Grain Size Analysis: Gr 0%/ Sa 4%/ Si 87%/ Cl 9%			
15		trace clay			14	SS	74				
					15	SS	55	Grain Size Analysis: Gr 9%/ Sa 11%/ Si 74%/ Cl 6%			
16		**SILT**, sandy, some gravel, trace clay, very dense, reddish brown, wet, occasional shale fragments: (TILL)		192.60 16.00	16	SS	72/ 0.250				
17					17	SS	74/ 0.200	Grain Size Analysis: Gr 11%/Sa 31%/ Si 51%/ Cl 7%			
18					18	SS	95/ 0.275				
		SILT, sandy, trace gravel and clay, very dense, reddish brown, wet, occasional to numerous shale fragments: (TILL/SHALE COMPLEX)		190.39 18.21	19	SS	100/ 0.075	Grain Size Analysis: Gr 10%/Sa 36%/ Si 48%/ Cl 6%			
19		**SHALE**, highly weathered, with grey hard layers		189.63 18.97	20	SS	100/ 0.075				
					21	SS	100/ 0.050				

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 3/2/20

RECORD OF BOREHOLE 19-42A

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station
Project No. 25063

LOCATION : Highway 401, Milton, ON

STARTED : November 19, 2019
SHEET 3 OF 3

COMPLETED : November 20, 2019
N 4 825 972.6 E 595 386.4
DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) (40 80 120 160) / WATER CONTENT, PERCENT (wp, w, wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
21					22	SS	100/ 0.100		○		
				187.22	23	SS	100/ 0.050		○		
		END OF BOREHOLE AT 21.38m. BOREHOLE BACKFILLED WITH BENTONITE-PORTLAND GROUT, ASPHALT AT SURFACE.		21.38							
22											
23											
24											
25											
26											
27											
28											
29											

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 3/2/20

RECORD OF BOREHOLE 19-43A

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station
Project No. 25063

LOCATION : Highway 401, Milton, ON

STARTED : November 17, 2019
SHEET 1 OF 2

COMPLETED : November 18, 2019
N 4 825 998.2 E 575 357.4
DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	COMMENTS / DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	SHEAR STRENGTH: Cu, KPa (nat V - ✤, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160 / WATER CONTENT, PERCENT wp w wl 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		208.47							
		TOPSOIL: (50mm)		0.05							
		SAND and **GRAVEL**: (FILL)			1	SS	14				
				207.78							
		CLAY, silty, trace to some sand, trace gravel, firm, brown, moist: (FILL)		0.69							
1					2	SS	5				
				206.95							
		CLAY, silty, some sand, trace gravel, very stiff to hard, brown, moist: (TILL)		1.52							
2					3	SS	20	Grain Size Analysis: Gr 4%/ Sa 29%/ Si 46%/ Cl 21%			
					4	SS	30				
3											
					5	SS	19				
4											
				204.05							
		SILT, clayey, some sand to sandy, trace gravel, very stiff to hard, grey, moist: (TILL)		4.42							
	Hollow Stem Augers				6	SS	18	Grain Size Analysis: Gr 3%/ Sa 38%/ Si 47%/ Cl 12%			
5											
6											
					7	SS	26				
7											
					8	SS	40	Grain Size Analysis: Gr 5%/ Sa 29%/ Si 55%/ Cl 11%			
8											
				199.78							
		SILT and **SAND**, some clay, trace gravel, very dense, grey, moist, occasional cobbles and boulders: (TILL)		8.69							
9					9	SS	90/ 0.300	Grain Size Analysis: Gr 4%/ Sa 37%/ Si 49%/ Cl 10%			

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 2/25/20

RECORD OF BOREHOLE 19-43A

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station
Project No. 25063
LOCATION : Highway 401, Milton, ON
STARTED : November 17, 2019
SHEET 2 OF 2
COMPLETED : November 18, 2019
N 4 825 998.2 E 575 357.4
DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	COMMENTS
								DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
								SHEAR STRENGTH: Cu, KPa nat V - ✚ Q - ✖ rem V - ● Cpen ▲ 40 80 120 160
								WATER CONTENT, PERCENT wp w wl 10 20 30 40
								ADDITIONAL LAB. TESTING
								PIEZOMETER OR STANDPIPE INSTALLATION
11	Hollow Stem Augers				10	SS	70	
12					11	SS	100/ 0.200	
13					12	SS	50/ 0.100	
14		**SILT**, trace sand, trace gravel, very dense, grey, wet		194.45 14.02	13	SS	76	
15					14	SS	57	Grain Size Analysis: Gr 0%/ Sa 4%/ Si 88%/ Cl 8% Non-Plastic
		SAND, silty, very dense, reddish brown, wet, with occasional silt seams and layers		192.93 15.54	15	SS	55	
16					16	SS	42	Grain Size Analysis: Gr 0%/ Sa 43%/ Si 53%/ Cl 4%
17		**SILT**, sandy, some clay, some gravel, very dense, reddish brown, occasional shale fragments: (TILL)		191.81 16.66	17	SS	100/ 0.200	
		SILT, sandy, gravelly, very dense, reddish brown, wet, occasional to numerous shale fragments: (TILL/SHALE COMPLEX)		191.22 17.25	18	SS	88/ 0.225	Grain Size Analysis: Gr 27%/Sa 30%/ Si 39%/ Cl 4%
18		**SHALE**, highly weathered, red, with grey hard layers		190.42 18.05	19	SS	100/ 0.100	
		END OF SAMPLING AT 18.29m AND START CORING. FOR ROCK CORE REFER TO BOREHOLE 19-43AR.		18.29				
19								

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 2/25/20

RECORD OF BOREHOLE 19-43AR

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Highway 401, Milton, ON — INCLINATION: Vertical
STARTED : November 17, 2019 — AZIMUTH: Vertical
COMPLETED : November 18, 2019 — N 4 825 998.2 E 575 357.4
SHEET 1 OF 1
DATUM Geodetic

FR-FRACTURE, CL-CLEAVAGE, J-JOINT, B-BEDDING; RU-ROUGH UNDULATING, RP-ROUGH PLANAR, SU-SMOOTH UNDULATING, SP-SMOOTH PLANAR; T-TIGHT, HARD, SA-SLIGHTLY ALTERED, CLAY FREE, SC-SWELLING, SOFT CLAY; HOR-HORIZONTAL, D-DIPPING, V-VERTICAL

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min)	FLUSH / COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER .3 m	DISCONTINUITY DATA: DIP wrt Core Axis	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	Unconfined Compressive Strength (MPa)	FIELD/LABORATORY TESTING RESULTS
				190.18												
19	HQ Coring	**SHALE**, slightly weathered to fresh, laminated, red, fair to excellent quality, very weak to medium strong, very thinly to thickly bedded with slightly weathered to fresh, grey, weak to strong, slightly calcareous hard layers (<50mm except noted) clay seam (50mm) at 18.5m occasionally vuggy		18.29	1											
20					2											
21				187.13												
		END OF BOREHOLE AT 21.34m. BOREHOLE BACKFILLED WITH BENTONITE-PORTLAND GROUT TO SURFACE.		21.34												
22																
23																
24																
25																
26																
27																
28																

Unconfined Compressive Strength (MPa): 25, 50, 75

FIELD/LABORATORY TESTING RESULTS
- Point Load Test Diametral
- Point Load Test Axial
- Laboratory UCS Test

GROUNDWATER ELEVATIONS

WATER LEVEL UPON COMPLETION — WATER LEVEL IN WELL/PIEZOMETER

LOGGED : OA
CHECKED : KF

THURBER

ROCKM4 TEL-25063.GPJ 2/27/20

RECORD OF BOREHOLE 19-43B

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Eighth Line South, Halton Hills, ON
STARTED : September 3, 2019 — SHEET 1 OF 3
COMPLETED : September 4, 2019 — N 4 826 022.6 E 595 327.8 — DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	COMMENTS / DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	SHEAR STRENGTH: Cu, KPa (nat V - ✚, rem V - ●, Q - ✖, Cpen ▲) 40 80 120 160 / WATER CONTENT, PERCENT (wp, w, wl) 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		209.02							
		TOPSOIL: (50mm)		0.05							
		CLAY, silty, trace sand, trace gravel, very stiff to hard, brown, moist: (FILL)			1	SS	23		○		Flushmount Well Protector Set In Concrete
				208.33							
		CLAY, silty, some sand to sandy, trace gravel, very stiff to hard, brown: (TILL)		0.69							
1	Hollow Stem Augers				2	SS	39		○		
					3	SS	30	Grain Size Analysis: Gr 8%/ Sa 24%/ Si 47%/ Cl 21%	○ —		
2					4	SS	24		○		
3					5	SS	26		○		
4				204.76							
		SILT, clayey, some sand to sandy, trace gravel, hard, brown: (TILL)		4.26							
5					6	SS	21	Grain Size Analysis: Gr 6%/ Sa 38%/ Si 44%/ Cl 12%	⊖		
6					7	SS	50/ 0.125		○		
7	Mud Rotary/Tricone										
8					8	SS	67	Grain Size Analysis: Gr 6%/ Sa 32%/ Si 47%/ Cl 15%	○ —		Bentonite
				200.33							
		SILT and **SAND**, some clay, some gravel, very dense, brown, wet, occasional cobbles and boulders: (TILL)		8.69							
9					9	SS	50/ 0.150		○		

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION — ▼ WATER LEVEL IN WELL/PIEZOMETER

December 18, 2019

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 2/25/20

RECORD OF BOREHOLE 19-43B

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Eighth Line South, Halton Hills, ON
STARTED : September 3, 2019 — SHEET 2 OF 3
COMPLETED : September 4, 2019 — N 4 826 022.6 E 595 327.8 — DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT	SHEAR STRENGTH: Cu, KPa (nat V - ✤, rem V - ●, Q - ✖, Cpen ▲) / WATER CONTENT, PERCENT (wp, w, wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
					10	SS	60/ 0.100				
11											
				197.29							
		SILT, some clay to clayey, some sand, trace gravel, very dense, grey, wet, with numerous clay layers		11.73							
12					11	SS	78	Grain Size Analysis: Gr 4%/ Sa 20%/ Si 41%/ Cl 35%			
13											
					12	SS	97/ 0.250				
14				194.72							
		SAND, some silt to silty, very dense, grey, wet		14.30							
					13	SS	73	Grain Size Analysis: Gr 0%/ Sa 71%/ Si 27%/ Cl 2%			
15	Mud Rotary/Tricone										
					14	SS	40				Filter Sand
16											
					15	SS	73				
17					16	SS	63	Grain Size Analysis: Gr 0%/ Sa 66%/ Si 32%/ Cl 2%			
					17	SS	83/ 0.275	Grain Size Analysis: Gr 0%/ Sa 77%/ Si 21%/ Cl 2%			Slotted Screen
		SILT and **SAND**, trace gravel, very dense, reddish brown, wet, numerous shale fragments: (TILL/SHALE COMPLEX)		191.11 17.91							
18					18	SS	50/ 0.125	Grain Size Analysis: Gr 6%/ Sa 44%/ Si 46%/ Cl 4% Non-Plastic			
		SHALE, highly weathered, red, with grey hard layers		190.31 18.71							
19				189.97	19	SS	50/ 0.050				
		END OF SAMPLING AT 19.05m AND START CORING. FOR ROCK CORE REFER TO BOREHOLE 19-43BR.		19.05							
		Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.									

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER

December 18, 2019

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 2/25/20

RECORD OF BOREHOLE 19-43B

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station
Project No. 25063
LOCATION : Eighth Line South, Halton Hills, ON
STARTED : September 3, 2019
SHEET 3 OF 3
COMPLETED : September 4, 2019
N 4 826 022.6 E 595 327.8
DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	SHEAR STRENGTH: Cu, KPa (nat V - ✤, rem V - ●, Q - ✖, Cpen ▲; 40 80 120 160) / WATER CONTENT, PERCENT (wp, w, wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL READINGS:

DATE	DEPTH(m)	ELEV.(m)
Oct 02/19	0.98	208.04
Nov 04/19	0.65	208.37
Nov 28/19	-0.05	209.07
Dec 18/19	0.02	209.00

21
22
23
24
25
26
27
28
29

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION

▼ WATER LEVEL IN WELL/PIEZOMETER
December 18, 2019

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 2/25/20

RECORD OF BOREHOLE 19-43BR

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Eighth Line South, Halton Hills, ON — INCLINATION: Vertical
STARTED : September 3, 2019 — AZIMUTH: Vertical
COMPLETED : September 4, 2019 — N 4 826 022.6 E 595 327.8
SHEET 1 OF 1
DATUM Geodetic

FR-FRACTURE, CL-CLEAVAGE, J-JOINT, B-BEDDING; RU-ROUGH UNDULATING, RP-ROUGH PLANAR, SU-SMOOTH UNDULATING, SP-SMOOTH PLANAR; T-TIGHT, HARD, SA-SLIGHTLY ALTERED, CLAY FREE, SC-SWELLING, SOFT CLAY; HOR-HORIZONTAL, D-DIPPING, V-VERTICAL

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min)	FLUSH / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER .3 m	DISCONTINUITY DATA: DIP wrt Core Axis	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	Unconfined Compressive Strength (MPa)	FIELD/LABORATORY TESTING RESULTS
				189.97												
	HQ Coring	**SHALE**, slightly weathered to fresh, laminated, red, poor to fair quality, very weak to medium strong, very thinly to thickly bedded with slightly weathered to fresh, grey, weak to strong, slightly calcareous hard layers (<50mm except noted)		19.05	1											
20		hard layers (100mm) at 19.1m and (175mm) at 19.6m clay seam (50mm) at 19.2m			2											
21		clay seams (25mm) at 20.0m, (25mm) at 20.2m and (50mm) at 20.4m														
22		clay seam (100mm) at 22.6m			3											
				186.16												
23		END OF BOREHOLE AT 22.86m.		22.86												
24																
25																
26																
27																
28																

FIELD/LABORATORY TESTING RESULTS
- Point Load Test Diametral
- Point Load Test Axial
- Laboratory UCS Test

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER

LOGGED : OA
CHECKED : KF

THURBER

ROCKM4 TEL-25063.GPJ 2/27/20

RECORD OF BOREHOLE 19-44

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Eighth Line South, Halton Hills, ON
STARTED : September 5, 2019 — SHEET 1 OF 3
COMPLETED : September 9, 2019 — N 4 826 128.5 E 595 227.1 — DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	COMMENTS
		GROUND SURFACE		210.11				
		SAND and **GRAVEL:** (FILL)		0.08				
		CLAY, silty, trace sand, trace to some gravel, firm, brown: (FILL)			1	SS	10	
				209.42				
		CLAY, silty, some sand, trace gravel, very stiff, brown: (TILL)		0.69				
1	Hollow Stem Augers				2	SS	20	
					3	SS	25	
2								
					4	SS	25	
3								
					5	SS	24	
4					6	SS	16	Grain Size Analysis: Gr 2%/ Sa 32%/ Si 49%/ Cl 17%
					7	SS	29	
5				204.85				
		SILT, clayey, trace to some sand, trace gravel, occasional cobbles and boulders, hard, grey: (TILL)		5.26	8	SS	56	
6					9	SS	83	
				203.34				
		SILT and **SAND**, some clay, trace gravel, very dense, grey, moist, occasional shale fragments and cobbles: (TILL)		6.77	10	SS	85/ 0.280	
7	Mud Rotary/Tricone							
					11	SS	100/ 0.175	
8								
					12	SS	100/ 0.150	
				201.27				
9		**SILT**, some clay to clayey, trace to some sand, very dense, grey, wet, occasional to numerous clay layers		8.84				
					13	SS	73	Grain Size Analysis: Gr 0%/ Sa 9%/ Si 53%/ Cl 38%

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH: Cu, KPa — nat V - ✚ Q - ✖ — rem V - ● Cpen ▲ — 40 80 120 160

WATER CONTENT, PERCENT — wp w wl — 10 20 30 40

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: Flushmount Well Protector Set In Concrete; Bentonite

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER December 18, 2019

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 2/27/20

RECORD OF BOREHOLE 19-44

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Eighth Line South, Halton Hills, ON
STARTED : September 5, 2019 — SHEET 2 OF 3
COMPLETED : September 9, 2019 — N 4 826 128.5 E 595 227.1 — DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	SHEAR STRENGTH: Cu, KPa (nat V - ✚ Q - ✖ / rem V - ● Cpen ▲) 40 80 120 160 / WATER CONTENT, PERCENT (wp w wl) 10 20 30 40	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
				199.81	14	SS	48				
		SAND, some silt to silty, trace to some gravel to gravelly, very dense, brown, wet, occasional cobbles		10.30							
11					15	SS	67/ 0.305				
					16	SS	50/ 0.125				
12					17	SS	50/ 0.125				
13					18	SS	50/ 0.150				
					19	SS	92/ 0.225				
14	Mud Rotary/Tricone	silty, grey, wet									
					20	SS	70				
15											
					21	SS	70				
16											
					22	SS	93/ 0.280	Grain Size Analysis: Gr 0%/ Sa 59%/ Si 38%/ Cl 3%			
		SILT and **SAND**, trace clay, trace gravel, very dense, reddish brown, occasional shale fragments: (TILL)		193.51 16.60							
17					23	SS	50/ 0.100				
					24	SS	50/ 0.150				
18											
		SILT, sandy, some clay, some gravel, very dense, reddish brown, numerous shale fragments: (TILL/SHALE COMPLEX)		191.97 18.14	25	SS	100/ 0.150	Grain Size Analysis: Gr 28%/Sa 39%/ Si 29%/ Cl 4%			
		SHALE, highly weathered, red, with grey hard layers		191.36 18.75							
19		END OF SAMPLING AT 19.05m AND START CORING. FOR ROCK CORE REFER TO BOREHOLE 19-44R.		191.06 19.05	26	SS	100/ 0.00				
		Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen.									

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER

December 18, 2019

LOGGED : OA
CHECKED : KF

THURBER

RECORD OF BOREHOLE 19-44

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Eighth Line South, Halton Hills, ON
STARTED : September 5, 2019 — SHEET 3 OF 3
COMPLETED : September 9, 2019 — N 4 826 128.5 E 595 227.1 — DATUM Geodetic

DEPTH SCALE (metres)	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	COMMENTS: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)	SHEAR STRENGTH: Cu, KPa (nat V - ✤, rem V - ●, Q - ✖, Cpen ▲; 40 80 120 160) / WATER CONTENT, PERCENT (wp, w, wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION

WATER LEVEL READINGS:

DATE	DEPTH(m)	ELEV.(m)
Oct 02/19	2.19	207.92
Nov 04/19	1.90	208.21
Nov 28/19	1.64	208.47
Dec 18/19	1.11	209.00

21
22
23
24
25
26
27
28
29

GROUNDWATER ELEVATIONS

▽ WATER LEVEL UPON COMPLETION

▼ WATER LEVEL IN WELL/PIEZOMETER
December 18, 2019

LOGGED : OA
CHECKED : KF

THURBER

THURBER2S TEL-25063.GPJ 2/27/20

RECORD OF BOREHOLE 19-44R

PROJECT : South Georgetown Wastewater Servicing Wastewater Main & Pumping Station — Project No. 25063
LOCATION : Eighth Line South, Halton Hills, ON — INCLINATION: Vertical
STARTED : September 5, 2019 — AZIMUTH: Vertical
COMPLETED : September 9, 2019 — N 4 826 128.5 E 595 227.1
SHEET 1 OF 1
DATUM Geodetic

FR-FRACTURE, CL-CLEAVAGE, J-JOINT, B-BEDDING; RU-ROUGH UNDULATING, RP-ROUGH PLANAR, SU-SMOOTH UNDULATING, SP-SMOOTH PLANAR; T-TIGHT, HARD, SA-SLIGHTLY ALTERED, CLAY FREE, SC-SWELLING, SOFT CLAY; HOR-HORIZONTAL, D-DIPPING, V-VERTICAL

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	RUN No.	PENETRATION RATE (m/min)	FLUSH / COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER .3 m	DISCONTINUITY DATA: DIP wrt Core Axis	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	Unconfined Compressive Strength (MPa)	FIELD/LABORATORY TESTING RESULTS
				191.06												
	HQ Coring	**SHALE**, slightly weathered to fresh, laminated, red, poor to fair quality, very weak to medium strong, very thinly to thickly bedded with slightly weathered to fresh, grey, weak to strong, slightly calcareous hard layers (<50mm except noted)		19.05	1											
20		clay seam (125mm) at 20.0m			2											
21																
22		vertical fracture (300mm) at 21.3m highly fractured zone (25mm) at 21.6m			3											
23		clay seam (50mm) at 21.6m and (25mm) at 22.4m hard layer (75mm) at 22.9m		187.09												
		END OF BOREHOLE AT 23.01m.		23.01												
24																
25																
26																
27																
28																

FIELD/LABORATORY TESTING RESULTS
- Point Load Test Diametral
- Point Load Test Axial
- Laboratory UCS Test

Filter Sand
Slotted Screen

GROUNDWATER ELEVATIONS
▽ WATER LEVEL UPON COMPLETION ▼ WATER LEVEL IN WELL/PIEZOMETER

LOGGED : OA
CHECKED : KF

THURBER

ROCKM4 TEL-25063.GPJ 2/27/20

THURBER

Appendix C

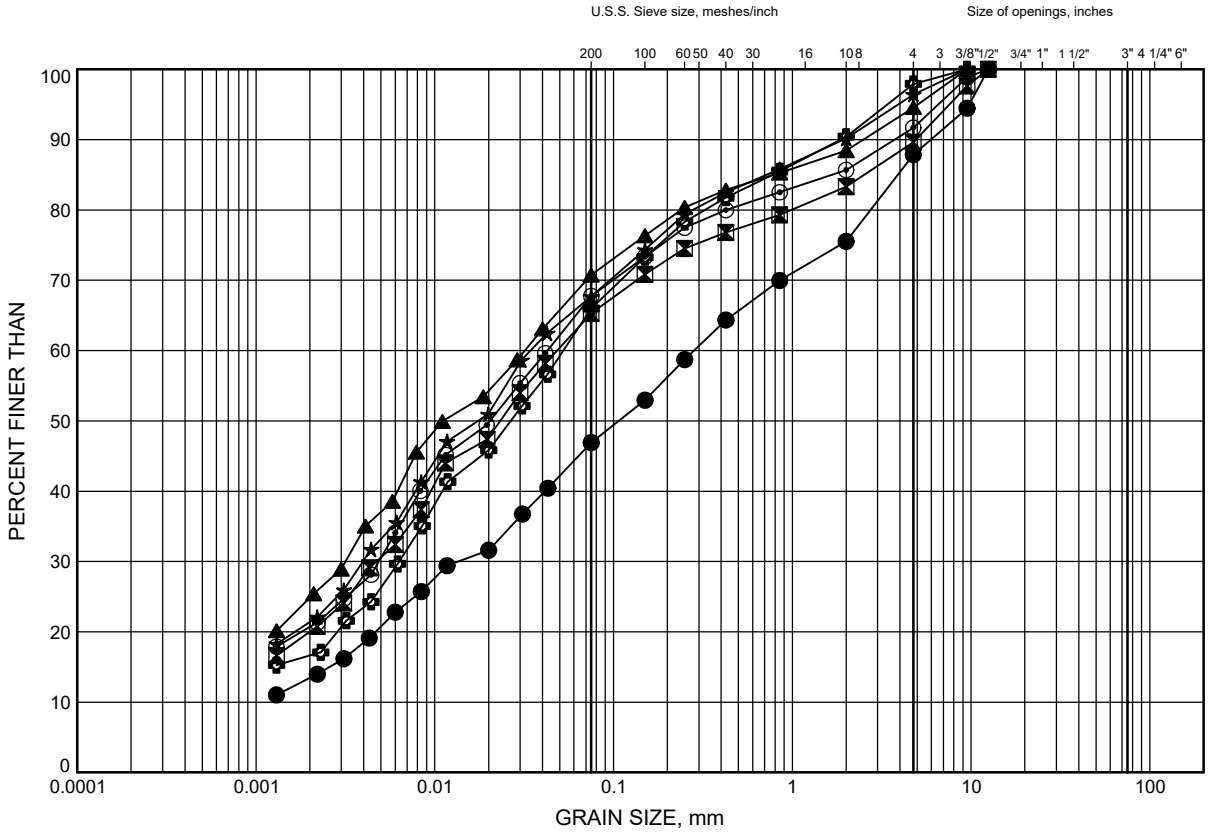
Geotechnical Laboratory Soil Test Results

South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

GRAIN SIZE DISTRIBUTION

FIGURE C1

Silty CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-41	3.35	203.27
⊠	19-42A	2.59	206.01
▲	19-42B	1.83	206.15
★	19-43A	1.83	206.64
⊙	19-43B	1.83	207.19
✿	19-44	4.11	205.99

Date March 2020

Project 25063

THURBER

Prep'd AN

Chkd. KF

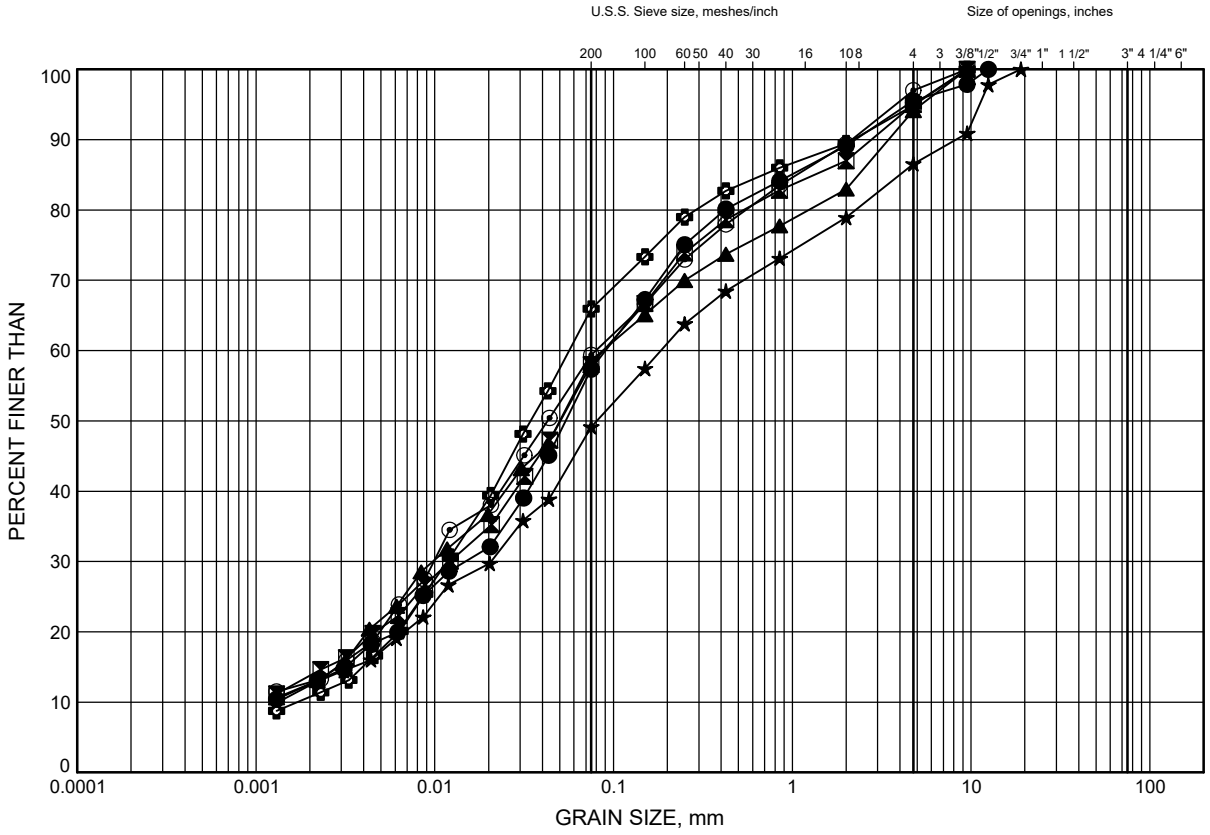
GRAIN SIZE DISTRIBUTION - THURBER TEL-25063.GPJ 3/6/20

South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

GRAIN SIZE DISTRIBUTION

FIGURE C2

Clayey SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-41	9.45	197.17
⊠	19-42A	7.92	200.68
▲	19-42B	4.88	203.10
★	19-42B	7.92	200.05
⊙	19-43A	4.88	203.59
✿	19-43A	7.92	200.55

Date March 2020

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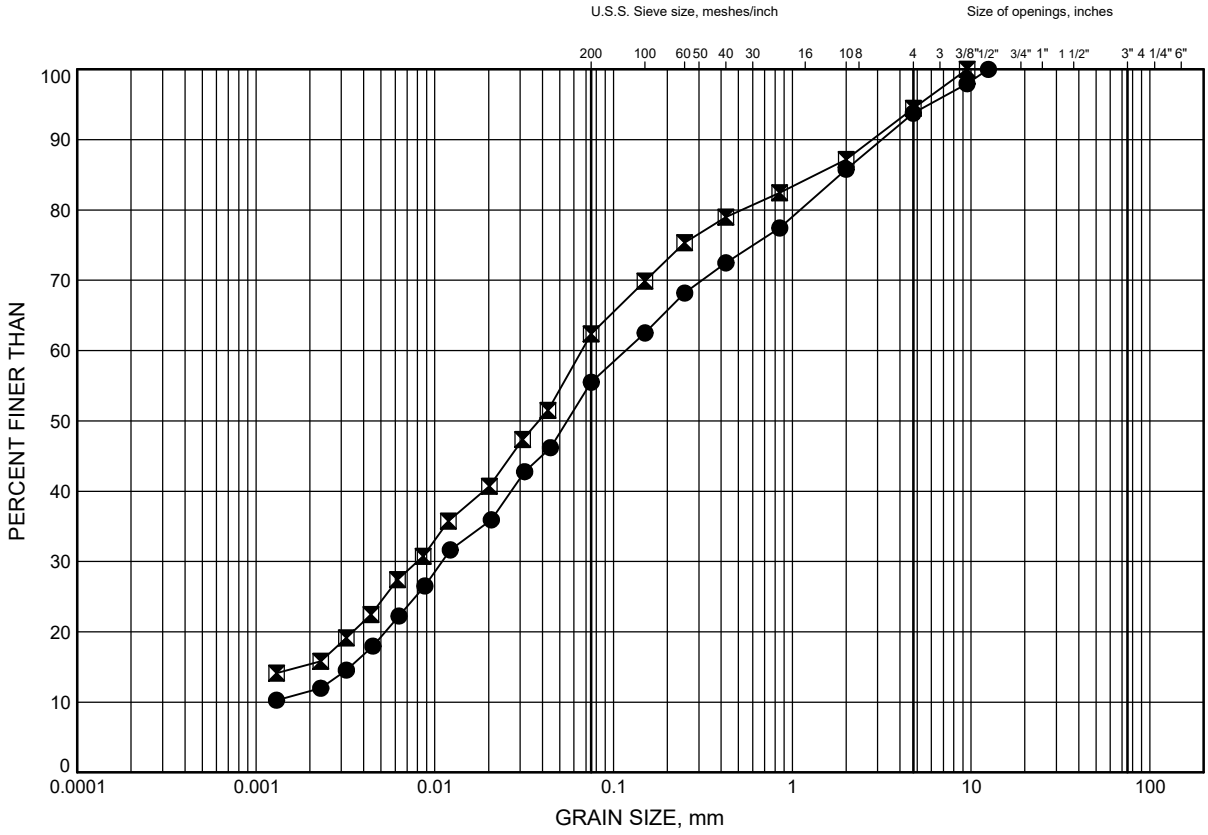
GRAIN SIZE DISTRIBUTION - THURBER TEL-25063.GPJ 3/6/20

South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

GRAIN SIZE DISTRIBUTION

FIGURE C3

Clayey SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-43B	4.88	204.14
⊠	19-43B	7.92	201.10

Date March 2020

Project 25063

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Chkd. KF

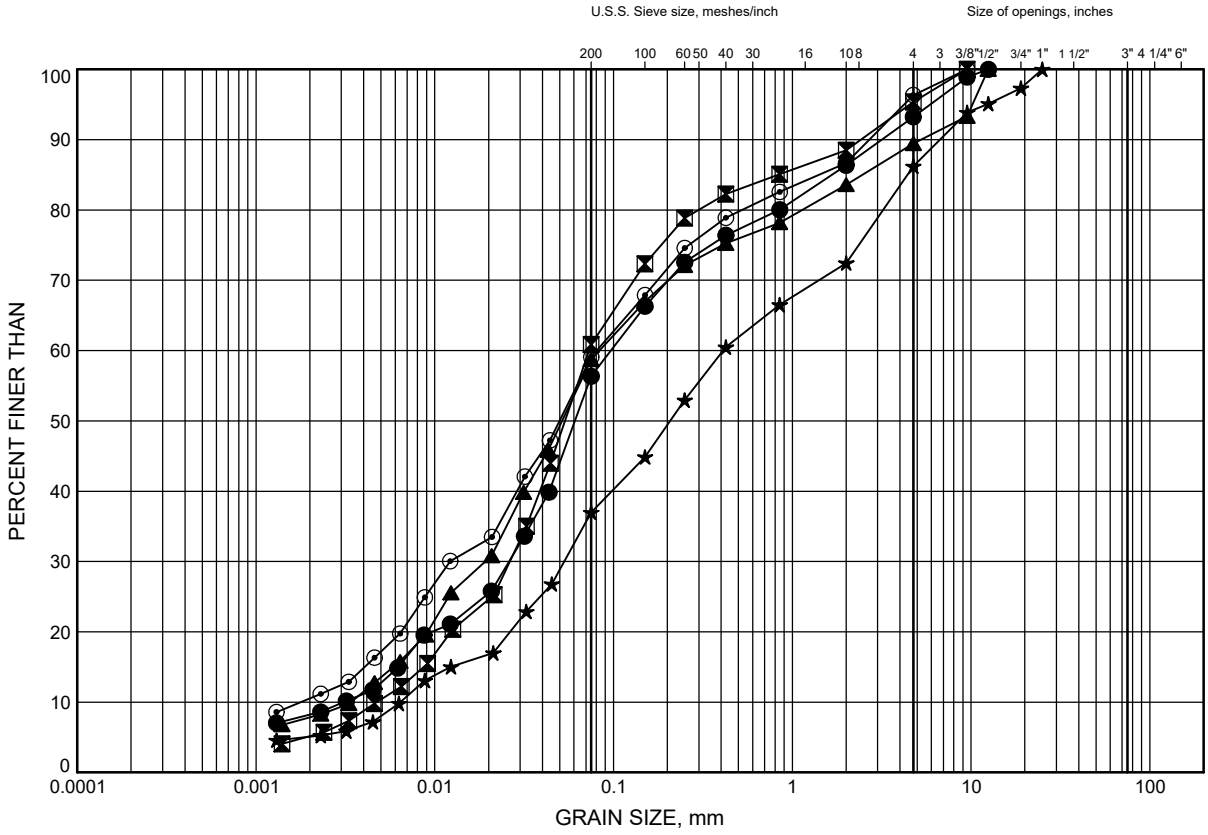
GRAIN SIZE DISTRIBUTION - THURBER TEL-25063.GPJ 3/6/20

South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

GRAIN SIZE DISTRIBUTION

FIGURE C4

SILT and SAND TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-41	16.31	190.31
⊠	19-42A	10.97	197.63
▲	19-42A	17.07	191.53
★	19-42B	12.50	195.48
⊙	19-43A	9.45	199.02

Date March 2020

Project 25063

THURBER

Prep'd SN

Chkd. KF

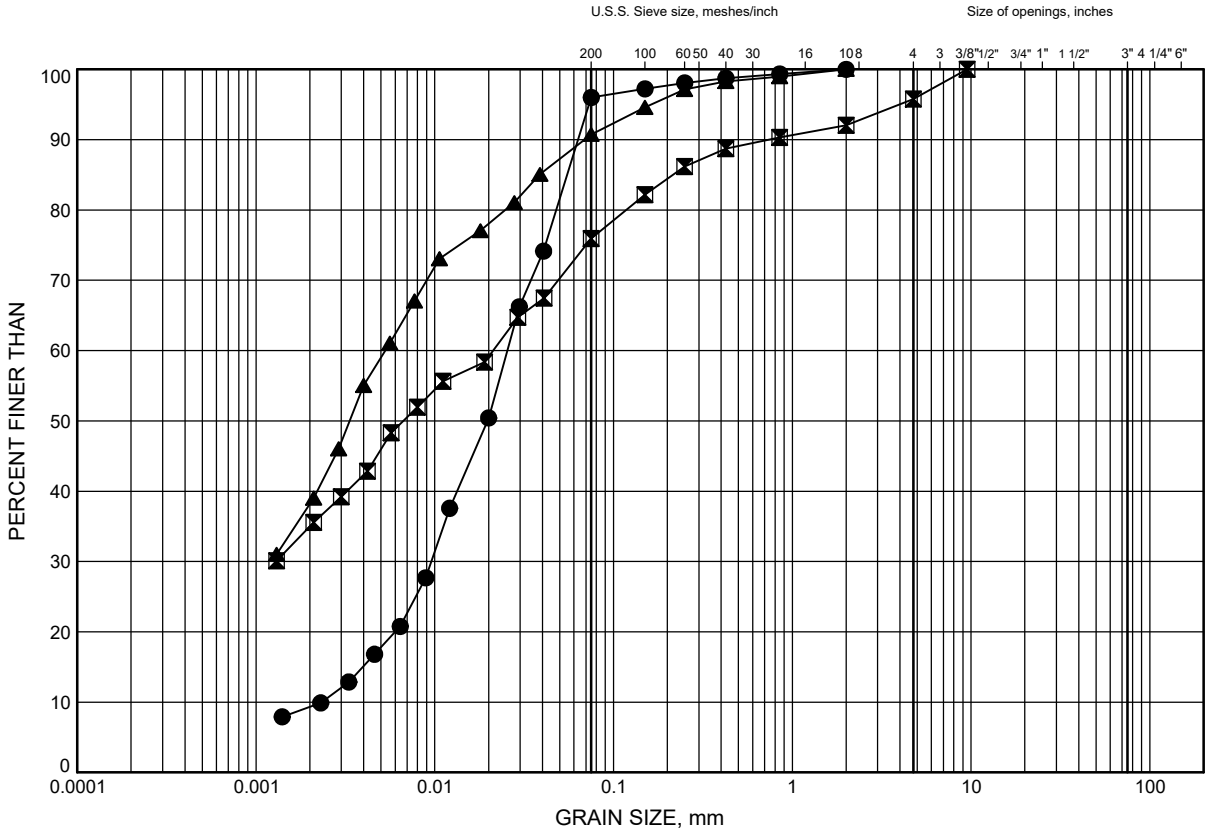
GRAIN SIZE DISTRIBUTION - THURBER TEL-25063.GPJ 3/6/20

South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

GRAIN SIZE DISTRIBUTION

FIGURE C5

Clayey SILT to Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-42A	14.02	194.58
⊠	19-43B	12.47	196.55
▲	19-44	9.42	200.68

Date March 2020

Project 25063

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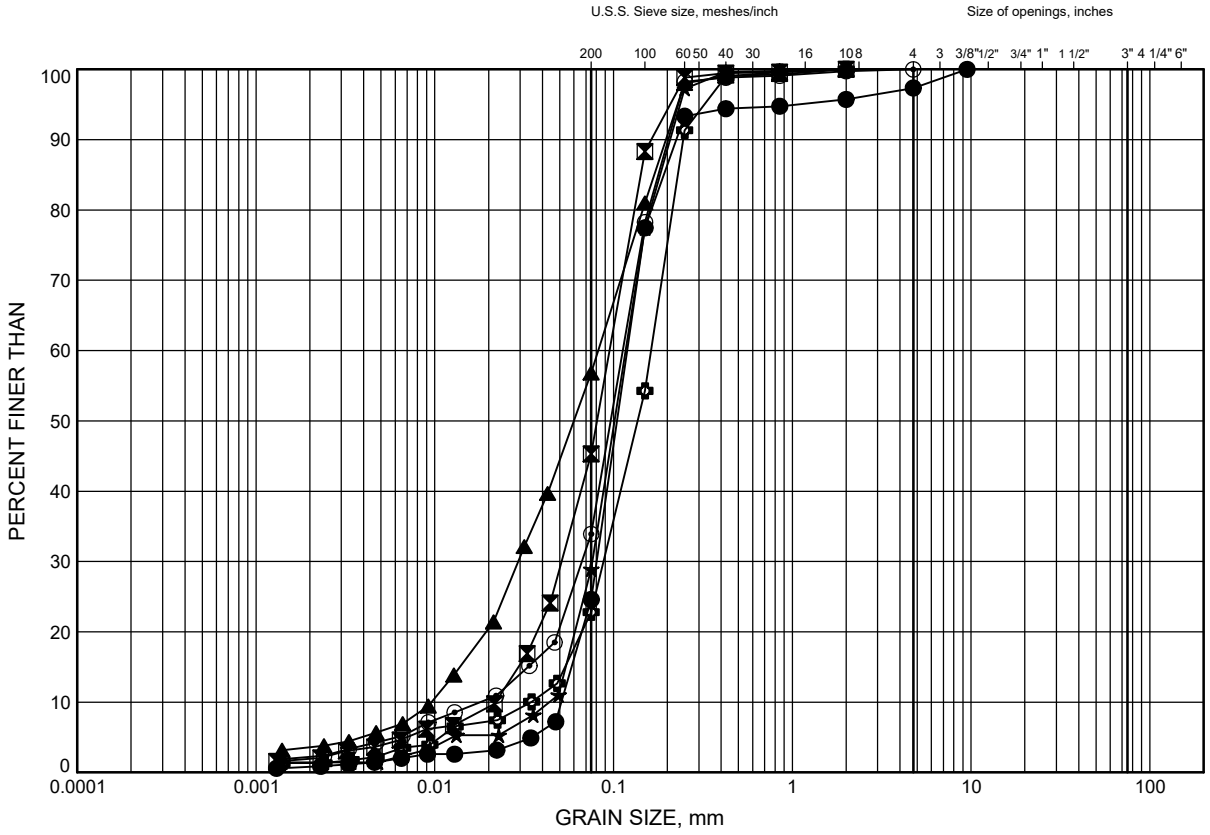
GRAIN SIZE DISTRIBUTION - THURBER TEL-25063.GPJ 3/6/20

South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

GRAIN SIZE DISTRIBUTION

FIGURE C6

SILT and SAND, Silty SAND, SAND, SAND and GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-41	15.54	191.07
⊠	19-42B	15.54	192.43
▲	19-43A	16.31	192.16
★	19-43B	14.78	194.24
⊙	19-43B	17.07	191.95
✿	19-43B	17.75	191.27

Date March 2020

Project 25063

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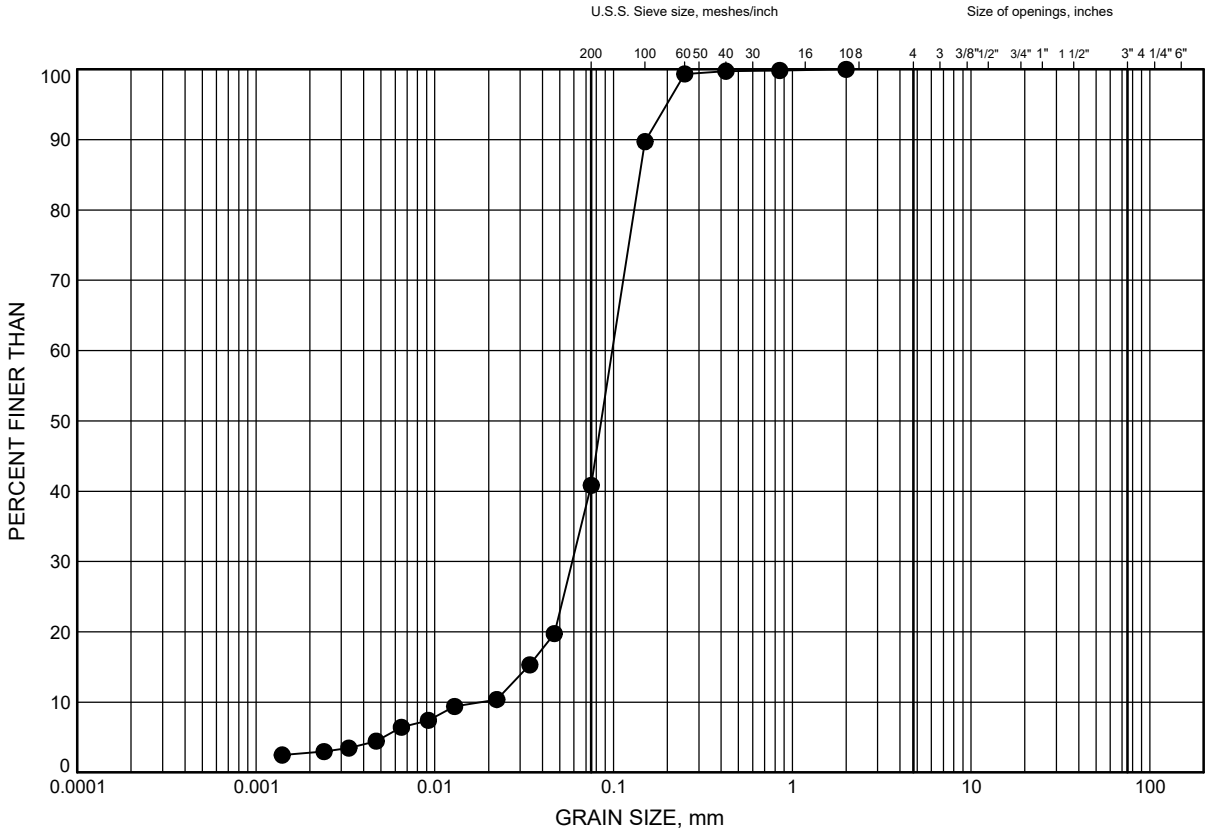
GRAIN SIZE DISTRIBUTION - THURBER TEL-25063.GPJ 3/6/20

South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

GRAIN SIZE DISTRIBUTION

FIGURE C7

SILT and SAND, Silty SAND, SAND, SAND and GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-44	16.31	193.80

Date March 2020

Project 25063

THURBER

Prep'd AN

Chkd. KF

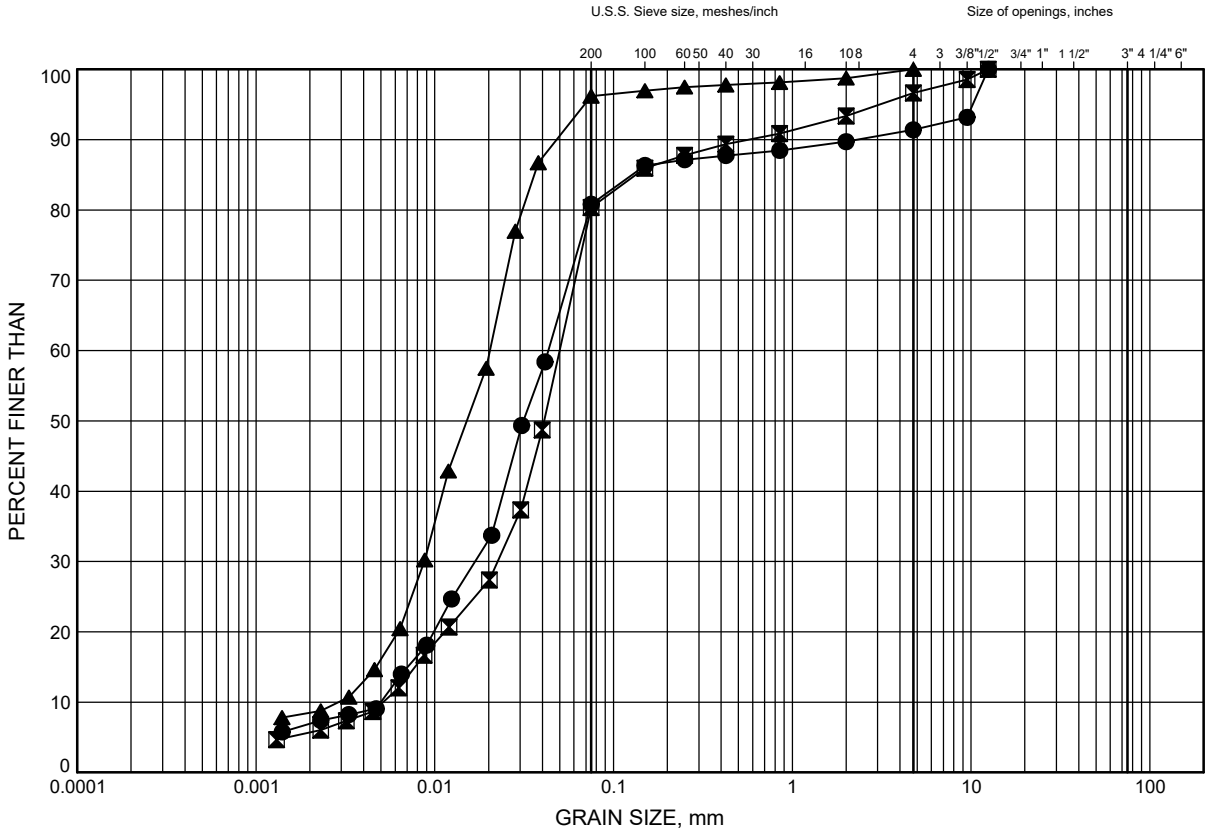
GRAIN SIZE DISTRIBUTION - THURBER TEL-25063.GPJ 3/6/20

South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

GRAIN SIZE DISTRIBUTION

FIGURE C8

SILT, Sandy SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-42A	15.54	193.06
⊠	19-42B	14.02	193.95
▲	19-43A	14.78	193.69

Date March 2020

Project 25063

THURBER

Prep'd AN

Chkd. KF

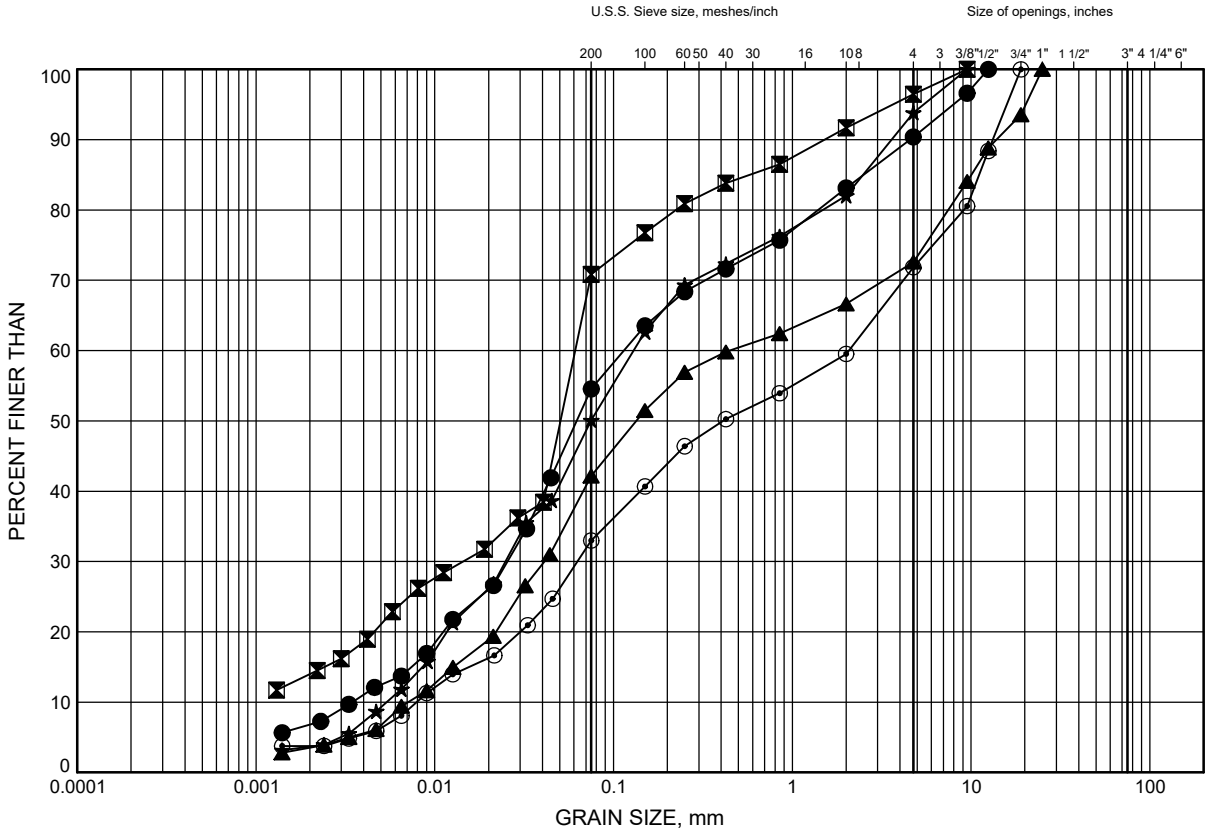
GRAIN SIZE DISTRIBUTION - THURBER TEL-25063.GPJ 3/6/20

South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

GRAIN SIZE DISTRIBUTION

FIGURE C9

TILL/SHALE COMPLEX



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-42A	18.59	190.01
⊠	19-42B	17.07	190.91
▲	19-43A	17.83	190.64
★	19-43B	18.35	190.67
⊙	19-44	18.59	191.51

Date March 2020

Project 25063

THURBER

Prep'd AN

Chkd. KF

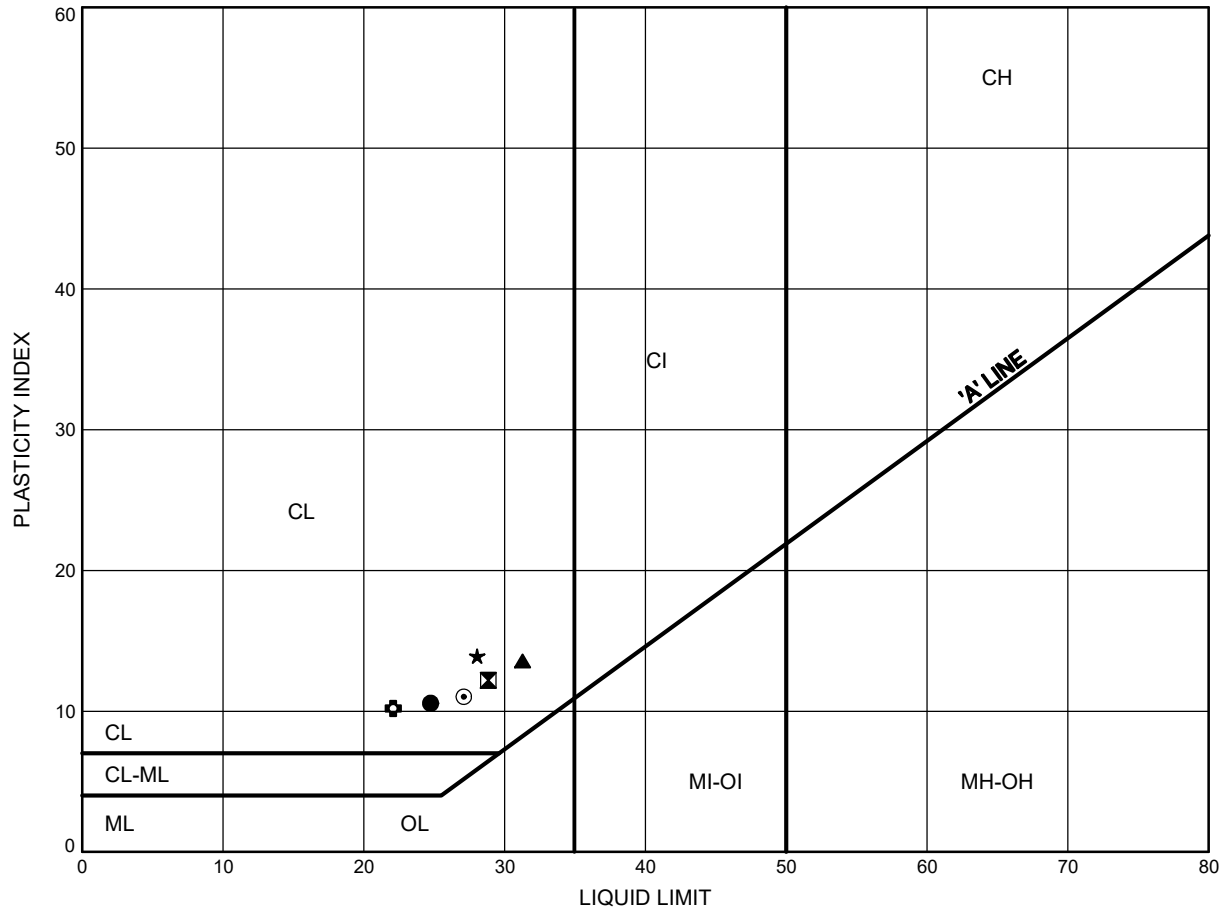
GRAIN SIZE DISTRIBUTION - THURBER TEL-25063.GPJ 3/6/20

South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

ATTERBERG LIMITS TEST RESULTS

FIGURE C10

Silty CLAY TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-41	3.35	203.27
⊠	19-42A	2.59	206.01
▲	19-42B	1.83	206.15
★	19-43A	1.83	206.64
⊙	19-43B	1.83	207.19
✿	19-44	4.11	205.99

Date March 2020

Project 25063

THURBER

Prep'd AN

Chkd. KF

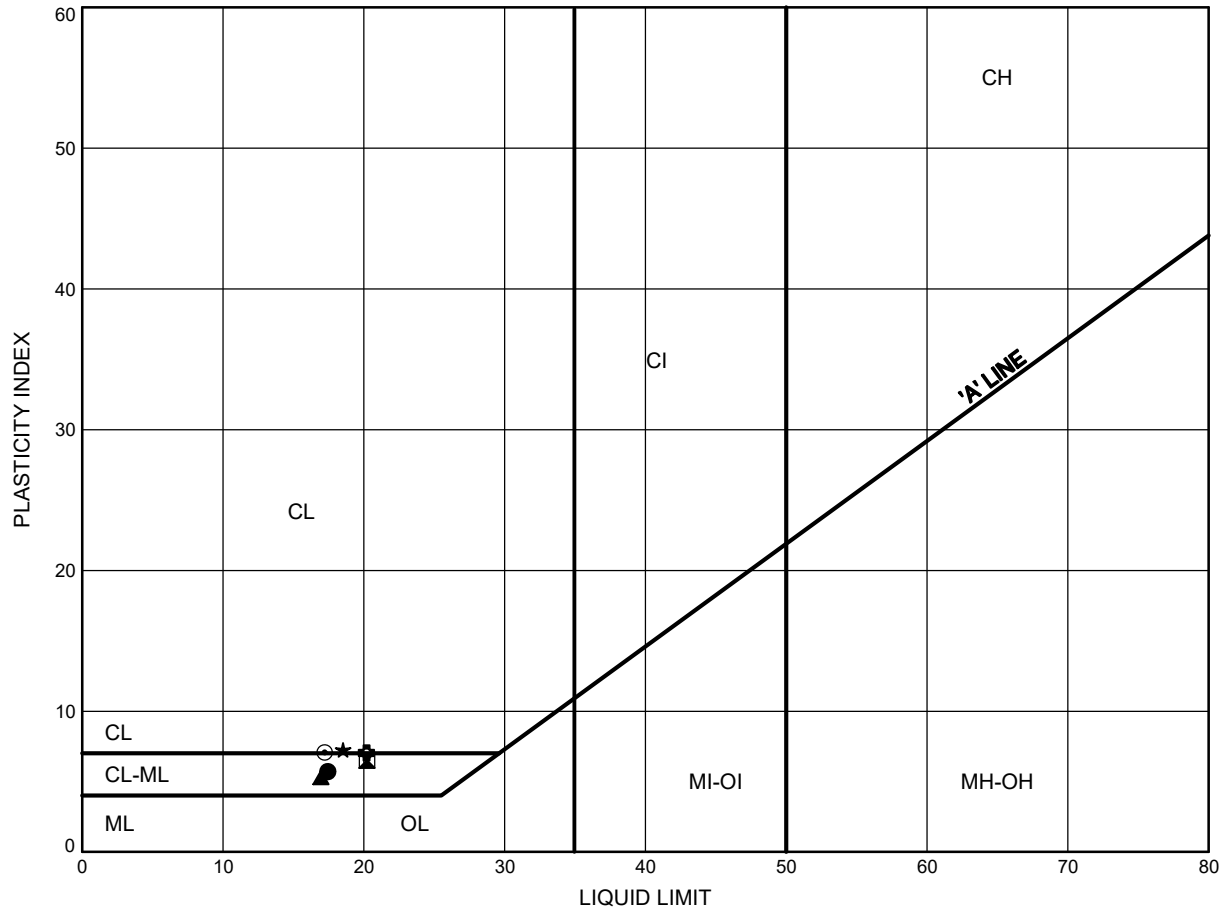
THURBALT TEL-25063.GPJ 3/6/20

South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

ATTERBERG LIMITS TEST RESULTS

FIGURE C11

Clayey SILT TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-41	9.41	197.21
⊠	19-42B	4.88	203.10
▲	19-42B	7.81	200.16
★	19-43A	4.88	203.59
⊙	19-43A	7.92	200.55
✿	19-43B	4.88	204.14

Date March 2020

Project 25063

THURBER

Prep'd AN

Chkd. KF

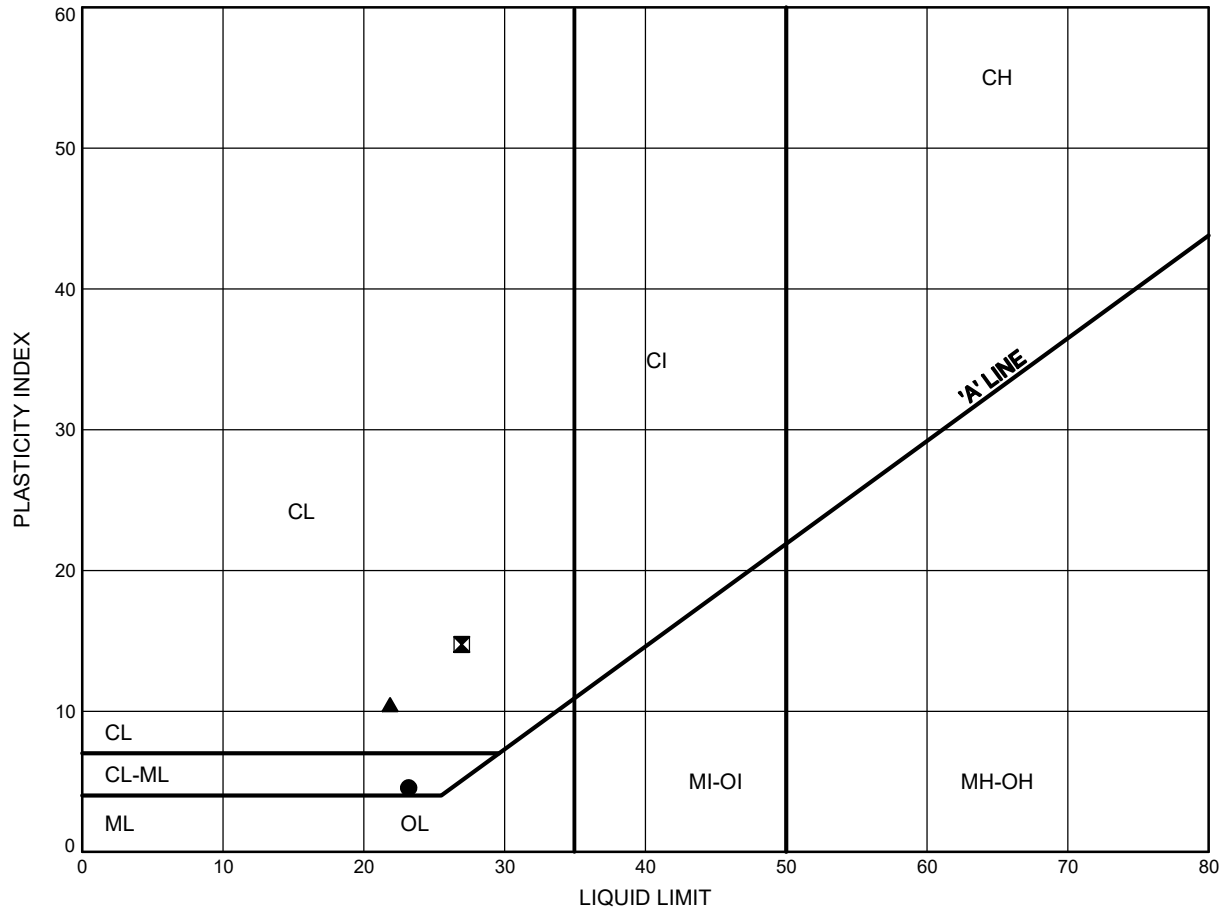
THURBALT TEL-25063.GPJ 3/6/20

South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

ATTERBERG LIMITS TEST RESULTS

FIGURE C12

Clayey SILT to Sily CLAY



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-42A	14.02	194.58
⊠	19-43B	12.47	196.55
▲	19-44	9.42	200.68

Date March 2020

Project 25063

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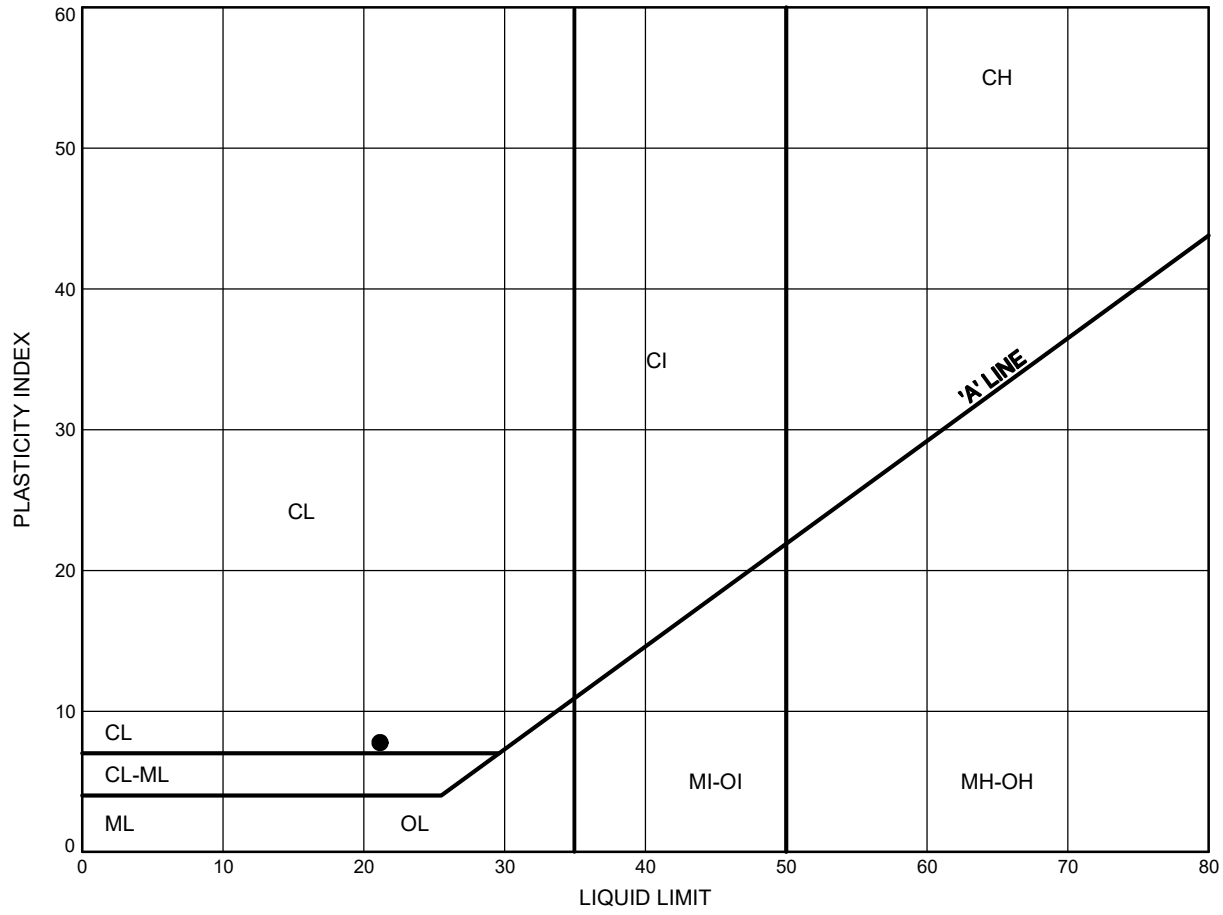
South Georgetown Wastewater Servicing Wastewater Main & Pumping Station

ATTERBERG LIMITS TEST RESULTS

FIGURE C13

TILL/SHALE COMPLEX



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-42B	16.98	190.99

Date March 2020

Project 25063

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Prep'd AN

Chkd. KF

THURBALT TEL-25063.GPJ 3/6/20

THURBER

Appendix D

Geotechnical Laboratory Rock Test Results

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET
ASTM D5731-16

Job No:	25063	**Date Drilled:**	02-Aug-19
Client:	Hatch	**Date Tested:**	04-Sep-19
Project Name:	South Georgetown WWS/PS	**Tester:**	SB+RG
Core Size:	HQ **BH No :** 19-41	**Reviewed by:**	KF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	18.7	Axial	9.0	63.0	63.5	2.0	47.4	Shale	Medium Strong
2	2	19.6	Diametral	9.0	63.1	44.2	2.4	57.4	Shale/Hard Layer	Strong
3	2	19.7	Axial	5.8	61.5	62.6	1.3	31.1	Shale	Medium Strong
4	3	21.6	Axial	6.2	63.2	63.3	1.4	32.5	Shale	Medium Strong
5	3	22.0	Diametral	8.8	63.1	44.1	2.3	55.9	Shale/Hard Layer	Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
* Diametral Test should have 0.7 x D on either side of test point.
* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET
ASTM D5731-16

Job No:	25063	**Date Drilled:**	31-Jul-19
Client:	Hatch	**Date Tested:**	03-Sep-19
Project Name:	South Georgetown WWS/PS	**Tester:**	JHP+SB
Core Size:	HQ **BH No :** 19-42B	**Reviewed by:**	KF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	19.7	Axial	3.5	63.2	57.2	0.8	19.9	Shale	Weak
2	2	19.9	Diametral	0.5	63.2	43.3	0.1	3.3	Shale	Very Weak
3	2	20.5	Axial	7.3	63.3	66.0	1.5	37.2	Shale	Medium Strong
4	2	21.3	Axial	3.2	63.2	63.3	0.7	16.6	Shale	Weak
5	3	21.5	Axial	5.9	63.2	63.2	1.3	31.2	Shale	Medium Strong
6	3	22.1	Diametral	2.3	63.4	43.6	0.6	14.7	Shale	Weak
7	3	22.8	Axial	6.2	63.7	63.7	1.3	31.9	Shale	Medium Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
* Diametral Test should have 0.7 x D on either side of test point.
* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET
ASTM D5731-16

Job No:	25063	**Date Drilled:**	18-Nov-19
Client:	Hatch	**Date Tested:**	03-Dec-19
Project Name:	South Georgetown WWS/PS	**Tester:**	HL
Core Size:	HQ **BH No :** 19-43A	**Reviewed by:**	KF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	18.8	Diametral	2.1	63.2	87.8	0.5	13.0	Shale	Weak
2	1	19.2	Axial	7.9	63.2	63.3	1.7	41.6	Shale	Medium Strong
3	2	20.1	Axial	7.0	63.1	63.2	1.5	36.6	Shale	Medium Strong
4	2	20.8	Axial	8.1	63.2	85.7	1.4	33.5	Shale	Medium Strong
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34 It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET
ASTM D5731-16

Job No:	25063	**Date Drilled:**	04-Sep-19
Client:	Hatch	**Date Tested:**	10-Sep-19
Project Name:	South Georgetown WWS/PS	**Tester:**	MP+JHP
Core Size:	HQ **BH No :** 19-43B	**Reviewed by:**	KF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	2	20.4	Axial	4.8	63.4	69.7	1.0	23.2	Shale	Weak
2	2	21.2	Axial	3.2	63.4	69.1	0.7	15.6	Shale	Weak
3	3	21.8	Axial	7.9	63.4	64.2	1.7	41.1	Shale	Medium Strong
4	3	22.2	Axial	5.1	63.8	44.7	1.5	35.0	Shale	Medium Strong
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34 It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing

* Diametral Test should have 0.7 x D on either side of test point.

* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET
ASTM D5731-16

Job No:	25063	**Date Drilled:**	04-Sep-19
Client:	Hatch	**Date Tested:**	10-Sep-19
Project Name:	South Georgetown WWS/PS	**Tester:**	MP+JHP
Core Size:	HQ **BH No :** 19-44	**Reviewed by:**	KF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	2	20.5	Axial	5.1	63.4	64.2	1.1	26.2	Shale	Medium Strong
2	2	21.1	Axial	1.9	63.8	44.7	0.5	12.7	Shale	Weak
3	3	21.7	Axial	6.3	62.8	63.4	1.4	33.0	Shale	Medium Strong
4	3	22.1	Axial	6.0	63.4	69.7	1.2	29.3	Shale	Medium Strong
5	3	23.0	Diametral	11.3	63.4	69.1	3.0	71.2	Shale/Hard Layer	Strong
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* It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
  Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
* Diametral Test should have 0.7 x D on either side of test point.
* Correlation factor to obtain UCS values is 24.

Last Modified: September 14, 2016

THURBER ENGINEERING LTD.
GEOTECHNICAL ▪ ENVIRONMENTAL ▪ MATERIALS

UNCONFINED COMPRESSION TEST REPORT

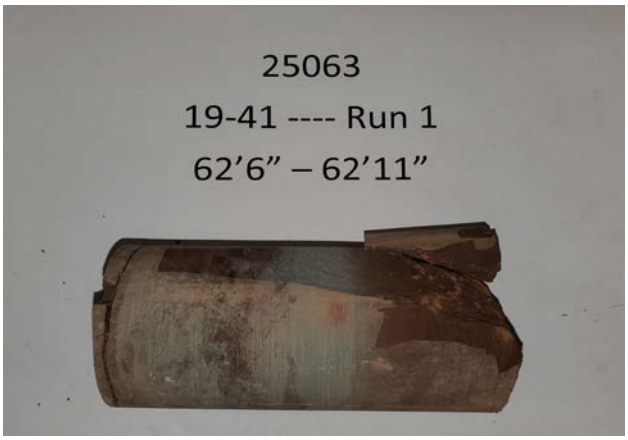
ASTM D7012-14

CLIENT:	Hatch Ltd.	FILE NUMBER:	25063
PROJECT NAME:	South Georgetown Servicing Wastewater-Main and Pumping Station	REPORT DATE:	9-Oct-19
BOREHOLE No.:	19-41	TEST DATE:	3-Oct-19
SAMPLE No.:	HQ RUN 1		
SAMPLE DEPTH:	19.05 -19.18 m		
DESCRIPTION:	Shale		

Avg. Height (cm):	13.3	Weight (g):	1065.0
Avg. Diameter (cm):	6.3	Wet Density (kg/m^3):	2,570
H. to Dia. Ratio**:	2.1:1	Dry Density (kg/m^3):	2,493
Cross Sectional Area (cm^2):	31.22	Moisture Content* (%):	3.1
Sample Volume (cm^3):	414.44		

ORIGINAL SPECIMEN

FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.1%	/ min
MAXIMUM COMPRESSIVE LOAD:	26.8	kN
UNCONFINED COMPRESSIVE STRENGTH:	8.6	MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen conform to ASTM D7012-14.

TEST DONE BY: EA
REVIEWED BY: WM

THURBER ENGINEERING LTD.
GEOTECHNICAL ▪ ENVIRONMENTAL ▪ MATERIALS

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Hatch Ltd.	FILE NUMBER:	25063
PROJECT NAME:	South Georgetown Servicing Wastewater-Main and Pumping Station	REPORT DATE:	9-Oct-19
BOREHOLE No.:	19-42B	TEST DATE:	3-Oct-19
SAMPLE No.:	HQ RUN 1		
SAMPLE DEPTH:	19.23 - 19.38 m		
DESCRIPTION:	Shale		

Avg. Height (cm):	15.1	Weight (g):	1232.6
Avg. Diameter (cm):	6.3	Wet Density (kg/m^3):	2,590
H. to Dia. Ratio**:	2.4:1	Dry Density (kg/m^3):	2,497
Cross Sectional Area (cm^2):	31.42	Moisture Content* (%):	3.7
Sample Volume (cm^3):	475.86		

ORIGINAL SPECIMEN

FRACTURED SPECIMEN

AVG. RATE OF STRAIN TO FAILURE:	1.0%	/ min
MAXIMUM COMPRESSIVE LOAD:	29.6	kN
UNCONFINED COMPRESSIVE STRENGTH:	9.4	MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen conform to ASTM D7012-14.

TEST DONE BY: EA
REVIEWED BY: WM

THURBER ENGINEERING LTD.
GEOTECHNICAL ▪ ENVIRONMENTAL ▪ MATERIALS

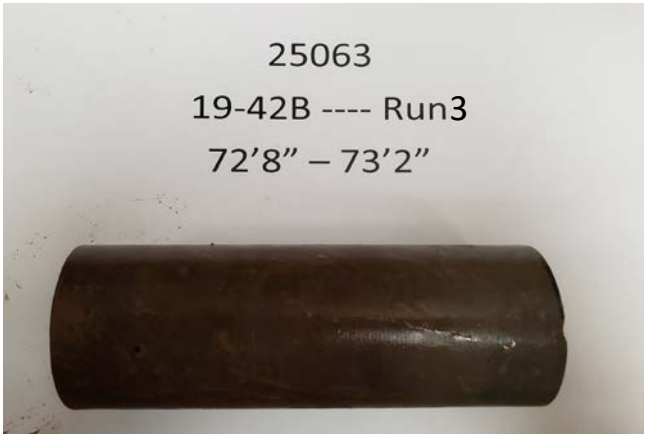
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Hatch Ltd.	FILE NUMBER:	25063
PROJECT NAME:	South Georgetown Servicing Wastewater-Main and Pumping Station	REPORT DATE:	9-Oct-19
BOREHOLE No.:	19-42B	TEST DATE:	3-Oct-19
SAMPLE No.:	HQ RUN 3		
SAMPLE DEPTH:	22.15-22.30 m		
DESCRIPTION:	Shale		

Avg. Height (cm):	15.3	Weight (g):	1249.2
Avg. Diameter (cm):	6.3	Wet Density (kg/m^3):	2,589
H. to Dia. Ratio**:	2.4:1	Dry Density (kg/m^3):	2,487
Cross Sectional Area (cm^2):	31.62	Moisture Content* (%):	4.1
Sample Volume (cm^3):	482.57		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN

AVG. RATE OF STRAIN TO FAILURE:	1.0%	/ min
MAXIMUM COMPRESSIVE LOAD:	52.8	kN
UNCONFINED COMPRESSIVE STRENGTH:	16.7	MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen conform to ASTM D7012-14.

TEST DONE BY: EA
REVIEWED BY: WM

THURBER ENGINEERING LTD.
GEOTECHNICAL ▪ ENVIRONMENTAL ▪ MATERIALS

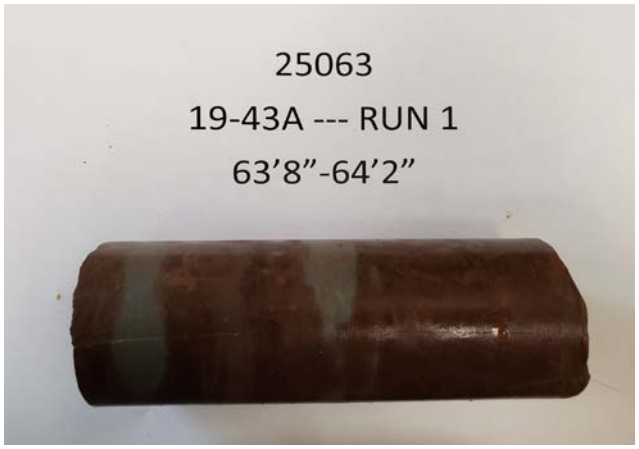
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

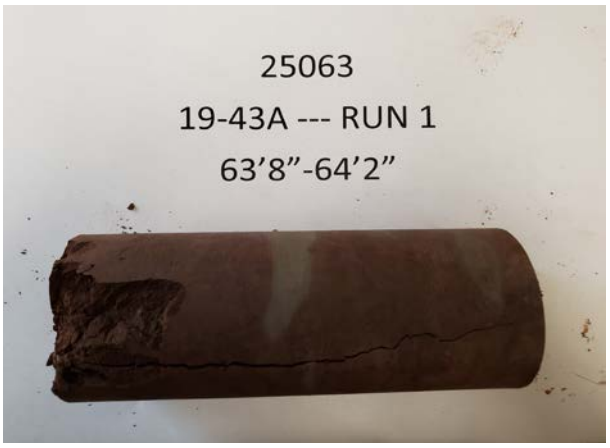
CLIENT:	Hatch Ltd.	FILE NUMBER:	25063
PROJECT NAME:	South Georgetown Servicing Wastewater-Main and Pumping Station	REPORT DATE:	3-Dec-19
BOREHOLE No.:	19-43A	TEST DATE:	9-Dec-19
SAMPLE No.:	HQ RUN 1		
SAMPLE DEPTH:	19.41-19.56 m		
DESCRIPTION:	Shale		

Avg. Height (cm):	15.4	Weight (g):	1316.4
Avg. Diameter (cm):	6.3	Wet Density (kg/m^3):	2,714
H. to Dia. Ratio**:	2.4:1	Dry Density (kg/m^3):	2,589
Cross Sectional Area (cm^2):	31.47	Moisture Content* (%):	4.8
Sample Volume (cm^3):	484.95		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.0%	/ min
MAXIMUM COMPRESSIVE LOAD:	22.7	kN
UNCONFINED COMPRESSIVE STRENGTH:	7.2	MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen conform to ASTM D7012-14.

TEST DONE BY: EA
REVIEWED BY: WM

THURBER ENGINEERING LTD.
GEOTECHNICAL ▪ ENVIRONMENTAL ▪ MATERIALS

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Hatch Ltd.	FILE NUMBER:	25063
PROJECT NAME:	South Georgetown Servicing Wastewater-Main and Pumping Station	REPORT DATE:	9-Oct-19
BOREHOLE No.:	19-43B	TEST DATE:	3-Oct-19
SAMPLE No.:	HQ RUN 2		
SAMPLE DEPTH:	20.04 - 20.19 m		
DESCRIPTION:	Shale		

Avg. Height (cm):	15.2	Weight (g):	1235.6
Avg. Diameter (cm):	6.3	Wet Density (kg/m^3):	2,585
H. to Dia. Ratio**:	2.4:1	Dry Density (kg/m^3):	2,468
Cross Sectional Area (cm^2):	31.43	Moisture Content* (%):	4.7
Sample Volume (cm^3):	478.02		

ORIGINAL SPECIMEN

FRACTURED SPECIMEN

AVG. RATE OF STRAIN TO FAILURE:	1.0% / min
MAXIMUM COMPRESSIVE LOAD:	7.3 kN
UNCONFINED COMPRESSIVE STRENGTH:	2.3 MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen conform to ASTM D7012-14.

TEST DONE BY: EA
REVIEWED BY: WM

THURBER ENGINEERING LTD.
GEOTECHNICAL ▪ ENVIRONMENTAL ▪ MATERIALS

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Hatch Ltd.	FILE NUMBER:	25063
PROJECT NAME:	South Georgetown Servicing Wastewater-Main and Pumping Station	REPORT DATE:	9-Oct-19
BOREHOLE No.:	19-44	TEST DATE:	3-Oct-19
SAMPLE No.:	HQ RUN 1		
SAMPLE DEPTH:	19.38 -19.51 m		
DESCRIPTION:	Shale		

Avg. Height (cm):	13.0	Weight (g):	1057.1
Avg. Diameter (cm):	6.3	Wet Density (kg/m^3):	2,595
H. to Dia. Ratio**:	2:1	Dry Density (kg/m^3):	2,496
Cross Sectional Area (cm^2):	31.44	Moisture Content* (%):	4.0
Sample Volume (cm^3):	407.40		

ORIGINAL SPECIMEN

FRACTURED SPECIMEN

AVG. RATE OF STRAIN TO FAILURE:	1.2%	/ min
MAXIMUM COMPRESSIVE LOAD:	45.5	kN
UNCONFINED COMPRESSIVE STRENGTH:	14.5	MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen conform to ASTM D7012-14.

TEST DONE BY: EA
REVIEWED BY: WM

THURBER

Appendix E

Bedrock Core Photographs

South Georgetown Wastewater
Servicing Wastewater Main and Pumping Station
Photographs of Rock Core

Borehole 19-41 – Runs 1 and 2 – 18.29-20.88 m

Borehole 19-41 – Run 3 – 20.88-22.40 m

South Georgetown Wastewater
Servicing Wastewater Main and Pumping Station
Photographs of Rock Core

Borehole 19-42B – Runs 1 and 2 – 19.05-21.58 m

Borehole 19-42B – Run 3 – 21.58-23.11 m

South Georgetown Wastewater
Servicing Wastewater Main and Pumping Station
Photographs of Rock Core

Borehole 19-43A – Runs 1 and 2 – 18.29-21.34 m

South Georgetown Wastewater
Servicing Wastewater Main and Pumping Station
Photographs of Rock Core

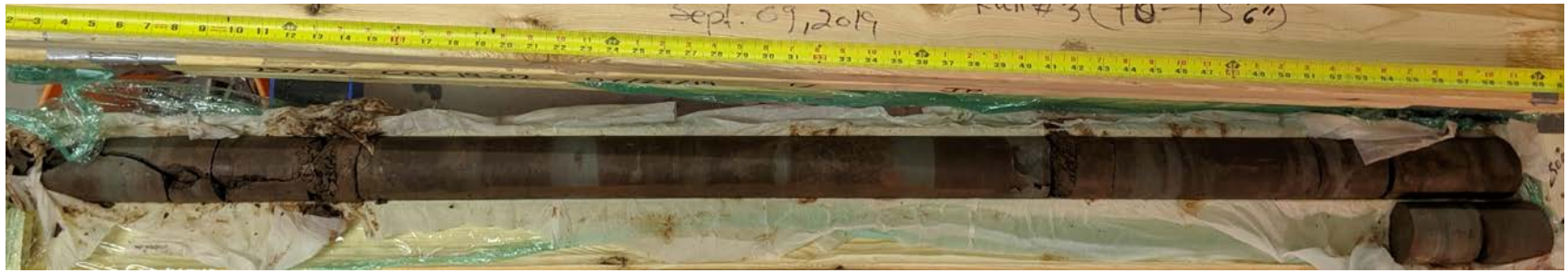
Borehole 19-43B – Runs 1 and 2 – 19.05-21.34 m

Borehole 19-43B – Run 3 – 21.34-22.86 m

South Georgetown Wastewater
Servicing Wastewater Main and Pumping Station
Photographs of Rock Core

Borehole 19-44 – Runs 1 and 2 – 19.05-21.34 m

Borehole 19-44 – Run 3 – 21.34-23.01 m



THURBER

Appendix F

Single Well Response Tests Results

THURBER ENGINEERING LTD.

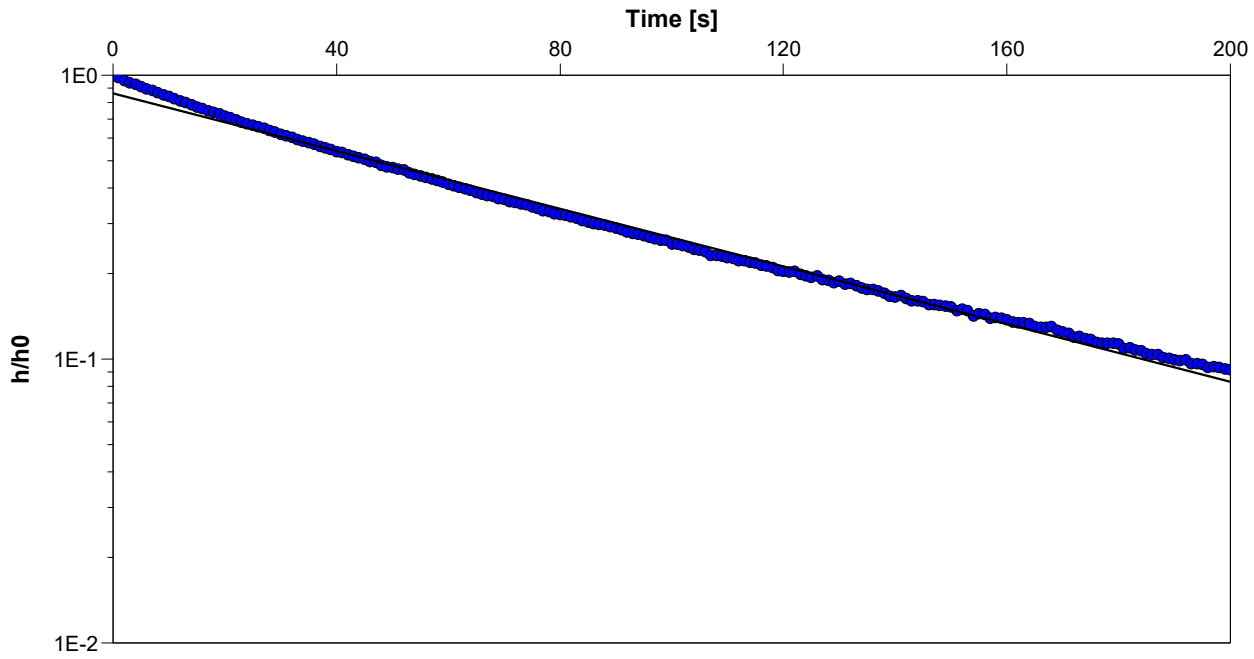
Slug Test Analysis Report

Project: Halton S Georgetown WW Main & Pump Stn

Number: 25063

Client: Hatch / Halton Region

Location: Halton	Slug Test: 19-41	Test Well: 19-41
Test Conducted by: JZ		Test Date: 2019-10-25
Analysis Performed by: JZ	Checked by: DH	Analysis Date: 2019-11-06
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
19-41	5.8×10^{-6}	

Artesian

THURBER ENGINEERING LTD.

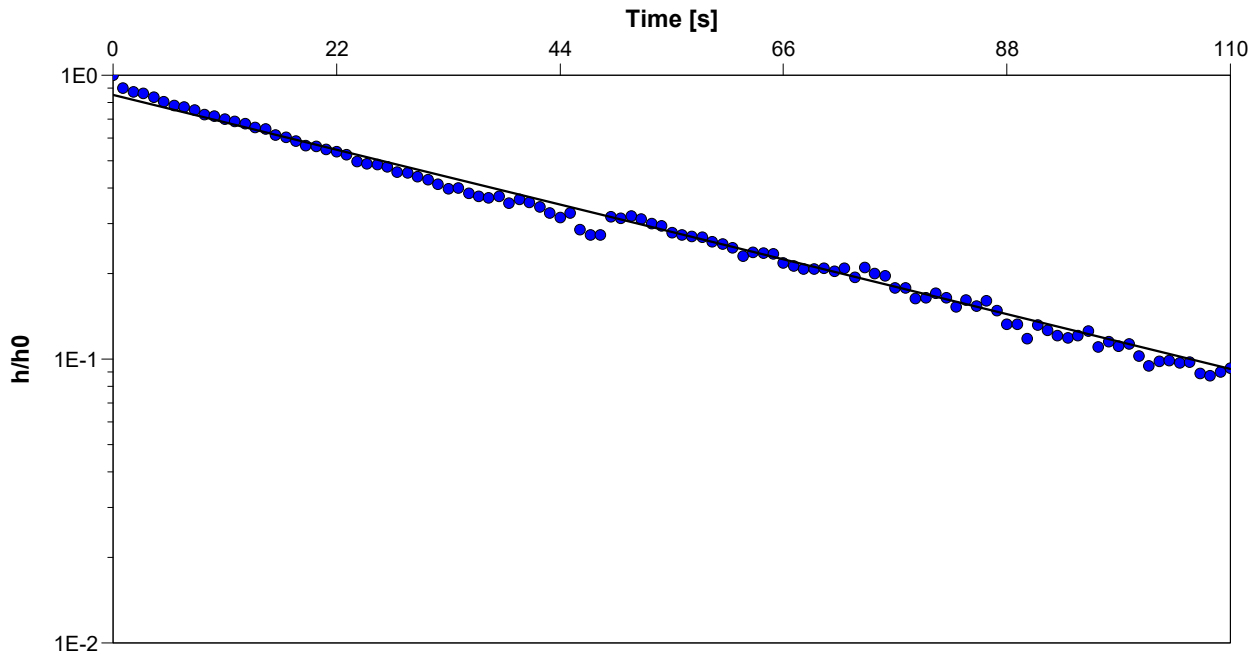
Slug Test Analysis Report

Project: Halton S Georgetown WW Main & Pump Stn

Number: 25063

Client: Hatch / Halton Region

Location: Halton	Slug Test: 19-42B	Test Well: 19-42B
Test Conducted by: JZ		Test Date: 2019-10-25
Analysis Performed by: JZ	Checked by: DH	Analysis Date: 2019-11-06
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
19-42B	1.0×10^{-5}	

Artesian

THURBER ENGINEERING LTD.

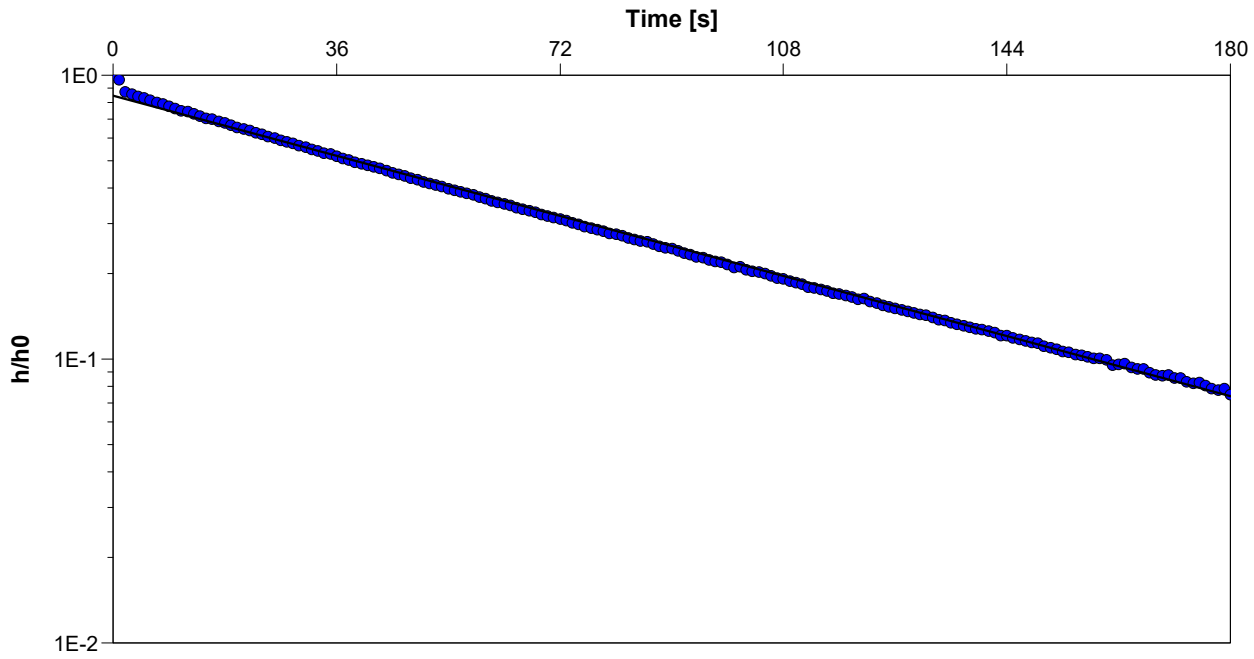
Slug Test Analysis Report

Project: Halton S Georgetown WW Main & Pump Stn

Number: 25063

Client: Hatch / Halton Region

Location: Halton	Slug Test: 19-43B	Test Well: 19-43B
Test Conducted by: JZ		Test Date: 2019-11-04
Analysis Performed by: JZ	Checked by: DH	Analysis Date: 2019-11-06
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
19-43B	6.7×10^{-6}	

THURBER ENGINEERING LTD.

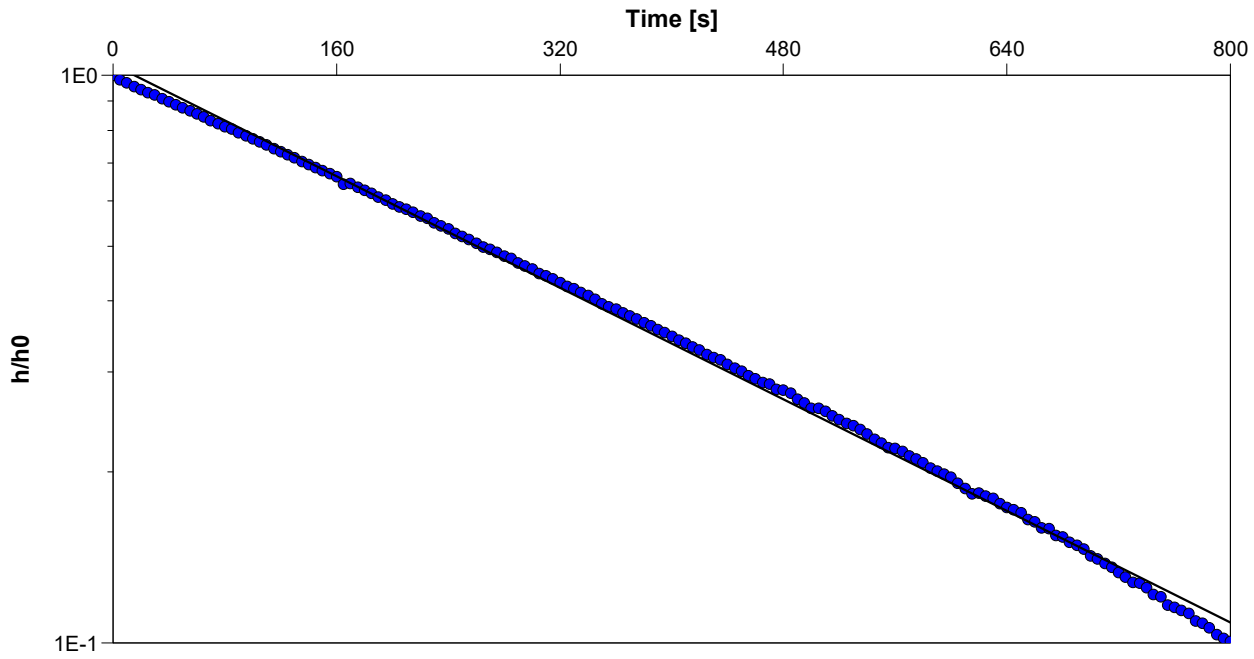
Slug Test Analysis Report

Project: Halton S Georgetown WW Main & Pump Stn

Number: 25063

Client: Hatch / Halton Region

Location: Halton	Slug Test: 19-44	Test Well: 19-44
Test Conducted by: JZ		Test Date: 2019-11-04
Analysis Performed by: JZ	Checked by: DH	Analysis Date: 2019-11-06
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
19-44	1.4×10^{-6}	

THURBER

Appendix G

Groundwater Environmental Quality

THURBER

Table G1 - Summary of Analytical Groundwater Testing Results

Well ID	Screened Material	CoA	Halton Sanitary & Combined Sewer				PWQO Table 2 Limits				O.Reg. Table 1 Coarse				O.Reg. Table 2 Coarse			
			Exceeding Parameter	Units	Value	Limit	Exceeding Parameter	Units	Value	Limit	Exceeding Parameter	Units	Value	Standard	Exceeding Parameter	Units	Value	Standard
19-41	Silty Sand	14786	No Exceedances				Aluminum (total)	µg/L	240	75	No Exceedances				No Exceedances			
							Aluminum (dissolved)	µg/L	175	75								
							Boron (total)	µg/L	207	200								
							Iron (total)	µg/L	1350	300								
							Phosphorus (total)	µg/L	31	10								
							4AAP-Phenolics	mg/L	0.003	0.001								
		14647					Aluminum (total)	µg/L	1320	75								
							Iron (total)	µg/L	2320	300								
							Phosphorus (total)	µg/L	62	10								
19-42 B	Silty Sand & Clayey Silt Till	14786	No Exceedances				Aluminum (total)	µg/L	484	75	No Exceedances				No Exceedances			
							Aluminum (dissolved)	µg/L	188	75								
							Iron (total)	µg/L	1390	300								
							Phosphorus (total)	µg/L	67	10								
19-43B	Silty Sand & Silt and Sand Till	15941	No Exceedances				Iron (total)	µg/L	1200	300	No Exceedances				No Exceedances			
		14731					Aluminum (total)	µg/L	136	75								
19-44	Shale	15941	No Exceedances				Aluminum (total)	µg/L	245	75	No Exceedances				No Exceedances			
							Arsenic (total)	µg/L	6	5								
							Iron (total)	µg/L	441	300								
							Phosphorus (total)	µg/L	13	10								
							4AAP-Phenolics	mg/L	0.002	0.001								
		14731					Aluminum (total)	µg/L	104	75								
							Arsenic (total)	µg/L	5.1	5								
							Boron (total)	µg/L	1350	200								

General Notes:

Certificate of Analysis supersedes results presented here in case of any discrepancy.
Only parameters presented in Certificate of Analyses were analyzed. Criteria not assessed where noted.
Some parameter limits in the PWQO depend on the result of other parameters (e.g. Aluminum limits are dependent on pH values). An effort to adjust for these dependencies was made herein.
4AAP-Phenolics - PWQOs indicates value of 0.001 mg/L to be used as a screening tool and that isomer specific PWQOs should be employed where possible; however specific phenol assessment not included in scope of work.

FINAL REPORT

CA14786-NOV19 R1

25063

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS

Client	Thurber Engineering Ltd.
Address	103 2010 Winston Park Drive, Oakville Canada, L6H 5R7 Phone: 289-455-7296. Fax:
Contact	Karel Furbacher
Telephone	289-455-7296
Facsimile	
Email	kfurbacher@thurber.ca
Project	25063
Order Number	
Samples	Ground Water (5)

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	CA14786-NOV19
Received	11/20/2019
Approved	12/10/2019
Report Number	CA14786-NOV19 R1
Date Reported	12/31/2019

COMMENTS

RL - SGS Reporting Limit

Temperature of Sample upon Receipt: 3 degrees C
Cooling Agent Present:Yes
Custody Seal Present:No

Chain of Custody Number:N/A

PWQO - Provincial Water Quality Objectives
Limits based on MOE PIBS 3303E publication July 1994 reprinted February 1999
a PWQO limit based on pH >6.5-9.0 (at pH 4.5-5.5 PWQO = 15ug/L, pH >5.5-6.5 PWQO 10% above background levels in geological area.
b PWQO limit based on Hardness <75 mg/L (For Hardness >75 mg/L PWQO = 1100 ug/L)
c PWQO limit based on Hardness 0-100 mg/L(For Hardness >100 mg/L PWQO = 0.5 ug/L)
d PWQO limit based on Cr VI (PWQO limit for Cr III = 8.9 ug/L)
e PWQO limit based on Hardness 0-20 (For Hardness >20 mg/L PWQO = 5 ug/L)
f PWQO limit based on Hardness <30 (For Hardness 30-80 PWQO = 3 ug/L, & >80 PWQO=5)

SIGNATORIES

Brad Moore Hon. B.Sc

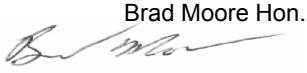


TABLE OF CONTENTS

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **BTEX** (WATER)

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

L2 = SANSEW / WATER / - - Halton Sewer Discharge By Law - Sanitary and Combined Sewer Discharge - BL_2_03

	Sample Number				9	12
	Sample Name				19-41	19-42B
	Sample Matrix				Ground Water	Ground Water
	Sample Date				19/11/2019	19/11/2019
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
BTEX						
Benzene	ug/L	0.5	100	10	< 0.5	< 0.5
Ethylbenzene	ug/L	0.5	8	160	< 0.5	< 0.5
Toluene	ug/L	0.5	0.8	16	< 0.5	< 0.5
Xylene (total)	ug/L	0.5			< 0.5	< 0.5
m/p-xylene	ug/L	0.5	2		< 0.5	< 0.5
o-xylene	ug/L	0.5	40		< 0.5	< 0.5
General Chemistry						
Conductivity	uS/cm	2			639	529
Alkalinity	mg/L as CaCO3	2			298	264
Carbonate	mg/L as CaCO3	2			< 2	< 2
Bicarbonate	mg/L as CaCO3	2			298	264
Biochemical Oxygen Demand (BOD5)	mg/L	2		300	< 4↑	< 4↑
Total Suspended Solids	mg/L	2		350	25	35
Total Kjeldahl Nitrogen	as N mg/L	0.5		100	0.6	0.7

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **Metals and Inorganics** (WATER)

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

L2 = SANSEW / WATER / - - Halton Sewer Discharge By Law - Sanitary and Combined Sewer Discharge - BL_2_03

Sample Number					9	12
Sample Name					19-41	19-42B
Sample Matrix					Ground Water	Ground Water
Sample Date					19/11/2019	19/11/2019
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
Metals and Inorganics						
Cyanide (total)	mg/L	0.01		2	< 0.01	< 0.01
Fluoride	mg/L	0.06		10	0.34	0.21
Bromide	mg/L	0.3			< 0.3	< 0.3
Sulphate	mg/L	0.2		1500	34	23
Hardness	mg/L as CaCO3	0.05			295	305
Aluminum (total)	µg/L	0.1	15	50000	240	484
Aluminum (0.2µm)	µg/L	0.1	15		175	188
Antimony (total)	µg/L	0.09	20	5000	< 0.09	< 0.09
Arsenic (total)	µg/L	0.2	5	1000	0.8	0.4
Boron (total)	µg/L	2	200		207	116
Barium (total)	µg/L	0.02			121	174
Beryllium (total)	µg/L	0.007	11	5000	0.016	0.023
Cadmium (total)	µg/L	0.003	0.1	1000	0.005	0.011
Chromium (total)	µg/L	0.08		3000	0.69	2.22
Cobalt (total)	µg/L	0.004	0.9	5000	0.184	0.377
Copper (total)	µg/L	0.2	1	3000	1.0	2.0
Iron (total)	µg/L	7	300	50000	1350	1390
Lead (total)	µg/L	0.01	1	3000	0.25	0.61
Manganese (total)	µg/L	0.01		5000	55.4	62.4
Molybdenum (total)	µg/L	0.04	40	5000	13.0	2.48
Nickel (total)	µg/L	0.1	25	3000	0.5	1.6
Phosphorus (total)	µg/L	3	10	10000	31	67

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **Metals and Inorganics** (WATER)

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

L2 = SANSEW / WATER / - - Halton Sewer Discharge By Law - Sanitary and Combined Sewer Discharge - BL_2_03

					Sample Number	9	12
					Sample Name	19-41	19-42B
					Sample Matrix	Ground Water	Ground Water
					Sample Date	19/11/2019	19/11/2019
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
Metals and Inorganics (continued)						
Selenium (total)	µg/L	0.04	100	5000	< 0.04	< 0.04
Silver (total)	µg/L	0.05	0.1	5000	< 0.05	< 0.05
Tin (total)	µg/L	0.06		5000	0.19	0.37
Titanium (total)	µg/L	0.05		5000	6.16	14.5
Uranium (total)	µg/L	0.002	5		0.208	0.077
Vanadium (total)	µg/L	0.01	6		0.29	0.86
Zinc (total)	µg/L	2	20	3000	3	11
Oil and Grease						
Oil & Grease (total)	mg/L	2			< 2	< 2
Oil & Grease (animal/vegetable)	mg/L	4		150	< 4	< 4
Oil & Grease (mineral/synthetic)	mg/L	4		15	< 4	< 4
Other (ORP)						
pH	no unit	0.05	8.5	10	8.22	8.20
Free Cyanide	µg/L	2	5		< 2	< 2
Chloride	mg/L	0.2			27	6.8
Chromium VI	µg/L	0.2	1		0.3	0.4
Mercury	µg/L	0.01		50	< 0.01	< 0.01

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **PAHs** (WATER)

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

L2 = SANSEW / WATER / - - Halton Sewer Discharge By Law - Sanitary and Combined Sewer Discharge - BL_2_03

	Sample Number				9	12
	Sample Name				19-41	19-42B
	Sample Matrix				Ground Water	Ground Water
	Sample Date				19/11/2019	19/11/2019
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
PAHs						
Naphthalene	µg/L	0.5	7	140	< 0.5	< 0.5
PHCs						
F1 (C6-C10)	µg/L	25			< 25	< 25
F1-BTEX (C6-C10)	µg/L	25			< 25	< 25
F2 (C10-C16)	µg/L	100			< 100	< 100
F3 (C16-C34)	µg/L	200			< 200	< 200
F4 (C34-C50)	µg/L	200			< 200	< 200
Chromatogram returned to baseline at nC50	Yes / No	no			YES	YES
Phenols						
4AAP-Phenolics	mg/L	0.001	0.001	1	0.003	0.001
VOCs						
Chloroform	µg/L	0.5		40	< 0.5	< 0.5
1,4-Dichlorobenzene	µg/L	0.5	4	80	< 0.5	< 0.5
Methylene Chloride	µg/L	0.5	100	2000	< 0.5	< 0.5
Tetrachloroethylene	µg/L	0.5	50	1000	< 0.5	< 0.5
Trichloroethylene	µg/L	0.5	20	400	< 0.5	< 0.5

EXCEEDANCE SUMMARY

Parameter	Method	Units	Result	PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E L1	SANSEW / WATER / - - Halton Sewer Discharge By Law - Sanitary and Combined Sewer Discharge - BL_2_03 L2
19-41					
Aluminum	SM 3030/EPA 200.8	µg/L	240		15
Aluminum (dissolved)	SM 3030/EPA 200.8	µg/L	175		15
Boron	SM 3030/EPA 200.8	µg/L	207		200
Iron	SM 3030/EPA 200.8	µg/L	1350		300
Phosphorous	SM 3030/EPA 200.8	µg/L	31		10
4AAP-Phenolics	SM 5530B-D	mg/L	0.003		0.001
19-42B					
Aluminum	SM 3030/EPA 200.8	µg/L	484		15
Aluminum (dissolved)	SM 3030/EPA 200.8	µg/L	188		15
Copper	SM 3030/EPA 200.8	µg/L	2.0		1
Iron	SM 3030/EPA 200.8	µg/L	1390		300
Phosphorous	SM 3030/EPA 200.8	µg/L	67		10

QC SUMMARY

Alkalinity

Method: SM 2320 | Internal ref.: ME-CA-[ENVIEWL-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
Alkalinity	EWL0366-NOV19	mg/L as CaCO3	2	< 2	0	10	96	80	120	NA		

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENVIIC-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
Bromide	DIO0407-NOV19	mg/L	0.3	<0.3	5	20	97	80	120	115	75	125
Chloride	DIO0411-NOV19	mg/L	0.2	<0.2	4	20	96	80	120	106	75	125
Sulphate	DIO0411-NOV19	mg/L	0.2	<0.2	8	20	95	80	120	101	75	125
Chloride	DIO0431-NOV19	mg/L	0.2	<0.2	0	20	94	80	120	110	75	125

QC SUMMARY

Biochemical Oxygen Demand

Method: SM 5210 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-007

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
Biochemical Oxygen Demand (BOD5)	BOD0042-NOV19	mg/L	2	< 2	2	30	89	70	130	98	70	130

Carbonate/Bicarbonate

Method: SM 2320 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Carbonate	EWL0366-NOV19	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		
Bicarbonate	EWL0366-NOV19	mg/L as CaCO3	2	< 2	0	10	NA	90	110	NA		

QC SUMMARY

Conductivity

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0366-NOV19	uS/cm	2	< 2	0	10	95	90	110	NA		

Cyanide by SFA

Method: SM 4500 | Internal ref.: ME-CA-[ENV]SFA-LAK-AN-005

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
Cyanide (total)	SKA0235-NOV19	mg/L	0.01	<0.01	ND	10	99	90	110	91	75	125
Free Cyanide	SKA0243-NOV19	ug/L	2	<2	ND	10	101	90	110	107	75	125

Fluoride by Specific Ion Electrode

Method: SM 4500 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-014

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
Fluoride	EWL0354-NOV19	mg/L	0.06	<0.06	2	10	108	90	110	113	75	125

QC SUMMARY

Hexavalent Chromium by SFA

Method: EPA218.6/EPA3060A | Internal ref.: ME-CA-[ENV]SKA-LAK-AN-012

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
Chromium VI	SKA0247-NOV19	ug/L	0.2	<0.2	0	20	107	80	120	119	75	125

Inorganics-General

Method: EPA 7471A/SM 3112B | Internal ref.: ME-CA-[ENV]SPE-LAK-AN-004

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
Mercury	EHG0022-NOV19	ug/L	0.01	< 0.00001	ND	20	86	80	120	87	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-IENVISPE-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
Silver (total)	EMS0166-NOV19	ug/L	0.05	<0.00005	ND	20	NV	90	110	81	70	130
Aluminum (total)	EMS0166-NOV19	ug/L	0.1	<0.001	5	20	98	90	110	124	70	130
Aluminum (0.2µm)	EMS0166-NOV19	ug/L	0.1	<0.001	5	20	98	90	110	124	70	130
Arsenic (total)	EMS0166-NOV19	ug/L	0.2	<0.0002	1	20	99	90	110	109	70	130
Barium (total)	EMS0166-NOV19	ug/L	0.02	<0.00002	1	20	102	90	110	127	70	130
Beryllium (total)	EMS0166-NOV19	ug/L	0.007	<0.000007	ND	20	103	90	110	112	70	130
Boron (total)	EMS0166-NOV19	ug/L	2	<0.002	2	20	102	90	110	NV	70	130
Cadmium (total)	EMS0166-NOV19	ug/L	0.003	<0.000003	12	20	96	90	110	105	70	130
Cobalt (total)	EMS0166-NOV19	ug/L	0.004	<0.000004	5	20	97	90	110	109	70	130
Chromium (total)	EMS0166-NOV19	ug/L	0.08	<0.00008	ND	20	98	90	110	113	70	130
Copper (total)	EMS0166-NOV19	ug/L	0.2	<0.0002	5	20	101	90	110	106	70	130
Iron (total)	EMS0166-NOV19	ug/L	7	<0.007	ND	20	105	90	110	NV	70	130
Manganese (total)	EMS0166-NOV19	ug/L	0.01	<0.00001	0	20	101	90	110	ND	70	130
Molybdenum (total)	EMS0166-NOV19	ug/L	0.04	<0.00004	1	20	101	90	110	127	70	130
Nickel (total)	EMS0166-NOV19	ug/L	0.1	<0.0001	0	20	98	90	110	107	70	130
Lead (total)	EMS0166-NOV19	ug/L	0.01	<0.00001	1	20	102	90	110	105	70	130
Phosphorus (total)	EMS0166-NOV19	ug/L	3	<0.003	ND	20	105	90	110	NV	70	130
Antimony (total)	EMS0166-NOV19	ug/L	0.09	<0.0009	ND	20	103	90	110	111	70	130
Selenium (total)	EMS0166-NOV19	ug/L	0.04	<0.00004	ND	20	99	90	110	109	70	130
Tin (total)	EMS0166-NOV19	ug/L	0.06	<0.00006	1	20	102	90	110	NV	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS (continued)

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-IENVISPE-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
Titanium (total)	EMS0166-NOV19	ug/L	0.05	<0.00005	4	20	106	90	110	NV	70	130
Uranium (total)	EMS0166-NOV19	ug/L	0.002	< 0.000002	0	20	102	90	110	108	70	130
Vanadium (total)	EMS0166-NOV19	ug/L	0.01	<0.00001	5	20	97	90	110	113	70	130
Zinc (total)	EMS0166-NOV19	ug/L	2	<0.002	2	20	99	90	110	119	70	130
Silver (total)	EMS0170-NOV19	ug/L	0.05	<0.00005	ND	20	109	90	110	84	70	130
Aluminum (total)	EMS0170-NOV19	ug/L	0.1	<0.001	5	20	96	90	110	79	70	130
Arsenic (total)	EMS0170-NOV19	ug/L	0.2	<0.0002	9	20	98	90	110	106	70	130
Barium (total)	EMS0170-NOV19	ug/L	0.02	<0.00002	11	20	104	90	110	NV	70	130
Beryllium (total)	EMS0170-NOV19	ug/L	0.007	<0.000007	ND	20	99	90	110	111	70	130
Boron (total)	EMS0170-NOV19	ug/L	2	<0.002	12	20	104	90	110	NV	70	130
Cadmium (total)	EMS0170-NOV19	ug/L	0.003	<0.000003	ND	20	100	90	110	103	70	130
Cobalt (total)	EMS0170-NOV19	ug/L	0.004	<0.000004	10	20	99	90	110	104	70	130
Chromium (total)	EMS0170-NOV19	ug/L	0.08	<0.00008	ND	20	98	90	110	107	70	130
Copper (total)	EMS0170-NOV19	ug/L	0.2	<0.0002	1	20	100	90	110	99	70	130
Iron (total)	EMS0170-NOV19	ug/L	7	<0.007	ND	20	102	90	110	NV	70	130
Manganese (total)	EMS0170-NOV19	ug/L	0.01	<0.00001	1	20	99	90	110	NV	70	130
Molybdenum (total)	EMS0170-NOV19	ug/L	0.04	<0.00004	3	20	104	90	110	85	70	130
Nickel (total)	EMS0170-NOV19	ug/L	0.1	<0.0001	0	20	99	90	110	100	70	130
Lead (total)	EMS0170-NOV19	ug/L	0.01	<0.00001	ND	20	100	90	110	101	70	130
Phosphorus (total)	EMS0170-NOV19	ug/L	3	<0.003	ND	20	105	90	110	NV	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS (continued)

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-[ENV]SPE-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
Antimony (total)	EMS0170-NOV19	ug/L	0.09	<0.0009	ND	20	104	90	110	110	70	130
Selenium (total)	EMS0170-NOV19	ug/L	0.04	<0.00004	14	20	102	90	110	93	70	130
Tin (total)	EMS0170-NOV19	ug/L	0.06	<0.00006	13	20	104	90	110	NV	70	130
Titanium (total)	EMS0170-NOV19	ug/L	0.05	<0.00005	3	20	104	90	110	NV	70	130
Uranium (total)	EMS0170-NOV19	ug/L	0.002	2e-006	10	20	100	90	110	111	70	130
Vanadium (total)	EMS0170-NOV19	ug/L	0.01	< 0.00001	ND	20	98	90	110	106	70	130
Zinc (total)	EMS0170-NOV19	ug/L	2	<0.002	7	20	98	90	110	83	70	130
Aluminum (0.2µm)	EMS0182-NOV19	ug/L	0.1	<0.001	6	20	107	90	110	117	70	130

Metals in aqueous samples - ICP-OES

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-[ENV]SPE-LAK-AN-003

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
Hardness	EMS0166-NOV19	mg/L as CaCO3	0.05	<0.05	0	20	103	90	110	NV	70	130
Hardness	EMS0170-NOV19	mg/L as CaCO3	0.05	<0.05	1	20	99	90	110	NV	70	130

QC SUMMARY

Oil & Grease

Method: MOE E3401 | Internal ref.: ME-CA-IENVIGC-LAK-AN-019

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
Oil & Grease (total)	GCM0348-NOV19	mg/L	2	<2	NSS	20	97	75	125			

Oil & Grease-AV/MS

Method: MOE E3401/SM 5520F | Internal ref.: ME-CA-IENVIGC-LAK-AN-019

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
Oil & Grease (animal/vegetable)	GCM0348-NOV19	mg/L	4	< 4	NSS	20	NA	70	130			
Oil & Grease (mineral/synthetic)	GCM0348-NOV19	mg/L	4	< 4	NSS	20	NA	70	130			

Petroleum Hydrocarbons (F1)

Method: CCME Tier 1 | Internal ref.: ME-CA-IENVIGC-LAK-AN-010

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
F1 (C6-C10)	GCM0409-NOV19	ug/L	25	<25	ND	30	105	60	140	81	60	140

QC SUMMARY

Petroleum Hydrocarbons (F2-F4)

Method: CCME Tier 1 | Internal ref.: ME-CA-[ENV]GC-LAK-AN-010

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
F2 (C10-C16)	GCM0381-NOV19	µg/L	100	<100	ND	30	85	60	140	110	60	140
F3 (C16-C34)	GCM0381-NOV19	µg/L	200	<200	ND	30	85	60	140	110	60	140
F4 (C34-C50)	GCM0381-NOV19	µg/L	200	<200	ND	30	85	60	140	110	60	140

pH

Method: SM 4500 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0366-NOV19	no unit	0.05	NA	0		100			NA		

QC SUMMARY

Phenols by SFA

Method: SM 5530B-D | Internal ref.: ME-CA-IENVISFA-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
4AAP-Phenolics	SKA0223-NOV19	mg/L	0.001	<0.001	NV	10	107	90	110	116	75	125

Semi-Volatile Organics

Method: EPA 3510C/8270D | Internal ref.: ME-CA-IENVIGC-LAK-AN-005

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
Naphthalene	GCM0358-NOV19	ug/L	0.5	< 0.5	NSS	30	101	50	140	NSS	50	140

Suspended Solids

Method: SM 2540D | Internal ref.: ME-CA-IENVIEWL-LAK-AN-004

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
Total Suspended Solids	EWL0363-NOV19	mg/L	2	< 2	1	10	NV	90	110	NA		
Total Suspended Solids	EWL0378-NOV19	mg/L	2	< 2	0	10	NV	90	110	NA		

QC SUMMARY

Total Nitrogen

Method: SM 4500-N C/4500-NO3- F | Internal ref.: ME-CA-[ENV]SFA-LAK-AN-002

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
Total Kjeldahl Nitrogen	SKA0226-NOV19	as N mg/L	0.5	<0.5	ND	10	103	90	110	103	75	125

Volatile Organics

Method: EPA 5030B/8260C | Internal ref.: ME-CA-[ENV]GC-LAK-AN-004

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
1,4-Dichlorobenzene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	98	60	130	102	50	140
Benzene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	94	60	130	99	50	140
Chloroform	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	94	60	130	98	50	140
Ethylbenzene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	96	60	130	101	50	140
m/p-xylene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	97	60	130	103	50	140
Methylene Chloride	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	91	60	130	94	50	140
o-xylene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	98	60	130	103	50	140
Tetrachloroethylene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	95	60	130	101	50	140
Toluene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	94	60	130	100	50	140
Trichloroethylene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	94	60	130	89	50	140

QC SUMMARY

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.

-- End of Analytical Report --

SGS

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

Request for Laboratory Services and CHAIN OF CUSTODY

No:

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: Kim Sheard
Received Date: 11 / 20 / 19 (mm/dd/yy)
Received Time: 08 : 00 (hr : min)
Received By (signature):
Custody Seal Present: Yes ☐ No ☑
Custody Seal Intact: Yes ☐ No ☑
Cooling Agent Present: Yes ☑ No ☐ Type: ice
Temperature Upon Receipt (°C) 3 , 3 , 3
LAB LIMS #: NOV14786

REPORT INFORMATION	INVOICE INFORMATION
Company: Thurber Engineering Ltd.	☐ (same as Report Information)
Contact: Karel Furbacher/John Zoldy	Company: Thurber Engineering Ltd.
Address: 2010 Winston Park Drive, Suite 103, Oakville, ON, L6H 5R7	Contact: Judy Bikas
Phone: 905-829-8666	Address: 2010 Winston Park Drive, Suite 103, Oakville, ON, L6H 5R7
Fax:	Phone: 905-829-8666
Email: kfurbacher@thurber.ca;jzoldy@thurber.ca	Email: jbikas@thurber.ca

Quotation #: 2019 818
P.O. #:
Project #: 25063
Site Location/ID:

TURNAROUND TIME (TAT) REQUIRED

☒ Regular TAT (5-7days)
TAT's are quoted in business days (exclude statutory holidays & weekends).
Samples received after 6pm or on weekends: TAT begins next business day

RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days
PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date:

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

REGULATIONS

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

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

Sewer By-Law:
☑ Sanitary
☑ Storm
Municipality: Halton

RECORD OF SITE CONDITION (RSC) ☐ YES ☒ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Thurb-Halt-PWQO-153 Package	COMMENTS:
1	[redacted]	11-19-19	11:20	22	water	✓	
2	19-41	↓	12:00	22	water	✓	19-39 & Cr VI-IC bottle spilled after sampling + refilled
3	[redacted]		2:00	22	water	✓	
4	[redacted]		4:20	22	water	✓	
5	19-42B	↓	5:00	22	water	✓	
6							
7							
8							
9							
10							
11							
12							

Observations/Comments/Special Instructions

Sampled By (NAME): JACQUELINE PIGEON Signature: [signature] Date: 11 / 19 / 19 (mm/dd/yy)
Relinquished by (NAME): JACQUELINE PIGEON Signature: [signature] Date: 11 / 19 / 19 (mm/dd/yy) 6:35PM

Pink Copy - Client
Yellow & White Copy - SGS

Revision #: 1.2
Date of Issue: 09 Sept, 2019

FINAL REPORT

CA14786-NOV19 R1

25063

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS

Client	Thurber Engineering Ltd.
Address	103 2010 Winston Park Drive, Oakville Canada, L6H 5R7 Phone: 289-455-7296. Fax:
Contact	Karel Furbacher
Telephone	289-455-7296
Facsimile	
Email	kfurbacher@thurber.ca
Project	25063
Order Number	
Samples	Ground Water (5)

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	CA14786-NOV19
Received	11/20/2019
Approved	12/10/2019
Report Number	CA14786-NOV19 R1
Date Reported	12/31/2019

COMMENTS

RL - SGS Reporting Limit

Temperature of Sample upon Receipt: 3 degrees C
Cooling Agent Present:Yes
Custody Seal Present:No

Chain of Custody Number:N/A

PWQO - Provincial Water Quality Objectives
Limits based on MOE PIBS 3303E publication July 1994 reprinted February 1999
a PWQO limit based on pH >6.5-9.0 (at pH 4.5-5.5 PWQO = 15ug/L, pH >5.5-6.5 PWQO 10% above background levels in geological area.
b PWQO limit based on Hardness <75 mg/L (For Hardness >75 mg/L PWQO = 1100 ug/L)
c PWQO limit based on Hardness 0-100 mg/L(For Hardness >100 mg/L PWQO = 0.5 ug/L)
d PWQO limit based on Cr VI (PWQO limit for Cr III = 8.9 ug/L)
e PWQO limit based on Hardness 0-20 (For Hardness >20 mg/L PWQO = 5 ug/L)
f PWQO limit based on Hardness <30 (For Hardness 30-80 PWQO = 3 ug/L, & >80 PWQO=5)

SIGNATORIES

Brad Moore Hon. B.Sc

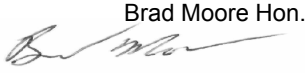


TABLE OF CONTENTS

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **BTEX** (WATER)

L1 = REG153 / GROUND WATER / COARSE - TABLE 1 - All Types of Property Uses - UNDEFINED

L2 = REG153 / GROUND WATER / COARSE - TABLE 2 - All Types of Property Uses - UNDEFINED

				Sample Number	9	12	
				Sample Name	19-41	19-42B	
				Sample Matrix	Ground Water	Ground Water	
				Sample Date	19/11/2019	19/11/2019	
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**	
BTEX							
Benzene	ug/L	0.5	0.5	5	< 0.5	< 0.5	
Ethylbenzene	ug/L	0.5	0.5	2.4	< 0.5	< 0.5	
Toluene	ug/L	0.5	0.8	24	< 0.5	< 0.5	
Xylene (total)	ug/L	0.5	72	300	< 0.5	< 0.5	
m/p-xylene	ug/L	0.5			< 0.5	< 0.5	
o-xylene	ug/L	0.5			< 0.5	< 0.5	
General Chemistry							
Conductivity	uS/cm	2			639	529	
Alkalinity	mg/L as CaCO3	2			298	264	
Carbonate	mg/L as CaCO3	2			< 2	< 2	
Bicarbonate	mg/L as CaCO3	2			298	264	
Biochemical Oxygen Demand (BOD5)	mg/L	2			< 4↑	< 4↑	
Total Suspended Solids	mg/L	2			25	35	
Total Kjeldahl Nitrogen	as N mg/L	0.5			0.6	0.7	

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **Metals and Inorganics** (WATER)

L1 = REG153 / GROUND WATER / COARSE - TABLE 1 - All Types of Property Uses - UNDEFINED

L2 = REG153 / GROUND WATER / COARSE - TABLE 2 - All Types of Property Uses - UNDEFINED

			Sample Number		9	12
			Sample Name		19-41	19-42B
			Sample Matrix		Ground Water	Ground Water
			Sample Date		19/11/2019	19/11/2019
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
Metals and Inorganics						
Cyanide (total)	mg/L	0.01			< 0.01	< 0.01
Fluoride	mg/L	0.06			0.34	0.21
Bromide	mg/L	0.3			< 0.3	< 0.3
Sulphate	mg/L	0.2			34	23
Hardness	mg/L as CaCO3	0.05			295	305
Aluminum (total)	µg/L	0.1			240	484
Aluminum (0.2µm)	µg/L	0.1			175	188
Antimony (total)	µg/L	0.09			< 0.09	< 0.09
Arsenic (total)	µg/L	0.2			0.8	0.4
Boron (total)	µg/L	2			207	116
Barium (total)	µg/L	0.02			121	174
Beryllium (total)	µg/L	0.007			0.016	0.023
Cadmium (total)	µg/L	0.003			0.005	0.011
Chromium (total)	µg/L	0.08			0.69	2.22
Cobalt (total)	µg/L	0.004			0.184	0.377
Copper (total)	µg/L	0.2			1.0	2.0
Iron (total)	µg/L	7			1350	1390
Lead (total)	µg/L	0.01			0.25	0.61
Manganese (total)	µg/L	0.01			55.4	62.4
Molybdenum (total)	µg/L	0.04			13.0	2.48
Nickel (total)	µg/L	0.1			0.5	1.6
Phosphorus (total)	µg/L	3			31	67
Selenium (total)	µg/L	0.04			< 0.04	< 0.04

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **Metals and Inorganics** (WATER)

L1 = REG153 / GROUND WATER / COARSE - TABLE 1 - All Types of Property Uses - UNDEFINED

L2 = REG153 / GROUND WATER / COARSE - TABLE 2 - All Types of Property Uses - UNDEFINED

				Sample Number	9	12
				Sample Name	19-41	19-42B
				Sample Matrix	Ground Water	Ground Water
				Sample Date	19/11/2019	19/11/2019
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
Metals and Inorganics (continued)						
Silver (total)	µg/L	0.05			< 0.05	< 0.05
Tin (total)	µg/L	0.06			0.19	0.37
Titanium (total)	µg/L	0.05			6.16	14.5
Uranium (total)	µg/L	0.002			0.208	0.077
Vanadium (total)	µg/L	0.01			0.29	0.86
Zinc (total)	µg/L	2			3	11
Oil and Grease						
Oil & Grease (total)	mg/L	2			< 2	< 2
Oil & Grease (animal/vegetable)	mg/L	4			< 4	< 4
Oil & Grease (mineral/synthetic)	mg/L	4			< 4	< 4
Other (ORP)						
pH	no unit	0.05			8.22	8.20
Free Cyanide	µg/L	2	5	66	< 2	< 2
Chloride	mg/L	0.2	790	790	27	6.8
Chromium VI	µg/L	0.2	25	25	0.3	0.4
Mercury	µg/L	0.01			< 0.01	< 0.01

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **PAHs** (WATER)

L1 = REG153 / GROUND WATER / COARSE - TABLE 1 - All Types of Property Uses - UNDEFINED

L2 = REG153 / GROUND WATER / COARSE - TABLE 2 - All Types of Property Uses - UNDEFINED

					Sample Number	9	12
					Sample Name	19-41	19-42B
					Sample Matrix	Ground Water	Ground Water
					Sample Date	19/11/2019	19/11/2019
Parameter		**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
PAHs							
Naphthalene		µg/L	0.5	7	11	< 0.5	< 0.5
PHCs							
F1 (C6-C10)		µg/L	25	420	750	< 25	< 25
F1-BTEX (C6-C10)		µg/L	25			< 25	< 25
F2 (C10-C16)		µg/L	100	150	150	< 100	< 100
F3 (C16-C34)		µg/L	200	500	500	< 200	< 200
F4 (C34-C50)		µg/L	200	500	500	< 200	< 200
Chromatogram returned to baseline at nC50		Yes / No	no			YES	YES
Phenols							
4AAP-Phenolics		mg/L	0.001			0.003	0.001
VOCs							
Chloroform		µg/L	0.5	2	2.4	< 0.5	< 0.5
1,4-Dichlorobenzene		µg/L	0.5	0.5	1	< 0.5	< 0.5
Methylene Chloride		µg/L	0.5	5	50	< 0.5	< 0.5
Tetrachloroethylene		µg/L	0.5	0.5	1.6	< 0.5	< 0.5
Trichloroethylene		µg/L	0.5	0.5	1.6	< 0.5	< 0.5

EXCEEDANCE SUMMARY

Parameter	Method	Units	Result	REG153 / GROUND WATER / COARSE - TABLE 1 - All Types of Property Uses - UNDEFINED L1	REG153 / GROUND WATER / COARSE - TABLE 2 - All Types of Property Uses - UNDEFINED L2

QC SUMMARY

Alkalinity

Method: SM 2320 | Internal ref.: ME-CA-[ENVIEWL-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
Alkalinity	EWL0366-NOV19	mg/L as CaCO3	2	< 2	0	10	96	80	120	NA		

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENVIIC-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
Bromide	DIO0407-NOV19	mg/L	0.3	<0.3	5	20	97	80	120	115	75	125
Chloride	DIO0411-NOV19	mg/L	0.2	<0.2	4	20	96	80	120	106	75	125
Sulphate	DIO0411-NOV19	mg/L	0.2	<0.2	8	20	95	80	120	101	75	125
Chloride	DIO0431-NOV19	mg/L	0.2	<0.2	0	20	94	80	120	110	75	125

QC SUMMARY

Biochemical Oxygen Demand

Method: SM 5210 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-007

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
Biochemical Oxygen Demand (BOD5)	BOD0042-NOV19	mg/L	2	< 2	2	30	89	70	130	98	70	130

Carbonate/Bicarbonate

Method: SM 2320 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Carbonate	EWL0366-NOV19	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		
Bicarbonate	EWL0366-NOV19	mg/L as CaCO3	2	< 2	0	10	NA	90	110	NA		

QC SUMMARY

Conductivity

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0366-NOV19	uS/cm	2	< 2	0	10	95	90	110	NA		

Cyanide by SFA

Method: SM 4500 | Internal ref.: ME-CA-[ENV]SFA-LAK-AN-005

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
Cyanide (total)	SKA0235-NOV19	mg/L	0.01	<0.01	ND	10	99	90	110	91	75	125
Free Cyanide	SKA0243-NOV19	ug/L	2	<2	ND	10	101	90	110	107	75	125

Fluoride by Specific Ion Electrode

Method: SM 4500 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-014

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
Fluoride	EWL0354-NOV19	mg/L	0.06	<0.06	2	10	108	90	110	113	75	125

QC SUMMARY

Hexavalent Chromium by SFA

Method: EPA218.6/EPA3060A | Internal ref.: ME-CA-[ENV]SKA-LAK-AN-012

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
Chromium VI	SKA0247-NOV19	ug/L	0.2	<0.2	0	20	107	80	120	119	75	125

Inorganics-General

Method: EPA 7471A/SM 3112B | Internal ref.: ME-CA-[ENV]SPE-LAK-AN-004

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
Mercury	EHG0022-NOV19	ug/L	0.01	< 0.00001	ND	20	86	80	120	87	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-IENVISPE-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
Silver (total)	EMS0166-NOV19	ug/L	0.05	<0.00005	ND	20	NV	90	110	81	70	130
Aluminum (total)	EMS0166-NOV19	ug/L	0.1	<0.001	5	20	98	90	110	124	70	130
Aluminum (0.2µm)	EMS0166-NOV19	ug/L	0.1	<0.001	5	20	98	90	110	124	70	130
Arsenic (total)	EMS0166-NOV19	ug/L	0.2	<0.0002	1	20	99	90	110	109	70	130
Barium (total)	EMS0166-NOV19	ug/L	0.02	<0.00002	1	20	102	90	110	127	70	130
Beryllium (total)	EMS0166-NOV19	ug/L	0.007	<0.000007	ND	20	103	90	110	112	70	130
Boron (total)	EMS0166-NOV19	ug/L	2	<0.002	2	20	102	90	110	NV	70	130
Cadmium (total)	EMS0166-NOV19	ug/L	0.003	<0.000003	12	20	96	90	110	105	70	130
Cobalt (total)	EMS0166-NOV19	ug/L	0.004	<0.000004	5	20	97	90	110	109	70	130
Chromium (total)	EMS0166-NOV19	ug/L	0.08	<0.00008	ND	20	98	90	110	113	70	130
Copper (total)	EMS0166-NOV19	ug/L	0.2	<0.0002	5	20	101	90	110	106	70	130
Iron (total)	EMS0166-NOV19	ug/L	7	<0.007	ND	20	105	90	110	NV	70	130
Manganese (total)	EMS0166-NOV19	ug/L	0.01	<0.00001	0	20	101	90	110	ND	70	130
Molybdenum (total)	EMS0166-NOV19	ug/L	0.04	<0.00004	1	20	101	90	110	127	70	130
Nickel (total)	EMS0166-NOV19	ug/L	0.1	<0.0001	0	20	98	90	110	107	70	130
Lead (total)	EMS0166-NOV19	ug/L	0.01	<0.00001	1	20	102	90	110	105	70	130
Phosphorus (total)	EMS0166-NOV19	ug/L	3	<0.003	ND	20	105	90	110	NV	70	130
Antimony (total)	EMS0166-NOV19	ug/L	0.09	<0.0009	ND	20	103	90	110	111	70	130
Selenium (total)	EMS0166-NOV19	ug/L	0.04	<0.00004	ND	20	99	90	110	109	70	130
Tin (total)	EMS0166-NOV19	ug/L	0.06	<0.00006	1	20	102	90	110	NV	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS (continued)

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-IENVISPE-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
Titanium (total)	EMS0166-NOV19	ug/L	0.05	<0.00005	4	20	106	90	110	NV	70	130
Uranium (total)	EMS0166-NOV19	ug/L	0.002	< 0.000002	0	20	102	90	110	108	70	130
Vanadium (total)	EMS0166-NOV19	ug/L	0.01	<0.00001	5	20	97	90	110	113	70	130
Zinc (total)	EMS0166-NOV19	ug/L	2	<0.002	2	20	99	90	110	119	70	130
Silver (total)	EMS0170-NOV19	ug/L	0.05	<0.00005	ND	20	109	90	110	84	70	130
Aluminum (total)	EMS0170-NOV19	ug/L	0.1	<0.001	5	20	96	90	110	79	70	130
Arsenic (total)	EMS0170-NOV19	ug/L	0.2	<0.0002	9	20	98	90	110	106	70	130
Barium (total)	EMS0170-NOV19	ug/L	0.02	<0.00002	11	20	104	90	110	NV	70	130
Beryllium (total)	EMS0170-NOV19	ug/L	0.007	<0.000007	ND	20	99	90	110	111	70	130
Boron (total)	EMS0170-NOV19	ug/L	2	<0.002	12	20	104	90	110	NV	70	130
Cadmium (total)	EMS0170-NOV19	ug/L	0.003	<0.000003	ND	20	100	90	110	103	70	130
Cobalt (total)	EMS0170-NOV19	ug/L	0.004	<0.000004	10	20	99	90	110	104	70	130
Chromium (total)	EMS0170-NOV19	ug/L	0.08	<0.00008	ND	20	98	90	110	107	70	130
Copper (total)	EMS0170-NOV19	ug/L	0.2	<0.0002	1	20	100	90	110	99	70	130
Iron (total)	EMS0170-NOV19	ug/L	7	<0.007	ND	20	102	90	110	NV	70	130
Manganese (total)	EMS0170-NOV19	ug/L	0.01	<0.00001	1	20	99	90	110	NV	70	130
Molybdenum (total)	EMS0170-NOV19	ug/L	0.04	<0.00004	3	20	104	90	110	85	70	130
Nickel (total)	EMS0170-NOV19	ug/L	0.1	<0.0001	0	20	99	90	110	100	70	130
Lead (total)	EMS0170-NOV19	ug/L	0.01	<0.00001	ND	20	100	90	110	101	70	130
Phosphorus (total)	EMS0170-NOV19	ug/L	3	<0.003	ND	20	105	90	110	NV	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS (continued)

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-[ENV]SPE-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
Antimony (total)	EMS0170-NOV19	ug/L	0.09	<0.0009	ND	20	104	90	110	110	70	130
Selenium (total)	EMS0170-NOV19	ug/L	0.04	<0.00004	14	20	102	90	110	93	70	130
Tin (total)	EMS0170-NOV19	ug/L	0.06	<0.00006	13	20	104	90	110	NV	70	130
Titanium (total)	EMS0170-NOV19	ug/L	0.05	<0.00005	3	20	104	90	110	NV	70	130
Uranium (total)	EMS0170-NOV19	ug/L	0.002	2e-006	10	20	100	90	110	111	70	130
Vanadium (total)	EMS0170-NOV19	ug/L	0.01	< 0.00001	ND	20	98	90	110	106	70	130
Zinc (total)	EMS0170-NOV19	ug/L	2	<0.002	7	20	98	90	110	83	70	130
Aluminum (0.2µm)	EMS0182-NOV19	ug/L	0.1	<0.001	6	20	107	90	110	117	70	130

Metals in aqueous samples - ICP-OES

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-[ENV]SPE-LAK-AN-003

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
Hardness	EMS0166-NOV19	mg/L as CaCO3	0.05	<0.05	0	20	103	90	110	NV	70	130
Hardness	EMS0170-NOV19	mg/L as CaCO3	0.05	<0.05	1	20	99	90	110	NV	70	130

QC SUMMARY

Oil & Grease

Method: MOE E3401 | Internal ref.: ME-CA-IENVIGC-LAK-AN-019

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
Oil & Grease (total)	GCM0348-NOV19	mg/L	2	<2	NSS	20	97	75	125			

Oil & Grease-AV/MS

Method: MOE E3401/SM 5520F | Internal ref.: ME-CA-IENVIGC-LAK-AN-019

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
Oil & Grease (animal/vegetable)	GCM0348-NOV19	mg/L	4	< 4	NSS	20	NA	70	130			
Oil & Grease (mineral/synthetic)	GCM0348-NOV19	mg/L	4	< 4	NSS	20	NA	70	130			

Petroleum Hydrocarbons (F1)

Method: CCME Tier 1 | Internal ref.: ME-CA-IENVIGC-LAK-AN-010

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
F1 (C6-C10)	GCM0409-NOV19	ug/L	25	<25	ND	30	105	60	140	81	60	140

QC SUMMARY

Petroleum Hydrocarbons (F2-F4)

Method: CCME Tier 1 | Internal ref.: ME-CA-[ENV]GC-LAK-AN-010

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
F2 (C10-C16)	GCM0381-NOV19	µg/L	100	<100	ND	30	85	60	140	110	60	140
F3 (C16-C34)	GCM0381-NOV19	µg/L	200	<200	ND	30	85	60	140	110	60	140
F4 (C34-C50)	GCM0381-NOV19	µg/L	200	<200	ND	30	85	60	140	110	60	140

pH

Method: SM 4500 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0366-NOV19	no unit	0.05	NA	0		100			NA		

QC SUMMARY

Phenols by SFA

Method: SM 5530B-D | Internal ref.: ME-CA-IENVISFA-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
4AAP-Phenolics	SKA0223-NOV19	mg/L	0.001	<0.001	NV	10	107	90	110	116	75	125

Semi-Volatile Organics

Method: EPA 3510C/8270D | Internal ref.: ME-CA-IENVIGC-LAK-AN-005

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
Naphthalene	GCM0358-NOV19	ug/L	0.5	< 0.5	NSS	30	101	50	140	NSS	50	140

Suspended Solids

Method: SM 2540D | Internal ref.: ME-CA-IENVIEWL-LAK-AN-004

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
Total Suspended Solids	EWL0363-NOV19	mg/L	2	< 2	1	10	NV	90	110	NA		
Total Suspended Solids	EWL0378-NOV19	mg/L	2	< 2	0	10	NV	90	110	NA		

QC SUMMARY

Total Nitrogen

Method: SM 4500-N C/4500-NO3- F | Internal ref.: ME-CA-[ENV]SFA-LAK-AN-002

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
Total Kjeldahl Nitrogen	SKA0226-NOV19	as N mg/L	0.5	<0.5	ND	10	103	90	110	103	75	125

Volatile Organics

Method: EPA 5030B/8260C | Internal ref.: ME-CA-[ENV]GC-LAK-AN-004

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
1,4-Dichlorobenzene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	98	60	130	102	50	140
Benzene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	94	60	130	99	50	140
Chloroform	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	94	60	130	98	50	140
Ethylbenzene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	96	60	130	101	50	140
m/p-xylene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	97	60	130	103	50	140
Methylene Chloride	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	91	60	130	94	50	140
o-xylene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	98	60	130	103	50	140
Tetrachloroethylene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	95	60	130	101	50	140
Toluene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	94	60	130	100	50	140
Trichloroethylene	GCM0384-NOV19	ug/L	0.5	<0.5	ND	30	94	60	130	89	50	140

QC SUMMARY

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.

-- End of Analytical Report --

Request for Laboratory Services and CHAIN OF CUSTODY

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- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

No:

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: Kim Sheard
Received Date: 11 / 20 / 19 (mm/dd/yy)
Received Time: 08 : 00 (hr : min)
Received By (signature):
Custody Seal Present: Yes ☐ No ☑
Custody Seal Intact: Yes ☐ No ☑
Cooling Agent Present: Yes ☑ No ☐ Type: ice
Temperature Upon Receipt (°C) 3 , 3 , 3
LAB LIMS #: NOV14786

REPORT INFORMATION	INVOICE INFORMATION
Company: Thurber Engineering Ltd.	☐ (same as Report Information)
Contact: Karel Furbacher/John Zoldy	Company: Thurber Engineering Ltd.
Address: 2010 Winston Park Drive, Suite 103, Oakville, ON, L6H 5R7	Contact: Judy Bikas
Phone: 905-829-8666	Address: 2010 Winston Park Drive, Suite 103, Oakville, ON, L6H 5R7
Fax:	Phone: 905-829-8666
Email: kfurbacher@thurber.ca;jzoldy@thurber.ca	Email: jbikas@thurber.ca

Quotation #: 2019 818
P.O. #:
Project #: 25063
Site Location/ID:

TURNAROUND TIME (TAT) REQUIRED

☒ Regular TAT (5-7days)
TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 6pm or on weekends: TAT begins next business day

RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days
PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date:

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

REGULATIONS

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

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

Sewer By-Law:
☑ Sanitary
☑ Storm
Municipality: Halton

RECORD OF SITE CONDITION (RSC) ☐ YES ☒ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Thurb-Halt-PWQO-153 Package	COMMENTS:
1	[redacted]	11-19-19	11:20	22	water	✓	
2	19-41	↓	12:00	22	water	✓	19-39 & Cr VI-IC bottle spilled after sampling + refilled
3	[redacted]		2:00	22	water	✓	
4	[redacted]		4:20	22	water	✓	
5	19-42B		5:00	22	water	✓	
6							
7							
8							
9							
10							
11							
12							

Observations/Comments/Special Instructions

Sampled By (NAME): JACQUELINE PIGEON Signature: [signature] Date: 11 / 19 / 19 (mm/dd/yy)
Relinquished by (NAME): JACQUELINE PIGEON Signature: [signature] Date: 11 / 19 / 19 (mm/dd/yy) 6:35PM

Pink Copy - Client
Yellow & White Copy - SGS

Revision #: 1.2
Date of Issue: 09 Sept, 2019

FINAL REPORT

CA15941-NOV19 R1

25063

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Brad Moore Hon. B.Sc
		Laboratory	SGS Canada Inc.
Address	103 2010 Winston Park Drive, Oakville Canada, L6H 5R7 Phone: 289-455-7296. Fax:	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Karel Furbacher	Telephone	705-652-2143
Telephone	289-455-7296	Facsimile	705-652-6365
Facsimile		Email	brad.moore@sgs.com
Email	kfurbacher@thurber.ca	SGS Reference	CA15941-NOV19
Project	25063	Received	11/29/2019
Order Number		Approved	12/12/2019
Samples	Ground Water (4)	Report Number	CA15941-NOV19 R1
		Date Reported	12/12/2019

COMMENTS

RL - SGS Reporting Limit

Temperature of Sample upon Receipt: 5 degrees C
Cooling Agent Present:Yes
Custody Seal Present:Yes

Chain of Custody Number:NA

PHC's F2 (C10-C16)and F3 (C16-C34) Duplicate; RPD is outside tolerance due to sample heterogeneity; organics extractions are whole bottle analysis and as such sample duplicates are “field” duplicates. Due to the limited solubility of PHCs in water, it can be difficult to obtain homogeneous field duplicates resulting in variability between sub-samples that exceed the method RPD criteria.

Naphthalene Duplicate; RPD for this parameter is outside control limits. The average of the two duplicates is less than five times the RL therefore a greater uncertainty is expected.

PWQO - Provincial Water Quality Objectives
Limits based on MOE PIBS 3303E publication July 1994 reprinted February 1999
a PWQO limit based on pH >6.5-9.0 (at pH 4.5-5.5 PWQO = 15ug/L, pH >5.5-6.5 PWQO 10% above background levels in geological area.
b PWQO limit based on Hardness <75 mg/L (For Hardness >75 mg/L PWQO = 1100 ug/L)
c PWQO limit based on Hardness 0-100 mg/L(For Hardness >100 mg/L PWQO = 0.5 ug/L)
d PWQO limit based on Cr VI (PWQO limit for Cr III = 8.9 ug/L)
e PWQO limit based on Hardness 0-20 (For Hardness >20 mg/L PWQO = 5 ug/L)
f PWQO limit based on Hardness <30 (For Hardness 30-80 PWQO = 3 ug/L, & >80 PWQO=5)

SIGNATORIES

Brad Moore Hon. B.Sc

TABLE OF CONTENTS

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **BTEX** (WATER)

L1 = REG153 / GROUND WATER / FINE - TABLE 1 - All Types of Property Uses - UNDEFINED

L2 = REG153 / GROUND WATER / FINE - TABLE 2 - All Types of Property Uses - UNDEFINED

				Sample Number	8	11
				Sample Name	19-43B	19-44
				Sample Matrix	Ground Water	Ground Water
				Sample Date	28/11/2019	28/11/2019
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
BTEX						
Benzene	ug/L	0.5	0.5	5	< 0.5	< 0.5
Ethylbenzene	ug/L	0.5	0.5	2.4	< 0.5	< 0.5
Toluene	ug/L	0.5	0.8	24	< 0.5	< 0.5
Xylene (total)	ug/L	0.5	72	300	< 0.5	< 0.5
m/p-xylene	ug/L	0.5			< 0.5	< 0.5
o-xylene	ug/L	0.5			< 0.5	< 0.5
General Chemistry						
Conductivity	uS/cm	2			601	2010
Alkalinity	mg/L as CaCO3	2			258	168
Carbonate	mg/L as CaCO3	2			< 2	< 2
Bicarbonate	mg/L as CaCO3	2			258	168
Biochemical Oxygen Demand (BOD5)	mg/L	2			< 4↑	5
Total Suspended Solids	mg/L	2			4	22
Total Kjeldahl Nitrogen	as N mg/L	0.5			0.6	1.4

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **Metals and Inorganics** (WATER)

L1 = REG153 / GROUND WATER / FINE - TABLE 1 - All Types of Property Uses - UNDEFINED

L2 = REG153 / GROUND WATER / FINE - TABLE 2 - All Types of Property Uses - UNDEFINED

					Sample Number	8	11
					Sample Name	19-43B	19-44
					Sample Matrix	Ground Water	Ground Water
					Sample Date	28/11/2019	28/11/2019
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
Metals and Inorganics						
Cyanide (total)	mg/L	0.01			< 0.01	< 0.01
Fluoride	mg/L	0.06			0.22	0.36
Bromide	mg/L	0.3			< 0.3	5.3
Sulphate	mg/L	0.2			46	220
Hardness	mg/L as CaCO3	0.05			279	589
Aluminum (total)	µg/L	1			12.1	245
Aluminum (0.2µm)	µg/L	1			1.6	5.0
Antimony (total)	µg/L	0.09			< 0.09	0.19
Antimony (dissolved)	µg/L	0.09	1.5	6	< 0.09	< 0.09
Arsenic (total)	µg/L	0.2			0.5	6.0
Arsenic (dissolved)	µg/L	0.2	13	25	0.6	6.1
Boron (dissolved)	µg/L	2	1700	5000	88	1110
Barium (dissolved)	µg/L	0.02	610	1000	124	50.4
Beryllium (total)	µg/L	0.007			< 0.007	0.028
Beryllium (dissolved)	µg/L	0.007	0.5	4	< 0.007	0.017
Cadmium (total)	µg/L	0.003			< 0.003	0.003
Cadmium (dissolved)	µg/L	0.003	0.5	2.7	< 0.003	0.004
Chromium (total)	µg/L	0.08			0.17	1.24
Chromium (dissolved)	µg/L	0.08	11	50	0.15	0.68
Cobalt (total)	µg/L	0.004			0.050	0.357
Cobalt (dissolved)	µg/L	0.004	3.8	3.8	0.085	0.328
Copper (total)	µg/L	0.2			< 0.2	0.8
Copper (dissolved)	µg/L	0.2	5	87	< 0.2	0.2

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **Metals and Inorganics** (WATER)

L1 = REG153 / GROUND WATER / FINE - TABLE 1 - All Types of Property Uses - UNDEFINED

L2 = REG153 / GROUND WATER / FINE - TABLE 2 - All Types of Property Uses - UNDEFINED

					Sample Number	8	11
					Sample Name	19-43B	19-44
					Sample Matrix	Ground Water	Ground Water
					Sample Date	28/11/2019	28/11/2019
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
Metals and Inorganics (continued)						
Iron (total)	µg/L	7			1200	441
Iron (dissolved)	µg/L	7			1080	323
Lead (total)	µg/L	0.01			< 0.01	0.46
Lead (dissolved)	µg/L	0.01	1.9	10	< 0.01	0.20
Magnesium (dissolved)	ug/L	1			26800	56400
Manganese (total)	µg/L	0.01			107	70.6
Manganese (dissolved)	µg/L	0.01			103	68.6
Molybdenum (total)	µg/L	0.04			4.14	13.4
Molybdenum (dissolved)	µg/L	0.04	23	70	5.10	12.2
Nickel (total)	µg/L	0.1			0.1	0.7
Nickel (dissolved)	µg/L	0.1	14	100	< 0.1	0.6
Potassium (dissolved)	ug/L	9			3230	10900
Phosphorus (total)	µg/L	3			9	13
Phosphorus (dissolved)	µg/L	3			12	7
Selenium (total)	µg/L	0.04			< 0.04	0.06
Selenium (dissolved)	µg/L	0.04	5	10	0.05	0.07
Silver (total)	µg/L	0.05			< 0.05	< 0.05
Silver (dissolved)	µg/L	0.05	0.3	1.5	< 0.05	< 0.05
Sodium (dissolved)	µg/L	10	490000	490000	25600	154000
Tin (total)	µg/L	0.06			0.68	1.99
Tin (dissolved)	µg/L	0.06			0.76	1.53
Titanium (total)	µg/L	0.05			0.51	7.03
Titanium (dissolved)	µg/L	0.05			0.91	2.82

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **Metals and Inorganics** (WATER)

L1 = REG153 / GROUND WATER / FINE - TABLE 1 - All Types of Property Uses - UNDEFINED

L2 = REG153 / GROUND WATER / FINE - TABLE 2 - All Types of Property Uses - UNDEFINED

					Sample Number	8	11
					Sample Name	19-43B	19-44
					Sample Matrix	Ground Water	Ground Water
					Sample Date	28/11/2019	28/11/2019
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
Metals and Inorganics (continued)						
Thallium (total)	µg/L	0.005			< 0.005	0.005
Thallium (dissolved)	µg/L	0.005	0.5	2	< 0.005	< 0.005
Uranium (dissolved)	µg/L	0.002	8.9	20	0.191	1.04
Vanadium (dissolved)	µg/L	0.01	3.9	6.2	0.07	0.15
Zinc (total)	µg/L	2			< 2	5
Zinc (dissolved)	µg/L	2	160	1100	7	3
Oil and Grease						
Oil & Grease (total)	mg/L	2			< 2	< 2
Oil & Grease (animal/vegetable)	mg/L	4			< 4	< 4
Oil & Grease (mineral/synthetic)	mg/L	4			< 4	< 4
Other (ORP)						
pH	no unit	0.05			8.06	7.87
Free Cyanide	µg/L	2	5	66	< 2	< 2
Chloride	mg/L	0.2	790	790	15	520
Chromium VI	µg/L	0.2	25	25	< 0.2	< 0.2
Mercury	µg/L	0.00001			< 0.00001	< 0.00001
Mercury (dissolved)	µg/L	0.01	0.1	1	< 0.01	< 0.01

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **PAHs** (WATER)

L1 = REG153 / GROUND WATER / FINE - TABLE 1 - All Types of Property Uses - UNDEFINED

L2 = REG153 / GROUND WATER / FINE - TABLE 2 - All Types of Property Uses - UNDEFINED

					Sample Number	8	11
					Sample Name	19-43B	19-44
					Sample Matrix	Ground Water	Ground Water
					Sample Date	28/11/2019	28/11/2019
Parameter		**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
PAHs							
Naphthalene		µg/L	0.5	7	11	< 0.5	< 0.5
PHCs							
F1 (C6-C10)		µg/L	25	420	750	< 25	< 25
F1-BTEX (C6-C10)		µg/L	25			< 25	< 25
F2 (C10-C16)		µg/L	100	150	150	< 100	< 100
F3 (C16-C34)		µg/L	200	500	500	< 200	< 200
F4 (C34-C50)		µg/L	200	500	500	< 200	< 200
Chromatogram returned to baseline at nC50		Yes / No	no			YES	YES
Phenols							
4AAP-Phenolics		mg/L	0.001			< 0.001	0.002
VOCs							
Chloroform		µg/L	0.5	2	22	< 0.5	< 0.5
1,4-Dichlorobenzene		µg/L	0.5	0.5	1	< 0.5	< 0.5
Methylene Chloride		µg/L	0.5	5	50	< 0.5	< 0.5
Tetrachloroethylene		µg/L	0.5	0.5	17	< 0.5	< 0.5
Trichloroethylene		µg/L	0.5	0.5	5	< 0.5	< 0.5

EXCEEDANCE SUMMARY

Parameter	Method	Units	Result	REG153 / GROUND WATER / FINE - TABLE 1 - All Types of Property Uses - UNDEFINED L1	REG153 / GROUND WATER / FINE - TABLE 2 - All Types of Property Uses - UNDEFINED L2

QC SUMMARY

Alkalinity

Method: SM 2320 I Internal ref.: ME-CA-[ENVIEWL-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
Alkalinity	EWL0009-DEC19	mg/L as CaCO3	2	< 2	5	10	100	80	120	NA		

Anions by IC

Method: EPA300/MA300-Ions1.3 I Internal ref.: ME-CA-[ENVIIC-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
Bromide	DIO0012-DEC19	mg/L	0.3	<0.3	ND	20	98	80	120	105	75	125
Chloride	DIO0014-DEC19	mg/L	0.2	<0.2	5	20	98	80	120	99	75	125
Sulphate	DIO0014-DEC19	mg/L	0.2	<0.2	8	20	98	80	120	98	75	125
Chloride	DIO0026-DEC19	mg/L	0.2	<0.2	5	20	97	80	120	122	75	125

QC SUMMARY

Biochemical Oxygen Demand

Method: SM 5210 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-007

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
Biochemical Oxygen Demand (BOD5)	BOD0059-NOV19	mg/L	2	< 2	18	30	100	70	130	NV	70	130

Carbonate/Bicarbonate

Method: SM 2320 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Carbonate	EWL0009-DEC19	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		
Bicarbonate	EWL0009-DEC19	mg/L as CaCO3	2	< 2	5	10	NA	90	110	NA		

QC SUMMARY

Conductivity

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0009-DEC19	uS/cm	2	3	0	10	100	90	110	NA		

Cyanide by SFA

Method: SM 4500 | Internal ref.: ME-CA-[ENV]SFA-LAK-AN-005

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
Cyanide (total)	SKA0018-DEC19	mg/L	0.01	<0.01	ND	10	101	90	110	90	75	125
Free Cyanide	SKA0052-DEC19	ug/L	2	<2	ND	10	92	90	110	91	75	125

Fluoride by Specific Ion Electrode

Method: SM 4500 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-014

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
Fluoride	EWL0004-DEC19	mg/L	0.06	<0.06	1	10	107	90	110	111	75	125

QC SUMMARY

Hexavalent Chromium by SFA

Method: EPA218.6/EPA3060A | Internal ref.: ME-CA-[ENVISKA-LAK-AN-012

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
Chromium VI	SKA0025-DEC19	ug/L	0.2	<0.2	3	20	103	80	120	90	75	125

Inorganics-General

Method: EPA 7471A/SM 3112B | Internal ref.: ME-CA-[ENVISPE-LAK-AN-004

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
Mercury	EHG0003-DEC19	ug/L	0.00001	< 0.00001	ND	20	100	80	120	101	70	130

Mercury by CVAAS

Method: EPA 7471A/SM 3112B | Internal ref.: ME-CA-[ENVISPE-LAK-AN-004

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
Mercury (dissolved)	EHG0003-DEC19	ug/L	0.01	< 0.00001	ND	20	100	80	120	101	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-IENVISPE-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
Silver (total)	EMS0001-DEC19	ug/L	0.05	<0.00005	ND	20	101	90	110	73	70	130
Aluminum (total)	EMS0001-DEC19	ug/L	1	<0.001	11	20	102	90	110	110	70	130
Aluminum (0.2µm)	EMS0001-DEC19	ug/L	1	<0.001	11	20	102	90	110	110	70	130
Arsenic (total)	EMS0001-DEC19	ug/L	0.2	<0.0002	ND	20	102	90	110	101	70	130
Barium (dissolved)	EMS0001-DEC19	ug/L	0.02	<0.00002	3	20	102	90	110	103	70	130
Beryllium (total)	EMS0001-DEC19	ug/L	0.007	<0.000007	ND	20	99	90	110	97	70	130
Boron (dissolved)	EMS0001-DEC19	ug/L	2	<0.002	8	20	104	90	110	NV	70	130
Cadmium (total)	EMS0001-DEC19	ug/L	0.003	<0.000003	6	20	101	90	110	106	70	130
Cobalt (total)	EMS0001-DEC19	ug/L	0.004	<0.000004	15	20	102	90	110	101	70	130
Chromium (total)	EMS0001-DEC19	ug/L	0.08	<0.00008	8	20	101	90	110	101	70	130
Copper (total)	EMS0001-DEC19	ug/L	0.2	<0.0002	0	20	104	90	110	104	70	130
Iron (total)	EMS0001-DEC19	ug/L	7	<0.007	11	20	105	90	110	NV	70	130
Potassium (dissolved)	EMS0001-DEC19	mg/L	9	<0.009	2	20	106	90	110	97	70	130
Magnesium (dissolved)	EMS0001-DEC19	mg/L	1	<0.001	2	20	104	90	110	100	70	130
Manganese (total)	EMS0001-DEC19	ug/L	0.01	<0.00001	2	20	103	90	110	98	70	130
Molybdenum (total)	EMS0001-DEC19	ug/L	0.04	<0.00004	12	20	103	90	110	109	70	130
Sodium (dissolved)	EMS0001-DEC19	mg/L	10	<0.01	2	20	103	90	110	99	70	130
Nickel (total)	EMS0001-DEC19	ug/L	0.1	<0.0001	2	20	102	90	110	100	70	130
Lead (total)	EMS0001-DEC19	ug/L	0.01	<0.00001	12	20	101	90	110	98	70	130
Phosphorus (total)	EMS0001-DEC19	ug/L	3	<0.003	ND	20	104	90	110	NV	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS (continued)

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-IENVISPE-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
Antimony (total)	EMS0001-DEC19	ug/L	0.09	<0.0009	ND	20	101	90	110	117	70	130
Selenium (total)	EMS0001-DEC19	ug/L	0.04	<0.00004	ND	20	106	90	110	102	70	130
Tin (total)	EMS0001-DEC19	ug/L	0.06	<0.00006	ND	20	100	90	110	NV	70	130
Titanium (total)	EMS0001-DEC19	ug/L	0.05	<0.00005	10	20	100	90	110	NV	70	130
Thallium (total)	EMS0001-DEC19	mg/L	0.005	<0.000005	ND	20	102	90	110	98	70	130
Uranium (dissolved)	EMS0001-DEC19	ug/L	0.002	<0.000002	ND	20	102	90	110	99	70	130
Vanadium (dissolved)	EMS0001-DEC19	ug/L	0.01	<0.00001	ND	20	102	90	110	101	70	130
Zinc (total)	EMS0001-DEC19	ug/L	2	<0.002	1	20	103	90	110	102	70	130
Aluminum (0.2µm)	EMS0032-DEC19	ug/L	1	<0.001	2	20	109	90	110	NV	70	130

Metals in aqueous samples - ICP-OES

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-IENVISPE-LAK-AN-003

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
Hardness	EMS0001-DEC19	mg/L as CaCO3	0.05	<0.05	1	20	104	90	110	100	70	130

QC SUMMARY

Oil & Grease

Method: MOE E3401 | Internal ref.: ME-CA-[ENVIGC-LAK-AN-019

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
Oil & Grease (total)	GCM0003-DEC19	mg/L	2	<2	NSS	20	108	75	125			

Oil & Grease-AV/MS

Method: MOE E3401/SM 5520F | Internal ref.: ME-CA-[ENVIGC-LAK-AN-019

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
Oil & Grease (animal/vegetable)	GCM0003-DEC19	mg/L	4	< 4	NSS	20	NA	70	130			
Oil & Grease (mineral/synthetic)	GCM0003-DEC19	mg/L	4	< 4	NSS	20	NA	70	130			

Petroleum Hydrocarbons (F1)

Method: CCME Tier 1 | Internal ref.: ME-CA-[ENVIGC-LAK-AN-010

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
F1 (C6-C10)	GCM0066-DEC19	ug/L	25	<25	ND	30	103	60	140	101	60	140

QC SUMMARY

Petroleum Hydrocarbons (F2-F4)

Method: CCME Tier 1 | Internal ref.: ME-CA-[ENV]GC-LAK-AN-010

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
F2 (C10-C16)	GCM0005-DEC19	µg/L	100	<100	32	30	87	60	140	106	60	140
F3 (C16-C34)	GCM0005-DEC19	µg/L	200	<200	33	30	87	60	140	106	60	140
F4 (C34-C50)	GCM0005-DEC19	µg/L	200	<200	ND	30	87	60	140	106	60	140

pH

Method: SM 4500 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0009-DEC19	no unit	0.05	NA	0		100			NA		

QC SUMMARY

Phenols by SFA

Method: SM 5530B-D | Internal ref.: ME-CA-[ENV]SFA-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
4AAP-Phenolics	SKA0014-DEC19	mg/L	0.001	<0.001	ND	10	106	90	110	96	75	125
4AAP-Phenolics	SKA0022-DEC19	mg/L	0.001	<0.001	ND	10	99	90	110	93	75	125

Semi-Volatile Organics

Method: EPA 3510C/8270D | Internal ref.: ME-CA-[ENV]GC-LAK-AN-005

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
Naphthalene	GCM0045-DEC19	ug/L	0.5	< 0.5	39	30	100	50	140	104	50	140

Suspended Solids

Method: SM 2540D | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-004

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
Total Suspended Solids	EWL0005-DEC19	mg/L	2	< 2	2	10	NV	90	110	NA		

QC SUMMARY

Total Nitrogen

Method: SM 4500-N C/4500-NO3- F | Internal ref.: ME-CA-[ENV]SFA-LAK-AN-002

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
Total Kjeldahl Nitrogen	SKA0017-DEC19	as N mg/L	0.5	<0.5	ND	10	106	90	110	111	75	125

Volatile Organics

Method: EPA 5030B/8260C | Internal ref.: ME-CA-[ENV]GC-LAK-AN-004

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
1,4-Dichlorobenzene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	100	60	130	100	50	140
Benzene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	98	60	130	98	50	140
Chloroform	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	99	60	130	99	50	140
Ethylbenzene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	102	60	130	99	50	140
m/p-xylene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	102	60	130	100	50	140
Methylene Chloride	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	93	60	130	94	50	140
o-xylene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	101	60	130	99	50	140
Tetrachloroethylene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	99	60	130	98	50	140
Toluene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	99	60	130	99	50	140
Trichloroethylene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	98	60	130	97	50	140

QC SUMMARY

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.

-- End of Analytical Report --

Request for Laboratory Services and CHAIN OF CUSTODY

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

No:

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: Oleg Mozhiv
Received Date: 11/29/19 (mm/dd/yy)
Received Time: 12 : 46 (hr : min)
Received By (signature):
Custody Seal Present: Yes ☑ No ☐
Custody Seal Intact: Yes ☑ No ☐
Cooling Agent Present: Yes ☐ No ☐ Type: Ice
Temperature Upon Receipt (°C) 5 , 5 , 5
LAB LIMS #: GA15941-NOV19

REPORT INFORMATION	INVOICE INFORMATION
Company: Thurber Engineering Ltd.	☐ (same as Report Information)
Contact: Karel Furbacher/John Zoldy	Company: Thurber Engineering Ltd.
Address: 2010 Winston Park Drive, Suite 103, Oakville, ON, L6H 5R7	Contact: Judy Bikas
Phone: 905-829-8666	Address: 2010 Winston Park Drive, Suite 103, Oakville, ON, L6H 5R7
Fax:	Phone: 905-829-8666
Email: kfurbacher@thurber.ca;jzoldy@thurber.ca	Email: jbikas@thurber.ca

Quotation #: 2019 818
P.O. #:
Project #: 25063
Site Location/ID:

TURNAROUND TIME (TAT) REQUIRED

☒ Regular TAT (5-7days)
TAT's are quoted in business days (exclude statutory holidays & weekends).
Samples received after 6pm or on weekends: TAT begins next business day

RUSH TAT (Additional Charges May Apply): ☐ 1 Day ☐ 2 Days ☐ 3 Days ☐ 4 Days
PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date:

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

REGULATIONS

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

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

Sewer By-Law:
☑ Sanitary
☑ Storm
Municipality: Halton

RECORD OF SITE CONDITION (RSC) ☐ YES ☒ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Thurb-Halt-PWQO-153 Package(Pkg A)		Thrub-PWQO-153 (Package B)																		COMMENTS:
1	19-43B	11/28/19	10:30	22	water	✓																				
2	[redacted]	↓	2:00	22	water	✓																				
3	[redacted]	↓	4:00	22	water	✓						✓														
4	19-44	↓	12:00	22	water	✓																				
5																										
6																										
7																										
8																										
9																										
10																										
11																										
12																										

Observations/Comments/Special Instructions

Sampled By (NAME): JACQUELINE PIGEON Signature: Date: 11/28/19 (mm/dd/yy)
Relinquished by (NAME): KAREL FURBACHER Signature: Date: 11/29/19 (mm/dd/yy)

Pink Copy - Client
Yellow & White Copy - SGS

Revision #: 1.2
Date of Issue: 09 Sept, 2019

FINAL REPORT

CA15941-NOV19 R1

25063

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Brad Moore Hon. B.Sc
		Laboratory	SGS Canada Inc.
Address	103 2010 Winston Park Drive, Oakville Canada, L6H 5R7 Phone: 289-455-7296. Fax:	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Karel Furbacher	Telephone	705-652-2143
Telephone	289-455-7296	Facsimile	705-652-6365
Facsimile		Email	brad.moore@sgs.com
Email	kfurbacher@thurber.ca	SGS Reference	CA15941-NOV19
Project	25063	Received	11/29/2019
Order Number		Approved	12/12/2019
Samples	Ground Water (4)	Report Number	CA15941-NOV19 R1
		Date Reported	12/12/2019

COMMENTS

RL - SGS Reporting Limit

Temperature of Sample upon Receipt: 5 degrees C
Cooling Agent Present:Yes
Custody Seal Present:Yes

Chain of Custody Number:NA

PHC's F2 (C10-C16)and F3 (C16-C34) Duplicate; RPD is outside tolerance due to sample heterogeneity; organics extractions are whole bottle analysis and as such sample duplicates are “field” duplicates. Due to the limited solubility of PHCs in water, it can be difficult to obtain homogeneous field duplicates resulting in variability between sub-samples that exceed the method RPD criteria.

Naphthalene Duplicate; RPD for this parameter is outside control limits. The average of the two duplicates is less than five times the RL therefore a greater uncertainty is expected.

PWQO - Provincial Water Quality Objectives
Limits based on MOE PIBS 3303E publication July 1994 reprinted February 1999
a PWQO limit based on pH >6.5-9.0 (at pH 4.5-5.5 PWQO = 15ug/L, pH >5.5-6.5 PWQO 10% above background levels in geological area.
b PWQO limit based on Hardness <75 mg/L (For Hardness >75 mg/L PWQO = 1100 ug/L)
c PWQO limit based on Hardness 0-100 mg/L(For Hardness >100 mg/L PWQO = 0.5 ug/L)
d PWQO limit based on Cr VI (PWQO limit for Cr III = 8.9 ug/L)
e PWQO limit based on Hardness 0-20 (For Hardness >20 mg/L PWQO = 5 ug/L)
f PWQO limit based on Hardness <30 (For Hardness 30-80 PWQO = 3 ug/L, & >80 PWQO=5)

SIGNATORIES

Brad Moore Hon. B.Sc

TABLE OF CONTENTS

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **BTEX** (WATER)

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

L2 = SANSEW / WATER / - - Halton Sewer Discharge By Law - Sanitary and Combined Sewer Discharge - BL_2_03

Sample Number					8	11
Sample Name					19-43B	19-44
Sample Matrix					Ground Water	Ground Water
Sample Date					28/11/2019	28/11/2019
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
BTEX						
Benzene	ug/L	0.5	100	10	< 0.5	< 0.5
Ethylbenzene	ug/L	0.5	8	160	< 0.5	< 0.5
Toluene	ug/L	0.5	0.8	16	< 0.5	< 0.5
Xylene (total)	ug/L	0.5			< 0.5	< 0.5
m/p-xylene	ug/L	0.5	2		< 0.5	< 0.5
o-xylene	ug/L	0.5	40		< 0.5	< 0.5
General Chemistry						
Conductivity	uS/cm	2			601	2010
Alkalinity	mg/L as CaCO3	2			258	168
Carbonate	mg/L as CaCO3	2			< 2	< 2
Bicarbonate	mg/L as CaCO3	2			258	168
Biochemical Oxygen Demand (BOD5)	mg/L	2		300	< 4 ↑	5
Total Suspended Solids	mg/L	2		350	4	22
Total Kjeldahl Nitrogen	as N mg/L	0.5		100	0.6	1.4

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **Metals and Inorganics** (WATER)

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

L2 = SANSEW / WATER / - - Halton Sewer Discharge By Law - Sanitary and Combined Sewer Discharge - BL_2_03

Sample Number	8	11
Sample Name	19-43B	19-44
Sample Matrix	Ground Water	Ground Water
Sample Date	28/11/2019	28/11/2019

Parameter	Units	RL	L1	L2	Result	Result
Metals and Inorganics						
Cyanide (total)	mg/L	0.01		2	< 0.01	< 0.01
Fluoride	mg/L	0.06		10	0.22	0.36
Bromide	mg/L	0.3			< 0.3	5.3
Sulphate	mg/L	0.2		1500	46	220
Hardness	mg/L as CaCO3	0.05			279	589
Aluminum (total)	µg/L	1	15	50000	12.1	245
Aluminum (0.2µm)	µg/L	1	15		1.6	5.0
Antimony (total)	µg/L	0.09	20	5000	< 0.09	0.19
Antimony (dissolved)	µg/L	0.09			< 0.09	< 0.09
Arsenic (total)	µg/L	0.2	5	1000	0.5	6.0
Arsenic (dissolved)	µg/L	0.2			0.6	6.1
Boron (dissolved)	µg/L	2			88	1110
Barium (dissolved)	µg/L	0.02			124	50.4
Beryllium (total)	µg/L	0.007	11	5000	< 0.007	0.028
Beryllium (dissolved)	µg/L	0.007			< 0.007	0.017
Cadmium (total)	µg/L	0.003	0.1	1000	< 0.003	0.003
Cadmium (dissolved)	µg/L	0.003			< 0.003	0.004
Chromium (total)	µg/L	0.08		3000	0.17	1.24
Chromium (dissolved)	µg/L	0.08			0.15	0.68
Cobalt (total)	µg/L	0.004	0.9	5000	0.050	0.357
Cobalt (dissolved)	µg/L	0.004			0.085	0.328
Copper (total)	µg/L	0.2	1	3000	< 0.2	0.8

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **Metals and Inorganics** (WATER)

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

L2 = SANSEW / WATER / - - Halton Sewer Discharge By Law - Sanitary and Combined Sewer Discharge - BL_2_03

Sample Number	8	11
Sample Name	19-43B	19-44
Sample Matrix	Ground Water	Ground Water
Sample Date	28/11/2019	28/11/2019

Parameter	Units	RL	L1	L2	Result	Result
Metals and Inorganics (continued)						
Copper (dissolved)	µg/L	0.2			< 0.2	0.2
Iron (total)	µg/L	7	300	50000	1200	441
Iron (dissolved)	µg/L	7			1080	323
Lead (total)	µg/L	0.01	1	3000	< 0.01	0.46
Lead (dissolved)	µg/L	0.01			< 0.01	0.20
Magnesium (dissolved)	ug/L	1			26800	56400
Manganese (total)	µg/L	0.01		5000	107	70.6
Manganese (dissolved)	µg/L	0.01			103	68.6
Molybdenum (total)	µg/L	0.04	40	5000	4.14	13.4
Molybdenum (dissolved)	µg/L	0.04			5.10	12.2
Nickel (total)	µg/L	0.1	25	3000	0.1	0.7
Nickel (dissolved)	µg/L	0.1			< 0.1	0.6
Potassium (dissolved)	ug/L	9			3230	10900
Phosphorus (total)	µg/L	3	10	10000	9	13
Phosphorus (dissolved)	µg/L	3			12	7
Selenium (total)	µg/L	0.04	100	5000	< 0.04	0.06
Selenium (dissolved)	µg/L	0.04			0.05	0.07
Silver (total)	µg/L	0.05	0.1	5000	< 0.05	< 0.05
Silver (dissolved)	µg/L	0.05			< 0.05	< 0.05
Sodium (dissolved)	µg/L	10			25600	154000
Tin (total)	µg/L	0.06		5000	0.68	1.99
Tin (dissolved)	µg/L	0.06			0.76	1.53
Titanium (total)	µg/L	0.05		5000	0.51	7.03

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **Metals and Inorganics** (WATER)

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

L2 = SANSEW / WATER / - - Halton Sewer Discharge By Law - Sanitary and Combined Sewer Discharge - BL_2_03

Sample Number	8	11
Sample Name	19-43B	19-44
Sample Matrix	Ground Water	Ground Water
Sample Date	28/11/2019	28/11/2019

Parameter	Units	RL	L1	L2	Result	Result
Metals and Inorganics (continued)						
Titanium (dissolved)	µg/L	0.05			0.91	2.82
Thallium (total)	µg/L	0.005	0.3		< 0.005	0.005
Thallium (dissolved)	µg/L	0.005			< 0.005	< 0.005
Uranium (dissolved)	µg/L	0.002			0.191	1.04
Vanadium (dissolved)	µg/L	0.01			0.07	0.15
Zinc (total)	µg/L	2	20	3000	< 2	5
Zinc (dissolved)	µg/L	2			7	3
Oil and Grease						
Oil & Grease (total)	mg/L	2			< 2	< 2
Oil & Grease (animal/vegetable)	mg/L	4		150	< 4	< 4
Oil & Grease (mineral/synthetic)	mg/L	4		15	< 4	< 4
Other (ORP)						
pH	no unit	0.05	8.5	10	8.06	7.87
Free Cyanide	µg/L	2	5		< 2	< 2
Chloride	mg/L	0.2			15	520
Chromium VI	µg/L	0.2	1		< 0.2	< 0.2
Mercury	µg/L	0.00001		50	< 0.00001	< 0.00001
Mercury (dissolved)	µg/L	0.01			< 0.01	< 0.01

Client: Thurber Engineering Ltd.
Project: 25063
Project Manager: Karel Furbacher
Samplers: Jacqueline Pigeon

PACKAGE: **PAHs** (WATER)

L1 = PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E

L2 = SANSEW / WATER / - - Halton Sewer Discharge By Law - Sanitary and Combined Sewer Discharge - BL_2_03

	Sample Number				8	11
	Sample Name				19-43B	19-44
	Sample Matrix				Ground Water	Ground Water
	Sample Date				28/11/2019	28/11/2019
Parameter	**Units**	**RL**	**L1**	**L2**	**Result**	**Result**
PAHs						
Naphthalene	µg/L	0.5	7	140	< 0.5	< 0.5
PHCs						
F1 (C6-C10)	µg/L	25			< 25	< 25
F1-BTEX (C6-C10)	µg/L	25			< 25	< 25
F2 (C10-C16)	µg/L	100			< 100	< 100
F3 (C16-C34)	µg/L	200			< 200	< 200
F4 (C34-C50)	µg/L	200			< 200	< 200
Chromatogram returned to baseline at nC50	Yes / No	no			YES	YES
Phenols						
4AAP-Phenolics	mg/L	0.001	0.001	1	< 0.001	0.002
VOCs						
Chloroform	µg/L	0.5		40	< 0.5	< 0.5
1,4-Dichlorobenzene	µg/L	0.5	4	80	< 0.5	< 0.5
Methylene Chloride	µg/L	0.5	100	2000	< 0.5	< 0.5
Tetrachloroethylene	µg/L	0.5	50	1000	< 0.5	< 0.5
Trichloroethylene	µg/L	0.5	20	400	< 0.5	< 0.5

EXCEEDANCE SUMMARY

Parameter	Method	Units	Result	PWQO / WATER / - - Table 2 - General - July 1999 PIBS 3303E L1	SANSEW / WATER / - - Halton Sewer Discharge By Law - Sanitary and Combined Sewer Discharge - BL_2_03 L2
19-43B					
Iron	SM 3030/EPA 200.8	µg/L	1200	300	
19-44					
Aluminum	SM 3030/EPA 200.8	µg/L	245	15	
Arsenic	SM 3030/EPA 200.8	µg/L	6.0	5	
Iron	SM 3030/EPA 200.8	µg/L	441	300	
Phosphorous	SM 3030/EPA 200.8	µg/L	13	10	
4AAP-Phenolics	SM 5530B-D	mg/L	0.002	0.001	

QC SUMMARY

Alkalinity

Method: SM 2320 I Internal ref.: ME-CA-[ENVIEWL-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
Alkalinity	EWL0009-DEC19	mg/L as CaCO3	2	< 2	5	10	100	80	120	NA		

Anions by IC

Method: EPA300/MA300-Ions1.3 I Internal ref.: ME-CA-[ENVIIC-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
Bromide	DIO0012-DEC19	mg/L	0.3	<0.3	ND	20	98	80	120	105	75	125
Chloride	DIO0014-DEC19	mg/L	0.2	<0.2	5	20	98	80	120	99	75	125
Sulphate	DIO0014-DEC19	mg/L	0.2	<0.2	8	20	98	80	120	98	75	125
Chloride	DIO0026-DEC19	mg/L	0.2	<0.2	5	20	97	80	120	122	75	125

QC SUMMARY

Biochemical Oxygen Demand

Method: SM 5210 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-007

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
Biochemical Oxygen Demand (BOD5)	BOD0059-NOV19	mg/L	2	< 2	18	30	100	70	130	NV	70	130

Carbonate/Bicarbonate

Method: SM 2320 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Carbonate	EWL0009-DEC19	mg/L as CaCO3	2	< 2	ND	10	NA	90	110	NA		
Bicarbonate	EWL0009-DEC19	mg/L as CaCO3	2	< 2	5	10	NA	90	110	NA		

QC SUMMARY

Conductivity

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0009-DEC19	uS/cm	2	3	0	10	100	90	110	NA		

Cyanide by SFA

Method: SM 4500 | Internal ref.: ME-CA-[ENV]SFA-LAK-AN-005

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
Cyanide (total)	SKA0018-DEC19	mg/L	0.01	<0.01	ND	10	101	90	110	90	75	125
Free Cyanide	SKA0052-DEC19	ug/L	2	<2	ND	10	92	90	110	91	75	125

Fluoride by Specific Ion Electrode

Method: SM 4500 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-014

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
Fluoride	EWL0004-DEC19	mg/L	0.06	<0.06	1	10	107	90	110	111	75	125

QC SUMMARY

Hexavalent Chromium by SFA

Method: EPA218.6/EPA3060A | Internal ref.: ME-CA-[ENVISKA-LAK-AN-012

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
Chromium VI	SKA0025-DEC19	ug/L	0.2	<0.2	3	20	103	80	120	90	75	125

Inorganics-General

Method: EPA 7471A/SM 3112B | Internal ref.: ME-CA-[ENVISPE-LAK-AN-004

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
Mercury	EHG0003-DEC19	ug/L	0.00001	< 0.00001	ND	20	100	80	120	101	70	130

Mercury by CVAAS

Method: EPA 7471A/SM 3112B | Internal ref.: ME-CA-[ENVISPE-LAK-AN-004

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
Mercury (dissolved)	EHG0003-DEC19	ug/L	0.01	< 0.00001	ND	20	100	80	120	101	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-IENVISPE-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
Silver (total)	EMS0001-DEC19	ug/L	0.05	<0.00005	ND	20	101	90	110	73	70	130
Aluminum (total)	EMS0001-DEC19	ug/L	1	<0.001	11	20	102	90	110	110	70	130
Aluminum (0.2µm)	EMS0001-DEC19	ug/L	1	<0.001	11	20	102	90	110	110	70	130
Arsenic (total)	EMS0001-DEC19	ug/L	0.2	<0.0002	ND	20	102	90	110	101	70	130
Barium (dissolved)	EMS0001-DEC19	ug/L	0.02	<0.00002	3	20	102	90	110	103	70	130
Beryllium (total)	EMS0001-DEC19	ug/L	0.007	<0.000007	ND	20	99	90	110	97	70	130
Boron (dissolved)	EMS0001-DEC19	ug/L	2	<0.002	8	20	104	90	110	NV	70	130
Cadmium (total)	EMS0001-DEC19	ug/L	0.003	<0.000003	6	20	101	90	110	106	70	130
Cobalt (total)	EMS0001-DEC19	ug/L	0.004	<0.000004	15	20	102	90	110	101	70	130
Chromium (total)	EMS0001-DEC19	ug/L	0.08	<0.00008	8	20	101	90	110	101	70	130
Copper (total)	EMS0001-DEC19	ug/L	0.2	<0.0002	0	20	104	90	110	104	70	130
Iron (total)	EMS0001-DEC19	ug/L	7	<0.007	11	20	105	90	110	NV	70	130
Potassium (dissolved)	EMS0001-DEC19	mg/L	9	<0.009	2	20	106	90	110	97	70	130
Magnesium (dissolved)	EMS0001-DEC19	mg/L	1	<0.001	2	20	104	90	110	100	70	130
Manganese (total)	EMS0001-DEC19	ug/L	0.01	<0.00001	2	20	103	90	110	98	70	130
Molybdenum (total)	EMS0001-DEC19	ug/L	0.04	<0.00004	12	20	103	90	110	109	70	130
Sodium (dissolved)	EMS0001-DEC19	mg/L	10	<0.01	2	20	103	90	110	99	70	130
Nickel (total)	EMS0001-DEC19	ug/L	0.1	<0.0001	2	20	102	90	110	100	70	130
Lead (total)	EMS0001-DEC19	ug/L	0.01	<0.00001	12	20	101	90	110	98	70	130
Phosphorus (total)	EMS0001-DEC19	ug/L	3	<0.003	ND	20	104	90	110	NV	70	130

QC SUMMARY

Metals in aqueous samples - ICP-MS (continued)

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-IENVISPE-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
Antimony (total)	EMS0001-DEC19	ug/L	0.09	<0.0009	ND	20	101	90	110	117	70	130
Selenium (total)	EMS0001-DEC19	ug/L	0.04	<0.00004	ND	20	106	90	110	102	70	130
Tin (total)	EMS0001-DEC19	ug/L	0.06	<0.00006	ND	20	100	90	110	NV	70	130
Titanium (total)	EMS0001-DEC19	ug/L	0.05	<0.00005	10	20	100	90	110	NV	70	130
Thallium (total)	EMS0001-DEC19	mg/L	0.005	<0.000005	ND	20	102	90	110	98	70	130
Uranium (dissolved)	EMS0001-DEC19	ug/L	0.002	<0.000002	ND	20	102	90	110	99	70	130
Vanadium (dissolved)	EMS0001-DEC19	ug/L	0.01	<0.00001	ND	20	102	90	110	101	70	130
Zinc (total)	EMS0001-DEC19	ug/L	2	<0.002	1	20	103	90	110	102	70	130
Aluminum (0.2µm)	EMS0032-DEC19	ug/L	1	<0.001	2	20	109	90	110	NV	70	130

Metals in aqueous samples - ICP-OES

Method: SM 3030/EPA 200.8 | Internal ref.: ME-CA-IENVISPE-LAK-AN-003

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
Hardness	EMS0001-DEC19	mg/L as CaCO3	0.05	<0.05	1	20	104	90	110	100	70	130

QC SUMMARY

Oil & Grease

Method: MOE E3401 | Internal ref.: ME-CA-[ENVIGC-LAK-AN-019

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
Oil & Grease (total)	GCM0003-DEC19	mg/L	2	<2	NSS	20	108	75	125			

Oil & Grease-AV/MS

Method: MOE E3401/SM 5520F | Internal ref.: ME-CA-[ENVIGC-LAK-AN-019

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
Oil & Grease (animal/vegetable)	GCM0003-DEC19	mg/L	4	< 4	NSS	20	NA	70	130			
Oil & Grease (mineral/synthetic)	GCM0003-DEC19	mg/L	4	< 4	NSS	20	NA	70	130			

Petroleum Hydrocarbons (F1)

Method: CCME Tier 1 | Internal ref.: ME-CA-[ENVIGC-LAK-AN-010

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
F1 (C6-C10)	GCM0066-DEC19	ug/L	25	<25	ND	30	103	60	140	101	60	140

QC SUMMARY

Petroleum Hydrocarbons (F2-F4)

Method: CCME Tier 1 | Internal ref.: ME-CA-[ENV]GC-LAK-AN-010

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
F2 (C10-C16)	GCM0005-DEC19	µg/L	100	<100	32	30	87	60	140	106	60	140
F3 (C16-C34)	GCM0005-DEC19	µg/L	200	<200	33	30	87	60	140	106	60	140
F4 (C34-C50)	GCM0005-DEC19	µg/L	200	<200	ND	30	87	60	140	106	60	140

pH

Method: SM 4500 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0009-DEC19	no unit	0.05	NA	0		100			NA		

QC SUMMARY

Phenols by SFA

Method: SM 5530B-D | Internal ref.: ME-CA-[ENV]SFA-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
4AAP-Phenolics	SKA0014-DEC19	mg/L	0.001	<0.001	ND	10	106	90	110	96	75	125
4AAP-Phenolics	SKA0022-DEC19	mg/L	0.001	<0.001	ND	10	99	90	110	93	75	125

Semi-Volatile Organics

Method: EPA 3510C/8270D | Internal ref.: ME-CA-[ENV]GC-LAK-AN-005

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
Naphthalene	GCM0045-DEC19	ug/L	0.5	< 0.5	39	30	100	50	140	104	50	140

Suspended Solids

Method: SM 2540D | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-004

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
Total Suspended Solids	EWL0005-DEC19	mg/L	2	< 2	2	10	NV	90	110	NA		

QC SUMMARY

Total Nitrogen

Method: SM 4500-N C/4500-NO3- F | Internal ref.: ME-CA-[ENV]SFA-LAK-AN-002

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
Total Kjeldahl Nitrogen	SKA0017-DEC19	as N mg/L	0.5	<0.5	ND	10	106	90	110	111	75	125

Volatile Organics

Method: EPA 5030B/8260C | Internal ref.: ME-CA-[ENV]GC-LAK-AN-004

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
1,4-Dichlorobenzene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	100	60	130	100	50	140
Benzene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	98	60	130	98	50	140
Chloroform	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	99	60	130	99	50	140
Ethylbenzene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	102	60	130	99	50	140
m/p-xylene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	102	60	130	100	50	140
Methylene Chloride	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	93	60	130	94	50	140
o-xylene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	101	60	130	99	50	140
Tetrachloroethylene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	99	60	130	98	50	140
Toluene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	99	60	130	99	50	140
Trichloroethylene	GCM0016-DEC19	ug/L	0.5	<0.5	ND	30	98	60	130	97	50	140

QC SUMMARY

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.

-- End of Analytical Report --

Request for Laboratory Services and CHAIN OF CUSTODY

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

No:

Page 1 of 1

Laboratory Information Section - Lab use only

Received By: Oleg Mozhiv
Received Date: 11/29/19 (mm/dd/yy)
Received Time: 12:46 (hr : min)
Received By (signature):
Custody Seal Present: Yes ☑ No ☐
Custody Seal Intact: Yes ☑ No ☐
Cooling Agent Present: Yes ☐ No ☐ Type: Ice
Temperature Upon Receipt (°C) 5, 5, 5
LAB LIMS #: GA15941-NOV19

REPORT INFORMATION	INVOICE INFORMATION
Company: Thurber Engineering Ltd.	☐ (same as Report Information)
Contact: Karel Furbacher/John Zoldy	Company: Thurber Engineering Ltd.
Address: 2010 Winston Park Drive, Suite 103, Oakville, ON, L6H 5R7	Contact: Judy Bikas
Phone: 905-829-8666	Address: 2010 Winston Park Drive, Suite 103, Oakville, ON, L6H 5R7
Fax:	Phone: 905-829-8666
Email: kfurbacher@thurber.ca;jzoldy@thurber.ca	Email: jbikas@thurber.ca

Quotation #: 2019 818
P.O. #:
Project #: 25063
Site Location/ID:

TURNAROUND TIME (TAT) REQUIRED

☒ Regular TAT (5-7days)

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

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

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date:

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

REGULATIONS

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

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

Sewer By-Law:
☑ Sanitary
☑ Storm
Municipality: Halton

RECORD OF SITE CONDITION (RSC) ☐ YES ☒ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Thurb-Halt-PWQO-153 Package(Pkg A)		Thrub-PWQO-153 (Package B)																		COMMENTS:
1	19-43B	11/28/19	10:30	22	water	✓																				
2	[redacted]	↓	2:00	22	water	✓																				
3	[redacted]	↓	4:00	22	water	✓						✓														
4	19-44	↓	12:00	22	water	✓																				
5																										
6																										
7																										
8																										
9																										
10																										
11																										
12																										

Observations/Comments/Special Instructions

Sampled By (NAME): JACQUELINE PIGEON **Signature:** [signature] Date: 11/28/19 (mm/dd/yy)
Relinquished by (NAME): KAREL FURBACHER **Signature:** [signature] Date: 11/29/19 (mm/dd/yy)

Pink Copy - Client
Yellow & White Copy - SGS

Revision #: 1.2
Date of Issue: 09 Sept, 2019

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

THURBER

Appendix H

Tunnelman’s Ground Classification System

Tunnelman's Ground Classification System (after Heuer, 1974)

Classification		Behaviour	Typical Soil Type
Firm		Heading can be advanced without initial support, and final lining can be constructed before ground starts to move.	Loess above water table; hard clay, marl, cemented sand and gravel when not highly overstressed.
Raveling	Slow Raveling	Chunks or flakes of material begin to drop out of the arch or walls sometime after the ground has been exposed; due to loosening or to overstress and "brittle" fracture (ground separates or breaks along distinct surfaces opposed to squeezing ground). In fast raveling ground, the process starts within a few minutes; otherwise the ground is slow raveling.	Residual soils or sand with small amounts of binder may be fast raveling below the water table, slow raveling above. Stiff fissured clays may be slow or fast raveling depending upon degree of overstress.
	Fast Raveling		
Squeezing		Ground squeezes or extrudes plastically into tunnel, without visible fracturing or loss of continuity, and without perceptible increase in water content. Ductile, plastic yield and flow due to overstress.	Ground with low frictional strength. Rate of squeeze depends on degree of overstress. Occurs at shallow to medium depth in clay of very soft to medium consistency. Stiff to hard clay under high cover may move in combination with ravelling at excavation surface and squeezing at depth behind surface.
Running	Cohesive Running	Granular materials without cohesion are unstable at a slope greater than their angle of repose (+/-30^{o} to 35^{o}). When exposed at steeper slopes they run like granulated sugar or dune sand until the slope flattens to the angle of repose.	Clean dry granular materials. Apparent cohesion in moist sand, or weak cementation in any granular soil, may allow the material to stand for a brief period of ravelling before it breaks down and runs. Such behaviour is cohesive-running.
	Running		
Flowing		A mixture of soil and water flows into the tunnel like a viscous fluid. The material can enter the tunnel from the invert as well as the face, crown, and walls, and can flow for great distances, completely filling the tunnel in some cases.	Below the water table in silt, sand or gravel without enough clay content to give significant cohesion and plasticity. May also occur in highly sensitive clay when such material is disturbed.
Swelling		Ground absorbs water, increases in volume, and expands slowly into the tunnel.	Highly pre-consolidated clay with plasticity index in excess of about 30, generally containing significant percentages of montmorillonite.

Modified from Terzaghi (1950)

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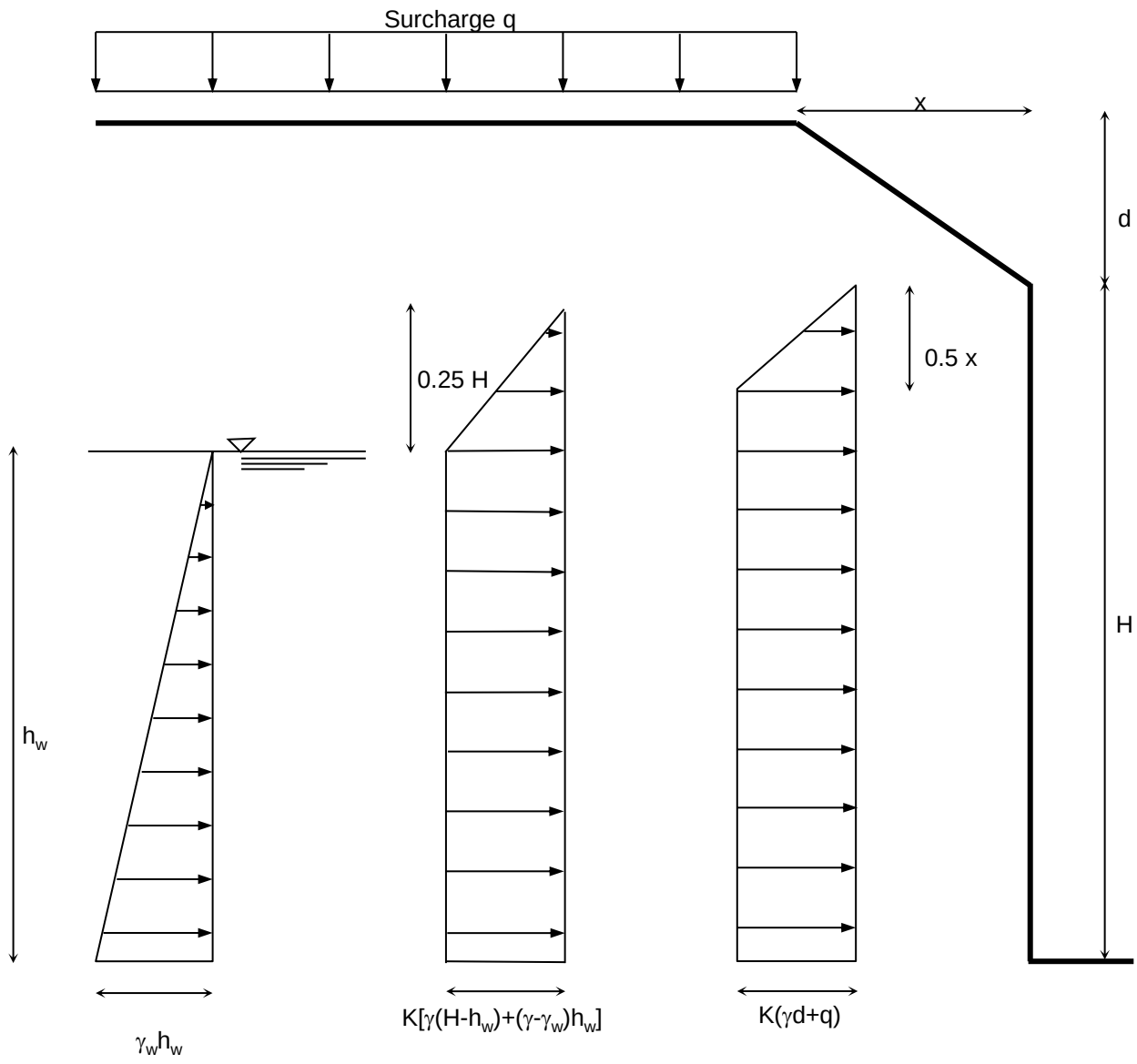
Appendix I

Lateral Earth Pressure Figures



H = shoring wall height above base of excavation

h_w = 0 (free draining retaining wall)

γ = unit weight of soil

γ_w = unit weight of water

K = earth pressure coefficient

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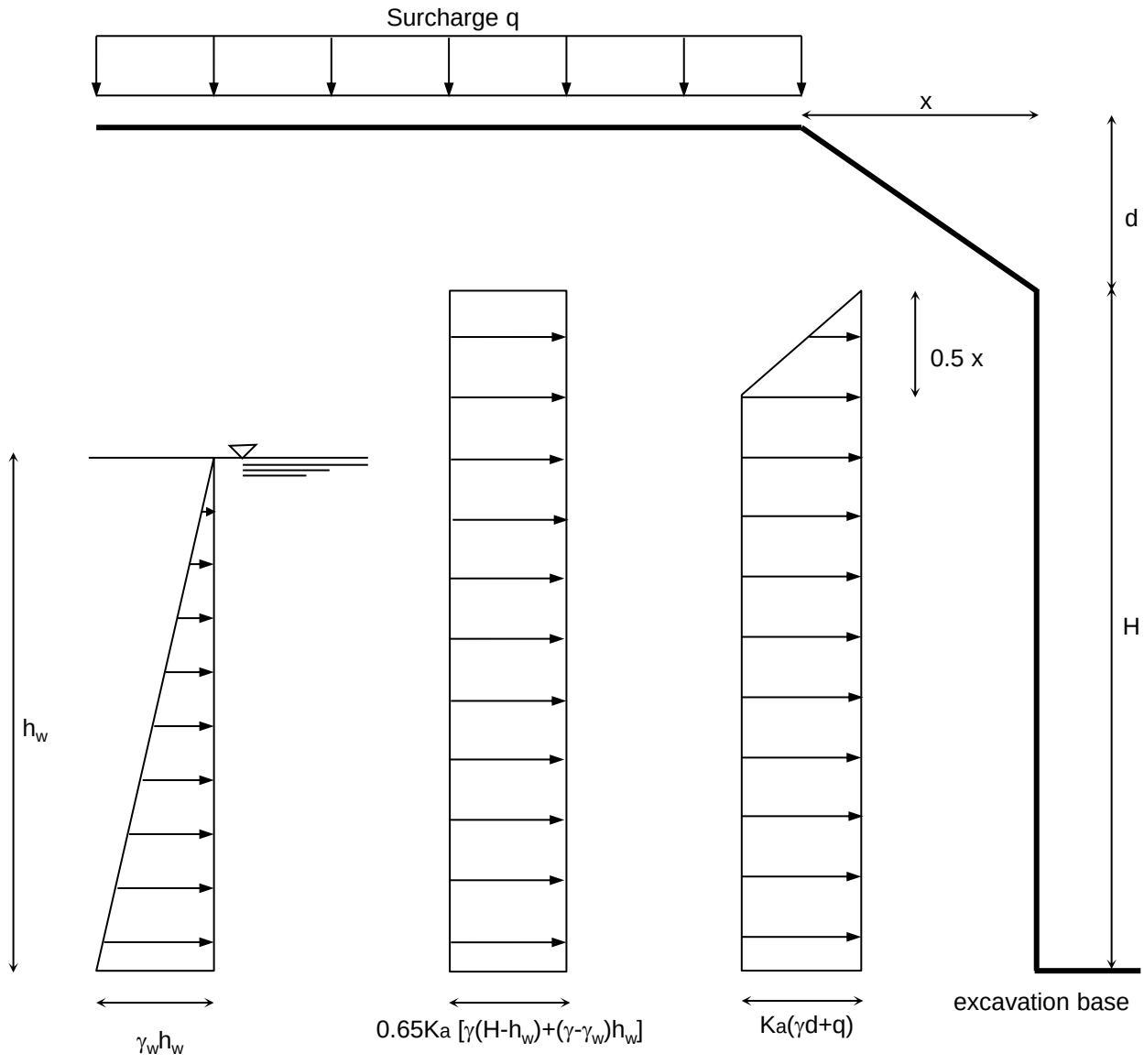
LATERAL PRESSURE DISTRIBUTION
Temporarily Braced Shoring
Stiff Cohesive Soils

FIGURE I1



H = retaining wall height above top of rock

h_w = see geotechnical report for groundwater conditions

γ = unit weight of soil

γ_w = unit weight of water

K = earth pressure coefficient

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LATERAL PRESSURE DISTRIBUTION

Temporarily Braced Shoring in Sand

FIGURE I2

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Appendix J

Instrumentation and Monitoring Plan

MONITORING PROGRAM **- Item No.**
PROPOSED TRENCHLESS CROSSING

Special Provision

GENERAL

1.1 Scope

This special provision contains the requirements for the supply, installation and monitoring of the following instruments:

- Surface Monitoring Point (SMP)
- Settlement Rod (SR)

The instruments shall be installed along the centreline of the trenchless crossing and in array. Each array consists of a group of instruments installed approximately perpendicular to the trenchless crossing.

1.2 Purpose

The purpose of these instruments is to monitor settlements during trenchless installation of the proposed wastewater main under Highway 401.

The methodologies and rate of installation may need to be adjusted as a result of the instrumentation readings.

1.3 Contractor's Scope of Work

The Contractor shall be fully responsible to procure, install, protect, monitor, reduce and transmit data for all monitoring instruments and to decommission the instruments as described herein.

The required survey of all the instruments shall be carried out by the Contractor's qualified surveyors.

1.4 Or equal

The term ‘or equal’ shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration.

1.5 Notification

The Owner, the Ontario Ministry of Transportation (MTO), the Contract Administrator (CA), and CA’s Geotechnical Consultant, shall be notified five days in advance of commencing the installation of instruments. All instruments shall be installed and their baseline readings (see Section 6.3) established to the satisfaction of all parties listed above not less than five days in advance of the trenchless installation operations.

1.6 Instrument Installation and Monitoring Requirements

The Contractor shall be prepared to install and monitor all instruments.

1.7 Drawings

Reference shall be made to Drawing J1 in Appendix J for instrument locations.

1.8 Subsurface Conditions

The subsurface conditions at the site are described in Thurber’s Report titled: “Foundation Investigation and Design Report, South Georgetown Wastewater Servicing, Wastewater Main, Trenchless Crossing under Highway 401 at Eighth Line South, Milton & Halton Hills, Ontario, by Thurber Engineering Ltd., Reference No. 25063, dated March 30, 2020”.

2 INSTALLATION

2.1 Generals

SMPs will be installed along the centreline of traffic lanes and / or paved shoulders in arrays of either three (3) instruments or one (1) single instrument. SRs will be installed on the side slopes along the proposed sewer centreline.

2.2 Instrument Location

The Contractor's surveyors shall accurately survey the location of each instrument to obtain coordinates and elevations.

2.3 Survey Benchmarks

The Contractor's surveyors shall identify or establish non-yielding survey benchmarks (BM) at the site in order to carry out elevation surveying and achieve the accuracy specified below.

2.4 Accuracy of Surveying for Elevations

Elevations shall be surveyed to an accuracy of $\pm$ 2 millimetres or better.

2.5 Materials and Equipment

The Contractor shall supply all materials and equipment required for installation of the instrumentation.

2.6 Protection of Instruments

All instruments shall be adequately protected by the Contractor such that they are not damaged during construction. Any instrument damaged directly or indirectly by the Contractor's work shall be immediately replaced by the Contractor at the Contractor's expense.

Instruments installed in the travelled portion of the roadway (lanes and shoulders) shall be protected to avoid puncturing of vehicle tires.

2.7 Installation Program

Instrument installation and baseline readings shall be completed before any trenchless installation operations.

3 SURFACE MONITORING POINT (SMP) - SUPPLY & INSTALLATION

3.1 General

3.1.1 Scope

This Section contains the requirements for the supply and installation of SMPs.

The purpose of SMP is to monitor settlement of asphalt paved surface. The ground movement readings shall assist in assessing the sewer performance and any need to modify the installation methodology as required. Settlement is measured by level surveying the SMPs with reference to stable, non-settling benchmarks.

3.1.2 General Procedure

SMPs shall be rigidly affixed so as not to move relative to the asphalt pavement surface to which they are attached.

3.1.3 Location

The locations of SMPs are shown on Drawing J1.

3.2 Materials

3.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the SMPs.

3.2.2 Steel Markers

The Contractor shall supply hardened steel markers with an exposed convex head, similar to surveyor's PK nails, treated or coated to resist corrosion. The steel markers shall have a minimum diameter of 12 mm and have sufficient length for anchoring in the pavement and to withstand the weather conditions and effects of traffic.

The exposed nail head shall be equipped with reflective paint or reflective tape to allow for measurements with total-station equipment.

3.3 Installation

3.3.1 General

Traffic shall be managed by the Contractor using short term lane closures in accordance with the Ontario Traffic Manual (OTM), Book 7.

3.4 Documentation

Relevant installation details shall be recorded and documented. These include, but are not limited to:

- SMP easting, northing and elevation;
- Dates of installation;
- Installation notes / sketches.

4 SETTLEMENT ROD (SR) - SUPPLY & INSTALLATION

4.1 General

4.1.1 Scope

This Section contains the requirements for the supply and installation of SRs.

The purpose of SR is to monitor the settlement of the ground and highway embankments along the proposed sewer alignment. The settlement readings shall assist in assessing the sewer performance and any need to modify the installation methodology as required. Settlement is measured by surveying the top of the rod with reference to stable, non-settling benchmarks.

4.1.2 General Procedure

The SR shall consist of a 12 to 18 mm diameter rebar encased in a PVC pipe used as a friction reducing sleeve.

The assembly shall be placed in a drilled hole and backfilled with anchor grout and clean washed sand.

4.1.3 Location

The locations of SRs are shown on Drawing J1.

4.2 Materials

4.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the SRs.

4.2.2 Rod

The Contractor shall supply 12 to 18 mm diameter steel rebars in the required lengths in order to complete this installation.

The top end of each rod shall be equipped with reflective paint or reflective tape to allow for measurements with total-station equipment.

4.2.3 Anchor

The Contractor shall supply concrete for anchoring the lower end of the steel rebar. The concrete shall be prepared in accordance with OPSS 1350 with a minimum compressive strength of 10 MPa.

4.2.4 Sand

The Contractor shall supply clean washed sand. The sand will be Sakcrete washed general purpose sand, or equal.

4.2.5 Friction Reducing Sleeve

The Contractor shall supply a friction reducing sleeve consisting of Schedule 40, 50 mm O.D. PVC pipe cut perpendicular to the axis of the pipe.

4.2.6 Protective Casing

The Contractor shall supply protective steel casings installed flush with the ground surface where the SRs are installed in shoulders that can be travelled by vehicles.

4.3 Installation

4.3.1 General

The Contractor shall install SRs as stated or emphasized below. Traffic control for instrument installation shall be managed by the Contractor, as required, using short term lane closures in accordance with the Ontario Traffic Manual (OTM), Book 7.

4.3.2 Rod

The rod shall be centered in the borehole.

4.3.3 Friction Reducing Sleeve

The friction reducing sleeve shall extend for the length of the rod above the anchor grout.

4.4 Documentation

Relevant installation details shall be recorded and documented. These include, but are not limited to:

- SR location, easting and northing;
- Elevation of top of rod;
- Dates of installation;
- Installation notes / sketches.

5 DECOMMISSIONING OF INSTRUMENTS

5.1 General

The Contractor shall decommission all SMPs and SRs after the completion of the monitoring program as directed by CA and CA's Geotechnical Consultant.

6.1 General

The instrumentation monitoring services specified herein apply to all the SMPs and SPs for this site. The requirements include data collection, reporting, data reduction and data transmission.

The Monitoring Consultant shall carry out the monitoring program for this project. The required tasks include the following:

- Supply materials and equipment required for monitoring;
- Survey the instruments with no interference with the traffic on the highway and its ramps;
- Compile and reduce the survey data as described in Section 6.4.2;
- Transmit the settlement data and associated pipe installation / construction activities to CA, CA's Geotechnical Consultant and MTO;
- Notify CA, CA's Geotechnical Consultant and MTO of any required modifications to the construction procedures;
- Notify CA, CA's Geotechnical Consultant and MTO of any modifications of the original site conditions related to pipe installation or otherwise, including appearance of cracks on the pavement and shoulder, concrete barriers etc;
- Notify immediately CA, CA's Geotechnical Consultant and MTO if Review or Alert Levels have been reached or exceeded and follow the procedures outlined in Section 6.5.

6.2 Purpose

The purpose of this program is to monitor settlement of the paved surfaces and embankments at selected locations during the trenchless installation of the sewer

The rate and / or methodology of trenchless installation may need to be adjusted based on the instrumentation readings.

6.3 Reading Schedule and Frequency

The Contractor shall keep a complete record in electronic and hard copy formats of all instrumentation survey and associated data, including the location of the advancing face at the time of each survey.

Monitoring shall commence after the installation of an instrument. Monitoring is to continue as specified in this document and as required by CA and CA's Geotechnical Consultant.

The minimum monitoring frequencies along with the anticipated number of readings are given in Table 6.1 below. The monitoring frequency is the same for each individual instrument. Instruments shall be read more frequently as required by CA and CA's Geotechnical Consultant.

Table 6.1 - Minimum Monitoring Frequency

STAGE	FREQUENCY	ANTICIPATED NO. OF READINGS PER INSTRUMENT (**)
Baseline Readings (*)	3 readings on 2 consecutive days	3
Just prior to start of trenchless installation	Once	1
During trenchless installation	A minimum of three (3) sets of readings be taken daily for all instruments located, provided that movements are within anticipated limits. Monitoring of movements is also required during work stoppages, such as during non-operation periods (off-shifts) or weekends.	Variable
After completion of installation	After the end of installation, all instruments shall be read weekly for the first month.	4

(*) Baseline Readings: Instrument elevation readings taken prior to trenchless installation to provide a baseline against which all subsequent readings are compared to assess settlements of the ground.
(**) Number of readings may vary.

6.4 Specific Requirements

6.4.1 Surveying

The elevations of the instruments shall be surveyed to an accuracy of plus/minus two (±2) millimetres or better, and shall be reported to the nearest millimetre. Shoulder and lane closures for instrument readings are not permitted.

6.4.2 Data Recording and Data Reduction

For every instrument elevation reading the following information shall be recorded electronically in an Excel spreadsheet containing the following information:

- Date and time of the day
- Location of the advancing face (i.e. distance from launching point) at the time of data recording
- Construction activities (e.g. sewer installation underway; weekend – no construction; boulder encountered at the advancing face of installation, etc)
- Pavement visual survey (e.g.: No visual pavement distress; 1 mm wide, 3 m long pavement crack parallel to west shoulder and close to instruments No. A, B and C, sketches and photos, etc.)
- Instrument Number
- Settlement Array Number
- Horizontal distance measured along the sewer alignment between the advancing face of installation and the instrument or array of instruments that contains the instrument being monitored
- Instrument elevation
- Instrument settlement

The settlement data shall be presented in X-Y charts as follows:

- Settlement versus Time for each instrument
- Settlement versus Distance from the advancing face of installation for each instrument
- Settlement profile for different dates along each of the sewer alignment
- Settlement profile for different dates along each of the settlement arrays

Reported information should be supplemented by sketches, diagrams and plots as necessary.

6.4.3 Data Transmission

All settlement data obtained on a particular day shall be reported in electronic format to CA, CA's Geotechnical Consultant and MTO not later than mid-day on the next calendar day. Any unusual movements deduced from the field data must be reported immediately before leaving the site.

6.5 Criteria for Assessment

The following settlement levels are to be observed:

Review Level – A maximum value of 10 mm relative to the baseline or zero readings. If the Review Level is exceeded, the Contractor shall immediately notify CA, CA's Geotechnical Consultant and MTO, and review and discuss response actions. The Contractor shall submit a plan of action to prevent Alert Level from being reached. All construction work shall be continued such that Alert Level is not reached.

Alert Level – A maximum value of 15 mm relative to the baseline or zero readings. If the Alert Level is reached or exceeded, or lesser ground settlements cause or threaten to cause damage to utilities or the highway pavement, as indicated by monitoring instruments or direct observation, the Contractor shall cease installation operation immediately and inform CA, CA's Geotechnical Consultant and MTO. No construction shall take place until all the following conditions are satisfied:

- The cause of the settlement has been identified;
- The Contractor submits a corrective / preventive plan;
- Any corrective and / or preventive measure deemed necessary by the Contractor is implemented;
- CA, CA's Geotechnical Consultant and MTO deem it is safe to proceed.

7 CONTRACTOR'S RESPONSIBILITY FOR RESTORATION

Notwithstanding the monitoring program to assess the adequacy of the trenchless installation method to control potential ground movements and groundwater, the Contractor is responsible for reinstatement (such as surface paving and fill placement) should ground movements or other surface distress occurs.

LEGEND:

- SURFACE MONITORING POINT (SMP)
- SETTLEMENT ROD (SR)

8 0 8 16m

SCALE 1:400

HATCH

SOUTH GEORGETOWN WASTEWATER SERVICING
WASTEWATER MAIN
HIGHWAY 401 CROSSING
MILTON & HALTON HILLS, ONTARIO
INSTRUMENTATION AND MONITORING PROGRAM

JOB# 25063

THURBER ENGINEERING LTD.

ENGINEER:	DRAWN:	APPROVED:
KF	AN	RP
DATE:	SCALE:	DRAWING No.
MARCH 2020	1:400	J1

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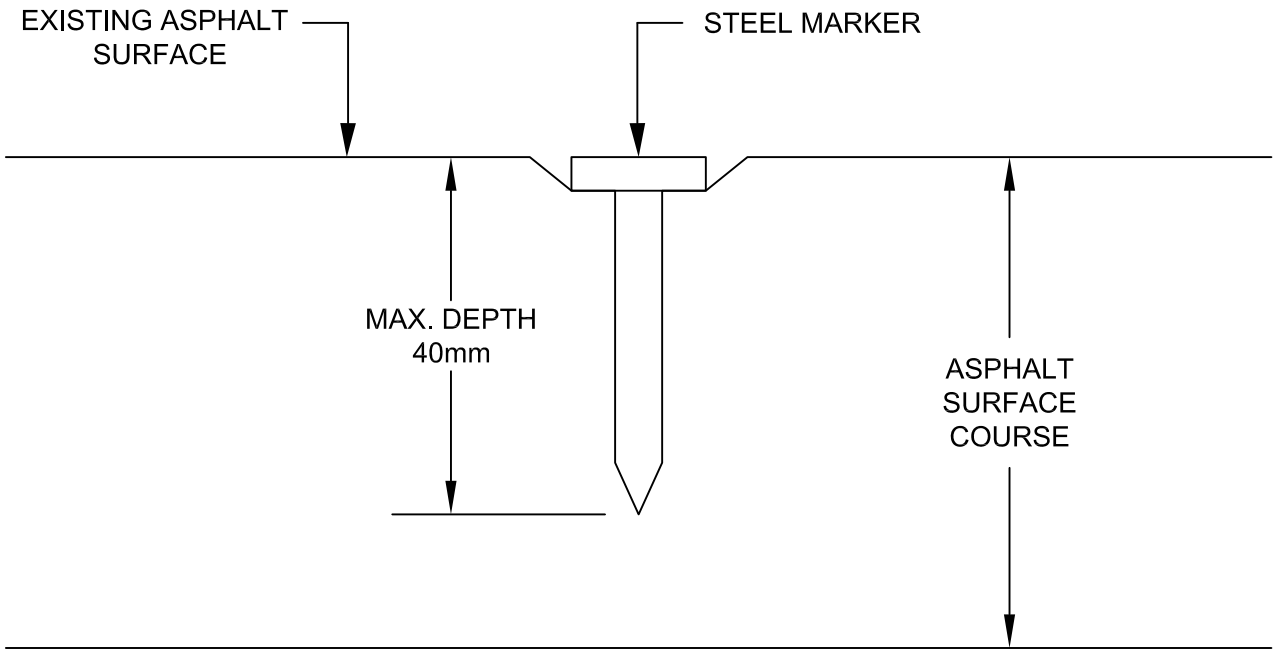

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SURFACE MONITORING POINT DETAILS

FIGURE 1

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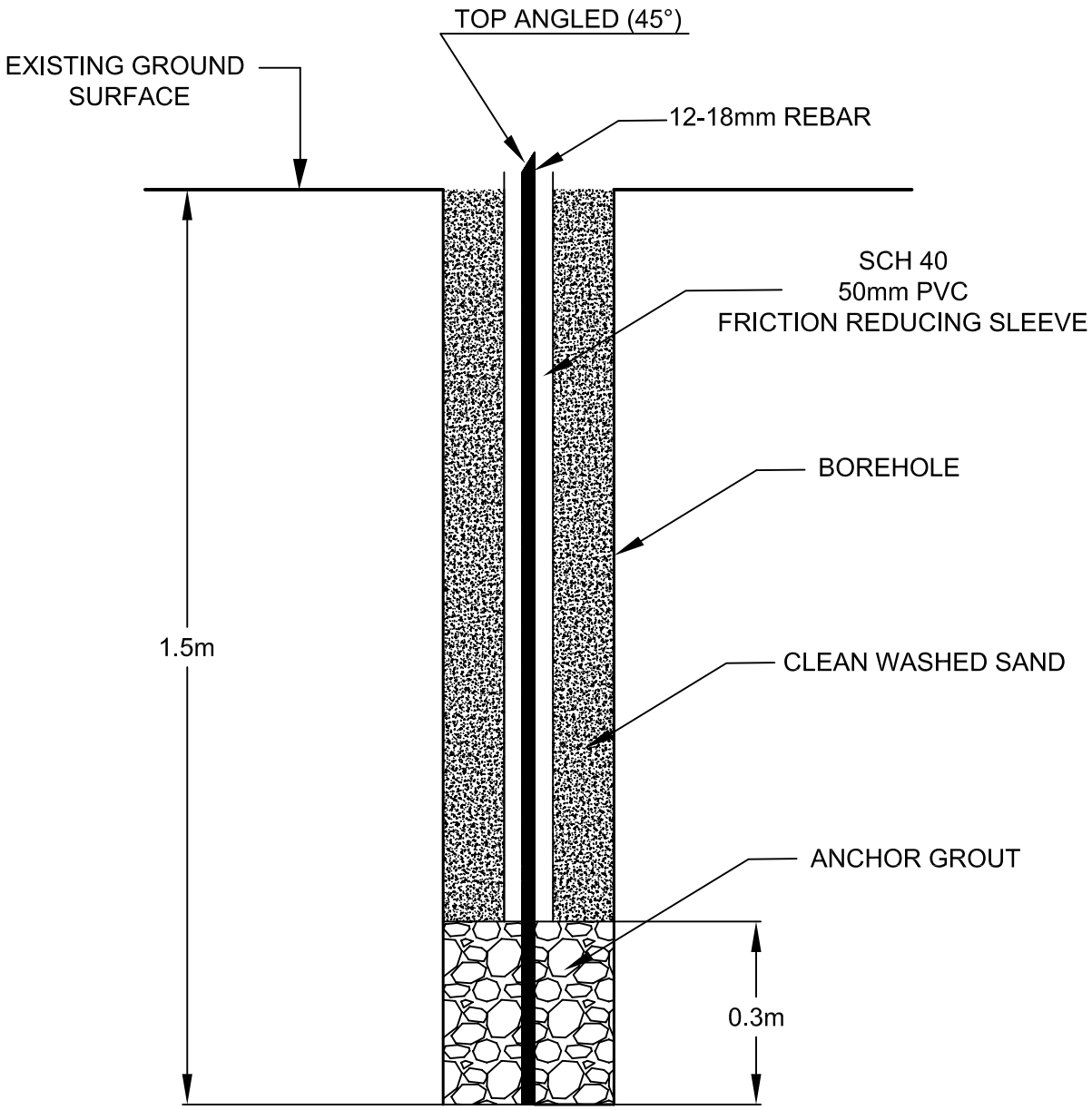

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SETTLEMENT ROD DETAILS

FIGURE 2

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Appendix K

Dewatering Estimates

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Geologic Model Assumptions and Hydraulic Conductivity Calculations

Parameter	Units	Shaft for MH17 ~100 m S of ROW	Shaft for MH18 ~160 m N of ROW
Initial Groundwater Elevation	masl	207.5	209.0
Ground Surface Elevation	masl	206.6	210.1
Bottom of Shaft Assumed for Dewatering	masl	189.8	190.4
Target Groundwater Elevation	masl	188.8	190.4
Geologic Unit 1		Si-Cl Till	Si-Cl Till
K Unit 1	cm/s	7.0E-04	7.0E-04
Elevation of Bottom of Unit 1	masl	196.9	203.3
Saturated Thickness Unit 1	m	9.7	5.7
Geologic Unit 2		Si-Sa Till	Si-Sa Till
K Unit 2	cm/s	4.0E-04	4.0E-04
Elevation of Bottom of Unit 2	masl	194.4	199.8
Saturated Thickness Unit 2	m	2.5	3.5
Geologic Unit 3		Sand	Sand
K Unit 3	cm/s	3.9E-03	3.9E-03
Elevation of Bottom of Unit 3	masl	189.3	192.0
Saturated Thickness Unit 3	m	5.1	7.8
Geologic Unit 4		Shale	Shale
K Unit 4	cm/s	2.1E-03	2.1E-03
Elevation of Bottom of Unit 4	masl	184.2	187.1
Saturated Thickness Unit 4	m	0.5	1.6
Geologic Unit 5			
K Unit 5	cm/s	0.0E+00	0.0E+00
Elevation of Bottom of Unit 5	masl		
Saturated Thickness Unit 5	m	0.0	0.0
Weighted Average K for Q Estimate	cm/s	1.6E-03	2.1E-03
Largest K for ROI Estimate	cm/s	3.9E-03	3.9E-03

Table of Geologic Model Units

Geologic Units	K (cm/s)
Si-Cl Till	7.0E-04
Si-Sa Till	4.0E-04
Sand	3.9E-03
Shale	2.1E-03
Sand and Gravel @ 19-69	1.5E-02
Sand and Gravel Till @ 19-15	1.2E-03

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Dewatering Calculations

Parameter	Units	Shaft for MH17 ~100 m S of ROW	Shaft for MH18 ~160 m N of ROW	Totals
Weighted Average K for Q Estimate (see separate calculation table)	cm/s	1.6E-03	2.1E-03	
Hydraulic Conductivity converted to m/day	m/day	1.4E+00	1.8E+00	
Input height of groundwater pressure (H)	m	19.7	19.6	
Input dewatering height (h)	m	1	1	
Input length of excavation (x, a)	m	15	15	
Input width of excavation (b)	m	15	15	
Input/calculate radius of trench (r_w or r_s)	m	7.5	7.5	
Length to width ratio	unitless	1.0	1.0	
Net water table lowering	m	18.7	18.6	
Equation Type		Radial	Radial	
Radii of Influence				
Sichardt Equation (Ro based on K, H, h) Based on Weighted Average K for Q Calc	m	225	256	
Ro = Sichardt + (rw or rs)	m	233	264	
Largest K for ROI Estimate	cm/s	3.9E-03	3.9E-03	
Hydraulic Conductivity converted to m/day	m/day	3.4E+00	3.4E+00	
Sichardt Equation (Ro based on K, H, h) Based on Highest Geologic Unit K	m	350	348	
Calculate alternative Ro using Bear, 1979: Ro=1.5(Tt/S)^0.5				
T	m²/day	27.47	35.66	
t	days	180	180	
S	unitless	0.2	0.2	
Alternate Ro	m	240	270	
Selected ROI for Impact Assessment	**m**	**350**	**350**	
Calculated Flow Rate				
Base groundwater flow	**L/day**	**494,000**	**615,000**	**1,109,000**
Safety factor on groundwater flow	unitless	3	3	
Groundwater flow with safety factor	L/day	1,482,000	1,845,000	3,327,000
Rainfall entering excavation	mm	50	50	
Duration to remove rainfall	hours	24	24	
Flow rate to remove rainfall	L/day	11,000	11,000	22,000
Budgeted peak flow rate	**L/day**	**1,493,000**	**1,856,000**	**3,349,000**
=	L/s	17.3	21.5	38.8
=	gal/min	228	284	512

Flow rate estimates rounded to nearest 1,000 L/day.
Selected ROI rounded to nearest 10 m.

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Theory and Formulae

Trench Flow

Steady State flow to a trench for an unconfined aquifer.

Use this equation when a/b > 1.5.

Equation 4.0

$$Q = \frac{\pi K\left(H^2 - h^2\right)}{\ln R_0 / r_w} + 2\left[\frac{xK\left(H^2 - h^2\right)}{2L}\right]$$

Equation 4.1

$$r_w = \frac{a+b}{\pi}$$

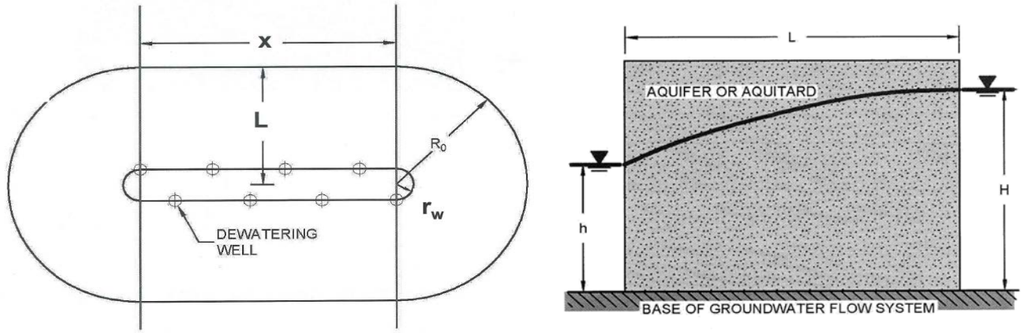

Figure 4.2 (Driscoll, 1986)

Note: L and Ro are the same distance

*Note: H, h measurements are relative to base of active groundwater

rw can be calculated (Eqn 4.1) or input = 1/2 the width of the trench.

For trench eqn estimate better if value is input as 1/2 the width of trench, Rw must be smaller than Ro

Rs for trench can be distance from centre line of trench to line of dewatering points.

Radial flow to well in unconfined aquifer (Dupuit Equation):

$$Q = \frac{\pi K\left(H^2 - h^2\right)}{\ln R_0 / r_w}$$

Partial Penetration Factor (F) Kozeny 1933

F = L/b*(1+cos(PI*L/(2b))*sqrt(r/2L))

where:

L = Vertical length from which water is being extracted

r = single well radius

b = saturated aquifer thickness

L/r must be > 30

L/b must be < 0.5

Assumption made that same factor may be applied to equivalent well and trench equations.

Multiple wells

The majority of dewatering systems comprise a number of wells or wellpoints arranged around the perimeter of a proposed excavation in straight lines or other configurations. Methods of calculating the total yield and drawdown at any point for such systems are given by Mansur and Kaufman[9] and by Powers[10].

For such systems, a simplifying assumption is to consider that the wells act as a single large well of radius r_s which then replaces the term r_w in the above equations for determination of flow. Methods of calculating r_s for the more common well configurations are given in Figure 28.

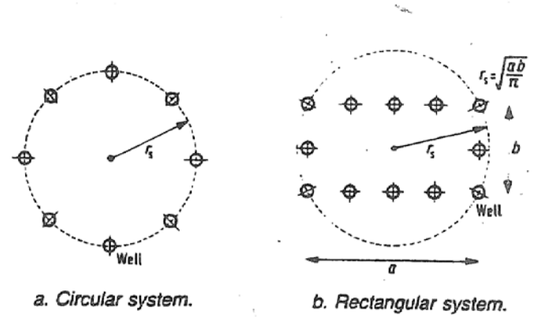

Figure 28

Radius of Influece

Ro is determined by the Sichardt Equation:

Ro = 3000(H-hw)K^0.5 when K is in m/s

Ro equals sichardt equatio FROM STAN DENHOED

add rw to Ro calculated from Sichardt's euquation

rw as indicated in formulae

Alternative equation by Bear (Bear, J., 1979. **Hydraulics of Groundwater**, McGraw-Hill, New York, 569p) $R_o = 1.5(Tt/S)^{0.5}$ where **T** is transmissivity in **m^2/day**, **t** is pumping duration in **days. R_o** will be in **metres.**

Hydraulic Conductivity and Grain Size

K = D10^2 , Hazen, where D10 = grain size diameter for 10% passing (smallest 10%) in mm and K in cm/s

OR

$$K = \left(\frac{\rho g}{\mu}\right)\left[\frac{n^3}{(1-n)^2}\right]\left(\frac{d_{10}^2}{180}\right)$$

Kozeny Carman equation

Image from groundwatersoftware.com

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Appendix L

List of Standard Specifications, Special Provisions, NSSP and Suggested Text for NSSP

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List of OPSS and OPSD Referenced in this Report

OPSS.PROV 517

OPSS.PROV 539

SP 517F01

Non-Standard Special Provision

Pipe Installation by Trenchless Method
Instrumentation and Monitoring Program

Suggested Text for NSSP on "Pipe Installation by Trenchless Method"

Cobbles, boulders or other obstructions may be present within the existing highway embankment fill and native tills. The Contractor's equipment and methodology must be able to handle and remove such obstructions. It is noted that a minimum casing diameter of 750 mm is required for removal of obstructions.

Suggested Text for SP517F01 on "Dewatering System – Design Storm Return Period and Preconstruction Survey Distance"

Preconstruction Survey Distance: 350 m
Dewatering Engineer Requirements: Yes

CONSTRUCTION SPECIFICATION FOR THE INSTALLATION OF PIPES BY TRENCHLESS METHODS

TABLE OF CONTENTS

1.0 SCOPE

This specification covers the requirements for the installation of pipe by a selected trenchless method.

2.0 REFERENCES

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, General

OPSS 180 Management of Disposal of Excess Material

Ontario Provincial Standard Specifications, Construction

OPSS 401 Trenching, Backfilling, and Compacting
OPSS 402 Excavating, Backfilling, and Compacting for Maintenance Holes, Catch Basins, Ditch Inlets and Valve Chambers
OPSS 403 Rock Excavation for Pipelines, Utilities, and Associated Structures in Open Cut
OPSS 404 Support Systems
OPSS 409 Closed-Circuit Television (CCTV) Inspection of Pipelines

OPSS 491	Preservation, Protection, and Reconstruction of Existing Facilities
OPSS 492	Site Restoration Following Installation of Pipelines, Utilities and Associated Structures
OPSS 517	Dewatering
OPSS 539	Temporary Protection Systems

Ontario Provincial Standard Specifications, Material

OPSS 1004	Aggregates - Miscellaneous
OPSS 1350	Concrete - Materials and Production
OPSS 1440	Steel Reinforcement for Concrete
OPSS 1802	Smooth Walled Steel Pipe
OPSS 1820	Circular and Elliptical Concrete Pipe
OPSS 1840	Non-Pressure Polyethylene (PE) Plastic Pipe Products

CSA Standards

B182.6	Profile polyethylene (PE) sewer pipe and fittings for leak-proof sewer applications
A3000	Cementitious Materials Compendium
W59	Welded Steel Construction (Metal Arc Welding)

American Society for Testing and Materials (ASTM) International Standards

A 252	Standard Specification for Welded and Seamless Steel Pipe Piles
D 2657	Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
D 3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
D6910	Standard Specification for Marsh Funnel Viscosity of Clay Construction Slurries
F 894	Standard Specification for Polyethylene Large Diameter Profile Wall Sewer and Drain Pipe

International Organization for Standardization/International Electrotechnical Commission (ISO/IEC)

17025	General Requirements for the Competence of the Testing and Calibration Laboratories

3.0 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Auger Jack & Bore means a method of forming a horizontal bore in the subsurface by simultaneously or alternately jacking into the ground a casing pipe and rotating a cutter head at the lead end of an auger flight with removal of material from inside the casing by using continuous-flight augers.

Backreamer or Reamer means a cutting head suitably designed for the subsurface conditions that is attached to drilling equipment and used to enlarge the bore

Bore Path means a drilled path according to the grade and alignment tolerances specified in the Contract Documents.

Design Engineer means the Engineer retained by the Contractor who produces the design and working drawings and other engineering documents required of the Contractor. The Design Engineer shall be licensed to practice in the Province of Ontario.

Design Checking Engineer means the Engineer retained by the Contractor who checks the original design and working drawings. The design checking engineer shall be licensed to practice in the Province of Ontario, shall not be an employee of the Contractor and shall be independent from the Design Engineer.

Digger Shield/Hand Mining means a method of forming a horizontal bore in the subsurface by essentially simultaneously jacking a casing pipe, with or without a protective shield at the lead end, into the ground while tunnelling and removal of earth and rock is completed using manually-operated tools (e.g., pneumatic spades, rams, shovels, breaker bars, etc.) or a "digger" type shield with a hydraulic excavator arm or "road-header" rock cutting machine to remove materials from inside the shield and liner pipe.

Horizontal Directional Drilling (HDD) means horizontal directional boring or guided boring.

Drilling Fluids means a mixture of water and additives, such as bentonite, polymers, surfactants, and soda ash, designed to block the pore space on a bore wall, reduce friction in the bore, and to suspend and carry cuttings to the surface.

Drilling Fluid Hydraulic Fracture or "Frac Out" means a condition where the drilling fluid's pressure in the bore is sufficient to fracture the soil and/or rock materials and allow the drilling fluids to migrate to the surface at an unplanned location.

Earth Pressure Balance (EPB) means a tunnelling system that provides support to the excavated face of the ground and resistance to groundwater inflow through the pressure of mixed earth, rock and any drilling fluids or additives (spoil) as maintained by and in a chamber behind the cutting face of a tunnel boring machine through which spoil can pass only by manner of controlled-load relieving gates or an internal screw-conveyor that is separate from subsequent spoil conveyance systems (e.g., flight augers, belt conveyor, spoil bucket rail cars, etc.). Trenchless systems that apply pressure to the excavated face of the ground only through mechanical and jacking forces on metal parts of the machinery (e.g., steel parts of cutting tools, adjustable gates or doors at cutting face, etc.) will not be considered equivalent to EPB systems.

Excavation means all materials encountered regardless of type and extent and shall include removal of natural soil, boulders, cobbles, wood and fill regardless of means necessary to break consolidated materials for removal.

Environmentally Sensitive Area (ESA) means areas specified in the Contract Documents that are prohibited from entry or use.

Fill means man-made mixture of previously placed or handled materials such as sand, clay, silt, gravel, broken rock, sometimes containing organic and/or deleterious materials, placed in an excavation or other area to raise the surface elevation.

Guidance System means an electronic system capable of indicating the position, depth and orientation of the drill head during the directional drilling process.

Hand Mining means a method of forming a horizontal bore in the subsurface by simultaneously jacking ahead while tunnelling advances using hand–mining (man-entry operation or "Jack and Mine") or a "digger" type shield with a hydraulic excavator arm to remove materials from inside the liner pipe.

Inadvertent Returns means the unexpected flow of fluids, saturated materials (or flowing soil) towards the drilling rig that typically originated from an artesian aquifer encountered during the drilling process.

Loss of Circulation means the discontinuation of the flow of drilling fluid in the bore back to the entry or exit point or other planned recovery points.

Microtunnelling means an underground method of constructing a passage by using a microtunnel boring machine (MTBM) or hand mining using a shield to support the opening.

Pilot Bore means the initial bore to set directional controlled horizontal and vertical alignment between the connecting points.

Pipe Jacking means a method for installing steel casing, concrete pipe or other acceptable material in the subsurface utilizing hydraulically operated jacks of adequate number and capacity for the smooth and uniform advancement of the casing or pipe.

Pipe means pipe culverts, pipe storm and sanitary sewers, watermain pipe, conduits and ducts.

Pipe Ramming means a method for installing steel casings utilizing the energy from a percussion hammer to advance a steel casing with a cutting shoe attached at the front end of the casing.

Project Superintendent means an individual representing the Contractor that oversees the trenchless or tunnelling operation qualified to provide the services specified in the Contract Documents.

Pullback means that part of the HDD method in which the drilling equipment is pulled back through the bore path to the entry point.

Reaming means a process for enlarging the bore path

Rock means natural beds or massive fragments, or the hard, stable, cemented part of the earth's crust, igneous, metamorphic, or sedimentary in origin, which may or may not be weathered and includes boulders having a volume of 0.5 m^3 or greater.

Shaft means an excavation used as entry and/or exit points, alternatively called entry/exit pits, from which the trenchless method is initiated for the installation of the pipe product.

Slurry Pressure Balance (SPB) means a tunnelling system that provides support to the excavated face of the ground and resistance to groundwater inflow through the pressure of slurry as maintained by and in a chamber behind the cutting face of a TBM or MTBM through which spoil can pass only by manner of controlled-pressure and controlled flow slurry pumping systems.

Strike Alert means a system that is intended to alert and protect the operator in the case of inadvertent drilling into an electrical utility cable. The strike alert system consists of a sensor and an alarm connected to the drill rig and a grounding stake. The alarm may be audio or visual or both.

Slurry means a mixture of soil and/or rock cuttings, and drilling fluid.

Soil means all soils except those defined as rock, and excludes stone masonry, concrete, and other manufactured materials.

Spoil means mix of earth cuttings, rock cuttings, water (groundwater or added water), bentonite, polymers and/or other additives that is discharged from the trenchless construction systems.

Trenchless Installation means an underground method of constructing a passage open at both ends that

involves installing a pipe product by auger jack & boring, pipe ramming, horizontal directional drilling, or tunnelling.

Trenchless Contractor means the subcontractor retained by the Prime Contractor qualified to provide the services specified in the Contract Documents.

Tunnelling means an underground method of constructing a passage using a tunnel boring machine (TBM) operated by personnel within the tunnel, a microtunnel boring machine (MTBM) operated by personnel at a remote control station or excavation using a shield to support the opening and protect workers.

Zone of Influence means a zone defined by lines projected outward and upward at 45 degrees from horizontal to the ground surface from the vertical and horizontal alignment of the pipe constructed using trenchless/tunnel methods.

4.0 DESIGN AND SUBMISSION REQUIREMENTS

4.01 Design

4.01.01 General

The Contractor shall determine the most appropriate method of installation for each location within the terms of this specification.

The installation method selected for each pipe crossing shall be designed for the subsurface conditions as reported in the Contract Documents.

The detailed design of the installation method selected to carry out the work as specified in the Contract Documents shall be completed.

4.02 Submission Requirements

4.02.01 Qualifications

At least two weeks prior to construction, the names of the Project Superintendent, Trenchless contractor, Design Engineer, and Design Checking Engineer shall be submitted to the Contract Administrator.

4.02.01.01 Project Superintendent

The Project Superintendent shall have a minimum of five years' experience on projects with similar scope and complexity.

During construction, the project superintendent shall not change without written permission from the Contract Administrator. A proposal for a change in the project superintendent shall be submitted at least one week prior to the actual change in project superintendent.

4.02.01.02 Trenchless Contractor

The Trenchless Contractor shall have a minimum of five years' experience on projects with similar scope and complexity

4.02.01.03 Design Engineer

The Design Engineer shall have a minimum of five years' experience on projects with similar scope and complexity

4.02.01.04 Design Checking Engineer

The Design Checking Engineer shall have a minimum of five years' experience on projects with similar scope and complexity

4.02.02 Working Drawings

Three sets of Working Drawings for the trenchless installation method selected shall be submitted to the Contract Administrator (CA) for purposes of documentation and quality assurance at least two week prior to the commencement of the work. All Working Drawings shall bear the seal and signature of the Design Engineer and Design Checking Engineer.

The working drawings shall be submitted to the Contract Administrator under cover with a Request to Proceed.

The Contractor shall not proceed with the work until a Notice to Proceed has been received from the Contract Administrator

A copy of the Working Drawings shall be kept at the site during construction.

Information and details shown on the Working Drawings shall include, but not be limited to:

a) Plans and Details:

i. Plans and profiles defining all horizontal and vertical alignment positions and positions of all utilities and other infrastructure within the zone of influence of the work;
ii. A work plan outlining the materials, procedures, methods and schedule to be used to execute the work.
iii. A list of personnel, including backup personnel, and their qualifications and experience.
iv. A safety plan including the company safety manual and emergency procedures.
v. The work area layout.
vi. An erosion and sediment control plan that includes a contingency plan in the event the erosion and sediment control measures fail.
vii. A contingency plan with specific details of the manner in which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the liner.
viii. A drilling fluid management plan, if applicable, that addresses control of frac-out pressures, any potential environmental impacts and includes a contingency plan detailing emergency procedures in the event that the fluid management plan fails.
ix. Lighting, ventilation and fire safety details as may be required by applicable occupational health and safety regulations.

x. Excavated materials disposal plan.
xi. Locations of protection systems.

b) Designs

i. Primary liner design (e.g., steel liner plates, steel ribs and wood lagging, steel casing pipe, etc.),
ii. Design assumption and material data when materials other than those specified are proposed for use.
iii. Drill path design, details of alignment and alignment control, maximum curvature and reaming stages.

c) Materials:

i. Certification from the manufacturer that the product furnished on the contract meets the specifications cited in the manufacturer's product specification and that the materials supplied are suitable for the application.
ii. Manufacturer data sheets for all drilling fluids and additives for use in Earth Pressure Balance, Slurry Pressure Balance
iii. Manufacturer data sheets for drilling systems.
iv. Mix designs, target rheology criteria (e.g., viscosity, density, shear strength, gel time, pressure-filtration – fluid losses under pressure, etc.) and additive dosage rates for all slurries and EPB TBM and MTBM operations.
v. The proposed grout mix design for grouts to be used for lubricating jacking pipe and for filling of voids and annular spaces.
vi. Compressive strength of concrete pipe products.
vii. Pipe class for all steel pipe products.
viii. Steel for Permanent Casings
- One copy of a mill test certificate certifying that the steel meets the requirements for the appropriate standards for permanent casings shall be submitted to the Contract Administrator at the time of delivery.
- Where mill test certificates originate from a mill outside Canada or the United States of America, the information on the mill certificates shall be verified by testing by a Canadian laboratory. The laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests or type of tests required by the material standard specified on the mill test certificate.
- The mill test certificates shall be stamped with the name of the Canadian testing laboratory and appropriate wording stating that the material conforms to the specified material requirements. The stamp shall include the appropriate material specification number, the date (i.e., yyyy-mm-dd), and the signature of an authorized officer of the Canadian testing laboratory

ix. The Contractor shall submit the followings to the Contract Administrator two weeks prior to construction:

- type, source, and physical and chemical properties of bentonite, polymer or other additives;
- source of water;
- method of mixing;
- the water to solids ratio and the mass and volumes of the constituent parts, including any

chemical admixtures or physical treatment employed to achieve required physical properties;

- details of procedure to be used for monitoring physical properties of slurry, drilling fluids and tunnelling fluids or EPB spoil; and method of disposal of the slurry, drilling fluids and associated spoil

d) Upstream/Downstream Portal Installation Procedure:

i. The access shaft or entry/exit pit details, as applicable.
ii. Face support and other temporary support details, if applicable.

e) Primary Liner/Secondary Liner Installation and Grouting Procedure:

i. Excavation and pipe installation procedures, including methods to handle obstructions and prevent soil cave-in.
ii. Details of tunnelling equipment/methods to be used for the works.

f) Excavation and Dewatering:

i. Equipment and methods for control, handling, treatment, and disposal of groundwater and water or fluids introduced by the Contractor;
ii. Equipment and methods for maintaining control of ground inflow at the excavation face during excavation;
iii. Equipment and methods for removal of cobbles and boulders;
iv. Manufacturer data sheets for each TBM, shield, tunnelling system or drilling system noting all intermediate and final cut dimensions, and methods and equipment for controlling and measuring drilling fluid, SPB and EPB pressures;
v. Methods for measuring excavated volumes or weights of earth and rock materials cut from ground on a per meter or per pipe basis up to a maximum of 3 m long intervals per measurement;
vi. Target operating pressures (minimum and maximum) and range of expected pressure variation for slurry or EPB spoil at excavated face or drilling fluids at lead end of drilling equipment and in annular gap between maximum excavated dimensions and outside dimensions of tunnelling equipment, drilling equipment and primary liner systems;
vii. Basis for setting target operating conditions (pressures, flow rates, advance rates) and the relationship of target operating conditions to ground conditions;
viii. Basis for selection of excavation tools (e.g., bits, TBM face tools, MTBM face tools, excavator fittings, etc.) as related to expected ground conditions;
ix. Jacking forces for installation of pipe, for driving of trenchless equipment forward and, in the case of Auger Jack & Bore, for advancing the lead end of the casing ahead of the lead end of the auger cutting tools.

g) Monitoring Method:

Methods, equipment, frequency and repeatability (accuracy and precision) of data collection to be employed for measuring and monitoring shall be submitted for:

i. Maintaining the alignment of the installation;
ii. EPB, SPB and drilling fluid pressures at the leading edge of excavation (face), flow rates and volume or weights of spoil;
iii. Jacking forces on pipes, linings and cutting tools;
iv. Torque, total revolutions and revolution rates on rotating equipment such as TBM or MTBM heads, auger flights, drill bits, etc.

v. Grout injection pressures and volumes;
vi. Longitudinal position of all casings and excavation cutting tools (auger flight heads, TBM face, drill bit position, etc.);
vii. Ground displacements (heave and settlement); and noise and ground vibrations induced by trenchless construction

4.02.03 Quality Control Certificate

The Contractor shall submit a Quality Control Certificate to the Contract Administrator for documentation and quality assurance purposes, prepared and stamped by the Design and Design Checking Engineers, a minimum of two weeks prior to commencement of work under this item. The Certificate shall state that the construction procedures are in conformance with the requirements and specifications of the contract documents.

The Contractor shall submit to the Contract Administrator a Quality Control Certificate sealed and signed by the Design and Design Checking Engineer upon completion of each of the following operations and prior to commencement of each subsequent operation for each pipe installation:

Site Surveying (as noted in Section 4.02)
Excavation for pits including dewatering of excavations
Jacking/Ramming/Directional Drilling of Casing/Liner
Installation of the Product
Grouting Operations

Each Quality Control Certificate shall state that the work has been carried out in general conformance with the contract documents, specifications and/or stamped working drawings.

The Contractor shall submit a Request to Proceed to the Contract Administrator upon completion of each of the milestones.

The Contractor shall not proceed to the subsequent operation until a Notice to Proceed has been received from the Contract Administrator

In addition, upon completion of the installation of the pipe at each location, the Contractor shall submit to the Contract Administrator a final Quality Control Certificate sealed and signed by the Design and Design Checking Engineer. The Certificate shall state that the pipe has been installed in general conformance with the Contractor's Submission and Design Requirements, stamped working drawings and contract documents.

5.0 MATERIALS

5.01 Pipe

5.01.01 General

The product shall be concrete pipe, steel pipe or high density polyethylene pipe as specified.

All joints shall be suitable for jacking operations as specified in the working drawings.

Fittings shall be suitable and compatible with the class and type of pipe with which they will be used.

All fittings shall be designed to be watertight.

5.01.02 Steel Pipe

Steel pipe shall be according to ASTM A252.

All steel casing pipe shall be square cut.

Steel casing pipe shall meet a straightness tolerance of 1.5 mm/m. When placed anywhere on the pipe parallel to the pipe axis, there shall not be a gap more than 1.5 mm between a 1 m long straightedge and the pipe.

5.01.03 HDPE Pipe

High density polyethylene (HDPE) pipe according to OPSS 1840 shall be used in accordance with ASTM D3350.

Fittings shall be according to CAN/CSA-B182.6 or ASTM F894 and suitable for the class and type of pipe with which they will be used.

Jointing of HDPE piping shall be completed according to the manufacturer's recommended procedures and ASTM D2657. Where conflicts exist between the manufacturer's instructions and ASTM D2657, the manufacturer's instructions are to be followed.

Jointing of HDPE piping to other piping materials or appurtenances shall be completed using flanged connections.

5.01.04 Concrete Pipe

Concrete pipe shall be according to OPSS 1820.

5.02 Concrete

Concrete shall be according to OPSS 1350. The concrete strength shall be as specified on the Working Drawings.

5.03 Steel Reinforcement

Steel reinforcement for concrete work shall be according to OPSS 1440.

5.04 Wood

Wood shall be according to OPSS 1601.

5.05 Drilling Fluids

Drilling fluid shall be mixed according to the working drawings.

Selection of drilling fluid type shall be based on the soils encountered in the subsurface investigation.

The drilling fluids shall be mixed according to the manufacturer's recommendations.

Slurry shall be mixed according to the submitted slurry design and be appropriate for the anticipated subsurface conditions. The viscosity of slurry used for SPB tunnelling shall be no less than 40 seconds Marsh Funnel viscosity, as defined by ASTM D6910, measured prior to introduction of groundwater and spoil and as required to ensure:

a) development of appropriate filter cake at excavation face to provide slurry support pressures exceeding ground and groundwater pressures at excavation face;
b) lubricate installation of primary liners as required;
c) transport spoil through pipe systems;

5.06 Grout

Purging grout shall conform to the requirements of OPSS 1004 wetted with only sufficient water to make the mixture plastic

6.0 EQUIPMENT

6.01 Auger Jack & Bore

Except in the case of dewatering to at least 1 m below the tunnel/bore invert for the full length of the pipe alignment, Auger Jack & Bore shall not be used and will not be permitted where subsurface conditions indicate that saturated gravel, sand and silt soils may be encountered at pipe level or within one pipe diameter above or below outside pipe dimensions.

Pipe auger jack & bore equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein.

Specific details of the equipment with which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the liner shall be submitted to the Contract Administrator for information purposes prior to proceeding with the works.

The lead end of the auger shall be maintained at least one pipe diameter inside the lead end of the casing. The auger cutting tools shall not extend to or beyond the lead end of the casing at any time unless specific exception is provided by the Ministry prior to construction. Submittals shall identify anticipated jacking forces for advancing casing ahead of leading edge of auger cutting tools in addition to friction forces that are to be overcome by jacking systems

6.02 Pipe Ramming

Pipe ramming equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein.

The pipe ramming hammer(s) shall be capable of driving the pipe casing from the entry pit to the exit pit through the existing subsurface conditions at the site without removal of soil from within the casing until the lead end of the pipe is outside the zone of influence for any overlying infrastructure.

Specific details of the equipment with which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the pipe shall be submitted to the Contract Administrator for information purposes prior to proceeding with the works.
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6.03 Horizontal Directional Drilling

6.03.01 General

The Horizontal Directional Drilling equipment shall consist of a directional drilling rig and a drilling fluid mixing and delivery system to successfully complete the product installation without exceeding the maximum tensile strength of the product being installed.

6.03.02 Drilling Rig

The horizontal directional drilling rig shall:

a) Consist of a leak free hydraulically powered boring system to rotate, push, and pull hollow drill pipe into the ground at a variable angle while delivering a pressurized fluid mixture to a guidable drill head.

b) Have drill rod that is suitable for both the drill and the product pipe installation.

c) Contain a drill head that is steerable, equipped with the necessary cutting surfaces and fluid jets, and be suitable for the anticipated ground conditions.

d) Have adequate reamers and down-bore tooling equipped with the necessary cutting surfaces and fluid jets to facilitate the product installation and be suitable for the anticipated ground conditions.

e) Contain a guidance system to accurately guide boring operations.

f) Be anchored to the ground to withstand the rotating, pushing, and pulling forces required to complete the product installation.

g) Be grounded during all operations unless otherwise specified by the drilling rig manufacturer.

6.03.03 Drill Head

The drill head shall be steerable by changing its rotation, be equipped with the necessary cutting surfaces and drilling fluid jets, and be of the type for the anticipated subsurface conditions,

6.03.04 Guidance System

The guidance system shall be setup, installed, and operated by trained and experienced personnel. The operator shall be aware of any magnetic or electromagnetic anomalies and shall consider such influences in the operation of the guidance system when a magnetic or electromagnetic system is used.

6.03.05 Drilling Fluid Mixing System

The drilling fluid mixing system shall be of sufficient size to thoroughly and uniformly mix the required drilling fluid.

6.03.06 Drilling Fluid Delivery System

The delivery system shall have a means of measuring and controlling fluid pressures and be of sufficient flow capacity to ensure that all slurry volumes are adequate for the length and diameter of the final bore and the anticipated subsurface conditions. Connections between the delivery pump and drill pipe shall be leak-free.

6.04 Tunnelling

Tunnelling equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein. Specific details of tunnelling equipment included in the submission shall be provided for:

a) rock or boulder breaking and removal;

b) equipment used within shields for spilling, fore-poling, face drainage, breasting boards/plates and for otherwise maintaining support of the tunnel crown and face under all anticipated conditions;

c) jacking systems;

d) alignment control systems;

Use of rock fracturing chemicals shall only be considered subject to a field demonstration satisfactory to the Ministry prior to its use. Use of explosives is prohibited without specific application and acceptance by the Ministry prior to construction.

6.05 Microtunnelling Equipment

The Contractor shall be responsible for selecting microtunnelling equipment which, based on past experience, has proven to be satisfactory for excavation of the soils that will be encountered.

The Contractor shall employ microtunnelling equipment that will be capable of handling the various anticipated ground conditions.

The MTBM shall also be capable of controlling loss of soil ahead of and around the machine and shall provide continuous pressurized support of the excavated face.

a) Remote Control System – The Contractor shall provide a MTBM that includes a remote control system with the following features:

i. Allows for operation of the system without the need for personnel to enter the microtunnel. Has a display available to the operator, at a remote operation console, showing the position of the shield in relation to a design reference together with other information such as face pressure, roll, pitch, steering attitude, valve positions, thrust force cutter head torque, rate of advance and installed length.

ii. Integrates the system of excavation and removal of spoil and its simultaneous replacement by Product Pipe. As each pipe section is jacked forward, the control system shall synchronize all of the operational functions of the system.

iii. The system shall be capable of adjusting the face pressure to maintain face stability for the particular soil condition encountered.

iv. The system shall monitor and continuously balance the soil and ground water pressure to prevent loss of soil or uncontrolled ground water inflow.
v. The pressure at the excavation face shall be managed by controlling the volume of spoil removal with respect to the advance rate.
vi. The system shall include a separation process designed to provide adequate separation of the spoil from the slurry so that slurry with a sediment content within the limits required for successful microtunnelling, can be returned to the cutting face for reuse. Appropriately contain spoil at the site prior to disposal.
vii. The type of separation process shall be suited to the size of microtunnel being constructed, the soil type being excavated, and the work space available at each work area.
viii. The system shall allow the composition of the slurry to be monitored to maintain the slurry weight and viscosity limits required.

b) Active Direction Control - Provide an MTBM that includes an active direction control system with the following features:

i. Controls line and grade by a guidance system that relates the actual position of the MTBM to a design reference Provides active steering information that shall be monitored and transmitted to the operating console and recorded.
ii. Provides positioning and operation information to the operator on the control console.

6.05.01 Pipe Jacking Equipment

Provide a pipe jacking system with the following features:

a) Has the main jacks mounted in a jacking frame located in the launch shaft.
b) Has a jacking frame that successively pushes towards a receiving shaft, a string of Product Pipe that follows the microtunnelling excavation equipment.
c) Has sufficient jacking capacity to push the microtunnelling excavation equipment and the string of pipe through the ground.
d) The main jack station may be complemented with the use of intermediate jacking stations as required.
e) Has a capacity at least 20 percent greater than the calculated maximum jacking load.
f) Develops a uniform distribution of jacking forces on the end of the casing pipe.
g) Provides and maintains a pipe lubrication system at all times to lower the friction developed on the surface of the pipe during jacking.
h) Jack Thrust Blocking shall adequately support the jacking pressure developed by the main jacking system.
i) Special care shall be taken when setting the pipe guide rails in the jacking shaft to ensure correctness of the alignment, grade, and stability.

6.05.02 Spoil Separation System

The Contractor shall determine the type of spoil separation equipment needed for each drive based on the geotechnical information available and other project constraints.

6.05.03 Electrical Equipment, Fixtures and Systems

Electrical equipment shall be suitably insulated for noise reduction. Noise produced by electrical equipment must comply with local municipal noise by-laws.
Electrical systems shall conform to requirements of the Canadian Electrical Code – CSA C22.1.

7. CONSTRUCTION

7.01 General

The Contractor shall notify the Contract Administrator at least 48 hours in advance of starting work. The proposed method of pipe installation to be used by the Contractor shall be subject to the limitations presented in the following subsections.

The Project Superintendent shall supervise the work at all times.

7.01.01 Layout, Alignment and Depth Control

The location of the installation shall be established from the lines, elevations and tolerances specified in the Contract Documents. The pipe installation shall be to the horizontal and vertical alignments specified in the Contract Drawings. Deviations from location, alignment, grades and/or invert levels shall be corrected by the Contractor at no cost to the Ministry.

All reference points necessary to construct the pipe installation and appurtenances shall be laid out.

The Contractor shall calibrate tracking and locating equipment at the beginning of each work day, and shall monitor and record the alignment and depth readings provided by the tracking system every 2 m.

The Contract Administrator shall be provided with the assistance and access necessary to check the layout of the pipe installation and associated appurtenances.

The Contractor shall submit records of the alignment and depth of the installation to the Contract Administrator at the completion of the installation.

7.01.02 Construction Shafts

Construction shafts shall be specified in the Contractor's submission. The boundaries and protection of these shall be as required to contain all disturbances to areas outside of the ESA limits.

Shafts shall be maintained in a drained condition.

A minimum 2.4 m high secure fence shall be installed around the perimeter of the construction shaft area with gates and truck entrances. The fence shall be removed on completion of the work.

7.01.03 Protection Systems

The construction of all protection systems shall be according to OPSS539. Where the stability, safety, or function of an existing roadway, watercourse, other works, proposed works or ESA’s may be impaired due to the method of operation, protection shall be provided. Protection may include sheathing, shoring, and piles where necessary to prevent damage to such works or proposed works.

7.01.04 Settlement or Heave

Any disturbance to the ground surface (settlement or heave) as a result of the pipe installation shall be immediately corrected by the Contractor, at no additional cost to the Ministry.

7.01.05 Stability of Excavation

The construction methods, plant, procedures, and precautions employed shall ensure that excavations are stable, free from disturbance, and maintained in a drained condition.

The construction methods, plant, procedures, and materials employed shall prevent the migration of soil and/or rock material into the excavation from adjacent ground.

7.01.06 Preservation and Protection of Existing Facilities

Preservation and protection of existing facilities shall be according to OPSS 491.

Minimum horizontal and vertical clearances to existing facilities as specified in the Contract Documents shall be maintained. Clearances shall be measured from the nearest edge of the largest cut diameter required to the nearest edge of the facility being paralleled or crossed.

Existing underground facilities shall be exposed to verify its horizontal and vertical locations when the outlet pipe path comes within 1.0 m horizontally or vertically of the existing facility. Existing facilities shall be exposed by non-destructive methods. The number of exposures required to monitor work progress shall be as specified in the Contract Documents.

7.01.07 Transporting, Unloading, Storing and Handling Materials

Manufacturer's handling and storage recommendations shall be followed.

7.01.08 Trenching, Backfilling and Compacting

Trenching, backfilling, and compacting for entry and exit points or other locations along the pipe path shall be according to OPSS 401.

7.01.09 Support Systems

Support systems shall be according to OPSS 404.

If any open excavation will encroach into the highway embankment the protection system shall satisfy the requirements for Performance Level 2 as specified in OPSS 539.

7.01.10 Dewatering

The work of this Section includes control, handling, treatment, and disposal of groundwater. The Contractor shall review the foundation investigation report for reference to soil and groundwater conditions on the project site and plan a dewatering scheme accordingly.

The Contractor shall control groundwater inflows to excavations to maintain stability of surrounding ground, to prevent erosion of soil, to prevent softening of ground exposed in the excavation, and to avoid interfering with execution of the work.

The Contractor shall maintain excavations free of standing water at all times during excavation, including while concrete is curing.

Should water enter the excavation in amounts that could adversely affect the performance of the work or could cause loss of ground, the Contractor shall take immediate steps to control the inflow.

The Contractor is alerted that seepage zones of perched water within the fill materials should be expected, particularly where granular materials are excavated.

Dewatering shall be according to OPSS 517.

7.01.11 Removal of Cobbles and Boulders

The Contractor is alerted that cobbles and boulders should be anticipated in the soil deposits at the site. Accordingly, the Contractor shall address the removal of cobbles and boulders in the proposed method of construction. Removal of cobbles shall be expected to be routine and will not be considered cause for obstruction. The Contractor shall immediately inform the Contract Administrator of any obstruction encountered.

7.01.14 Management of Excess Material

Management of excess material shall be according to OPSS 180. Satisfactory re-usable excavated material required for backfill shall be separated from unsuitable excavated material.

7.01.15 Site Restoration

Site restoration shall be according to OPSS 492.

7.02 Auger Jack & Bore Installation

7.02.01 Method of Installation Procedure

The installation procedure to be used shall be subject to the following limitations:

a) Hydraulically operated jacks of adequate number and capacity shall be provided to ensure smooth and uniform advancement without over-stressing of the pipe.
b) A suitably padded jacking head or collar shall be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.
c) The jacking pipe shall be fully supported in the jacking pit at the specified line and grade.
d) Selection of the excavation method and jacking equipment shall take into consideration the conditions at each pipe crossing.

7.02.02 Pipe Installation

Concrete pipe joints shall be water tight and according to OPSS 1820 and must withstand jacking forces, determined by the Contractor.

During the jacking of the liner the space between the liner and the wall of the excavated volume (e.g., maximum cut diameter) shall be kept filled with bentonite slurry. Upon completion of jacking, the space between the liner and the wall of the excavated volume shall be filled with grout or slurry with gel strength properties demonstrated to be sufficient to form a semi-solid or solid gap filling material, prevent ground convergence around the pipe and subsequent ground surface subsidence and prevent long-term water flow at the outside boundary of any pipe and ground.

The annular space between the liner and the product shall be fully grouted with a water tight, expandable and stable grout.

7.03 Pipe Ramming Installation

For pipe ramming installation the following requirements apply:

Only smooth walled steel pipe shall be used. Butt welding of pipe joints shall conform to CAS W59.

Ramming equipment of adequate capacity shall be provided to ensure smooth and uniform advancement between the shafts/pits without overstressing of the pipe. Delays shall be avoided between ramming operations.

A ramming head shall be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.

Two or more lubricated guide rails or sills shall be provided of sufficient length to fully support the pipe at the specified line and grade in the ramming pit. Pipe shall be installed to the line and grade specified.

Removal of materials from within the pipe shall not be undertaken until the lead end of the pipe has passed fully through and beyond the zone of influence of any overlying infrastructure.

Following installation of the liner pipe, all material shall be removed from the pipe to the satisfaction of the Contract Administrator. Any voids remaining between the pipe and the excavation wall shall be grouted as soon as the pipe is rammed. The annular space between the liner pipe and the product shall be fully grouted with a water tight, expandable and stable grout.

7.04 Horizontal Directional Drilling Installation

7.04.01 General

When strike alerts are provided on a drilling rig, they shall be activated during drilling and maintained at all times.

For horizontal directional drilling, the contractor shall ensure that during pilot hole drilling the maximum degree of deviation or “dog-leg” shall be 2.5 degrees per 9 m drill pipe length. Any deviation exceeding 2.5 degrees will necessitate a pull-back and straightening of the alignment at the Contractor’s sole expense. The pilot hole exit location shall be within 0.5m of the target location.

7.04.02 Site Preparation

The work site shall be graded or filled to provide a level working area for the drilling rig. No alterations beyond what is required for HDD operations are to be made. All activities shall be confined to designated work areas.

7.04.03 Pilot Bore

The pilot bore shall be drilled along the bore path in accordance with the grade, alignment, and tolerances as indicated on the Contractor’s submitted drilling plan to ensure that the product is installed to the line and grade shown on the Contract Drawings. The Contractor’s methods shall take into consideration the conditions at each crossing within the pipe alignment and shall be suitable to advance through such obstructions such as cobbles and boulders and address the potential for deflection off these obstruction and/or soil conditions.

In the event the pilot bore deviates from the submitted path, the Contract Administrator shall be notified. The

Contract Administrator may require the Contractor to pullback, fill and abandon the hole and re-drill from the location along the bore path before the deviation.

If a drill hole beneath highways, roads, watercourses or other infrastructure must be abandoned, the hole shall be backfilled with grout or bentonite to prevent future subsidence and subsurface water conveyance.

The Contractor shall maintain drilling fluid pressure and circulation throughout the HDD process, including during the initial pilot bore and during the reaming process.

The Contractor shall at all times and for the entire length of the installation alignment be able to demonstrate the horizontal and vertical position of the alignment, the fluid volume used, return rates and pressures.

7.04.04 Drilling Fluid Losses to Surface ("Frac-Out")

To reduce the potential for hydraulic fracturing of the hole during horizontal directional drilling, a minimum depth of cover of 5 m shall be maintained between the top of pipe and the surface of any pavements or beds of water courses. Sections of the pipe close to the entry and exit pit with less than 5 m cover shall be cased. The Contractor shall ensure that drilling fluid pressures are properly set and controlled for the full length of the bore to prevent frac-out for the depth of cover available between the bottom of the pavement structure (bottom of the subbase material) and the top of the bore.

Once a fluid loss or frac-out event is detected, the Contractor shall halt operations immediately and conduct a detailed examination of the drill path and implement measures to collect all fluids discharged to surface, mitigate and prevent additional fluid loss.

7.04.05 Reaming

The bore shall be reamed using the appropriate tools to a diameter at least 50% greater than the outside diameter of the product.

7.04.06 Product Installation

7.04.06.0 General

The product shall be jointed according to manufacturer's recommendations. The length of the product to be pulled shall be jointed as one length before commencement of the continuous pulling operation.

The product shall be protected from damage during the pullback operation.

The minimum allowable bending radius for the product shall not be contravened.

Product shall be allowed to recover to static conditions from thermal and installation stresses before connections to new or existing facility are made. Product recovery time shall be according to manufacturers recommendations.

7.04.06.02 Pullback and Grouting

After successfully reaming the bore to the required diameter, the product pipe shall be pulled through the bore path. Once the pullback operation has commenced, it shall continue without interruption until the product pipe is completely pulled into bore unless otherwise approved by the Contract Administrator.

A swivel shall be used between the reamer and the product being installed to prevent rotational forces from being transferred to the product. A weak link or breakaway connector shall be used to prevent excess pulling force from damaging the product.

The product pipe shall be inspected for damage where visible at excavation pits and where it exits the bore. Any damage noted shall be rectified to the satisfaction of the Contract Administrator.

The pull back and reaming operations shall not exceed the fluid circulation rate capabilities. Reaming and back pulling operations shall be planned to insure that, once started, all reaming and back pulling operations are completed without stopping and within the permitted work hours.

The space between the pipe and the walls of the excavated volume shall be filled with grout or slurry with gel strength properties demonstrated to be sufficient to form a semi-solid or solid gap filling material, prevent ground convergence around the pipe and subsequent ground surface subsidence and prevent long-term water flow at the outside boundary of any pipe and ground.

7. 05 Tunnelling Installation

7.05.01 General

Excavation of native soil and fill shall be done in a manner to control groundwater inflow to the excavation and to prevent loss of ground into the excavation.

Methods of excavating the tunnel shall be capable of fully supporting the face and shall accommodate the removal of boulders and other oversize objects from the face. Continuous ground support shall be maintained during excavation.

As the excavation progresses, the Contractor shall continuously monitor (every 2 m) indications of support distress, such as cracking, deflection or failure of support system and subsidence of ground near the excavation.

The Contractor shall provide ventilation and lighting in accordance with OHSA requirements for the entire length of the tunnel installed as tunneling progresses.

The tunnel is to be kept sufficiently dry at all times to permit work to be performed in a safe and satisfactory manner.

The Contractor shall maintain clean working conditions at all times in tunnels.

If excavation threatens to endanger personnel, the Work, or adjacent property, the Contractor shall cease excavation and make the excavation face secure. The Contractor shall then evaluate methods of construction and revise as necessary to ensure the safe continuation of the work.

The Contractor shall maintain tunnel excavation line and grade to provide for construction of final lining within specified tolerances.

7.05.01 Tunnelling Method

The tunnelling method shall be suitable to provide face support in changing ground conditions that may be encountered during the progress of the work. The selection of the tunnelling method should consider the soil

conditions at each pipe crossing and the presence of obstructions, such as cobbles and boulders, with respect to the tunnel alignment.

7.05.02 Primary Liner (Support System)

Primary support systems shall prevent deterioration, loosening, or unravelling of ground surfaces exposed by excavation.

The primary liner support system shall be designed and installed to achieve the intended performance requirements.

Primary liner support system shall maintain the safety of personnel, minimize ground movement into the excavation, ensure stability and maintain strength of ground surrounding the excavation.

The primary liner shall be designed to support all subsurface conditions and hydrostatic pressures and to withstand any additional loads caused by installation and grouting, and shall ensure that no ground loading or other loading will be placed on the new work until after design strength has been reached.

The primary liner shall be installed so that the exterior is as tight as possible to the excavated surface of the tunnel and allows the placement of the full design thickness of the secondary lining.

Primary support systems shall be compatible with the encountered ground conditions, with the method of excavation, with methods for control of water, and with placement of the permanent lining.

All voids between the primary lining and the wall of the excavated volume shall be filled with cement grout or slurry with gel strength properties demonstrated to be sufficient to form a semi-solid or solid gap filling material, prevent ground convergence around the pipe and subsequent ground surface subsidence and prevent long-term water flow at the outside boundary of any pipe and ground. If an unexpanded liner is used, the space outside the liner plates shall be filled at least daily.

7.05.03 Secondary Liner

7.05.03.01 Placing of Grout

The void outside the finished secondary liner shall be filled with cement grout according to the Contractor's submission.

Grout shall not be placed until the lining has achieved 85% of its specified strength or 30 MPa. Grouting shall be limited to such sequences and programs as are necessary to avoid damaging any part of the works or any other structure or property. Grout mix design shall be chemically and thermally compatible with all pipe systems.

7.06 Microtunnelling

7.06.01 General

Excavation of soil, rock and fill shall be done in a manner to control and prevent groundwater inflow to the tunnel.

The MTBM shall be capable of fully supporting the face and shall accommodate the removal of boulders and other obstructions from the face. Continuous ground support shall be maintained during excavation.

The tunnel is to be kept well drained at all times to permit work to be performed in a safe and satisfactory manner.

The Contractor shall maintain clean working conditions at all times.

In the event that excavation threatens to endanger personnel, the Work, adjacent property, roadways, railways, waterways, or the public in any way, the Contractor shall cease excavation. The Contractor shall then evaluate the methods of construction and revise as necessary to ensure the safe continuation of the Work.

The Contractor shall maintain the tunnel excavation line and grade to provide for construction of the product within the specified tolerances.

7.06.02 Method of Installation

The installation procedure to be used shall be subject to the following limitations:

- The jacking pipe shall be fully supported in the jacking pit at the specified line and grade.
- Selection of the excavation method and jacking equipment shall take into consideration the subsurface conditions within the tunnel alignment.
- Perform microtunnelling operations in a manner that will minimize the movement of the ground in front of and surrounding the tunnel in conformance with the limits listed in the Contract Documents.
- Prevent damage to structures and utilities above and in the vicinity of the microtunnelling operations.

- Excavated diameter should be the minimum size required to permit pipe installation by jacking.
- Whenever there is a condition encountered which could endanger the microtunnel excavation or adjacent structures if tunnelling operations cease, continue to operate without intermission including 24-hour working days, weekends and holidays, until the condition no longer exists.
- Maintain an envelope of lubricant around the exterior of the pipe during the jacking and excavation operation to reduce the exterior soil/pipe friction and possibility of the pipe seizing in place.
- In the event a section of pipe is damaged during the jacking operation or a joint failure occurs, as evidenced by inspection, visible ground water inflow or other observations, the Contractor shall submit for approval his methods for repair or replacement of the pipe.

7.06.03 Casing Installation

Casing must withstand the jacking forces determined by the Contractor.

The space between the Casing and the wall of the excavation shall be kept filled with lubricant during the pipe jacking operation. Upon completion of pipe jacking, the space between the Casing and the wall of the excavation shall be filled with grout that is compatible with the Casing.

The Casing shall act as a support system to maintain the safety of personnel, minimize ground movement into the excavation, ensure stability and maintain strength of ground surrounding the Casing.

The Casing shall be designed to support all subsurface conditions and hydrostatic pressures and to withstand any additional loads caused by installation and grouting.

7.07 Instrumentation and Monitoring

The work specified in this Section includes furnishing and installing instruments for monitoring of settlement (and heave) and ground stability.

7.07.01 Surface Monitoring Points

Surface settlement points for monitoring ground stability shall be installed at the pavement/ground surface level on the shoulder, side slope and pavement at intervals of 5 m or less along the tunnel alignment centreline and as arrays of three points in each shoulder of the highway crossing and centred on the tunnel alignment. The equipment and procedures used for settlement monitoring during construction must be capable of surveying the settlement point elevations to within a repeatability (combined accuracy and precision of equipment and methods) ± 2 mm of the actual elevation.

Surface settlement markers shall be hardened steel markers treated or coated to resist corrosion, with an exposed convex head having a minimum diameter of 12 mm and similar to surveyor's PK nails. Markers shall be rigidly affixed so as not to move relative to the surface to which it is attached. Traffic shall be managed by the contractor using short-term lane closures in accordance with the Ontario Traffic Manual (OTM). Surface markers shall be recessed or otherwise designed for safe passage of vehicles at highway speeds and protected from snow removal equipment in the event that work occurs during snow removal seasons.

7.07.02 In-Ground Monitoring Points

In-ground settlement monitoring points shall be 12-18 mm rebar encased in a 50-70 mm, SCH40 PVC pipe,

set to a depth of 1.5 m below ground surface or below frost penetration depth whichever is greater. The assembly shall be placed in a drill hole, backfilled with uniform sand and provided with protective covers suitable for high vehicular traffic areas.

7.07.03 Installation, Replacement and Abandonment

The Contractor shall install all settlement monitoring points a minimum of two weeks prior to the start of works to permit baseline surveying to be completed. The settlement monitoring points shall be clearly labelled for easy field identification. The Contractor shall submit to the Contract Administrator a site plan showing the locations of the monitoring points, a geodetic survey of the settlement monitoring points including station, offset and elevation. Instruments damaged by the Contractor's operations or other causes shall be replaced and surveyed at the time of installation within 24 hours at no additional cost. At the completion of the job, the Contractor shall abandon all instrumentations installed during the course of the Work and restore the surface at instrument locations.

7.07.03 Monitoring and Reporting Frequency

The Contractor shall survey and otherwise obtain elevations of all settlement monitoring points at the following time intervals:

a) Three consecutive readings at least one week prior to commencement of the work (Baseline Reading);
b) Once per shift or once daily during tunnelling operations period whichever results in the more frequent reading intervals; and
c) Weekly after completion of the work for one month, or until such time at which all parties agree that further movement has stopped.

All readings shall be submitted to the Contract Administrator for information purposes on a weekly basis.

Each report shall include all survey data collected in tabular and graphical format as plots of time versus settlement in comparison to survey data collected prior to commencement of the work.

7.07.03 Benchmarks

Two independent benchmarks shall be used for all settlement monitoring surveying and shall be located sufficiently outside the zone of influence such that the benchmarks are not influenced by any trenchless or other construction activity or weather conditions (e.g., frost heave). All surveying shall be reported using the geodetic datum and coordinate system as defined in the Contract Documents.

7.08 Criteria for Assessment of Roadway Subsidence/Heave

Based on the monitoring of ground movement as specified in Subsections 4.02 and 7.07, the following represents trigger levels that define magnitude of movement and corresponding action:

a) Review Level: If a maximum value of 10 mm relative to the baseline readings is reached, the Contractor shall review or modify the method, rate or sequence of construction or ground stabilization measures to mitigate further ground displacement. If this Review Level is exceeded, the Contractor shall immediately notify the CA and review and discuss response actions. The Contractor shall submit a plan of action to prevent Alert Levels from being reached. All construction work shall be continued such that the Alert Level is not reached.

b) Alert Level: If a maximum value of 15 mm relative to the baseline readings is reached, the Contractor shall cease construction operations, inform the Contract Administrator and execute pre-planned measures to secure the site, to mitigate further movements and to assure safety of public and maintain traffic. No construction shall take place until all of the following conditions are satisfied:

i. The cause of the settlement has been identified.
ii. The Contractor submits a corrective/preventive plan.
iii. Any corrective and/or preventive measure deemed necessary by the Contractor is implemented.
iv. The CA deems it is safe to proceed.

9. MEASUREMENT FOR PAYMENT

Measurement shall be by Plan Quantity Payment as may be revised by Adjusted Plan Quantity Payment in metres, following along the centre line of the pipes from centre to centre of maintenance holes or chambers (catch basins) or from/to the end of the pipe where no maintenance hole or chamber is installed, of the actual length of pipe installed by trenchless methods.

10. BASIS OF PAYMENT

Payment at the contract price shall be full compensation for all labour, equipment and materials required for excavation (regardless of material encountered), dewatering, sheathing and shoring, supply and installation of pipe liners, settlement instrumentation and monitoring, site restoration, and all other work necessary to complete the installation as specified.

Payment for the pipe installed inside the pipe liner shall be paid separately under the appropriate tender items.

Where a protection system is made necessary because of the Contractor's operations (e.g., choice of trenchless installation method), the cost shall be included in this item and shall be full compensation for all labour, equipment and materials required to carry out the work including subsequently removing the temporary protection system and performing any necessary restoration work.

Payment for connecting intercepted drains and service connections shall be made on the following basis:

(a) Where such drains and service connections are shown on the contract drawings the cost of connections shall be included in the contract price for pipe installation.

(b) Where such drains and service connections are not shown on the contract drawings, the cost of connections will be considered an allowable extra to the contract.

Payment for removal of boulders exceeding Boulder Volume Rations (BVR) and Boulder Number Ration (BNR) shall be by Time and Material.