Peto MacCallum Ltd.
CONSULTING ENGINEERS

GEOTECHNICAL INVESTIGATION
HARRIS NO. 1 MUNICIPAL DRAIN, HIGHWAY 19
TOWNSHIP OF SOUTH WEST OXFORD, ONTARIO

for

DIETRICH ENGINEERING LIMITED

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Peto MacCallum Ltd.
CONSULTING ENGINEERS

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Mr. Greg Nancekivell, C.E.T.
Dietrich Engineering Limited
155 Frobisher Drive
Unit G116
Waterloo, Ontario
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Dear Mr. Nancekivell

Geotechnical Investigation
Harris No.1 Municipal Drain, Highway 19
Township of South West Oxford, Ontario

Peto MacCallum Ltd. (PML) is pleased to present the results of the geotechnical investigation for the proposed municipal drain crossing of Highway 19 by trenchless methods.

The proposed municipal drain crossing is approximately 100 m north of the Ebenezer Road and Highway 19 intersection and is part of the Harris No. 1 Drain that runs from northeast to southwest of the proposed crossing.

As the project involves the crossing of Highway 19, the crossing must comply with the Ministry of Transportation (MTO) "Guidelines for Foundation Engineering – Tunnelling Specialty for Corridor Encroachment Permit Application" dated April, 2008.

We trust this report has been completed within our terms of reference and is sufficient for your current needs. Should you have further questions, please do not hesitate to contact our office.

Sincerely

Peto MacCallum Ltd.

M. Molodecki

Marian S. Molodecki, P.Eng.
Senior Consultant
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BARRIE, BRAMPTON, HAMILTON, KITCHENER, TORONTO

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GEOTECHNICAL REPORT
For
Harris No. 1 Municipal Drain – Highway 19
Township of South West Oxford, Ontario

1. INTRODUCTION

A proposed municipal drain crossing of Highway 19 is planned in the Township of South West Oxford, Ontario, using a trenchless method. The crossing is part of the Harris No. 1 Drain that runs from northeast to southwest of the drain crossing, located between the east road limit (Station -0+003) and the west road limit (Station 0+027).

Based on the information provided by Dietrich Engineering Limited, the trenchless portion of the crossing configuration includes a 750 mm diameter by 24 m long steel casing. The planned invert level of the casing is understood to be between Elevation 47.93 and 47.97, approximately 3 m below the travelled lanes of Highway 19. The overall crossing will extend the entire width of the 30 m highway right of way (from the east to the west property limits). The location of the crossing is shown on the appended Borehole Location Plan, Drawing 1.

As the project involves the crossing of Highway 19, the crossing must comply with the Ministry of Transportation (MTO) "Guidelines for Foundation Engineering – Tunnelling Specialty for Corridor Encroachment Permit Application" dated April, 2008, a copy of which has been provided in Appendix A. This foundation investigation and design report has been prepared as per the project requirements and the above noted MTO guidelines.

2. SITE DESCRIPTION

The Highway 19 crossing site is located approximately 100 m north of the Ebenezer Road and Highway 19 intersection, in the Township of South West Oxford, Ontario. The proposed municipal drain crossing will extend from the northeast side to southwest of Highway 19 and is part of the Harris No.1 Drain. The land on both sides of the crossing is currently being used for agricultural purposes. A concrete box culvert (approximately 10 m north of the proposed drain) and a storm drainage pipe with a diameter of 300 mm at invert level 48.67 (6 m south of the proposed drain) cross beneath Highway 19, as shown on the appended Borehole Location Plan, Drawing 1.

Grades along the highway corridor have been raised such that the travelled lanes of the highway are about 1 m above the level of the natural topography of the lands located to each side of the highway.

The Highway 19 right of way (property limits) at the crossing site is approximately 30 m in width. The highway is a divided provincial road with one north bound and one south bound lane.

3. INVESTIGATION METHODOLOGY

The field work for the proposed crossing was carried out on August 3, 2012. The investigation program comprised two boreholes drilled to depth of 9.6 m. The boreholes were located on the granular road shoulders and approximately 3 m from the location of the proposed drain; Borehole 1 was located on the north side and Borehole 2 was located south of the proposed municipal drain, as shown on the appended Borehole Location Plan, Drawing 1.

Boreholes were advanced using a CME 55 truck mounted drill rig equipped with continuous flight hollow stem augers. The drilling equipment was supplied and operated by a specialist drilling contractor working under subcontract to PML.

Representative samples of the overburden were taken at regular intervals in the boreholes throughout the depths explored. Standard penetration tests were carried out during the sampling using conventional split spoon equipment.

The field work was supervised throughout by a member of PML's engineering staff who directed drilling and sampling operations, prepared the stratigraphic logs, monitored ground water conditions and processed the recovered samples.

The proposed crossing alignment was marked in the field by Dietrich Engineering Limited. The borehole locations were established in field by PML in advance of drilling. The borehole locations were surveyed by PML and are referenced to the following temporary benchmark (TBM), provided by Dietrich Engineering Limited:

TBM 1: Top centre downstream end of concrete box culvert
As shown on appended Borehole Location Plan, Drawing 1
Elevation: 50.00 (metric, local)

The ground water conditions at the borehole locations were assessed during drilling by visual examination of the soil, the sampler and drill rods as samples were retrieved and when appropriate, by measurement of the water level in the borehole.

Soils were identified in the field according to the Unified Soil Classification System and adjusted to the MTO Soil Classification system, after detailed examination of recovered samples and laboratory testing.

The laboratory testing program comprised visual examination and moisture content determination on all recovered samples. Six particle size distribution analyses and two Atterberg limit tests were conducted on selected soil samples to determine specific properties of the main soil types encountered. Results of the particle size distribution analyses are presented on the appended Figures 1 to 6 and the results of the Atterberg Limit tests are shown on the appended Figure 7.

4. SUBSURFACE CONDITIONS

Reference is made to the appended Log of Borehole sheets for details of the field work including soil descriptions, inferred stratigraphy, standard penetration test (SPT) N values, ground water observations, laboratory moisture content test results and Atterberg limit test results.

In general, the subsurface soil and ground water conditions encountered along the proposed crossing alignment at the borehole locations consisted of surficial fill overlying topsoil and native deposits of sand which in turn are underlain by silty clay till layer that extended to the termination depths of Borehole 1 and 2. Reference is made to Drawing 2 for the soil profile along the alignments of the boreholes.

4.1 Fill

Surficial fill/road shoulder pavement was encountered in Boreholes 1 and 2 and extended to the depth of 1.50 m (Elevation 49.60). The upper fill/pavement layer generally consisted of sand and gravel (up to depths between 0.45 and 0.60 m). The lower portion of fill forming the roadway embankment generally comprised clayey silt that extended to depths of 1.50 m.

SPT N values measured in the upper portion of the fill layer (i.e., sand and gravel) ranged from 34 to 37 blows per 0.3 m penetration, indicating dense conditions.

The moisture content of the fill was between 2.6 to 7.7%. The result of a grain size distribution analysis conducted on a sample of the fill is presented on Figure 1, attached.

4.2 Topsoil

Topsoil was encountered in Boreholes 1 and 2 below the surficial fill. The topsoil layer was 1.1 m thick and terminated at Elevation 48.5.

The moisture content of the topsoil was between 4.1 to 23.1%. The result of a grain size distribution analysis conducted on a sample of the topsoil is presented on Figure 2, attached.

4.3 Sand

Sand deposits were encountered at depth of 2.6 m (Elevation 48.5) underlying the fill and topsoil layers in Boreholes 1 and 2. The deposit generally comprised sand, some gravel in Borehole 1 and sand, gravelly to some gravel in Borehole 2.

SPT N values measured in the sand ranged from 20 to 46 blows per 0.3 m penetration, indicating compact to dense conditions in Boreholes 1 and 2.

The moisture content of the sand deposit ranged from about 9.9 to 14.6%. The results of grain size distribution analyses conducted on samples of the sand deposit are presented on Figures 3 and 4, attached.

4.4 Silty Clay Till

Silty clay till was encountered at depths of 4.7 and 4.6 m (Elevation 46.5 and 46.6) below the sand deposits in Boreholes 1 and 2, respectively. Seams of silty sand were noted in the silty clay till layer below the depth of 4.7 and 9.2 m, in Boreholes 1 and 2, respectively.

SPT N values measured in the till layer ranged from 10 to 22 blows per 0.3 m penetration, indicating stiff to very stiff conditions. Below the depth of 9.2 m, the SPT N values 46 and 63 were measured in Boreholes 1 and 2, respectively, indicating hard conditions.

Two Atterberg limit tests were conducted on samples of the silty clay till layer. The measured plasticity index (PI) were recorded to be 13 (Borehole 1, SS9) and 10 (Borehole 2, SS8), as shown on the appended Figure 7.

The moisture content of the till layer ranged from about 13.2 to 26.3%. The results of grain size distribution analyses conducted on samples of the silty clay till layer are presented on Figures 5 and 6, attached.

4.5 Ground Water

Ground water observations during the course of the field work are summarized on the appended Log of Borehole sheets. Wet to saturated conditions were generally observed during the drilling operations below the depth of 2.6 m (Elevation 48.5). Free water was observed at 2.9 and 3.4 m depths (Elevation 48.2 and 47.7) in Boreholes 1 and 2, respectively. It is believed that the ground water occurs as a perched condition within the sand stratum, controlled by the underlying silty clay till. The ground water levels at the site are subject to seasonal fluctuations and precipitation patterns. It should be noted that due to the stiff to very stiff nature of the silty clay till layer below the sand deposits, elevated water levels can be expected following rainfall events.

5. DISCUSSION AND RECOMMENDATIONS

A proposed municipal drain crossing of Highway 19 is planned in the Township of South West Oxford, Ontario, using a trenchless method. The crossing is part of the Harris No. 1 Drain that runs from northeast to southwest of the drain crossing, located between the east road limit (Station -0+003) and the west road limit (Station 0+027).

Based on the information provided by Dietrich Engineering Limited, the trenchless portion of the crossing configuration includes a 750 mm diameter by 24 m long steel casing. The planned invert level of the casing is understood to be between Elevation 47.93 and 47.97, approximately 3 m below the travelled lanes of Highway 19. The overall crossing will extend the entire width of the 30 m highway right of way (from the east to the west property limits). The location of the crossing is shown on the appended Borehole Location Plan, Drawing 1.

The subsurface soils encountered in the boreholes at the casing invert levels 48.91 and 47.97 comprised topsoil and sand. The materials at the indicated invert levels were saturated and water-bearing at the time of the fieldwork. The sand deposit is compact to dense at the location of Borehole 1 and compact in Borehole 2. Ground water observations carried out during the drilling operations indicate that the tunnel will generally be located 0.5 m below the observed ground water table (Elevation 48.5), at the crossing site.

Based on the available project information and the subsurface soil and ground water conditions encountered at the crossing site, tunnelling methods which could be used on this project include jack and bore, pipe ramming, and micro-tunnelling.

Alternative configurations and installation methods may also be considered, provided they meet the needs of the project proponent and the MTO.

Further, the recommendations presented are based on the boreholes drilled during the subsurface investigation carried out along the currently proposed alignment. Additional subsurface investigation will be required if the crossing alignment is altered / shifted.

5.1 Tunnelling Methods

Regardless of the method used, it is recommended that the contractor prepare a plan in advance of construction outlining the details of the installation to provide instructions for the construction crews, and provide a possible contingency action plan should difficulties occur during the tunnelling operations. The plan should also be reviewed by the project proponent and the MTO prior to construction. Upon request, PML can assist in reviewing the plan to check that assumptions regarding soil and ground water conditions are appropriate.

It should be noted that the stratigraphy between boreholes may vary and areas of weaker or denser soil may be present along the planned route.

It should further be noted that the tunnelling operations should take into account the presence of existing infrastructure at the site, in particular, the existing concrete box culvert which is located 10 m north of the proposed crossing. The final work plan should be reviewed to check that the existing culvert will not be affected. Reference is made to Figure 8, appended, to determine if shoring or underpinning of the culvert is indicated.

Reference is also given to Ontario Provincial Standard Specifications (OPSS) 415, Construction Specifications for Pipeline and Utility Installation by Tunnelling.

A general description of the tunnelling methods which could be used on this project is presented below.

5.1.1 Jack and Bore

Jack and bore typically involves the simultaneous advancement of a continuous flight auger and conduit pipe. The auger is used to excavate soil in advance of the pipe and transport cuttings back to the receiving pit where they are removed. Rotary power to the auger and pushing force is provided by a drill rig located within a jacking pit. Jack and bore is a common method of trenchless installation and in appropriate site and soil conditions is expected to be preferable from a cost perspective.

Jack and bore installation(s) should be conducted in accordance with OPSS 416, Construction Specifications for Pipeline and Utility Installation by Jacking and Boring.

For this site the relatively shallow ground water level could hinder or prevent a jack and bore installation. In wet soils there is potential for ground surface subsidence due to running of wet soil into the bore, which could result in voids. To eliminate this potential, ground water control measures would be required at the jacking and receiving pits as well as along the length of the bore. Overall, the site needs to be dewatered below the tunnelling depths. If construction is planned for wet Fall seasons or following rainfall events, elevated ground water levels can be expected and ground water control along the boring path may require the installation of well points, collection pipes and pumping systems located within the Highway 19 right of way.

Reference is given to the Staging Excavations section for recommendations pertaining to the construction of entry and receiving pits.

In addition, the presence of cobbles and boulders in the site soils will increase the risk for alignment deviations to occur and a significant disadvantage of this method is that the alignment cannot be corrected during pipe advancing. Also, a soil plug should be maintained to mitigate face instability and void formation within the cohesionless soil layers.

5.1.2 Pipe Ramming

Pipe ramming installation is analogous to driving an open ended tube pile horizontally. Impact forces from a percussive hammer are used to advance a conduit pipe from an entry pit to a receiving pit. During the advance, most of the soil being penetrated fills the conduit rather than being excavated. The rammed conduit is terminated in a receiving pit at which point the soil contained in the pipe is removed. Pipe ramming is not guided and becomes impractical in presence of cobbles and boulders.

In addition to the dewatering measures that will be required at the entry and receiving pits, dewatering measures will be necessary along the length of the bore as well. Since the tunnelling depth is very close to the natural ground surface (between Elevation 49 and 50), the force generated by the hammering operations will increase the risk for soil disturbance along the route of the boring. Furthermore, the ground water level is above the tunnelling depth and therefore the occurrence of alignment deviations within non-cohesive soils (i.e., sand) is more probable.

Pipe ramming can be conducted through soils with cobbles and boulders; however, difficult driving can be expected. The presence of dense sand, above the liner invert level at Borehole 1, could also impede the operation; If it becomes essential to clean out the liner prior to egress, soil plug should be maintained to mitigate against face failure and void formation.

5.1.3 Micro-tunnelling

Micro-tunnelling is also an available method of trenchless installation that does not require dewatering prior to advancing the tunnel. It also reduces the risk of ground losses during tunnelling. These machines typically utilize pressurized bentonite slurry to counterbalance the earth and water pressures acting at the tunnel face. The excavated soil is withdrawn in a controlled manner to prevent loss of ground during tunnel advance. The slurry is circulated back through the tunnel to transport cuttings to a settling tank. The micro-tunnelling machine can also be specified to have the capability to crush boulders. Given the machines ability to control soil and water pressures at the face, dewatering prior to advancing the tunnel would not be necessary with this tunnelling method.

This method is considered to be the method that does not require dewatering to be carried out along the tunnelling length and also minimizes the risk of loss of ground and ground surface settlement.

5.1.4 Assessment of Tunnelling Methods

The following table summarizes the advantages and disadvantages of the tunnelling methods described.

TUNNELLING METHOD	ADVANTAGES	DISADVANTAGES
Jack and Bore	▪ Contractor availability ▪ Good for shorter tunnel lengths ▪ Good gradient control ▪ No interior annular space to grout (no inner conduit planned) ▪ Minor residual space may be present surrounding liner exterior, which would require grouting ▪ Least costly method	▪ Ground water control is required for the bore and shafts ▪ Elevated potential for ground subsidence if adequate ground water lowering is not achieved ▪ Once operation is started it should continue without stoppage until complete to mitigate potential for sloughing of face and void formation
Pipe Ramming	▪ Contractor availability ▪ Operations do not need to continue without stoppages ▪ No interior annular space to grout (no inner conduit planned) ▪ Minor residual space may be present surrounding liner exterior, which would require grouting ▪ Cost effective	▪ Ground water control is required ▪ If boulder is encountered, soil from within the pipe must be removed, there would be a potential for loss of ground during removal of boulder ▪ Dense sand layer at Borehole 1 could impede progress
Micro-tunnelling	▪ Does not require ground water lowering ▪ Machine is able to counter-balance earth and water pressures in a controlled manner, thereby reducing the risk of ground losses during tunnelling ▪ Machine can also be specified to have the capability to crush boulders	▪ Contractor Availability ▪ Most costly method ▪ Grouting of annular space behind liner would be required

All three installation methods are technically feasible for the crossing. Dewatering of the site below the tunnelling depth at staging pit locations (and potentially along the length of the bore) is required for jack and bore and pipe ramming. Based on the above considerations, the jack and bore method is recommended as the preferred method.

5.1.5 Monitoring

The ground surface over the tunnel route may become distorted and distressed by tunnelling. The most common type of distress is settlement caused by loss of ground around the tunnel. Heave of the ground surface and or inadvertent drilling fluid returns are also possible depending on the type of installation. Mitigation of the distress or distortion on the travelled lanes of Highway 19 would be a major inconvenience to highway users and possibly a safety issue.

Distress at the ground surface is generally prevented or minimized by good construction practices and proper planning. In this regard, preparation of an installation plan as noted above is recommended.

It is also recommended that the project proponent implement a monitoring program to check the condition of the ground over the tunnel before, during and upon completion of construction. The monitoring program should be carried out by a qualified geotechnical consulting firm that is MTO RAQS approved and should conform to the MTO Settlement Monitoring Guidelines for Tunnelling which are presented in Appendix A. As noted in the appendix, monitoring points should be installed over the proposed tunnelling route at a maximum interval of 5 m. Monitoring period should begin prior to tunnelling, extend throughout the duration and continue at least 2 weeks after completion of tunnelling. Measurement of the monitoring points should be done at least 3 times a day for everyday in the monitoring period. A pavement condition survey should also be carried out prior to commencement of construction and following completion of construction.

Monitoring points should be marked using a method approved by MTO. Monitoring points should also be functional throughout the monitoring period and should not deteriorate because of highway traffic, maintenance activities and weather conditions.

If distress is observed during construction the contractor should be informed and corrective action should be undertaken immediately. Specific corrective action will be dependent on the nature of the distress and type of installation. Regardless, the process should be outlined in the monitoring program and be part of the contingency actions in the contractor's installation plan.

Settlement or heave of the roadway from tunnel installation carried out in accordance with the recommendations noted in this report should be less than 10 mm. If settlement or heave of the ground surface exceeds 10 mm, the construction process should be reviewed and adjusted to mitigate further disturbances for the remainder of the tunnelling work.

If total settlement or heave exceeds 15 mm, tunnelling operations should be terminated, the site secured against further deterioration, and mitigative action should be undertaken immediately to reinstate the roadway, ditches and/or the existing storm sewer.

All actions to prevent, secure, or mitigate destruction or damage to the highway and associated features should be done in accordance with and approved by MTO.

5.2 Staging Excavations

It is anticipated that open cut excavations will be used for staging areas and tie points to the tunnelling segment. These excavations are understood to be located within the Highway 19 right of way. Reference is given to OPSS 201, 503 and 565 for specifications associated with site preparation.

5.2.1 Excavation and Ground Water Control

Excavations for access pits and tie-in locations will extend though surficial fill, topsoil and into predominantly non-cohesive native soils. Provided adequate ground water control is achieved, the onsite soils are classified as Type 3 materials as defined in the Occupational Health and Safety Act (OHSA). Excavations within Type 3 soil that are to be entered by workers, may not be steeper than one horizontal to one vertical (1H:1V) from the base of the excavation. Workers should not enter an unprotected excavation if there is evidence of ongoing ground water seepage in the banks.

Excavations for staging pits are expected to extend about 1 m below the observed ground water level and will require ground water control measures. The extent of ground water control will depend on the depth of excavation below the ground water level; the ground water level should be maintained at a minimum depth of 0.50 m below the bottom invert of the casing. The actual dewatering methods should be established at the contractor's discretion within the context of a performance specification for the project. Regardless of the dewatering method chosen, the hydraulic head and ground water inflow must be properly controlled to ensure a stable and safe excavation and to facilitate construction. The design of the dewatering system should be specified to maintain and control ground water at least 0.3 m below the excavation base level, in order to provide a stable excavation base throughout construction.

It should be noted that, under the Ontario Water Resources Act, the Water Taking and Transfer Regulation 387/04, a Permit to Take Water (PTTW) from the Ministry of Environment (MOE) is required if the dewatering discharge is greater than 50,000 L/day.

Excavation of test pits during the time of construction is recommended for determination of the ground water level. If higher ground water levels are encountered, the pumping rates can exceed 50,000 L/day. In this case, a PTTW will be required together with a hydrogeological study in support of the PTTW application. A detailed review of the final design invert levels relative to the observed ground water levels is recommended to determine if detailed hydrogeologic work will be required.

Reference is also given to OPSS 517 and 518 which pertain to construction dewatering.

Construction stage dewatering is expected to have negligible impact on existing infrastructure, provided the existing infrastructure is founded on competent native soils such as compact to dense sandy gravel, sands and silts, or hard clayey silt till.

Although boulders were not encountered in the boreholes during the field investigation their presence should be anticipated within the native deposits in addition to the presence of cobbles.

It is recommended that test pits be excavated during the tendering stage so contractors bidding on the project can evaluate for themselves the soil and ground water conditions to be encountered and to assess the dewatering requirements.

6. CLOSURE

The field work was carried out under the supervision of Mr. D. Brice, working under the direction of Mr. R. Agahzadeh, P.Eng., Manager, Geotechnical Services. The drilling equipment was supplied and operated by London Soil Test Limited. The laboratory work was carried out in the PML Kitchener laboratory.

This report was prepared by Ms. K. Pejman, Project Supervisor, and reviewed by Mr. M. Molodecki, P.Eng., Senior Consultant, Geotechnical and Geoenvironmental Services.

We trust this report has been completed within the terms of reference and is sufficient for your current needs. Should you have further questions, do not hesitate to contact our office.

Sincerely

Peto MacCallum Ltd.

Katayoon Pejman, BESc.
Project Supervisor

LICENSED PROFESSIONAL ENGINEER
M.S. MOLODECKI
32305013
Nov 1/12
PROVINCE OF ONTARIO

Marian S. Molodecki, P.Eng.
Senior Consultant
Geotechnical and Geoenvironmental Services

KP/MSM:kp

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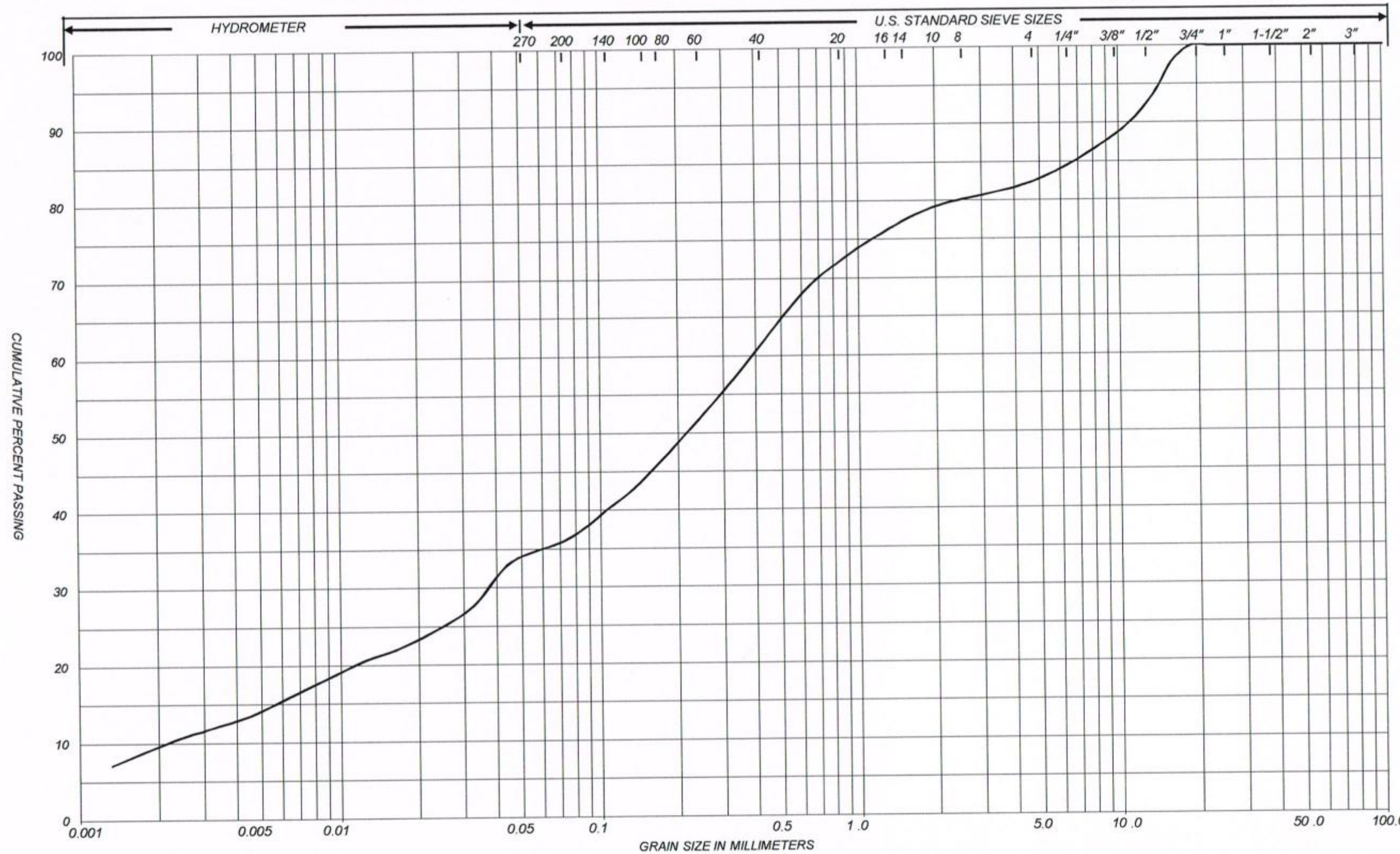
PML REF. 12KF033
FIGURE NO. 1
LAB NO.: 32665

PARTICLE SIZE DISTRIBUTION CHART



UNIFIED	SILT & CLAY			SAND: FINE	SAND: MEDIUM	SAND: COARSE	GRAVEL			COBBLES
M.I.T.	CLAY	SILT: FINE	SILT: MEDIUM	SILT: COARSE	SAND: FINE	SAND: MEDIUM	SAND: COARSE	GRAVEL		COBBLES
U.S. BUREAU	CLAY	SILT		SAND: VERY FINE	SAND: FINE	SAND: MEDIUM	SAND: COARSE	GRAVEL		

REMARKS Borehole 1, Sample SS 2, Depth 0.7 to 1.2 m
FILL

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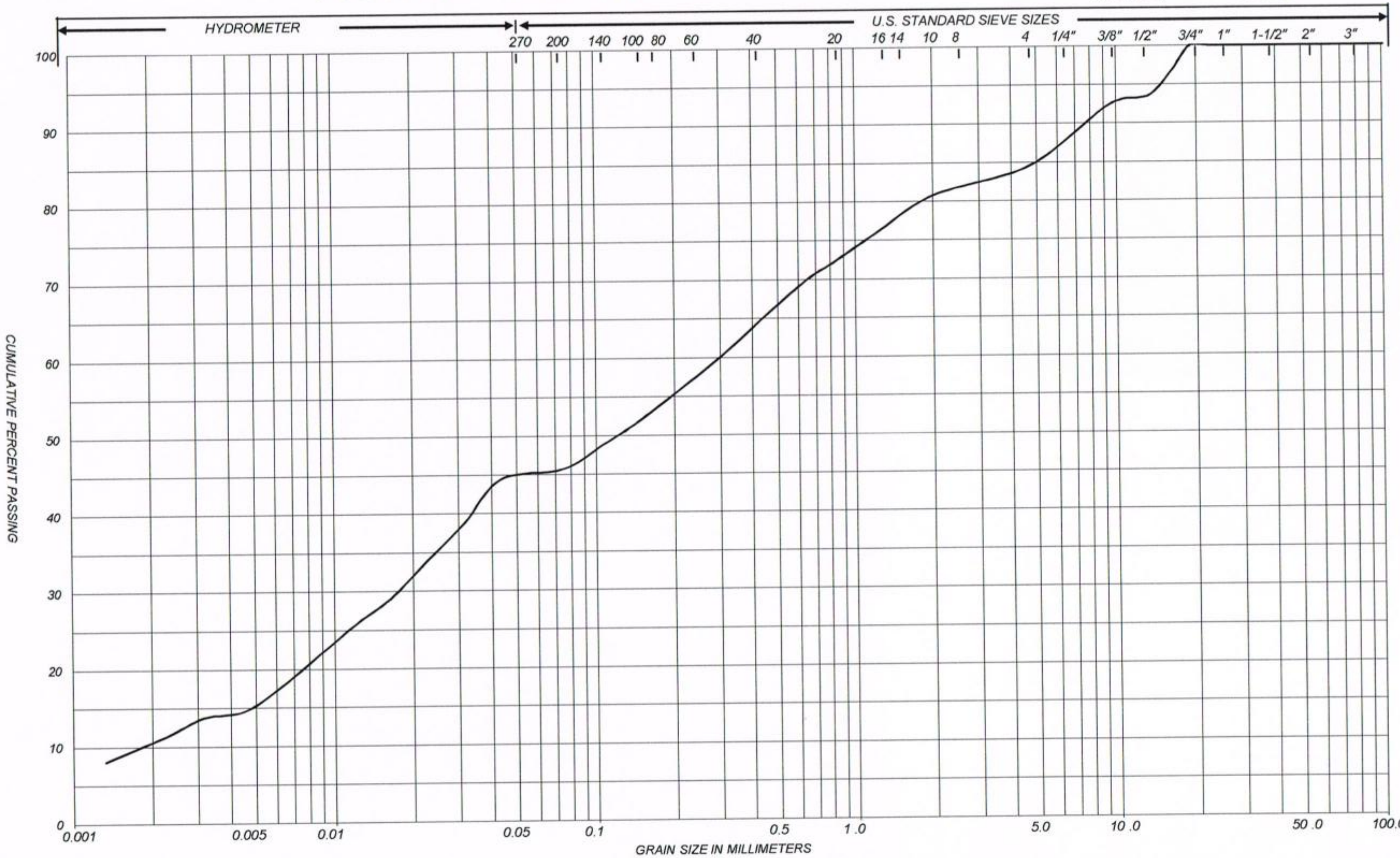
PML REF.	12KF033
FIGURE NO.	2
LAB NO.:	32666

PARTICLE SIZE DISTRIBUTION CHART



UNIFIED	SILT & CLAY	SAND: FINE	SAND: MEDIUM	SAND: COARSE	GRAVEL	COBBLES
M.I.T.	CLAY; SILT: FINE, MEDIUM, COARSE	SAND: FINE	SAND: MEDIUM	SAND: COARSE	GRAVEL	COBBLES
U.S. BUREAU	CLAY; SILT	SAND: VERY FINE, FINE	SAND: MEDIUM	SAND: COARSE	GRAVEL	

REMARKS Borehole 1, Sample SS 4, Depth 2.3 to 2.7 m

TOPSOIL

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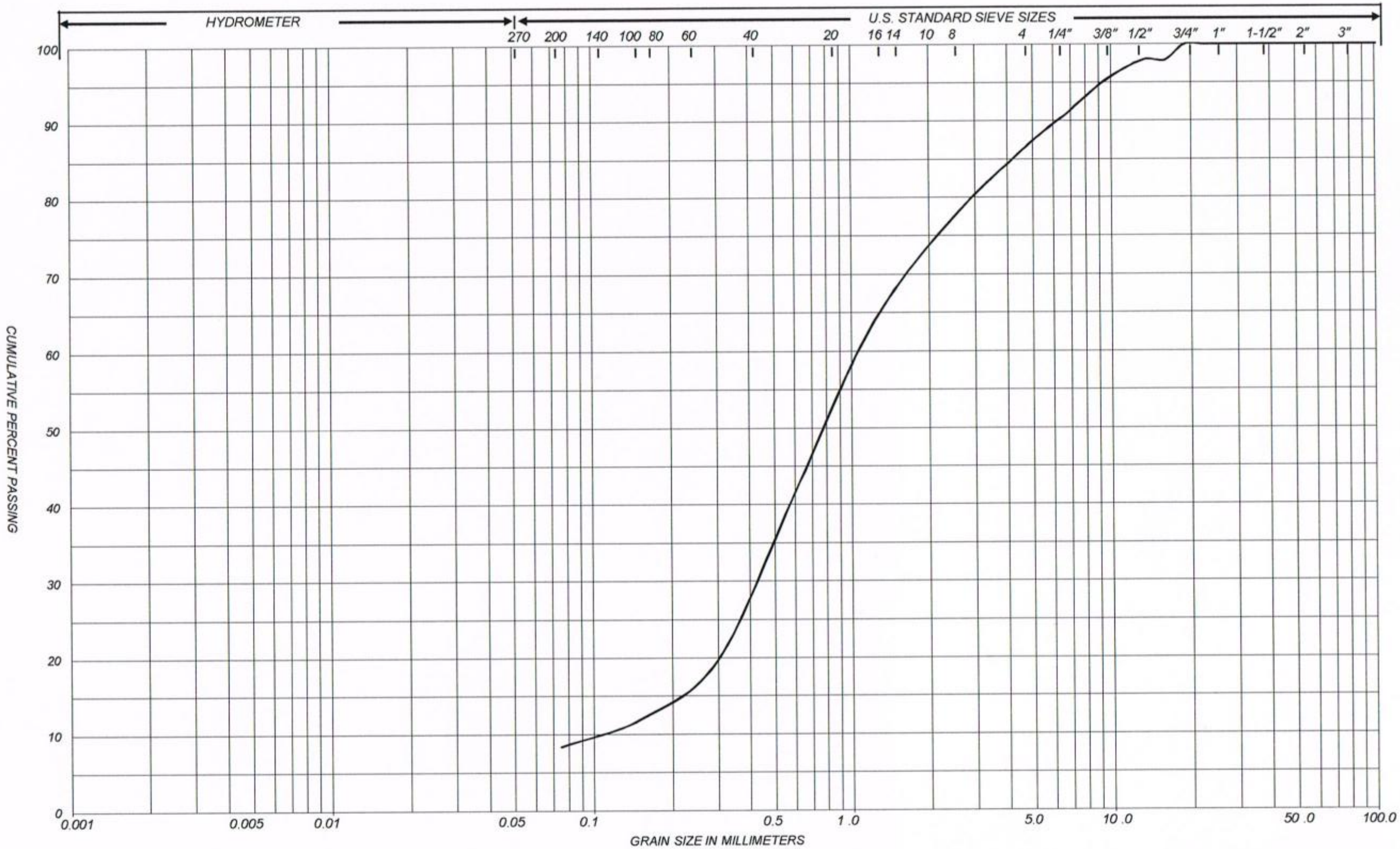
PARTICLE SIZE DISTRIBUTION CHART

PML REF. 12KF033
FIGURE NO. 3
LAB NO.: 32667



UNIFIED	SILT & CLAY			SAND: FINE	SAND: MEDIUM	SAND: COARSE	GRAVEL	COBBLES	
M.I.T.	CLAY	SILT: FINE	SILT: MEDIUM	SILT: COARSE	SAND: FINE	SAND: MEDIUM	SAND: COARSE	GRAVEL	COBBLES
U.S. BUREAU	CLAY	SILT	SAND: VERY FINE	SAND: FINE	SAND: MEDIUM	SAND: COARSE	GRAVEL		

REMARKS Borehole 1, Sample SS 6, Depth 3.8 to 4.3 m
SAND

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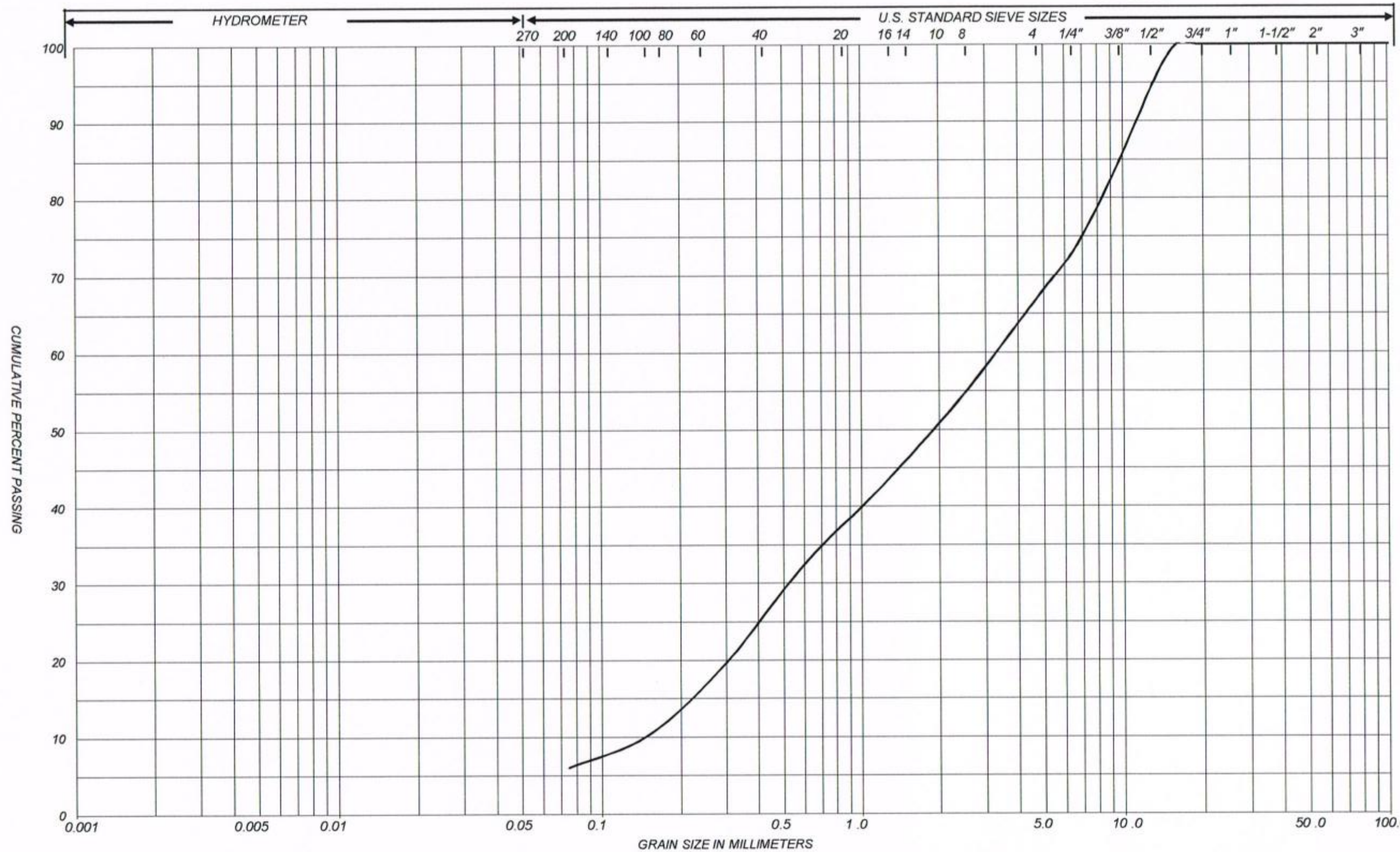
PML REF. 12KF033
FIGURE NO. 4
LAB NO.: 32668

PARTICLE SIZE DISTRIBUTION CHART



SILT & CLAY				FINE SAND		MEDIUM SAND		COARSE SAND	GRAVEL	COBBLES	UNIFIED
CLAY	FINE SILT	MEDIUM SILT	COARSE SILT	FINE SAND		MEDIUM SAND	COARSE SAND		GRAVEL	COBBLES	M.I.T.
CLAY		SILT		VERY FINE SAND	FINE SAND	MEDIUM SAND	COARSE SAND		GRAVEL		U.S. BUREAU

REMARKS Borehole 2, Sample SS 6, Depth 3.8 to 4.3 m

SAND

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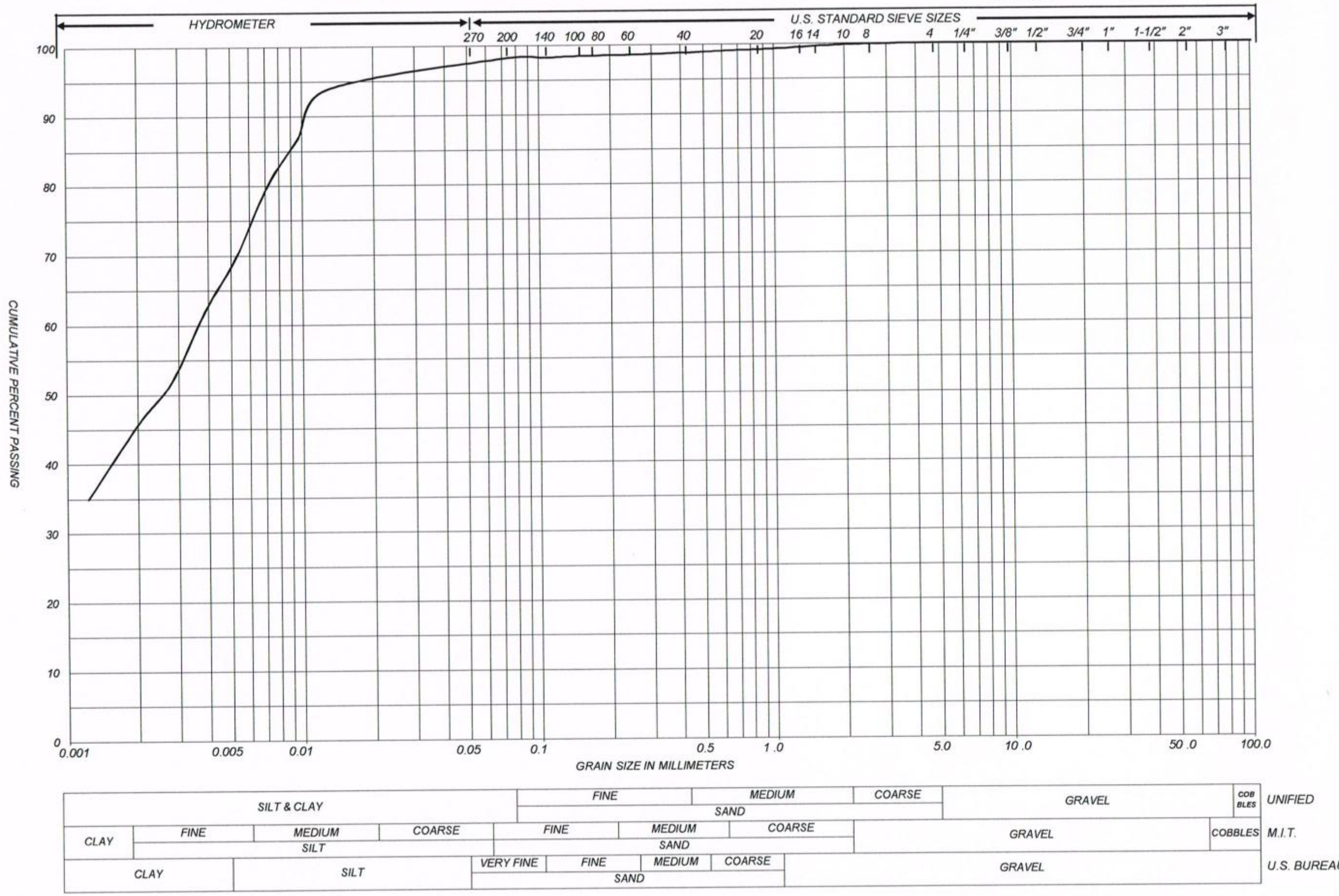
PML REF. 12KF033
FIGURE NO. 5
LAB NO.: 32669

PARTICLE SIZE DISTRIBUTION CHART



REMARKS Borehole 1, Sample SS 9, Depth 6.1 to 6.6 m
SILTY CLAY TILL

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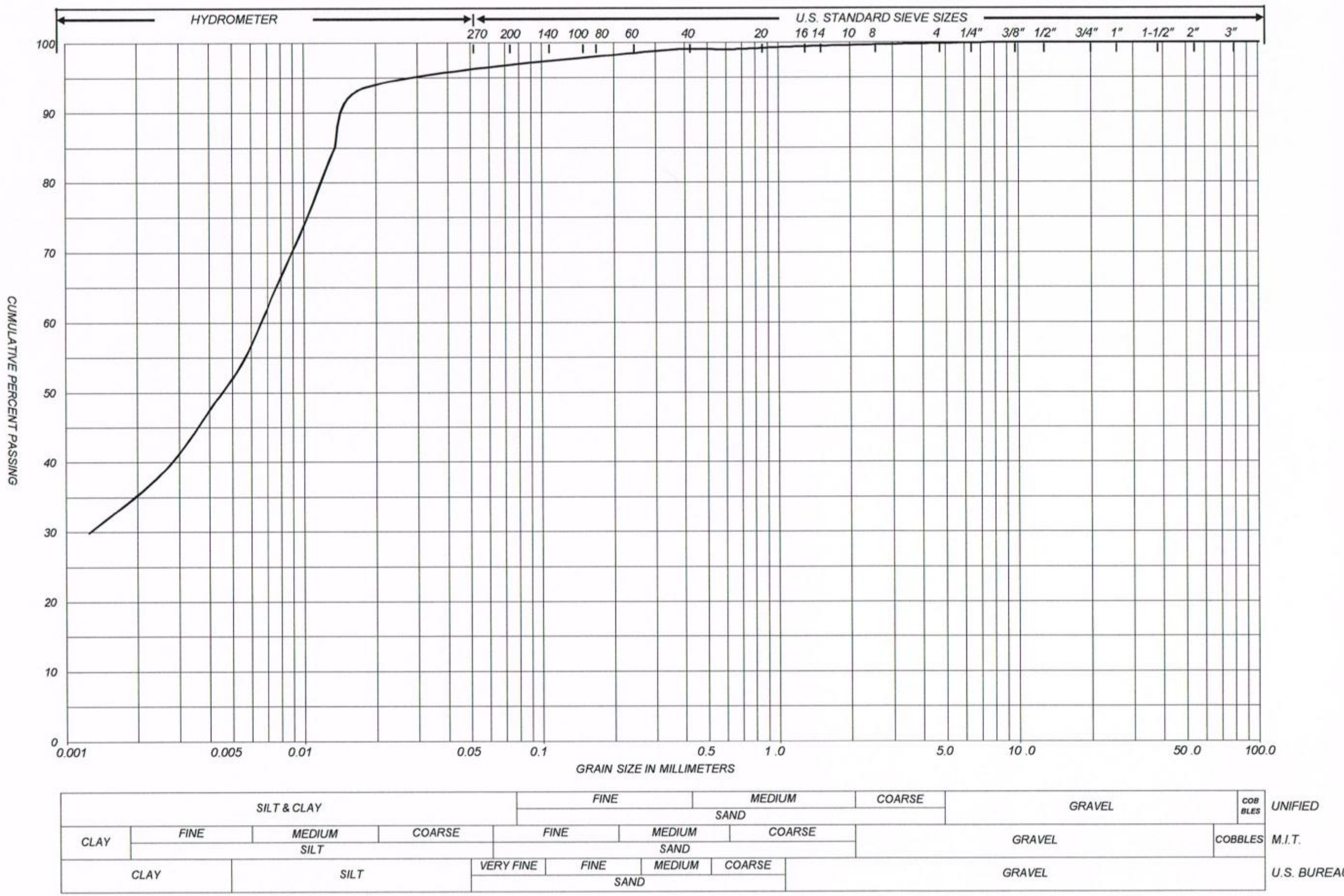
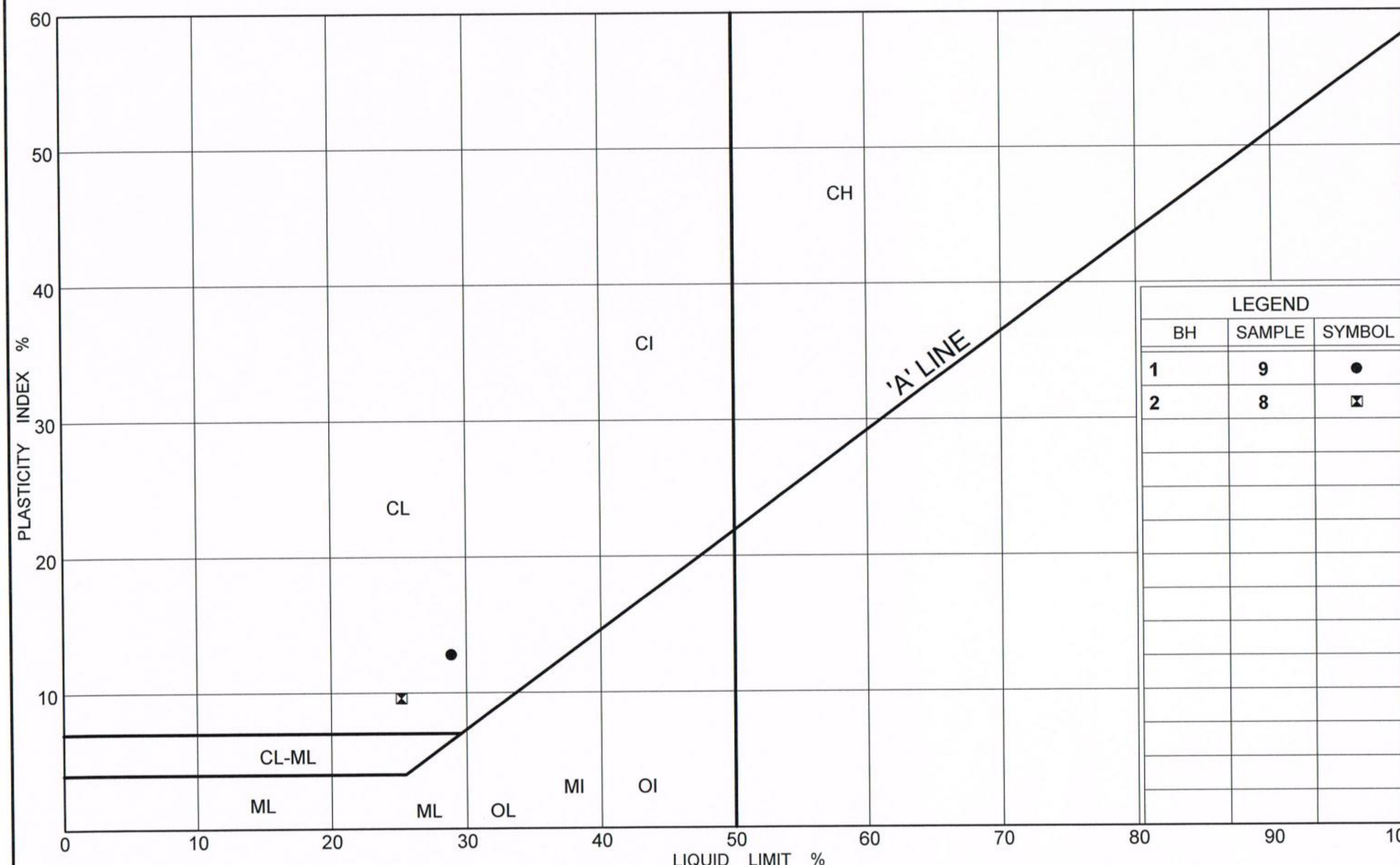
PARTICLE SIZE DISTRIBUTION CHART

PML REF. 12KF033
FIGURE NO. 6
LAB NO.: 32700



REMARKS Borehole 2, Sample SS 8, Depth 5.3 to 5.8 m

SILTY CLAY TILL



LEGEND		
BH	SAMPLE	SYMBOL
1	9	●
2	8	⧗

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PLASTICITY CHART
Silty Clay Till

PML REF.	12KF033
FIGURE No.	7
DATE	November 2012

NOTES

1. The need to underpin existing footings/utilities is dependent upon soil type, proximity of the existing facility to the face of the excavation, loads imposed on the foundation and permissible movements.

   ZONE A:
   Foundations of relatively heavy and/or settlement sensitive structures/utilities located in Zone A generally require underpinning.

   ZONE B:
   Foundations of structures located within Zone B generally do not require underpinning. Consideration should be given to underpinning of settlement sensitive utilities or heavy foundation units located in this zone.

   ZONE C:
   Utilities and foundations located within Zone C do not normally require underpinning.

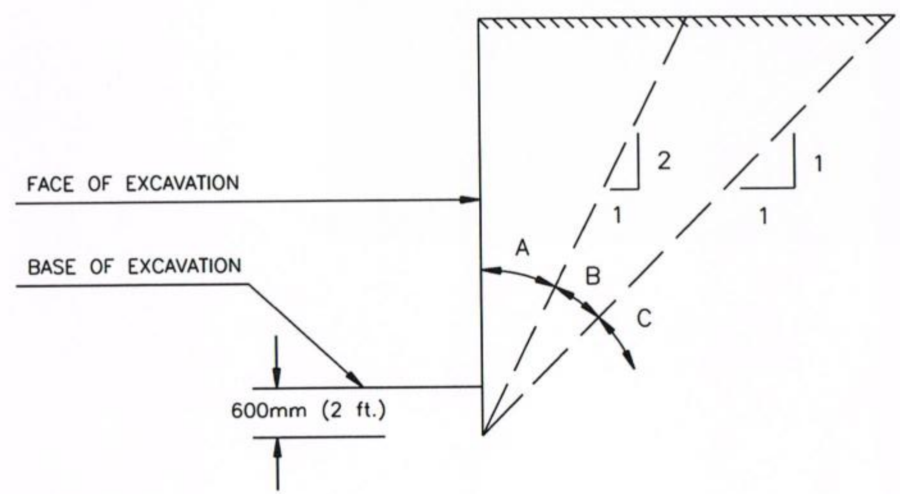
   Underpinning of foundations located in Zones A and B should extend at least into Zone C.

2. As an alternative to underpinning, it may be possible to control movement of existing utilities and foundations by supporting the face of the excavation with bracing/tiebacks or a rigid (caisson) wall. Horizontal and vertical earth pressures imposed on the excavation wall by non–underpinned foundations must be considered in the design of the support system.

3. A condition survey should be conducted prior to construction and appropriate monitoring (surface and insitu) carried out during construction to monitor any movement which may occur.

4. All work should be carried out in accordance with the Occupational Health and Safety Act and local regulations. Good quality workmanship and construction practices are to be employed.

5. This sheet is to be read in conjunction with text of report for this project. Additional comments and recommendations concerning these general guidelines will be provided if required.



Peto MacCallum Ltd. CONSULTING ENGINEERS	STANDARD DRAWING GENERAL RECOMMENDATIONS REGARDING UNDERPINNING OF FOUNDATIONS/UTILITIES LOCATED CLOSE TO EXCAVATION	DATE	JOB NUMBER	FIGURE NO.
		November 2012	12KF033	8

LIST OF ABBREVIATIONS

PENETRATION RESISTANCE

Standard Penetration Resistance N: - The number of blows required to advance a standard split spoon sampler 0.3 m into the subsoil. Driven by means of a 63.5 kg hammer falling freely a distance of 0.76 m.

Dynamic Penetration Resistance: - The number of blows required to advance a 51 mm, 60 degree cone, fitted to the end of drill rods, 0.3 m into the subsoil. The driving energy being 475 J per blow.

DESCRIPTION OF SOIL

The consistency of cohesive soils and the relative density or denseness of cohesionless soils are described in the following terms:

CONSISTENCY	N (blows/0.3 m)	c (kPa)	DENSENESS	N (blows/0.3 m)
Very Soft	0 - 2	0 - 12	Very Loose	0 - 4
Soft	2 - 4	12 - 25	Loose	4 - 10
Firm	4 - 8	25 - 50	Compact	10 - 30
Stiff	8 - 15	50 - 100	Dense	30 - 50
Very Stiff	15 - 30	100 - 200	Very Dense	> 50
Hard	> 30	> 200		

WTPL	Wetter Than Plastic Limit
APL	About Plastic Limit
DTPL	Drier Than Plastic Limit

TYPE OF SAMPLE

SS	Split Spoon	TW	Thinwall Open
WS	Washed Sample	TP	Thinwall Piston
SB	Scraper Bucket Sample	OS	Oesterberg Sample
AS	Auger Sample	FS	Foil Sample
CS	Chunk Sample	RC	Rock Core
ST	Slotted Tube Sample	USS	Undisturbed Shear Strength
PH	Sample Advanced Hydraulically	RSS	Remoulded Shear Strength
PM	Sample Advanced Manually		

SOIL TESTS

Qu	Unconfined Compression	LV	Laboratory Vane
Q	Undrained Triaxial	FV	Field Vane
Qcu	Consolidated Undrained Triaxial	C	Consolidation
Qd	Drained Triaxial		

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LOG OF BOREHOLE NO. 1

PROJECT Harris No. 1 Municipal Drain
LOCATION South-West Oxford, Ontario
BORING METHOD Continuous Flight Hollow Stem Augers
BORING DATE: 03/08/2012
PML REF.: 12KF033
ENGINEER R. Agahzadeh
TECHNICIAN D. Brice

GROUND ELEVATION 51.10

SOIL PROFILE

DEPTH in METRES	ELEVATION	DESCRIPTION
0.0	51.10	FILL: Dense brown sand and gravel, trace silt, damp
0.60	50.50	becoming dark brown to grey clayey silt, some sand, some gravel, DTPL
1.50	49.60	TOPSOIL: Dark grey to black sandy silt, some gravel, contains organic matter, moist
2.6	48.5	SAND: Compact to dense grey sand, some gravel, some silt, saturated
4.7	46.5	SILTY CLAY TILL: Stiff to very stiff grey silty clay, trace sand, trace gravel, DTPL, occasional silty sand seams, wet
9.2	42.0	becoming hard
9.6	41.5	BOREHOLE TERMINATED AT 9.6 m

SAMPLES

NUMBER	TYPE	BLOWS/0.3m N - VALUES
1	SS	37
2	SS	9
3	SS	7
3A	GS	
4	SS	12
5	SS	31
6	SS	46
7	SS	18
8	SS	17
9	SS	11
10	SS	12
11	SS	46

SHEAR STRENGTH C_u (kPa): 50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
BLOWS/0.3M: 20 40 60 80

LIQUID LIMIT — W_L
PLASTIC LIMIT — W_P
WATER CONTENT — W
WATER CONTENT %: 10 20 30

UNIT WEIGHT γ kN/m³

GROUND WATER OBSERVATIONS AND REMARKS

GRAIN SIZE DISTRIBUTION (%) GR SA SI&CL

~1.0	18 46 36
~2.5	15 39 46
3.8	Sampler wet from 3.8 m.
~4.0	13 78 8
~6.0	0 2 98
9.6	Upon completion of drilling borehole caved to 3.4 m with free water at 2.9 m.

NOTES:

WATER LEVEL OBSERVED DURING / UPON COMPLETION OF DRILLING
WATER LEVEL MEASURED IN MONITORING WELL
+ UNDISTURBED FIELD VANE
⊕ REMOLDED FIELD VANE
⊛ LAB SHEAR TEST
▲ POCKET PENETROMETER
◆ POCKET TORVANE
CHECKED BY K.P

Peto MacCallum Ltd.
CONSULTING ENGINEERS

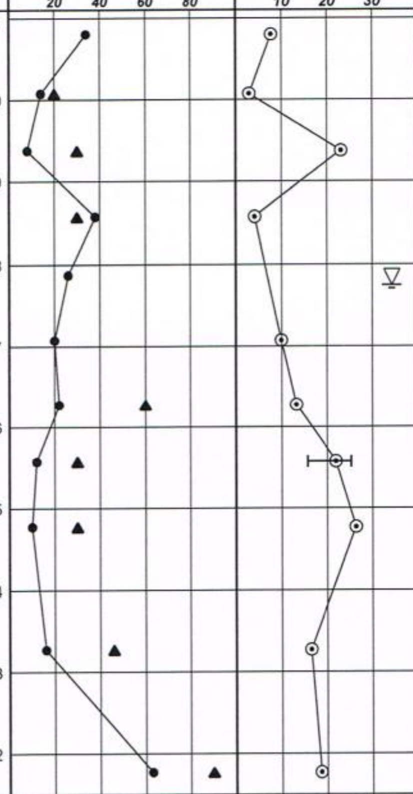
LOG OF BOREHOLE NO. 2

PROJECT Harris No. 1 Municipal Drain
LOCATION South-West Oxford, Ontario
BORING METHOD Continuous Flight Hollow Stem Augers
BORING DATE: 03/08/2012
PML REF.: 12KF033
ENGINEER R. Agahzadeh
TECHNICIAN D. Brice

GROUND ELEVATION 51.10

DEPTH in METRES / ELEV.	SOIL PROFILE DESCRIPTION
0.45 / 50.65	FILL: Dense brown sand and gravel, trace silt, damp
1.50 / 49.60	becoming stiff brown clayey silt, trace sand, trace gravel, DTPL
2.6 / 48.5	TOPSOIL: Dark grey to black sandy silt, some gravel, rootlets, contains organic matter, moist
3.1 / 48.1	SAND: Compact grey sand, gravelly to some gravel, some silt, wet
4.6 / 46.6	becoming saturated
5.3 / 45.8	SILTY CLAY TILL: STiff to very stiff grey silty clay, trace sand, trace gravel, DTPL
9.2 / 42.0	becoming APL
9.6 / 41.5	becoming hard, occasional silty sand seam, wet
	BOREHOLE TERMINATED AT 9.6 m

SAMPLE NUMBER	TYPE	BLOWS/0.3m N-VALUES
1	SS	34
2	SS	14
3	SS	8
4	SS	38
5	SS	26
6	SS	20
7	SS	22
8	SS	12
9	SS	10
10	SS	16
11	SS	63



UNIT WEIGHT γ kN/m³

GROUND WATER OBSERVATIONS AND REMARKS — GRAIN SIZE DISTRIBUTION (%) GR SA SI&CL

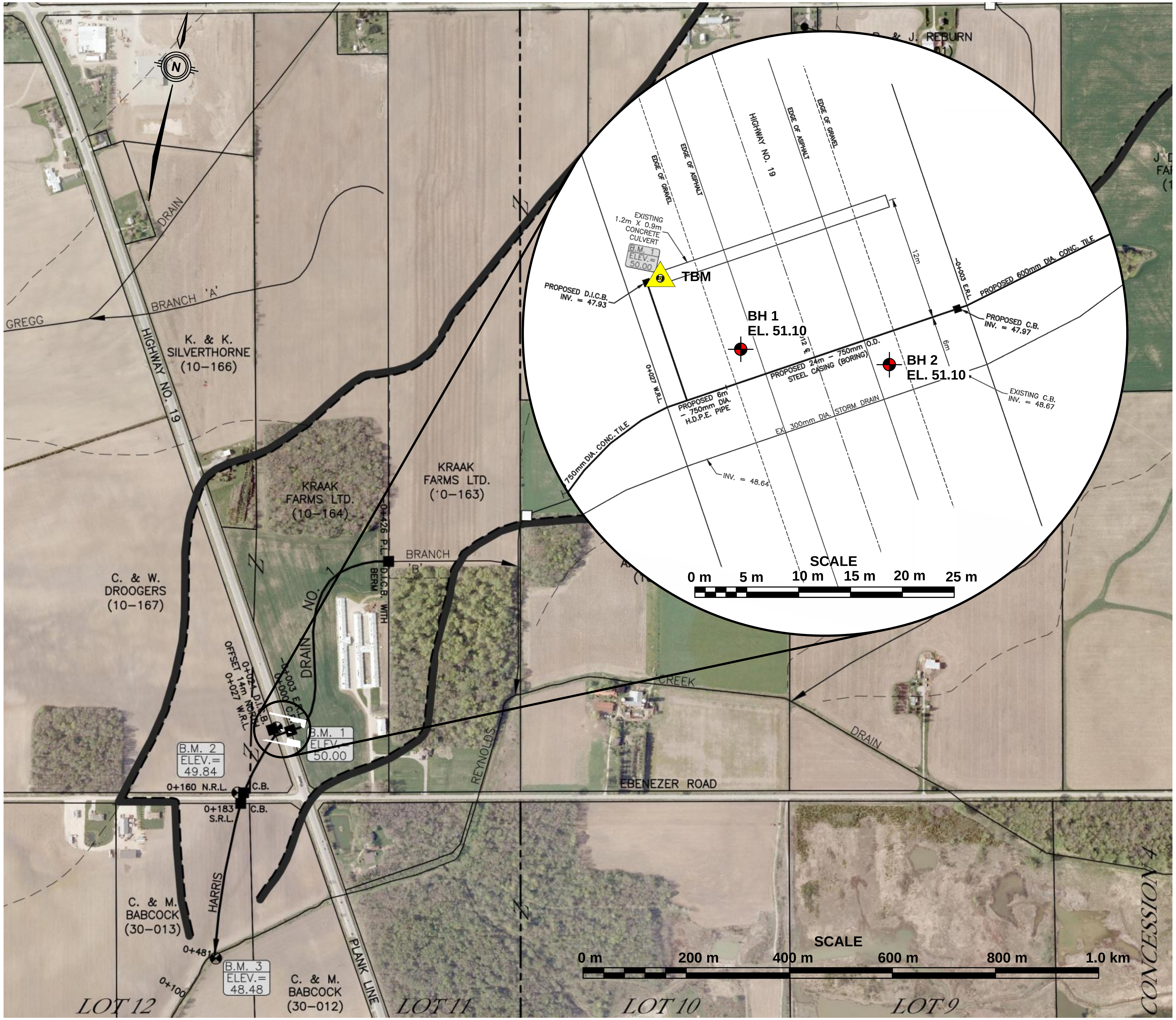
- Sampler wet from 3.8 m.
- Sample 6: 33 61 6
- Sample 8: 0 1 98
- Upon completion of drilling borehole caved to 6.3 m with free water at 3.4 m.

NOTES:

WATER LEVEL OBSERVED DURING / UPON COMPLETION OF DRILLING
WATER LEVEL MEASURED IN MONITORING WELL

\+ UNDISTURBED FIELD VANE
⊕ REMOLDED FIELD VANE
⊛ LAB SHEAR TEST
▲ POCKET PENETROMETER
◆ POCKET TORVANE

CHECKED BY K.P



KEY PLAN

LEGEND:

BOREHOLE

TEMPORARY BENCHMARK (TBM) :
TOP CENTRE DOWNSTREAM END OF CONCRETE BOX CULVERT FROM DIETRICH ENGINEERING PROJECT 1069, DRAWING 1
ELEVATION 50.00 (METRIC, LOCAL)

REFERENCE:

BOREHOLE LOCATION PLAN REPRODUCED FROM DRAWING SUPPLIED BY CLIENT.

NOTE:

THE INFERRED STRATIGRAPHY REFERRED TO IN THE REPORT IS BASED ON THE DATA FROM THESE BOREHOLES SUPPLEMENTED BY GEOLOGICAL EVIDENCE. THE ACTUAL STRATIGRAPHY BETWEEN THE BOREHOLES MAY VARY.

DIETRICH ENGINEERING LIMITED

HARRIS NO. 1 MUNICIPAL DRAIN

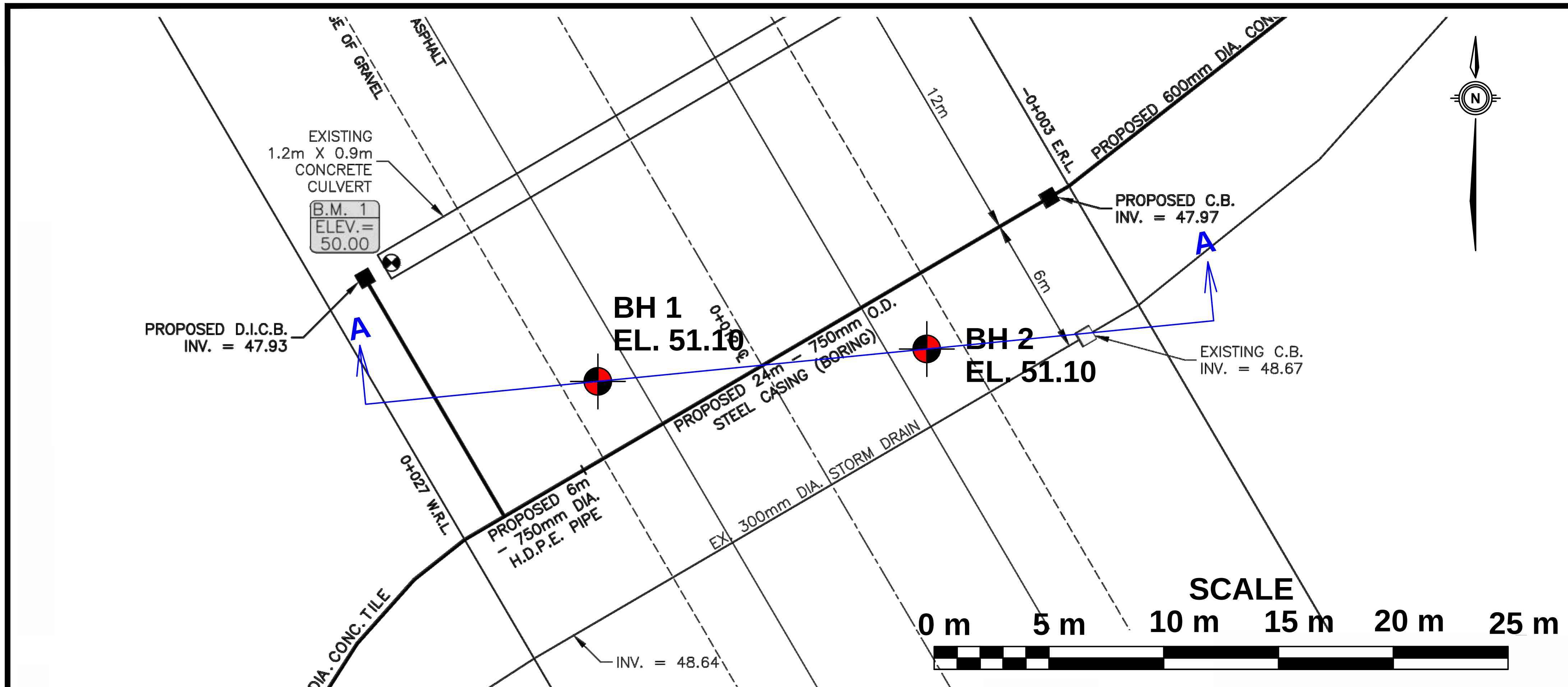
HIGHWAY 19, SOUTH-WEST OXFORD, ONTARIO

GEOCRES NO. 40I15-41

BOREHOLE LOCATION PLAN

Peto MacCallum Ltd.
CONSULTING ENGINEERS

DRAWN	D. BRICE	DATE	SCALE	PML REF.	DWG. NO.
CHECKED	K. PEJMAN	NOVEMBER 2012	AS SHOWN	12KF033	1
APPROVED	M. MOLODECKI				



KEY PLAN

LEGEND:

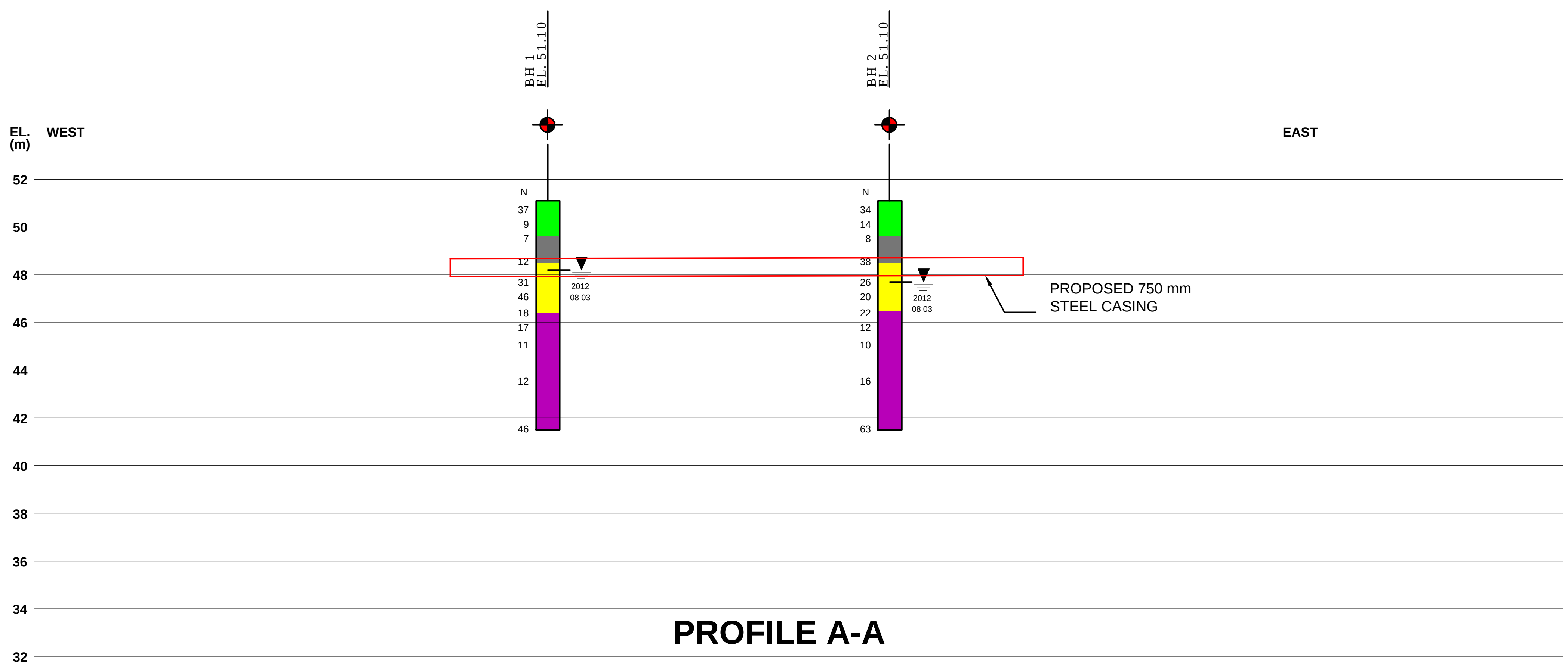
- BOREHOLE LOCATION
- FILL
- TOPSOIL
- SAND
- SILTY CLAY TILL

REFERENCE:

HYDROGEOLOGICAL PROFILE REPRODUCED FROM DRAWING SUPPLIED BY CLIENT.

NOTE:

THE INFERRED STRATIGRAPHY REFERRED TO IN THE REPORT IS BASED ON THE DATA FROM THESE BOREHOLES SUPPLEMENTED BY GEOLOGICAL EVIDENCE. THE ACTUAL STRATIGRAPHY BETWEEN THE BOREHOLES MAY VARY.



PROFILE A-A

DIETRICH ENGINEERING LIMITED

HARRIS NO. 1 MUNICIPAL DRAIN

HIGHWAY 19, SOUTH-WEST OXFORD, ONTARIO

GEOCRES NO. 40I15-41

SOIL PROFILE DRAWING

Peto MacCallum Ltd.
CONSULTING ENGINEERS

DRAWN	D. BRICE	DATE	SCALE	PML REF.	DWG. NO.
CHECKED	K. PEJMAN	NOVEMBER 2012	AS SHOWN	12KF033	2
APPROVED	M. MOLODECKI				

APPENDIX A

MINISTRY OF TRANSPORTATION'S
"GUIDELINES FOR FOUNDATION ENGINEERING – TUNNELLING SPECIALTY
FOR CORRIDOR ENCROACHMENT PERMIT APPLICATION"

Guidelines For Foundation Engineering – Tunnelling Specialty
For Corridor Encroachment Permit Application

These guidelines specify MTO's minimum requirements for the Foundation Engineering – Tunnelling Specialty component of submissions from proponents of development within the Ministry of Transportation's (MTO) corridor permit control area. The Foundation Engineering – Tunnelling Specialty component of submissions is a requirement for the permit application only and do not cover all the design requirements.

The complexity ratings of Foundations Engineering services are defined in Table 1.

Table 1: Complexity ratings for tunnelling specialty services

Highway Classification	Tunnel Excavation Diameter (ϕ)					
	$\leq$ 1 m		>1 m & $\leq$ 2 m		>2 m	
	Minimum Overburden Cover * (m)					
	$\geq 3\phi$ (or 1.5 m whichever is greater)	$< 3\phi$ (or 1.5 m whichever is greater)	$\geq 3\phi$	$< 3\phi$ (or 1.5 m whichever is greater)	$\geq 3\phi$	$< 3\phi$ (or 1.5 m whichever is greater)
Kings Highway	**Low**	**Medium**	**Medium**	**High**	**High**	**High**
400 Series Freeway	**Medium**	**High**	**High**	**High**	**High**	**High**

*Minimum overburden cover is the vertical distance measured from the lowest ground elevation to the crown of the tunnel.

Foundations Engineering consultants that are registered in the MTO consultant acquisition system (RAQS) at complexity ratings identified in Table 1 are eligible to provide Foundations Engineering services for this project. Alternatively, the proponents may propose a Foundations Engineering consultant that is not registered in RAQS, in which case, the proponent must submit sufficient documentation to demonstrate that the consultant's qualifications meet or exceed the RAQS complexity requirements.

For Engineering Materials Testing and Evaluation, the consultant shall be qualified for Soil and Rock testing of complexity level at least equal to that identified for this project.

Consultant services shall be provided in accordance with the most recent editions of the Canadian Highway Bridge Design Code (CHBDC), and the 'Guideline for Professional Engineers Providing Geotechnical Engineering Services' published by the Professional Engineers of Ontario.

The designated principal contact identified for Foundations Engineering services by MTO shall sign, and where required, seal, all submissions and correspondence that are submitted to MTO.

Services include, but are not restricted to, conducting a site investigation that shall be of sufficient scope to verify design assumptions and to provide the contractor with adequate subsurface information for design and construction planning.

Sufficient subsurface (factual) information is required to determine the vertical and horizontal extent of subsurface materials (including both soil and rock) and their pertinent engineering properties and groundwater conditions.

Subsurface information is usually acquired by advancing boreholes, laboratory testing of soil samples and rock core samples, performing in-situ tests such as standard penetration tests, dynamic cone tests, and piezocone tests (CPTU) and test pits.

Minimum requirements for Subsurface Investigation and Recommendations

A minimum of one borehole shall be advanced at each end of tunnel crossing. The boreholes shall be located outside but within 2 m of the tunnel's excavated footprint.

Spacing between the boreholes shall not exceed 50 m. In case of larger spacing between the boreholes, additional boreholes shall be advanced except where significant traffic disruptions might occur and where consistent conditions are evident.

Boreholes shall be advanced to 3 tunnel diameters (excavated diameters) below invert. If bedrock is encountered earlier, the borehole shall advance to at least 3 m below the invert of tunnel into the bedrock.

The investigations, if required, shall be supplemented with additional and deeper boreholes to verify consistent conditions and existence of boulders within critical foundation zones.

Sampling and testing, consisting of Standard Penetration Test, thin wall tube sample, rock cores, and MTO Field Vane Test where appropriate, shall be conducted to develop a comprehensive subsurface model. Semi-continuous sampling at 0.75m (2.5ft) intervals is required within overburden; whereas, sampling interval of 1.5m (5.0ft) is required below the tunnel invert.

Where encountered, the bedrock-soil interface shall be determined by geological definition and not the by the material properties.

All aspects of implementation of means of subsurface investigations including, but not limited to, planning, licensing, construction, maintenance, abandonment, and reporting, shall be in accordance with Ministry of the Environment Regulation 903 and its amendments (the water well regulation under the OWRA).

Boreholes and piezometer tubes shall be backfilled with a suitable bentonite/cement mixture. Test pits shall be backfilled with suitable material and either re-vegetated or otherwise protected from erosion. Temporary open holes shall be adequately covered.

Holes in roads shall be backfilled as required to prevent future settlement and acceptably patched where pavement surfaces have been damaged. Backfilling requirements shall be described in the Foundation Investigation and Design Report.

Where encountered, artesian groundwater conditions shall be sealed. Details of the artesian condition and the sealing operation shall be included in the Foundation Investigation Report.

Fieldwork shall be carried out in accordance with the Occupational Health and Safety Act.

Traffic protection in accordance with MTO requirements shall be provided during the course of any field investigations. However, where significant traffic disruptions might occur, boreholes may be relocated or numbers reduced with MTO's approval.

The locations and ground surface elevations of all boreholes, test pits and soundings shall be surveyed and referred to fixed reference points and data. Locations are to be identified by co-ordinates (Northing and Easting). The vertical accuracy of survey readings shall be within 0.1m; whereas, horizontal accuracy shall be within 0.5m.

Minimum Laboratory Testing Requirements:

Laboratory testing shall consist of routine testing of 25% of samples. One routine lab test is defined as natural water content plus Atterberg Limit plus grain size distribution tests. Complex laboratory testing is defined by all other tests including compressive strength, shear strength, consolidation, permeability and triaxial testing. Laboratory testing requirements shall be supplemented with additional routine and complex tests if required to verify strata boundaries and properties and behaviour of critical subsurface zones.

Borehole Log Preparation and Foundation Drawing:

Borehole log sheets, figures and drawings shall be prepared in accordance with MTO standards. The Foundation Drawing shall consist of a plan showing the locations of all borings, test pits and soundings and various stratigraphical longitudinal profiles and stratigraphical cross-sections at each tunnel structure foundation element and groundwater levels.

Minimum Requirements for the Foundation Investigation and Design Report:

A Foundation Investigation and Design Report shall consist of the factual subsurface information (including the field and laboratory test information) and the recommendations required for foundation design.

The report shall be signed and sealed by two professional engineers, registered with the Professional Engineers of Ontario, representing the consulting firm; one of them shall be the firm's designated principal contact for MTO's Foundations Engineering projects.

- The Foundation Investigation component of the report shall contain:
- Site Description - including topography, vegetation, drainage, existing land use, and structures.
- Investigation Procedures - including site investigation and lab testing procedures.
- Description of Subsurface Conditions - including soil, boulders, rock and groundwater conditions.
- Miscellaneous Section - that identifies the name of the drilling company, the laboratory where testing was performed, the persons who carried out the field supervision, and those who wrote and reviewed the report.

The Foundation Design component of the report shall present discussion and recommendations for design. The consultant shall analyse field data and test results and make comprehensive and practical recommendations pertaining to temporary, interim and permanent conditions at the Project.

The consultant shall identify and evaluate all reasonable and appropriate alternatives for the proposed tunnel crossing. Alternatives may include, but not limited to, jack & bore, pipe jacking using TBM, pipe ramming, micro-tunnelling (if economically feasible), utility tunnelling using TBM (two pass system), Horizontal Directional Drilling (HDD)and cut and cover methods.

The consultant shall identify and present overview assessments of the advantages, disadvantages, costs and risks/consequences of alternative tunnelling methods in a table. The report should conclude a preferred alternative from foundation engineering and cost effectiveness perspective.

In the development and design of the preferred alternative, the Consultant shall, as applicable, address:

- impacts on the land use and property, traffic and transportation, and environment,
- length and diameter constraints
- control of face stability
- capability of boulder excavation
- evaluation of temporary and permanent support
- alignment control
- estimated settlements and heave and management of these deformations
- special access and egress requirements for TBM's and other similar equipment such as those used for the Jack & Bore method including recommendations for vertical shafts and jacking pits;
- shored and un-shored alternatives for open-cut excavation;
- groundwater control & dewatering;
- the long-term stability of the tunnel;

- relative rosts; and
- traffic management and contractor access for each alternative.

If borehole logs available from previous projects are included to meet the requirements of field investigations then the accuracy of subsurface information from these boreholes remains the responsibility of consultant except in situations where MTO specify the use of previous boreholes. Borehole logs from previous studies that are appended to the report shall be reformatted to meet the MTO's requirements.

The final foundation recommendations shall detail the geometric, material and strength properties of the new tunnel crossing plus the liner, bedding and backfill requirements, and slope and embankment restoration requirements. The invert elevation should be assessed in view of the subsurface conditions and the anticipated open face stability control.

The consultant is responsible for developing contract documents sufficient to implement the design. This typically includes:

- Contract specifications for materials and specialized construction activities, and
- Recommendations for methods of overcoming anticipated construction problems, in particular, those relating to dewatering, boulder excavation, alignment control and the stability of excavations and embankments. .

The consultant shall develop a detailed instrumentation and monitoring program that meets the requirements of these guidelines. (see Appendix for typical settlement monitoring guidelines).

The consultant is responsible for preparing Traffic Control Plans and to obtain approvals and an Encroachment Permit from the Ministry, which are required for lane closures necessary to install the settlement monitoring points.

The tunnelling consultant shall ensure that the foundations engineering component of the project is adequately reflected in the design drawings, specifications and related contract documents.

Written confirmation is required from the Proponent and the tunnelling consultant that the design package submitted to MTO have been reviewed by the tunnelling consultant and that all recommendations have been satisfactorily incorporated in the contract package.

APPENDIX: SETTLEMENT MONITORING GUIDELINES - TUNNELING

The purpose of settlement monitoring is to prevent damage to existing utilities and highway structures along the tunnel alignment. Ground settlement include settlement due to lost ground and dewatering/drainage.

Instrumentation Arrays

All measurement points shall be installed and surveyed before the start of excavation to establish benchmarks/baseline.

Surface Monitoring Points

Surface monitoring points will be installed to cover the whole length of the tunnel with in the right of way under the jurisdiction of MTO (Figure 1).

Surface monitoring points will be located at not greater than 5m intervals along the tunnel alignment. The surface monitoring will be identified using paint marks on the pavement. Surface monitoring points installed on the unpaved right of way shall be founded below frost penetration depths. The interval and/or marking of the points should be changed with MTO's approval where traffic disruptions might occur.

The final instrumentation plan should be finalised when Contractor's proposed construction method is available.

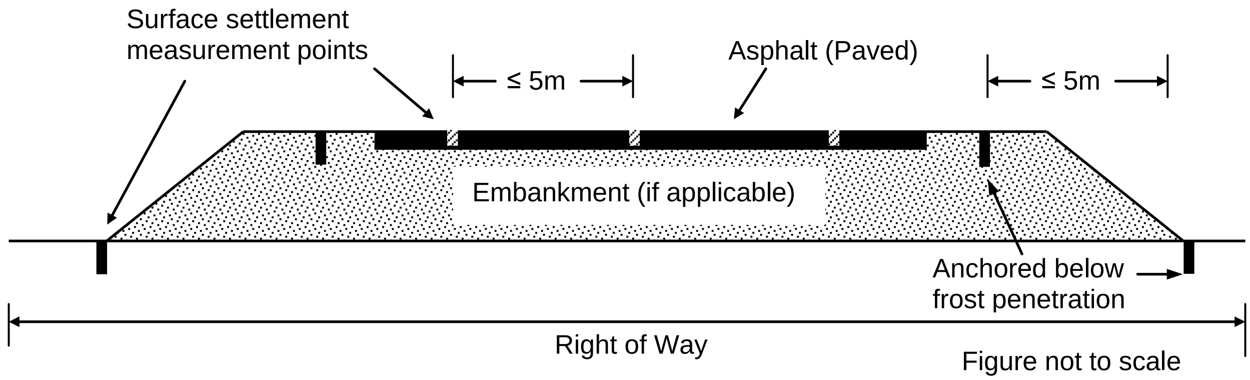


Figure 1: Typical configuration of surface settlement monitoring points along the tunnel alignment.

Condition Survey

A condition survey for the pavement will be carried out prior to commencement of construction and documented for the purpose of requirement of restoration. The condition survey shall document visible flaws such as cracks, distortions and deviations, heaves, and depressions. This surface survey will be completed during the installation of the monitors and again once the tunnel has been completed.

Reading Frequency

An average of at least two readings shall be taken to establish the initial conditions.

The reading and collection of data from the surface monitoring points shall be read and recorded by the Contractor during the construction period and after construction for period of at least 2 weeks provided that further settlement has stopped.

A minimum of three (3) sets of reading be taken daily, provided that movements are within anticipated limits. Otherwise, the frequencies should increase according to a pre-planned interval.

Monitoring of movements is required during work stoppages, such as during non-operation period (off-shifts) or weekends. A minimum of three (3) sets of readings should be taken daily.

Measurements of the monitoring points shall be reported promptly to MTO for review.

Data Collection and Data Transfer

A procedure is required to be established in consultation with MTO so that the monitoring data and the interpreted data will reach all parties as soon as necessary. The contract administrator/consultant and the Contractor should interpret monitoring data as needed for the purpose of on-going construction. The Foundation Engineer should be contacted for technical support to the prime Consultant in the interpretation of ground movements and review of the Contractor’s response when Review and Alert Levels are reached.

Criteria for Assessment

The acceptable surface settlement (or heave) will be according to criteria as specified below.

Baseline Reading – A baseline reading of the instrumentation shall be taken prior to commencement of the work. An average of at least two initial readings shall be recorded as baseline reading.

Review Level – A maximum value of 10 mm relative to the baseline readings is suggested for this project. If this level is reached, the method, rate or sequence of construction, or ground stabilization measures should be reviewed or modified to mitigate further ground displacements.

Alert Level – A maximum value of 15mm relative to the baseline readings is suggested for this project. If this level is reached, the Contractor shall cease construction operations and to execute pre-planned measures to secure the site, to mitigate further movements and to assure safety of public and maintain traffic.

Review of Contractor's Proposed Method

MTO, the Proponent's prime consultant and Foundation Engineer should review the Contractor's proposed method of construction. The proposed method should include a description of the potential loss of ground, and calculation of the maximum settlement in relation to the Contractor's procedure and equipment, alternative/remedial measures when review level of measurement is reached; and contingency/remedial measures when alert level of measurement is reached.

Contractor's Responsibility For Restoration and Warranty Provision

In addition to the monitoring program to assess the adequacy of the construction method to control potential ground movements and groundwater, the Contractor is responsible for reinstatement (such as surface paving) should movements or other surface distress occur, and provide a reasonable warranty period acceptable to MTO. Remedial measures shall be approved by MTO; however, MTO maintains the right to perform the maintenance at the proponent's expense.

Construction Monitoring

The Proponent shall retain a qualified Geotechnical Consultant to supervise the installation of surface settlement points on site and to provide direction, technical input and field inspection on this project.