THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
CULVERT 11-17025-008 REPLACEMENT
HIGHWAY 11
MORRISON TOWNSHIP
G.W.P. No. 5056-12-00

GEOCRES Number: 31D-580

Report to

Ainley Group Limited

5012-E-0008

August 29, 2014

File: 19-6478-0

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual data obtained from a foundation investigation conducted by Thurber Engineering Ltd. (Thurber) at a culvert replacement site on Highway 11 near Gravenhurst, Ontario.

No previous foundation investigation information near the subject culvert was available.

The purpose of this investigation was to obtain subsurface information at the site and, based on that data, provide a comprehensive model of the subsurface conditions including borehole location plans, stratigraphic profiles, records of boreholes, laboratory test results and a written description of the subsurface conditions.

Thurber was retained by the Ainley Group Limited (Ainley) to carry out this foundation investigation under MTO Agreement Number 5012-E-0008.

2 SITE DESCRIPTION

Culvert 11-17025-008 is located within a tangent section on Highway 11, approximately 4.0 km north of the Severn River Bridge in the Township of Morrison. Sparrow Lake D Road and Rainbow Circle intersect with Highway 11 approximately 100 m to the north. A private entrance is located approximately 20 m to the south on the southbound side. The existing highway at this site includes two through lanes and an auxiliary lane in both the northbound and southbound directions which are separated by a median barrier. Gravel shoulders are present to the outside on either side of the highway. A 3-cable Guide Rail is present on the southbound side while an overhead utility line transverses the site near the northbound right-of-way limit.

A 600 mm corrugated steel pipe (CSP) 36.8 m in length is present at the site with a cover of approximately 2.4 m of fill. The grade of the existing Highway 11 in the vicinity of the culvert is at approximately 244.5 m geodetic. The invert elevation is 241.68 m on the east side and

241.5 m on the west side, indicating average gradients of approximately 0.5 % and a flow direction from east to west.

The site is located in a rural area with brush, forested land and occasional residential properties. Bedrock outcrops are present within 20 m in both directions along the highway. Local topography is generally rugged.

The site is located within the Canadian Shield. Soil cover is thin and consists primarily of glacial till and glaciolacustrine (clay, varved clay and silt) deposits with localized organic deposits.

3 SITE INVESTIGATION AND FIELD TESTING

The borehole investigation and field testing program was carried out between March 5 and 7, 2014 to augment information acquired during a pavement investigation at this site. The foundation program consisted of drilling and sampling two boreholes (numbered 14-1 and 14-2) to depths of 5.3 m below ground surface (elevations 240.9 m to 240.5 m) near the existing culvert inlet and outlet. Prior to the start of drilling, the borehole locations were staked in the field and utility clearances were obtained. The staked borehole locations were subsequently surveyed by staff under the direction of Ainley.

Portable drilling equipment including an electric core drill with NW casing and a tripod with a pulley and 140 lb SPT hammer was used to advance the inlet and outlet boreholes. Soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT).

A pavement engineering investigation was carried out in August 2013 and included ten boreholes drilled with a truck mount CME Drill Rig through the embankment to depths ranging from 4.4 to 7.6 m below ground surface. Hollow stem augers were used to advance the boreholes through the embankment fill and overburden soil. In seven of the boreholes (23-1, 23-5, 23-6, 23-7, 23-8, 23-9 and 23-10), soil samples were obtained at selected intervals using a 50 mm diameter split spoon sampler in conjunction with Standard Penetration Testing (SPT). The remaining three boreholes (23-2, 23-3 and 23-4), provide an indication of the depth to bedrock as inferred by auger refusal. Approximate locations of the boreholes are shown on the Borehole Location and Soil Strata Drawing in Appendix A.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, secured the recovered soil samples in labelled containers, and transported the samples to Thurber's laboratory for further examination and testing.

The boreholes were backfilled with a bentonite-grout mix. Boreholes through asphalt were capped with 150 mm of premium cold-mix asphalt.

Results of field drilling and sampling are presented on the Record of Borehole sheets in Appendix B.

4 LABORATORY TESTING

Soil samples were subjected to Visual Identification and to natural moisture content determination. Selected soil samples were subjected to grain size distribution analyses (sieve and hydrometer). The results of this laboratory testing program are shown on the Record of Borehole sheets in Appendix B and on the figures in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

5.1 General

Reference is made to the Record of Borehole sheets in Appendix B for details of the soil stratigraphy encountered in the boreholes. A stratigraphic profile for the culvert replacement alignment is presented on the Borehole Locations and Soil Strata Drawing in Appendix A for illustrative purposes. An overall description of the stratigraphy is given in the following paragraphs; however, the factual data presented in the record of boreholes governs any interpretation of the site conditions.

In general, the subsurface conditions encountered in the boreholes located on the highway embankment consist of asphalt and/or fill overlying silty sand to silt deposits underlain by probable bedrock. More detailed descriptions of the individual strata are presented below.

5.2 Pavement Structure

Boreholes 23-1and 23-5 were advanced through the southbound speed change lane of Highway 11 while boreholes 23-6, 23-7, 23-8, 23-9 and 23-10 were advanced through the northbound speed change lane of Highway 11. The thickness of the asphalt was 95 mm in the southbound direction and 135 to 140 mm in the northbound direction.

Granular fill material consisting of sand with silt to sand with silt and gravel was present directly beneath the asphalt in Boreholes 23-1, 23-5, 23-6, 23-7, 23-8, 23-9 and 23-10 and extended to a depth of 0.8 m below ground surface. The base of the granular fill was encountered at elevations ranging from 242.7 to 243 m.

SPT N-values ranged from 13 to 41 blows per 0.3 m penetration indicating a compact to dense relative density. The water contents of the recovered fill samples ranged between 3% and 9%. Grain size analyses conducted on three samples of the granular fill are presented on Figure 1 in Appendix C. These results are summarized in the following table.

Soil Particles	%
Gravel	7 to 26
Sand	67 to 82
Silt and Clay	7 to 11

5.3 Embankment Fill

Embankment fill consisting of sand with silt to sand with silt and gravel was encountered below the pavement structure in Boreholes 23-1, 23-5, 23-6, 23-7, 23-8, 23-9 and 23-10. The thickness of the embankment fill ranged from 1.4 to 2.2 m. The base of the embankment fill was encountered at elevations ranging from 240.6 to 241.6 m.

SPT N-values ranged from 3 to 34 blows per 0.3 m penetration, indicating a very loose to dense state. The water contents of the recovered fill samples ranged between 4% and 10%. Grain size analyses conducted on four samples of embankment fill are presented on Figure 2 in Appendix C. The results are summarized in the following table.

Soil Particles	%
Gravel	10 to 23
Sand	71 to 84
Silt and Clay	6 to 9

Cobbles were inferred to be present between 2.3 and 3.0 m depths within the embankment fill in Borehole 23-8 based on grinding noises and vibration during advancement of the augers. Asphalt fragments were noted in the fill in Boreholes 23-1 and 23-5.

5.4 Organic Material

Organic material ranging from 50 mm to 100 mm in thickness was encountered at the ground surface in Boreholes 14-1 and 14-2. The thickness of the surficial organic material may vary between and beyond the borehole locations, and the limited data is not suitable for estimating stripping quantities.

5.5 Sandy Silt to Silty Sand

The surficial materials and fill were underlain by a sandy silt to silty sand deposit in all boreholes. In Boreholes 23-1, 23-5, 23-6, 23-9 and 23-10 the upper portion contained organic material; this layer was up to 0.8 m in thickness. Cobbles were noted from 3.7 m to 4.5 m depth in Borehole 23-1 and rock fragments were observed in Borehole 23-1 and 14-1 at a depth of 4.5 m to 5.2 m. The sandy silt to silty sand layer was observed to extend the full borehole depth in all boreholes except Boreholes 23-1, 23-7, 23-9 and 14-1. In these four boreholes the underside of the silty sand/sandy silt layer was observed at depths ranging from 4.7 m to 7.3 m (elevation 239.1 m to 235.6 m).

SPT N-values measured within this deposit ranged from 1 to 73 blows per 0.3 m penetration, but were typically indicative of a very loose to compact state. The colour of the sandy silt/silty sand ranged from brown to grey.

The moisture content of the samples tested ranged from 12% to 91% with the higher value recorded within the upper portion of Borehole 23-9 which contained organic material. A number of samples of this deposit were subjected to gradation analysis. The results are summarized in the table below and presented on Fig. No 3, 4 and 5 in Appendix C.

Soil Particles	%
Gravel	0 to 4
Sand	32 to 83
Silt	15 to 62
Clay	2 to 12

5.6 Silt

Silt layers were noted within the sandy silt/silty sand deposit in Boreholes 23-5 and 14-2. In Borehole 14-2 the silt was found in two distinct layers, the top of the first was at an elevation of 238.8 m and had a thickness of 0.7 m while the top of the second layer was found at 237.2 m and had a thickness of 1.5 m. The top of the silt deposit in Borehole 23-5 was at an elevation 240.0 m and this deposit had a thickness of 2.1 m.

SPT N-values measured within this deposit ranged from 10 to 22 blows per 0.3 m penetration, indicating a loose to compact state. The colour of the silt was grey in all cases.

The moisture content of the samples tested ranged from 22% to 31%. Three samples of this deposit were subjected to gradation analysis. The results are summarized in the table below and presented on Figure 6 in Appendix C.

Soil Particles	%
Gravel	0 to 2
Sand	2 to 3
Silt	78 to 88
Clay	7 to 20

Atterberg limit testing on samples from this layer indicated it to be a non-plastic material.

5.7 Sand with Gravel

A sand with gravel layer was observed at a depth of 7.0 m below ground surface in Borehole 23-7. This unit extended to the termination depth of the borehole at 7.5 m (elevation 236.0 m). It was observed to be compact based on an SPT N value of 16 blows per 0.3 m of penetration.

5.8 Bedrock

Boreholes 23-1, 23-9 and 14-1 were terminated at refusal on probable bedrock. Boreholes 23-2, 23-3 and 23-4 were drilled unsampled as rock probes to provide a further indication of bedrock depth. The following table provides a summary of the available information.

Borehole	Depth to Probable Bedrock	Probable Bedrock Elevation
23-1	4.7 m	239.1 m
23-2 Probe	4.5 m	239.3 m
23-3 Probe	not encountered to 4.5 m	deeper than 239.2 m
23-4 Probe	not encountered to 7.6 m	deeper than 236.1 m
23-5	not encountered to 6.7 m	deeper than 237.0 m
23-6	not encountered to 7.6 m	deeper than 235.9 m
23-7	not encountered to 7.5 m	deeper than 236.0 m
23-8	not encountered to 4.4 m	deeper than 239.2 m
23-9	7.3 m	236.3 m
23-10	not encountered to 7.5 m	deeper than 236.2 m
14-1	5.3 m	235.6 m

14-2	not encountered to 5.3 m	deeper than 235.2 m

It is noted that bedrock outcrops are present to the northwest and southeast of this culvert site.

5.9 Groundwater Conditions

Free water was observed in Boreholes 14-1, 14-2, 23-1 and 23-8 at the time of drilling at elevations of 240.9 m, 240.1 m, 240.8 m and 241.0 m respectively. Water at the inlet of the culvert was observed at approximately elevation 240.9 m at the time of drilling.

Where surface water is present, the groundwater level should be assumed to coincide with the local surface water level. Local high water levels and the effects of heavy rainfalls must also be taken into consideration.

6 MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Ainley arranged for the survey of the borehole locations, and provided the northing and easting coordinates and ground surface elevations.

Walker Drilling of Utopia, Ontario, supplied and operated the truck-mounted CME 75 drill rig to carry out the drilling, sampling and in-situ testing operations on the existing highway platform. Ohlmann Geotechnical Services (OGS) Inc. of Almonte, Ontario, supplied and operated the portable drill rig.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Justin Gray, Ms. Eckie Siu and Mr. Christopher Murray of Thurber. Laboratory testing was carried out by Thurber in its MTO-approved laboratory.

Overall project management and direction of the field program was provided by Dr. Fred Griffiths, P.Eng. Interpretation of the field data and preparation of this report was completed by Dr. Fred Griffiths. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Fred J. Griffiths, P.Eng.
Associate/Senior Foundations Engineer

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

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This section of the report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to design the culvert crossing under Highway 11. The project consists of the design of a new culvert to replace an existing culvert that passes below the six lanes of highway. The estimated AADT at this site is 22,400 (2010).

A corrugated steel pipe (CSP) with an approximate diameter of 0.6 m is present at the site. The culvert is approximately 37 m in length. Water flows from east to west and the culvert invert elevation is 241.68 and 241.5 m on the east and west sides respectively indicating an average gradient of approximately 0.5%. The top of pavement at the Highway 11 centreline above the culvert is at approximately elevation 244.5 m. The slopes of the existing embankment are graded at approximately 3.0 horizontal to 1 vertical (3.0H:1V) and are approximately 3.8 m high on the west side and 3.4 m high on the east side.

A general arrangement drawing for the proposed replacement culvert was not available to Thurber at the time of preparation of this report. It is understood that the proposed culvert will be 0.8 m in diameter and installed to the same invert elevations as the existing CSP.

The borehole information indicates that the base of the embankment fill ranges from elevation 240.6 to 241.6. The majority of the excavation for the new culvert will therefore be within the embankment fill which was observed to consist of loose to compact sand with silt to sand with silt and gravel. The underlying material consists of very loose to compact sandy silt to silty sand. Organic material was noted in the native soils at the transition between fill and native material. Groundwater levels at the time of the investigations were noted at elevations ranging from 240.1 m to 241.0 m.

This report presents an evaluation of feasible methods for replacement of the culvert. The discussions and recommendations presented in this report are based on our understanding of the project and on the factual data obtained during the course of this investigation.

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8 CONSTRUCTION METHODOLOGY OPTIONS

The following installation options have been considered for the replacement of Culvert 11-17025-008:

- Staged, Supported Open Excavation
- Trenchless Techniques

The following subsections provide additional description and comparison of the options.

8.1 Option 1: Staged, Supported Open Excavation

The soils described at this site are considered to be suitable for excavation using trench excavating equipment normally used by contractors for culvert installation. Cobbles are reported in one borehole and the contract documents must identify this to bidders with an NSSP (see suggested wording in Appendix E). The frequency of cobbles is not considered to be high enough to prevent the use of suitable trenching excavation equipment. All excavation must be carried out in accordance with the requirements of the Ontario Occupational Health and Safety Act (OHSA). The permitted trench geometry and shoring requirements will be governed by the OHSA soil classification. For the purposes of OHSA, the sandy silt and silty sand, other cohesionless soils and fills encountered at this site are classed as Type 3 Soils above the water table. If any attempt is made to excavate below the water table, the soils must be treated as Type 4.

A roadway protection system would likely be required but would not need to be water-tight. Both a sheet pile system or an H-pile with timber lagging system are considered feasible. The shoring design would need to meet the requirements of OPSS 539 Performance Level 2. The assessment of the need for and the design of the roadway protection system is the responsibility of the contractor. The roadway protection system must be designed by a professional engineer experienced in the design of such systems. Earth pressure parameters for temporary shoring design are provided in Table 9.1.

Where the trench will be excavated to a level below the groundwater level prevailing at the time of construction, the contractor must implement such groundwater control and ground support systems as are required to install the culvert in a safe, stable, unwatered excavation. The assessment of the need for and the design of such dewatering systems is the responsibility of the contractor.

The bedding for the culvert must conform to the requirements of OPSD 802 series. Additional bedding requirements imposed by the pipe supplier must also be followed. It is recommended that the bedding material consist of OPSS Granular "A". The organic containing layer observed beneath the embankment fill should be removed from beneath the new culvert. It is recommended that the trench backfill consist of Granular "B" Type II. The bedding and backfill must be placed in regular lifts and compacted in accordance with OPSS 501. The backfill must be placed and compacted in simultaneous lifts on both sides of the culvert such that the top of backfill elevation is the same on both sides of the culvert at all times. Heavy compaction equipment must not be used adjacent to the walls and roof of the culvert.

The anticipated founding level for the culvert would range from 241.7 m at the inlet to 241.5 m at the outlet. This elevation is within the sand with silt fill. Foundation bearing resistance recommendations for the culvert are provided below:

Table 8.1 – Foundation Bearing Resistance Recommendations

Foundation Width (m)	Factored Geotechnical Resistance at ULS (kPa)	Bearing Pressure at SLS (kPa)
0.8	150	100

The factored geotechnical resistance at ultimate limits states (ULS) includes a resistance factor of 0.5. The geotechnical resistances are based on a footing subjected to vertical concentric loading. Where eccentric or inclined loads are applied, the resistance used in the design must be reduced in accordance with the CHBDC Clause 6.7.3 and 6.7.4. The bearing pressure at serviceability limit state (SLS) corresponds to the sustained pressure resulting in 25 mm of total settlement. It is noted that a reduction in load is anticipated at this site as the replacement pipe will have a larger diameter than the existing. No settlement is anticipated as a result of the proposed installation.

The advantage of the open cut method is that it is a relatively simple method. It is the preferred alternative if open cutting is allowed.

The main disadvantage is that the construction would have to be staged to maintain traffic. Traffic would need to be reduced to a single lane in each direction and the ramps would likely need to be closed for at least a portion of the construction schedule. Two staging scenarios are envisioned: half and half approach with a median cross-over or an outside/inside approach with no crossover.

This method can be considered for use provided staged construction coupled with excavation and reinstatement of the highway is acceptable.

8.2 Option 2 Trenchless Techniques

Trenchless installations should be carried out in accordance with the requirements of the Non-Standard Special Provision (NSSP) “Pipe Installation by Trenchless Methods”. A copy of this NSSP is attached in Appendix E.

Trenchless methods that are typically considered to install pipes under highways include:

- Jack and bore
- Pipe ramming
- Micro-tunnelling (MTBM)
- Hand Mining
- Horizontal Directional Drilling

Selection of an appropriate trenchless method must be the responsibility of the Contractor and will depend on the relative costs and risks associated with each method. The experience of the Contractor is of primary importance for trenchless installation. Amongst the important issues discussed in the NSSP are maintenance of alignment, handling of oversized obstructions and disposal of cuttings.

The proposed culvert has a diameter of 800 mm and the length of the highway crossing is approximately 40 m. These factors limit the range of trenchless installation techniques that would be economically viable at this site to Jack and Bore and Pipe Ramming. Directional Drilling is typically limited to smaller diameter pipes. Conversely, Hand Tunnelling typically requires a larger diameter than the 0.8 m proposed. Microtunnelling (MTBM) with pipe jacking is not considered economically viable for the limited length of the proposed installation.

Both the Jack and Bore and Pipe Ramming methods would typically install a steel liner pipe on the appropriate alignment. The replacement culvert would be installed within the steel liner pipe and the annulus grouted. It is estimated that the cover above the steel pipe will be limited to approximately 2 m at the roadway centreline which is approximately 1.8 tunnel diameters. Further discussions are presented below:

Option 2a: Jack and Bore

Jack and bore installation involves pushing an oversized liner pipe and removing the soil by augering inside the pipe as it is advanced. The diameter and length of the proposed work is suitable for the Jack and Bore technique. The embankment fill material is non-cohesive and loose to compact. This method is less suitable for cohesionless soils where the water table is above the invert of the pipe. Cobbles were noted in one of the boreholes; boulders were not encountered. It is anticipated that should they be encountered during construction, the cobbles would be extracted by the auger.

Option 2b: Pipe Ramming

In this system, the sleeve pipe is driven from the access point to the exit point using an air-powered percussion hammer. After the sleeve has been fully or partially driven, the soil is removed by augering techniques. The pipe ramming technique can accommodate the removal of boulders. This method has versatility in accommodating a variety of subsurface conditions and is general suitable for cohesionless soils with water seepage problems. Dewatering is usually not required for this method. The Pipe Ramming technique does not require a backstop for reaction purposes. This technique has a further advantage in that there is only a small over-cut around the pipe, thus there is a lower potential to cause settlement of the pavement surface.

A potential disadvantage occurs in situations where there is insufficient cover above the pipe and surface heave can occur as the pipe is being rammed. The 2± m cover at this site is considered to be indicative of a risk for surface heave. Careful monitoring of the pavement surface is recommended and if pavement heave is noted, the contractor must adjust his procedure to minimize heave. The alignment control can be adversely affected if oversize obstructions are encountered.

8.3 Recommended Construction Approach

A table is provided in Appendix D comparing the construction methodology options described in Sections 8.1 and 8.2 above.

Based on our review of these options and the assumption that the traffic staging issues are a major disadvantage, it is recommended that the culvert be replaced with a trenchless technique. Although the selection of a suitable trenchless technique is the responsibility of the contractor, in light of the cohesionless fill through which the culvert is to be installed and the potential that the water level may rise above the culvert invert, Pipe Ramming is the preferred solution at this site.

The impact of the proposed culvert installation method on the highway surface and any existing nearby structures and underground utilities must be assessed. The contract documents must require the contractor to monitor the highway surface before, during and after the trenchless installation using pavement markers. If settlement or heave reaches an alert level, all work must stop and the site be secured until a decision is taken on how to proceed. At the review level, the contractor should advise the Contract Administrator as to how he is improving his methods in order to reduce settlement or heave. The recommended alert level is 15 mm of displacement and the corresponding review level should be 10 mm.

9 ENTRY AND EXIT PITS

The design of safe and stable entry and exit pits for the trenchless excavation is the responsibility of the contractor. Dewatering of the pits is also the contractor’s responsibility. The contract documents should direct the contractor to provide roadway protection if any excavation will encroach into the highway embankment. Protection must be provided in accordance with OPSS 539. Level 2 Protection is considered to be appropriate.

The recommendations presented in this section apply to the calculation of earth pressures for roadway protection, trench shoring and shoring required for launch pits and receiving pits that may be required for installing the culvert under the existing highway.

Earth pressures acting on the structure may be assumed to be triangular and to be governed by the characteristics of the soil being retained. Computation of earth pressures must take account of the groundwater level. Above the groundwater level, pressures are based on the bulk unit weight of the soil. Below the groundwater level, the pressures must be based on the submerged unit weight of the soil plus the hydrostatic pressure if the retained soil is not fully drained.

The earth pressures must be computed in accordance with the CHBDC and above the groundwater level the following expression applies:

$$P_h = K(\gamma_h + q)$$

Below the groundwater level, the pressure must be computed from the expression:

$$P_h = K\left(\gamma' h_w + \gamma H_y + q\right) + h_w \gamma_w$$

Where:

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

K = earth pressure coefficient (see below)

γ = unit weight of retained soil (see table below)

γ' = submerged unit weight of soil = (γ-10) kN/m^3

γ_w = unit weight of water, use 10 kN/m^3

h = depth below top of fill, but above water level, where pressure is computed (m)

h_w = depth below the groundwater level (m)

H_y = total depth from surface of retained material to the groundwater level (m)

q = value of any surcharge (kPa)

If the retaining structure is retaining compacted backfill, in accordance with Clause 6.9.3 of the CHBDC a compaction surcharge must be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or 1.7 m for Granular A or Granular B Type II.

The factors in Table 9.1 are "ultimate" values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the Canadian Highway Bridge Design Code.

Table 9.1- Earth Pressure Coefficient (K)

Condition	Earth Pressure Coefficient (K)							
	OPSS Granular A or OPSS Granular B Type II Φ = 35°, γ = 22.8 kN/m³		OPSS Granular B Type I Φ = 32°, γ = 21.2 kN/m³		Native Soil Φ = 28°, γ = 20 kN/m³		Embankment Fill Φ = 30°, γ = 20 kN/m³	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.27	0.4	0.31	0.48	0.36	0.5	0.33	0.54
At rest (Restrained Wall)	0.43	0.62	0.47	0.7	0.53	-	0.5	0.76
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-	2.8	-	3	-

9.1 Groundwater Dewatering

The proposed installation is above the observed groundwater level, however seasonal and other fluctuations should be anticipated. Construction dewatering is the responsibility of the contractor who must provide effective dewatering to install the culvert in the dry. Use of adequate sumps and pumps is anticipated as a dewatering means.

9.2 Erosion Control

Erosion protection should be provided at the culvert inlet and outlet areas. Design of the erosion protection measures must consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

Typically, rip-rap should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the outlets should be in accordance with OPSD 810.010. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS 804.

It is recommended that a clay seal or a concrete cut-off wall be used to minimize the potential for erosion near the inlet area. The clay seal should extend a minimum of 0.3 m above the high water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS 1205. A geosynthetic clay liner may be used as a clay seal.

10 CONSTRUCTION CONCERNS

Potential construction concerns that have been identified for this project include the following:

10.1 Loss of Ground/Surface Heave

Trenchless installations at relatively shallow depth below a highway inherently include some risk of loss of ground into the bore for the Jack and Bore method and heave of the pavement for the Pipe Ramming method. The Contractor`s methodology selection must recognize and take into consideration these inherent risks. Contingency plans should be in place to manage any adverse impacts on the highway.

10.2 Groundwater Control

Groundwater control in the form of sumps and pumps will be required for installation of the proposed works. Surface runoff should be diverted away from excavations at all times.

10.3 Obstructions

The embankment fill was observed to contain cobbles and the fill may contain other obstructions. The Contractor`s equipment and methodology must be selected to handle such obstructions and successfully remove them without jeopardizing the highway. The impact of obstructions on the pipe alignment should be assessed.

10.4 Buried Utilities

The Contractor must accurately establish, in three dimensions, the locations of all buried utilities crossing or closely paralleling the culvert alignment. Any discrepancies from the Contract Drawings must be reported to the Contract Administrator.

11 CLOSURE

Preparation of this foundation design report was carried out by Dr. Fred Griffiths, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng.

Fred J. Griffiths, P.Eng.
Associate/Senior Foundations Engineer

P.K. Chatterji, P.Eng.
Principal, Designated MTO Contact

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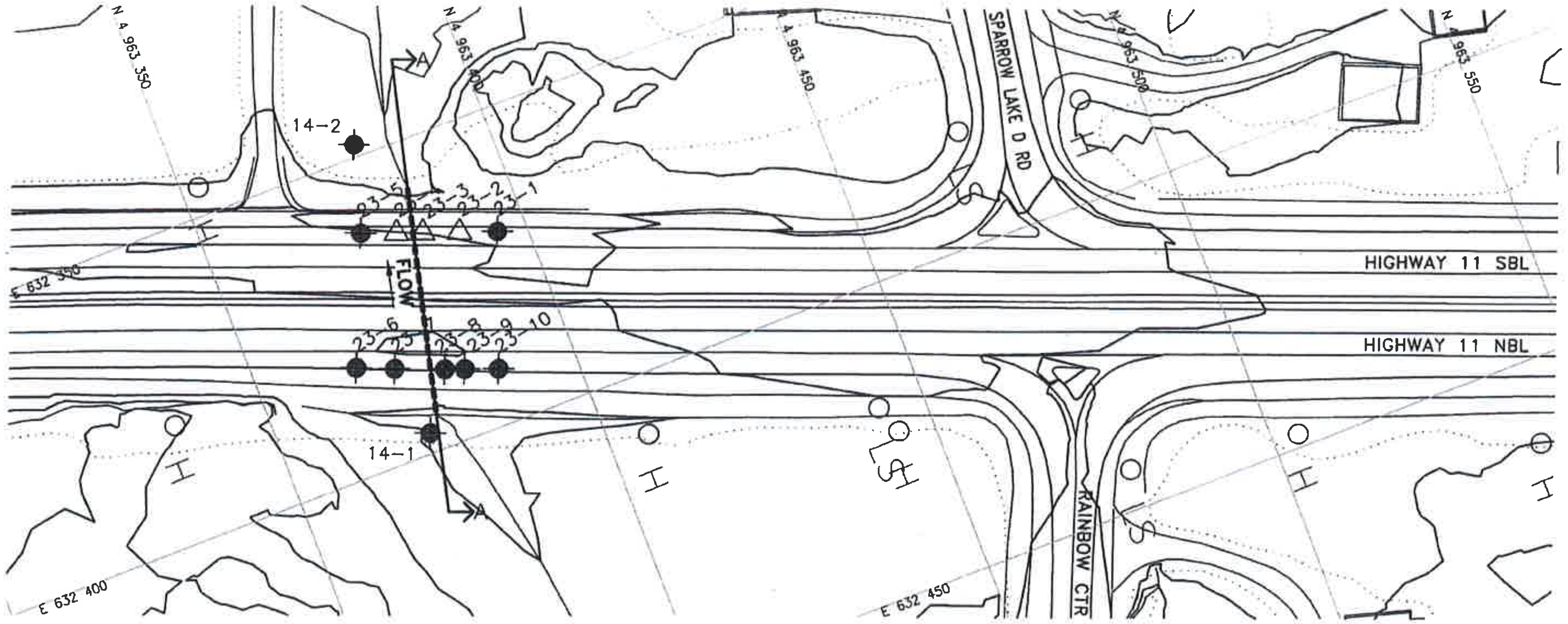
Appendix A

Borehole Locations and Soil Strata Drawings



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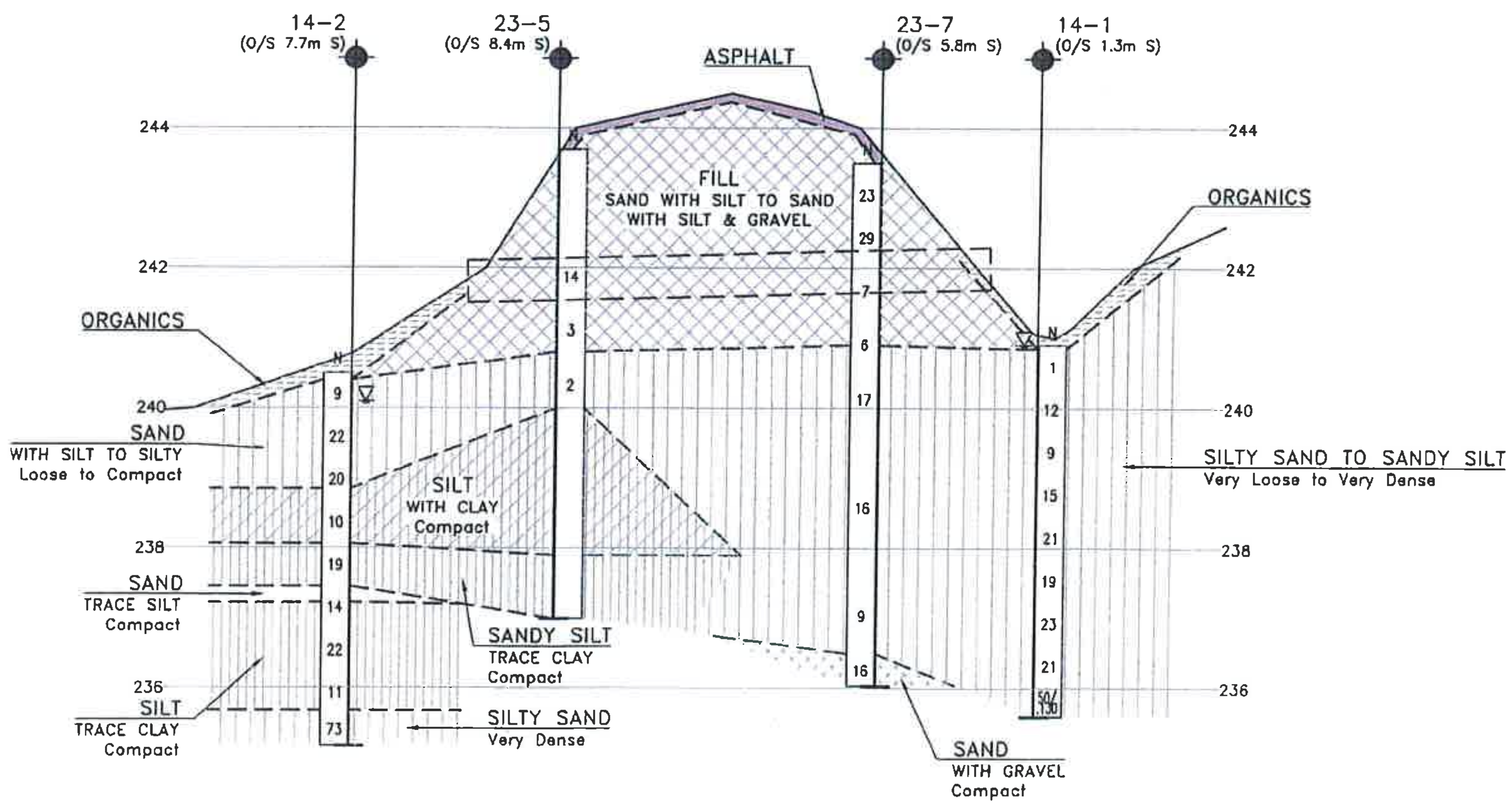


SECTION A–A THROUGH CULVERT 23

10 0 10 20m H 1:500
2 0 2 4 V 1:100

METRIC

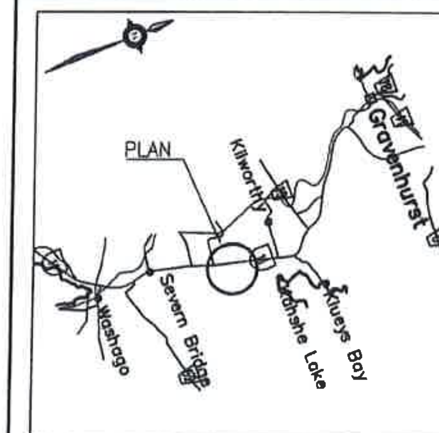
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
WP No 5056-12-00

HIGHWAY 11
S. OF SPARROW LAKE D RD
CULVERT 23
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET
1

THURBER ENGINEERING LTD



KEYPLAN

LEGEND

●	Borehole
⌖	Borehole and Cone
△	Bedrock Probe
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
14-1	240.9	4 963 373.5	632 396.7
14-2	240.5	4 963 378.5	632 348.0
23-1	243.8	4 963 395.2	632 369.8
23-10	243.7	4 963 387.4	632 390.9
23-2	243.8	4 963 389.4	632 367.7
23-3	243.7	4 963 383.9	632 365.6
23-4	243.7	4 963 379.9	632 364.1
23-5	243.7	4 963 374.5	632 361.9
23-6	243.5	4 963 366.1	632 382.3
23-7	243.5	4 963 371.8	632 384.7
23-8	243.6	4 963 379.3	632 387.8
23-9	243.6	4 963 382.3	632 388.9

-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.

GEOCRES No. 31D-580

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN CM	CHK PC	CODE	LOAD	DATE AUG 2014	
DRAWN MFA	CHK CM	SITE	STRUCT	DWG 1	

FILENAME: H:\Drafting\19\6478\0\ied4780-Plan&Profile(Culvert23)-UTM83-17.dwg
PLOTDATE: 8/27/2014 1:37 PM

Appendix B

Explanation of Terms and Symbols

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.

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			

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 14-1

METRIC

GWP#	5056-12-00	LOCATION	Southbound Highway 11 N 4 963 373.5 E 632 396.7	ORIGINATED BY	CM
HWY	11	BOREHOLE TYPE	Portable Split Spoon	COMPILED BY	GM
DATUM	Geodetic	DATE	2014.03.06 - 2014.03.06	CHECKED BY	FG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	NATURAL MOISTURE CONTENT (%) (approx.)	GR	SA	SI	CL
240.9 / 0.0	**Organic material (50mm)** Dark Brown									
0.1	**Silty Sand** Loose to compact, Brown to Grey, Wet	1	SS	1						
		2	SS	12	240		0	50	48	2
		3	SS	9						
		4	SS	15	239		0	61	36	3
		5	SS	21	238					
		6	SS	19						
		7	SS	23	237		0	68	30	2
		8	SS	21	236					
		9	SS	50/ 130mm			4	52	41	3
235.6 / 5.3	-Trace rock fragments at 5.2m									
	End of Borehole Probable Bedrock Groundwater observed at elevation 240.9 m at time of drilling									

Plot axes: 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; WATER CONTENT (%) 20 40 60 (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L); 138 plotted at ground surface; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%).

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 14-2

METRIC

GWP# 5056-12-00 LOCATION Northbound Highway 11 N 4 963 378.5 E 632 348.0 ORIGINATED BY ES
HWY 11 BOREHOLE TYPE Portable Split Spoon COMPILED BY GM
DATUM Geodetic DATE 2014.03.05 - 2014.03.05 CHECKED BY FG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
240.5											
0.0 / 0.1	**Organic material (100mm)** Dark brown Frozen	1	SS	9	▽	240					
	Silty Sand Loose to compact Brown Moist Trace silt	2	SS	22				0	83	15	2
238.8 / 1.7		3	SS	20		239					
	Silt with clay Compact Grey	4	SS	10				0	2	82	16
238.1 / 2.4	**Sandy Silt**, trace clay Compact Brown Moist	5	SS	19		238		0	35	53	12
237.5 / 3.0	**Sand**, trace silt Compact Brown to grey Moist	6	SS	14		237					
237.2 / 3.3	**Silt**, trace clay Compact Brown/grey Moist	7	SS	22				2	3	88	7
		8	SS	11		236					
235.7 / 4.8	**Silty Sand** Very dense Brown Moist	9	SS	73				0	71	24	5
235.2 / 5.3	End of Borehole										

Groundwater observed at elevation 240.1 m at time of drilling

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 (%)

+ ³, × ³: Numbers refer to Sensitivity
20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 19-6478-0 SITE 23.GPJ 2012TEMPLATE(MTO).GDT 29/8/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 23-1

METRIC

GWP#	5056-12-00	LOCATION	Southbound Highway 11, 10+010 N 4 963 395.2 E 632 369.8	ORIGINATED BY	JAG
HWY	11	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	GM
DATUM	Geodetic	DATE	2013.08.22 - 2013.08.22	CHECKED BY	FG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
243.8									
0.0 / 0.1	**95mm ASPHALT**								
	Sand with silt and gravel, Compact, Brown, Dry, **FILL**	1	SS	13			○		
243.0 / 0.8	Sand with silt and gravel, occasional asphalt fragments, Compact, Brown, Moist, **FILL**	2	SS	27		243	○		
		3	SS	10		242	○		
241.6 / 2.2	**Sand** trace organic material, trace gravel, Loose to compact, Brown, Wet	4	SS	4	∇	241	○		
		5	SS	13			○		
	-occasional cobbles from 3.7 to 4.5 m	6	SS	13		240	○		
239.3 / 4.5	**Sand** with silt, occasional rock fragments, Brown, Wet	7	SS	50/ 100mm			○		
239.1 / 4.7	End of Borehole. Auger refusal on possible bedrock. Groundwater observed at elevation 240.8 m at time of drilling								

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

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 23-5

METRIC

GWP# 5056-12-00 | LOCATION Southbound Highway 11, 9+990 N 4 963 374.5 E 632 361.9 | ORIGINATED BY JAG

HWY 11 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY GM

DATUM Geodetic | DATE 2013.08.22 - 2013.08.22 | CHECKED BY FG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
243.7										
0.0 / 0.1	**95mm ASPHALT**									
242.9 / 0.8	Sand with silt, Dense to compact, Brown, **FILL**	1	AS		243	○	7	82	11 (SI+CL)	
241.6 / 2.1	Sand with silt and gravel, Compact, Brown, Moist, **FILL**	2	AS			○	16	75	9 (SI+CL)	
		3	SS	14	242	○				
240.8 / 2.9	Sand with silt and gravel, occasional asphalt fragments, Looses, Brown, Moist, **FILL**	4	SS	3	241	○				
240.0 / 3.7	**Sand with organic material**, Very Loose, Brown, Moist	5	SS	2	240	○				
237.9 / 5.8	**Silt** with clay, Compact, Grey	6	AS		239	○	0	2	78	20
237.0 / 6.7	**Sandy silt**, Compact, Grey	7	AS		238	○	0	43	53	4
	End of Borehole				237					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "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)

+³, ×³: Numbers refer to Sensitivity; 20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 19-6478-0 SITE 23.GPJ 2012TEMPLATE(MTO).GDT 29/8/14

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 23-6

1 OF 1 **METRIC**

GWP# 5056-12-00 LOCATION Northbound Highway 11, 9+990 N 4 963 366.1 E 632 382.3 ORIGINATED BY JAG

HWY 11 BOREHOLE TYPE Hollow Stem Augers COMPILED BY GM

DATUM Geodetic DATE 2013.08.23 - 2013.08.23 CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
243.5						
0.0	**140mm ASPHALT**					
0.1	Sand with silt and gravel, Dense, Brown, Dry, **FILL**	1	SS	33	243	
242.7 / 0.8	Sand with silt and gravel, Compact, Brown, Moist, **FILL**	2	SS	27		15 79 6 (SI+CL)
		3	SS	10	242	
241.1 / 2.4	**Sand** with organic material, Very loose, Brown, Wet	4	SS	1	241	
240.8 / 2.7	**Sandy Silt**, Compact, Grey to brown, Wet	5	SS	20	240	0 39 57 4
		6	SS	7	239	
		7	SS	9		
		8	AS		238	
		9	SS	7	237	
		10	AS		236	
235.9 / 7.6	End of Borehole					

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

Columns: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 23-7

METRIC

GWP# 5056-12-00
LOCATION Northbound Highway 11, 9+995 N 4 963 371.8 E 632 384.7
ORIGINATED BY JAG

HWY 11
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY GM

DATUM Geodetic
DATE 2013.08.27 - 2013.08.27
CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
243.5					
0.0	**135mm ASPHALT**				
0.1	Sand with silt and gravel Compact Brown Dry **FILL**	1	SS	23	243
242.7 / 0.8	Sand with silt and gravel Compact to loose Brown Dry **FILL**	2	SS	29	242
		3	SS	7	
240.9 / 2.6	**Sandy silt** Compact to Loose Brown Wet	4	SS	6	241
		5	SS	17	240
		6	SS	16	239, 238
		7	SS	9	237
236.5 / 7.0	**Sand with Gravel** Compact Grey Wet	8	SS	16	
236.0 / 7.5	End of Borehole				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "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

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 23-8

METRIC

GWP# 5056-12-00
LOCATION Northbound Highway 11, 10+001 N 4 963 379.3 E 632 387.8
ORIGINATED BY JAG
HWY 11
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY GM
DATUM Geodetic
DATE 2013.08.23 - 2013.08.23
CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
243.6											
0.0	**140mm ASPHALT**										
0.1	Sand with silt and gravel, Compact, Brown, **FILL**	1	SS	21		243	○	26	67	7 (SI+CL)	
242.8 / 0.8	Sand with silt and gravel, Compact to loose, Brown, **FILL**	2	SS	19			○				
		3	SS	8		242	○				
	-cobbles from 2.3m to 3.0m	4	SS	7	▽	241	○				
240.6 / 3.0	**Sandy silt**, Compact, Brown, Wet	5	SS	13			○	0	50	47	3
						240					
		6	SS	15			○				
239.2 / 4.4	End of Borehole Groundwater observed at elevation 241.0 m at time of drilling										

SOIL PROFILE; SAMPLES; STRAT PLOT; 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 (%)

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 23-9

METRIC

GWP# 5056-12-00 | LOCATION Northbound Highway 11, 10+005 N 4 963 382.3 E 632 388.9 | ORIGINATED BY JAG

HWY 11 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY GM

DATUM Geodetic | DATE 2013.08.27 - 2013.08.27 | CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
243.6							
0.0	**135mm ASPHALT**						
0.1	Sand with silt and gravel, Dense, Brown, **FILL**	1	SS	41	243	○	15 74 11 (SI+CL)
242.8 / 0.8	Sand with silt to sand with silt and gravel, Dense to compact, Brown, **FILL**	2	SS	34		○	10 84 6 (SI+CL)
		3	SS	10	242	○	23 71 6 (SI+CL)
241.1 / 2.5	**Sand with organic material** trace gravel, Very loose, Brown	4	SS	4	241	91	
240.8 / 2.8	**Sandy silt**, Compact, Brown	5	SS	21		○	0 32 62 6
		6	SS	17	240	○	
		7	SS	12	239	○	
		8	SS	15	238	○	
		9	SS	22	237	○	
		10	SS	50/ 100mm		○	
236.3 / 7.3	End of Borehole, Probable Bedrock						

Column headings: SOIL PROFILE; SAMPLES; 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; STRAT PLOT.

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 23-10

METRIC

GWP# 5056-12-00
LOCATION Northbound Highway 11, 10+010 N 4 963 387.4 E 632 390.9
ORIGINATED BY JAG
HWY 11
BOREHOLE TYPE Hollow Stem Augers
COMPILED BY GM
DATUM Geodetic
DATE 2013.08.27 - 2013.08.27
CHECKED BY FG

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
243.7							
0.0 / 0.1	**135mm ASPHALT**						
	Sand with silt and gravel, Dense, Brown, Dry, **FILL**	1	SS	32			
242.9 / 0.8						243	
	Sand with silt and gravel, Compact to loose, Brown, Dry, **FILL**	2	SS	28			
		3	SS	9		242	
241.5 / 2.2							
241.3 / 2.4	**Sand** trace gravel, trace organic material, Very loose, Brown, Wet	4	SS	4		241	
	Sandy silt, Loose to Compact, Brown/grey, Wet	5	SS	17		240	
		6	SS	9		239	
						238	
		7	SS	12		237	
236.2 / 7.5	End of Borehole						

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

+ 3, × 3: Numbers refer to Sensitivity

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

Appendix C

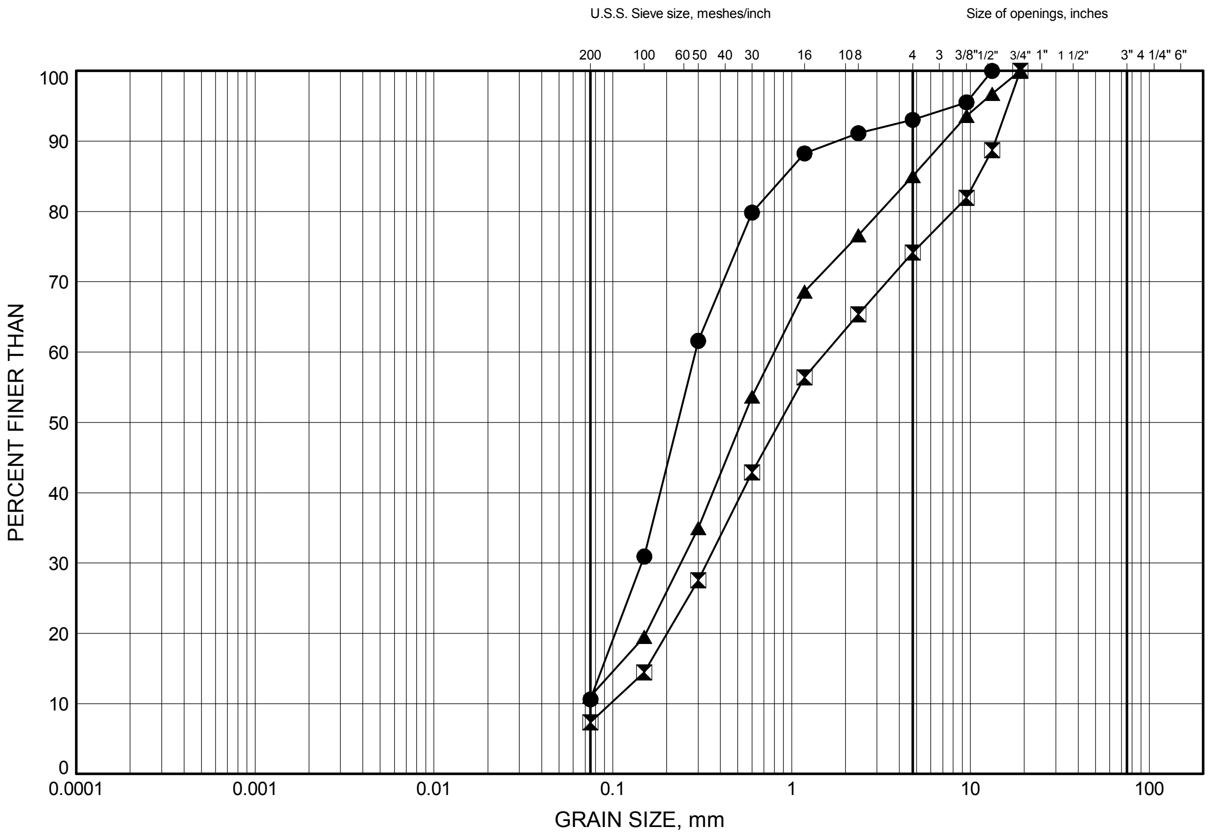
Laboratory Test Results

Culvert 11-17025-008

GRAIN SIZE DISTRIBUTION

FIGURE 1

Granular Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	23-5	0.46	243.24
⧗	23-8	0.46	243.14
▲	23-9	0.46	243.14

Date March 2014

GWP# 5056-12-00

THURBER

Prep'd CM

Chkd. FJG

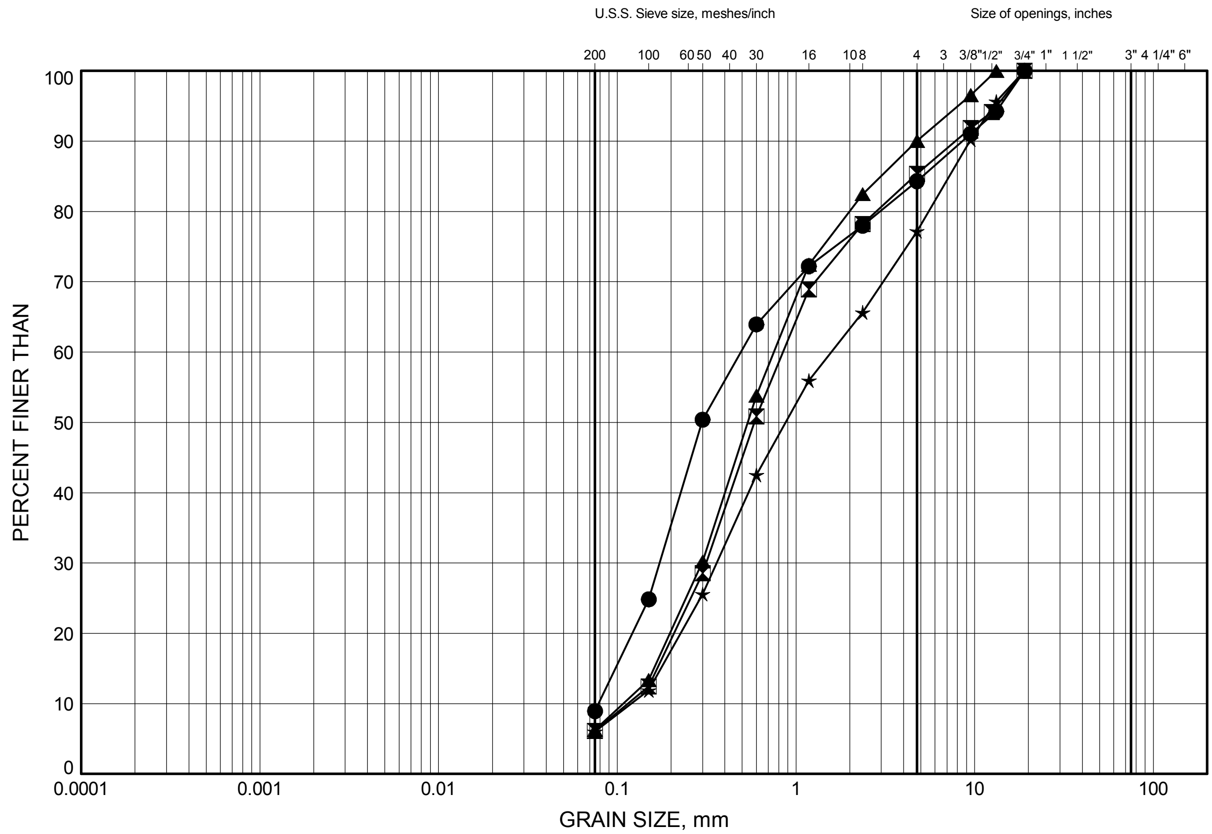
GRAIN SIZE DISTRIBUTION - THURBER 19-6478-0 SITE 23.GPJ 21/3/14

Culvert 11-17025-008

GRAIN SIZE DISTRIBUTION

FIGURE 2

Embankment Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	23-5	1.07	242.63
⧗	23-6	1.07	242.43
▲	23-9	1.07	242.53
★	23-9	1.83	241.77

Date March 2014

GWP# 5056-12-00

THURBER

Prep'd CM

Chkd. FJG

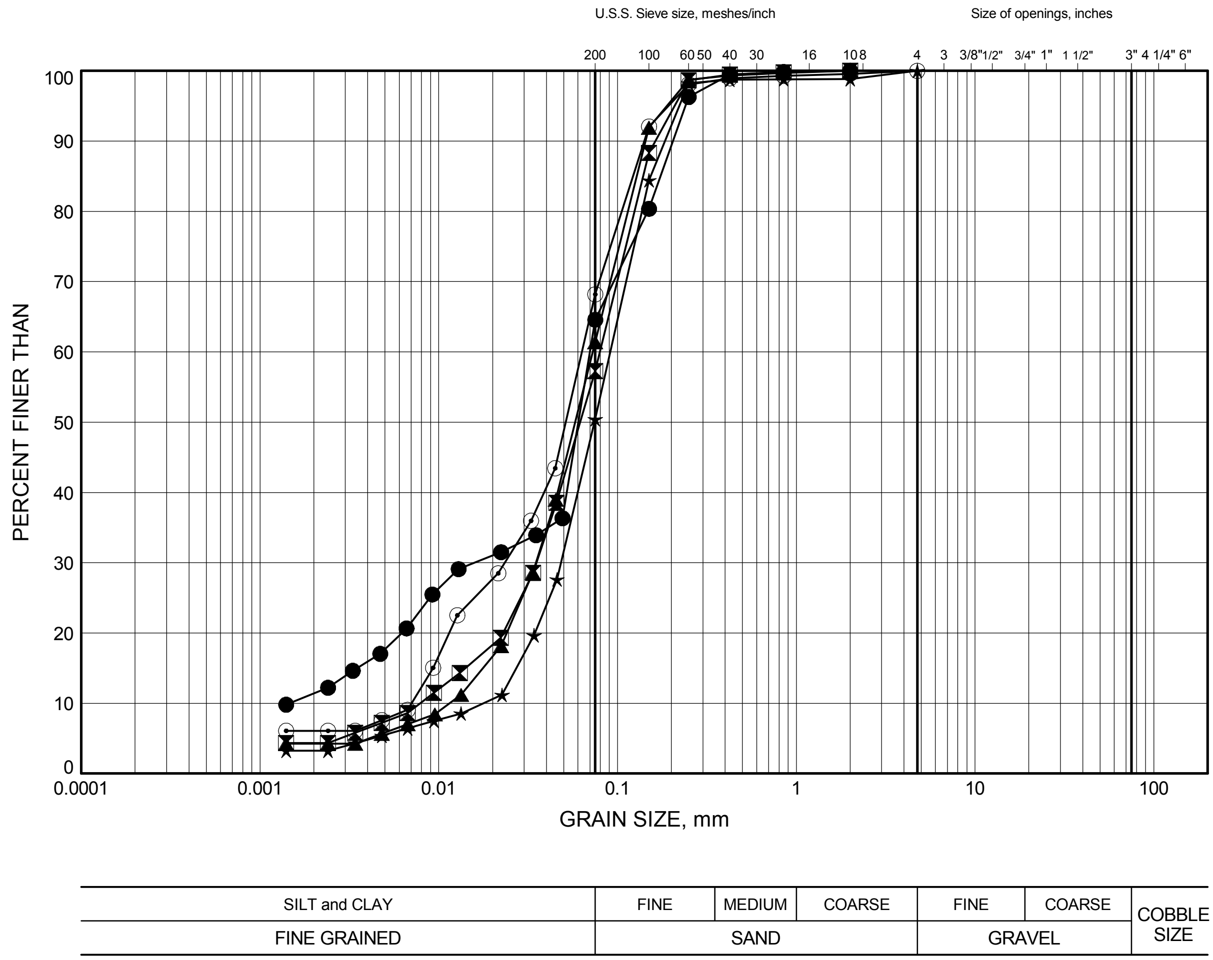
GRAIN SIZE DISTRIBUTION - THURBER 19-6478-0 SITE 23.GPJ 21/3/14

Culvert 11-17025-008

GRAIN SIZE DISTRIBUTION

FIGURE 3

Sandy Silt



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-2	2.74	237.76
⧗	23-5	6.40	237.30
▲	23-6	3.35	240.15
★	23-8	3.35	240.25
⊙	23-9	3.35	240.25

Date March 2014

GWP# 5056-12-00

Prep'd CM

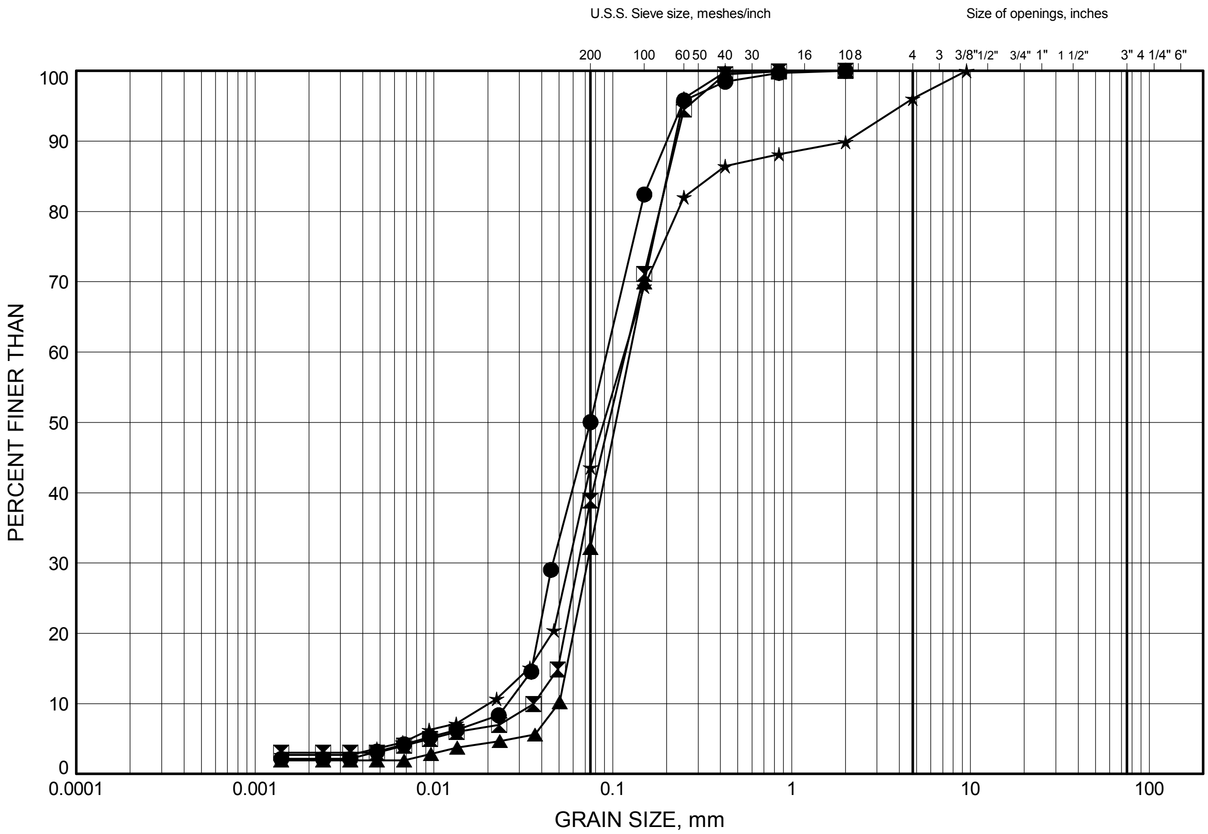
Chkd. FJG

Culvert 11-17025-008

GRAIN SIZE DISTRIBUTION

FIGURE 4

Silty Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-1	0.91	239.98
⧗	14-1	2.13	238.77
▲	14-1	3.96	236.94
★	14-1	5.09	235.81

Date March 2014

GWP# 5056-12-00

THURBER

Prep'd CM

Chkd. FJG

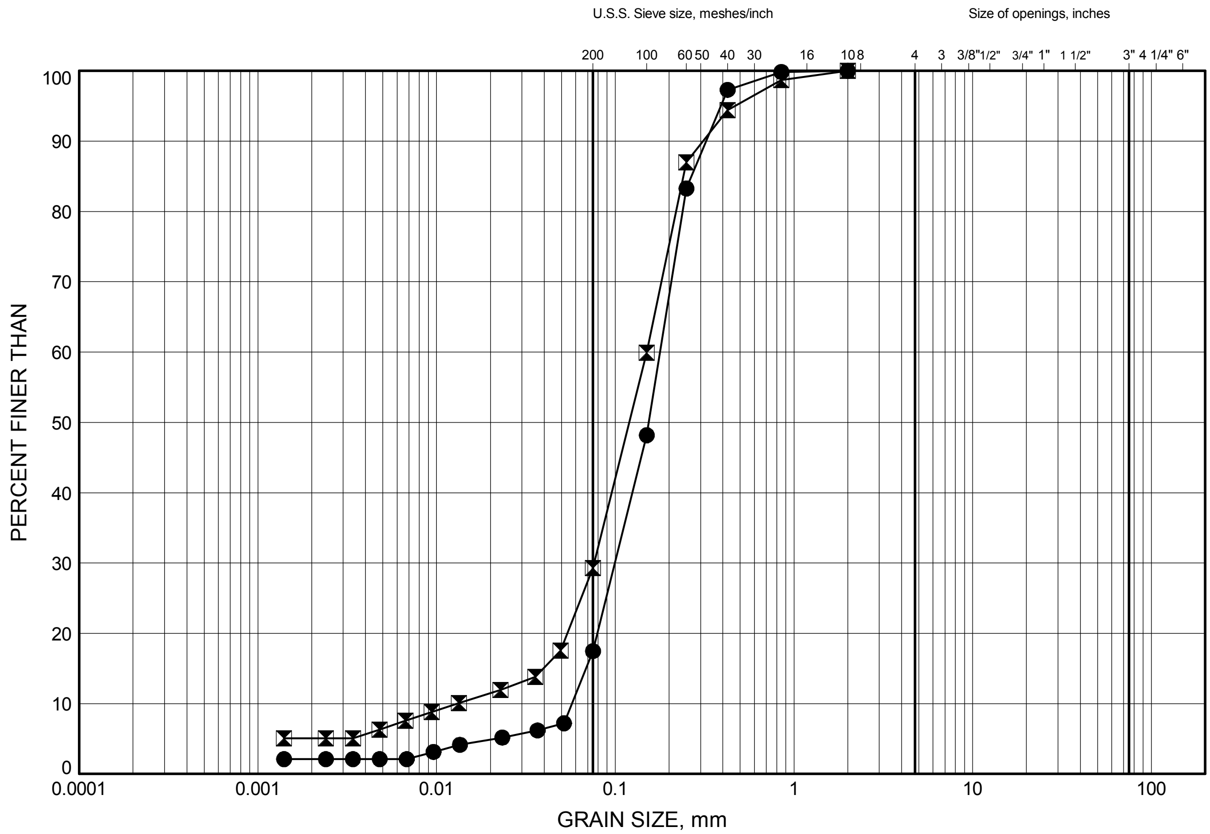
GRAIN SIZE DISTRIBUTION - THURBER 19-6478-0 SITE 23.GPJ 21/3/14

Culvert 11-17025-008

GRAIN SIZE DISTRIBUTION

FIGURE 5

Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-2	0.91	239.58
⧗	14-2	5.11	235.39

GRAIN SIZE DISTRIBUTION - THURBER 19-6478-0 SITE 23.GPJ 21/3/14

Date March 2014

GWP# 5056-12-00

THURBER

Prep'd CM

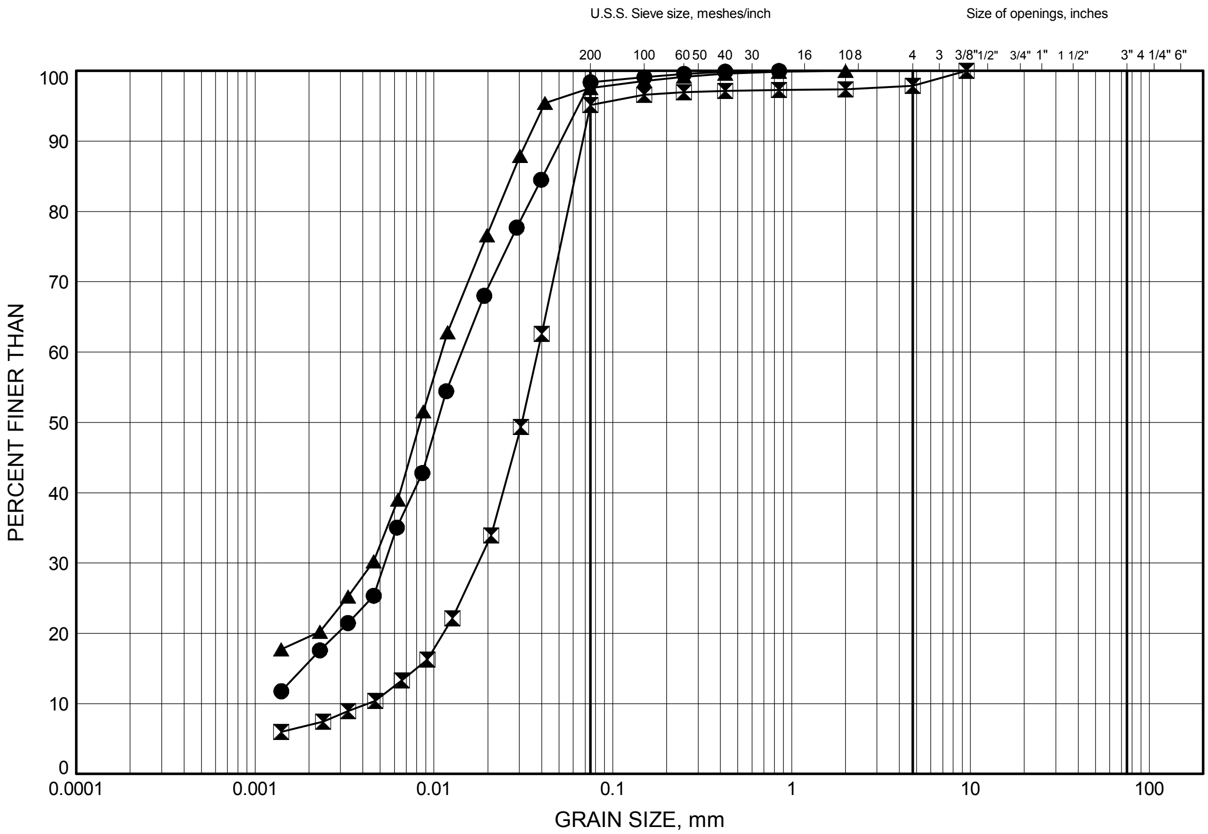
Chkd. FJG

Culvert 11-17025-008

GRAIN SIZE DISTRIBUTION

FIGURE 6

Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-2	2.13	238.37
⧗	14-2	3.96	236.54
▲	23-5	4.88	238.82

Date March 2014

GWP# 5056-12-00

THURBER

Prep'd CM

Chkd. FJG

Appendix D

Foundation Alternative Comparisons

THURBER

COMPARISON OF CONSTRCUTION METHODOLOGY OPTIONS

1. Staged, Supported Open Excavation	2a: Trenchless Jack and Bore	2b: Trenchless Pipe Ramming
Advantages: i. Well known, readily available technology.	***Advantages:*** i. Avoids open cut. ii. Does not require staging. iii. Relatively well known technology and readily available. iv. Permits installation of a sleeve on line and grade.	***Advantages:*** i. Avoids open cut. ii. Does not require staging. iii. Suitable for installing a sleeve pipe on line and grade. iv. Perhaps best control over potential settlement of pavement.
Disadvantages: i. Requires staging, i.e. closure of existing highway lanes ii. It introduces a cut in the existing highway. iii. Requires roadway protection	***Disadvantages:*** i. Potential for some loss of ground and settlement of the highway. Monitoring program required. The risk increases if the groundwater level is above the culvert inlet.	***Disadvantages:*** i. Technology less available in local area. ii. Risk of heave at roadway surface. Careful monitoring and adjustments to procedures may be required if pavement heave is noted.
Cost: Moderate due to roadway protection **Least risky option if Staged Open Cut is permitted**	***Cost:*** Moderate. **Feasible with risk of ground loss**	***Cost:*** Moderately high. **RECOMMENDED**

Appendix E

Non Standard Special Provisions

The following Special Provision is referenced in this report:

- **Amendment to OPSS 120, August 1994**

The contract documents should contain a NSSP containing the following, or similar, wording: Cobbles and Boulders

"The Contractor is notified that the soils at this site may contain cobbles and boulders that may impede the progress of trenching or trenchless installation. The soil conditions are described in the Foundation Investigation Report prepared for the site. Reference should be made to that document for a description of soil conditions. "

Groundwater and Dewatering

"The Contractor is notified that the site may be prone to high groundwater levels and that these levels may be higher than the water levels shown in the Foundation Investigation Report prepared for this site. While reference should be made to that report for a description of the encountered conditions, the Contractor must satisfy himself regarding the groundwater levels likely to prevail at the time of construction and be prepared to implement dewatering procedures.

The Contractor is further notified that failure to implement dewatering in advance of excavating below the groundwater table may result in sloughing and boiling of the soil in the excavation and a loss in stability and bearing resistance. "

PIPE INSTALLATION BY TRENCHLESS METHOD – Item No.

Non Standard Special Provision	January 2012

1. SCOPE

This specification covers the general requirements for the installation of pipes by trenchless methods.

The Contractor shall determine the most appropriate method of installation. Specifications for Jack and Bore, Pipe Ramming, Directional Drilling, and Tunnelling are provided herein, and shall be applied to the installation method considered feasible by the Contractor.

OPSS 415 (Construction Specification for Pipeline and Utility Installation by Tunnelling), OPSS 416 (Construction Specification for Pipeline and Utility Installation by Jacking and Boring) and OPSS 450 (Construction Specification for Pipeline and Utility Installation in Soil by Horizontal Directional Drilling) shall not be used to do the work for the above tender item.

2. REFERENCES

This specification refers to the following standards, specifications, or publications:

Foundation Investigation Report, Culvert 11-17025-008 Replacement, Highway 11, Morrison Township, Ontario, GWP 5056-12-00, by Thurber Engineering Ltd., Reference No. 19-6478-0.

Ontario Provincial Standard Specifications, General

OPSS 180	Management and Disposal of Excess Material

Ontario Provincial Standard Specifications, Construction

OPSS 504	Preservation, Protection, and Reconstruction of Existing Facilities
OPSS 507	Site Restoration Following Installation of Pipelines, Utilities and Associated Structures in Open Cut
OPSS 514	Trenching, Backfilling, and Compaction
OPSS 517	Dewatering of Pipeline, Utility, and Associated Structure Excavation
OPSS 538	Support Systems
OPSS 539	Protection Schemes

Ontario Provincial Standard Specifications, Material

OPSS 1004	Aggregates - Miscellaneous
OPSS 1350	Concrete - Materials and Production
OPSS 1440	Steel Reinforcement for Concrete
OPSS 1802	Smooth Walled Steel Pipe

MTO Specifications

OPSS 1820	Material Specification for Circular Concrete Pipe
OPSS 1840	Material Specification for Non-Pressure Polyethylene Plastic Pipe Products

American Society for Testing and Materials (ASTM) International Standards

ASTM A252-93	Welding and Seamless Steel Pipe Piles
ASTM D2657-03	Standard Practice for Heat Fusion Joining of Polyelofin Pipe and Fittings
ASTM D3350	Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
ASTM F894	Polyethylene Large Diameter Profile Wall Sewer and Drain Pipe

Canadian Standards Association Standards:

CSA B182.6	Profile Polyethylene Sewer Pipe and Fittings.
CAN/CSA A5-93	Portland Cement
CSA W59	Welded Steel Construction (Metal Arc Welding)

3. DEFINITIONS

For the purpose of this specification, the following definitions apply:

Backreamer: a cutting head suitably designed for the subsurface conditions that is attached to the end of a drill string to enlarge the pilot bore during a pullback operation.

Bore Path: a drilled path according to the grade and alignment tolerances specified in the Contract Documents.

Design Engineer: means the Engineer retained by the Contractor who produces the original design and working drawings. The design engineer shall be licensed to practice in the Province of Ontario.

Design Checking Engineer: means the Engineer retained by the Contractor who checks the original design and working drawings. The design checking engineer shall be licensed to practice in the Province of Ontario.

Digger Shield/Hand Mining: a method of forming a horizontal bore in the subsurface by essentially simultaneously jacking ahead while tunnelling advances using hand–mining (man-entry operation or "Jack and Mine) or a "digger" type shield with a hydraulic excavator arm to remove materials from inside the liner pipe.

Drilling Fluids: a mixture of water and additives, such as bentonite, polymers, surfactants, and soda ash, designed to block the pore space on a bore wall, reduce friction in the bore, and to suspend and carry cuttings to the surface.

Drilling Fluid Fracture or Frac Out: a condition where the drilling fluid's pressure in the bore is sufficient to overcome the in situ confining stress, thereby fracturing the soil and/or rock materials and allowing the drilling fluids to migrate to the surface at an unplanned location.

Engineer: a Professional Engineer licensed by the Professional Engineers of Ontario to practice in the Province of Ontario.

Excavation: includes all materials encountered regardless of type and extent. Excavation shall include removal of natural soil, large boulders, cobbles, wood and fill regardless of means necessary to break consolidated materials for removal.

Environmentally Sensitive Area (ESA): areas adjacent to construction that are off limits to the Contractor as specified elsewhere in the Contract.

Fill: man-made mixture of previously placed/handled materials such as sand, clay, silt, gravel, broken rock, sometimes containing organic and/or deleterious materials, placed in an excavation or other area to raise the surface elevation.

Grouting: injection of grout into voids.

Guidance System: an electronic system capable of locating the position, depth and orientation of the drill head during the directional drilling process.

Directional Drilling (DD): directional boring or guided boring.

HDPE: high density polyethylene.

Inadvertent Returns: the flow of unexpected fluids, saturated materials (or running soil) towards the drilling rig that typically originated from an artesian aquifer encountered during the drilling process.

Jack and Bore: a method of forming a horizontal bore in the subsurface by essentially simultaneously jacking ahead and rotating a cutter head, followed by removal of material from inside the bore.

Loss of Circulation: the discontinuation of the flow of drilling fluid in the bore back to the entry or exit point or other planned recovery points.

Pilot Bore: the initial bore to set directional controlled horizontal and vertical alignment between the connecting points.

Pipe Jacking: a method for installing steel casing or concrete pipe in the subsurface utilizing hydraulically operated jacks of adequate number and capacity to ensure smooth and uniform advancement without overstressing the liner/pipe.

Pipe Ramming: a method for installing steel casings utilizing the energy from a percussion hammer to advance a steel casing with a cutting shoe attached at the front end of the casing.

Primary Liner (Support): system installed prior to or concurrent with excavation, to maintain stability of an excavation and to support earth or rock and any structure utilities or other facilities in or on the supported earth or rock mass, until the excavation is completed.

Product: pipe culverts, pipe sewers, watermain pipe and sanitary pipe.

Pullback: that part of the DD method in which the drill string is pulled back through the bore path to the entry point.

Quality Verification Engineer (QVE): an Engineer who has a minimum of five (5) years experience in the field of pipe installation using trenchless methods or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the contract. The Quality Verification Engineer shall be retained by the Contractor to certify that the work is in general conformance with the contract documents and to issue Certificate(s) of Conformance.

Reaming: a process for pulling a tool attached to the end of the drill string through the bore path to enlarge the bore and mix the cuttings with the drilling fluid. This typically includes multiple passes.

Rock: natural beds or massive fragments, or the hard, stable, cemented part of the earth's crust, igneous, metamorphic, or sedimentary in origin, which may or may not be weathered and includes boulders having a size equivalent to 0.3 m in diameter or greater.

Secondary Liner: concrete pipe, HDPE pipe or un-reinforced cast-in-place concrete, installed subsequent to tunnel excavation.

Shaft: vertically sided excavation used as entry and/or exit points from which the trenchless method is initiated or directed for the installation of product.

Strike Alert: a system that is intended to alert and protect the operator in the case of inadvertent drilling into an electrical utility cable. The strike alert system consists of a sensor and an alarm connected to the drill rig and a grounding stake. The alarm may be audio or visual or both.

Slurry: a mixture of soil and/or rock cuttings, and drilling fluid.

Soil: all materials except those defined as rock, and excludes stone masonry, concrete, and other manufactured materials; includes rock fragments having an equivalent size less than 0.3 m in diameter.

Tunnelling: an underground method of constructing a passage open at both ends that involves installing a pipe.

4. DESIGN AND SUBMISSION REQUIREMENTS

4.01 General

The Contractor's documentation, submission requirements and installation methods shall specifically consider and address the subsurface conditions at each pipe crossing as identified in the Foundation Investigation Report.

4.02 Working Drawings

Three copies of stamped working drawings for portal or shaft construction, primary liner, excavation, secondary lining, dewatering and groundwater control and grouting shall be submitted to the Contract Administrator (CA) at least one (1) week prior to the commencement of the work for information purposes. All submissions shall bear the seal and signature of the Design Engineer and Design Checking Engineer. The Contractor shall have a copy of the stamped working drawings at the site during construction.

As a minimum, working drawings/details pertaining to the tunnel design and construction shall include the following (as appropriate):

a) Plans, Elevations and Details:

- A work plan outlining the materials, procedures, methods and schedule to be used to execute the work;
- A list of personnel, including backup personnel, and their qualifications and experience;
- A safety plan including the company safety manual and emergency procedures;
- The work area layout;
- An erosion and sediment control plan that includes a contingency plan in the event the erosion and sediment control measures fail;
- A drilling fluid management plan, if applicable, that addresses control of frac-out pressures, any potential environmental impacts and includes a contingency plan detailing emergency procedures in the event that the fluid management plan fails;
- Lighting, ventilation and fire safety details as may be required by applicable occupational health and safety regulations; and
- Excavated materials disposal plan.

b) Design Criteria:

- Primary liner design details, if applicable; and
- Design assumption and material data when materials other than those specified are proposed for use.
- Drill path design, details of alignment and alignment control, maximum curvature and reaming stages;

c) Materials:

- Certification from the manufacturer that the product furnished on the contract meets the specifications cited in the manufacturer’s product specification and that the materials supplied are suitable for the application; and
- Material mixture for filling voids and installation procedures.

d) Upstream/Downstream Portal Installation Procedure:

- The access shaft or entry/exit pit details designed and stamped/signed by the Design Engineer, as applicable; and
- Face support and other temporary support details, if applicable.

e) Primary Liner/Secondary Liner Installation and Grouting Procedure:

- Excavation and pipe jacking procedures, including methodology to handle obstructions and preventing soil cave-in; and
- Details of tunnelling equipment/methods to be used for the works.

f) Excavation and Dewatering:

- Ground control/dewatering details, as applicable, describing the proposed method for control, handling, treatment, and disposal of water.

g) Monitoring Method

- The methods to be employed to monitor and maintain the alignment of the installation;

4.03 Site Survey

Prior to commencing the work, the Contractor shall, at each pipe location, layout the alignment and install settlement monitoring points.

4.04 Certificate of Conformance

The Contractor shall submit details of the sequence and method of construction to the Quality Verification Engineer for review, prepared and stamped by the Design Engineer. The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of one week prior to commencement of work under this item. The Certificate shall state that the construction procedures are in conformance with the requirements and specifications of the contract documents.

The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer upon completion of each of the following operations and prior to commencement of each subsequent operation for each pipe installation:

Site Surveying (as noted in Section 4.02)
Excavation for pits including dewatering of excavation
Jacking/Ramming/Directional Drilling of Casing/Liner
Excavation and Dewatering
Installation of the Product
Grouting Operations

Each Certificate of Conformance shall state that the work has been carried out in general conformance with the contract documents, specifications and/or stamped working drawings.

In addition, upon completion of the installation of the pipe at each location, the Contractor shall submit to the Contract Administrator a **final** Certificate of Conformance sealed and signed by the Quality Verification Engineer. The Certificate shall state that the pipe has been installed in general conformance with the Contractor's Submission and Design Requirements, stamped working drawings and contract documents.

The Design Engineer will not be permitted to carry out the work of the Quality Verification Engineer.

5. MATERIALS

5.01 Product

The product shall be concrete pipe or high density polyethylene pipe as specified.

5.02 Concrete

Concrete shall be according to OPSS 1350. The concrete strength shall be as specified in the Contractor's design submission.

5.03 Concrete Reinforcement

Steel reinforcing for concrete work shall be according to OPSS 1440.

5.04 Timber

Timber shall be sound, straight, and free from cracks, shakes and large or loose knots.

5.05 Grout

The Contractor shall submit the proposed grout mix design for grouts to be used for lubricating jacking pipe and for filling of voids and annular spaces. Purging grout shall consist of a mixture of one part Portland cement conforming to the requirements of CAN/CSA A5-93 and two parts mortar sand conforming to OPSS 1004 wetted with only sufficient water to make the mixture plastic.

5.06 Jack and Bore Materials

5.06.01 Pipe Materials

Steel pipe shall conform with ASTM A252-95 welded joints suitable for jacking operations. The Contractor shall select pipe class for pipe jacking.

Concrete pipe as per OPSS 1820.

Fittings shall be suitable for and compatible with the class and type of pipe with which they will be used.

5.07 Pipe Ramming Materials

5.07.01 Pipe Materials

Steel pipe shall conform with ASTM A 252-93 welded joints.
New steel casing when specified shall be smooth wall carbon steel pipe according to ASTM A252-93 Grade 2.

Used steel casing can be used provided that the steel casing can resist the applicable static and dynamic loadings.

Pipe wall thickness shall be determined by the Contractor based on static and dynamic loads from traffic loading and anticipated ramming forces for selected pipe and driven pipe lengths. The wall thickness shall be increased as required to ensure the casing is not damaged during handling and installation. A minimum wall thickness of 50 mm and minimum yield strength of 240 MPa is required.

Pipe segments shall be determined by the Contractor.

Steel pipe joints shall be pressure fit type or welded.

All steel casing pipe shall be square cut.

Steel casing pipe shall have roundness such that the difference between the major and minor outside diameters shall not exceed 1% of the specified nominal outside diameter or 6 mm, whichever is less.

Steel casing pipe shall have a minimum allowable straightness of 1.5 mm maximum per metre of length.

5.07.02 Mill Certificates

For permanent casing, the Contractor shall submit to the Contract Administrator at the time of delivery one copy of the mill certificate, indicating that the steel meets the requirements for the appropriate standards for casings.

Where mill test certificates originate from a mill outside Canada or the United States of America the Contractor shall have the information on the mill certificate verified by testing by a Canadian laboratory. The laboratory shall be accredited by a Canadian National Accreditation Body to comply with the requirements of ISO/IEC Guide 25 for the specific tests or type of tests required by the material standard specified on the mill test certificate. The mill test certificates shall be stamped with the name of the Canadian testing laboratory and appropriate wording stating that the material conforms to the specified material requirements. The stamp shall include the appropriate material specification number, the date and the signature of an authorized officer of the Canadian testing laboratory.

5.08 Directional Drilling Materials

5.08.01 Drilling Fluids

The drilling fluids shall be mixed according to the manufacturer's recommendations and be appropriate for the anticipated subsurface conditions.

5.08.02 Pipe Materials

High Density Polyethylene (HDPE) pipe as per OPSS 1840 shall be used in accordance with ASTM D3350.

The requirements for fittings shall be suitable for and compatible with the class and type of pipe with which they will be used and in according to CAN/CSA-B182.6 or ASTM F894.

The Contractor shall determine the required dimensional ratio (DR) of the HDPE pipe to support all subsurface conditions and hydrostatic pressures, and to withstand the grouting pressure and installation forces. The Contractor shall identify these forces in his submission requirements.

The Contractor's submission shall demonstrate, in conjunction with the manufacturer's specifications, that the heat resistance of the pipe material is sufficient to tolerate without damage the heat of hydration generated by grout curing.

Fittings shall be suitable for and compatible with the class and type of pipe with which they will be used.

Jointing of HDPE piping shall be completed by thermal butt fusion in accordance with manufacturer's recommended procedures and as outlined in the latest revision of ASTM D2657. All manufacturer's recommendations and procedures shall be followed during the jointing process.

Jointing of HDPE piping to other piping materials or appurtenances shall be completed using flanged connections.

5.09 Tunnelling Materials

5.09.01 Primary Liner

Tunnelling methods will require installation of a primary liner to provide support and stability to the excavation.

5.09.02 Secondary Liner

Concrete or High Density Polyethylene Pipe shall be used according to the following requirements.

5.09.02.01 Concrete Pipe

Concrete pipe as per OPSS 1820 shall be used. The Contractor shall select the pipe class to withstand grouting pressure and installation forces. The Contractor shall identify these forces in his submission requirements.

Fittings shall be suitable for and compatible with the class and type of pipe with which they will be used.

5.09.02.02 High Density Polyethylene (HDPE)

High Density Polyethylene (HDPE) pipe as per OPSS 1840 shall be used in accordance with ASTM D3350.

The requirements for fittings shall be according to CAN/CSA-B182.6 or ASTM F894.

The Contractor shall determine the required dimensional ratio (DR) to withstand the grouting pressure and installation forces. The Contractor shall identify these forces in his submission requirements.

Fittings shall be suitable for and compatible with the class and type of pipe with which they will be used.

Jointing of HDPE piping shall be completed by thermal butt fusion in accordance with manufacturer's recommended procedures and as outlined in the latest revision of ASTM D2657. All manufacturer's recommendations and procedures shall be followed during the jointing process.

Jointing of HDPE piping to other piping materials shall be completed using flanged connections.

6. EQUIPMENT

6.01 Jack & Bore Equipment

Jack & bore equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein.

Specific details of the manner in which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the liner shall be submitted to the Contract Administrator for information purposes prior to proceeding with the works.

6.02 Pipe Ramming Equipment

Pipe ramming equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein.

The pipe ramming hammer(s) shall be capable of driving the pipe casing from the drive pit through the existing subsurface conditions at the site.

Specific details of the manner in which rock or boulders will be broken and removed from the face and the face will be protected to prevent soil loss into the pipe shall be submitted to the Contract Administrator for information purposes prior to proceeding with the works.

6.03 Directional Drilling Equipment

6.03.01 General

The directional drilling equipment shall consist of a directional drilling rig and a drilling fluid mixing and delivery system of sufficient capacity to successfully complete the product installation without exceeding the maximum tensile strength of the product being installed.

6.03.02 Drilling Rig

The directional drilling rig shall:

- consist of a leak free hydraulically powered boring system to rotate, push, and pull hollow drill pipe into the ground at a variable angle while delivering a pressurized fluid mixture to a guidable drill head;
- contain a guidance system to accurately guide boring operations;
- be anchored to the ground to withstand the rotating, pushing, and pulling forces required to complete the product installation; and
- be grounded during all operations unless otherwise specified by the drilling rig manufacturer.

6.03.03 Drill Head

The drill head shall be steerable by changing its rotation, be equipped with the necessary cutting surfaces and drilling fluid jets, and be of the type for the anticipated subsurface conditions,

6.03.04 Guidance System

The guidance system shall be setup, installed, and operated by trained and experienced personnel. The operator shall be aware of any magnetic or electromagnetic anomalies and shall consider such influences in the operation of the guidance system when a magnetic or electromagnetic system is used.

6.03.05 Drilling Fluid Mixing System

The drilling fluid mixing system shall be of sufficient size to thoroughly and uniformly mix the required drilling fluid.

6.03.06 Drilling Fluid Delivery System

The delivery system shall have a means of measuring and controlling fluid pressures and be of sufficient flow capacity to ensure that all slurry volumes are adequate for the length and diameter of the final bore and the anticipated subsurface conditions. Connections between the delivery pump and drill pipe shall be leak-free.

6.04 Tunnelling Equipment

Tunnelling equipment shall be determined by the Contractor and shall be identified in the submission requirements specified herein.

Specific details of the manner in which rock or boulders will be broken and removed from the tunnel face shall be submitted to the Contract Administrator information purposes. Use of explosives or rock fracturing chemicals shall only be considered subject to a field demonstration satisfactory to the Ministry prior to its use.

7. CONSTRUCTION

7.01 General

The Contractor shall notify the Contract Administrator at least 48 hours in advance of starting work. The proposed method of pipe installation shall be subject to the limitations presented in the following subsections.

7.01.01 Layout, Alignment and Depth Control

The location of the installation shall be established from the lines, elevations and tolerances specified in the Contract Documents. The pipe installation shall be to the horizontal and vertical alignments specified in the Contract Drawings. Deviations from location, alignment, grades and/or invert levels shall be corrected by the Contractor at no cost to the Ministry.

All reference points necessary to construct the pipe installation and appurtenances shall be laid out.

The Contractor shall calibrate tracking and locating equipment at the beginning of each work day, and shall monitor and record the alignment and depth readings provided by the tracking system at every 5 m in normal conditions and every 2 m where precise alignment control is necessary;

The Contract Administrator shall be provided with the assistance and access necessary to check the layout of the pipe installation and associated appurtenances.

All excavations shall be carried out in accordance with the Occupational Health and Safety Act (OHSA) of Ontario.

For directional drilling, the contractor shall ensure that during pilot hole drilling the maximum degree of deviation or “dog-leg” shall be 2.5 degrees per 9m drill pipe length. Any deviation exceeding 2.5 degrees will necessitate a pull-back and straightening of the alignment at the Contractor’s sole expense. The pilot hole exit location shall be within 0.5m of the target location.

7.01.02 Shafts

Shafts shall be specified in the Contractor's submission. The boundaries and protection of these shall be as required to contain all disturbances to areas outside of the ESA limits.

Shafts shall be maintained in a drained condition.

A minimum 2.4 m high secure fence shall be installed around the perimeter of the construction shaft area with gates and truck entrances. The fence shall be removed on completion of the work.

7.01.03 Protection Systems

The construction of all protection systems shall be according to OPSS 539. Where the stability, safety, or function of an existing roadway, watercourse, other works, proposed works or ESA's may be impaired due to the method of operation, protection shall be provided. Protection systems include primary liner and portal excavation support systems. Protection may include sheathing, shoring, and piles where necessary to prevent damage to such works or proposed works

7.01.04 Settlement or Heave

Any disturbance to the ground surface (settlement or heave) as a result of the pipe installation shall be immediately corrected by the Contract, at no additional cost to the Ministry.

7.01.05 Stability of Excavation

The construction methods, plant, procedures, and precautions employed shall ensure that excavations are stable, free from disturbance, and maintained in a drained condition.

The construction methods, plant, and materials employed shall prevent the migration of soil and/or rock material into the excavation from adjacent ground.

7.01.06 Preservation and Protection of Existing Facilities

Preservation and protection of existing facilities shall be according to OPSS 504.

Existing underground facilities shall be exposed to verify its horizontal and vertical locations when the outlet pipe path comes within 1.0 m horizontally or vertically of the existing facility. Existing facilities shall be exposed by non-destructive methods.

7.01.07 Transporting, Unloading, Storing and Handling Materials

Manufacturer's handling and storage recommendations shall be followed.

7.01.08 Trenching, Backfilling and Compacting

Trenching, backfilling, and compacting for entry and exit points or other locations along the pipe path shall be according to OPSS 514.

7.01.09 Dewatering

The work of this Section includes control, handling, treatment, and disposal of groundwater. The Contractor shall review the foundation investigation report for reference to soil and groundwater conditions on the project site and plan a dewatering scheme accordingly.

The Contractor shall control groundwater inflows to excavations to maintain stability of surrounding ground, to prevent erosion of soil, to prevent softening of ground exposed in the excavation, and to avoid interfering with execution of the work.

The Contractor shall maintain excavations free of standing water at all times during excavation, including while concrete is curing.

Should water enter the excavation in amounts that could adversely affect the performance of the work or could cause loss of ground, the Contractor shall take immediate steps to control the inflow.

The Contractor is alerted that seepage zones of perched water within the fill materials should be expected, particularly where granular materials are excavated.

Dewatering shall be according to OPSS 517.

7.01.10 Removal of Boulders

The Contractor is alerted that cobbles and boulders should be anticipated in the soil deposits at the site. Accordingly, the Contractor shall address the removal of cobbles and boulders in the proposed method of construction. The Contractor shall immediately inform the Contract Administrator of any obstruction encountered.

7.01.11 Record Keeping

Verification record requirements of the alignment and depth of the installation shall be as specified in the Contract Documents. A copy of the verification records shall be given to the Contract Administrator at the completion of the installation.

7.01.12 Testing

Testing of the product installation shall consist of verifying the specified grade between the two ends of the pipe and passing of water from the median end of the pipe to the outlet end to confirm gravity flow conditions.

7.01.13 Management and Disposal of Excess Material

Management and disposal of excess material shall be according to OPSS 180. Satisfactory re-usable excavated material required for backfill shall be separated from unsuitable excavated material.

7.01.14 Site Restoration

Site restoration shall be according to OPSS 507.

7.01.15 Supervision

A qualified individual, who is experienced in the pipe installation by trenchless methods shall supervise the work at all times.

7.02 Jack and Bore Installation

7.02.01 Method of Installation Procedure

The installation procedure to be used shall be subject to the following limitations:

- Hydraulically operated jacks of adequate number and capacity shall be provided to ensure smooth and uniform advancement without over-stressing of the pipe.
- A suitably padded jacking head or collar shall be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.
- The jacking pipe shall be fully supported in the jacking pit at the specified line and grade.
- Selection of the excavation method and jacking equipment shall take into consideration the conditions at each pipe crossing.

7.02.02 Pipe Installation

Concrete pipe joints shall be water tight and according to OPSS 1820 and must withstand jacking forces, determined by the Contractor.

During the jacking of the liner the space between the liner and the wall of the excavation shall be kept filled with bentonite slurry. Upon completion of jacking, the space between the liner and the wall of the excavation shall be filled with grout.

The annular space between the liner and the product shall be fully grouted with a water tight, expandable and stable grout.

7.03 Pipe Ramming Installation

For pipe ramming installation the following requirements apply:

Only smooth walled steel pipe shall be used. But welding of pipe joints shall conform to CAS W59.

Ramming equipment of adequate capacity shall be provided to ensure smooth and uniform advancement without overstressing of the pipe. Delays shall be avoided between ramming operations.

A ramming head shall be provided to transfer and distribute jacking pressure uniformly over the entire end bearing area of the pipe.

Two or more lubricated guide rails or sills shall be provided of sufficient length to fully support the pipe at the specified line and grade in the ramming pit. Pipe shall be installed to the line and grade specified.

Following installation of the liner pipe, all material shall be removed from the pipe to the satisfaction of the Contract Administrator. Any voids remaining between the pipe and the excavation wall shall be grouted as soon as the pipe is rammed. The annular space between the liner pipe and the product shall be fully grouted with a water tight, expandable and stable grout.

7.04 Directional Drilling Installation

7.04.01 General

When strike alerts are provided on a drilling rig, they shall be activated during drilling and maintained at all times.

7.04.02 Site Preparation

The work site shall be graded or filled to provide a level working area for the drilling rig. No alterations beyond what is required for DD operations are to be made. All activities shall be confined to designated work areas.

7.04.03 Pilot Bore

The pilot bore shall be drilled along the bore path in accordance with the grade, alignment, and tolerances as indicated on the Contractor's submitted drilling plan to ensure that the product is installed to the line and grade shown on the Contract Drawings. The Contractor's methods shall take into consideration the conditions at each crossing within the pipe alignment and shall be suitable to advance through such obstructions such as cobbles and boulders and address the potential for deflection off these obstruction and/or soil conditions.

In the event the pilot bore deviates from the submitted path, the Contract Administrator shall be notified. The Contract Administrator may require the Contractor to pullback and re-drill from the location along the bore path before the deviation.

In the event that a drilling fluid fracture, inadvertent returns, or loss of circulation occurs during pilot bore drilling operations, the Contract Administrator shall be advised of the event and action shall be taken in accordance with the Contractor's submitted contingency plan.

At the entry and exit points, there is potential for ravelling of the existing soil, fill and or weathered rock areas along the alignment. This is conventionally addressed by the use of drilling fluid. However, casing may be required. The Contractor's methods shall take into consideration the potential need to install sections of casing to manage ravelling at or near ground surface.

If a drill hole beneath the highway must be abandoned, the hole shall be backfilled with grout or bentonite to prevent future subsidence.

The Contractor shall maintain drilling fluid pressure and circulation throughout the DD process, including during the initial pilot bore and during the reaming process.

The Contractor shall at all times and for the entire length of the installation alignment be able to demonstrate the horizontal and vertical position of the alignment, the fluid volume used, return rates and pressures.

7.04.04 Drilling Fluid Fracture (Frac-Out)

In order to reduce the potential for hydraulic fracturing of the hole during directional drilling, a minimum depth of cover of 5m is normally maintained between the pipe and the ground surface. Sections of the pipe close to the exit pit with less than 5m cover shall be cased. The Contractor shall ensure that drilling fluid pressures are properly set and controlled to prevent frac-out, for the depth of cover available between the bottom of the pavement structure (bottom of the subbase material) and the top of the bore.

Since fluid loss normally occurs in fault zones, fracture zones, or seams of coarse material, fluid migration does not always gravitate to the surface, thus making detection difficult. Once a fluid loss is detected, the Contractor shall halt operations immediately and conduct a detailed examination of the drill path and implement measures to mitigate fluid loss. If no surface migration is evident, resume operation while paying particular attention to fluid monitoring.

In the event of a fluid migration to the surface occurring, the Contractor shall halt all operations immediately, isolate the migration site, and recover fluids. Once the fracture is controlled, continue drilling operations with the operator paying particular attention to the fracture points

7.04.05 Reaming

The bore shall be reamed using the appropriate tools to a diameter at least 50% greater than the outside diameter of the product.

7.04.06 Product Installation

7.04.06.01 General

The product shall be jointed according to manufacturer's recommendations. The length of the product to be pulled shall be jointed as one length before commencement of the continuous pulling operation.

The product shall be protected from damage during the pullback operation.

The minimum allowable bending radius for the product shall not be exceeded.

Product shall be allowed to recover before connections to new or existing facility are made. Product recovery time shall be according to manufacturers recommendations.

7.04.06.02 Pullback and Grouting

After successfully reaming the bore to the required diameter, the product shall be pulled through the bore path. Once the pullback operation has commenced, it shall continue without interruption until the product is completely pulled into bore unless otherwise approved by the Contract Administrator.

A swivel shall be used between the reamer and the product being installed to prevent rotational forces from being transferred to the product. When specified in the Contract Documents, a weak link or breakaway connector shall be used to prevent excess pulling force from damaging the product.

The product shall be inspected for damage where visible at excavation pits and where it exits the bore. Any damage noted shall be rectified to the satisfaction of the Contract Administrator,

The pull back and reaming operations shall not exceed the fluid circulation rate capabilities. Reaming and back pulling operations shall be planned to insure that, once started, all reaming and back pulling operations are completed without stopping and within the permitted work hours.

The space between the pipe and the excavation walls shall be filled with grout.

7. 05 Tunnelling Installation

7.05.01 General

The method of tunnelling shall be selected by the Contractor and shall be submitted to the Contract Administrator prior to commencement of the work for information purposes.

Excavation of native soil and fill shall be done in a manner to control groundwater inflow to the excavation and to prevent loss of ground into the excavation.

Methods of excavating the tunnel shall be capable of fully supporting the face and shall accommodate the removal of boulders and other oversize objects from the face. Continuous ground support shall be maintained during excavation.

As the excavation progresses, the Contractor shall continuously monitor (every 2m) indications of support distress, such as cracking, deflection or failure of support system and subsidence of ground near the excavation.

The Contractor shall advance the ventilation system as a regular part of the normal excavation cycle.

The Contractor shall provide lighting in accordance with OHSA requirements for the entire length of the tunnel.

The tunnel is to be kept sufficiently dry at all times to permit work to be performed in a safe and satisfactory manner.

The Contractor shall maintain clean working conditions at all times in tunnels.

In the event that excavation threatens to endanger personnel, the Work, or adjacent property, the Contractor shall cease excavation. The Contractor shall then evaluate methods of construction and revise as necessary to ensure the safe continuation of the work.

The Contractor shall maintain tunnel excavation line and grade to provide for construction of final lining within specified tolerances.

7.05.01 Tunnelling Method

The tunnelling method shall be suitable to provide face support in changing ground conditions that may be encountered during the progress of the work. The selection of the tunnelling method should consider the soil conditions at each pipe crossing and the presence of obstructions, such as cobbles and boulders, with respect to the tunnel alignment.

7.05.02 Primary Liner (Support System)

Primary support systems shall prevent deterioration, loosening, or unravelling of ground surfaces exposed by excavation.

The primary liner support system shall be designed and installed to achieve the intended performance requirements.

Primary liner support system shall maintain the safety of personnel, minimize ground movement into the excavation, ensure stability and maintain strength of ground surrounding the excavation.

The primary liner shall be designed to support all subsurface conditions and hydrostatic pressures and to withstand any additional loads caused by installation and grouting, and shall ensure that no ground loading or other loading will be placed on the new work until after design strength has been reached.

The primary liner shall be installed so that the exterior is as tight as possible to the excavated surface of the tunnel and allows the placement of the full design thickness of the secondary lining.

Primary support systems shall be compatible with the encountered ground conditions, with the method of excavation, with methods for control of water, and with placement of the permanent lining.

All voids between the primary lining and the surface of the excavation shall be filled with cement grout. If an unexpanded liner is used, the space outside the liner plates shall be grouted at least daily.

7.05.03 Secondary Liner

7.05.03.01 Placing of Grout

The void outside the finished secondary liner shall be filled with cement grout according to the Contractor's submission.

Grout shall not be placed until the lining has achieved 85% of its specified strength or 30 MPa. Grouting shall be limited to such sequences and programs as are necessary to avoid damaging any part of the works or any other structure or property.

7.06 Instrumentation Monitoring

The work specified in this Section includes furnishing and installing instruments for monitoring of settlement and ground stability.

Surface settlement markers for monitoring ground stability shall be installed at the pavement/ground surface level on the shoulder, side slope and pavement at not greater than 5 m intervals along the tunnel alignment and as an array of three in ground (1.5 m depth) measurement points on the shoulder of the highway perpendicular to the alignment. The equipment and procedures used for settlement monitoring during construction must be capable of surveying the settlement point elevations to within ± 1 mm of the actual elevation.

Surface settlement markers shall be hardened steel markers treated or coated to resist corrosion, with an exposed convex head having a minimum diameter of 12 mm and similar to surveyor's PK nails. Markers shall be rigidly affixed so as not to move relative to the surface to which it is attached. Traffic shall be managed by the contractor using short term lane closures in accordance with the Ontario Traffic Manual (OTM).

In general, settlement monitoring points shall be 12-18 mm rebar encased in a 50-70 mm, SCH40 PVC pipe, set to a depth of 1.5 m below ground surface. The assembly shall be placed in a drill hole and backfilled with uniform sand as shown on the Contract Drawings.

The Contractor shall install all surface settlement instruments a minimum of one week prior to the start of works.

The surface settlement instruments shall be clearly labelled for easy identification.

The Contractor shall submit to the Contract Administrator a site plan showing the locations of the monitoring points, a geodetic survey of the settlement monitoring points including station, offset and elevation recorded at the following time intervals:

- Three consecutive readings at least one week prior to commencement of the work (Baseline Reading);
- Once per shift during tunnelling operations period; and
- Weekly after completion of the work for one month, or until such time at which all parties agree that further movement has stopped.

All readings shall be submitted to the Contract Administrative for information purposes on a weekly basis. Each report shall include all survey data collected in tabular and graphical format as plots of time versus settlement in comparison to survey data collected prior to commencement of the work.

7.07 Criteria for Assessment of Roadway Subsidence/Heave

Based on the monitoring of ground movement as specified in Subsection 4.02, the following represents trigger levels that define magnitude of movement and corresponding action:

- Review Level: If a maximum value of 10 mm relative to the baseline readings is reached, the Contractor shall review or modify the method, rate of sequence of construction or ground stabilization measures to mitigate further ground displacement.

  If the Review Level is exceeded, the Contractor shall immediately notify the CA and review and discuss response actions. The Contractor shall submit a plan of action to prevent Alert Levels from being reached. All construction work shall be continued such that the Alert Level is not reached.

- Alert Level: If a maximum value of 15 mm relative to the baseline readings is reached, the Contractor shall cease construction operations, inform the Contract Administrator and execute pre-planned measures to secure the site, to mitigate further movements and to assure safety of public and maintain traffic.
  - No construction shall take place until all the following conditions are satisfied:
    - The cause of the settlement has been identified.
    - The Contractor submits a corrective/preventive plan.
    - Any corrective and/or preventive measure deemed necessary by the Contractor is implemented.
    - The CA deems it is safe to proceed.

The Contractor shall avoid damaging instrumentation during construction. Instrumentation that is damaged as a result of the Contractor's operation shall be repaired or replaced by the Contractor within one business day. The costs for replacement/repair shall be borne by the Contractor.

At the completion of the job, the Contractor shall abandon all instrumentations installed during the course of the Work.

9. MEASUREMENT FOR PAYMENT

Measurement shall be by Plan Quantity Payment as may be revised by Adjusted Plan Quantity Payment in metres, following along the centre line of the pipes from centre to centre of maintenance holes or chambers (catch basins) or from/to the end of the pipe where no maintenance hole or chamber is installed, of the actual length of pipe installed by trenchless methods.

10. BASIS OF PAYMENT

Payment at the contract price shall be full compensation for providing all labour, equipment and materials required for excavation (regardless of material encountered), dewatering, sheathing and shoring, supply and installation of pipe liners, settlement monitoring and instrumentations site restoration and for all other work necessary to complete the installation as specified.

Payment for the rigid or flexible pipe conduits installed inside the pipe liners shall be paid separately under the appropriate tender items.

Where a protection system is made necessary because of the Contractor’s operations (e.g. choice of trenchless installation method), the cost shall be included in this item and shall be full compensation for all labour, equipment and materials required to carry out the work including subsequently removing the temporary protection system and performing any necessary restoration work.

Payment for connecting intercepted drains and service connections shall be made on the following basis:

(a) Where such drains and service connections are shown on the contract drawings the cost of connections shall be included in the contract price for pipe installation.

(b) Where such drains and service connections are not shown on the contract drawings, the cost of connections will be considered an allowable extra to the contract.

Payment for removal of boulders/obstructions greater than an equivalent 0.3 m in diameter shall be on a time and materials basis. The Contractor shall inform the Contract Administrator when boulders/obstructions are encountered and prior to removal to allow for proper and accurate tracking of time and material charges.

Notes to Designer:

Under Section 7.01.06, minimum horizontal and vertical clearances to existing facilities shall be identified in the Contract Documents. Clearances shall be measured from the nearest edge of the largest cut diameter required to the nearest edge of the facility being paralleled or crossed. The number of exposures required to monitor work progress shall be specified in the Contract Documents.