



# **Geotechnical Investigation Proposed Water Treatment Plant Holding Tank Nakina, Ontario**

**Prepared For:**

**WSP**

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Ref. No. 20-222

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## **1 Introduction**

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

It is understood that the proposed project will consist of a 5 x 2 m holding tank founded 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 16, 2020. Two boreholes were advanced at locations determined by the client. 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. A thin walled tube sample was collected in the silt.

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 Borehole Location Plan (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 log and laboratory test reports, Enclosures 2 through 5. In general, the subsurface stratigraphy consists of a layer of fill overlying silt to the limit of the boreholes.

#### **3.1 Fill**

Fill consisting of a mixture of gravel, sand, silt, and zones of clay was encountered at the surface of both boreholes and extended to depths of 3.1 m at Borehole 1 and 2.4 m at Borehole 2. This material is in a loose to compact condition, with an SPT N-values of 5 to 11 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.

#### **3.2 Silt**

Silt with trace sand was identified underlying the fill at both boreholes and extended to the termination of the boreholes at depths of 10.3 m at Borehole 1 and 3.6 m at Borehole 2. Grain size analysis carried out on selected samples indicates that the silt can consist of 0 % gravel, 2 to 7 % sand, and 93 to 98 % silt/clay sized particles. Atterberg limit testing indicates this material is non plastic. This silt deposit is in a loose to compact condition, with an SPT N-values of 6 to 12 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.

#### **3.3 Groundwater**

The groundwater level was measured at the completion of drilling and again up to 3 hours after the completion of the boreholes. Water level readings were taken within the augers.

Groundwater levels measured at the time of investigation varied from 1.8 to 2.3 m below ground surface. It is likely that 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 the placement of fill or concrete 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 Mat Foundation**

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, loose to compact native silt.
- 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 <sup>3</sup>
	Depth of Cover 0.0 m	Depth of Cover 0.5 m	Depth of Cover 0.0 m	Depth of Cover 0.5 m	
0.6	90	160	50	50	1900-2600
1.0	90	160	55	55	2200-2880
1.5	90	160	70	70	2680-3280

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

As no weather data was available for Nakina, data from Geraldton and Armstrong was used. Based on the Ministry of Environment's published weather and climatic data and the methodology prescribed by the Canadian Foundation Engineering Manual (CFEM) 4<sup>th</sup> Edition, the design frost depth for coarse grained soils (such as Granular B, Type I backfill) has been estimated to be 3.8 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 (3.8 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 3.5 m beyond the edge of the foundation. With this insulation configuration, frost can be expected penetrate up to 0.6 m below the insulation. The use of at least 0.6 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, soft, very loose soils, disturbed and/or deleterious material must be removed from below the foundation footprint to expose at least loose to compact native silt. 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 silt 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	$\phi'$ (°)	Bulk Unit Weight of Soil, $\gamma$ (kN/m <sup>3</sup> )	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. Where construction in the “dry” is required, temporary dewatering of the excavation to a level below the base of excavation and excavation slopes will be required to facilitate a stable excavation. 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. Dewatering measures should be provided by a qualified contractor/consultant. As an alternative, construction in the “wet” or flooded conditions may be considered.

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.

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.

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### 13 Closure

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

Yours truly,

For TBT ENGINEERING

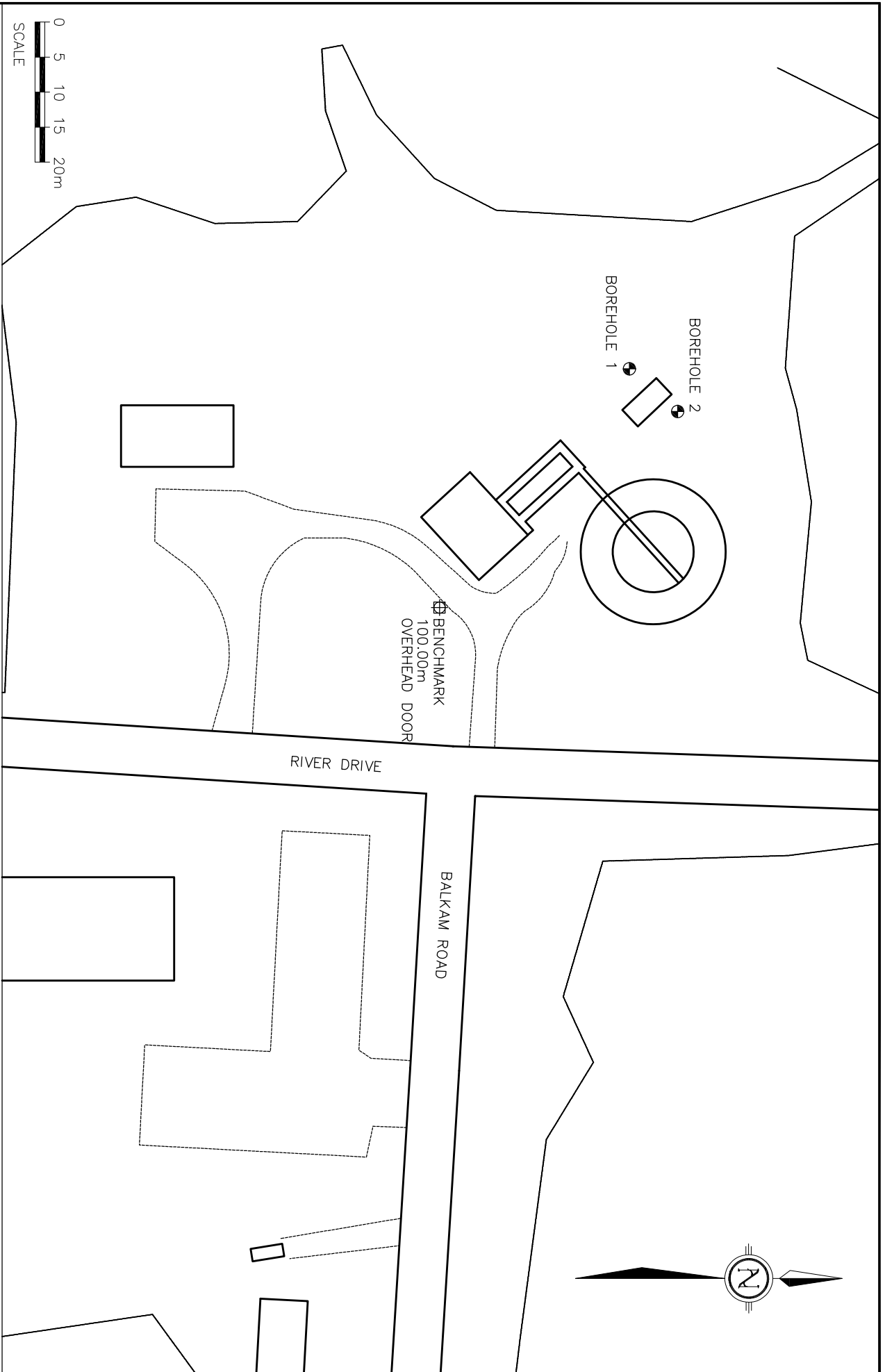


Dean Vale, P.Eng.  
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**ENCLOSURES**



Scale:  
AS SHOWN

Date:  
JUNE 23, 2020

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

**BOREHOLE LOCATION PLAN**

PROPOSED HOLDING TANK  
WATER TREATMENT PLANT

NAKINA

ONTARIO

Client:

WSP

Project No:

20-222



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ENCLOSURE

# LOG OF BOREHOLE 1

PROJECT: **Proposed Holding Tank**  
 LOCATION: **Water Treatment Plant**  
**Nakina, Ontario**  
 CLIENT: **WSP**  
 SURFACE ELEV.: **98.8 metres**

EQUIPMENT: **HS Auger**  
 DIAMETER: **80mm ID**  
 DATE: **June 16, 2020**  
 TBT REF. No.: **20-222**

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	DEPTH SCALE	CPT (kPa)		PLASTIC LIMIT (W <sub>p</sub> )	NATURAL MOISTURE CONTENT (W)	LIQUID LIMIT (W <sub>L</sub> )	REMARKS
DEPTH	ELEV.	DESCRIPTION	STRAT PLOT	% RECOVERY			TYPE	"N" VALUES				
							×	⊗	◆	■	●	GR SA SI CL
1	98	FILL - SAND & GRAVEL - Silty, brown			AS							Water level @ 2.1 m on completion. Water level @ 2.0 3 hours after completion. Cave @ 2.3 m.
		- SAND & GRAVEL & CLAY - compact			SS	6						
2	97	- CLAY - some sand, trace gravel, firm			SS	5						
3	96	- SAND - Silty, some gravel, brown, loose			SS	7						
4	95	SILT - trace sand, brown, compact			SS	11						
5	94				SS	12						0 2 (98) Non Plastic.
6	93	- loose			SS	6						
7	92				TW							
8	91	- grey, compact			SS	10						0 7 (93) Non Plastic.
9	90	- loose			SS	8						
10	89				SS	9						
		End of Borehole @ 10.3 m.										
	88											

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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:**

✕<sup>3</sup> ★<sup>3</sup>: Numbers refer to Sensitivity

**ENCLOSURE 2**

# LOG OF BOREHOLE 2

PROJECT: **Proposed Holding Tank**  
 LOCATION: **Water Treatment Plant**  
**Nakina, Ontario**  
 CLIENT: **WSP**  
 SURFACE ELEV.: **98.6 metres**

EQUIPMENT: **HS Auger**  
 DIAMETER: **80mm ID**  
 DATE: **June 16, 2020**  
 TBT REF. No.: **20-222**

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	DEPTH SCALE	CPT (kPa)		WATER CONTENT (%)			REMARKS
DEPTH	ELEV.	DESCRIPTION	STRAT PLOT	% RECOVERY			TYPE	"N" VALUES	FIELD VANE (kPa)	LAB VANE (kPa)	PLASTIC LIMIT (W <sub>p</sub> )	
0	98.6	TOPSOIL - 25 mm, brown	[Cross-hatch pattern]		AS							Water level @ 2.0 m on completion. Water level @ 1.8 m 1 hour after completion. Cave @ 2.1 m.
1	98	FILL - SILT - trace sand, brown, compact				SS	11					
2	97	- trace sand, trace gravel, trace clay			SS	9						
3	96	- SAND & GRAVEL - Silty			SS	22						
4	95	SILT - trace sand, brown/grey, compact			SS	8						
5	94	- loose										
6	93	End of Borehole @ 3.6 m.										
7	92											
8	91											
9	90											
10	88											

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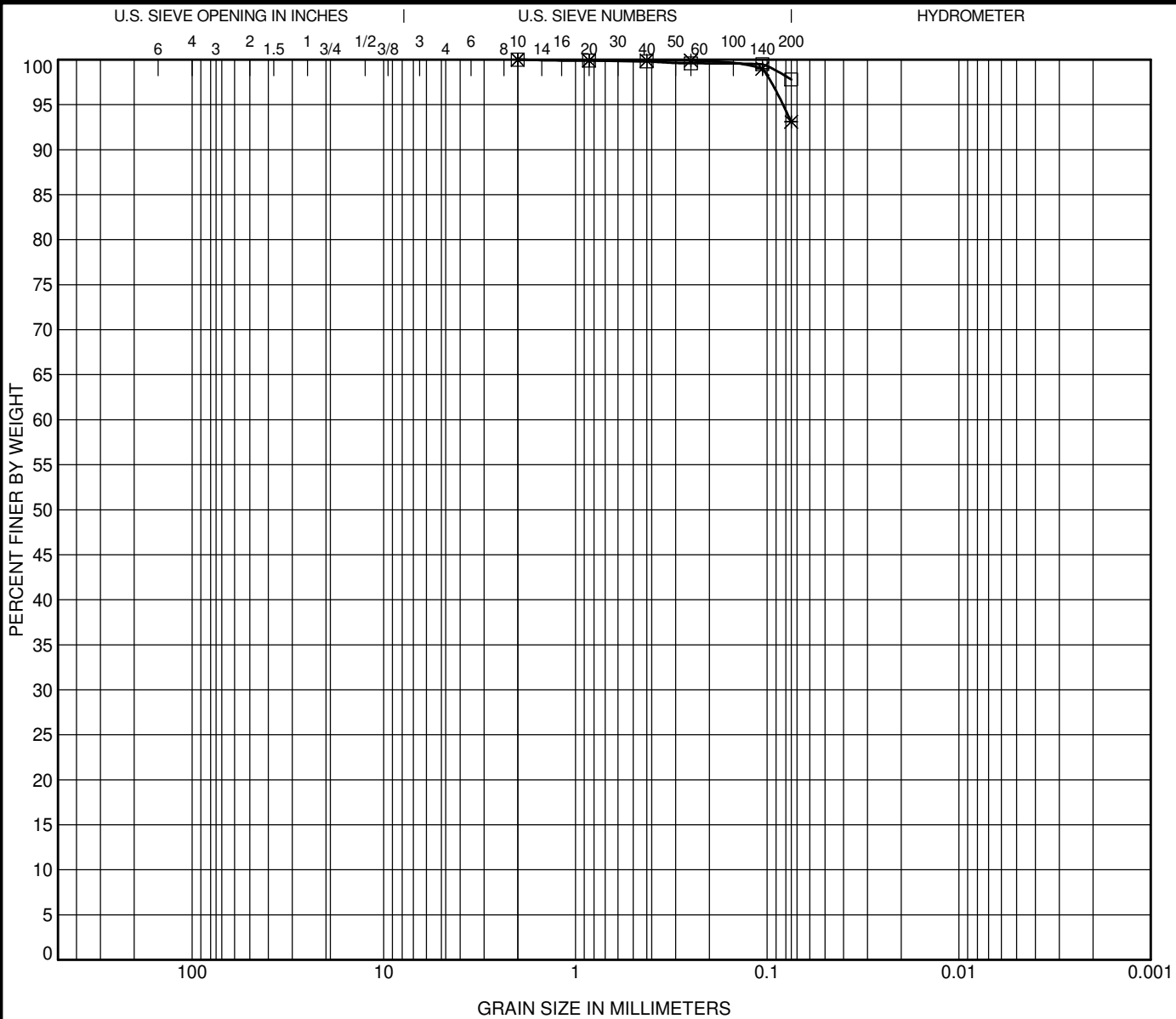
**SAMPLE TYPE LEGEND**

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:**

✕<sup>3</sup> ★<sup>3</sup>: 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	2				0.0	2.2	97.8	
* 1	8.10	2				0.0	6.9	93.1	



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### GRAIN SIZE DISTRIBUTION

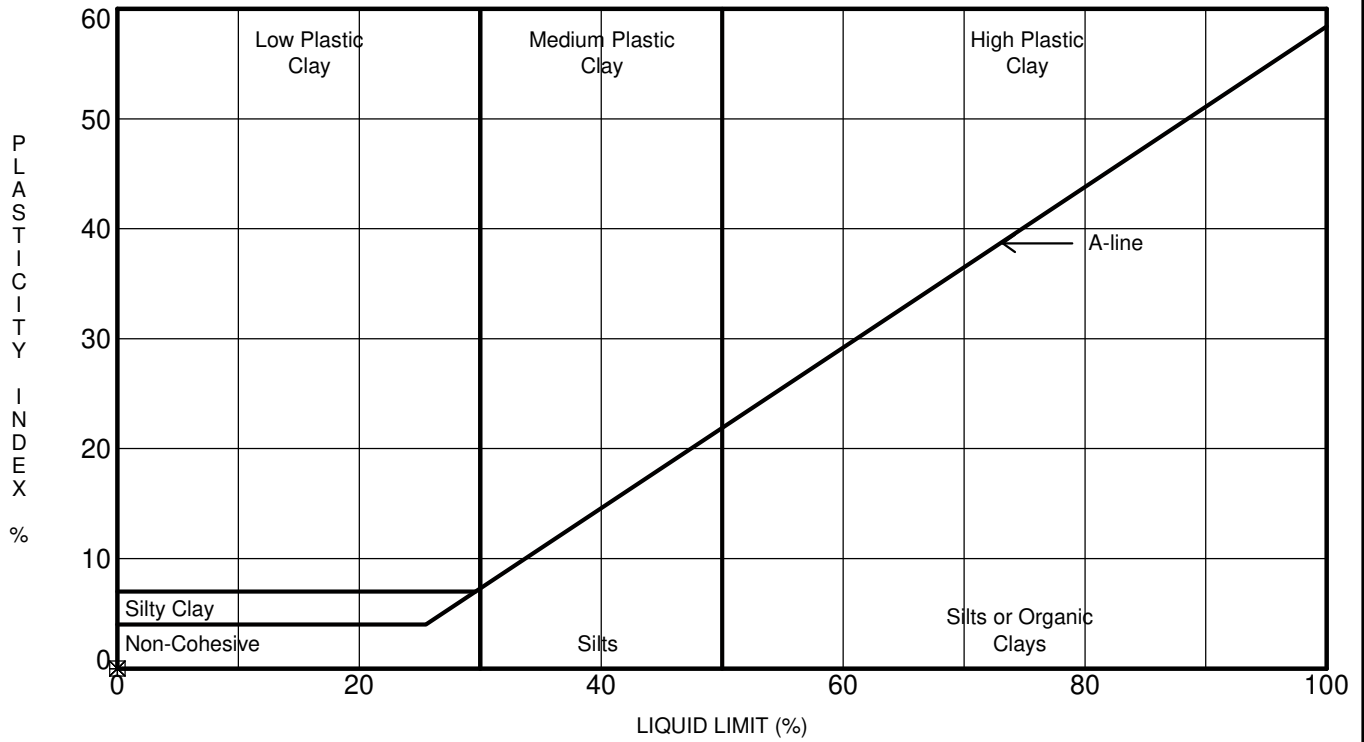
Project: Proposed Holding Tank

Location: Water Treatment Plant

Number: 20-222

ENCLOSURE 4





Test Hole	Sample No.	Depth (m)	LL%	PL%	PI%	M/C%
□ 1		4.60	NP	NP	NP	24
* 1		8.10	NP	NP	NP	

TBT ATTERBURG METRIC 20-222 NAKINA.GPJ CAN LAB.GDT 6-22-20



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### ATTERBERG LIMIT RESULT

Project: Proposed Holding Tank

Location: Water Treatment Plant

Number: 20-222

**ENCLOSURE 5**