Geotechnical Investigation
Proposed Water Treatment Plant
Holding Tank
Long Lac, Ontario

Prepared For:
WSP
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July 7, 2020 Ref. No. 20-223

Table of Contents

Enclosures

1 Introduction

TBT Engineering Limited (TBTE) has been retained by WSP to conduct a geotechnical investigation for a proposed holding tank located at the Long Lac wastewater treatment plant in Long Lac ON.

It is understood that the proposed project will consist of a 5 x 2 m holding tank buried at a depth of 0.5 m below grade. The height of the holding tank and foundation loads were not known at the time of this report. No raise in grade is expected at the site.

A total of 2 boreholes were advanced for the proposed holding tank

2 Field Investigation and Laboratory Testing

The field investigation was conducted on June 15, 2020. Two boreholes were advanced within the proposed footprint of the holding tank. The boreholes were advanced utilizing a drill rig equipped for geotechnical testing and sampling.

During the drilling operations, soil samples were obtained from the auger flights and using the techniques of the standard penetration test (SPT). This involves driving a 51 mm diameter thick-walled sampler into the soil under the energy of a 63.5 kg weight falling through 760 mm. The number of blows required to drive the sampler 0.3 m is known as the standard penetration blow count (N) which provides an indication of the condition or consistency of the soil. Following completion of the test, a representative soil sample is obtained from within the sampler. Thin walled Shelby tubes were used to obtain relatively undisturbed samples of the clay.

Classification and index tests were subsequently performed in the laboratory on samples collected from the boreholes to aid in the selection of the soil's engineering properties. Laboratory tests included natural moisture contents, gradation analyses and Atterberg limits.

The ground surface elevation at the Borehole was surveyed by TBTE and was referenced to the floor elevation of the overhead door of the existing building, as shown on the Site Plan drawing (Enclosure 1). The benchmark was assigned a local elevation of 100.0 m. The borehole location/coordinates were recorded using a Garmin hand-held GPS.

A water level reading was taken within the open hollow stem augers prior to leaving site.

3 Sub-Surface Conditions

Details of the subsurface conditions are provided on the borehole logs and laboratory test reports, Enclosures 2 through 5. In general, the subsurface stratigraphy consists of a layer of fill overlying clays and silts. Peat was identified underlying the fill at Borehole 2

3.1 Fill

Fill consisting of a mixture of gravel, sand, silt, and clay was encountered at the surface of both boreholes and extended to depths of 1.5 m at Borehole 1 and 1.8 m at Borehole 2. This material is in a loose condition, with an SPT N-value of 9 blows per 0.3 m. Pockets of wood debris was identified. This material is considered frost susceptible and is capable of forming ice lenses and heaving when freezing and should not be used as structural backfill.

3.2 Peat

75 mm of peat was present underlying the fill at Borehole 2.

3.3 Upper Clay

Clay with trace sand was encountered underlying the fill at Borehole 1 and underlying the peat at Borehole 2 and extended to depths ranging from 2.2 to 2.8 m at Boreholes 1 and 2 respectively. This material is in a firm to stiff consistency, with a SPT N-values of 7 to 10 blows per 0.3 m. This material is considered frost susceptible and is capable of forming ice lenses and heaving when freezing and should not be used as structural backfill.

3.4 Upper Silt

Silt with trace sand was identified underlying the upper clay at both boreholes and extended to the depths of 2.8 m at Borehole 1 and 3.6 m at Borehole 2. It should be noted that Borehole 2 was terminated within this material. Atterberg limit testing indicates this material is non plastic. This silt deposit is in a compact condition, with an SPT N-values of 12 to 27 blows per 0.3 m. This material is considered frost susceptible and is capable of forming ice lenses and heaving when freezing and should not be used as structural backfill.

3.5 Lower Clay

Varved clay was present underlying the upper silt at Borehole 1 and extended to a depth of 4.1 m. Varved clay consists of a layered structure with alternating layers consisting of clay of varying plasticity. Atterberg limit tests completed on a selected sample (containing multiple layers) indicates the clay is of medium plasticity with the natural moisture content near the plastic limit. This material is in a very stiff consistency, as indicated by field vanes and lab vanes exceeding 100 kPa. Individual clay varves may be weaker. This material is considered frost susceptible and is capable of forming ice lenses and heaving when freezing and should not be used as structural backfill.

3.6 Lower Silt

Silt with trace sand was identified underlying the lower clay at Borehole 1 and extended to a depth of 7.8 m. Grain size analysis carried out on a selected sample indicates that this material can consist of 0 % gravel, 1 % sand, and 99 % silt/clay sized particles. Atterberg limit testing on a selected sample indicates this material is non plastic. This silt deposit is in a loose to compact condition, with an SPT N-values ranging from 5 to 10 blows per 0.3 m. This material is considered frost susceptible and is capable of forming ice lenses and heaving when freezing and should not be used as structural backfill.

3.7 Sand and Silt

Sand and silt with trace gravel was encountered underlying the lower silt at Borehole 1 and extended to the termination of the borehole at a depth of 10.2 m. Occasional cobbles were noted within this material. Grain size analysis carried out on a selected sample indicates that this material can consist of 10 % gravel, 41 % sand, and 49 % silt/clay sized particles. This silt deposit is in a compact condition, with an SPT N-values ranging from 12 to 24 blows per 0.3 m.

3.8 Groundwater

The groundwater level was measured at the completion of drilling and again up to 14 hours after the completion of the boreholes. Water level readings were taken within the augers. Groundwater levels are varied from 2.0 to 2.3 m. It is possible the groundwater levels did not have sufficient time to stabilize. Groundwater levels may vary from season to season and from the effects of heavy precipitation events. For design and construction purposes, the groundwater level should be assumed to be at ground surface.

4 General Commentary on Geotechnical Design Recommendations

All design recommendations presented in this report assume that an adequate level of construction monitoring during excavation and construction will be provided. An adequate level of construction monitoring is examination of all excavation surfaces prior to fill or concrete placement to ensure the integrity of the subgrade. Full-time monitoring, materials testing, and compaction testing should be provided.

It is understood that no raise in site grade is planned. Should this not be the case, the recommendations provided should be reassessed.

Unless noted otherwise, foundation parameters provided herein are for static, vertically and concentrically loaded foundations in compression.

5 Shallow Foundations

It is understood that the proposed holding tank foundation will consist of a 5 x 2 m mat foundation founded at a depth of up to 0.5 m below existing grade.

All foundation reactions and resistances provided are subject to the following conditions:

- All existing fill, organic soils, disturbed or deleterious material must be removed from below the proposed foundations to expose, at a minimum firm native clay with an undrained shear strength of 25 kPa.
- Foundations shall be placed on a compacted granular pad which shall be founded on native loose to compact silt. The minimum pad thickness shall be as indicated in the table below. The granular pad shall be constructed as described in Section 6.
- The underside of foundation must be founded with a depth of cover as detailed in the table below.
- All provided Ultimate Limit State (ULS) and Serviceability Limit State (SLS) values are based on foundation loading only.

Table 6.1: Factored Geotechnical Resistances and Unfactored Reactions for 5 x 2 m Mat Foundation

Compacted Granular Pad Thickness (m)	Factored Gross Geotechnical Resistance (ULS) (kPa)		Net Geotechnical Reaction (SLS) for 25 mm Settlement (kPa)		Estimated Effective Modulus of Subgrade Reaction, kN/m^3
	Depth of Footing 0 m	Depth of Footing 0.5 m	Depth of Footing 0 m	Depth of Footing 0.5 m	
0.5	90	120	60	65	2480-3800
1.0	90	160	65	70	2760-4200
1.5	90	160	75	80	3040-4600

The above geotechnical resistances utilize a resistance factor of 0.5 in terms of ULS. The geotechnical reactions have been estimated based on a maximum of 25 mm of settlement for foundation loading. A flexible foundation was assumed. It has been assumed that the existing grade will be maintained. Consolidation testing may be considered to refine settlement analyses.

Design parameters for alternate foundation configurations (e.g. alternate widths, depth of cover and the use of a thicker compacted granular pad) may be provided upon request.

6 Compacted Granular Pad

The granular pad base should consist of Granular A or Granular B, Type 1 fill (as per OPSS.PROV 1010 Apr 2013) compacted to at least 98% of Standard Proctor Maximum Dry Density (SPMDD). The base of the compacted granular pad shall extend horizontally beyond the edge of the footing by a minimum distance equal to the as-built thickness of the pad below the underside of the foundation. The use of a heavy non-woven geotextile should be placed between the fill for the pad and silt subgrade.

If construction conditions require working in the “wet”, the granular pad can be replaced with a 19 mm clear stone fill (completely wrapped with a heavy non-woven geotextile). The 19 mm clear stone may be placed below the water level without compaction; however, the clear stone pad should be surface compacted (once above the water level) to tighten up the fill and minimize settlements. Once above the water level, compacted Granular A or B Type 1 fill may be used over the clear stone. A non-woven geotextile filter must be used between the granular fill and clear stone.

7 Effects on Adjacent Structures

Existing foundations of the adjacent structures may be subject to new settlements if the new footings are placed near the existing footings. Where a clear distance between the existing foundation and the new foundations is less than 3.5 m of the new foundation, new settlements on the existing structure may be realized. The amount of settlement experienced by the existing foundation will range from 100 % (directly adjacent) to 40 % (1.5 m away) of the settlement experience by the new foundation.

Construction should be planned so as to not undermine existing foundations or services or cause damaging earth movements.

8 Frost Penetration and Protection Measures

8.1 Frost Penetration

Based on the Ministry of Environment’s published weather and climatic data for Nakina and the methodology prescribed by the Canadian Foundation Engineering Manual (CFEM) 4th Edition, the design frost depth for coarse grained soils (such as Granular B, Type I backfill) has been estimated to be 3.6 m.

8.2 Frost Protection Measures – Unheated Foundations

Frost heave occurs when ice lenses form in the soils below a foundation element and heave upon freezing. The degree of heave will depend on the type of soil, depth of frost penetration below the foundation and water content within the soil. For foundations **not** constructed at or below the design frost depth (3.6 m), rigid high-density extruded polystyrene insulation (such as Styrofoam Highload) is required to be placed below the foundation. The insulation shall have a thickness of 150 mm and extend 3.3 m beyond the edge of the foundation. With this insulation configuration, frost can be expected penetrate up to 0.5 m below the insulation. The use of at least 0.5 m of non-frost susceptible fill (such as Granular A, or B Type 1) should be placed below the insulation. Due to volumetric expansion of water within the non-frost susceptible fill, frost heave in the order of 5 mm may occur. The insulation shall be protected as per the manufacturer’s requirements. The structural designer must ensure that the selected product has adequate properties to withstand the design loads.

8.3 Frost Jacking

Frost jacking occurs when the soils around a foundation element adfreeze to the foundation. When the frost susceptible soils expand during freezing, the foundation element is lifted upward. To limit the effects of frost jacking, the foundation excavations should start at least 1.0 m from the edge of foundation and have side slopes no steeper than 1H:1V and the excavation should be backfilled with a non-frost susceptible, free draining fill such as Granular B, Type I. The backfill should be capped with a less permeable soil and surface grade provided to shed runoff before it enters the backfill.

9 Subgrade Preparation

All existing fill, slough, very soft to soft, very loose soils, disturbed and/or deleterious material must be removed from below the foundation footprint to expose at least firm clay with an undrained shear strength 25 kPa. The subgrade should be inspected prior to fill and/or concrete placement. Foundation excavations and bearing surfaces should be protected at all times from rain, freezing temperature, excessive drying or the ingress of groundwater before, during and after construction.

The clay subgrade soils found at the site are sensitive to disturbance. Equipment and/or worker traffic on this material should be kept to a minimum during excavation to prevent excessive disturbance and loss of strength of the subgrade. The subgrade may be subject to “pumping” conditions during compaction. Sufficient time should be allowed for the “pumping” conditions to dissipate between compacted fill lifts and prior to placement of concrete.

10 Backfill and Lateral Earth Pressures

Design earth pressures are a function of the backfill used. Backfill against structures should consist of non-frost susceptible free draining fill such as Granular B, Type I fill (OPSS). In addition to using non-frost susceptible backfill, drainage measures should be considered to minimize the effects of frost induced loads.

Lateral loads should include active or at-rest pressures as appropriate, as well as any live loadings and a compaction surcharge. Active loads are appropriate for yielding conditions while at-rest pressures should be used for non-yielding cases. The design should also consider the effects of hydrostatic pressures. Design soil pressure coefficients are provided as follows:

Table 10.1: Lateral Earth Pressure Coefficients.

Material	ϕ' (°)	Bulk Unit Weight of Soil, γ (kN/m^3)	Lateral Earth Pressure Coefficients, K		
			Active, K_a	At Rest, K_0	Passive, K_p
Granular A	35	21	0.27	0.43	3.69
Granular B, Type I	32	21	0.31	0.47	3.25
Native Silts	28	19	0.36	0.53	2.77

A factor of safety or resistance factor has not been included in the above coefficients. The effects of groundwater should be considered by the designer.

11 Excavations

All excavations for this project should be constructed in accordance with the requirements of the Occupational Health and Safety Act of Ontario.

Temporary excavations carried out above the groundwater level may be cut at slopes of 2.5H:1V. Based on the observed groundwater level at site, excavations are expected to extend below the groundwater level. Excavation slopes constructed below the groundwater level are liable to slough to flat slopes. The ingress of water through the variable fill may be excessive and may require extra dewatering efforts to maintain a stable excavation slope. Dewatering may prove challenging especially if the water level is within the permeable fill material or where permeable zones are encountered at the time of construction. Where the excavation depth extends below the groundwater level at the time of construction, dewatering to a level below the base of excavation is recommended. Given the presence of shallow clay layers underlain by more permeable silts, there is a risk of sudden bottom heave due to artesian pressure below the clay. As the water pressure within the silt layers below the clay is unknown, the use of pressure relief wells or well points should be considered to depressurize the silts layers. The water pressure below the clay should be lowered to below 70% of the total stress (at time of excavation) above the base of clay. Dewatering measures should be provided by a qualified contractor/consultant. This will limit the risk of disturbance of the subgrade. Alternate measures may also be considered to mitigate these risks.

Where excavations are located in close proximity to existing foundations and services, the excavation and any associated dewatering must be planned and executed to prevent damaging earth movements on the existing foundations or services. Appropriate dewatering or structural designer should be consulted.

Surface surcharges should not be placed in close proximity to the edge of excavation unless the stability of the excavation slope has been assessed.

12 Limitations

Conclusions and recommendations presented in this report are based on the information determined at the borehole location. Subsurface and groundwater conditions beyond this location may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

The design recommendations provided in this report are based on the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

Benchmarks and elevations referred to in this report are used primarily to establish relative elevation differences at the borehole location and should not be used for other purposes, such as grading, excavating, planning, development, etc.

Groundwater levels indicated are based on the information described within the report. The presence of all conditions that could affect the type and scope of dewatering procedures which may be considered cannot readily be determined from a borehole. These include local and seasonal fluctuations of the groundwater level, changes in soil conditions, thin and/or discontinuous layers of highly permeable soils, etc.

In no way does the information contained within this report reflect any environmental aspect of the site or soil.

13 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate the contact us at your convenience.

Yours truly,
For TBT ENGINEERING

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PROVINCE OF ONTARIO

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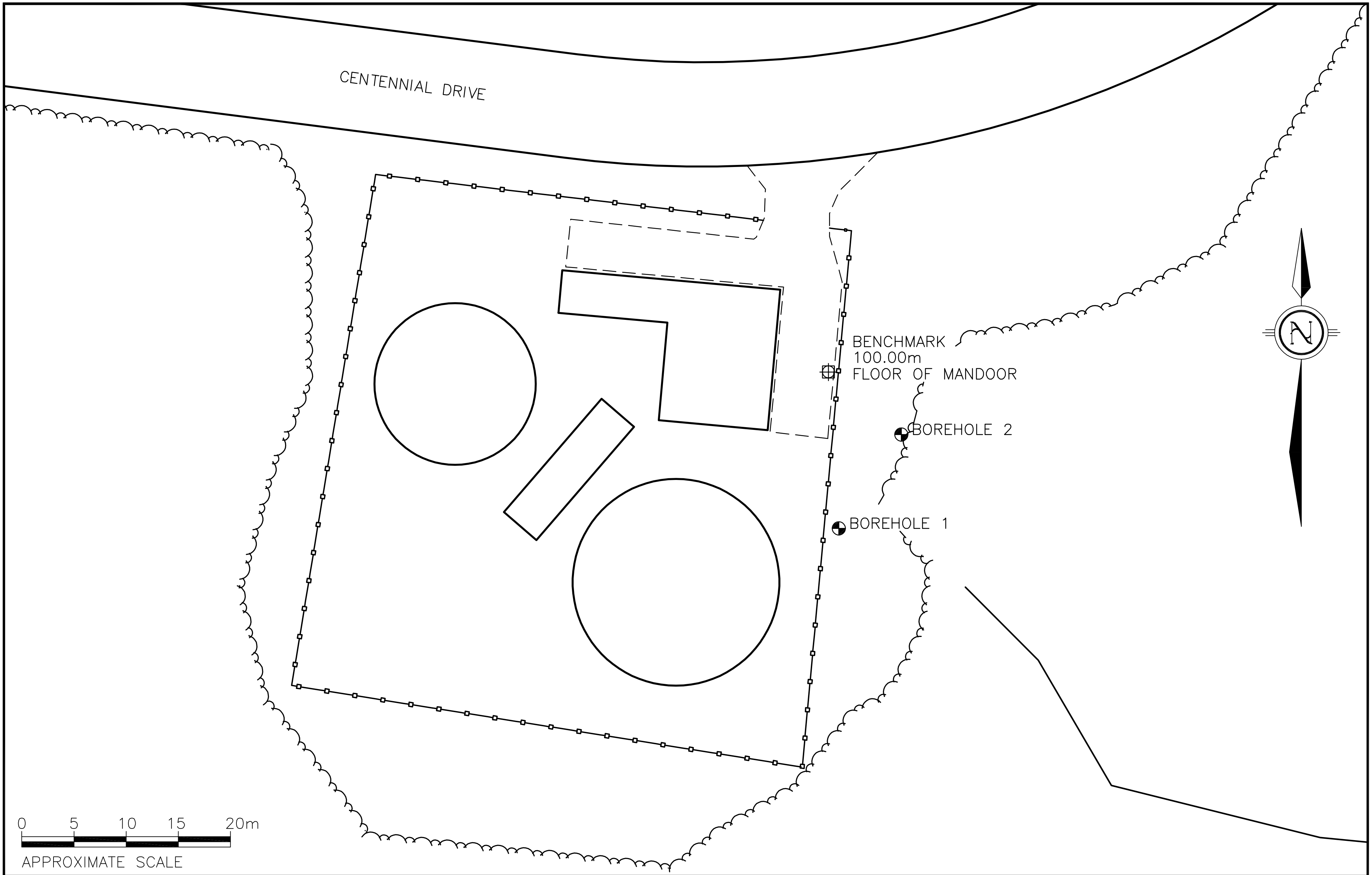
ENCLOSURES



Scale:
AS SHOWN

Date:
JUNE 23, 2020

Drawn By: T.G.
Checked By: D.V.

BOREHOLE LOCATION PLAN

PROPOSED HOLDING TANK
WATER TREATMENT PLANT

LONGLAC
ONTARIO

Client:
WSP

Project No: 20–223

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ENCLOSURE 1

File Path: C:\Users\tblunden\OneDrive – TBT Engineering Ltd\ File Name: 20–223 Borehole Location Plan.dwg

LOG OF BOREHOLE 1

PROJECT: **Proposed Holding Tank**
LOCATION: **Water Treatment Plant**
Longlac, Ontario
CLIENT: **WSP**
SURFACE ELEV.: **99.8 metres**

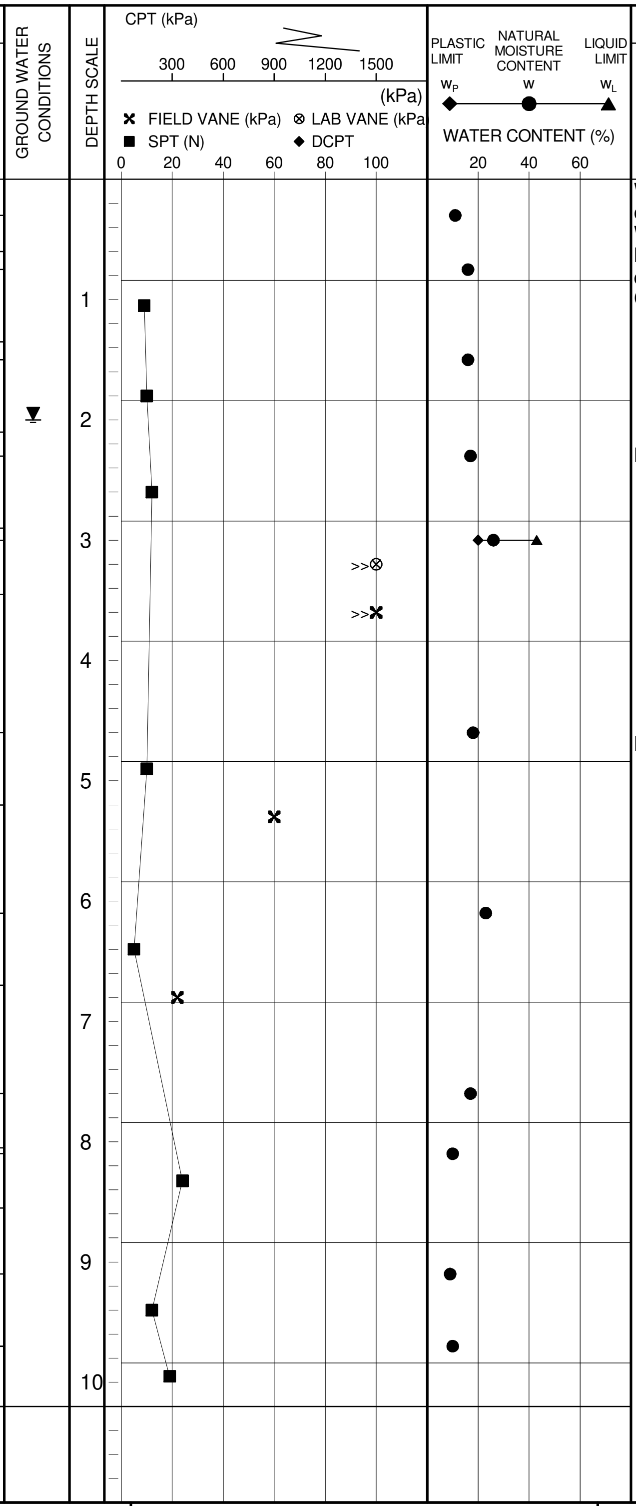
EQUIPMENT: **HS Auger**
DIAMETER: **80mm ID**
DATE: **June 15, 2020**
TBT REF. No.: **20-223**

SOIL PROFILE

DESCRIPTION
FILL - 50 mm, SAND & GRAVEL - brown - WOOD - 50 mm - - - - - - SAND & GRAVEL & CLAY - brown, loose - - - - - - CLAY - imbedded sand, trace wood, brown
CLAY - trace sand, trace gravel, grey, stiff
SILT - grey, compact
CLAY - varved, brown, very stiff
SILT - trace sand, grey, compact - - - - - - grey, loose - - - - - - - occasional cobbles cobbles
SILT & SAND - trace gravel, occasional cobbles, grey, compact
End of Borehole @ 10.2 m.

SAMPLES

TYPE	"N" VALUES
AS	
SS	9
SS	10
SS	12
TW	
SS	10
SS	5
TW	
SS	24
SS	12
SS	19



REMARKS

Water level @ 2.3 m on completion.
Water level @ 2.0 m 2 hours after completion.
Cave @ 5.5 m.

Non Plastic.

Non Plastic.

	GRAIN SIZE DISTRIBUTION (%)		
GR	SA	SI	CL
0	1	(99)	
10	41	(49)	

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SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
PT	Hiller Peat Sampler

NOTES:

× 3 ★ 3 : Numbers refer to Sensitivity

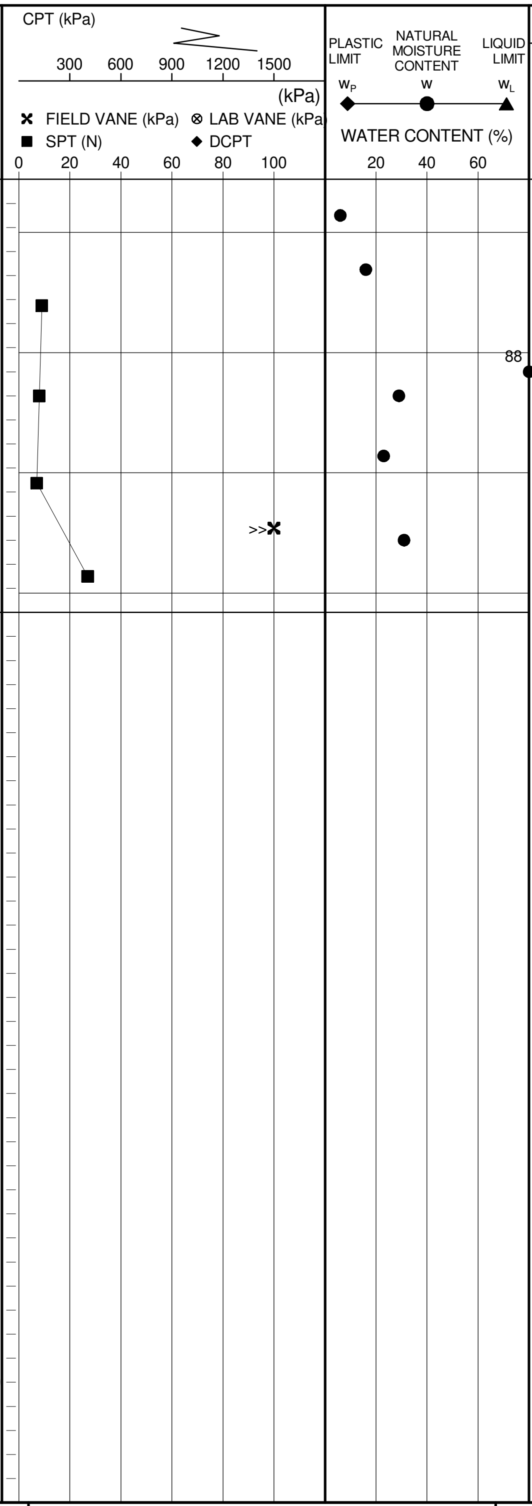
ENCLOSURE 2

LOG OF BOREHOLE 2

PROJECT: **Proposed Holding Tank**
LOCATION: **Water Treatment Plant**
Longlac, Ontario
CLIENT: **WSP**
SURFACE ELEV.: **99.4 metres**

EQUIPMENT: **HS Auger**
DIAMETER: **80mm ID**
DATE: **June 15, 2020**
TBT REF. No.: **20-223**

SOIL PROFILE		SAMPLES			REMARKS
DEPTH / ELEV.	DESCRIPTION	TYPE	"N" VALUES	GROUND WATER CONDITIONS	
0.0 / 99.4	TOPSOIL - 50 mm				Dry on compeltion. Water level @ 2 m 14 hours after completion. Cave @ 3.0 m.
	FILL - SAND & GRAVEL & SILT & CLAY - loose	AS			
		SS	9		
1.8	PEAT - 75 mm, brown				
	CLAY - grey/brown, firm	SS	8	▼ (2 m)	
		SS	7		
2.9	SILT - trace sand, brown, compact	SS	27		Non Plastic.
3.6	End of Borehole @ 3.6 m.				



GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

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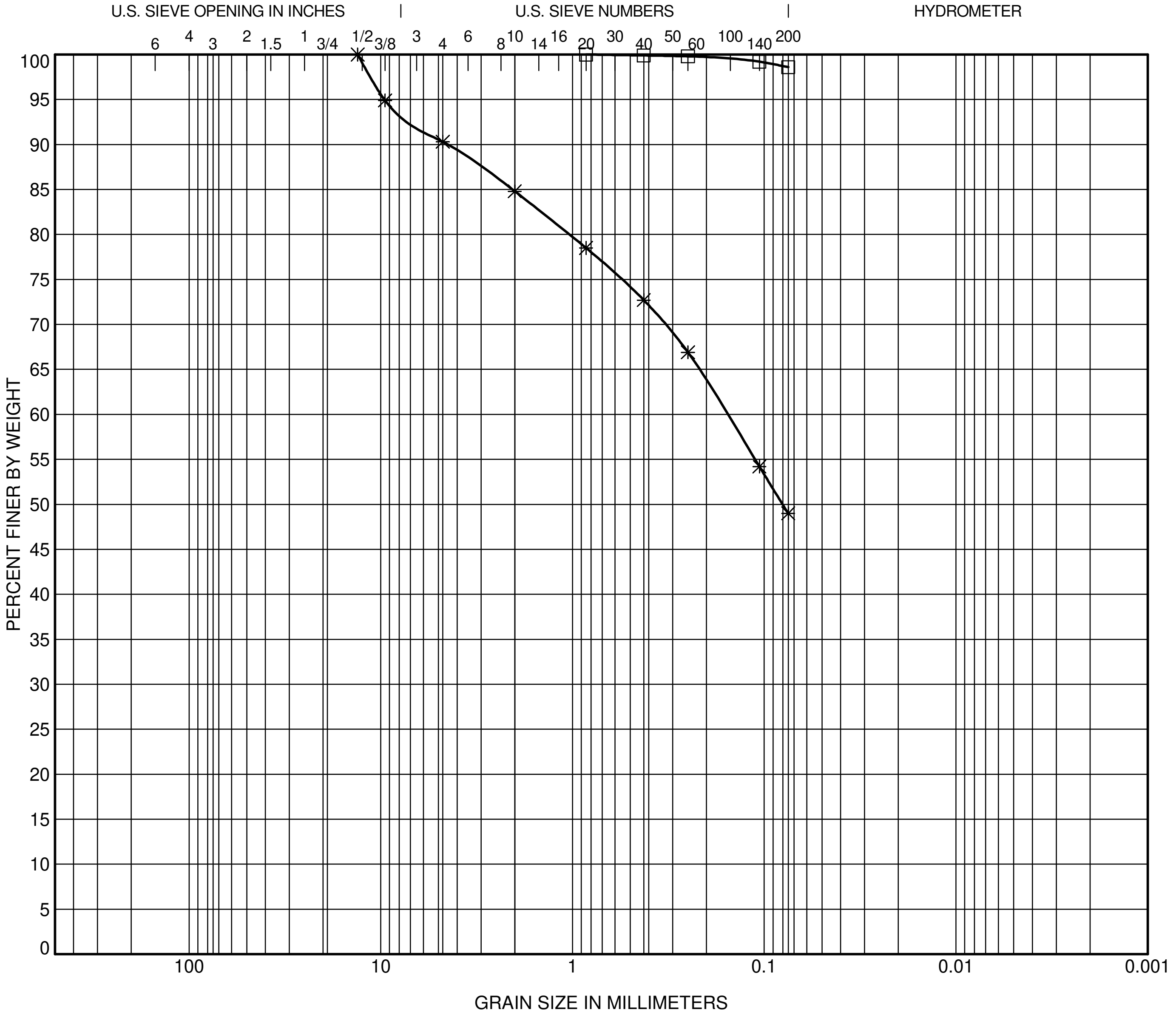
SAMPLE TYPE LEGEND

AS	Auger Sample
SS	Split Spoon Sample
TW	70mm Thin Wall Tube
CC	Concrete Core
RC	Rock Core
PS	Ponar Sample
CB	Core Barrel
PT	Hiller Peat Sampler

NOTES:

✖ ^{3} ★ ^{3}: Numbers refer to Sensitivity

ENCLOSURE 3



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Remarks:.

	Test Hole	Depth (m)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□	**1**	**4.60**	**0.85**				**0.0**	**1.4**	**98.6**	
✳	**1**	**8.10**	**13.2**	**0.157**			**9.7**	**41.3**	**49.0**	

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GRAIN SIZE DISTRIBUTION

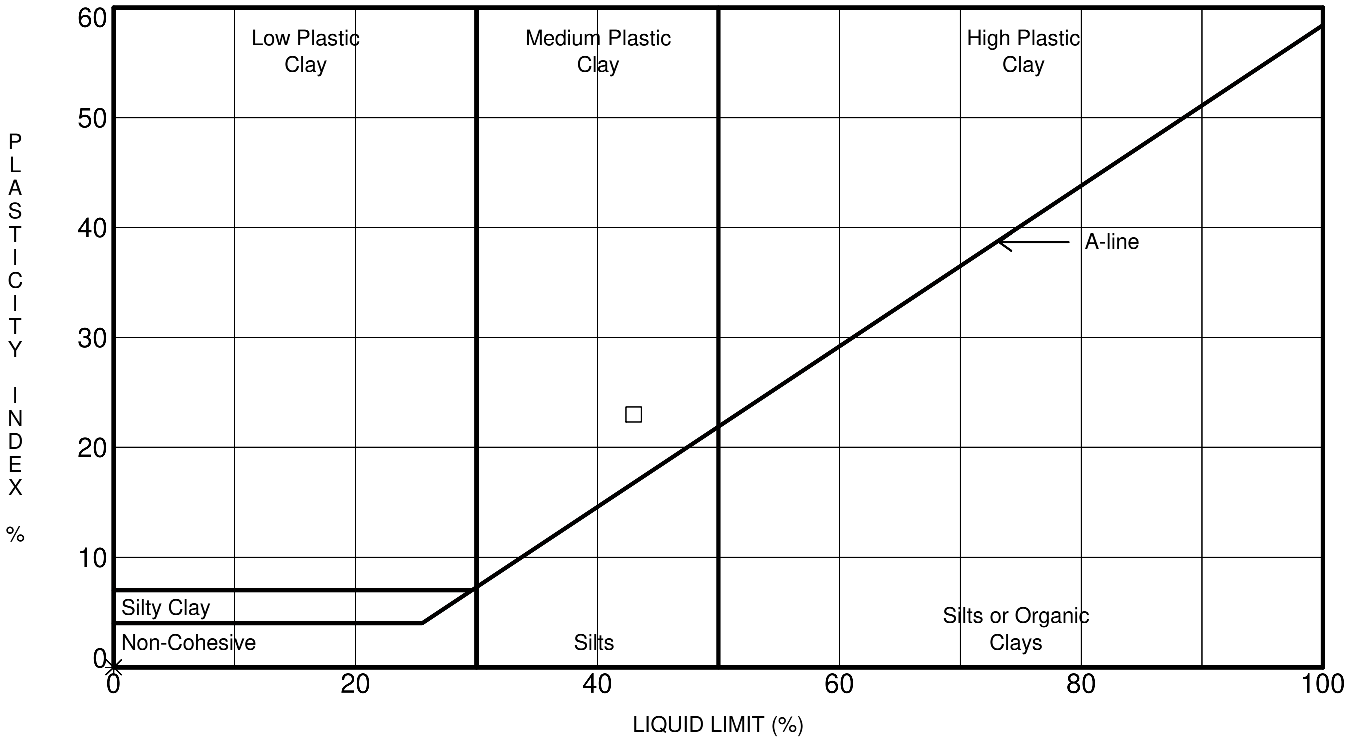
Project:

Location:

Number: 20-223

ENCLOSURE 4

TBT GS(NO DESC) 20-223 LONGLAC.GPJ CAN LAB.GDT 6-23-20



	Test Hole	Sample No.	Depth (m)	LL%	PL%	PI%	M/C%
□	**1**		**3.00**	**43**	**20**	**23**	**26**
✳	**1**		**4.60**	**NP**	**NP**	**NP**	**18**
+	**2**		**3.00**	**NP**	**NP**	**NP**	**31**

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ATTERBERG LIMIT RESULT

Project: Proposed Holding Tank

Location: Water Treatment Plant

Number: 20-223

ENCLOSURE 5