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FOUNDATION INVESTIGATION AND DESIGN REPORT
CULVERTS AND STORMWATER PONDS
NEW CROSSING OF HIGHWAY 400 AT HARVIE AND BIG BAY POINT ROAD
BARRIE, ONTARIO

Geocres Number:

Report to

HATCH

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PART 1: FACTUAL INFORMATION

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1.0 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the culverts, stormwater ponds and stream realignment proposed in connection with the new crossing of Highway 400 at Harvie Road and Big Bay Point Road in Barrie, Ontario.

The proposed new crossing of Highway 400 will connect Harvie Road currently terminated to the west of Highway 400, to Big Bay Point Road currently ending at Fairview Road to the east of Highway 400. The underpass structure location is situated over an existing culvert carrying Whiskey Creek under Highway 400. The culvert will be relocated, the creek will be realigned, and stormwater ponds will be developed.

The purpose of the investigation was to explore the subsurface conditions at the locations of the proposed drainage facilities and, based on the data obtained, to provide borehole logs, borehole location plans, stratigraphic profiles, and a written description of the subsurface conditions at the site.

Thurber carried out the investigation as a sub-consultant to Hatch who are preparing the detailed crossing design for The City of Barrie.

2.0 SITE DESCRIPTION

At present, Highway 400 at the proposed crossing site conveys six lanes of traffic, with three lanes in each direction, separated by a steel box guiderail and approximately 1.0 m wide paved median shoulders in both directions. At the proposed structure location, one additional through lane enters into the Barrie ONroute Service Centre in the northbound direction.

Harvie Road is a paved two-lane rural roadway which is presently closed approximately 600 m west of Highway 400. Existing Big Bay Point Road east of Fairview Road is a two lane municipal roadway with gravel shoulders.

The site is located at the south end of Barrie in a largely vacant area surrounded by commercial/light industrial development and residential subdivisions. The lands to the northwest and northeast of the site are generally forested with the exception of the service centre. Earthworks have been carried out on the lands to the south of Harvie Road, and the property on the south side of Big Bay Point Road was formerly occupied by a large brewery, since demolished.

A small watercourse (Whiskey Creek) crosses under Highway 400 from the southwest to northeast at the structure location, eventually discharging into Kempenfelt Bay. The invert level of the existing culvert under Highway 400 falls from Elev. 282.3 at the inlet to Elev. 281.4 at the outlet. The roadway surface on the Highway 400 embankment is at approximate Elev. 291.2. Photographs of the site are provided in Appendix C.

The study area is located within the western extent of the Peterborough Drumlin Field physiographic region, a rolling till plain located north of the Oak Ridges Moraine. This region generally comprises sandy till drumlins or drumlinoid hills with sand, silt or clay deposits in the intervening lowlands. At the site, the surficial materials are expected to comprise glaciofluvial ice-contact sands, with localized glaciolacustrine silt and clay deposits to the west of Highway 400. The underlying bedrock is expected to lie at a depth in excess of 100 m.

3.0 SITE INVESTIGATION AND FIELD TESTING

The site investigation was carried out in several stages during the period January 11 to February 24, 2017, and comprised fourteen boreholes designated D-01 to D-15 (excluding D-03) drilled to depths of 9.6 to 18.7 m at culvert locations, in storm pond areas, and along the stream alignment. Permission was not received from a landowner to drill at the programmed location of Borehole D-03.

In addition, nine boreholes drilled in the vicinity of the proposed creek channel and storm pipe alignments for other facilities (Boreholes HF-01, HF-07, RW-01, UP-02, and UP-05 to UP-09) have been included in this report.

The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawings provided in Appendix F. The borehole locations for the drainage facilities were selected by Hatch on the basis of preliminary design concepts.

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All borehole locations were cleared of utilities prior to commencement of drilling. The boreholes were repositioned as necessary in consideration of surface features, underground utilities, and site access. Of note were the numerous underground utilities and overhead wires present along the Harvie – Big Bay Point Road corridor, and no permission to access the lands south of Harvie Road.

Hollow stem augers were used to advance the boreholes in the overburden, and soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Portable tripod drilling equipment was employed to advance Borehole D-12 in a ditch area inaccessible to a conventional drill rig.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers (19mm diameter) were installed and enclosed in filter sand in selected boreholes to permit groundwater level monitoring. The details of the piezometers are shown in Table 3.1.

Table 3.1 – Piezometer Details

Borehole	Piezometer Tip		Slotted Screen Length (m)
	Depth (m)	Elevation (m)	
D-01	12.4	280.0	1.5
D-06	15.7	274.7	1.5
D-09	15.6	273.2	1.5
D-10	12.6	268.7	1.5
D-12	12.6	267.0	1.5
D-13	9.6	276.9	1.5
D-15	9.6	268.2	1.5
HF-01	9.6	279.8	1.5
RW-01	18.7	266.5	1.5
UP-06	21.1	266.2	3.0

The boreholes in which no piezometers were installed were backfilled with bentonite and cuttings to the ground surface in general accordance with MOE Regulation 903.

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4.0 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A. Selected samples were subjected to gradation analysis. The results of this testing program are shown on the Record of Borehole sheets and on the laboratory test result figures attached in Appendix B.

5.0 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference should be made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy are presented in Appendix A and on the "Borehole Locations and Soil Strata" drawings in Appendix F. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general terms, the subsurface stratigraphy encountered in the boreholes consists of a surficial topsoil layer or pavement structure overlying fill or native sands and silts, underlain by a deep deposit of sand.

More detailed descriptions of the individual strata are presented below.

5.1 Pavement Structure

Asphalt pavement was encountered in Boreholes D-07 and D-08 drilled on the paved shoulder of Highway 400, and in Borehole D-09 drilled in a former parking lot. The pavement structure on the highway shoulder consisted of 125 mm of asphalt overlying granular material extending to depths of 1.5 and 2.1 m (Elev. 290.0 and 289.6). In Borehole D-09, the pavement structure consisted of 100 mm of asphalt over 0.7 m of sand fill. Measured moisture contents in the granular material ranged from 4 to 14%.

5.2 Topsoil

A topsoil or organic layer was encountered at the ground surface in all boreholes except Boreholes D-07 to D-09 and D-15. The thickness of the topsoil layer typically ranged from 25 to 200 mm. Locally in Boreholes D-01, D-02 and UP-07, a 0.6 to 1.2 m thick layer of organic material was encountered. The topsoil thickness may vary between and beyond the borehole locations.

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5.3 Fill

Fill material typically comprising sand to silty sand, locally silt to clayey sandy silt, was encountered below the pavement structure or topsoil in Boreholes D-07, D-13, RW-01, UP-05, UP-06 and UP-08. SPT 'N' values obtained in the fill ranged from 2 to 32 blows/0.3 m, indicating a very loose to dense condition. Moisture contents of 4 to 18% were measured in the fill. The lower boundary of the fill was encountered at depths of 1.5 to 3.7 m (Elev. 287.8 and 282.4).

The results of grain size distribution tests carried out on fill samples are shown on Figures B1 and B2 in Appendix B and summarized below:

Gravel (%)	0 to 16
Sand (%)	47 to 80
Silt & Clay (%)	7 to 53

5.4 Sands and Silts

Cohesionless deposits varying in gradation from sand with trace silt to silt with some sand were encountered below the topsoil and fill in all boreholes except Boreholes D-12, D-13, UP-05, UP-06, UP-08 and UP-09. Locally, the lower 1.3 m of these deposits graded to a clayey silt in Boreholes D-01 and D-02, a gravelly zone was encountered in Boreholes D-08 and D-14, and a 0.2 m thick layer of black organic silt was encountered within these deposits in Borehole D-15. The total thickness of these units ranged from 1.0 to 6.0 m, with a lower boundary at depths of 1.1 to 6.4 m.

SPT 'N' values obtained in the sand/silt deposits varied widely from 1 to 75 blows/0.3 m, indicating a very loose to very dense relative density. Typically the 'N' values were less than 25 blows/0.3 m, and commonly less than 10 (loose to very loose). One value of 50 blows/0.125 m was obtained in a gravelly zone in Borehole D-08. Measured moisture contents ranged from 2 to 28%, typically about 10 to 25%, and up to 82% in organic/alluvial sediments in Borehole D-15.

The results of grain size distribution tests carried out on the sands and silts are shown on Figures B3 to B5 in Appendix B and summarized below:

Gravel (%)	0 to 23
Sand (%)	32 to 91
Silt (%)	5 to 60
Clay (%)	2 to 17

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5.5 Sand

A deep deposit of sand was encountered below the topsoil, fill and upper sand/silt deposits in all boreholes at depths of 0.1 to 6.4 m (Elev. 288.2 to 271.4). This deposit typically consisted of fine to medium grained sand with trace silt and gravel; several zones graded to silty or gravelly sand. All boreholes except Borehole D-11 were terminated in the sand at depths of 5.0 to 33.8 m (Elev. 280.0 to 249.8).

SPT 'N' values recorded in the sand deposit typically ranged from 40 to 100 blows/0.3 m penetration, indicating a dense to very dense relative density. 'N' values occasionally exceeded 100 blows/0.3 m. Locally in several boreholes drilled adjacent to Whiskey Creek (Boreholes D-04, D-10, D-11, D-12, RW-01, UP-02 and UP-09), lower 'N' values of 1 to 28 blows/0.3 m penetration were recorded to depths of 3.0 to 8.2 m, indicating the presence of very loose to compact materials in the creek channel, consistent with the findings in Borehole D-15.

Measured moisture contents in the sand ranged from 1 to 22%, generally less than 10%. The results of grain size distribution tests carried out on sand samples are shown on Figures B6 to B11 included in Appendix B and also summarized below:

Gravel (%)	0 to 15	(one at 35%)
Sand (%)	59 to 97	
Silt & Clay (%)	3 to 24	

5.6 Silt

A silt layer was encountered below the sand deposit in Borehole D-11 at 11.7 m depth. The silt was compact as evidenced by a recorded 'N' value of 22 blows/0.3 m. A moisture content of 24% was measured. Borehole D-11 was terminated in the silt at 12.8 m depth.

A silt layer was also encountered within the sand deposit between depths of 19.1 and 20.9 m in Borehole UP-05. An 'N' value of 109 blows/0.3 m (very dense) and a moisture content of 21% were obtained in this layer.

5.7 Groundwater Levels

Groundwater conditions were observed in the boreholes during and upon completion of drilling, and water levels in the monitoring wells and piezometers were subsequently recorded. The groundwater depths and elevations observed in the open boreholes and measured in the wells/ piezometers after drilling are summarized in the following table.

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Table 5.1 - Recorded Groundwater Depths and Elevations

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
D-01	Mar. 30, 2017	Dry	-	In piezometer
D-02	Jan. 18, 2017	1.0	291.1	Upon completion
D-06	Mar. 30, 2017	Dry	-	In piezometer
D-09	Mar. 30, 2017	Dry	-	In piezometer
D-10	Mar. 30, 2017	Dry	-	In piezometer
D-11	Jan. 20, 2017	10.0	269.7	Upon completion
D-12	Mar. 30, 2017	10.2	269.4	In piezometer
D-13	Mar 30, 2017	Dry	-	In piezometer
D-15	Jan. 23, 2017	1.1	276.7	Upon completion
	Mar. 30, 2017	9.1	268.7	In piezometer
RW-01	Jan. 25, 2017	15.8	269.4	Upon completion
	Mar. 30, 2017	17.0	268.2	In piezometer
UP-02	Nov. 17, 2016	3.2	280.4	Upon completion
UP-05	Nov. 09, 2016	13.0	273.8	Upon completion
UP-06	Nov. 07, 2016	16.3	271.0	Upon completion
	Mar. 30, 2017	19.1	268.2	In piezometer

The above water level measurements are short-term observations and seasonal fluctuations of the groundwater level are to be expected.

6.0 MISCELLANEOUS

Thurber Engineering positioned the boreholes in the field using a hand-held GPS unit, with consideration of site features and access limitations. The co-ordinates and ground elevations at the borehole locations, excepting the boreholes located on Highway 400, were subsequently determined by DFP Surveyors.

Walker Drilling of Utopia, Ontario supplied and operated the drilling and sampling equipment for the field program.

Full time supervision of the field activities, including obtaining utility clearances, was carried out by Ms. Eckie Siu and Mr. Stephane Loranger of Thurber Engineering. Overall supervision of the field program was performed by Mr. Mohamed Hosney, P.Eng. and Mr. Murray Anderson, P.Eng. of Thurber.

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Interpretation of the field data and preparation of the report were performed by Mr. Murray Anderson, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7.0 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical recommendations for design of the culverts, storm drains, stormwater ponds, and stream channels associated with the proposed Harvie Road – Big Bay Point Road crossing of Highway 400.

The proposed crossing will connect Harvie Road from the west and Big Bay Point Road from the east with a new underpass structure over Highway 400. Whiskey Creek currently flows from southwest to northeast under Highway 400 at the proposed crossing location, and creek relocation will therefore be required. The preliminary drainage mosaic concept indicates that facilities proposed to address the drainage alterations include the following:

- A new 1.6 m diameter concrete pipe culvert under the proposed intersection of Harvie Road and Bryne Drive;
- A new 1.2 m diameter CSP or concrete pipe culvert crossing north to south under the west approach embankment immediately west of Highway 400;
- A 2.1 m diameter concrete pipe culvert under Highway 400 along the south side of the new underpass structure, to replace the existing 1.2m x 1.2m concrete box culvert presently carrying Whiskey Creek under Highway 400.
- An 2.1 m diameter concrete pipe culvert crossing south to north under the east approach embankment, providing an outlet from the new culvert under Highway 400;
- A 2.4m x 1.2m concrete box culvert under Fairview Road, to replace the existing 1.2m x 1.2m concrete box presently carrying Whiskey Creek under Fairview Road;

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- A storm sewer system to collect runoff from the crossing roadway structure, including two Oil/Grit Separator (OGS) devices;
- Expansion/modification of a SWM facility in the southwest quadrant of the intersection of Harvie Road and Bryne Drive. SWM ponds may also be developed on the west and east sides of Fairview Road in the northeast quadrant of the new crossing.
- A water quality swale in the northeast quadrant of the intersection of Big Bay Point Road and Fairview Road.

The discussion and recommendations presented in this report are based on the information provided by Hatch and on the factual data obtained in the course of the investigation.

The interpretation and recommendations are intended for the use of the design consultant and the City of Barrie, and shall not be relied upon by any other parties including the construction contractor, or used for any purposes other than development of the project design. Comments on construction methodology and equipment, where presented, are provided only to highlight those aspects that could affect the design of the project. Contractors must make their own assessment of the factual information presented in Part 1 of the report, and the implications on equipment selection, construction methodology, and scheduling.

7.1 Culverts

7.1.1 Harvie Road – Bryne Drive Intersection Culvert

Installation of a 1.6 m diameter concrete pipe culvert crossing northwest to southeast under the new Harvie Road – Bryne Drive intersection is proposed. The culvert will be installed by open cut excavation. Invert levels have not been established. Road grade over the culvert will be near Elev. 299.6.

The subsurface stratigraphy encountered in Boreholes D-01 and D-02 drilled at this location comprised a 1.2 and 0.9 m thick layer of peaty organics overlying generally compact native sands and silts, a clayey silt layer, then sand. Groundwater was observed at 1.0 m depth upon drilling completion in one borehole, and was not detected in a piezometer installed to 12.4 m depth in the other borehole.

The proposed culvert should be placed on the compact native sands and silts below the level of the peaty organic layer and any very loose/soft material. Based on the borehole information, suitable subgrade material is expected at a minimum depth of 1.5 m (Elev. 290.9 to 290.6) below existing grade.

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Following excavation to the design base level of the culvert, any remaining peat, topsoil, streambed deposits or very loose soils within the culvert footprint should be subexcavated. The exposed surface must be inspected to confirm that the subgrade is uniformly competent. Any fill placed below the culvert to re-establish the founding level should consist of compacted Granular A or B Type II material. This work should be carried out in accordance with OPSS 902.

Bedding and backfill to the culvert should be in accordance with OPSD 802.031 or 802.034 as applicable. A minimum 300 mm thickness of compacted Granular A bedding material is recommended below the culvert. The bedding thickness may need to be increased where subexcavation is required to remove deleterious materials below the design excavation level or a less competent subgrade is encountered.

The bedding material should be placed as soon as practical following inspection and approval of the final subgrade as protection from disturbance during construction.

7.1.2 West Approach Culvert

Installation of a 1.2 m diameter CSP or concrete pipe culvert crossing north to south under the west approach embankment immediately west of Highway 400 is proposed. The culvert will be installed by open cut excavation. Preliminary profile drawings indicate that the culvert invert will be near Elev. 286.4. Road grade over the culvert will be near Elev. 299.6.

The subsurface stratigraphy encountered in Boreholes D-05, UP-07, UP-02 and D-06 drilled at this location comprised a surficial topsoil layer overlying generally loose to very loose native sands and silts, underlain by dense to very dense sand contacted at depths of 3.0 to 6.1 m (Elev. 287.3 to 279.5). Groundwater was observed at 3.2 m depth upon drilling completion in one borehole, and was not detected in a piezometer installed to 15.7 m depth in the another borehole.

Based on the borehole information, the subgrade at the culvert inlet will vary from very dense sand at the inlet (Borehole D-05), to approximately 3.0 m of new embankment fill over loose to very loose sand and silt in the existing creek channel (Borehole UP-02), to compact sand at the south end (Borehole D-06).

Following excavation and embankment fill placement to the design base level of the culvert, any remaining peat, topsoil, streambed deposits or very loose soils within the culvert footprint should be subexcavated. The exposed surface must be inspected to confirm that the subgrade is uniformly competent. Any fill placed below the culvert to re-establish the founding level should

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consist of compacted Granular A or B Type II material. This work should be carried out in accordance with OPSS 902.

Bedding and backfill to the culvert should be in accordance with OPSD 802.010, 802.014, 802.031 or 802.034 as applicable. A minimum 300 mm thickness of compacted Granular A bedding material is recommended below the culvert. The bedding thickness may need to be increased where subexcavation is required to remove deleterious materials below the design excavation level or a less competent subgrade is encountered.

The bedding material should be placed as soon as practical following inspection and approval of the final subgrade as protection from disturbance during construction.

As noted above, the subgrade conditions along the culvert alignment are expected to vary significantly, from very dense sand at the inlet to new embankment fill over loose to very loose sand and silt in the existing creek channel, to compact sand at the south end. Further, the depth of new embankment fill placed over the culvert will vary along its length, with a maximum height of about 13 m above the culvert (and 3 m below) near the centre of the roadway. Therefore the culvert design should include appropriate cambering to accommodate differential settlement along its length.

Based on elastic analysis, settlement under the embankment load is expected to be in the order of 150 mm under the maximum height of the embankment fill, which will be placed over loose to very loose deposits within the existing creek channel. Negligible settlement is expected at the ends of the culvert where the overlying fill thickness will be negligible and the foundation conditions are compact to very dense. The settlement should be immediate in nature and essentially complete by the end of embankment construction. Use of a flexible CSP culvert or pre-cast concrete sections with articulated joints is preferable to accommodate the settlement. Pre-cast joints should be wrapped with geotextile filter fabric to prevent infiltration of soil fines through the joints.

7.1.3 Highway 400 Crossing

Installation of a 2.1 m diameter concrete pipe culvert under Highway 400 is planned using trenchless methods. The upstream and downstream invert levels will be Elev. 283.8 and 282.7, respectively. Existing road grade on Highway 400 at the crossing location ranges from approximate Elev. 291.2 to 291.7. Based on these elevations, the minimum cover between the pipe crown and highway surface will be approximately 5.0 m.

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The subsurface stratigraphy encountered in Boreholes D-07 to D-08 drilled on the highway shoulders at the crossing location consisted of a surficial pavement structure overlying existing embankment fill extending to depths of 3.7 and 2.1 m (Elev. 287.8 and 289.6), underlain by native silts and sands, and a deep sand deposit. In Boreholes D-06 and D-09 drilled near the ends of the proposed crossing alignment, the native silts and sands were encountered below a surficial topsoil layer or pavement structure. Groundwater was not observed in the boreholes during drilling or measured in two piezometers installed to depths of 15.7 and 15.6 m.

Based on the borehole information, the proposed tunnel horizon will be located primarily within the underlying dense to very dense sand deposit. Towards the west end of the alignment, the upper part of the tunnel will extend into the compact (to stiff) silts and sands overlying the sand deposit. The stratigraphy at the tunnel horizon is illustrated on the Soil Strata Drawing in Appendix F. Groundwater is not expected to be encountered at the tunnel level.

All trenchless installation work should be carried out in general accordance with the requirements of the Non-Standard Special Provision (NSSP) “Pipe Installation by Trenchless Methods”. A suggested version of the NSSP is attached in Appendix D.

Selection of an appropriate trenchless method should 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. The Contractor must submit a detailed work plan including the proposed trenchless methodology and means of maintenance of alignment.

Comments regarding the feasibility of commonly used trenchless methods and some considerations for selection of appropriate methodology are provided below:

- Micro-tunnelling using a MTBM may be considered for use at this site. The equipment typically has high precision alignment control and versatility in accommodating varying subsurface conditions. Tunnel face conditions can be controlled to avoid loss of ground.

- Pipe ramming entails driving a casing for the full length of installation using a percussion hammer, then mechanically removing the soils within the casing when complete. Pipe ramming is expected to be a feasible alternative subject to the length of drive practical in the very dense sand.

- Pipe jacking is considered to be a feasible method of trenchless installation. Pipe jacking involves forcing the pipe forward through the ground using hydraulic jacks as the face of the tunnel is being excavated. Depending on the length of trenchless installation planned,

intermediate jacking stations may be required to advance the pipe through the very dense sand deposit. Further, measures may be required to maintain stability in the cohesionless, uniformly grade sand at the tunnel face.

- Jack and bore techniques are typically feasible for tunnel diameters of up to only 1.5 m, and in soils exhibiting cohesion. Therefore, jack and bore is not considered to be suitable for this culvert installation.

- Horizontal directional drilling procedures are generally unsuitable for an installation diameter in excess of 1.2 m.

- Conventional hand-mining using mechanical tools could be considered but is not expected to be the preferred method due to cost ineffectiveness and the potential impact on the work schedule.

In summary, micro-tunnelling and pipe ramming are the preferred methods of trenchless installation at this site. Pipe jacking may be considered provided the potential risks of face instability are addressed. It is recommended that the Contractor be alerted to the groundwater conditions at the site, the need to maintain stability of the tunnel face, and the need to avoid settlement and loss of ground over the tunnel.

Selection of the trenchless technique employed must take into account the need to avoid settlement and loss of ground below the roadway pavement on Highway 400. Assuming appropriate methodology is selected and bore face stability is maintained, and in view of the typically compact fill and native soils over the pipe crown, the proposed pipe installation is not expected to impact the roadway pavement. However, confirmatory monitoring of the roadway surface should be carried out during construction.

A settlement monitoring program and condition survey for tunnelling under the Hwy 400 right-of-way will need to be prepared in accordance with MTO's Guidelines for Foundation Engineering - Tunnelling Specialty for Corridor Encroachment Permit Application. In general, the monitoring program outlined in Section 7.06 "Instrumentation Monitoring" of the NSSP "Pipe Installation by Trenchless Method" included in Appendix D should satisfy the monitoring requirements for the highway pavement.

A number of underground municipal services and utility lines cross under Highway 400 in the general vicinity of the proposed culvert alignment. The potential impact on the utilities due to settlement and/or vibrations resulting from the tunnelling operations must be considered in the selection of the trenchless method to be employed. A pre-construction condition survey should

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be carried out to document the existing condition of the existing utilities, and a monitoring program implemented to confirm that settlement/vibrations remain within tolerable limits of any underground services potentially impacted by the installation process.

7.1.4 East Approach Crossing

Installation of a 2.1 m diameter concrete pipe culvert crossing south to north under the east approach embankment immediately east of Highway 400 is proposed. The culvert will be installed by open cut excavation. The invert level at the inlet to this section is expected to be near Elev. 282.7, matching the outlet of the Highway 400 culvert. Road grade over the culvert will be near Elev. 298.2.

The subsurface stratigraphy encountered in Boreholes D-09, UP-06, UP-08, UP-09, UP-05, RW-01 and D-10 drilled at this location comprised a surficial topsoil layer or pavement structure overlying very loose to compact sand and silt fill or native silty sand, underlain by very loose to very dense sand contacted at depths of 0.1 to 4.1 m (Elev. 286.3 to 280.2). Groundwater was measured at depths of 17.0 and 19.1 m (Elev. 268.2) in two piezometers and was not detected in two other piezometers installed to depths of 15.6 and 12.6 m.

Based on the borehole information, the subgrade at the culvert inlet will typically consist of dense to very dense sand, locally loose to very loose sand to silty sand at the outlet into the existing creek channel (Boreholes RW-01 and D-10).

Following excavation to the design base level of the culvert, any remaining peat, topsoil, streambed deposits or very loose soils within the culvert footprint should be subexcavated. The exposed surface must be inspected to confirm that the subgrade is uniformly competent. Any fill placed below the culvert to re-establish the founding level should consist of compacted Granular A or B Type II material. This work should be carried out in accordance with OPSS 902.

Bedding and backfill to the culvert should be in accordance with OPSD 802.031 or 802.034 as applicable. A minimum 300 mm thickness of compacted Granular A bedding material is recommended below the culvert. The bedding thickness may need to be increased where subexcavation is required to remove deleterious materials below the design excavation level or a less competent subgrade is encountered.

The bedding material should be placed as soon as practical following inspection and approval of the final subgrade as protection from disturbance during construction.

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The culvert design should include appropriate cambering to accommodate differential settlement along its length. Based on elastic analysis, settlement under the embankment load is expected to be in the order of 50 mm under the maximum height of the embankment fill. The settlement should be immediate in nature and essentially complete by the end of embankment construction. Use of pre-cast concrete sections with articulated joints is preferable to accommodate the settlement. Pre-cast joints should be wrapped with geotextile filter fabric to prevent infiltration of soil fines through the joints.

A number of underground municipal services and utility lines cross the alignment of the proposed culvert. It will be necessary to support and protect these facilities from damage during culvert installation. In this regards, consideration may be given to using trenchless methods as an alternative to open cut excavation. The potential impact on the utilities due to excavation, or due to settlement/ vibrations if tunnelling is used, must be considered in the selection of the installation method to be employed. A pre-construction condition survey should be carried out to document the existing condition of the existing utilities, and a monitoring program implemented to confirm that movements/vibrations remain within tolerable limits of the underground services.

7.1.5 Fairview Road Culvert

Replacement of the existing 1.2m x 1.2m concrete box presently carrying Whiskey Creek under Fairview Road with a 2.4m x 1.2m concrete box culvert is planned. The culvert will be installed by open cut excavation. The proposed upstream and downstream invert levels will be Elev. 279.5 and 278.4. The existing embankment height is approximately 5 m, and the proposed new embankment height will be about 14m (finished road grade near Elev. 293.0).

The subsurface stratigraphy encountered in Boreholes D-11 and D-12 drilled at this location comprised a surficial topsoil layer overlying loose to very loose native sand to silty sand, becoming compact below depths of 3.7 to 4.1 m (Elev. 275.9 to 275.6). Groundwater was observed at 10.0 m depth upon drilling completion in one borehole, and was measured at 10.2 m depth (Elev. 269.4) in a piezometer installed in the other borehole.

Based on the borehole information, the subgrade at the culvert base will consist of loose to very loose native sand to silty sand. For assessment of the culvert design, a factored geotechnical resistance at ULS of 250 kPa is recommended for the loose to very loose native soil at the anticipated base level. The geotechnical resistance at SLS will not apply, as the deflection of the culvert will be governed by elastic settlement of the foundation soils caused by construction of the overlying high fill embankment. Further comments on settlement are provided below.

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Following excavation to the design base level of the culvert, any remaining peat, topsoil, or streambed deposits within the culvert footprint should be subexcavated. The exposed surface must be inspected to confirm that the subgrade is uniformly competent. Any fill placed below the culvert to re-establish the founding level should consist of compacted Granular A or B Type II material. This work should be carried out in accordance with OPSS 902.

Bedding and backfill to the culvert should be in accordance with OPSD 802.010, 802.014, 802.031 or 802.034 as applicable. A minimum 300 mm thickness of compacted Granular A bedding material is recommended below the culvert. The bedding thickness may need to be increased where subexcavation is required to remove deleterious materials below the design excavation level or a less competent subgrade is encountered.

The bedding material should be placed as soon as practical following inspection and approval of the final subgrade as protection from disturbance during construction.

The culvert design should include appropriate cambering to accommodate differential settlement along its length. Based on elastic analysis, settlement under the embankment load is expected to be in the order of 200 mm under the maximum height of the embankment fill, decreasing to about 20 mm at the embankment toe. The settlement should be immediate in nature and essentially complete by the end of embankment construction. Use of pre-cast concrete sections with articulated joints is preferable to accommodate the settlement. Pre-cast joints should be wrapped with geotextile filter fabric to prevent infiltration of soil fines through the joints.

7.1.6 Culvert Backfill and Lateral Earth Pressures

Backfill to the culverts and any wingwalls should consist of free-draining granular material conforming to OPS Granular A or B Type II specifications. Backfill should be placed and compacted in simultaneous equal lifts on both sides of the culvert, and the top of backfill elevation should be within 500 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used on the roof of the culvert. Compaction should be carried out in accordance with OPSS.PROV 501.

Earth pressures acting on the structure may be assumed to impose a triangular distribution governed by the characteristics of the backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

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

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Where: p = horizontal earth pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see table below)

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

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

q = value of any surcharge (kPa)

The earth pressure coefficients are dependent on the material used as backfill. Recommended unfactored values are shown in Table 7.1. The at-rest coefficients should be employed for restrained walls. Active pressures should be used for any wingwalls.

Table 7.1 – Lateral Earth Pressure Coefficients

Loading Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°, \gamma = 21.2$ kN/m^3	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.39*	0.31	0.47*
At-rest (Restrained Wall)	0.43	-	0.47	-
Passive	3.7	-	3.3	-

* For wing walls.

The parameters in the table correspond to full mobilization of active and passive earth pressures, and require certain relative movements between the wall and adjacent soil to produce these conditions. The values to be used in design can be assessed from Figure C6.16 of the Commentary to the CHBDC.

In accordance with Clause 6.12.3 of the CHBDC, a compaction surcharge should 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.

7.1.7 Erosion Control

Erosion protection should be provided at the culvert inlet and outlet areas as applicable. Design of the erosion protection measures must consider hydrologic and hydraulic concerns and should be carried out by specialists experienced in this field. It is recommended that a concrete cut-off wall be used to minimize the potential for erosion near the inlet and outlet areas.

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Typically, rock protection should be provided over all surfaces with which creek water is likely to be in contact. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in accordance with OPSS.PROV 804.

7.2 Oil/Grit Separators

Oil/Grit separator structures will be installed within the storm manholes near the intersections of Harvie Road/Bryne Drive and Big Bay Point Road/Fairview Road. The nearest boreholes to these locations are Boreholes D-02 and D-13.

The OGS structures should be founded on compact native sands and silts at least 1.4 m below existing grade. The geotechnical resistances recommended for design of the OGS base placed on compact undisturbed sands and silts are 225 kPa at factored ULS and 150 kPa at SLS. The geotechnical resistance at SLS is based on an estimated settlement not exceeding 25 mm.

A minimum 300 mm thickness of compacted Granular A bedding material is recommended below the structure. The bedding thickness may need to be increased where subexcavation is required to remove deleterious materials below the design excavation level or a less competent subgrade is encountered.

7.3 SWM Ponds and Water Quality Swale

Expansion/modification of a SWM facility in the southwest quadrant of the intersection of Harvie Road and Bryne Drive is proposed. SWM ponds may also be developed on the west and east sides of Fairview Road in the northeast quadrant of the new crossing. A water quality swale is planned to the east of Fairview Road. Details of the proposed design are not established.

The subsurface stratigraphy revealed in the boreholes drilled in the project area are relatively consistent, comprising various deposits of sands and silts underlain by a deep deposit of sand. Based on piezometer readings, the groundwater level underlying the site is expected to be greater than 9 m below the ground surface.

Based on the results of the grain size distribution analyses, the permeability of the sands and silts is expected to vary substantially with the composition of the individual layer present at a particular depth and location. In general, the permeability is expected to range in the order of 10^{-2} to 10^{-6} cm/sec. The variability of the infiltration rates must be considered in the design.

The recommended inclination of the pond cut slopes was evaluated using the infinite slope method for cohesionless materials, for drained conditions and for the more critical case of rapid drawdown events (horizontal seepage conditions assumed). Based on this analysis, it is

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recommended that side slopes in zones subject to rapid drawdown due to abrupt fluctuations in water levels (i.e. above the permanent pool level) be inclined no steeper than 4.5H:1V to maintain stability. Below the permanent pool level, a maximum inclination of 3H:1V may be employed.

The sloped surfaces should be provided with erosion protection such as hydroseeding and vegetation, and rip-rap in areas of high flow velocities subject to erosion. Vegetation must be sufficiently established before the onset of winter. Granular sheeting or other measures may also be required in any areas exhibiting surficial instability. These areas are best identified by examination after pond excavation. The rip-rap should be underlain by geotextile or gravel sheeting to minimize infiltration of the underlying sands and silts into the rip rap.

7.4 Excavation and Groundwater Control

All excavation must be carried out in accordance with OPSS 902 and the Occupational Health and Safety Act (OHSA). For the purposes of assessing excavation slope requirements in compliance with the OHSA, the fill and upper loose to compact sand/silt deposits are classified as Type 3 soils. The underlying dense to very dense sand is classified as Type 2. Saturated cohesionless soils encountered within the creek channel may flow upon excavation and should be classified as Type 4 soils if flow diversion and/or dewatering is not provided.

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions. It is anticipated that a hydraulic excavator will be suitable. Provision must be made for the handling of pavement materials and potential obstructions in the fill.

Roadway protection should be provided in accordance with OPSS.PROV 539 and designed for Performance Level 2. Based on available subsurface information, a shoring system consisting of sheet piling or steel H-piles with timber lagging may be considered. Temporary shoring should be designed by a licensed Professional Engineer experienced in design of shoring with consideration of adjacent traffic loads and any sloping retained surfaces.

Given the depth of excavation, a temporary support system will likely be required for shaft construction at the trenchless crossing of Highway 400. The selection and design of the shoring system is the responsibility of the Contractor, however suitable systems may include a soldier pile and wood lagging system or a trench box enclosure. Soldier piles should be designed to extend below the base of excavation to satisfy horizontal equilibrium. Pre-augering may be required to install the soldier piles to adequate depth in the very dense sand.

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The temporary braced shoring system employed for the conditions at the site may be designed using the lateral pressure distribution shown on Figure E1, Appendix E, in conjunction with the following parameters.

K_a = 0.33

γ = 21 kN/m^3

The designer should determine if further protective measures are required for adjacent utilities or structures. This may require discussions with relevant owners of these facilities and design of temporary protection and support systems for particular utilities where required.

Based on the water levels measured in the monitoring wells and piezometers, the groundwater level at the site is greater than 9 m below the ground surface and is not expected to impact foundation excavations. However, Whiskey Creek appears to flow in a perched channel condition, and water should be anticipated during excavation at the ravine base. Further, perched water should also be anticipated above less permeable silt layers in the sand. Provided the creek flow is diverted from the construction area, dewatering measures such as pumping from filtered sumps should be adequate to remove any accumulation of water in the excavations. All culvert subgrades must be prepared in the dry.

Selection of the equipment and methodology to excavate and prepare the subgrade is the responsibility of the Contractor. The design of the shoring and dewatering system that may be required is also the responsibility of the Contractor and the Contract Documents must alert him to this responsibility.

8.0 CONSTRUCTION CONCERNS

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

- Fill, organic deposits or very loose native soil may locally extend to greater depths than identified in the boreholes. Additional sub-excavation may therefore be required prior to placement of the culvert bedding.

- Measures such as slope flattening may be required to provide a stable excavation where excessively loose cohesionless deposits and/or perched water are encountered during construction.

- Excavation within the creek ravine may encounter perched water. Perched conditions may be encountered elsewhere above less permeable silt layers in the sand. Stream

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diversion and additional dewatering measures may be required to provide stable excavations and enable construction in the dry.

- Care must be exercised during excavation to avoid disturbing the culvert subgrade. The exposed subgrade soils should be expeditiously inspected, approved and protected from disturbance by placement of the granular bedding and/or a mud slab.

- Selection of the trenchless technique employed for installing the culvert crossing under Highway 400 must take into account the need to avoid settlement and loss of ground below the roadway pavement. In particular, stability of the excavation face in the cohesionless sand at the tunnel horizon must be maintained. Confirmatory monitoring of the roadway surface should be carried out during construction, and contingency plans should be prepared to manage any adverse impacts that may arise.

- The Contractor must accurately establish the locations of any existing buried utilities in the vicinity of excavations and the proposed trenchless crossing. Measures to avoid damaging these facilities must be considered and implemented.

9.0 CLOSURE

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

Thurber Engineering Ltd.

Murray R. Anderson, P.Eng.
Senior Geotechnical Engineer

Dr. P.K. Chatterji, P.Eng.
Review Principal

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Appendix A

Record of Borehole Sheets

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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.

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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			

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RECORD OF BOREHOLE No D-01 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 937.3 E 289 421.9 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.11 - 2017.01.11 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
292.4	GROUND SURFACE										
0.0	**ORGANICS**, peaty Very Soft Dark Brown		1	SS	0		292				
	Sandy Loose		2	SS	5						
291.2											
1.2	**SAND**, some silt, trace gravel Loose to Compact Brown Wet		3	SS	12		291				4 82 12 2
289.9											
2.5	Sandy **SILT**, trace clay Compact Brown Wet		4	SS	15		290				
			5	SS	12		289				0 32 60 8
288.3											
4.1	**SAND** and **SILT**, trace clay Compact Brown Wet		6	SS	11		288				0 52 40 8
287.4											
~~287.9~~ 5.0	**SILT**, some sand, trace clay										
5.1	Compact Grey Moist						287				
	Clayey **SILT**, some sand, trace gravel Stiff to Hard Grey Moist		7	SS	65						
286.0							286				0 76 20 4
6.4	Silty **SAND**, trace gravel Very Dense Brown Moist										
			8	SS	101		285				
	Trace silt						284				
			9	SS	92/ 0.150		283				

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+ ³, × ³: Numbers refer to Sensitivity

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

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Ontario

THURBER

RECORD OF BOREHOLE No D-01 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 937.3 E 289 421.9 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.11 - 2017.01.11 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	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
	Continued From Previous Page										
	Silty **SAND**, trace gravel, trace silt Very Dense Brown Moist						282				
			10	SS	89/ 0.150		281		○		
280.0			11	SS	104/ 0.250		280		○		1 96 3 (SI+CL)
12.4	END OF BOREHOLE AT 12.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2017.03.30	Dry	-

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+ ³, × ³: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No D-02 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 925.2 E 289 468.5 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.18 - 2017.01.18 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
292.1	GROUND SURFACE						292				
0.0	**ORGANICS**, peaty, occasional wood fibres Very Loose Dark Brown Wet		1	SS	2						
291.2							291				
0.9	**SAND**, some silt, some gravel Loose to Compact Brown Wet		2	SS	4	▽					
			3	SS	14						20 61 16 3
289.8							290				
2.3	Silty **SAND**, trace gravel, occasional cobbles Compact Brown Wet		4	SS	20						
288.9							289				
3.2	Sandy **SILT**, trace clay Compact Brown Moist		5	SS	22						0 34 58 8
288.5							288				
3.6	Clayey **SILT**, trace sand, trace gravel Very Stiff to Hard Brown to Grey Moist										
287.2			6	SS	47		287				
4.9	**SAND**, trace silt, trace to some gravel Very Dense Brown Moist										
			7	SS	95		286				
							285				
			8	SS	87						11 81 8 (SI+CL)
							284				
			9	SS	58		283				

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

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Ontario

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RECORD OF BOREHOLE No D-02 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 925.2 E 289 468.5 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.18 - 2017.01.18 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	SAND, trace silt, trace gravel Very Dense Brown Moist						282				
			10	SS	66				○		
							281				
							280				
279.5			11	SS	80				○		
12.6	END OF BOREHOLE AT 12.6m. WATER LEVEL AT 1.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

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

20
15 5 (%) STRAIN AT FAILURE
10

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RECORD OF BOREHOLE No D-04 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 970.8 E 289 705.5 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.13 - 2017.01.13 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
286.3	GROUND SURFACE										
0.0	**TOPSOIL:** (25mm)		1	SS	7		286		○		
	SAND and **SILT**, trace gravel, trace organics Loose to Compact Dark Brown to Brown Moist		2	SS	16		285		○		
			3	SS	8				○		
284.0							284				
2.3	**SAND**, trace to some gravel, trace silt Loose to Compact Brown Moist		4	SS	9				○		15 79 6 (SI+CL)
			5	SS	25		283		○		
	Dense to Very Dense		6	SS	40		282		○		
			7	SS	52		281				
			8	SS	54		280		○		
			9	SS	55		279				
							278		○		
							277				

Continued Next Page

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No D-04 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 970.8 E 289 705.5 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.13 - 2017.01.13 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND, trace gravel, trace silt Very Dense Brown Moist						276				
			10	SS	65				○		
							275				
			11	SS	63		274		○		
							273				
			12	SS	65				○		
							272				
270.6			13	SS	80		271		○		
15.7	END OF BOREHOLE AT 15.7m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

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

15 20 10 5 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No D-05 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 090.8 E 289 741.4 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.12 - 2017.01.12 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
290.3	GROUND SURFACE										
0.0	**TOPSOIL:** (200mm)										
0.2	Loose Dark Brown Moist		1	SS	2		290		○		
	SAND and **SILT**, trace gravel, trace roots Very Loose Brown Moist		2	SS	3		289		○		
288.6											
1.7	Sandy **SILT**, trace gravel Compact to Very Dense Brown Moist		3	SS	27		288		○		
			4	SS	47				○		
287.3							287		○		
3.0	**SAND**, trace gravel, trace silt Very Dense Brown Moist		5	SS	81						
			6	SS	71		286		○		
			7	SS	60		285				
			8	SS	70		284		○		
			9	SS	92/ 0.275		283		○		
							282				
							281		○		

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-05 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 090.8 E 289 741.4 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.12 - 2017.01.12 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND, trace gravel, trace silt Very Dense Brown Moist						280				
			10	SS	89				○		
							279				
			11	SS	101		278		○		
							277				
			12	SS	88				○		
							276				
274.6			13	SS	92		275		○		
15.7	END OF BOREHOLE AT 15.7m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

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+ ³, × ³: Numbers refer to Sensitivity

20
15 ⊕ 5 (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-06 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 984.7 E 289 766.7 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.16 - 2017.01.16 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
290.4	GROUND SURFACE										
0.0	**TOPSOIL:** (50mm)										
0.0	**SAND**, some silt, some clay, trace gravel Loose Brown Moist to Wet		1	SS	6		290		○		
			2	SS	6				○		
			3	SS	4		289		○		
			4	SS	4		288		○		7 62 17 14
			5	SS	5		287		○		
286.3											
4.1	**SAND**, trace gravel, trace silt Compact Brown Moist		6	SS	15		286		○ ○		
285.3											
5.1	**SILT**, some clay, some sand Compact Brown Moist						285				
284.3											
6.1	**SAND**, trace to some gravel, trace silt Very Dense Brown Moist		7	SS	56		284		○		
			8	SS	64		283		○		
			9	SS	54		282				
							281		○		5 89 6 (SI+CL)

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

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

ONTMT4S MTO-11398.GPJ 2017TEMPLATE(MTO).GDT 17/6/28

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-06 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 984.7 E 289 766.7 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.16 - 2017.01.16 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND, trace silt, trace gravel Very Dense Brown Moist						280				
			10	SS	80				○		
							279				
			11	SS	71		278		○		
							277				
			12	SS	91				○		
							276				
274.7			13	SS	87		275		○		
15.7	END OF BOREHOLE AT 15.7m. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.03.30 Dry -										

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-07 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 999.7 E 289 808.7 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.02.26 - 2017.02.26 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
291.5	GROUND SURFACE										
0.0	**ASPHALT:** (125mm)										
0.1	**SAND**, some gravel, trace silt Compact Brown Moist (FILL)		1	GS			291		○		
			1	SS	11				○		
290.0							290				
1.5	Silty **SAND**, trace gravel Loose to Compact Brown Moist (FILL)		2	SS	9				○		3 65 29 3
			3	SS	21		289		○		
			4	SS	18				○		
287.8	Dark Brown						288				
3.7	Silty **SAND**, clayey, trace gravel Stiff Brown Moist										
			5	SS	11		287		○		6 51 30 13
285.9							286				
5.6	**SAND**, trace to some gravel, trace silt Very Dense Brown Moist		6	SS	62				○		
							285				
			7	SS	52		284		○		
							283				
			8	SS	71				○		
							282				

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-07 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 999.7 E 289 808.7 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.02.26 - 2017.02.26 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	SAND, trace silt, trace gravel Very Dense Brown Moist						281				
			9	SS	68				○		
							280				
			10	SS	64		279		○		2 94 4 (SI+CL)
							278				
			11	SS	82				○		
							277				
			12	SS	67		276		○		
							275				
			13	SS	97				○		
							274				
272.8			14	SS	110		273		○		
18.7	END OF BOREHOLE AT 18.7m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.6m, CONCRETE TO 0.2m, THEN ASPHALT TO SURFACE.										

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

20
15 5
10
(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-08 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 992.4 E 289 848.2 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.02.27 - 2017.02.27 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
291.7	GROUND SURFACE										
0.0	**ASPHALT:** (125mm)										
0.1	**SAND**, some gravel, trace silt Dense to Compact Brown Moist (FILL)		1	GS			291		○		
			1	SS	34				○		16 75 9 (SI+CL)
289.6			2	SS	16		290		○		
2.1	Silty **SAND**, trace gravel Loose to Compact Brown Wet to Moist		3	SS	4		289		○		
			4	SS	18		288		○		
287.6											
4.1	Gravelly **SAND**, trace silt Very Dense Brown Moist		5	SS	50/0.125		287		○		
286.2											
5.5	**SAND**, trace silt, trace gravel Very Dense Brown Moist		6	SS	59		286		○		
			7	SS	61		285				
							284		○		
			8	SS	86		283		○		
							282				

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Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-08 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 992.4 E 289 848.2 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.02.27 - 2017.02.27 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND, trace silt, trace gravel Very Dense Brown Moist										
			9	SS	71		281		○		
							280				
			10	SS	87				○		
							279				
							278				
			11	SS	77				○		
							277				
			12	SS	88				○		
							276				
							275				
			13	SS	79				○		
							274				
273.0			14	SS	92		273		○		1 95 4 (SI+CL)
18.7	END OF BOREHOLE AT 18.7m. BOREHOLE OPEN AND DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.6m, CONCRETE TO 0.2m, THEN ASPHALT TO SURFACE.										

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+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-09 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 031.4 E 289 897.6 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.24 - 2017.01.24 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
288.8	GROUND SURFACE										
0.0	**ASPHALT:** (100mm)										
0.1	**SAND**, some silt, trace gravel Brown Moist		1	GS					○		
288.0	(FILL)						288				
0.8	Silty **SAND**, trace clay, trace gravel Loose to Compact Brown Moist		1	SS	9				○		
			2	SS	10		287		○		9 58 23 10
286.3			3	SS	26				○		
2.5	**SAND**, trace gravel, trace silt Compact to Very Dense Brown Moist						286		○		
			4	SS	52				○		
			5	SS	42		285				
							284		○		
			6	SS	55		283		○		
							282				
			7	SS	70		281		○		
							280				
			8	SS	100/0.250				○		
							279				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

DRAFT

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-09 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 031.4 E 289 897.6 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.24 - 2017.01.24 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND, trace gravel, trace silt Very Dense Brown Moist										
			9	SS	105/ 0.225		278		○		
							277		○		
			10	SS	95						
							276				
			11	SS	90		275		○		0 96 4 (SI+CL)
							274				
273.2			12	SS	100/ 0.250				○		
15.6	END OF BOREHOLE AT 15.6m. BOREHOLE OPEN AND DRY UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.03.30 Dry -										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-10 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 162.4 E 289 897.0 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.19 - 2017.01.20 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
281.3	GROUND SURFACE										
0.0 / 0.1	**TOPSOIL:** (60mm)										
	Silty **SAND**, trace gravel, trace clay, trace rootlets, wood fibres Very Loose Brown Moist		1	SS	2		281				
280.2			2	SS	8						0 68 22 10
1.1	**SAND**, trace gravel, trace silt Very Loose to Compact Brown Moist		3	SS	5		280				
			4	SS	3		279				
			5	SS	1		278				
			6	SS	22		277				
			7	SS	28		276				
	Very Dense		8	SS	54		275				
			9	SS	52		274				
							273				
							272				

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

$15 \overset{20}{\underset{10}{\oplus}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-10 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 162.4 E 289 897.0 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.19 - 2017.01.20 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND, trace gravel, trace silt Very Dense Brown Moist						271				
			10	SS	75				○		0 96 4 (SI+CL)
							270				
268.7			11	SS	90		269		○		
12.6	END OF BOREHOLE AT 12.6m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.03.30 Dry -										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-11 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 230.4 E 289 955.2 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.20 - 2017.01.20 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
279.7	GROUND SURFACE										
0.0	**TOPSOIL:** (50mm)										
0.0	Silty **SAND**, trace gravel, trace roots and rootlets Very Loose Dark Brown		1	SS	3				○		
278.9	Moist						279				
0.8	Silty **SAND**, trace gravel Very Loose Brown Moist to Wet		2	SS	3				○		
277.7			3	SS	2		278		○		
2.0	**SAND**, trace silt, trace gravel Very Loose Brown Wet		4	SS	3		277		○		
			5	SS	3				○		
							276				
	Compact Moist		6	SS	11		275		○		
							274				
			7	SS	18				○		2 93 5 (SI+CL)
							273				
			8	SS	28		272		○		
							271				
			9	SS	25				○		
						▽	270				

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-11 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 230.4 E 289 955.2 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.20 - 2017.01.20 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND, trace silt, trace gravel Dense Brown Moist						269				
			10	SS	40				○		
268.0							268				
11.7	**SILT**, some sand, trace gravel Compact Brown Moist										
			11	SS	22				○		
266.9							267				
12.8	END OF BOREHOLE AT 12.8m. WATER LEVEL AT 10.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-12 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 248.7 E 289 991.6 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Tripod/NW Casing COMPILED BY AN

DATUM Geodetic DATE 2017.01.31 - 2017.02.01 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
279.6	GROUND SURFACE										
0.0	**TOPSOIL:** (100mm)										
0.1	**SAND**, some silt, trace gravel, trace roots and rootlets Loose Brown Moist		1	SS	5		279		○		
			2	SS	6				○		
			3	SS	9		278		○		
			4	SS	5				○		
			5	SS	7		277		○		6 78 11 5
			6	SS	6				○		
275.9							276				
3.7	**SAND**, trace silt, trace gravel Compact Brown Moist		7	SS	12				○		
			8	SS	17		275		○		
			9	SS	12				○		
			10	SS	13		274		○		7 90 3 (SI+CL)
			11	SS	25				○		
							273				
			12	SS	24				○		
							272				
	Very Dense		13	SS	113		271		○		
							270				

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Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-12 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 248.7 E 289 991.6 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Tripod/NW Casing COMPILED BY AN

DATUM Geodetic DATE 2017.01.31 - 2017.02.01 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	SAND, trace silt, trace gravel Very Dense Brown Wet						269				
			14	SS	100/ 0.275				○		0 93 7 (SI+CL)
							268				
267.0			15	SS	100/ 0.275		267		○		
12.6	END OF BOREHOLE AT 12.6m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.03.30 10.2 269.4										

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

$15 \overset{20}{\underset{10}{\oplus}} 5$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-13 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 074.8 E 290 038.4 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.24 - 2017.01.24 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.5	GROUND SURFACE										
0.0	**TOPSOIL:** (100mm)										
0.1	**SAND**, some gravel, trace roots and rootlets Compact Brown		1	SS	16		286		○		
285.7											
0.8	Moist (FILL)		2	SS	17				○		
	SAND, some silt, trace gravel Compact Brown Moist (FILL)						285				
			3	SS	16				○		9 80 11 (SI+CL)
			4	SS	18		284		○		
283.4											
3.1	**SAND**, trace silt, trace gravel Dense to Very Dense Brown Moist		5	SS	36				○		
							283				
			6	SS	50		282		○		
							281				
			7	SS	64				○		
							280				
			8	SS	73		279		○		1 95 4 (SI+CL)
							278				
			9	SS	100				○		
276.9							277				
9.6	END OF BOREHOLE AT 9.6m. BOREHOLE DRY UPON										

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-13 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 074.8 E 290 038.4 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.24 - 2017.01.24 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.03.30 Dry -										

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-14 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 169.5 E 290 055.1 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.23 - 2017.01.23 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.7	GROUND SURFACE										
0.0	**TOPSOIL:** (140mm)										
0.1	**SAND**, some silt, trace gravel, trace rootlets Loose Brown Moist		1	SS	2		283		○		
282.9											
0.8	Silty **SAND**, gravelly Compact to Dense Brown Moist		2	SS	18				○		23 57 20 (SI+CL)
281.9			3	SS	42		282		○		
1.8	**SAND**, trace silt, trace gravel Dense to Very Dense Brown Moist		4	SS	49		281		○		
			5	SS	53				○		
	Occasional black sand seams at 4.6m		6	SS	67		279		○		
			7	SS	71		278		○		
			8	SS	87		277		○		
			9	SS	77		276		○		
274.1							275		○		0 95 5 (SI+CL)
9.6	END OF BOREHOLE AT 9.6m. BOREHOLE DRY UPON										

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-14 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 169.5 E 290 055.1 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.23 - 2017.01.23 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

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

$\frac{20}{15 \quad 5}$ (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-15 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 255.8 E 290 148.8 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.23 - 2017.01.23 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
277.8	GROUND SURFACE										
0.0	Silty **SAND**, trace clay, trace rootlets, with organics Very Loose Dark Brown Moist		1	SS	1						
			2	SS	1	▽	277				0 63 27 10
276.4											
1.4	**SAND**, some silt, trace gravel Very Loose Brown		3	SS	1		276				
276.0											
1.8	Wet										
275.5	**SAND** and **SILT**, trace gravel Very Loose Dark Brown Wet		4	SS	7						0 91 5 4
2.3											
275.2											
2.6											
275.0											
2.8	**SAND**, trace silt Loose Brown Wet						275				
274.8											
3.0	**SAND** and **SILT**, trace gravel, trace organics Loose Dark Brown Wet		5	SS	3						
273.5	Organic **SILT** Loose Black Moist						274				
4.3	**SAND**, some silt, trace gravel Very Loose Dark Brown Saturated		6	SS	61		273				0 54 31 15
	Silty **SAND**, some clay Very Dense Brown Moist						272				
271.4			7	SS	75						
6.4	**SAND**, trace silt, trace gravel Very Dense Brown Moist						271				
			8	SS	98		270				1 91 8 (SI+CL)
							269				
			9	SS	96						
268.2											
9.6	END OF BOREHOLE AT 9.6m. WATER LEVEL AT 1.1m UPON										

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No D-15 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 255.8 E 290 148.8 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.23 - 2017.01.23 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.03.30 9.1 268.7										

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

15 10 20 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No HF-01 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 974.4 E 289 622.4 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.17 - 2017.01.17 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	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
289.4	GROUND SURFACE										
0.0	**TOPSOIL:** (175mm)										
0.2	Silty **SAND**, trace gravel, trace roots and rootlets Very Loose to Loose Dark Brown Moist		1	SS	2		289				
288.2			2	SS	7						3 71 18 8
1.2	**SAND**, trace to some gravel, trace silt, occasional cobbles Loose to Compact Brown Moist		3	SS	23		288				
	Very Dense		4	SS	67		287				
			5	SS	54		286				
			6	SS	59		285				12 82 6 (SI+CL)
			7	SS	61		284				
			8	SS	82/ 0.250		283				
			9	SS	70		282				
279.8							281				
9.6	END OF BOREHOLE AT 9.6m. Piezometer installation consists of						280				

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+ ³, × ³: Numbers refer to Sensitivity

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No HF-01 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 911 974.4 E 289 622.4 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.17 - 2017.01.17 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.03.30 Damaged -										

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

20
15 5
10
(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No HF-07 1 OF 1 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 133.4 E 290 054.9 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.23 - 2017.01.23 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
284.9	GROUND SURFACE										
0.0	**TOPSOIL:** (75mm)										
0.1	Silty **SAND**, trace gravel, trace clay Very Loose to Compact Brown Moist		1	SS	2						
			2	SS	7		284				
			3	SS	11		283				0 68 22 10
282.6											
2.3	**SAND**, trace to some gravel, trace silt Dense to Very Dense Brown Moist		4	SS	68		282				
			5	SS	49		281				
279.9			6	SS	59		280				
5.0	END OF BOREHOLE AT 5.0m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

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

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RW-01 1 OF 3 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 142.7 E 289 853.2 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.25 - 2017.01.25 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.2	GROUND SURFACE						285				
0.0	**TOPSOIL:** (50mm)										
0.0	**SAND**, some silt, trace gravel, trace roots and rootlets Very Loose Brown		1	SS	2				○		
284.4											
0.8	Moist (FILL)		2	SS	14		284		○		0 47 28 25
284.0	Clayey **SILT**, sandy										
1.2	Stiff Brown Moist (FILL)		3	SS	16				○		14 79 7 (SI+CL)
	SAND, trace to some gravel, trace silt Compact Brown Moist						283				
282.4	(FILL)		4	SS	14				○ ○		
2.8	Silty **SAND**, trace clay, trace gravel, occasional wood fibres Compact Grey to Dark Grey Moist		5	SS	15		282		○		7 63 26 4
281.1											
4.1	**SAND**, trace gravel, trace silt Loose to Compact Brown Moist		6	SS	6		281		○		
							280				
	Cobble		7	SS	50/ 0.025		279				
							278				
			8	SS	31				○		
							277				
	Dense to Very Dense		9	SS	45		276		○		0 97 3 (SI+CL)

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

$\frac{20}{15}$ 5 $\frac{}{10}$ (%) STRAIN AT FAILURE

DRAFT

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RW-01 2 OF 3 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 142.7 E 289 853.2 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.25 - 2017.01.25 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100) ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	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
	Continued From Previous Page										
	SAND, trace gravel, trace silt Dense to Very Dense Brown Moist						275				
			10	SS	53				○		
							274				
			11	SS	70		273		○		
							272				
			12	SS	56				○		
							271				
			13	SS	71		270		○		
						▽	269				
	Silty		14	SS	63		268		○		
266.5			15	SS	42		267		○		0 76 22 2
18.7	END OF BOREHOLE AT 18.7m. WATER LEVEL AT 15.8m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

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

$\frac{20}{15}$ $\frac{5}{10}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No RW-01 3 OF 3 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 142.7 E 289 853.2 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.25 - 2017.01.25 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.03.30 17.0 268.2										

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

$\frac{20}{15 \quad 5}$ (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-02 1 OF 4 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 040.9 E 289 759.7 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.11 - 2016.11.17 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.6	GROUND SURFACE										
0.0	**TOPSOIL:** (50mm)										
0.0	**SAND** and **SILT**, trace gravel, trace roots Loose Dark Brown Moist		1	SS	4		283		○		
282.4			2	SS	9				○		
1.2	**SAND**, trace gravel, trace silt Loose to Very Loose Brown Wet		3	SS	6		282		○		
			4	SS	3		281		○		
			5	SS	6	▽	280		○		
	Trace to some gravel Dense to Very Dense		6	SS	44		279		○		5 88 7 (SI+CL)
			7	SS	66		278		○		
			8	SS	43		277		○		
			9	SS	53		276		○		
							275				
							274				

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-02 2 OF 4 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 040.9 E 289 759.7 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.11 - 2016.11.17 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	SAND, trace gravel, trace silt Very Dense Brown Moist						273				
			10	SS	48				○		
							272				
			11	SS	76				○		
							271				
			12	SS	75		270		○		
	Some silt to silty		13	SS	74		269		○		
							268				
			14	SS	87		267		○		
							266				
			15	SS	54		265		○		
							264				

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Continued Next Page

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

$15 \oplus^{20}_{10} 5$ (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-02 3 OF 4 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 040.9 E 289 759.7 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.11 - 2016.11.17 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	SAND, fine grained, some silt to silty Very Dense Brown Wet		16	SS	71		263				0 86 14 (SI+CL)
			17	SS	103/ 0.200		262				
			18	SS	72		261				
			19	SS	84		260				
			20	SS	71		259				0 77 23 (SI+CL)
			21	SS	90		258				
			22	SS	100/ 0.225		257				
							256				
							255				
							254				

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Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-02 4 OF 4 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 040.9 E 289 759.7 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.11 - 2016.11.17 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND, fine grained, trace gravel, trace to some silt Very Dense Brown Wet		23	SS	101/ 0.225		253				
			24	SS	106/ 0.200		252				
							251				
249.8			25	SS	100/		250				1 90 9 (SI+CL)
33.8	END OF BOREHOLE AT 33.8m. WATER LEVEL AT 3.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH GROUT TO 0.5m, THEN HOLEPLUG TO SURFACE.				0.250						

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

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-05 1 OF 3 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 102.9 E 289 867.9 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.08 - 2016.11.09 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
286.8	GROUND SURFACE										
0.0	**TOPSOIL:** (40mm)										
0.0	**SAND**, trace to some gravel, some silt Loose to Compact Brown Moist (FILL)		1	SS	6		286		○		
			2	SS	7				○		9 80 11 (SI+CL)
			3	SS	14		285		○		
284.4											
2.4	**SAND**, trace silt Loose Light Brown Moist		4	SS	8		284		○		
	Dense		5	SS	43				○		
							283				
	Very Dense		6	SS	58		282		○		
							281				
			7	SS	59				○		0 96 4 (SI+CL)
							280				
			8	SS	77		279		○		
							278				
			9	SS	59				○		
							277				

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Continued Next Page

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-05 2 OF 3 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 102.9 E 289 867.9 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.08 - 2016.11.09 CHECKED BY MH

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa 20 40 60 80 100 (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	SAND, trace silt, occasional black sand seams Very Dense Light Brown Moist						276				
			10	SS	92				○		
							275				
			11	SS	86				○		
						▽	274				
			12	SS	104/ 0.250		273		○		
			13	SS	70		272		○		0 94 6 (SI+CL)
			14	SS	102/ 0.250		271				
							270		○		
			15	SS	101		269		○		
267.7							268				
19.1	**SILT**, trace sand, trace clay Very Dense Brown Wet						267				

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Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-05 3 OF 3 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 102.9 E 289 867.9 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.08 - 2016.11.09 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
	SILT, trace sand, trace clay Very Dense Brown Wet		16	SS	109				○		0 5 90 5
265.9							266				
20.9	**SAND**, trace to some silt Very Dense Brown Wet		17	SS	100/ 0.125		265		○		
			18	SS	100/ 0.225		264		○		
			19	SS	103/ 0.250		263		○		
							262				
260.6			20	SS	110/		261		○		
26.2	END OF BOREHOLE AT 26.2m. WATER LEVEL AT 13.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.				0.250						

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

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-06 1 OF 3 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 064.9 E 289 869.2 ORIGINATED BY ES

HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.04 - 2016.11.07 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
287.3	GROUND SURFACE										
0.0	**TOPSOIL:** (100mm)										
0.1	**SILT**, some clay, some sand, trace roots Loose Brown		1	SS	4		287		○		
286.5	Moist										
0.8	(FILL)		2	SS	32		286		○		
	Silty **SAND**, trace clay, trace gravel Dense Brown										
285.8	Moist										
1.5	(FILL)		3	SS	32		285		○		
	SAND, trace gravel, trace silt, occasional cobble Dense to Very Dense Light Brown Moist		4	SS	34				○		
			5	SS	37		284		○		
			6	SS	61		283		○		
			7	SS	52		282		○		
			8	SS	78		281		○		
			9	SS	61		280		○		0 91 9 (SI+CL)
							279				
							278				

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-06 2 OF 3 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 064.9 E 289 869.2 ORIGINATED BY ES

HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.04 - 2016.11.07 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	SAND, trace gravel, trace silt Very Dense Light Brown Moist						277				
			10	SS	107				○		
							276				
			11	SS	100/ 0.275		275		○		
							274				
			12	SS	105				○		2 92 6 (SI+CL)
							273				
			13	SS	74		272		○		
						▽	271				
			14	SS	60				○		
							270				
			15	SS	77		269		○		
							268				

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

$15 \overset{20}{\oplus} 5$ $\overset{10}{}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-06 3 OF 3 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 064.9 E 289 869.2 ORIGINATED BY ES

HWY 407 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.04 - 2016.11.07 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND, trace gravel, trace silt Very Dense Light Brown Moist		16	SS	100/ 0.250		267				
			17	SS	104/ 0.175		266				
264.3			18	SS	119/ 0.175		265				
23.0	END OF BOREHOLE AT 23.0m. WATER LEVEL AT 16.3m UPON COMPLETION. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.03.30 19.1 268.2										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-07 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 055.4 E 289 733.9 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.10 - 2016.11.10 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100) ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.1	GROUND SURFACE						289				
0.0	**TOPSOIL** Very Loose Dark Brown Moist		1	SS	2						
288.5							288				2 49 32 17
0.6	Silty **SAND**, some clay, trace gravel Loose to Compact Brown to Light Brown Moist		2	SS	6						
287.1			3	SS	21		287				
2.0	**SILT**, some sand, trace gravel Compact Brown Moist		4	SS	53						
286.4							286				
2.7	**SAND**, trace gravel, trace silt Very Dense Brown Moist		5	SS	61						
	Gravelly zone		6	SS	74		285				35 59 6 (SI+CL)
							284				
			7	SS	76		283				
							282				
			8	SS	81		281				
							280				
279.5			9	SS	104						2 91 7 (SI+CL)
9.6	END OF BOREHOLE AT 9.6m. BOREHOLE DRY UPON										

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

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-07 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 055.4 E 289 733.9 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.10 - 2016.11.10 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

DRAFT

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-08 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 087.8 E 289 875.6 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.07 - 2016.11.07 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
287.0	GROUND SURFACE										
0.0	**TOPSOIL:** (50mm)										
0.0	**SAND** and **SILT**, trace clay, trace roots Loose Dark Brown Moist (FILL)		1	SS	5				○		
			2	SS	8		286		○		0 55 37 8
			3	SS	6		285		○		
	Trace gravel, occasional wood fibres Compact		4	SS	16				○		
283.9							284				
3.1	**SAND**, trace gravel, trace silt Dense to Very Dense Light Brown Moist		5	SS	33				○		
			6	SS	56		283		○		3 92 5 (SI+CL)
			7	SS	67		282		○		
			8	SS	75		281		○		
			9	SS	101		280		○		2 92 6 (SI+CL)
277.4							279				
9.6	END OF BOREHOLE AT 9.6m. BOREHOLE DRY UPON						278				

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-08 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 087.8 E 289 875.6 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2016.11.07 - 2016.11.07 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

DRAFT

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-09 1 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 084.3 E 289 861.2 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.20 - 2017.01.20 CHECKED BY MH

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
284.8	GROUND SURFACE										
0.0	**TOPSOIL:** (125mm)										
0.1	**SAND**, trace gravel, trace silt Very Loose to Compact Brown Moist		1	SS	5				○		
			2	SS	3		284		○		
			3	SS	1		283		○		
			4	SS	14		282		○		
	Dense to Very Dense		5	SS	36		281		○		
			6	SS	46		280		○		4 89 7 (SI+CL)
			7	SS	51		279		○		
			8	SS	53		278				
			9	SS	55		277		○		
275.2							276				
9.6	END OF BOREHOLE AT 9.6m. BOREHOLE DRY UPON										

Continued Next Page

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

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No UP-09 2 OF 2 METRIC

W.P. _____ LOCATION Harvie / Big Bay Point Road N 4 912 084.3 E 289 861.2 ORIGINATED BY ES

HWY 400 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN

DATUM Geodetic DATE 2017.01.20 - 2017.01.20 CHECKED BY MH

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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.										

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

$\begin{matrix}20\\15\\10\end{matrix}$ 5 (%) STRAIN AT FAILURE

Appendix B

Laboratory Test Results

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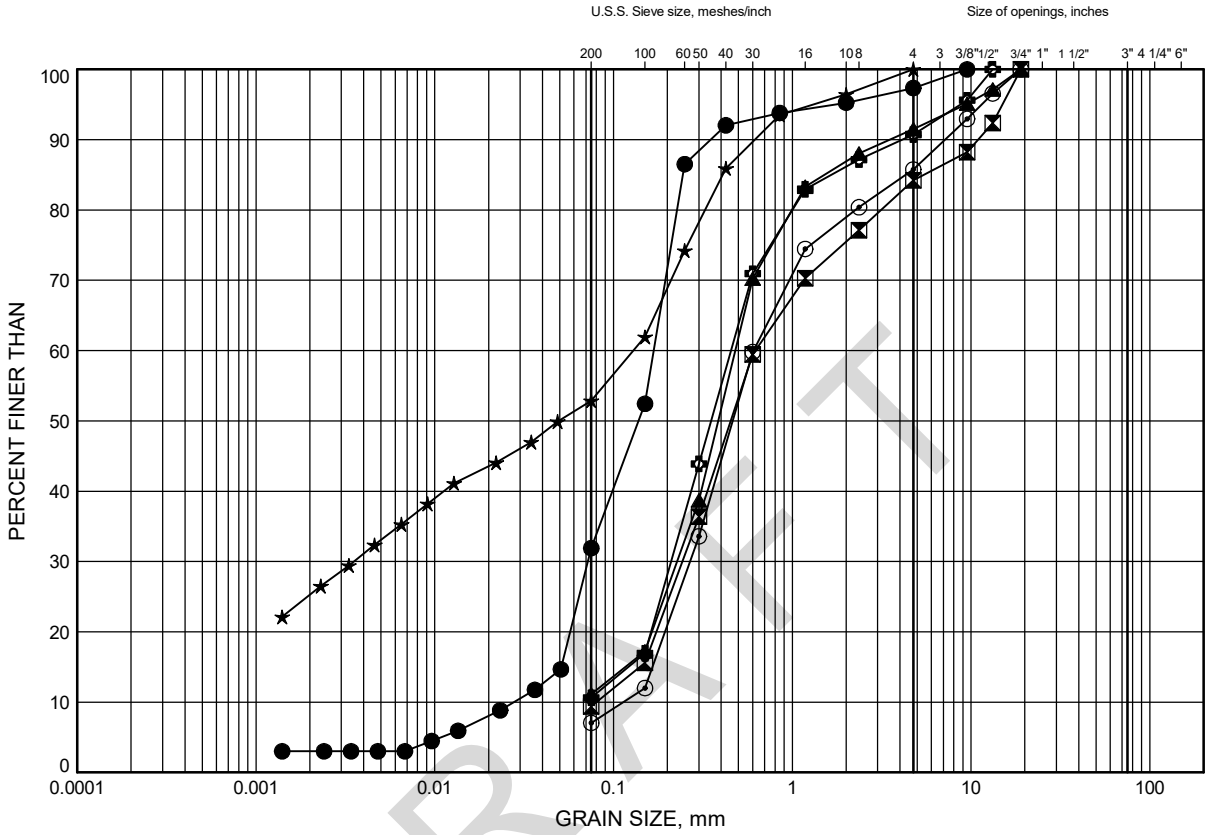
Harvie / Big Bay Point Road

GRAIN SIZE DISTRIBUTION

FIGURE B1

FILL



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

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LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	D-07	1.8	289.7
⊠	D-08	1.0	290.7
▲	D-13	1.8	284.7
★	RW-01	1.0	284.2
⊙	RW-01	1.8	283.3
✿	UP-05	1.1	285.7

Date June 2017

W.P.

THURBER

Prep'd MFA

Chkd. MRA

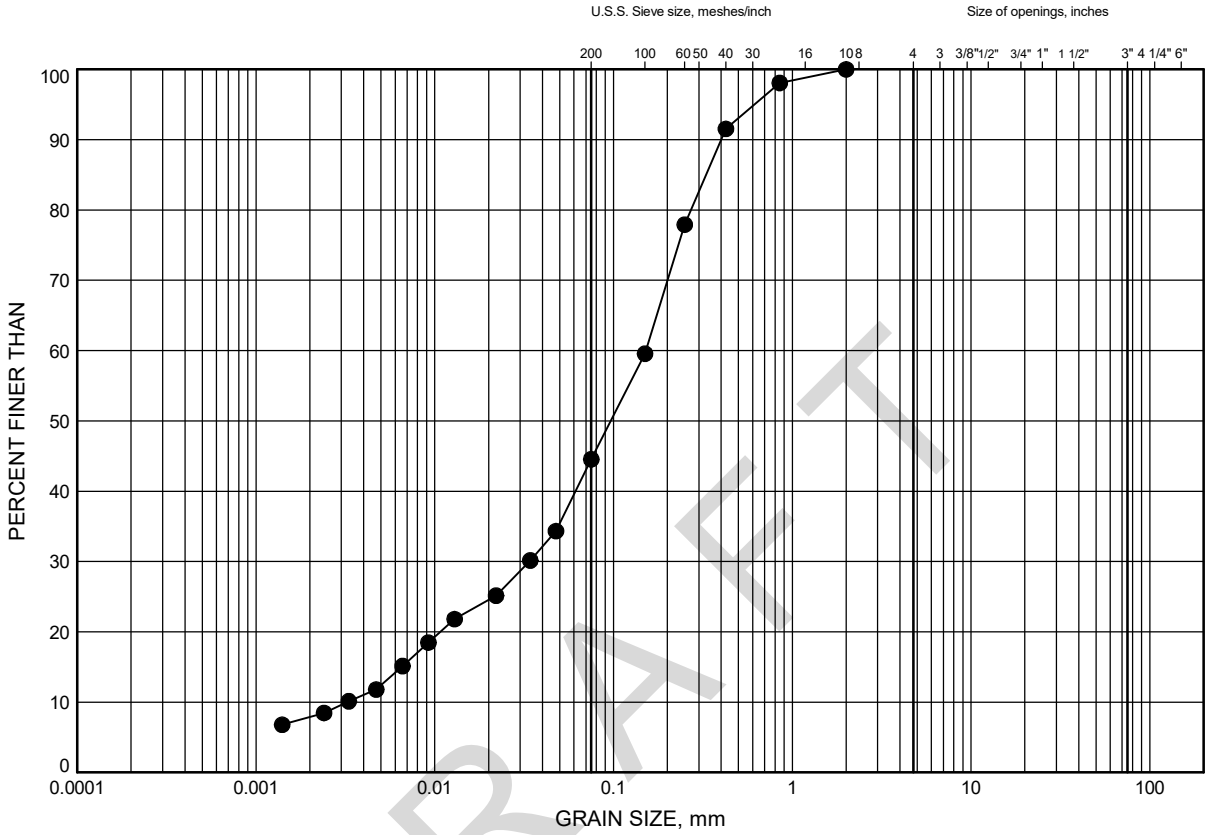
GRAIN SIZE DISTRIBUTION - THURBER MTO-11398.GPJ 6/22/17

Harvie / Big Bay Point Road

GRAIN SIZE DISTRIBUTION

FIGURE B2

FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	UP-08	1.1	286.0

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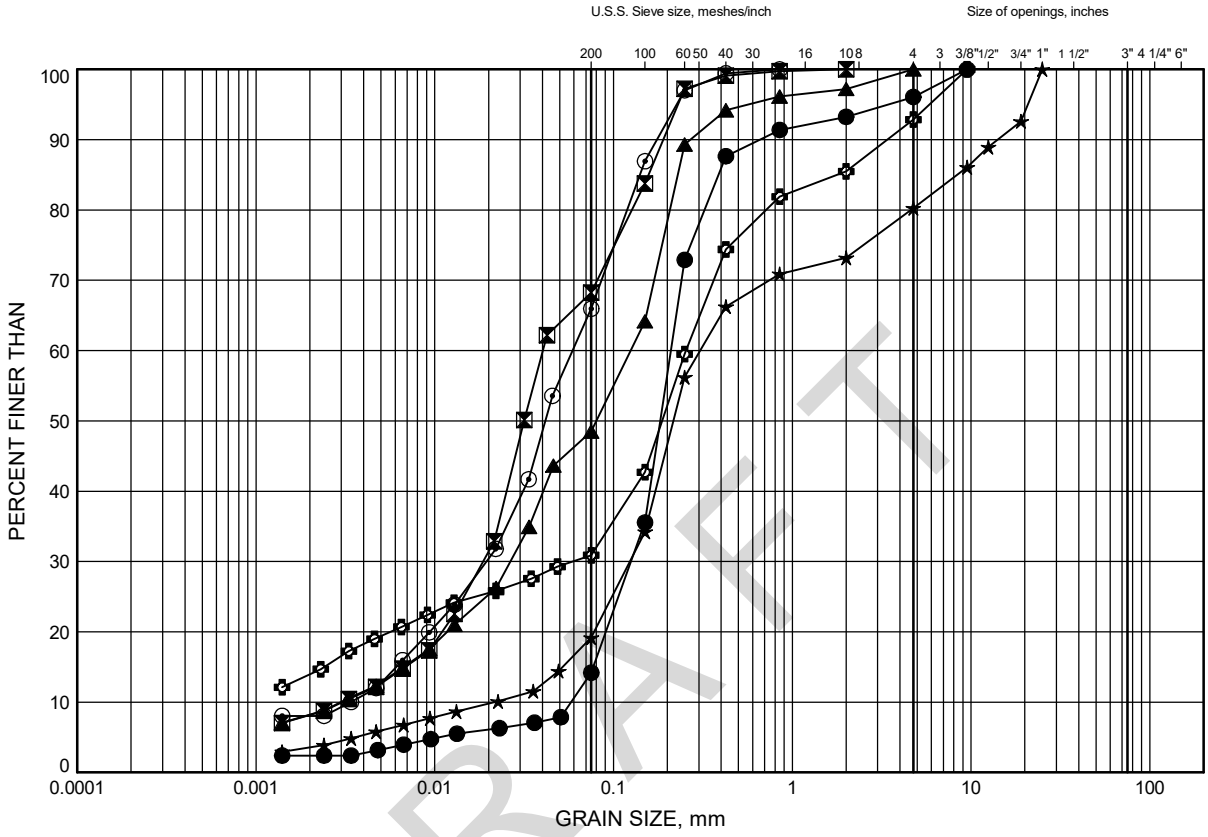
FIGURE B3

SANDS and SILTS



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

DRAFT

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	D-01	1.8	290.6
⊠	D-01	3.4	289.0
▲	D-01	4.8	287.6
★	D-02	1.8	290.3
⊙	D-02	3.4	288.8
✿	D-06	2.6	287.8

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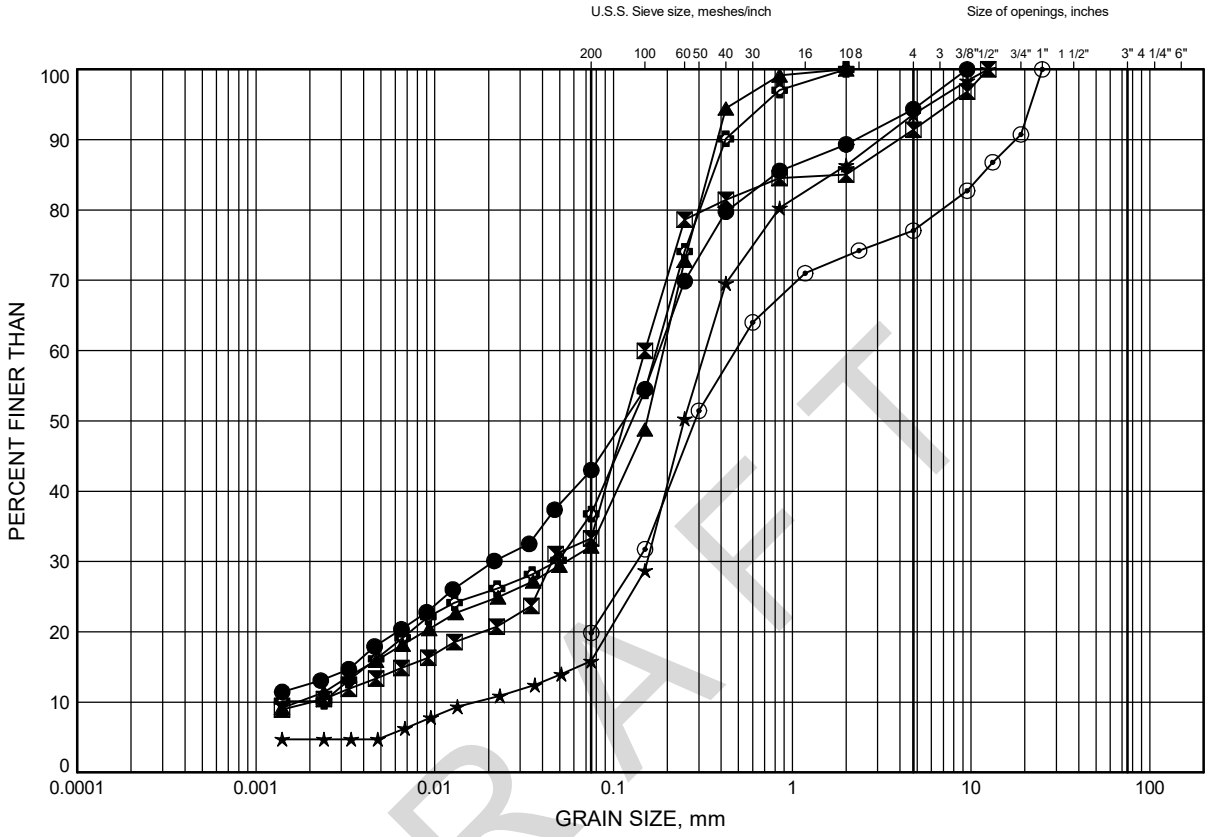
FIGURE B4

SANDS and SILTS



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

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LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	D-07	4.8	286.7
⊠	D-09	1.8	287.0
▲	D-10	1.1	280.2
★	D-12	2.7	276.9
⊙	D-14	1.1	282.7
✿	D-15	1.1	276.7

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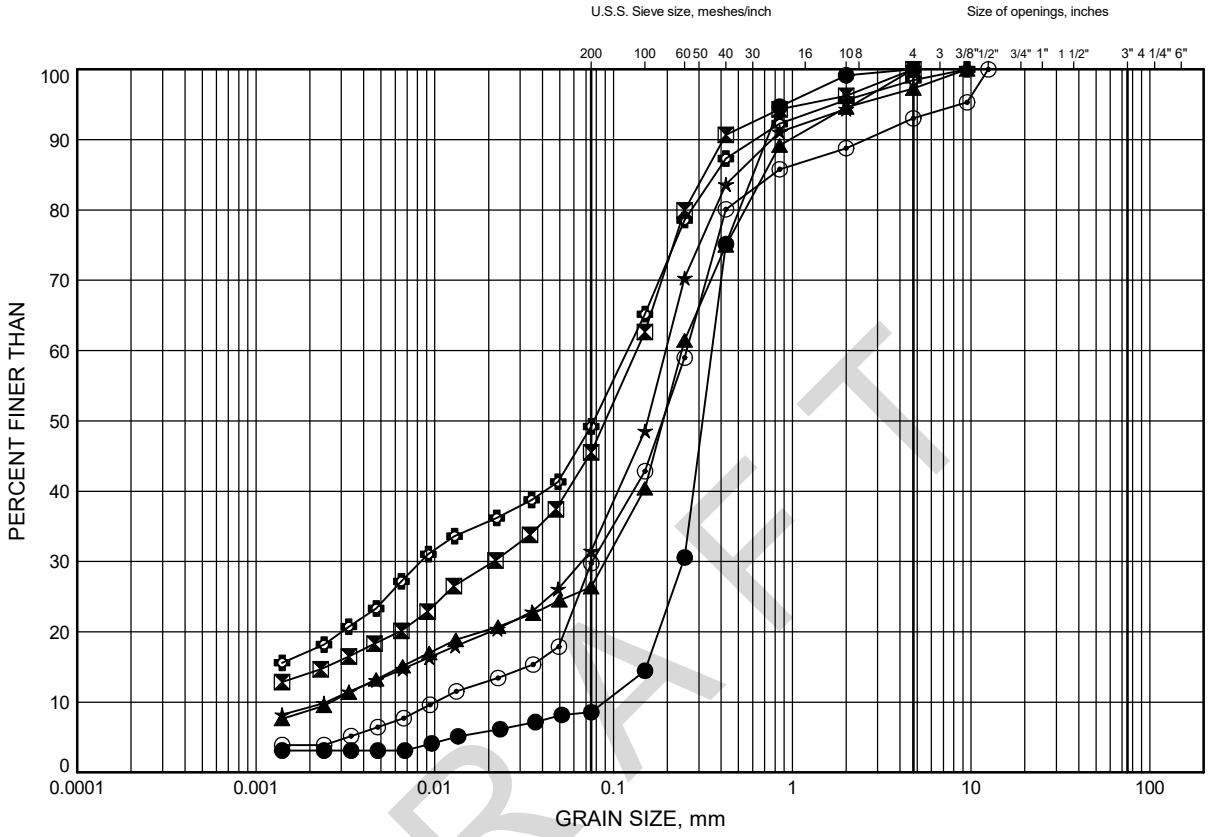
FIGURE B5

SANDS and SILTS



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

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LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	D-15	2.6	275.2
⊠	D-15	4.8	273.0
▲	HF-01	0.9	288.5
★	HF-07	1.8	283.1
⊙	RW-01	3.4	281.8
✿	UP-07	1.1	288.0

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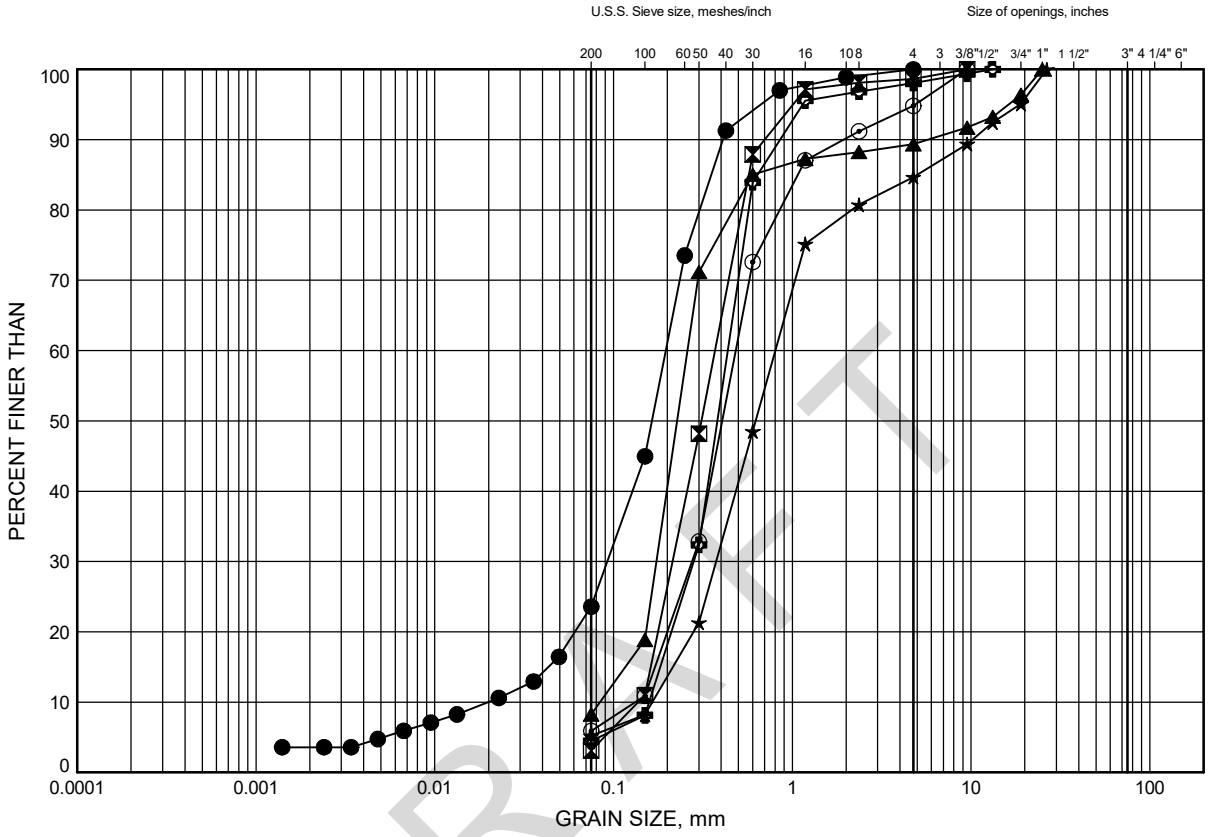
FIGURE B6

SAND



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

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LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	D-01	6.5	285.9
⊠	D-01	12.3	280.1
▲	D-02	7.8	284.3
★	D-04	2.6	283.7
⊙	D-06	9.4	281.0
✿	D-07	12.4	279.1

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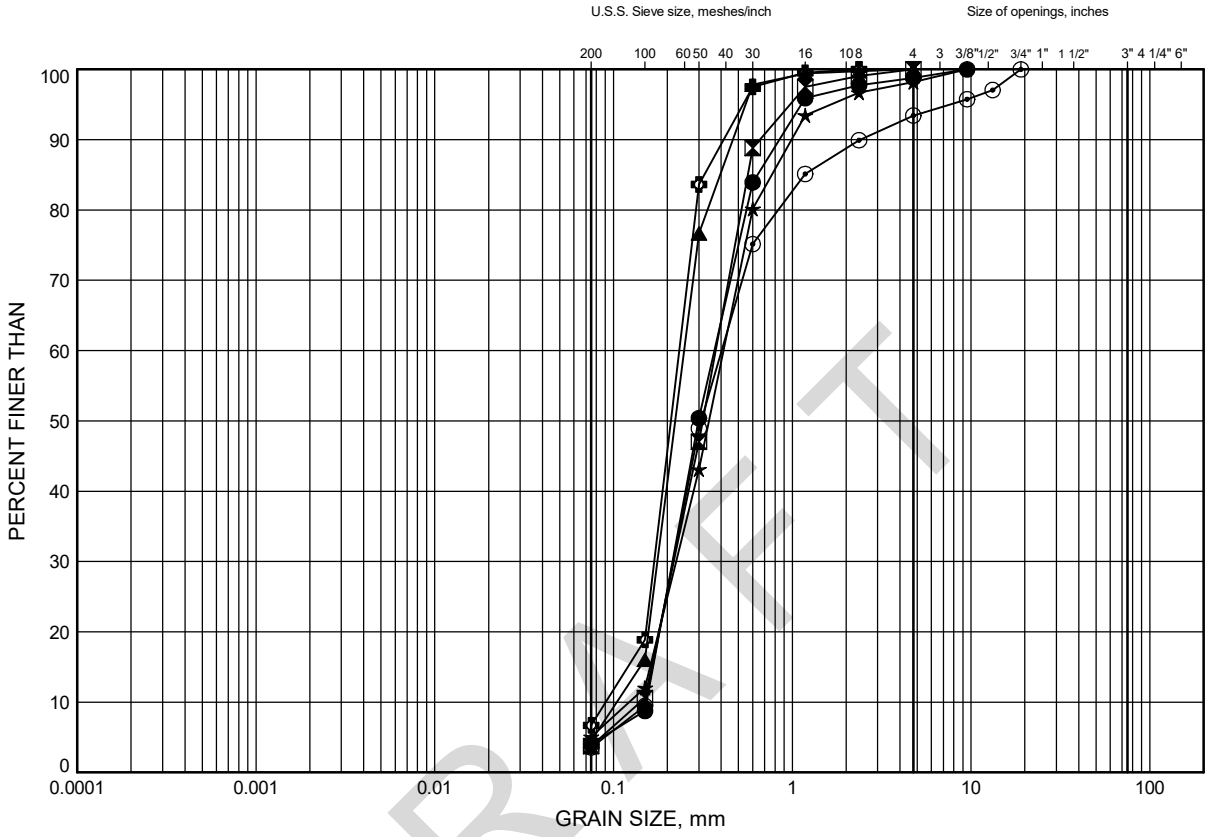
FIGURE B7

SAND



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

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LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	D-08	18.5	273.2
⊠	D-09	13.9	274.8
▲	D-10	10.9	270.4
★	D-11	6.4	273.3
⊙	D-12	5.8	273.8
✿	D-12	10.9	268.7

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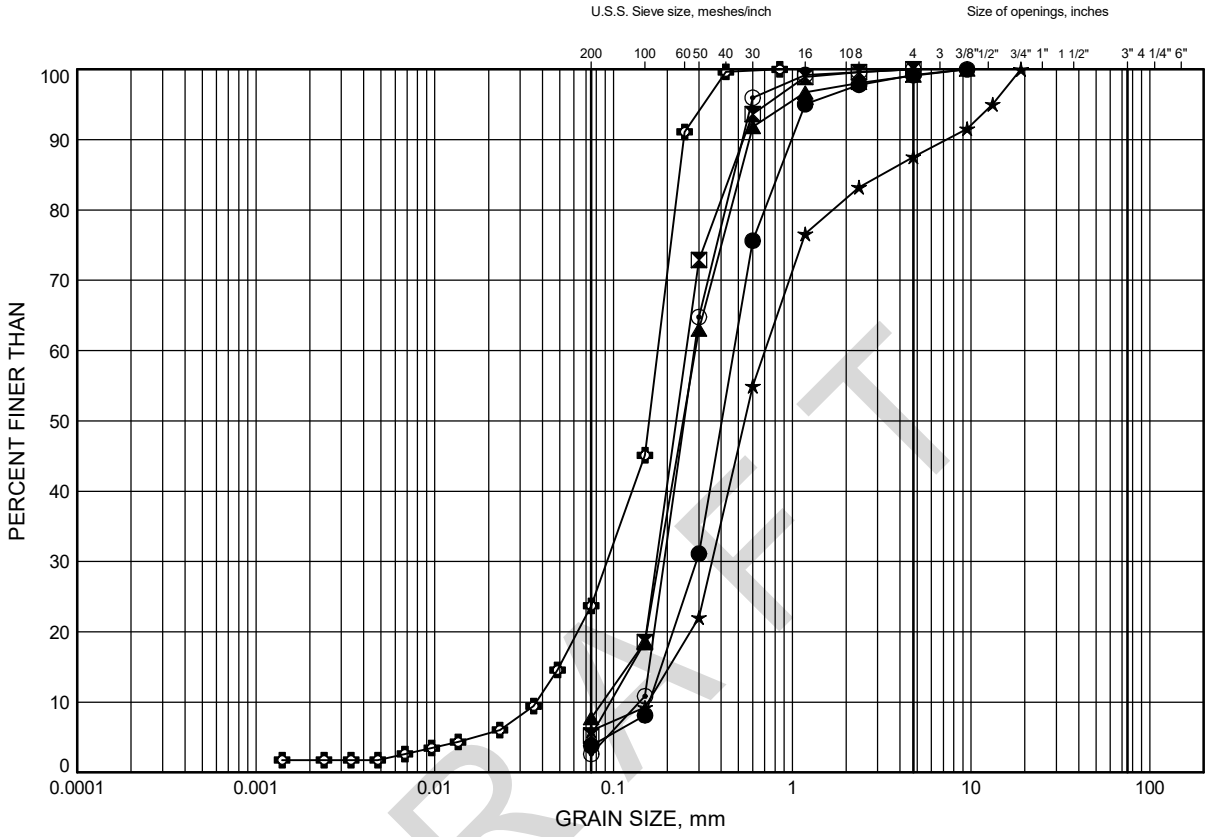
FIGURE B8

SAND



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

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LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	D-13	7.8	278.6
⊠	D-14	9.4	274.4
▲	D-15	7.8	270.0
★	HF-01	4.8	284.6
⊙	RW-01	9.4	275.8
✿	RW-01	18.5	266.7

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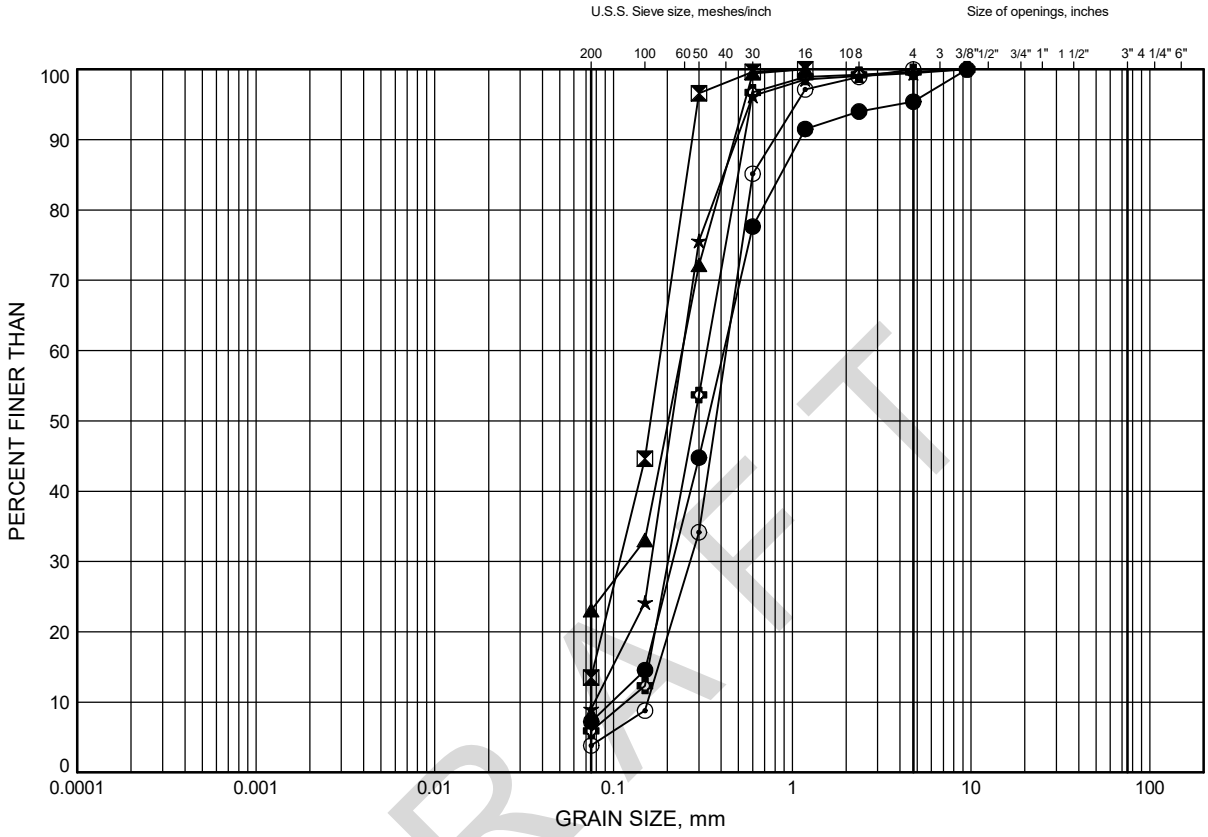
FIGURE B9

SAND



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

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LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	UP-02	4.9	278.7
⊠	UP-02	20.0	263.5
▲	UP-02	26.1	257.4
★	UP-02	33.7	249.9
⊙	UP-05	6.4	280.4
✿	UP-05	15.5	271.3

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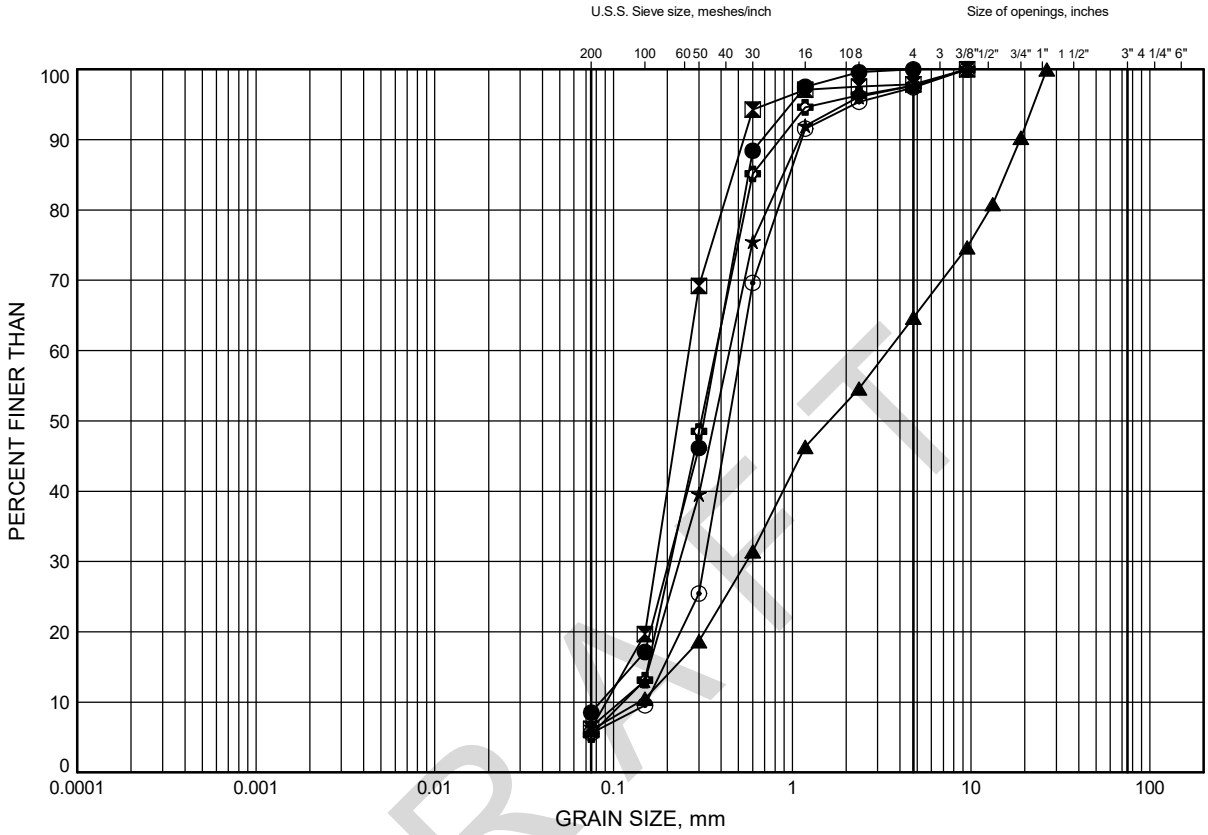
FIGURE B10

SAND



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

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LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	UP-06	9.4	278.0
⊠	UP-06	13.9	273.4
▲	UP-07	4.8	284.3
★	UP-07	9.4	279.7
⊙	UP-08	4.9	282.2
✿	UP-08	9.4	277.7

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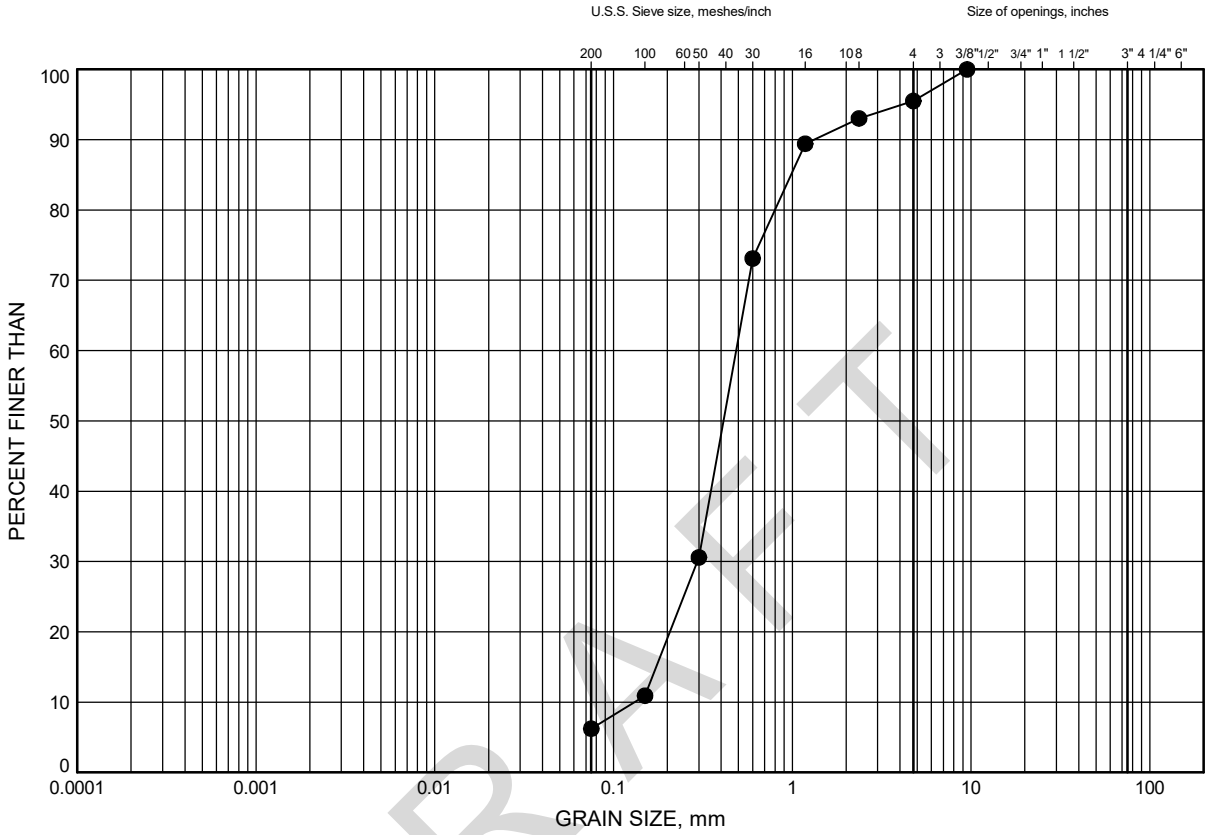
FIGURE B11

SAND



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

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LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	UP-09	4.8	280.0

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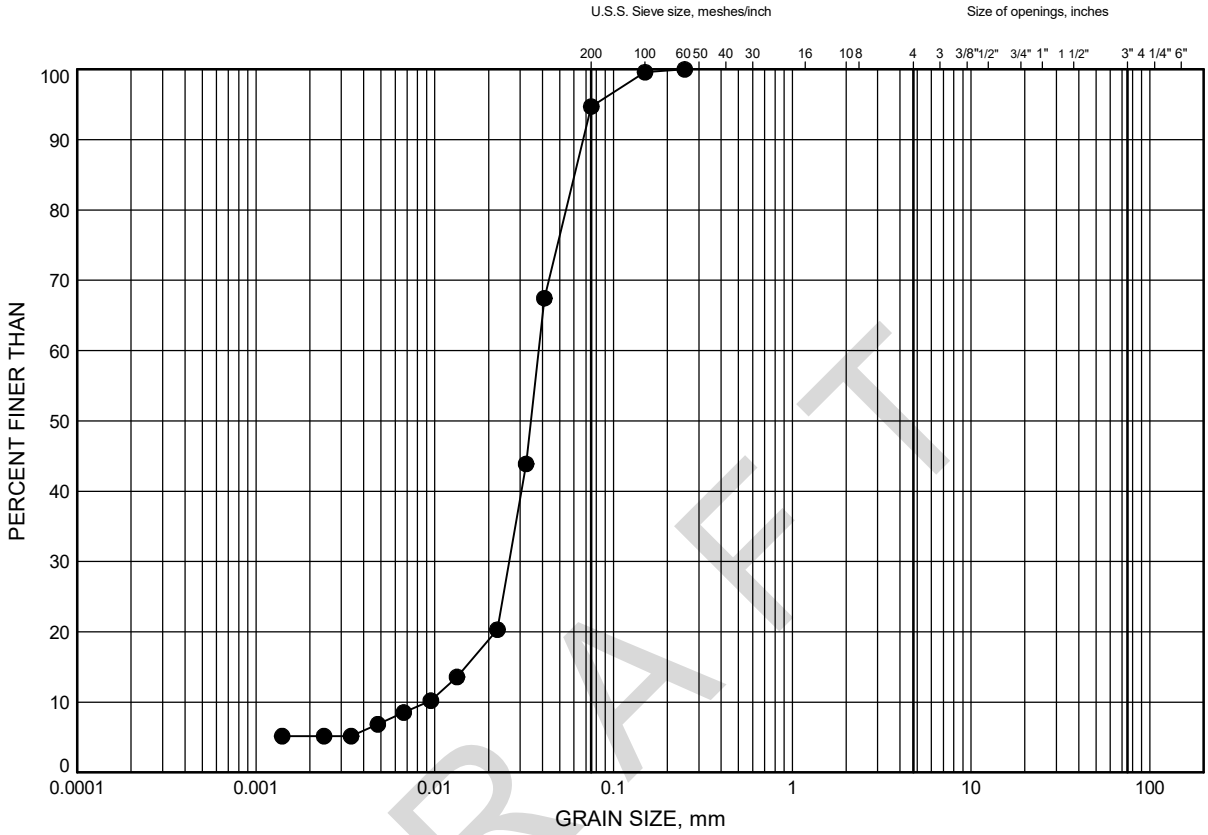
FIGURE B12

SILT



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

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LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	UP-05	20.0	266.8

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Appendix C

Site Photographs

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Photograph 1: Conditions near proposed Harvey Road / Bryne Drive intersection culvert

Photograph 2: Looking north towards existing Whiskey Creek culvert inlet

Photograph 3: Looking southeast towards proposed Whiskey Creek culvert inlet location

Photograph 4: Looking southwest towards proposed Whiskey Creek culvert outlet (to left)

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Photograph 5: Outlet of existing Fairview Road culvert

Appendix D

List of Standard Specifications and Special Provisions

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1) The following Standard Specifications and Special Provisions are referenced in this report:

OPSS.PROV 501

OPSS.PROV 539

OPSS.PROV 804

OPSS 902

OPSD 802.010

OPSD 802.014

OPSD 802.031

OPSD 802.034

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PIPE INSTALLATION BY TRENCHLESS METHOD – Item No.

Non Standard Special Provision May 2017

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, Culverts and Stormwater Ponds, New Crossing of Highway 400 at Harvie and Big Bay Point Road, Barrie, Ontario, prepared by Thurber Engineering Ltd., Reference No. 111398, dated May 2017.

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

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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.

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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.

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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

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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.

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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 manufacturer's 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.

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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.

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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

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- 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

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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.

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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.

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Appendix E

Figure – Braced Excavation

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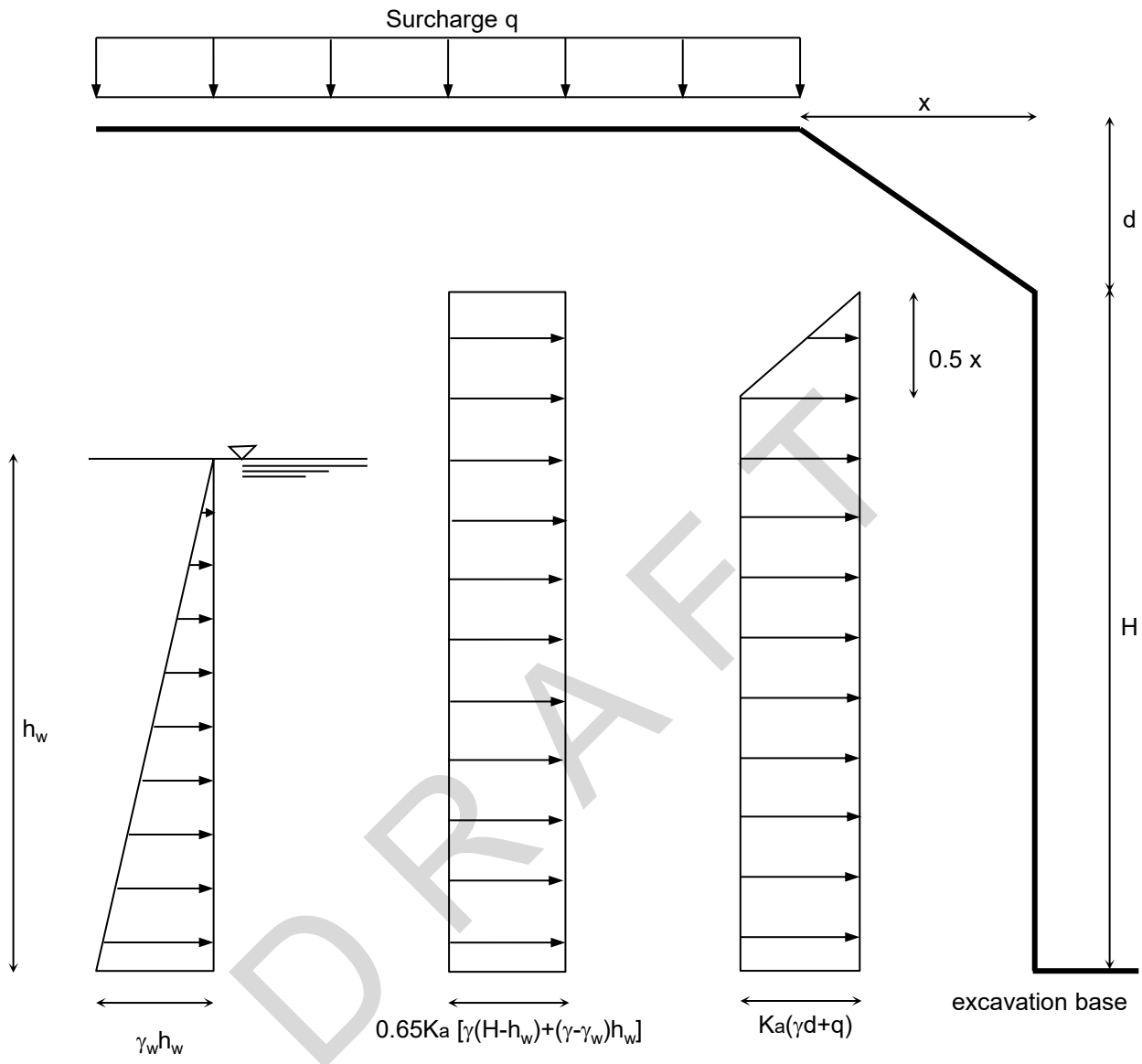

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H = retaining wall height above top of rock

hw = see geotechnical report for groundwater conditions

γ = unit weight of soil

γ_w = unit weight of water

K = earth pressure coefficient

THURBER

LATERAL PRESSURE DISTRIBUTION

Temporarily Braced Shoring in Sand

FIGURE E1

Appendix F

Borehole Locations and Soil Strata Drawings

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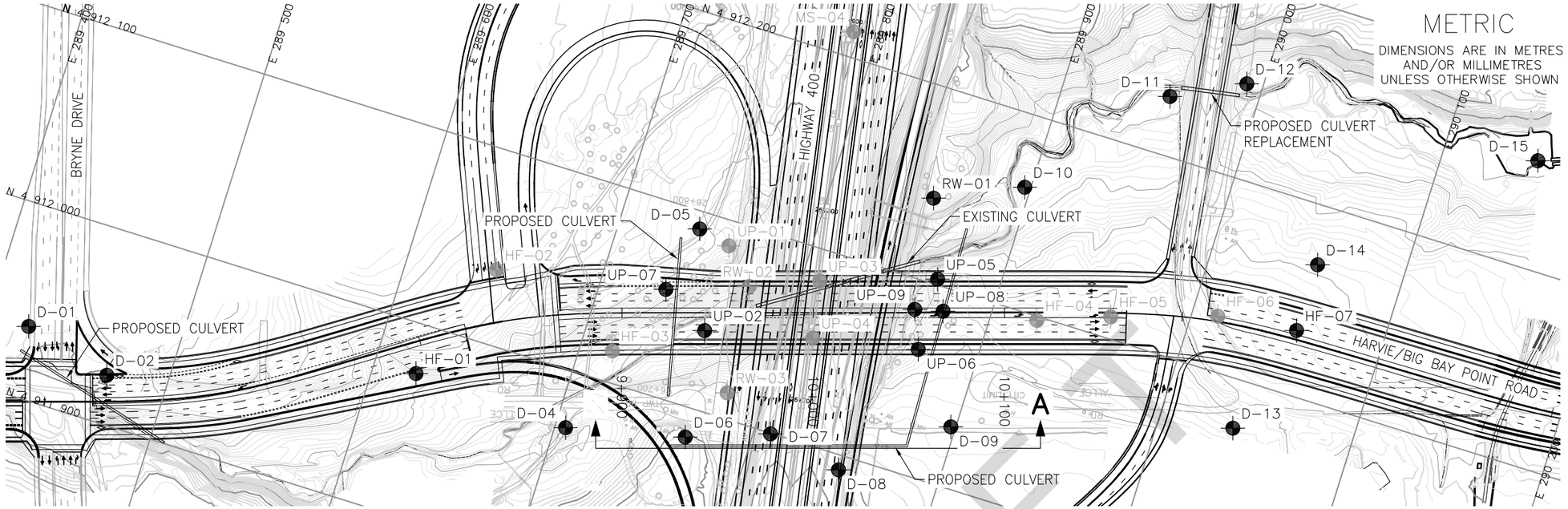
MINISTRY OF TRANSPORTATION, ONTARIO

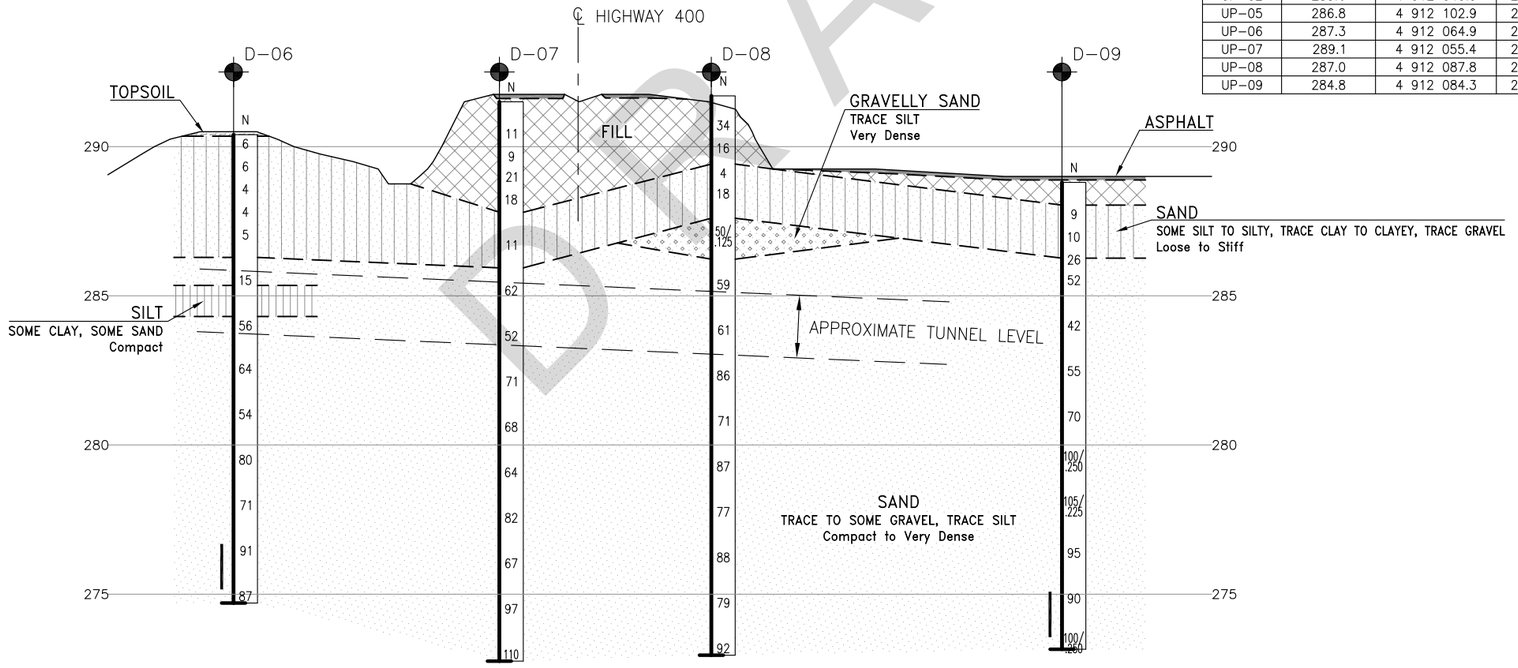


PLAN

50 0 50 100m

SCALE 1:2500

NO	ELEVATION	NORTHING	EASTING
D-15	277.8	4 912 255.8	290 148.8
HF-01	289.4	4 911 974.4	289 622.4
HF-07	284.9	4 912 133.4	290 054.9
RW-01	285.2	4 912 142.7	289 853.2
UP-02	283.6	4 912 040.9	289 759.7
UP-05	286.8	4 912 102.9	289 867.9
UP-06	287.3	4 912 064.9	289 869.2
UP-07	289.1	4 912 055.4	289 733.9
UP-08	287.0	4 912 087.8	289 875.6
UP-09	284.8	4 912 084.3	289 861.2



PROFILE A–A

20 0 20 40m H 1:1000

4 0 4 8m V 1:200

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CONT No
WP No

SHEET

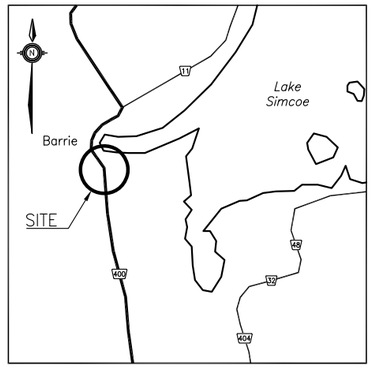
HIGHWAY 400
HARVIE/BIG BAY POINT ROAD
WHISKEY CREEK CROSSING
BOREHOLE LOCATIONS AND SOIL STRATA

HATCH

THURBER ENGINEERING LTD.

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
D-01	292.4	4 911 937.3	289 421.9
D-02	292.1	4 911 925.2	289 468.5
D-04	286.3	4 911 970.8	289 705.5
D-05	290.3	4 912 090.8	289 741.4
D-06	290.4	4 911 984.7	289 766.7
D-07	291.5	4 911 999.7	289 808.7
D-08	291.7	4 911 992.4	289 848.2
D-09	288.8	4 912 031.4	289 897.6
D-10	281.3	4 912 162.4	289 897.0
D-11	279.7	4 912 230.4	289 955.2
D-12	279.6	4 912 248.7	289 991.6
D-13	286.5	4 912 074.8	290 038.4
D-14	283.7	4 912 169.5	290 055.1

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No.

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	MRA	CHK	PKC	CODE	LOAD
DRAWN	MFA	CHK	MRA	SITE	STRUCT

DATE JUN 2017
DWG 1

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