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DRAFT
FOUNDATION INVESTIGATION AND DESIGN REPORT
NEW SALT/SAND STORAGE BUILDING
MTO PATROL YARD – MANITOU SITE
DISTRICT OF KENORA, ONTARIO
LAT. 49.2140, LONG. -92.8254
AGREEMENT NO. 6015-E-0023, ASSIGNMENT NO. 5
G.W.P. 6003-17-00

GEOCRES No.

Report to

Ministry of Transportation of Ontario

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TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1. INTRODUCTION 1
2. SITE DESCRIPTION 1
3. SITE INVESTIGATION AND FIELD TESTING 2
4. LABORATORY TESTING 3
5. SUBSURFACE CONDITIONS 3
   5.1 Asphalt 3
   5.2 Gravelly Sand Fill 4
   5.3 Sand and Silt Fill 4
   5.4 Silty Sand to Sandy Silt Fill 5
   5.5 Water Levels 5
6. MISCELLANEOUS 6

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. INTRODUCTION 8
8. GENERAL 9
9. BUILDING SUBGRADE PREPARATION 9
10. FOUNDATION RECOMMENDATIONS 9
    10.1 Strip Footings Founded below the Frost Depth in Silty Sand to Sandy Silt Fill 9
    10.2 Strip Footings on Existing Gravelly Sand Fill 11
11. SLOPE STABILITY AND FOUNDATION SETTLEMENT 11
    11.1 Stability 12
    11.2 Settlement 12
12. BACKFILL 12
13. LATERAL EARTH PRESSURE 12
14. EXCAVATION 13
15. GROUNDWATER CONTROL 14
16. CORROSION POTENTIAL 14
17. CONSTRUCTION CONCERNS 14
18. CLOSURE 15

Appendices

Appendix A	Record of Borehole Sheets
Appendix B	Laboratory Test Results
Appendix C	Site Photographs
Appendix D	List of Special Provisions and Suggested Text for NSSP
Appendix E	Borehole Locations and Soil Strata Drawing
Appendix F	Typical General Arrangement Drawing

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the site of a proposed salt and sand storage building located at an existing Ministry of Transportation of Ontario (MTO) Patrol Yard in Northwestern Ontario. The patrol yard is located on Highway 502, approximately 1.3 km north of Trout Road, in the District of Kenora, Ontario.

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

Thurber carried out the investigation as a consultant to the MTO under the Ministry of Transportation Ontario (MTO) Agreement Number 6015-E-0023.

2. SITE DESCRIPTION

The site is located on Highway 502, approximately 1.3 km north of Trout Road, in the District of Kenora, Ontario.

The site includes an existing sand dome, storage buildings, radio tower, and a marsh. There is an asphalt access road to the site and there is asphalt pavement around the existing sand dome and storage buildings. The remainder of the site, with the exception of the marsh located to the southwest, has a gravel surface. Probing of the marsh with a piece of steel rebar during the field

program determined that the marsh was relatively shallow, with the piece of rebar not penetrating more than a few inches below the surface of the marsh. The site terrain is generally flat and the area surrounding the site is heavily wooded. Photographs of the site are presented in Appendix C.

Quaternary mapping indicates that the general site area is located within an area characterized by exposed or near surface igneous and metamorphic rock covered by a discontinuous layer of drift.

According to MTO records, the site was historically a borrow pit, which has since been backfilled.

3. SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project was carried out between June 5 and 10, 2017, and consisted of drilling and sampling four boreholes (MAN-01 to MAN-04) at the corners of the proposed salt and sand storage facility. All four boreholes were terminated in overburden at depths of 5.2 to 8.2 m (Elev. 425.6 to 422.5 m).

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing in Appendix E. The boreholes were drilled near the corners of the proposed building that were staked out by the MTO prior to commencement of the field investigation. The coordinates and elevations of the boreholes are given on these drawings and on the individual Record of Borehole Sheets in Appendix A.

Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

Solid and hollow stems augers were used to advance the boreholes in the overburden. Samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with the Standard Penetration Test (SPT). Where auger refusal was encountered, N casing with a NQ core barrel was used to advance the boreholes.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, visually examined the recovered samples, and transported the samples to Thurber's laboratory in Oakville, Ontario, for further examination and laboratory testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. A standpipe piezometer consisting of a 25 mm diameter PVC pipe with slotted screen was installed in MAN-2 to permit monitoring of the groundwater level. Details of the piezometer

installation and other borehole completion details are on the Record of Borehole Sheets in Appendix A.

The boreholes in which no piezometers were installed were backfilled with bentonite and cuttings to the ground surface in general accordance with MOE Regulation 903. The piezometer in Borehole MAN-02 was abandoned in accordance with Reg. 903 upon completion of the field program.

4. LABORATORY TESTING

All recovered soil and rock samples were subjected to Visual Identification (VI) and moisture content determination. At least 25% of the recovered soil samples were also subjected to grain size distribution analysis (sieve and hydrometer). The results of the testing program are shown on the Record of Borehole Sheets in Appendix A and on the Figures contained in Appendix B.

5. SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole Sheets in Appendix A and the Borehole Locations and Soil Strata Drawing in Appendix E.

The stratigraphic boundaries shown on the borehole sheets and on the interpreted stratigraphic profile are inferred observations of drilling progress and from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

The subsurface conditions at the site consist of various cohesionless fill layers comprising gravelly sand fill layer overlying a silty sand to sandy silt fill layer. A discontinuous layer of silt and sand fill was encountered between the aforementioned layers in two of the boreholes.

A more detailed description of the subsurface conditions encountered in the boreholes is provided below.

5.1 Asphalt

Approxmately 50 mm of asphalt, representing the existing pavement, was encountered from ground surface in Boreholes MAN-02 and MAN-03 between Elev. 430.7 and 430.9 m.

5.2 Gravelly Sand Fill

A 0.9 to 2.1 m thick layer of brown gravelly sand, silty to some silt, fill was encountered below the asphalt pavement in MAN-02 and MAN-03, and from ground surface in MAN-01 and MAN-04. The upper boundary of the gravelly sand fill layer ranged from Elev. 430.3 to 430.9 m. The base of the layer ranged between Elev. 428.6 and 430.0 m.

SPT 'N' values recorded in this fill layer ranged from 3 blows per 0.3 m penetration to 30 blows per 0 m of penetration, suggesting a loose to dense relative density. Natural moisture contents measured on samples of the gravelly sand fill ranged from 5 to 19%

The results of grain size analyses conducted on samples of the gravelly sand fill are provided on the Record of Borehole sheets in Appendix A, and illustrated in Figure B1 of Appendix B. The results of the grain size analyses are also summarized in the table below.

Soil Particle	%
Gravel	15 to 29
Sand	52 to 53
Silt + Clay	19 to 32

5.3 Sand and Silt Fill

A 0.5 to 0.8 m thick layer of brown sand and silt fill was encountered underlying the gravelly sand fill in Boreholes MAN-01 and MAN-03. The sand and silt fill layer was described as having trace amounts of clay, gravel, and organics. This layer was not encountered in Boreholes MAN-02 and MAN-04. The upper boundary of the sand and silt fill layer ranged from Elev. 430.0 to 429.0 m. The base of the layer was encountered between Elev. 429.2 and 428.5 m.

SPT 'N' values recorded in the fill ranged from 9 to 17 blows per 0.3 m penetration, suggesting a loose to compact relative density. Natural moisture contents measured on samples of the sand and silt fill ranged from 8 to 21%.

The results of grain size analyses conducted on samples of the sand and silt fill are provided on the Record of Borehole shees in Appendix B1, and illustrated in Figure B2 of Appendix B. The results of the grain size analyses are also summarized in the table below.

Soil Particle	%
Gravel	3 to 7
Sand	39 to 47
Silt	39 to 50
Clay	7 to 8

5.4 Silty Sand to Sandy Silt Fill

A layer of grey silty sand to sandy silt, with gravel to trace gravel, fill was encountered underlying the gravelly sand fill layer in Boreholes MAN-02 and MAN-04, and below the sand and silt fill layer in Boreholes MAN-01 and MAN-03. The layer was noted to contain occasional cobbles and boulders. In Borehole MAN-01, pieces of wood was encountered within the layer at a depth of about 5.2 m, confirming the description of the layer as a fill layer. The upper boundary of the silty sand to sandy silt fill layer ranged from Elev. 429.2 to 428.5 m. The boreholes were terminated within the silty sand to sandy silt fill layer between Elev. 425.6 and 422.5 m.

SPT 'N' values recorded in the silty sand to sandy silt fill layer ranged from 18 blows per 0.3 m penetration to 50 blows per 0.075 m, suggesting a compact to very dense relative density. Natural moisture contents measured on samples of the silty sand to sandy silt fill ranged from 6 to 19%.

The results of grain size analyses conducted on samples of the silty sand to sandy silt fill are provided on the Record of Borehole shees in Appendix B1, and illustrated in Figure B3 of Appendix B. The results of the grain size analyses are also summarized in the table below.

Soil Particle	%
Gravel	0 to 48
Sand	31 to 60
Silt + Clay	13 to 69

5.5 Water Levels

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole MAN-2 to monitor the groundwater level at the site. The following table summarizes the water levels measured in the open boreholes and piezometer.

Table 5.1 – Water Level Measurements

Borehole	Date	Water Level (m)		Comment
		Depth	Elevation	
MAN-1	June 7, 2017	Not recorded	Not recorded	In open borehole
MAN-2	June 10, 2017	5.3	425.4	In piezometer
MAN-3	June 9, 2017	2.9	428.0	In open borehole
MAN-4	June 10, 2017	3.4	427.3	In open borehole

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6. MISCELLANEOUS

The boreholes locations were surveyed by Deltasurvey Inc. following completion of drilling.

RPM Drilling of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full time basis by Mr. Simon Paxton of Thurber. Overall supervision of the field program was provided by Mr. Geoff Lay, P.Eng., of Thurber.

Routine laboratory testing was carried out at Thurber's geotechnical laboratory in Oakville, Ontario. Interpretation of the field data and preparation of this report was carried out by Mr. Geoff Lay, P.Eng. The report was reviewed by Mr. Keli Shi, P.Eng., and Dr. P.K. Chatterji, P.Eng, a Designated Principal Contact for MTO Foundations Projects.

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Thurber Engineering Ltd.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. INTRODUCTION

This report presents interpretation of the geotechnical data in the factual report and provides foundation design recommendations to assist the design team to select and design a suitable foundation system for the proposed salt and sand storage facility.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon by any other parties including the construction or design-build contractor. The design-build contractor must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretations of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The discussion and recommendations presented in this report are based on our understanding of the project and the factual data obtained during the subsurface investigation.

8. GENERAL

The proposed salt/sand storage building will consist of reinforced concrete foundation walls and a steel frame superstructure and will be approximately 18.3 x 24.4 m in dimension.. A typical General Arrangement drawing for the proposed sand/salt storage structure provided to Thurber by MTO is attached in Appendix F.

9. BUILDING SUBGRADE PREPARATION

The typical General Arrangement drawing indicates that the surface of the interior of the facility will consist of 50 mm of asphalt pavement overlying 400 mm of Granular A. The pavement will be approximately at the existing ground surface.

Any topsoil, buried topsoil, organics, soft or deleterious material should be stripped from the site surface. The exposed subgrade should be proofrolled to detect any potential soft areas. Where soft areas are detected, these areas should be subexcavated and replaced with well-compacted Granular “A” satisfying the requirements of OPSS.PROV 1010. The final subgrade surface should be uniformly compacted to 98% of Standard Proctor Maximum Dry Density (SPMDD).

10. FOUNDATION RECOMMENDATIONS

The following alternative foundation types were considered for the sand and salt storage building:

- Strip footings founded below the frost depth in the silty sand to sandy silt fill
- Strip footings placed near the surface on the existing gravelly sand fill

While both foundation options are considered feasible, supporting the structure on strip footings founded below the frost depth in the compact to very dense silty sand to sandy silt fill will mitigate the risk of frost movement of the footings.

Alternatively, the frame structure could be supported on strip footings placed at a minimum depth of 0.5 m below the ground surface on the very loose to compact gravelly sand fill. If frost protection is not provided, frost-related footing movements should be expected.

10.1 Strip Footings Founded below the Frost Depth in Silty Sand to Sandy Silt Fill

The highest permitted founding elevations for footings founded below the frost depth on the compact to very dense silty sand to sandy silt fill are given in Table 10.1 below. Frost depth at this site is 2.4 m.

Table 10.1 – Highest Permitted Founding Elevations

Location	Borehole	Founding Soil Type	Min. Depth (m)	Highest Elevation (m)
SW Building Corner	MAN-1	Silty Sand to Sandy Silt with Gravel Fill	2.4	427.9
SE Building Corner	MAN-2	Silty Sand to Sandy Silt with Gravel Fill	2.4	428.3
NE Building Corner	MAN-3	Silty Sand to Sandy Silt, gravelly to trace gravel, Fill	2.4	428.5
NW Building Corner	MAN-4	Silty Sand to Sandy Silt, trace gravel, Fill	2.4	428.3

Spread footings founded on the compact to very dense silty sand to sandy silt with gravel fill at or below the above noted elevations should be designed using the following geotechnical resistance values, assuming a minimum 1 m wide footing subjected to vertical concentric loading:

Factored Geotechnical Resistance at ULS = 300 kPa

Factored Geotechnical Resistance at SLS = 200 kPa

The geotechnical resistance at SLS is based on an estimated settlement not exceeding 25 mm. This settlement should be essentially complete by the end of construction.

The resistance values are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

The lateral resistance developed along the base of concrete footings founded on the silty sand to sandy silt with gravel fill may be computed using an ultimate friction coefficient of 0.4.

The footing subgrade should be inspected by a geotechnical engineer following excavation, in accordance with OPSS 902 *(Excavating and Backfilling Structures)* to confirm that the soil conditions at the founding level are consistent with the design assumptions and that the base has been adequately cleaned of disturbed soil. The footing bases should be kept free of water and a 50 mm skim slab should be placed over the founding surface if structural concrete cannot be placed within 24 hours of excavation. Subgrade preparation should be carried out in the dry.

Where subexcavation is required to remove unsuitable material from below the design founding level, the founding surface should be re-established using engineered granular fill or concrete of the same class as the footing, The subexcavation should be stepped down gradually at slope not

steeper than 1H:1V and no individual step should be greater than 200 mm. The engineered fill must conist of OPSS Granular “A” placed in 150 mm lifts and compacted to 100% of SPMDD.

10.2 Strip Footings on Existing Gravelly Sand Fill

Consideration may be given to supporting the building on spread footings founded at the ground surface on the gravelly sand fill. The footings must not be placed on any layers of buried topsoil. As indicated earlier, if no frost protection is provided, some vertical movement of the footing due to frost action should be expected. If this is not acceptable, then the footing must be insulated from frost action by installing a minimum 50 mm thick layer of extruded polystyrene insulation over the top of the footing, extending a minimum distance of 2.5 m away from the outer edge of the footing.

Due to the presence of loose sand fill at some locations, this option would require initial compaction of the gravelly sand fill layer, prior to placement of the footing, in order to achieve a uniformly competent subgrade. This may be achieved through proofrolling of the sand fill to identify loose zones, subexcavation of the loose zones, followed by placement and compaction of OPSS 1010 Granular “A” to at least 95% of SPMDD.

Spread footings founded on the above prepared competent subgrade should be designed using the following geotechnical resistance values, assuming a minimum 1 m wide footing founded a minimum depth of 0.5 m below the ground surface and subjected to vertical concentric loading:

Factored Geotechnical Resistance at ULS = 150 kPa

Factored Geotechnical Resistance at SLS = 100 kPa

The geotechnical resistance at SLS is based on an estimated settlement not exceeding 25 mm.

The resistance values are for vertical, concentric loads. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

The lateral resistance developed along the base of concrete footings placed on the gravelly sand fill may be computed using an ultimate friction coefficient of 0.4.

11. SLOPE STABILITY AND FOUNDATION SETTLEMENT

The proposed facility will store sand/salt stockpiles to an estimated height in excess of 8 m. Foundation stability and settlement associated with the stockpiling of the sand/salt are addressed in the following sections.

11.1 Stability

Global stability of the stockpiles on the existing fill is not considered to be a concern based on the typically compact to dense state of the fill encountered within the proposed building footprint.

11.2 Settlement

Settlement analyses has been carried out to evaluate the effect of the placement of sand/salt stockpile on the foundation soils using the commercially available computer program *Settle-3D* from Rocscience. The settlement has been evaluated using estimated elastic deformation moduli for the cohesionless fills, which were estimated from correlations with the SPT "N" values and based on engineering judgement.

The analysis indicates that the placement of the stockpiles will result in about 30 mm of settlement in the loose gravelly sand fill. The ground settlements are expected to occur during placement of the stockpiles and will be essentially complete upon completion of full stockpile placement. It is estimated that less than 25 mm of settlement may occur at the foundation footing locations.

12. BACKFILL

Excavation for footing construction should be backfilled with free-draining granular materials such as per OPSS.PROV 1010 Grabular A or Granular B Type II. Care should be taken to maintain backfill on both sides of the wall at approximately same level to minimize unbalanced lateral forces. Care should be taken to not "over-compact" adjacent to the walls in order to not impose excessive lateral stresses. Compaction equipment to be used adjacent to the foundation walls should be restricted in accordance with OPSS.PROV 501.

13. LATERAL EARTH PRESSURE

The lateral earth pressures acting on the foundation wall from the backfill or stockpiled sand/salt may be assumed to be triangularly distributed. For a fully drained condition, the lateral pressure should be computed in accordance with the CHBDC 2014 but generally are given by the following equation:

$$p_h = K(\gamma h + q)$$

Where:

p_h = horizontal pressure on the wall at depth h (kPa)

K = coefficient of lateral earth pressure (see table below)

γ = unit weight of retained sand/salt (see table below)

h = depth below top of stockpile where pressure is computed (m)

q = value of any surcharge (kPa)

Recommended values of earth pressure coefficients for backfill and sand/salt stockpile are shown in the table below.

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35°; \gamma = 22.8$ kN/m^3		OPSS Granular B Type I (modified) $\phi = 32°; \gamma = 21.2$ kN/m^3		Sand/Salt Stockpile $\phi = 32°; \gamma = 16$ kN/m^3	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (**1.5H:1V**)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48	0.31	0.69
At-rest (Restrained Wall)	0.43	0.62	0.47	0.70	0.47	0.73
Passive	3.7	-	3.3	-	3.3	-

For non-yielding structures, at-rest horizontal earth pressures should be used for design. Active pressures should be used for any unrestrained wall.

14. EXCAVATION

All excavations must be carried out in accordance with the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the cohesionless fill materials above the water level may be classed as Type 3 soil and classed as Type 4 soil below the water table. Temporary shallow excavation may be formed unsupported with side slopes no steeper than 1H:1V. Flatter slopes may be required at locations where soils are less competent or where water seepage affects surficial stability.

The excavation and backfilling for foundation construction must be carried out in accordance with OPSS 902.

The selection of the method of excavating soils is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions. Excavation into the silty sand to sandy silt with gravel fill layer may encounter cobbles and boulders. The contractor's excavation equipment must be able to dislodge and remove these obstructions. An NSSP to alert the contractor of this requirement has been included in Appendix D.

Excavations should be inspected regularly for evidence of instability if they have been left open for extended period of time and following heavy rainfall. If required, remedial actions must be taken to ensure the stability of the excavation and the safety of workers.

15. GROUNDWATER CONTROL

Based on groundwater measurements in open boreholes and piezometer, the groundwater table is expected to be at least 2.9 m below the existing ground surface (below Elev. 428.0 m). Therefore, the temporary excavations for construction of footings founded in the silty sand to sandy silt fill are not anticipated to extend below the groundwater table and difficulties associated with groundwater control are not expected. Any groundwater seepage into the excavation through the gravelly sand fill which does occur may be removed using perimeter ditches and filtered sump pumping.

The design of an effective dewatering system is the responsibility of the contractor.

16. CORROSION POTENTIAL

All metal structural elements and concrete foundations will be exposed to chlorides in the deicing salt and must be provided with appropriate protection measures against the high chloride corrosion potential.

17. CONSTRUCTION CONCERNS

Care must be exercised during excavation to minimize disturbance of the founding subgrade. The exposed subgrade soils should be inspected, approved and protected from disturbance as soon as practicable.

Field inspection during construction is recommended to confirm the subgrade conditions. Accordingly, items such as building and pavement subgrade condition, backfilling methods, compaction of granular material should be inspected and tested by geotechnical personnel.

Groundwater seepage into the open excavations for footing construction is not anticipated over the course of construction. However, should groundwater seepage occur, it is anticipated that perimeter ditches and filtered sump pumping will be adequate for the control of groundwater prior to concrete placement.

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18. CLOSURE

Engineering analysis and preparation of the foundation design report was carried out by Mr. Geoff Lay, P.Eng. The report was reviewed by Mr. Keli Shi, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

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.

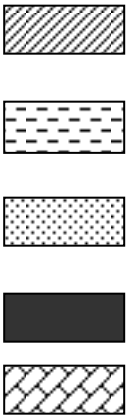
(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of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

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No MAN-01 1 OF 1 METRIC

GWP# 6003-17-00 LOCATION SW Building Corner, NAD 83-16 N 5 452 888.1 E 317 516.2 ORIGINATED BY SMP

HWY 502 BOREHOLE TYPE Hollow Stem Augers/ N Casing COMPILED BY AN

DATUM Geodetic DATE 2017.06.07 - 2017.06.07 CHECKED BY GRL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
430.3	GROUND SURFACE										
0.0	Gravelly **SAND**, silty to some silt Loose to Compact Brown Moist (FILL)		1	SS	12		430				
			2	SS	9						
429.0							429				
1.3	**SAND** and **SILT**, trace gravel, trace organics Compact Brown Moist (FILL)		3	SS	17						7 47 39 7
428.5											
1.8	Silty **SAND** to Sandy **SILT**, with gravel, occasional cobbles and boulders Very Dense Grey Moist to Wet (FILL)		4	SS	45		428				
			5	SS	86						
	Auger refusal at 2.4m on probable cobbles and boulders, switch to casing						427				
							426				
	Slough in augers resulting in probable erroneous N value		6	SS	18						
	Pieces of wood at 5.2m		7	SS	50/ 0.075		425				
424.2											
6.1	END OF BOREHOLE AT 6.1m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No MAN-02 1 OF 1 METRIC

GWP# 6003-17-00 LOCATION SE Building Corner, NAD 83-16 N 5 452 890.7 E 317 532.4 ORIGINATED BY SMP

HWY 502 BOREHOLE TYPE Hollow Stem Augers/N Casing/Dynamic Cone Penetration Test COMPILED BY AN

DATUM Geodetic DATE 2017.06.05 - 2017.06.05 CHECKED BY GRL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
430.7	GROUND SURFACE										
0.0 / 0.0	**ASPHALT:** (50mm)										
	Gravelly **SAND**, silty to some silt Compact Brown Moist (FILL)		1	SS	14				○		29 52 19 (SI+CL)
			2	SS	14		430		○		
	Auger refusal at 1.8m on probable cobbles and boulders, switch to casing		3	SS	30				○ ○		
428.9			4	SS	10/ 0.0		429				
1.8	Silty **SAND** to Sandy **SILT**, with gravel, occasional cobbles and boulders Compact to Very Dense Grey Moist (FILL)						428				
			5	SS	45						48 39 13 (SI+CL)
			6	SS	19		427				
			7	SS	50/ 0.075		426				
425.5											
5.2	End of sampling and start DCPT						425				
424.2											
6.5	END OF DCPT AT 6.5m UPON REFUSAL ON PROBABLE COBBLES OR BOULDERS. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.06.10 5.3 425.4										

$+^3$, $\times^3$: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No MAN-03 1 OF 1 METRIC

GWP# 6003-17-00 LOCATION NE Building Corner, NAD 83-16 N 5 452 910.4 E 317 529.7 ORIGINATED BY SMP

HWY 502 BOREHOLE TYPE Solid Stem Augers/N Casing COMPILED BY AN

DATUM Geodetic DATE 2017.06.09 - 2017.06.09 CHECKED BY GRL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
430.9	GROUND SURFACE										
0.0	**ASPHALT:** (50mm)										
0.0	Gravelly **SAND**, silty Compact Brown Moist (FILL)		1	SS	18						
430.0			2	SS	22		430				3 39 50 8
0.9	**SAND** and **SILT**, trace clay, trace gravel Compact Brown Moist (FILL)		3	SS	9						
429.2							429				
1.7	Silty **SAND** to Sandy **SILT**, trace clay, gravelly to trace gravel Dense to Very Dense Grey Moist (FILL)		4	SS	53						
			5	SS	29	▽	428				
			6	SS	31						
			7	SS	72		427				0 31 64 5
			8	SS	50/						
					0.225		426				
425.6											
5.3	END OF BOREHOLE AT 5.3m. WATER LEVEL AT 2.9m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No MAN-04 1 OF 1 METRIC

GWP# 6003-17-00 LOCATION NW Building Corner, NAD 83-16 N 5 452 900.9 E 317 511.1 ORIGINATED BY SMP

HWY 502 BOREHOLE TYPE Solid Stem Augers/N Casing COMPILED BY AN

DATUM Geodetic DATE 2017.06.10 - 2107.06.10 CHECKED BY GRL

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
430.7	GROUND SURFACE										
0.0	Gravelly **SAND**, silty, trace clay Very Loose to Loose Brown Moist to Wet (FILL)		1	SS	7						15 53 28 4
			2	SS	3		430				
			3	SS	6						
428.6							429				
			4	SS	46						
2.1	Silty **SAND** to Sandy **SILT**, trace clay, trace gravel Compact to Very Dense Grey Moist (FILL)		5	SS	28		428				7 60 29 4
	Cobbles at 2.3m		6	SS	19	▽					
			7	SS	32		427				0 45 50 5
			8	SS	28						
							426				
							425				
	Auger refusal at 5.8m		9	SS	50/ 0.125						
	Start DCPT at 6.1m DCPT refusal at 6.2m						424				
422.5			10	SS	50/ 0.100		423				
8.2	END OF DCPT AT 8.2m. WATER LEVEL AT 3.4m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS, THEN ASPHALT PATCH TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20
15 ⊕ 5 (%) STRAIN AT FAILURE
10

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THURBER

60 YEARS

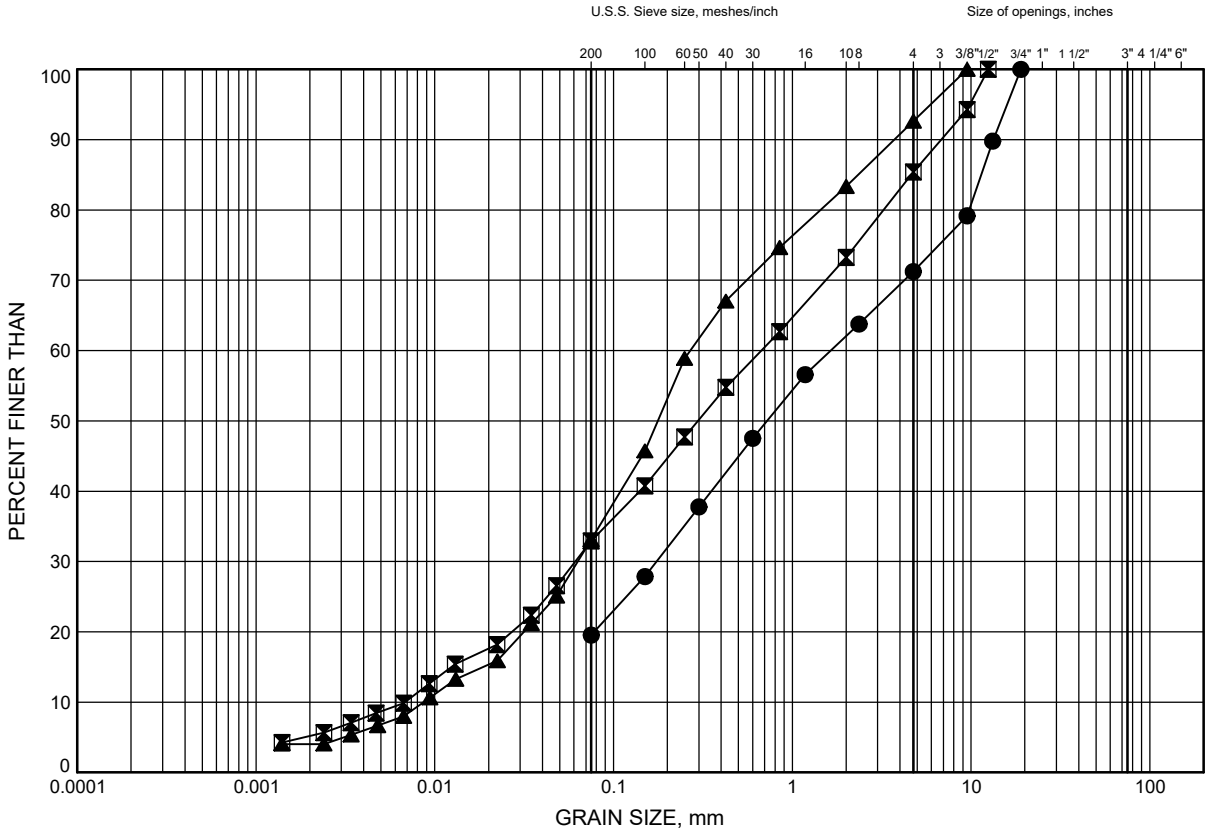
Appendix B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

FIGURE B1

Gravelly SAND, silty to some silt FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MAN-02	0.3	430.4
⊠	MAN-04	0.3	430.4
▲	MAN-04	2.7	428.0

Date August 2017

GWP# 6003-17-00

THURBER

Prep'd AN

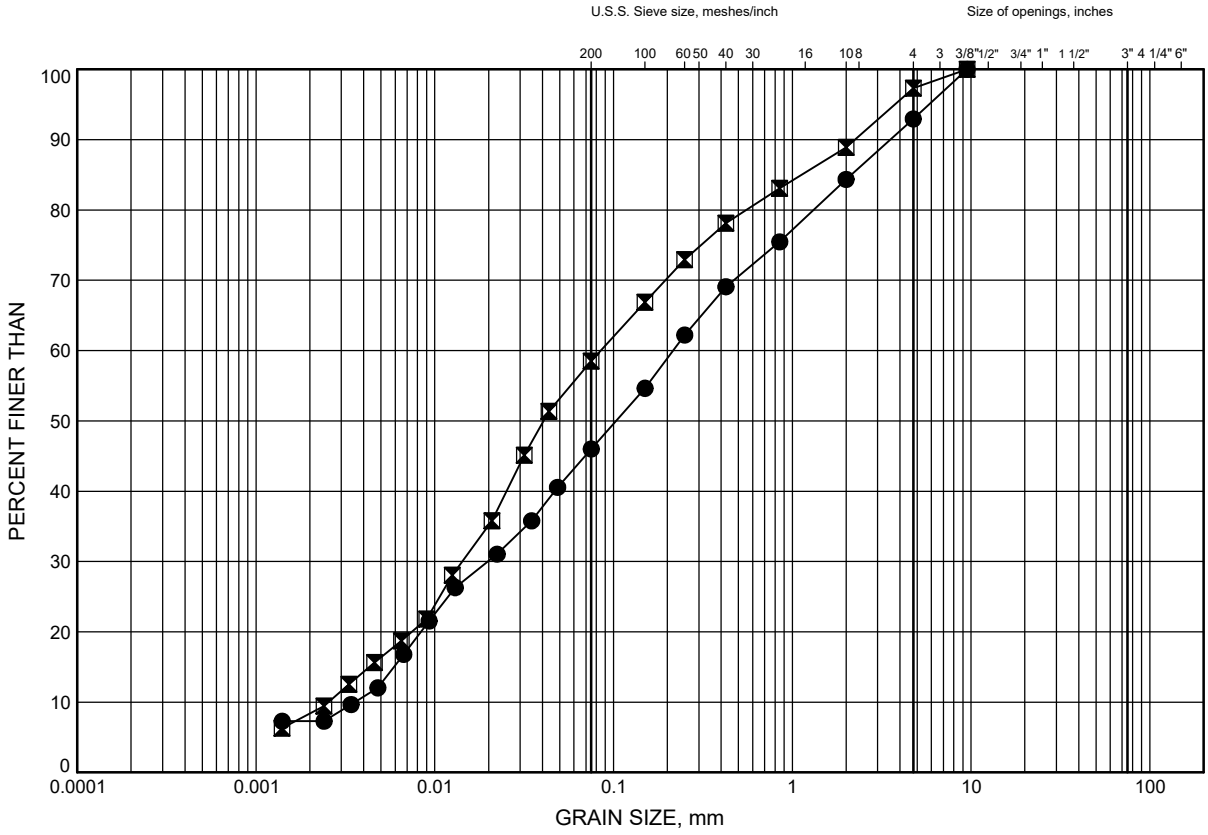
Chkd. GRL

GRAIN SIZE DISTRIBUTION - THURBER MTO-18934.GPJ 17/8/3

GRAIN SIZE DISTRIBUTION

FIGURE B2

SAND & SILT FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MAN-01	1.6	428.7
⊠	MAN-03	1.0	429.9

Date August 2017

GWP# 6003-17-00

THURBER

Prep'd AN

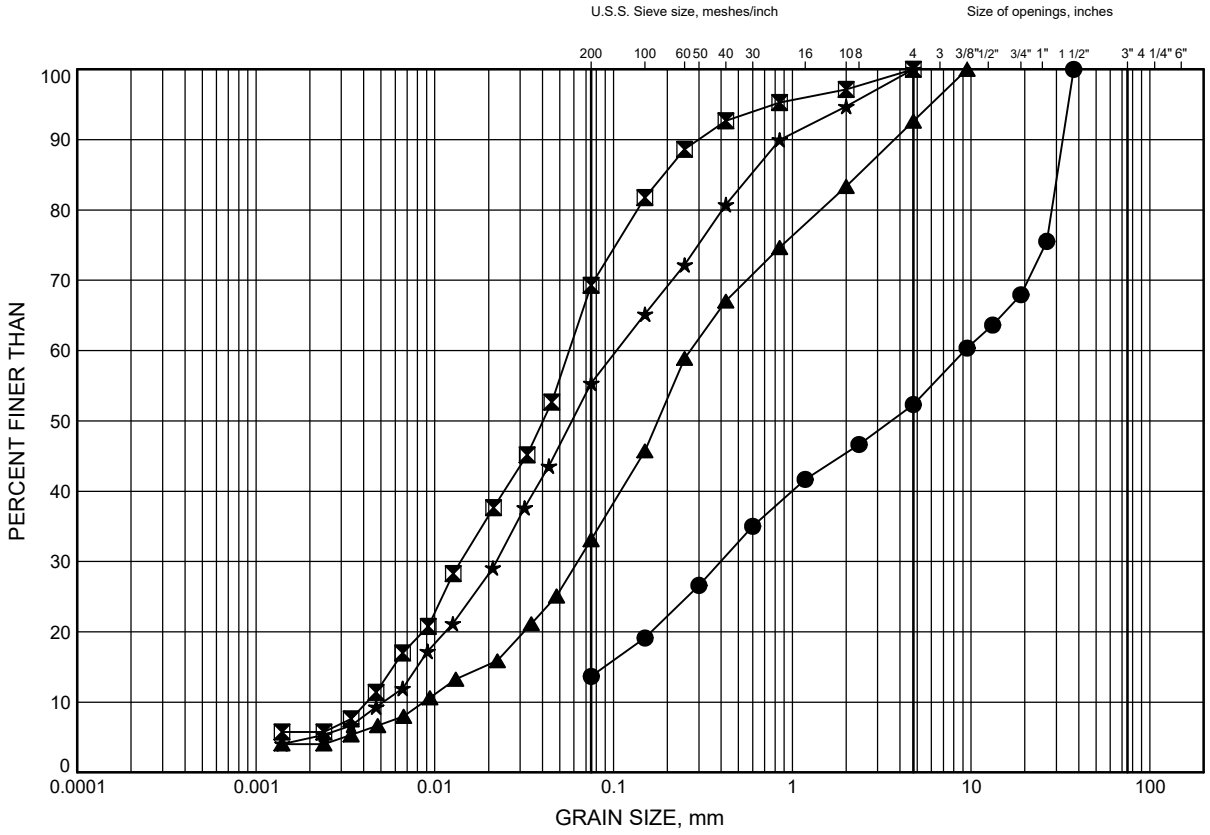
Chkd. GRL

GRAIN SIZE DISTRIBUTION - THURBER MTO-18934.GPJ 17/8/3

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty SAND to Sandy SILT, with gravel to trace gravel FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	MAN-02	3.4	427.3
⊠	MAN-03	4.0	426.9
▲	MAN-04	2.7	428.0
★	MAN-04	4.0	426.7

Date August 2017

GWP# 6003-17-00

THURBER

Prep'd AN

Chkd. GRL

GRAIN SIZE DISTRIBUTION - THURBER MTO-18934.GPJ 17/8/2

Appendix C

Site Photographs

Photograph 1 – Proposed building location showing drill rig on MAN-02, looking east

Photograph 2 – Proposed building location showing drill rig on MAN-01, looking east

THURBER

60 YEARS

Appendix D

List of Special Provisions and Suggested Text for NSSP

1. List of Special Provisions and OPSS Documents Referenced in this Report

- OPSS.PROV 501 – Construction Specification for Compacting
- OPSS.PROV 1010 – Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material
- OPSS 902 – Construction Specification for Excavating and Backfilling – Structures

2. Suggested Text for NSSP on "Sandy Silt to Sandy Silt"

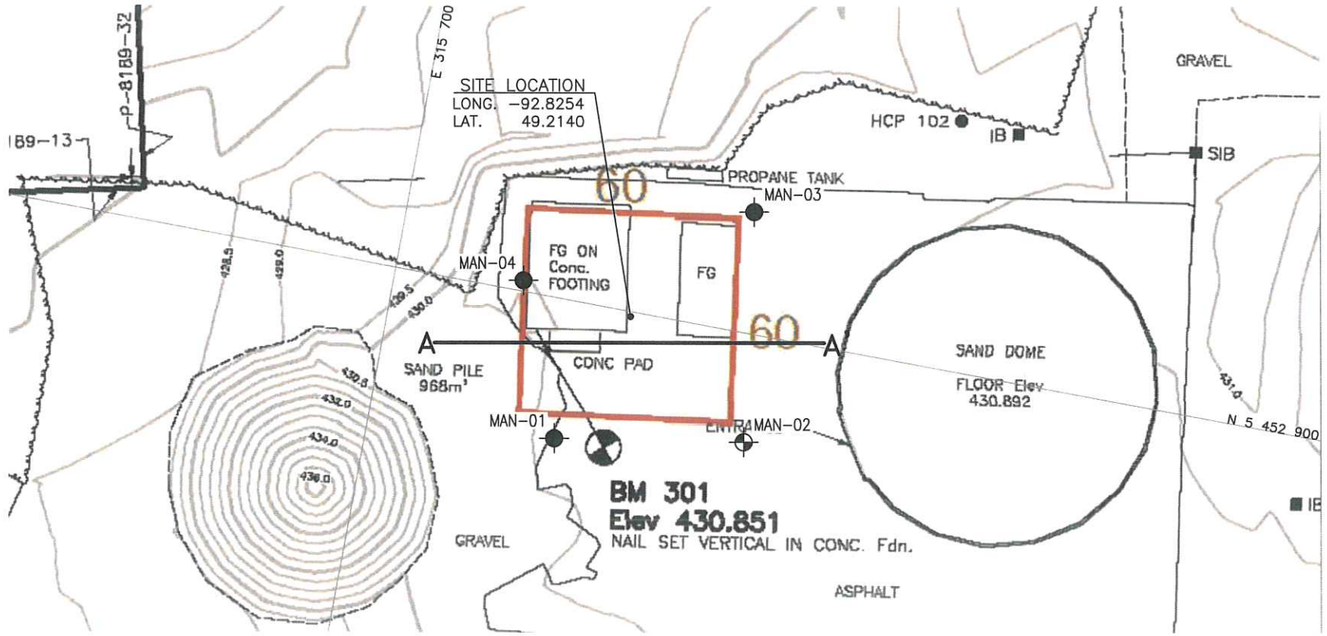
Occasional cobbles and boulders were noted within the sandy silt to silty sand with gravel layer. The presence of these cobbles and boulders may make excavation through the layer difficult. Excavation through this material may first be tried using bulk excavation techniques.

THURBER

60 YEARS

Appendix E

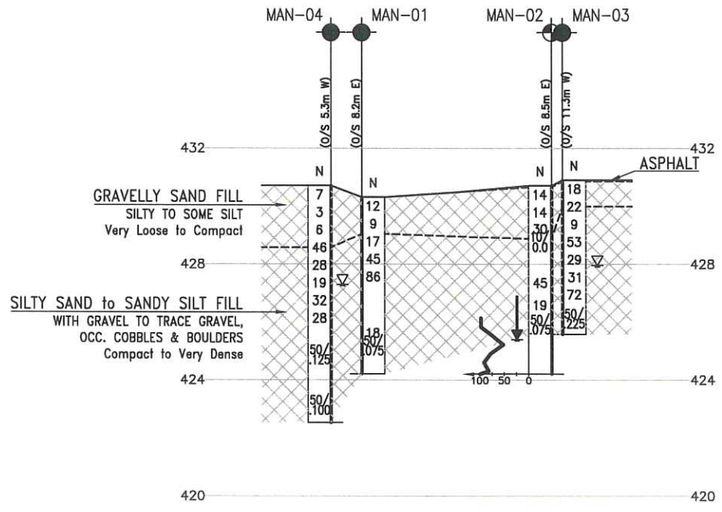
Borehole Locations and Soil Strata Drawing



PLAN

10 0 10 20m

SCALE 1:500



SECTION A–A'

20 0 20 40m H 1:1000

5 0 5 10m V 1:250

METRIC

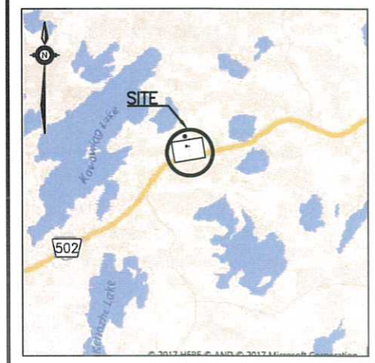
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 6003-17-00

NEW SALT/SAND STORAGE BUILDING
MTO PATROL YARD–MANITOU HIGHWAY 502
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND	
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
MAN–01	430.3	5 452 888.0	317 516.2
MAN–02	0.0	5 452 890.7	317 532.4
MAN–03	430.9	5 452 910.4	317 529.7
MAN–04	430.7	5 452 900.9	317 511.1

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Borehole locations are shown in MTM NAD–83 Zone 16 coordinates.

GEOCRES No. 52A-232

Aug. 4/2017

Aug 4/17

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	GRL	CHK	KS	CODE	LOAD
DRAWN	AN	CHK	GRL	SITE	STRUCT

DATE AUG 2017
DWG 1

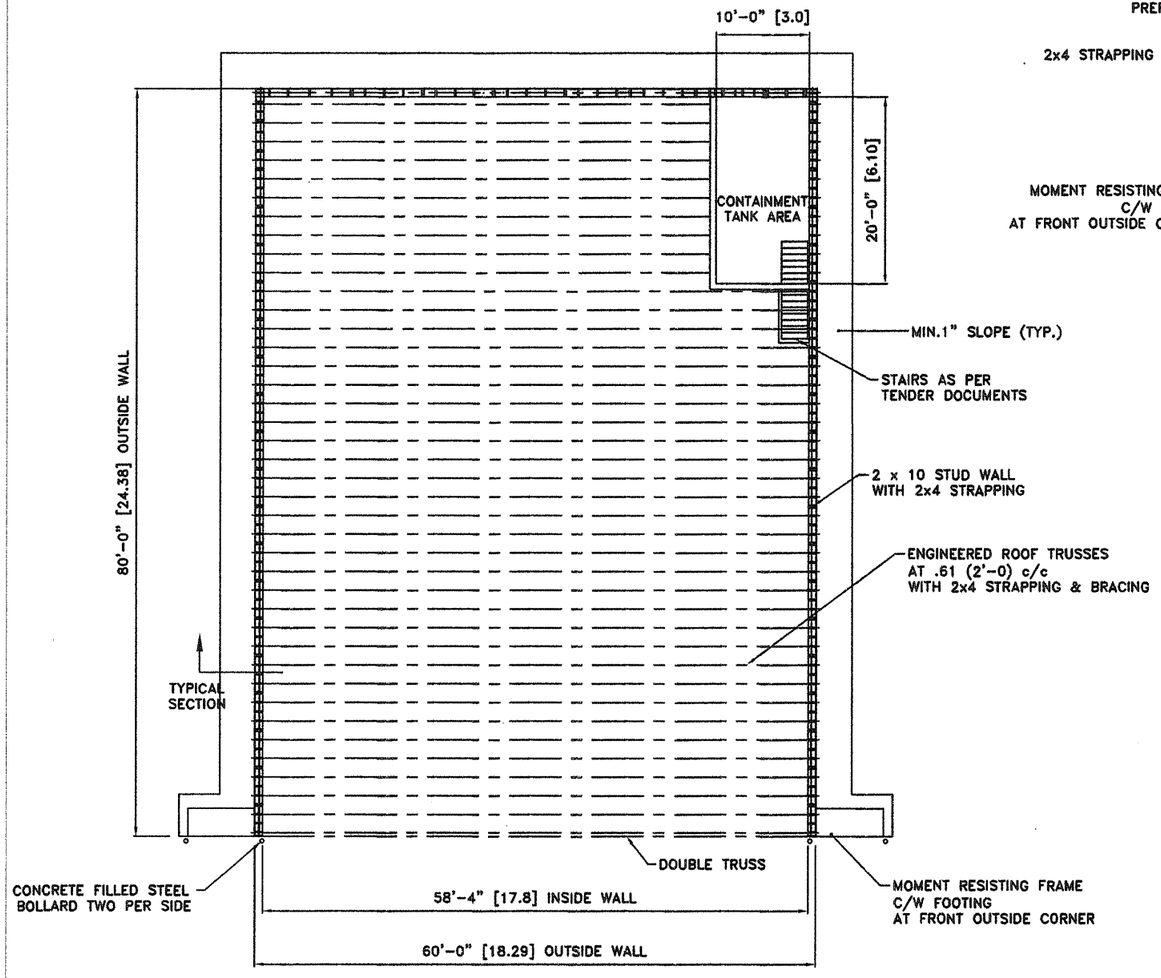
FILENAME: H:\Drafting\18000\18934\TED-18934-BHPP-Dryden-Manitou.dwg
PLOTDATE: 8/3/2017 3:03 PM

THURBER

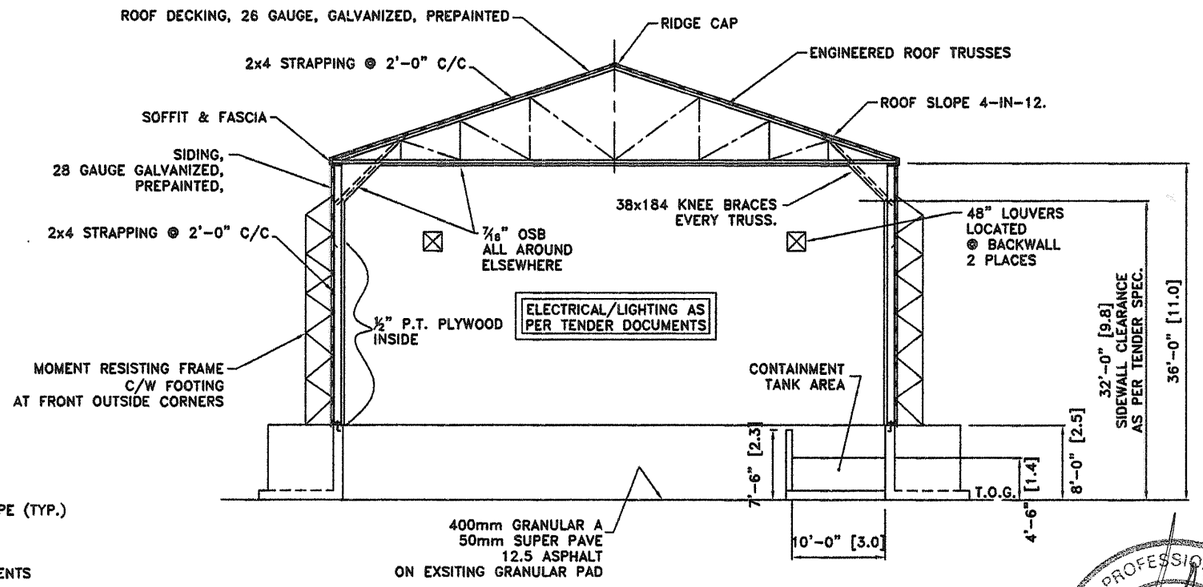
60 YEARS

Appendix F

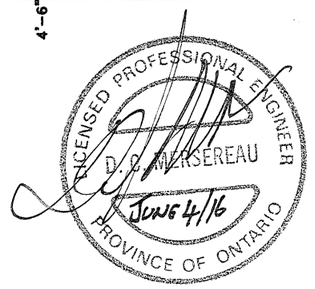
Typical General Arrangement Drawing



PLAN VIEW – FRONT OPEN



TYPICAL SECTION – FRONT OPEN



NOTES:

GENERAL:
1) ALL MATERIALS AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE ONTARIO BUILDING CODE AND LATEST REVISIONS (OBC 2012).
2) SCOPE OF WORK AS PER CONTRACT DOCUMENTS.

FOUNDATION:
1) FOUNDATION HAS BEEN DESIGNED FOR A MINIMUM PERMISSIBLE BEARING PRESSURE OF 200 KPa (4000 PSI).
2) FOUNDATION TO BE FOUNDED ON GRADE AS PERMITTED BY OBC 2006 4.2.4.4.(2)(b).
3) CONCRETE TO CONFORM TO CSA A23.1-04 AND CSA A23.3-04 AND SHALL HAVE A MINIMUM STRENGTH AT 28 DAYS OF 30 MPA AND SHALL CONTAIN 4% TO 7% ENTRAINED AIR.
4) STEEL REINFORCEMENT TO CONFORM TO CSA A23.3-04 AND CSA A23.1-04. EPOXY COATED REBAR TO BE USED IN ALL AREAS NOT COVERED BY A MINIMUM OF 500mm OF SOIL.
5) EXPOSED INTERIOR CONCRETE FOUNDATION TO BE COATED WITH SEALER AS PER TENDER SPECIFICATIONS.

LUMBER:
1) ALL LUMBER SHALL CONFORM TO THE REQUIREMENTS OF THE STANDARD GRADING RULES OF THE NATIONAL LUMBER GRADES AUTHORITY, AND TO CAN/CSA-O86-1 M89, "ENGINEERING DESIGN IN WOOD". ALL LUMBER SHALL BE DRY NO. 2 SPRUCE (SPF) OR BETTER.
2) ALL LUMBER IN CONTACT WITH THE CONCRETE SHALL MEET THE REQUIREMENTS OF CAN/CSA O80.0, CAN/CSA O80.2 FOR WOOD PRESERVATION.
3) NAILING OF WOODEN STRUCTURE TO BE DONE IN ACCORDANCE WITH GOOD PRACTICE AND THE REQUIREMENTS OF THE ONTARIO BUILDING CODE.
4) ORIENTATED STRAND BOARD (OSB) TO BE 7/16" OSB TYPE 2 OR BETTER.

ROOF TRUSSES:
1) ROOF TRUSSES TO BE DESIGNED BY ROOF MANUFACTURER.
2) LATERAL BRACING INSTALLED AS RECOMMENDED BY ROOF TRUSS MANUFACTURER.
3) INSTALLATION AS PER BCSI-BI-GUIDE FOR HANDLING, INSTALLING, RESTRAINING AND BRACING OF TRUSSES.
4) ROOF TRUSSES TO BE WOOD.
5) ROOF TRUSS UPLIFT ANCHORS TO BE INSTALLED AS PER TRUSS MANUFACTURER RECOMMENDATIONS.

SIDING/ROOFING:
1) ROOFING TO BE 26 GA VICWEST OR EQUIVALENT. TRIM TO BE WHITE.
2) SIDING TO BE 26 GA VICWEST OR EQUIVALENT. TRIM TO BE WHITE.
3) ROOF TRUSSES AND INTERIOR WALLS TO BE COVERED WITH 12mm OSB AND ½" P.T. PLYWOOD AS NOTED.

ELECTRICAL:
1) ELECTRICAL TO BE AS SPECIFIED IN TENDER DOCUMENT.

LOADS:
1) FOUNDATION IS DESIGNED TO WITHSTAND DEAD AND LIVE LOADS IMPOSED UPON IT BY THE SUPERSTRUCTURE AS WELL AS LOADS FROM LOADING EQUIPMENT.
2) ENVIRONMENTAL LOADS DEFINED IN O.B.C. FOR RED LAKE Ss=2.4 kPa, Sr=0.3 kPa, q (1/50)=0.28 kPa.
3) FOUNDATION LOADS DUE TO PILED SAND/SALT.

MINISTRY OF TRANSPORTATION ONTARIO
RED LAKE PATROL YARD
60 x 80 SAND/SALT STORAGE STRUCTURE
RED LAKE, ONTARIO
GENERAL ARRANGEMENT & NOTES
FOR CONSTRUCTION

REV	DATE REVISED (mm-dd-yy)
0	-

STORAGE SYSTEMS CONSTRUCTION CORP

DESIGNED:	SCALE:
D.M.	NTS
DRAWN:	DATE: (mm-dd-yy)
RM	05-13-16
PROJECT ENG:	DRAWING NO:
D.J.	L01
CONTRACT NO:	(1 OF 1)
122-716	