MERLEX ENGINEERING LTD.

CONSULTING GEOTECHNICAL ENGINEERS

FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT

CULVERT STATION 13+454 – TWP. OF PERRY
GWP 324-00-00
MEL SITE A

Highway 518, From Highway 11,
Westerly 13.0 km, and
From Star Lake Road, Northerly 1.2 km

MTO Huntsville Area

MEL Ref. No.: 10/03/10034A January 20, 2011

Submitted to:

AECOM Canada Ltd.
189 Wyld Street
North Bay, Ontario
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Geocres No. 31E-307

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APPENDICES

1.0 INTRODUCTION

Merlex Engineering Ltd. (MEL) has been retained by AECOM Canada Ltd., on behalf of the Ministry of Transportation of Ontario (MTO), to carry out a foundation investigation for a culvert located at Station 13+454, Township of Perry. GWP 324-00-00 on Highway 518 passes through parts of the Townships of Perry and McMurrich and is located from the junction of Highways 11 and 518 westerly for 13.0 km and from Star Lake Road at Emsdale, northerly 1.2 km. This foundation investigation project involves the replacement of one 760 mm diameter CSP culvert in an embankment that is 5.7 m high, above the culvert invert at centerline.

The foundation investigation location was specified by the MTO in the RFP/TPM documentation Agreement No. 5007-E-0030. The terms of reference for the scope of work are outlined in MEL's proposal P-09-077, dated June 2009. The purpose of the investigation was to determine the subsurface conditions in the area of the culvert and along a possible detour route. MEL investigated the foundation area by the drilling of boreholes, carrying out in-situ tests, and performing laboratory testing on select samples.

2.0 SITE DESCRIPTION

The CSP culvert is located on Highway 518 at Station 13+454, Township of Perry. The topography at the site is generally of moderate relief and the flow through the culvert is from the south to north side of the embankment. The vegetation to the north of the embankment at this culvert location consists of scrub and grasses with occasional coniferous and deciduous trees, with a generally low lying and flat land. To the south of the embankment the vegetation consists of scrub and mature coniferous and deciduous trees, in generally low lying land. Gravel entrances are present, to the north and south of the embankment, (both up and down chainage from the culvert) which are constructed with fill to meet the grade of the existing highway embankment.

The existing highway embankment supports two undivided lanes of highway, running in an east-west direction. The existing road embankment is 5.7 m higher than the culvert invert at centerline, with the paved surface at elevation 316.3 m and the culvert invert at elevation 310.6 m. The embankment slopes are approximately 2.5H:1V and 2.2H:1V at the right and left slopes, respectively. At the culvert location, a visual review indicated no signs of embankment instability, and there were no obvious signs of settlement of the pavement structure at the culvert location. The culvert report states that the bottom of the right end of the culvert is rusted out with the left end submerged and approximately 75% of the culvert rusted out. A further review of this culvert, once it has been dewatered, is scheduled. A pole line and high pressure gas main parallel the highway alignment to the south (right).

2.1 Site Physiography and Surficial Geology

This Highway 518 project is located in the Geomorphic Sub-province known as the Muskoka Ridges and Pockets at the west boundary of the Algonquin Uplands. The topography on this section of Highway 518 is rolling. There are exposed bedrock ridges. At many locations, significant layers of earth overlay the bedrock and organic terrain was also observed. At this specific culvert site, native overburden consists generally of a thin veneer of silty clay overlying loose to compact silts with auger refusal (presumably bedrock) around elevation 302 m (9 m depth) at the culvert location.

Bedrock in the area, as indicated on OGS Map 2441, is of the Late to Middle Precambrian Era. The project area comprises of Metasediments (conglomerates, greywacke, arkose, calcareous sandstones and siltstones, shale and derived metamorphic rocks).

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out during the period of June 26 to July 1 and July 12, 2010, when eight (8) sampled boreholes were advanced. Three boreholes were undertaken at the culvert location at Station 13+454, Perry Township, with two at the ends of the existing culverts and one through the embankment. Five additional borings were advanced along the proposed detour alignment to the left (north) of the existing embankment.

The field investigation was carried out using a Bombardier mounted CME drilling rig equipped with hollow stem augers, standard augers, and routine geotechnical sampling equipment. Soil samples were obtained at regular intervals of depth using the standard 50 mm O.D. split spoon sampler advanced in accordance with the Standard Penetration Test (SPT) procedures (ASTM D-1586) at the borehole locations. The SPT method involves advancing a 50 mm diameter split spoon sampler with the force of a 63.5 kg hammer freely dropping 760 mm mounted in a trip (automatic) hammer. The number of blows per 300 mm penetration was recorded as the “N” value. At the boreholes, a Dynamic Cone Penetration Test (DCPT) was carried out to give a continuous plot of the soil resistance with depth. When cohesive deposits were encountered, the in-situ strength was measured using an “N” size vane, vane collar, and calibrated torque meter. All samples taken during this investigation were stored in labeled airtight containers for transport to our North Bay laboratory for visual examination and select laboratory testing.

Groundwater conditions in the open boreholes were observed and recorded during and immediately following completion of the individual boreholes. All open boreholes were backfilled upon completion with compacted auger cuttings, in the general order they were removed and, where necessary, bentonite pellet backfill was added to the boreholes to bring them up to grade.

The field work for this investigation was under the full time direction of a senior member of our engineering staff, who was responsible for locating the boreholes, clearing the borehole locations of underground services, in-situ sampling and testing operations, logging of the boreholes, labeling and preparation of samples for transport to our North Bay laboratory, plus overall drill supervision. All samples received a visual confirmatory inspection in our laboratory. Laboratory testing of select samples included routine testing for natural moisture content determination and particle size analysis. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix B), with a summary of results presented on the laboratory sheets in Appendix C (Figure Nos. L-1 to L-7).

The location of the individual boreholes were determined in the field using highway chainage (established by others) and offset relative to highway centerline. The MTO co-ordinates, northing and easting, were then established for the boring locations. Elevations contained in this report are referenced to a geodetic datum.

4.0 SUBSURFACE CONDITIONS

Details of the subsurface conditions revealed by the investigation program are presented on the enclosed Record of Borehole Logs (Appendix B) and on Figure No. A-1 (Appendix C). Please note that stratigraphic delineation presented on the borehole logs and soil strata plot are the results of non-continuous sampling, response to drilling progress, the results of SPT and

Dynamic Cone Penetration Test (DCPT) plus field observations. Typically such boundaries represent transitions from one zone to another and are not an exact demarcation of specific geological unit. Additional consideration should be given to the fact that subsurface conditions may vary markedly between adjacent boreholes and beyond any specific boring location, and are shown on the drawings for design purposes only. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. A-1 to A-8 were recorded at 311.0, 316.2, 312.0, 314.8, 315.2, 313.6, 315.3, and 314.2 m, respectively.

4.1 Culvert, Station 13+454, Township of Perry – MEL SITE A

A plan, profile and cross section showing the borehole locations and stratigraphic sequences is shown on Figure No. A-1, Appendix C. During the course of the exploration program, three (3) sampled boreholes were put down at the culvert station, with Borehole Nos. A-1 and A-3 advanced at the culvert ends, and Borehole No. A-2, advanced through the embankment.

4.1.1 Organics

At Borehole No. A-1, some 150 mm of free water was encountered at surface, underlain by a surficial layer, some 450 mm thick of black fine fibrous rooty organics. At Borehole No. A-3 some 150 mm of grass and surficial organics was encountered.

4.1.2 Silty Clay

Underlying the surficial organics at Borehole Nos. A-1 and A-3, a deposit of brown silty clay containing trace to some sand was penetrated. The natural moisture content from samples of this deposit was in the order of 28 to 36%. Hydrometer analysis was carried out on three (3) samples of this deposit, the results of which indicated 0% gravel size particles, 2 to 18% sand size particles, 59 to 71% silt size particles, and 23 to 32% clay size particles (Figure No L-1,

Appendix C). Atterberg Limit testing was completed on three (3) samples of this deposit. The results indicated a plastic limit of 18 to 25% and a liquid limit of 31 to 37%, resulting in a USCS classification of CL to CI (Figure No. L-7, Appendix C). Based on field vane tests, which all indicated a shear strength of greater than 100 kPa, the consistency of this deposit was described as very stiff. This deposit was encountered to depths of 1.5 and 2.3 m below ground surface at Borehole Nos. A-1 and A-3, respectively (elevation 309.5 and 309.7 m, respectively).

4.1.3 Silt

Underlying the silty clay, at Borehole Nos. A-1 and A-3, a deposit of grey silt containing trace to some clay trace fine sand was penetrated. Natural moisture contents from samples of this deposit are in the order of 26 to 37%. Hydrometer analysis was carried out for six (6) samples of this deposit, the results of which indicated 0% gravel size particles, 1 to 7% sand size particles, 79 to 96% silt size particles, and 3 to 14% clay size particles (Figure No. L-2, Appendix C). Atterberg limit testing was carried out on the six samples and all samples were classified as non plastic. Based on the SPT values of 2 to 27 blows for 300 mm penetration, the compactness of this deposit was described as very loose to compact, generally compact. Auger refusal was encountered in this deposit at depth of 10.5 m below ground surface at Borehole No. A-3 (elevation 301.5 m).

4.1.4 Sand

Underlying the silt, at Borehole No. A-1, a deposit of silty fine sand containing trace gravel trace clay was penetrated at a depth of 7.3 m below grade (elevation 303.2 m). The natural moisture content from a sample of this deposit was in the order of 21%. Hydrometer analysis was carried out on one sample of this deposit, the results of which indicated 7% gravel size particles, 59% sand size particles, 32% silt size particles, and 2% clay size particles (Figure No. L-3, Appendix

C). Based on the SPT value of 48 blows per 300 mm penetration, the compactness of this deposit was described as dense. Auger refusal was encountered in this deposit at a depth of 8.7 m below ground surface (elevation 302.3 m).

4.1.5 Embankment Fill

At Borehole No. A-2, undertaken from the top of the embankment, a deposit of brown fine to medium sand containing trace silt trace gravel (fill) some 1.0 m in thickness was penetrated along the right shoulder. Natural moisture content from this sample was in the order of 5%. Auger refusal was encountered at a depth of 1.0 m. Two additional (unsampled) auger probes were advanced within 2 m of Borehole No. A-2 in an attempt to advance deeper into the embankment. Refusal was encountered at these auger probe locations at a depth of 1.0 and 1.1 m below ground surface. Based on drill response and previous a geotechnical investigation carried in this area, refusal was due to cobble/boulder sizes/rock fill. In addition, both embankment foreslopes had exposed blasted rock fill for the full face height. Refusal at Borehole No. A-2 was encountered at elevation 315.2 m. A series of geotechnical boreholes were advanced by MEL, from the top of the embankment between Stations 13+400 to 13+600. These boreholes refused on rock fill at depths of 0.7 to 1.2 m (see Geotechnical Borehole Logs, Appendix D).

4.2 Detour, Township of Perry – MEL SITE A

During the course of the exploration program, five (5) sampled boreholes were put down along the proposed detour alignment, with Boreholes Nos. A-4 to A-8 advanced to the left (north) of the existing embankment.

4.2.1 Organics

At Borehole Nos. A-5 and A-6, a surficial layer some 100 to 150 mm thick of grass (root mass) mixed with sand and gravel was encountered at surface.

4.2.2 Embankment Fill (Gravel Entrance)

At the surface at Borehole No. A-4, and underlying the grass and sand at Borehole No. A-5, a deposit of embankment fill, for a gravel entrance, was encountered. The fill varied in composition and was a heterogeneous mix of fine to medium sand trace to some silt trace clay to gravelly sand, to silt, trace to with clay trace fine sand. Trace asphalt was encountered in this deposit at a depth of 2.5 m below ground surface at Borehole No. A-4 and at a depth of 3.0 m in Borehole No. A-5. Wood pieces were also encountered at this depth at Borehole No. A-5. The natural moisture content from samples of this fill deposit was in the order of 8 to 33%. Gradation analysis was carried out on four (4) samples of this deposit, the results of which indicated 5 to 38% gravel size particles, 20 to 62% sand size particles, 11 to 51% silt size particles, and 1 to 24% clay size particles (Figure No. L-4, Appendix C). Atterberg Limit testing was carried out on two (2) samples of this deposit which exhibited plastic characteristics, the results of which indicated a liquid limit of 25 to 30% and a plastic limit of 16 to 20%, resulting in a USCS classification of CL (Figure No. L-7, Appendix C). Based on the SPT values of 0 (static weight of the hammer) to 95 blows per 300 mm penetration, the compactness of this deposit was highly variable and described as very loose to very dense, generally loose. This deposit extended to 3.8 and 5.5 m below ground surface at Borehole Nos. A-4 and A-5, respectively (elevations 311.0 and 309.7 m, respectively).

4.2.3 Rip Rap

At Borehole No. A-7, a deposit of rip rap/cobble and boulder sizes was encountered at surface. This deposit was encountered to depth of 1.0 m (elevation 314.3 m).

4.2.4 Sand

At Borehole No. A-8, a deposit of brown fine sand trace to some gravel trace silt containing occasional cobbles was encountered. The natural moisture content of samples of this deposit was in the order of 13 to 14%. Auger refusal was encountered at depth of 0.7 m below ground surface (elevation 313.5 m).

4.2.5 Silty Clay

Underlying the fill at Borehole No. A-4, and at surface at Borehole No. A-6, a deposit of grey silty clay was encountered. The natural moisture content from samples of this deposit was in the order of 41 to 43%. Based on field vane tests, which indicated a shear strength of greater than 100 kPa, the consistency of this deposit was described as very stiff. This deposit was encountered to depths of 5.6 and 1.2 m at Boreholes Nos. A-4 and A-6, respectively (elevations 309.2 and 312.4 m, respectively).

4.2.6 Silt

Underlying the fill at Borehole No. A-5, and underlying the silty clay at Borehole Nos. A-4 and A-6, and underlying the rip rap at Borehole No. A-7, a deposit of grey silt trace fine sand trace clay was encountered. The natural moisture content from samples of this deposit was in the order of 24 to 36%. Hydrometer analysis was carried out on four (4) samples of this deposit, the results of which indicated 0% gravel size particles, 0 to 2% sand size particles, 89 to 95% silt size particles, and 4 to 9% clay size particles (Figure No. L-5, Appendix C). Atterberg limit testing was carried out on the six samples and all samples were classified as non plastic. Based on the SPT values of 1 to 18 blows per 300 mm penetration, the compactness of this deposit was described as very loose to compact, generally loose. This deposit was encountered to a depth of 11.6 m below ground surface at Borehole No. A-5 (elevation 303.7 m). Whereas auger refusal was encountered in this deposit at depths of 12.0, 7.4, and 7.5 m below ground surface at Boreholes Nos. A-4, A-6, and A-7, respectively (elevations 302.8, 306.2, and 307.8 m, respectively).

4.2.7 Sand

Underlying the silt at Borehole No. A-5, a deposit of grey fine to medium sand with silt trace gravel trace clay was encountered. The natural moisture content from samples of this deposit was in the order of 14%. Hydrometer analysis was carried out on one sample of this deposit, the results of which indicated 8% gravel size particles, 66% sand size particles, 24% silt size particles, and 2% clay size particles (Figure No. L-6, Appendix C). A SPT value of 77 blows per 175 mm penetration was recorded, however this elevated STP result was due to the resistance of the underlying refusal material and not representative of the compactness of the thin sand layer. Auger refusal was encountered at depth of 12.5 m (elevation 302.5 m) in this deposit.

4.3 Groundwater Conditions

Groundwater and cave-in levels in the open boreholes were measured during the advance of the individual boreholes and upon completion. These levels were recorded on the individual Record of Borehole Log Sheets (Appendix B). The groundwater level was recorded at 0 (at surface) to 4.7 m depth in the boreholes at the toe of the embankment, with Borehole No. A-5 being dry following completion. At the culvert inlet (Borehole No. A-3) and outlet (Borehole No. A-1) the groundwater level in the open boreholes was recorded at elevation 311.4 and 311.0 m, respectively, at the time of this field investigation. These groundwater levels will fluctuate seasonally.

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M. A. Merleau, P. Eng.
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5.0 DESIGN COMMENTS AND RECOMMENDATIONS

5.1 General

The existing 760 mm CSP culvert, located at Station 13+454 in the Township of Perry, was identified as requiring replacement in the RFP. It is understood that the preferred method of culvert replacement was to detour the traffic to the north of the existing highway, along the route covered by Borehole Nos. A-4 to A-8. The adjacent culvert, at Station 13+543, was also identified in the RFP for replacement. Considering the close proximity of the two culverts, one continuous detour, on the left, would be constructed to allow replacement of both culverts. Ground conditions for the adjacent culvert replacement and detour are discussed in the FIDR for Culvert Station 13+543, Twp of Perry, Geocres No. 31E-308, produced under a separate cover. The embankment at the location of Culvert Station 13+454 is 5.7 m in height above the culvert invert at centerline. Based on data from this foundation investigation and the geotechnical investigation, which was also carried out by MEL, the embankment supporting the pavement structure has been constructed using granular soils (pavement structure) over rock fill.

The existing embankment supports two lanes of traffic and shoulders for a platform width of some 9.5 m and the culvert invert, at the centerline, is 5.7 m below the embankment grade. As such, the platform width is insufficient to allow the open cut method with traffic restricted to a single lane under a continuous 24 hour operation. Other methods of culvert installation, such as jack and bore or pipe ramming have been considered but are more costly in comparison to open cut with detour. In addition the gas pipeline paralleling the south toe of slope would have a major impact when using trenchless methods. Table A, Appendix E summarizes the advantage and disadvantages of various methods of culvert installation. Generally the next most cost effective method of culvert installation, if lining cannot be carried out, is to construct a detour/embankment widening. This method has been identified in the RFP and is discussed in the following.

It is anticipated that the existing culvert will be replaced using either a flexible or a rigid pipe of similar section, as the bottom of the existing culvert is rusted out at both ends. The decision on the type of culvert to be used will be made at the construction stage.

5.2 Foundation Consideration

The existing embankment is constructed of granular soil (pavement structure) overlying rock fill. At the culvert location, a visual review indicated no obvious signs of settlement of the pavement structure at the culvert location. The soil, below the culvert inlet end/south toe of slope (Borehole No. A-3) consists of a deposit of very stiff silty clay overlying a generally compact stratum of silt. Refusal was encountered to the south of the culvert at 10.5 m below ground surface (elevation 301.5 m). To the north of the existing culvert (outlet), a thin deposit of peat some 0.5 m in thickness was encountered. The culvert is founded in the deposit of very stiff silty clay, overlying the generally compact deposit of silt underlain by a deposit of sand. Refusal was encountered to the north of the culvert at 8.7 m below ground surface (elevation 302.3 m).

The existing 760 mm CSP inlet and outlet (elevations 310.2 and 311.0 m) are in the upper deposit of very stiff silty clay. The consistency of this deposit is adequate to support a properly bedded culvert. For a culvert founded at a similar invert elevation in the existing embankment fill a factored bearing resistance at ULS of 300 kPa can be used. A geotechnical reaction a SLS of 150 kPa reflects settlement considerations of the preloaded zone below the existing culvert and a settlement estimate of less than 25 mm.

To the north of the embankment, up chainage from the location of the existing culvert (at Borehole Nos. A-4 and A-5), there is an embankment supporting a gravel entrance. The embankment fill consists of surficial granular materials overlying a random mix of granular soils and earth. This fill was overlying the native very stiff silty clay at Borehole No. A-4. Underlying the silty clay at Borehole No. A-4 and underlying the embankment fill at Borehole No. A-5, a deposit of silt was encountered, overlying a deposit of sand at Borehole No. A-5. Auger refusal was encountered at a depth of 12.0 and 12.5 m below ground surface, at Boreholes Nos. A-4 and A-5 respectively (elevations 302.8 and 302.7 m, respectively). To the north of the embankment, down chainage of the culvert (Borehole Nos. A-6 to A-8), the soils consisted of a deposit of silty clay overlying a silt deposit at Borehole No. A-6, rip rap overlying a silt deposit at Borehole No. A-7, and a thin deposit of sand at Borehole No. A-8. Auger refusal was encountered at a depth 7.4, 7.5, and 0.8 m below ground surface, at Borehole Nos. A-6 to A-8, respectively (elevations 306.2, 314.3, 313.5 m, respectively).

The native mineral soils, below the surficial organics and entrance road fill, are competent to support the load associated with a detour embankment in the order of 4 to 5 m in height. This detour will have to accommodate the existing entranceways to the north.

5.3 Culvert Subgrade Preparation

Present plans call for a culvert replacement using open cut excavation techniques with traffic detoured to the north of the embankment. If the existing culvert section has not collapsed and there are no major obstructions along the length, lining the existing could be considered, provided it satisfies the hydraulic requirements. Lining would also be appropriate from a foundation perspective.

The embankment fill soils consist of granular materials (pavement structure) over rock fill. A review of the condition of the pavement surface, at the culvert location, revealed some longitudinal and transverse asphalt cracking, however no past patching, or settlement was observed, which indicates that the culvert and embankment fill has generally performed well in this area.

Considering the consistency of the silty clay and the compactness of the cohesionless material, as well as the preloaded state of the founding soils, combined with no new net load increase, long term settlement will be negligible. As such, installing the culvert on a camber will not be required at this site.

With an open cut installation, provide a Class B bedding as per OPSD 802.031 with a Granular A bedding material for a rigid pipe. If a flexible culvert is used for replacement embedment material can consist of Granular B Type I placed in accordance with OPSD 802.010. Since it is unknown, at the detailed design stage, what type of culvert will be used, we suggest that Granular A material be used for embedment and bedding, as well as cover in consideration of the minimal quantities required.

The existing embankment material, which contains rock fill, could be used as trench backfill if backfilled as per the attached Sketch SK-1, Appendix E.

A free draining granular material is recommended as appropriate cover and backfill to the culvert in order to insure the prevention of hydrostatic pressure build-up. When backfilling, the embankment fill should be placed in a balanced manner on the outer sides of the culvert.

Lateral earth pressures should be computed in accordance with the Canadian Highway Bridge Design Code (CHBDC). The design parameters are as follows:

	Granular A	**Granular B Type I**	**Rock Fill**
Angle of Internal Friction (degrees)	35	30	43
Unit weight (KN/m^3)	22	20	18.5
Active earth pressure (Ka)	0.27	0.33	0.19
At-rest earth pressure (Ko)	0.43	0.50	0.32

For rigid structures, such as precast concrete pipes, deflection cannot occur, as such the “at-rest” condition (Ko) applies. For flexible structures, such as CSP culverts, deflection can occur, as such the “active” condition (Ka) applies. The soils encountered in the embankment section are essentially cohesionless fill and falls within Soil Group I Classification when calculating earth pressures in accordance with Section 7 of the CHBDC.

5.4 Excavation and Embankment Reconstruction

All excavations greater than 1.2 m in depth must be sloped or shored in accordance with the Occupational Health and Safety Act Regulations for Construction Projects. Excavation for installation of the culvert will penetrate the existing embankment fills, which consist predominately of rock fill. Temporary open excavations will be stable, above the groundwater table, at an angle of 1H: 1V, as the embankment soils are considered a Type 3 soil as defined in the Occupational Health and Safety Act and Regulations for Construction. However, due to the random nature and possible large size pieces of rock (cobble, boulder sizes/rock fill), the temporary excavations may have to be cut back to a shallower angle in localized areas, depending upon rock fill size. Below the prevailing groundwater table, the slopes of open excavations will have to be flattened to 2H:1V or possibly shallower depending upon the method of dewatering employed.

Bedrock was not encountered within the anticipated depth of excavation, therefore bedrock excavation and/or blasting operations are not anticipated.

Excavations must be maintained in an unwatered condition during excavation and foundation construction and every reasonable effort must be made to prevent disturbing the founding subgrade. The groundwater level was measured between elevations 311.0 and 311.4 m at the boreholes at the culvert ends at the time of this investigation. Installation of the culvert replacement will require excavation between elevations 310.0 and 310.5 m (north and south end, respectively). Groundwater control, in accordance with OPSS 517 and 518, will be required to maintain a stable subgrade during the culvert extension installation. Local temporary sandbagging, at the inlet and outlet, combined with installation of filtered sumps and pumping from the base of the excavation, at a minimum, may be required to maintain the excavation in an unwatered condition during subgrade preparation. Based on the borehole located at the outlet (Borehole No. A-1), a fine fibrous peat/organics extending to depth 0.5 m below ground surface was encountered. Excavation of the peat/organics beyond the culvert end may be required to positively found the temporary sandbag dam and successfully control the groundwater. Ultimately, the method of dewatering will be the choice of the contractor, however the importance of maintaining the subgrade in an unwatered stable condition during excavation and foundation construction cannot be stressed enough.

5.5 Embankment Stability

The existing embankment platform is two lanes in width. A single lane detour will be constructed to allow for open cut construction at this culvert station. Temporary widening for staged construction will be carried out to the north. A thin layer of peat, extending to 0.5 m in depth at Borehole No. A-1, was identified along the route of the possible detour. Considering the temporary nature of the detour and embankment height, stripping of this relatively thin deposit will not be necessary as it will be displaced or mixed in with the embankment fill material during placement. This temporary detour will be removed following installation of the culvert. It is anticipated that granular fills will be used to construct the detour. Embankment slopes should be constructed to a 2H:1V slope.

To confirm the stability of the proposed detour during construction, a slope stability analysis was carried out on the embankment cross-sections at Station 13+454 with the widening constructed of granular fill, using the commercially available program SLOPE/W Version 4.23 produced by Geo-slope International. The factor of safety is defined as the ratio of the forces tending to resist failure to the driving forces tending to cause failure. The factor of safety for a failure arc through the underlying native soils (very stiff silty clay and compact silt) was calculated to be in the order of 2.4, which in this case is sufficient (see Figure No. S-1, Appendix E).

6.0 CLOSURE

Information provided in this report is valid only at the locations described above. Any assumptions of continuity of soil stratigraphy between boreholes, as shown on the enclosed cross-sections, is intended as an aid for design purposes only and does not constitute a statement of existing conditions for contractual or construction purposes. Field investigation was carried out using a CME drill rig mounted on a Bombardier carrier owned by Chrisdamat Management Ltd. The report was prepared by Mr. J. R. Berghamer, P. Eng and reviewed by the firm's principal and MTO designate Mr. M. A. Merleau, P. Eng.

Details of the investigation, the material analysis and recommendation in this report are considered to be complete. However, should any questions arise, please do not hesitate to contact the undersigned.

MERLEX ENGINEERING LTD.

M. A. Merleau, P. Eng.
Principal

J. R. Berghamer, P. Eng.

Z:\PROJECT FILES\2010\10034 - PAVE & FDN, Hwy 518 Sprucedale (AECOM)\`FOUNDATION\Reports\FINAL\Final - Site A - Station 13+454 - Twp of Perry\10034A- FINAL FIDR, Hwy 518 GWP 324-00-00 - SITE A, Culvert 13+454.doc

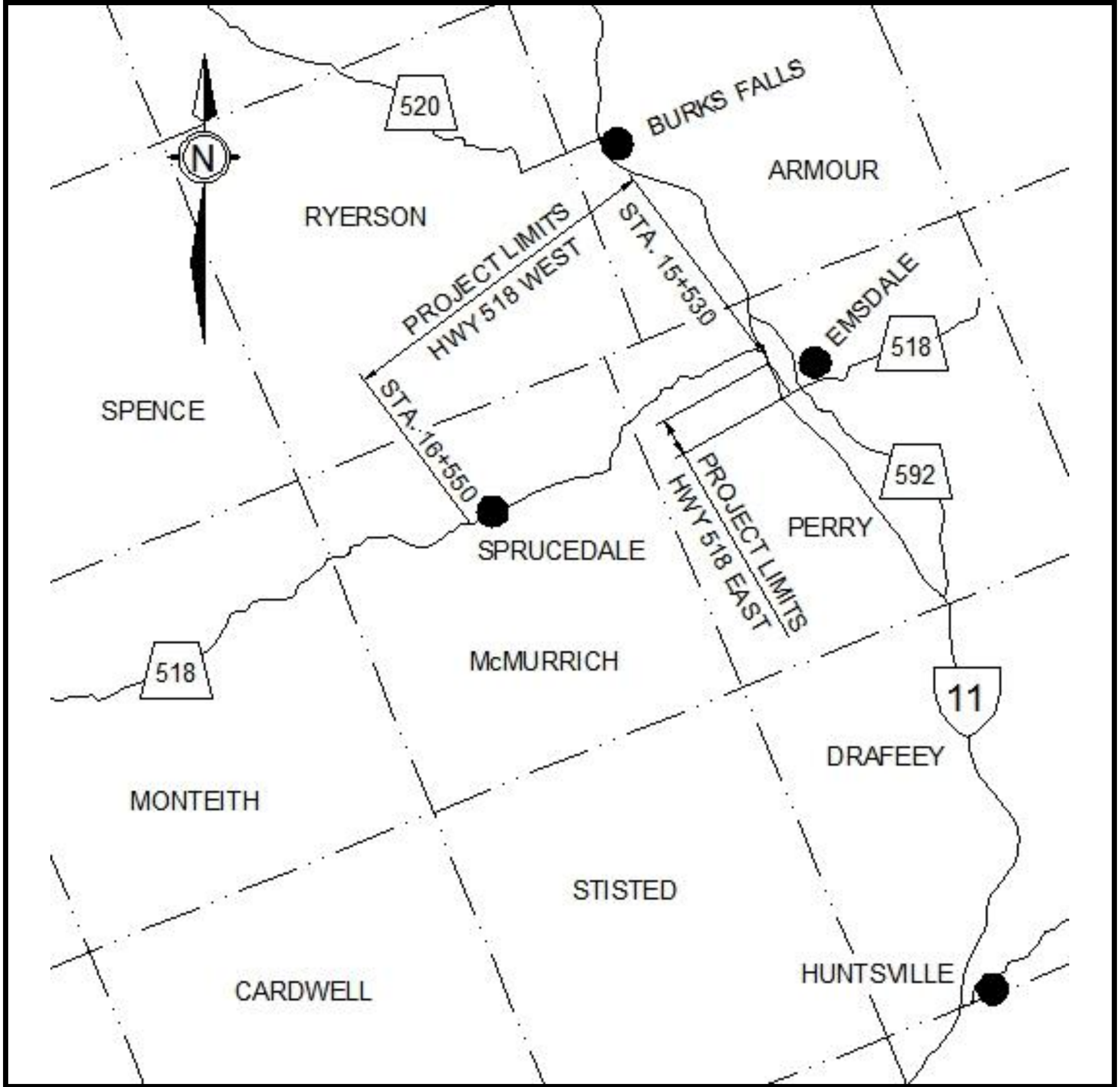
APPENDIX A

Figure No. 1: Key Plan

KEY PLAN

Figure No. 1

NOT TO SCALE



FINAL
FOUNDATION INVESTIGATION
AND DESIGN REPORT
GWP 324-00-00

Highway 518, From Highway 11, Easterly
Easterly 13.0 km and From
Star Lake Road Northerly 1.2 km

MEL Ref. No.: 10/03/10034A January 2011

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APPENDIX B

Enclosure No. 1: List of Abbreviations and Symbols

Enclosure Nos. 2 to 9: Record of Borehole Sheets

Enclosure No. 1

LIST OF ABBREVIATIONS & DESCRIPTION OF TERMS

The abbreviations and terms, used to describe retrieved samples and commonly employed on the borehole logs, on the figures and in the report are as follows:

1. ABBREVIATIONS

AS	Auger Sample
CS	Chunk Sample
DS	Denison type sample
FS	Foil Sample
HB	Hammer Bouncing
NFP	No Further Progress
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
RC	Rock core with size & percentage of recovery
SS	Split Spoon
ST	Slotted Tube
TO	Thin-walled, open
TP	Thin-walled, piston
WH	Sampler Advanced by static weight (weight of hammer and/or rods)
WS	Wash Sample

2. PENETRATION RESISTANCE/"N"

Dynamic Cone Penetration Test (DCPT):

A continuous profile showing the number of blows for each 300 mm of penetration of a 50 mm diameter 90° point cone driven by a 63 kg hammer falling 760 mm.

Plotted as ——●——●——●——●

Standard Penetration Test (SPT) or "N" Values

The number of blows of a 63 kg hammer falling 760 mm required to advance a 50 mm O.D. drive open sampler 300 mm.

3. SOIL DESCRIPTION

a) *Cohesionless Soils:*

"N" (blows/0.3 m)	*Relative Density*
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

3. SOIL DESCRIPTION (Cont'd)

b) *Cohesive Soils:*

Undrained Shear Strength (kPa)	*Consistency*
Less than 12	very soft
12 to 25	soft
25 to 50	firm
50 to 100	stiff
100 to 200	very stiff
over 200	hard

c) *Method of Determination of Undrained Shear Strength of Cohesive Soils:*

+ 3.2	- Field Vane test in borehole. The number denotes the sensitivity to remoulding.
D	- Laboratory Vane Test
¨	- Compression test in laboratory

For a saturated cohesive soil the undrained shear strength is taken as one-half of the undrained compressive strength.

4. TERMINOLOGY

Terminology used for describing soil strata is based on the proportion of individual particle sizes present in the samples (please note that, with the exception of those samples subject to a grain-size analysis, all samples were classified visually and the accuracy of visual examination is not sufficient to determine exact grain sizing):

Trace, or occasional	Less than 10%
Some	10 to 20%
With	20 to 30%
Adjective (i.e. silty or sandy)	30 to 40%
And (i.e. sand and gravel)	40 to 60%

5. LABORATORY TESTS

P	Standard Proctor Test
A	Atterberg Limit Test
GS	Grain Size Analysis
H	Hydrometer Analysis
C	Consolidation

SAMPLE DESCRIPTION NOTES:

1. **FILL:** The term fill is used to designate all man-made deposits of natural soil and/or waste materials. The reader is cautioned that fill materials can be very heterogeneous in nature and variable in depth, density and degree of compaction. Fill materials can be expected to contain organics, waste materials, construction materials, shot rock, rip-rap, and/or larger obstructions such as boulders, concrete foundations, slabs, abandoned tanks, etc.; none of which may have been encountered in the borehole. The description of the material penetrated in the borehole therefore may not be applicable as a general description of the fill material on the site as boreholes cannot accurately define the nature of fill material. During the boring and sampling process, retrieved samples may have certain characteristics that identify them as 'fill'. Fill materials (or possible fill materials) will be designated on the Borehole Logs. If fill material is identified on the site, it is highly recommended that testpits be put down to delineate the nature of the fill material. However, even through the use of testpits defining the true nature and composition of the fill material cannot be guaranteed. Fill deposits often contain pockets or seams of organics, organically contaminated soils or other deleterious material that can cause settlement or result in the production of methane gas. It should be noted that the origins and history of fill material is frequently very vague or non-existent. Often fill material may be contaminated beyond environmental guidelines and the material will have to be disposed of at a designated site (i.e. registered landfill). Unless requested or stated otherwise in this report, fill material on this site has not been tested for contaminants however, environmental testing of the fill material can be carried out at your request. Detection of underground storage tanks cannot be determined with conventional geotechnical procedures.

2. **TILL:** The term till indicates a material that is an unstratified, glacial deposit, heterogeneous in nature and, as such, may consist of mixtures and pockets of clay, silt, sand, gravel, cobbles and/or boulders. These heterogeneous deposits originate from a geological process associated with glaciation. It must be noted that due to the highly heterogeneous nature of till deposits, the description of the deposit on the borehole log may only be applicable to a very limited area and therefore, caution must be exercised when dealing with a till deposit. When excavating in till, contractors may encounter cobbles/boulders or possibly bedrock even if they are not indicated on the borehole logs. It must be appreciated that conventional geotechnical sampling equipment does not identify the nature or size of any obstruction.

3. **BEDROCK:** Auger refusal may be due to the presence of bedrock, but possibly could also be due to the presence of very dense underlying deposits, boulders or other large obstructions. Auger refusal is defined as the point at which an auger can no longer be practically advanced. It must be appreciated that conventional geotechnical sampling equipment does not differentiate between nature and size of obstructions that prevent further penetration of the boring below grade. Bedrock indicated on the borehole logs will be labeled 'possibly' or 'probable' etc. based on the response of the boring and sampling equipment, surrounding topography, etc. Bedrock can be proven at individual borehole locations, at your request, by diamond core drilling operations or, possibly, by testpits. It must also be appreciated that bedrock surfaces can be, and most times are, very erratic in nature (i.e. sheer drops, isolated rock knobs, etc.) and caution must be used when interpreting subsurface conditions between boreholes. A bedrock profile can be more accurately estimated, at the clients' request, through a series of closely positioned unsampled auger probes combined with core drilling.

4. **GROUNDWATER:** Although the groundwater table may have been encountered during this investigation and the elevation noted in the report and/or on the record of boreholes, it must be appreciated that the elevation of the groundwater table will fluctuate based upon seasonal conditions, localized changes, erratic changes in the underlying soil profile between boreholes, underlying soil layers with highly variable permeabilities, etc. These conditions may affect the design and type and nature of dewatering procedures. Cave-in levels recorded in borings give a general indication of the groundwater level in cohesionless soils however, it must be noted that cave-in levels may also be due to the relative density of the deposit, drilling operations etc.

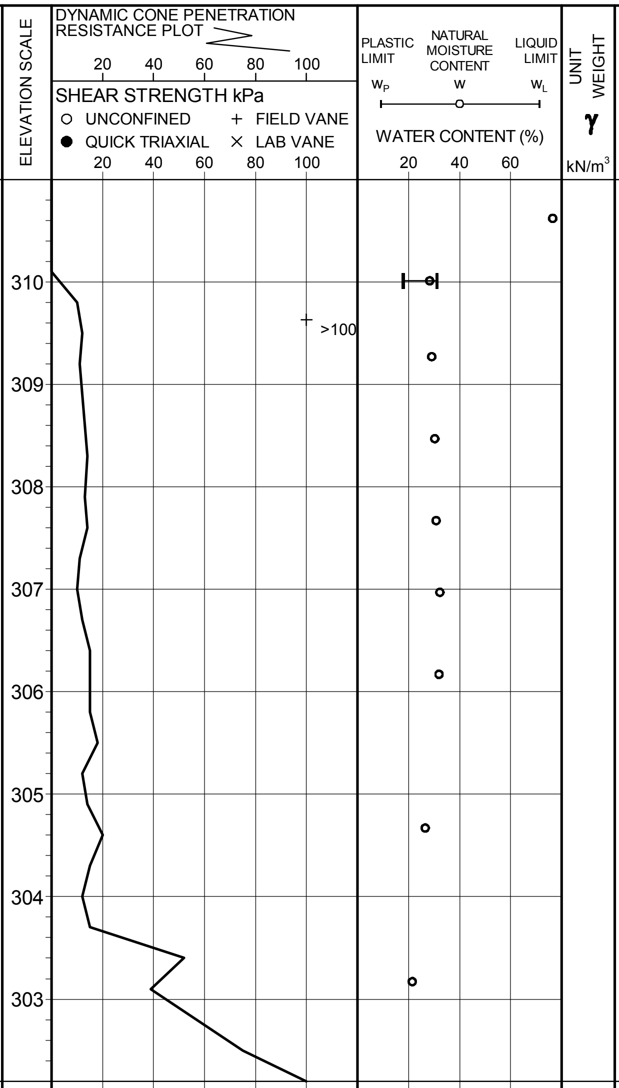
ENCLOSURE NO.:2 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. A-1

REFERENCE 10/03/10034 DATUM Geodetic LOCATION N 5044051.8 E 315552.0 - Perry Township ORIGINATED BY JL
PROJECT GWP 324-00-00 - Highway No. 518 - MEL Site A BOREHOLE TYPE CME 45B - Hollow Stem Augers COMPILED BY AT
CLIENT AECOM Canada Inc. DATE (Started/Completed) 10/6/28 - 10/6/28 TIME 2:30:00 PM CHECKED BY MAM

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
311.0	Ground Surface							
0.0	±150 mm surface water							
310.5 0.5	PEAT - black fine fibrous peat and organics	1	AS	N/A				
	SILTY CLAY - brown silty clay some sand (very stiff)	2	SS	5	0	18	59	23
309.5 1.5	SILT - grey silt trace to some clay trace fine sand	3	SS	7	0	7	79	14
		4	SS	11				
	(very loose/compact)	5	SS	2	0	1	96	3
		6	SS	5				
		7	SS	11	0	1	94	5
		8	SS	10				
303.7 7.3	SAND - silty fine to medium sand trace gravel trace clay (dense)	9	SS	43	7	59	32	2
302.3 302.2 8.7 8.8	Auger Refusal DCPT Refusal End of Borehole							



COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

+³, ×³ : Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS		
Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 10/6/28 2:30:00 PM	0	1.6
2)	-	-
3)	-	-

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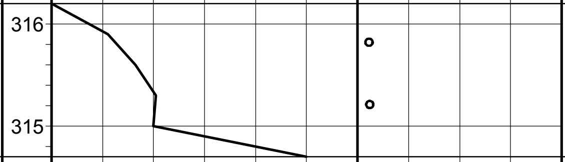
ENCLOSURE NO.:3 (Pg. 1 of 1)

RECORD OF BOREHOLE NO. A-2

METRIC

REFERENCE 10/03/10034 DATUM Geodetic LOCATION N 5044029.2 E 315560.0 - Perry Township ORIGINATED BY JL
PROJECT GWP 324-00-00 - Highway No. 518 - MEL Site A BOREHOLE TYPE CME 45B - Hollow Stem Augers COMPILED BY AT
CLIENT AECOM Canada Inc. DATE (Started/Completed) 10/7/12 - 10/7/12 TIME CHECKED BY MAM

SOIL PROFILE			SAMPLES				
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
316.2	Ground Surface						
0.0	FILL - fine to medium sand trace gravel trace silt	▨	1	AS	N/A		316
315.2 1.0	Auger Refusal		2	SS	18		315
314.7 1.5	DCPT Refusal End of Borehole						



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

COMMENTS

Undertook two additional borings within 2 m of Borehole No A-2 with auger refusal at 1.0 and 1.1 m depth.

The stratification lines represent approximate boundaries. The transition may be gradual.

$+^3, \times^3$: Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 10/7/12	DRY	-
2)	-	-
3)	-	-

MEL-GEO 10034 - SITE A - BOREHOLE LOGS.GPJ MEL-GEO.GDT 11/1/20

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ENCLOSURE NO.:4 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. A-3

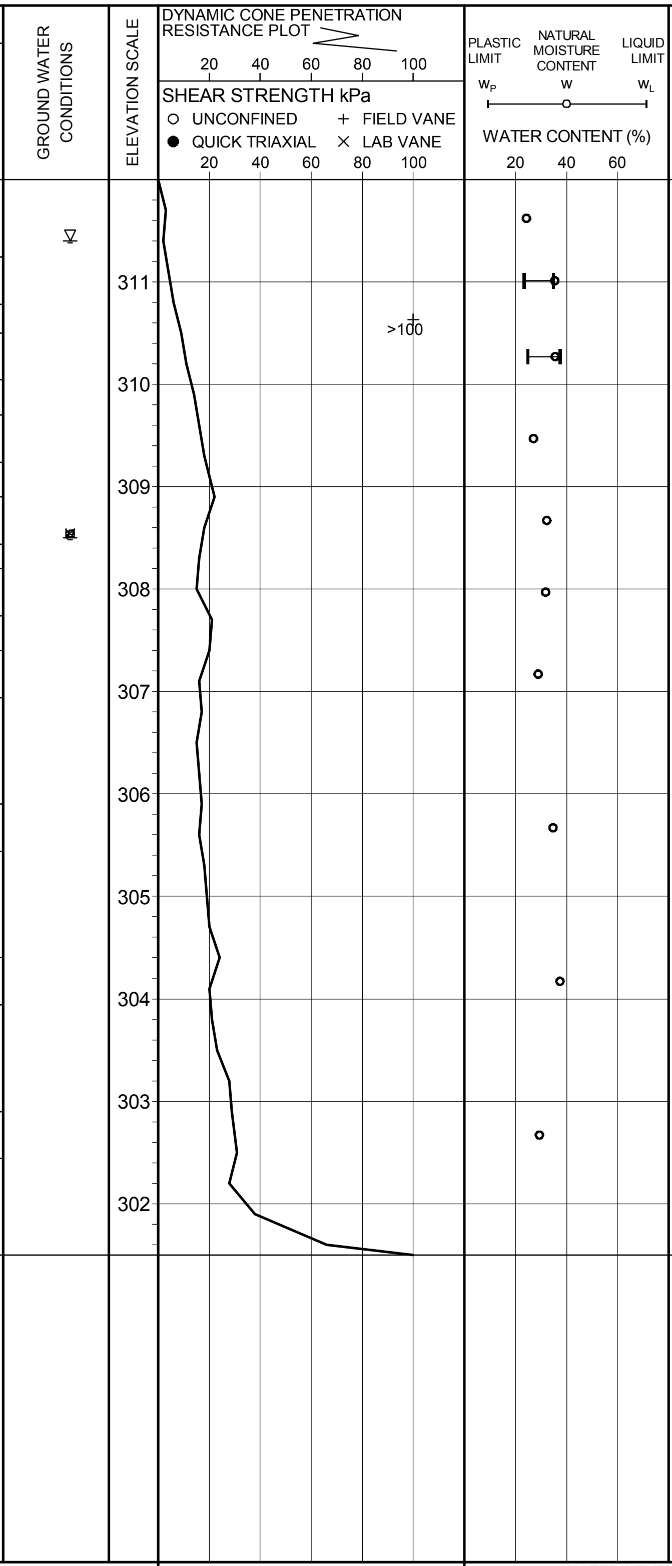
REFERENCE 10/03/10034 DATUM Geodetic LOCATION N 5044013.6 E 315569.5 - Perry Township ORIGINATED BY JL

PROJECT GWP 324-00-00 - Highway No. 518 - MEL Site A BOREHOLE TYPE CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Canada Inc. DATE (Started/Completed) 10/7/12 - 10/7/12 TIME CHECKED BY MAM

ELEV DEPTH	SOIL PROFILE DESCRIPTION
312.0	Ground Surface
0.0	±150 mm grass and organics SILTY CLAY - brown to grey silty clay trace sand (very stiff)
309.7 2.3	SILT - grey silt trace clay trace sand (loose/compact)
301.5 10.5	Auger Refusal DCPT Refusal End of Borehole

SAMPLES NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
1	AS	N/A				
2	SS	8	0	2	66	32
3	SS	9	0	2	71	27
4	SS	27				
5	SS	9	0	2	93	5
6	SS	24				
7	SS	4	0	2	95	3
8	SS	12				
9	SS	6				
10	SS	22	0	2	91	7



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

$+^3, \times^3$: Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

$○^{3\%}$ STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 10/7/12 1:00:00 PM	0.6 ▽	3.5
2)	-	-
3)	-	-

MEL-GEO 10034 - SITE A - BOREHOLE LOGS.GPJ MEL-GEO.GDT 11/1/20

ENCLOSURE NO.:5 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. A-4

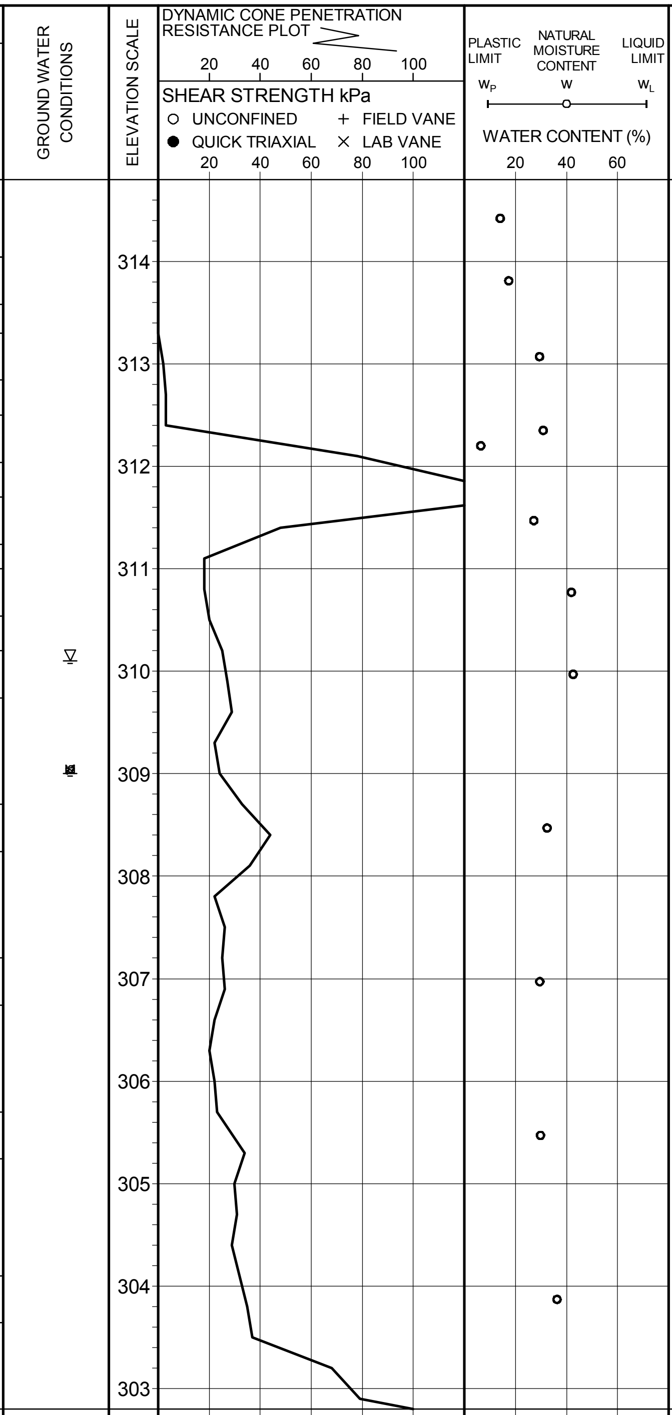
REFERENCE 10/03/10034 DATUM Geodetic
LOCATION N 5044048.5 E 315570.6 - Perry Township
ORIGINATED BY JL
PROJECT GWP 324-00-00 - Highway No. 518 - MEL Site A
BOREHOLE TYPE CME 45B - Hollow Stem Augers
COMPILED BY AT
CLIENT AECOM Canada Inc.
DATE (Started/Completed) 10/6/25 - 10/6/25 TIME 9:20:00 AM
CHECKED BY MAM

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
314.8	Ground Surface
0.0	FILL - brown fine sand some silt trace gravel trace organics
313.6 1.2	FILL - brown silt trace clay trace sand (compact)
312.4 2.4	FILL - fine to medium sand trace silt trace gravel trace asphalt (compact/very dense)
311.0 3.8	SILTY CLAY - grey silty clay (very stiff)
309.2 5.6	SILT - grey silt trace clay trace fine sand (very loose/loose)
302.8 12.0	Auger Refusal DCPT Refusal End if Borehole

SAMPLES

NUMBER	TYPE	"N" VALUES
1	AS	N/A
2	SS	48
3	SS	10
4	SS	64
5	SS	10
6	SS	6
7	SS	7
8	SS	2
9	SS	1
10	SS	8
11	SS	4



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

$+^3, \times^3$: Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

$\circ^{3\%}$ STRAIN AT FAILURE

WATER LEVEL RECORDS

	Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1)	10/6/29 9:25:00 AM	4.7	5.8
2)		-	-
3)		-	-

MEL-GEO 10034 - SITE A - BOREHOLE LOGS.GPJ MEL-GEO.GDT 11/1/20

ENCLOSURE NO.:6 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. A-5

REFERENCE 10/03/10034 DATUM Geodetic

LOCATION N 5044059.1 E 315594.3 - Perry Township

ORIGINATED BY JL

PROJECT GWP 324-00-00 - Highway No. 518 - MEL Site A

BOREHOLE TYPE CME 45B - Hollow Stem Augers

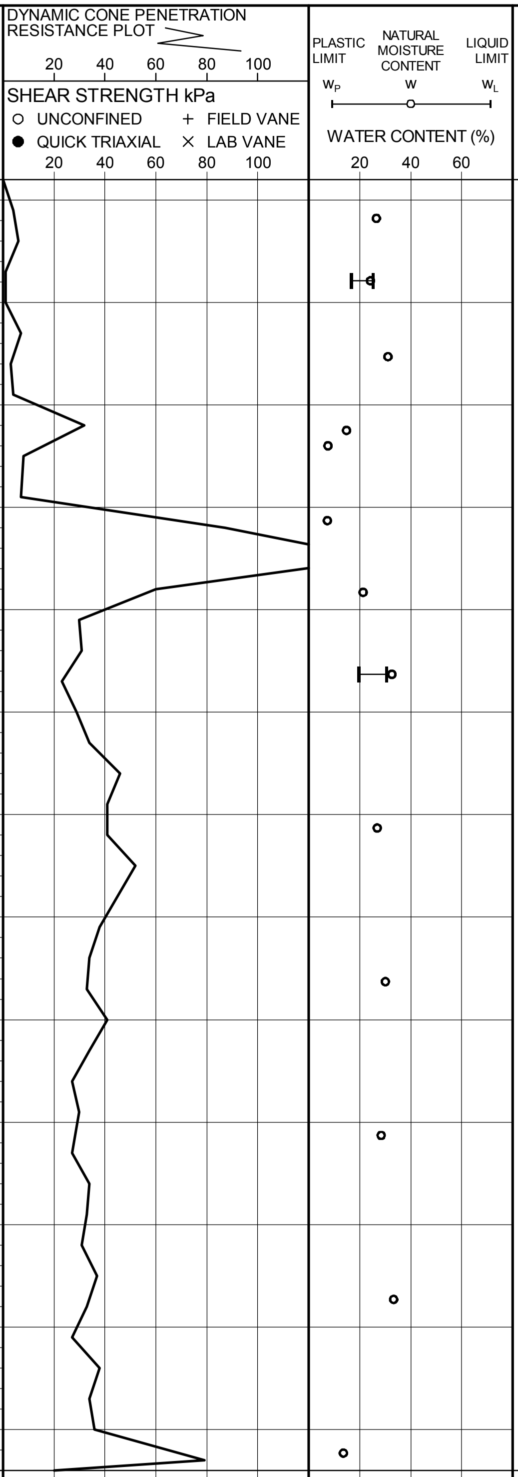
COMPILED BY AT

CLIENT AECOM Canada Inc.

DATE (Started/Completed) 10/6/29 - 10/6/29 TIME 12:30:00 PM

CHECKED BY MAM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
315.2	Ground Surface							
0.0	±150mm grass and mixed sand and gravel	1	AS	N/A				
	FILL - grey silt with clay and sand trace gravel	2	SS	WH	5	20	51	24
313.8 1.4	FILL - brown fine to medium sand some silt so silty trace clay some gravel to gravelly	3	SS	5	12	62	20	6
		4	SS	16				
	(compact/very dense)							
	trace asphalt	5	SS	95	38	50	11	1
	trace wood pieces	6	SS	13				
		7	SS	10	14	47	31	8
309.7 5.5	SILT - grey silt trace to some sand trace clay							
		8	SS	18				
	(loose/compact)							
		9	SS	4	0	1	94	5
		10	SS	6				
		11	SS	6				
303.6 11.6	SAND - fine to medium sand with silt trace gravel trace silt							
	(very dense)							
302.7		12	SS	77 / 175 mm	8	66	24	2
302.6 12.5	DCPT Refusal							
12.6	Auger Refusal End of Borehole							



COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

+³, ×³ : Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 10/6/29 12:30:00 PM	DRY	3.8
2)	-	-
3)	-	-

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ENCLOSURE NO.:7 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. A-6

REFERENCE 10/03/10034 DATUM Geodetic

LOCATION N 5044032.7 E 315528.4 - Perry Township

ORIGINATED BY JL

PROJECT GWP 324-00-00 - Highway No. 518 - MEL Site A

BOREHOLE TYPE CME 45B - Hollow Stem Augers

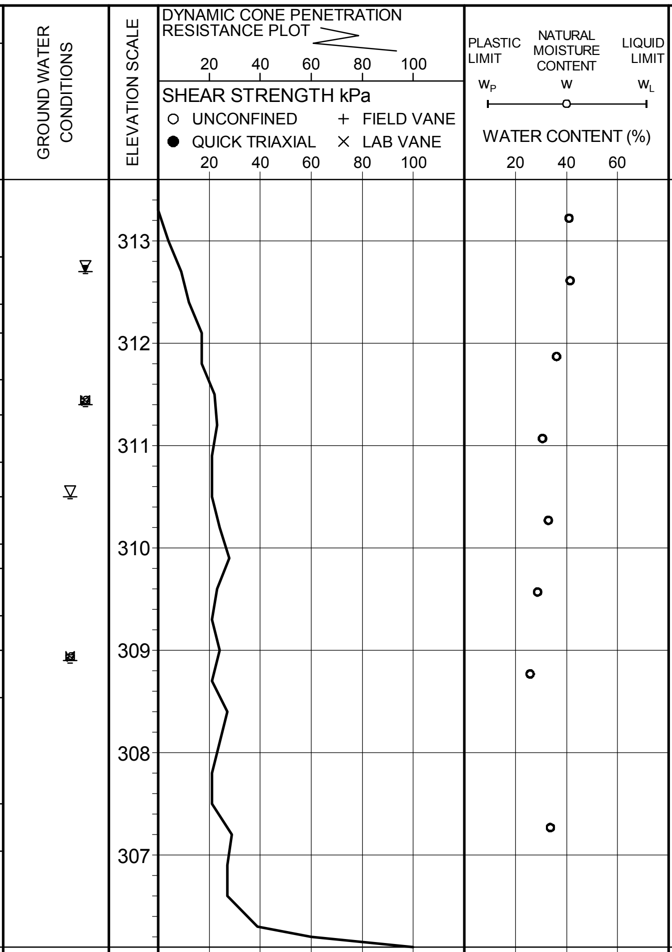
COMPILED BY AT

CLIENT AECOM Canada Inc.

DATE (Started/Completed) 10/7/1 - 10/7/1 TIME 11:30:00 AM

CHECKED BY MAM

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES
313.6	Ground Surface			
0.0	±100 mm grass and mixed sand and gravel SILTY CLAY - brown to grey silty clay	1	AS	N/A
		2	SS	9
312.4 1.2	(very stiff) SILT - grey silt trace clay trace to some sand	3	SS	13
		4	SS	9
	(loose/compact)	5	SS	7
		6	SS	9
		7	SS	8
		8	SS	10
306.2				
306.1 7.4	Auger Refusal			
7.5	DCPT Refusal End of Borehole			



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

$+^3, \times^3$: Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

$\bigcirc^{3\%}$ STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 10/7/1 11:30:00 AM	3.1 ∇	4.7
2) 10/7/1 12:00:00 PM	0.9 ∇	2.2
3)	- ▼	-

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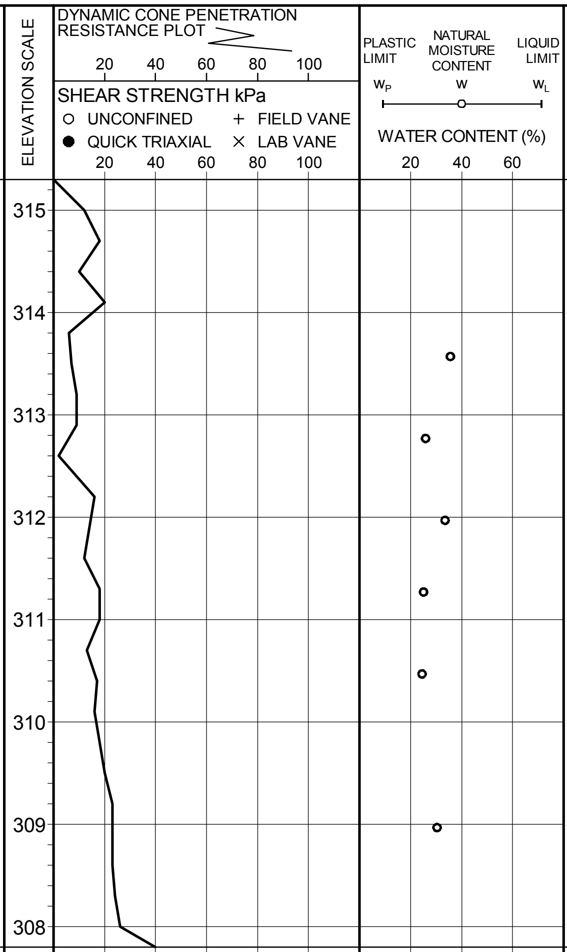
ENCLOSURE NO.:8 (Pg. 1 of 1)

METRIC

RECORD OF BOREHOLE NO. A-7

REFERENCE 10/03/10034 DATUM Geodetic
LOCATION N 5044013.7 E 315486.5 - Perry Township
ORIGINATED BY JL
PROJECT GWP 324-00-00 - Highway No. 518 - MEL Site A
BOREHOLE TYPE CME 45B - Hollow Stem Augers
COMPILED BY AT
CLIENT AECOM Canada Inc.
DATE (Started/Completed) 10/7/1 - 10/7/1 TIME 2:00:00 PM
CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			GR	SA	SI	CL
315.3	Ground Surface										
0.0	RIP RAP - rock shatter, cobbles/boulders										
314.3 1.0	SILT - grey silt trace silt trace sand										
			1	SS	10						
	(loose/compact)		2	SS	15			0	2	89	9
			3	SS	4			0	2	94	4
			4	SS	6						
			5	SS	8						
			6	SS	18			0	0	95	5
307.8 7.5	Auger Refusal DCPT Refusal End of Borehole										



COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

+³, ×³ : Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1)	- ∇	-
2)	- ∇	-
3)	- ▼	-

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ENCLOSURE NO.:9 (Pg. 1 of 1)

RECORD OF BOREHOLE NO. A-8

METRIC

REFERENCE 10/03/10034 DATUM Geodetic

LOCATION N 5044023.4 E 315510.6 - Perry Township

ORIGINATED BY JL

PROJECT GWP 324-00-00 - Highway No. 518 - MEL Site A

BOREHOLE TYPE CME 45B - Hollow Stem Augers

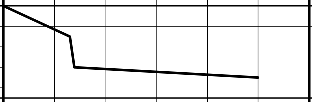
COMPILED BY AT

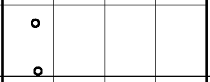
CLIENT AECOM Canada Inc.

DATE (Started/Completed) 10/7/12 - 10/7/12 TIME 9:50:00 AM

CHECKED BY MAM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES						
314.2	Ground Surface										
0.0	SAND - fine sand trace to some gravel trace silt occasional cobbles	⁘	1	AS	N/A	▽	314		○		
313.5											
310.7	DCPT Refusal		2	SS	50 / 125 mm				○		
0.9	Auger Refusal End of Borehole										





COMMENTS

The stratification lines represent approximate boundaries. The transition may be gradual.

$+^3$, $\times^3$: Numbers on right refer to Sensitivity
Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

	Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1)	10/7/12 9:50:00 AM	0.6 ▽	0.06
2)		-	-
3)		-	-

APPENDIX C

Figure No. A-1:	Borehole Locations & Soil Strata
Figure Nos. L-1 to L-6:	Summary Grain Size Analysis Graph
Figure No. L-7:	Atterberg Limits

GEOCRES No 31E-307
GWP No 324-00-00

HWY NO. 518 - Township of Perry
Sta. 13+454 - MEL Site A
Culvert Replacement and Detour
BOREHOLE LOCATIONS & SOIL STRATA

Figure A-1

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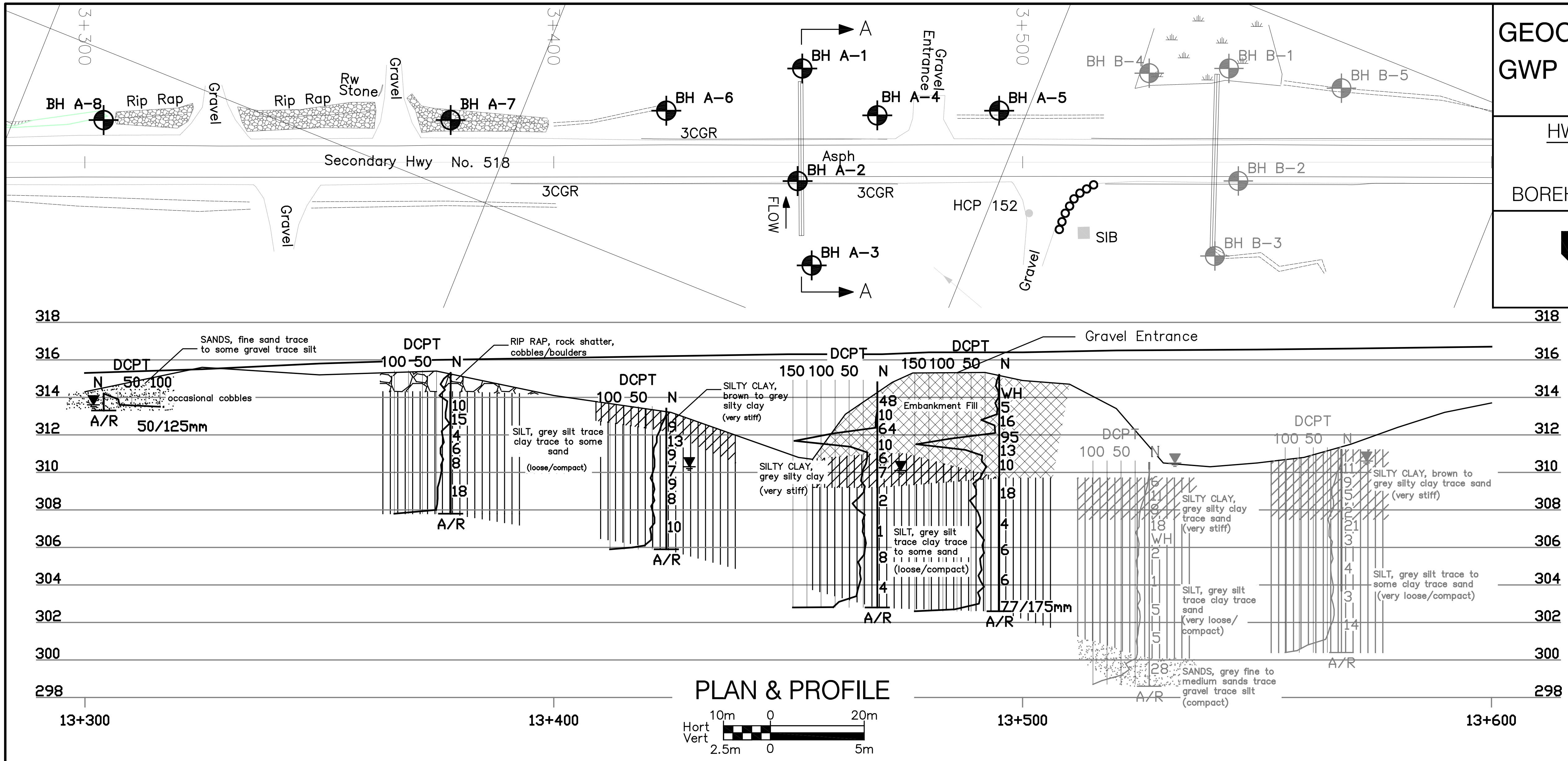
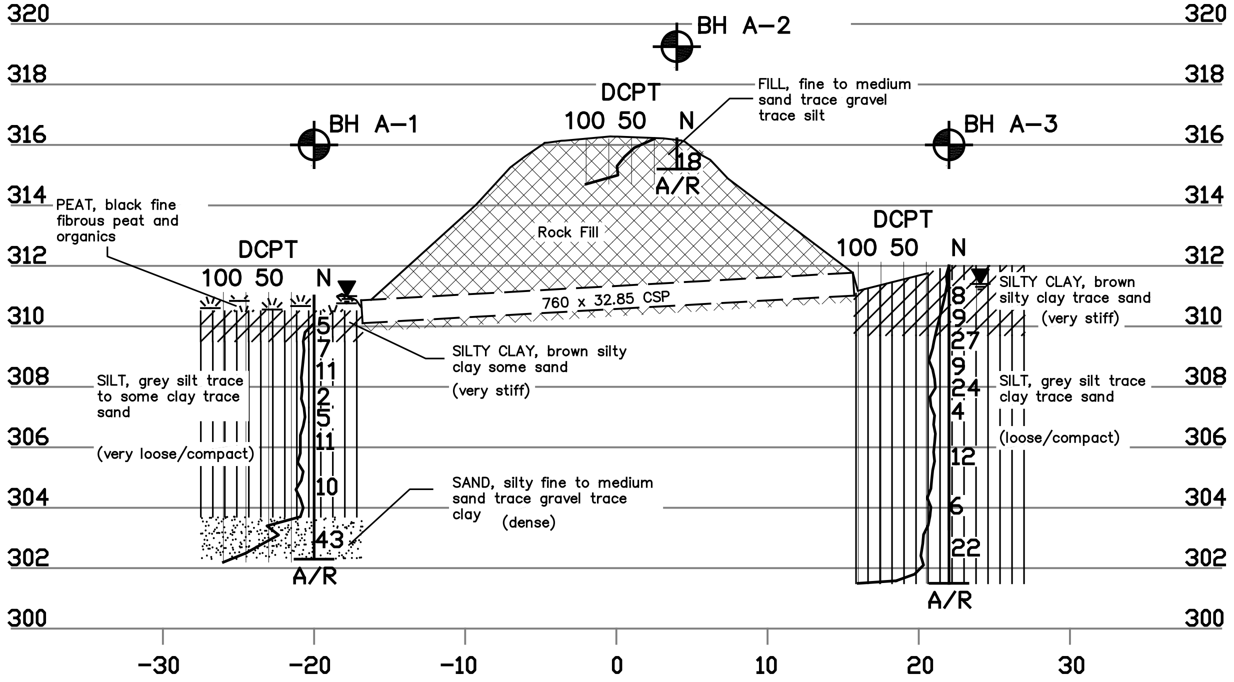
Consulting Geotechnical Engineers

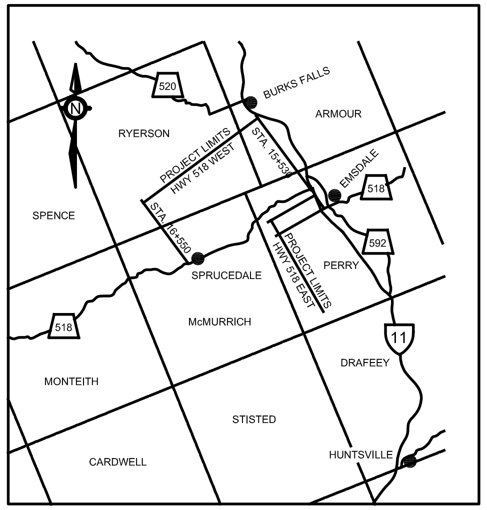


PLAN & PROFILE



CROSS SECTION A - A

Hort 5m 0 10m
Vert 2.5m 0 5m



KEY PLAN - NOT TO SCALE

LEGEND

⊕ Borehole
"N" Blows/0.3 m (Std Pen Test, 475 J/blow)
DCPT Blows/0.3 m (60° Cone, 475 J/blow)
▼ Water Level at Time of Investigation
A/R Auger Refusal at Elevation
E/S End of Sampling

Borehole No.	Co-ordinates		Elev.
	Northerly	Easterly	
Borehole No. A-1	5044051.8	315552.0	311.0
Borehole No. A-2	5044029.2	315560.0	316.2
Borehole No. A-3	5044013.6	315569.5	312.0
Borehole No. A-4	5044048.5	315570.6	314.8
Borehole No. A-5	5044059.1	315594.3	315.2
Borehole No. A-6	5044032.7	315528.4	313.6
Borehole No. A-7	5044013.7	315486.5	315.3
Borehole No. A-8	5044023.4	315510.6	314.2

NOTE 1:
The boundaries between soil strata have been established at the borehole locations only. The boundaries illustrated and stratigraphy between boreholes on this drawing are assumed based on borehole data and may vary. They are intended for design only.

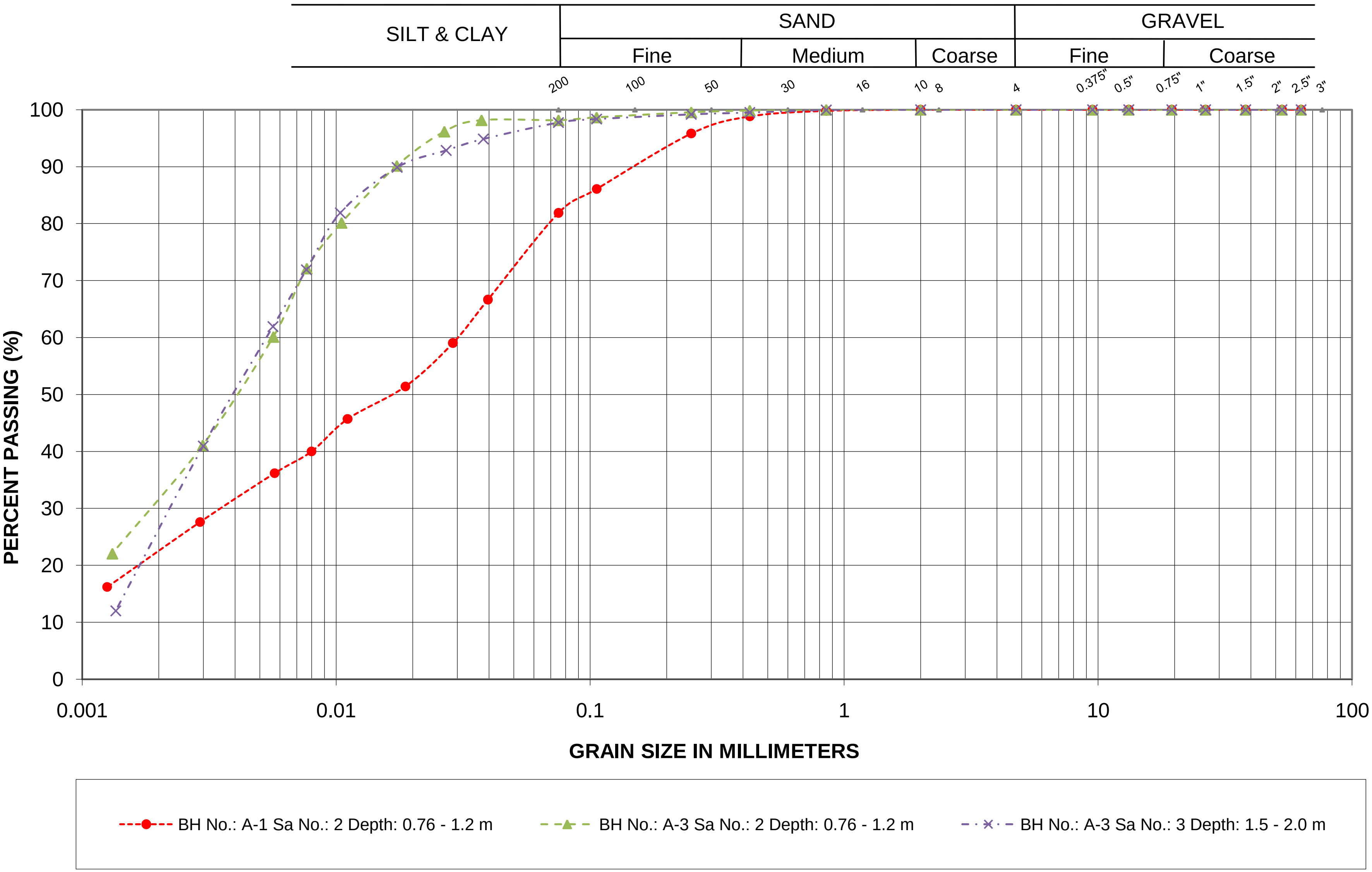
METRIC
Dimensions are in meters and/or millimeters unless otherwise shown. Stations are in kilometers + meters.

REVISIONS	DATE	BY	DESCRIPTION
	Nov. 19/10	RG	DRAFT

HWY No. 518 – Sta. 13+454 – Perry Township			DIST
SUBM'D			SITE A
DRAWN RG	CHK MAM	DATE October 2010	FIG A-1

Reference No.: 10/03/10034A
Date: January 2011

GRAIN SIZE ANALYSIS



PROJECT: G.W.P. 324-00-00
LOCATION: Hwy 518 MEL Site A

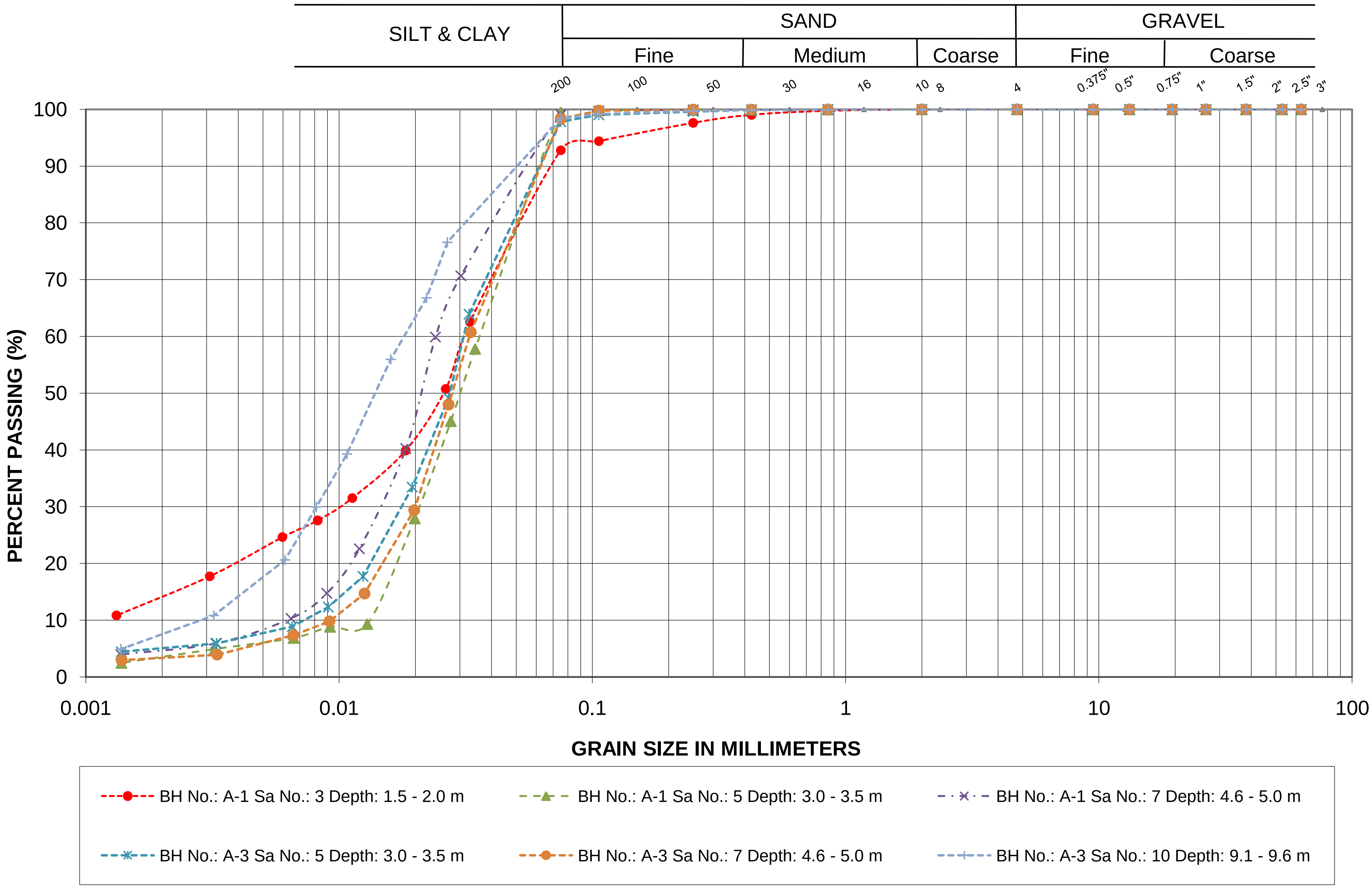
SILTY CLAY - Silty Clay

MERLEX ENGINEERING LTD.

FIGURE L-1

Reference No.: 10/03/10034A
Date: January 2011

GRAIN SIZE ANALYSIS



PROJECT: G.W.P. 324-00-00
LOCATION: Hwy 518 MEL Site A

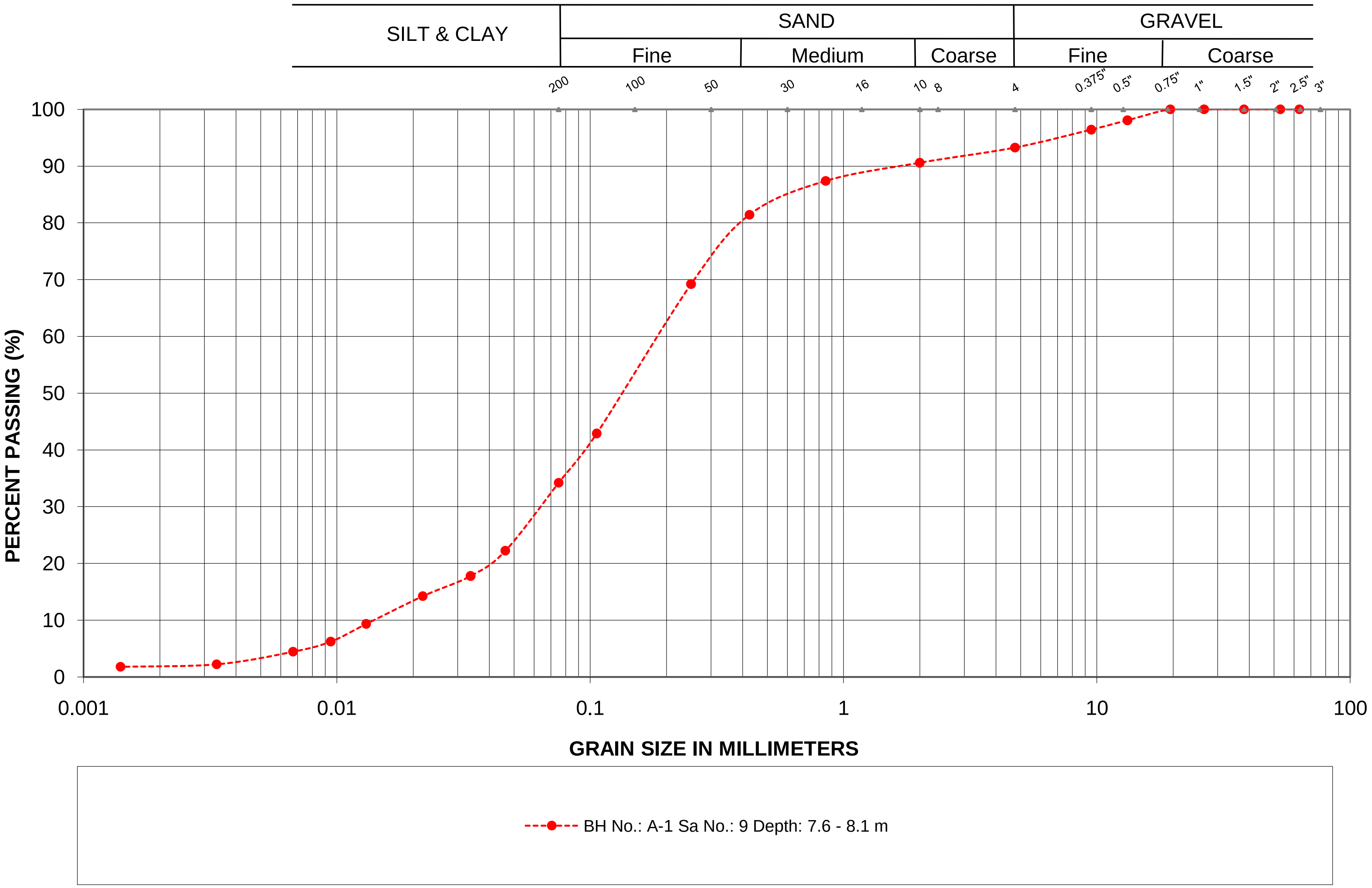
SILTS - Silt, Trace to Some Clay, Trace Sand

MERLEX ENGINEERING LTD.

FIGURE L-2

Reference No.: 10/03/10034A
Date: January 2011

GRAIN SIZE ANALYSIS



PROJECT: G.W.P. 324-00-00
LOCATION: Hwy 518 MEL Site A

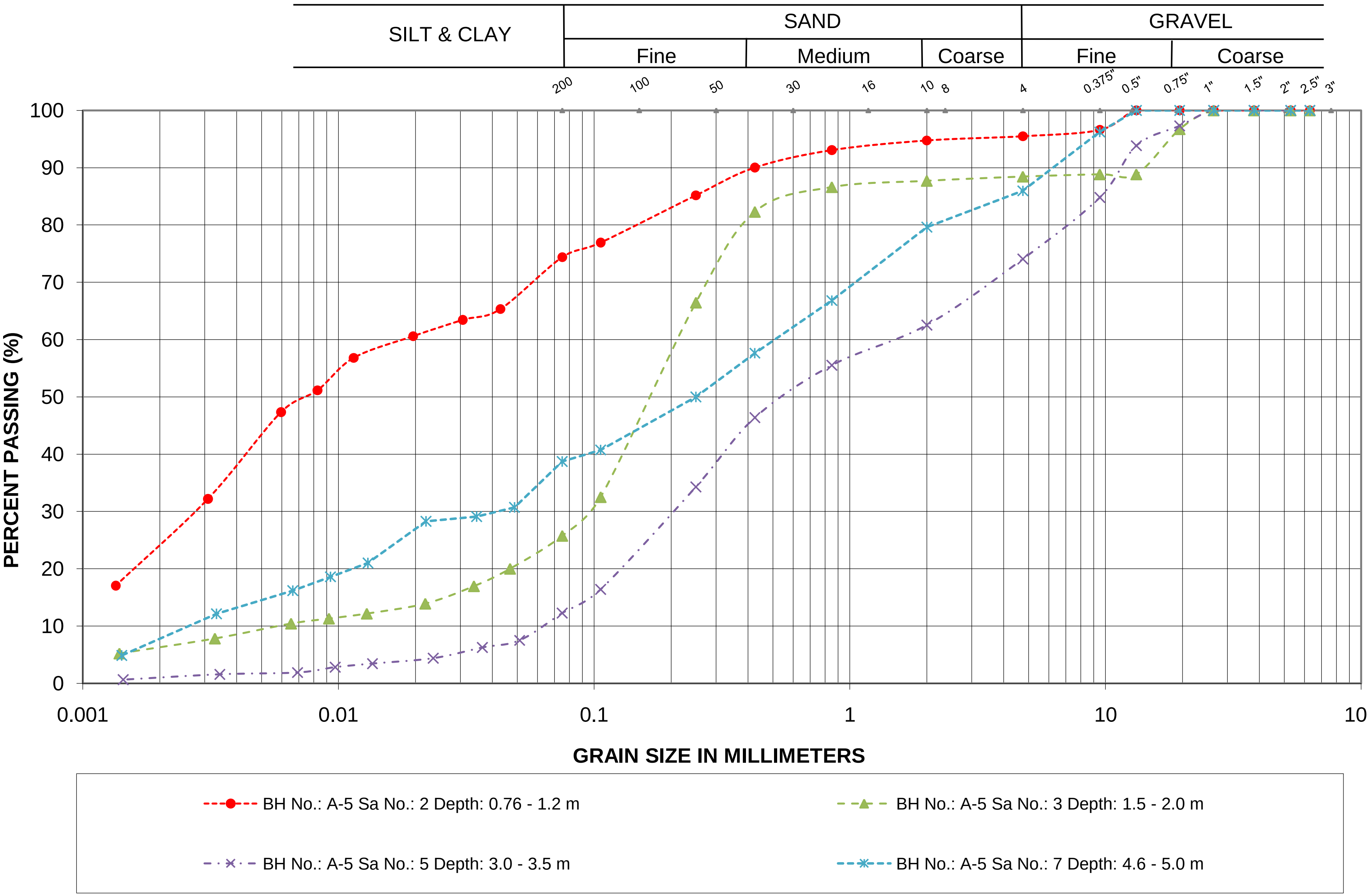
SANDS - Sand, With Silt, Trace Gravel, Trace Clay

MERLEX ENGINEERING LTD.

FIGURE L-3

Reference No.: 10/03/10034A
Date: January 2011

GRAIN SIZE ANALYSIS



PROJECT: G.W.P. 324-00-00
LOCATION: Hwy 518 MEL Site A

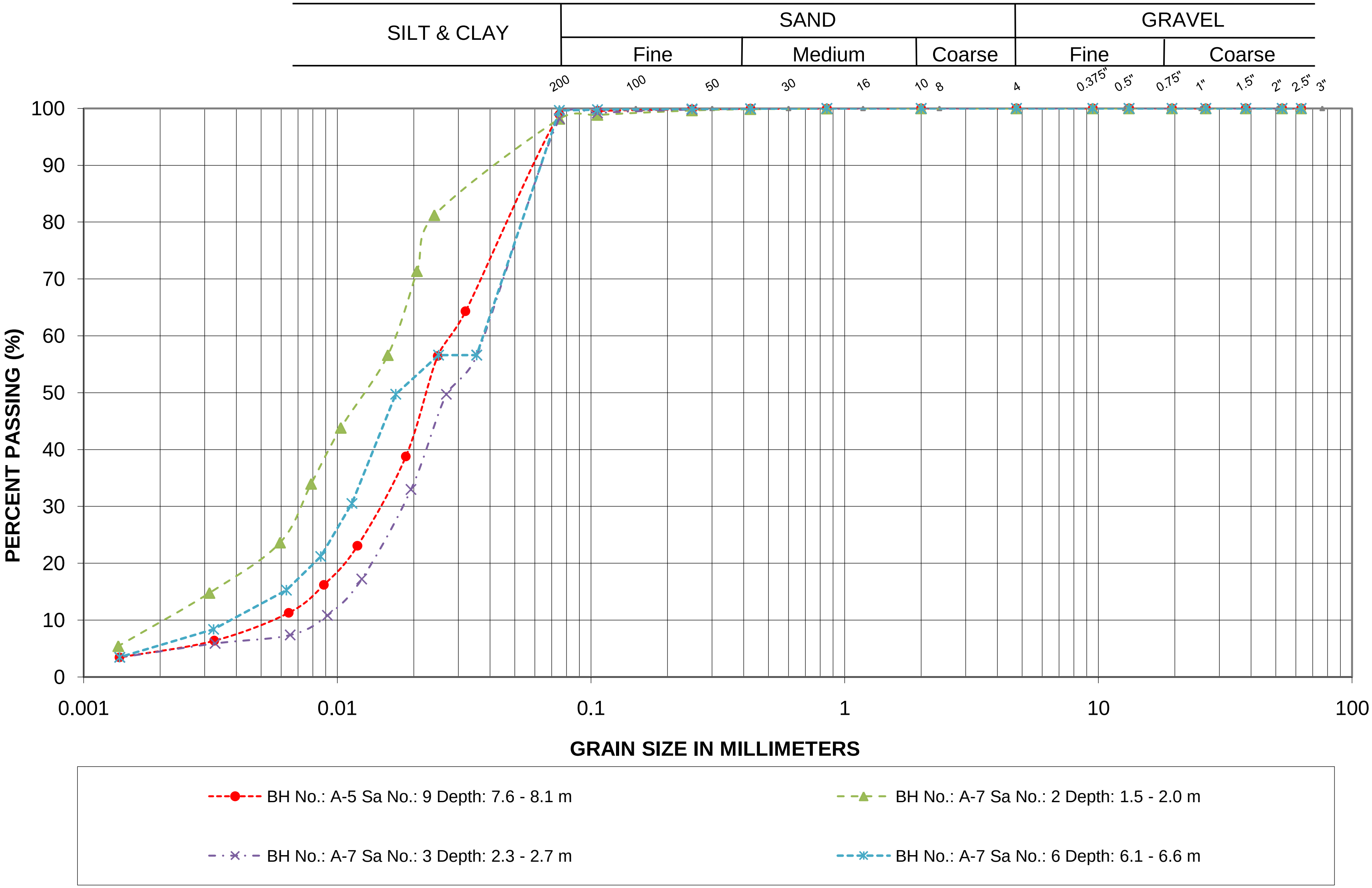
FILL - Embankment Fill, Varying Composition

MERLEX ENGINEERING LTD.

FIGURE L-4

Reference No.: 10/03/10034A
Date: January 2011

GRAIN SIZE ANALYSIS



PROJECT: G.W.P. 324-00-00
LOCATION: Hwy 518 MEL Site A

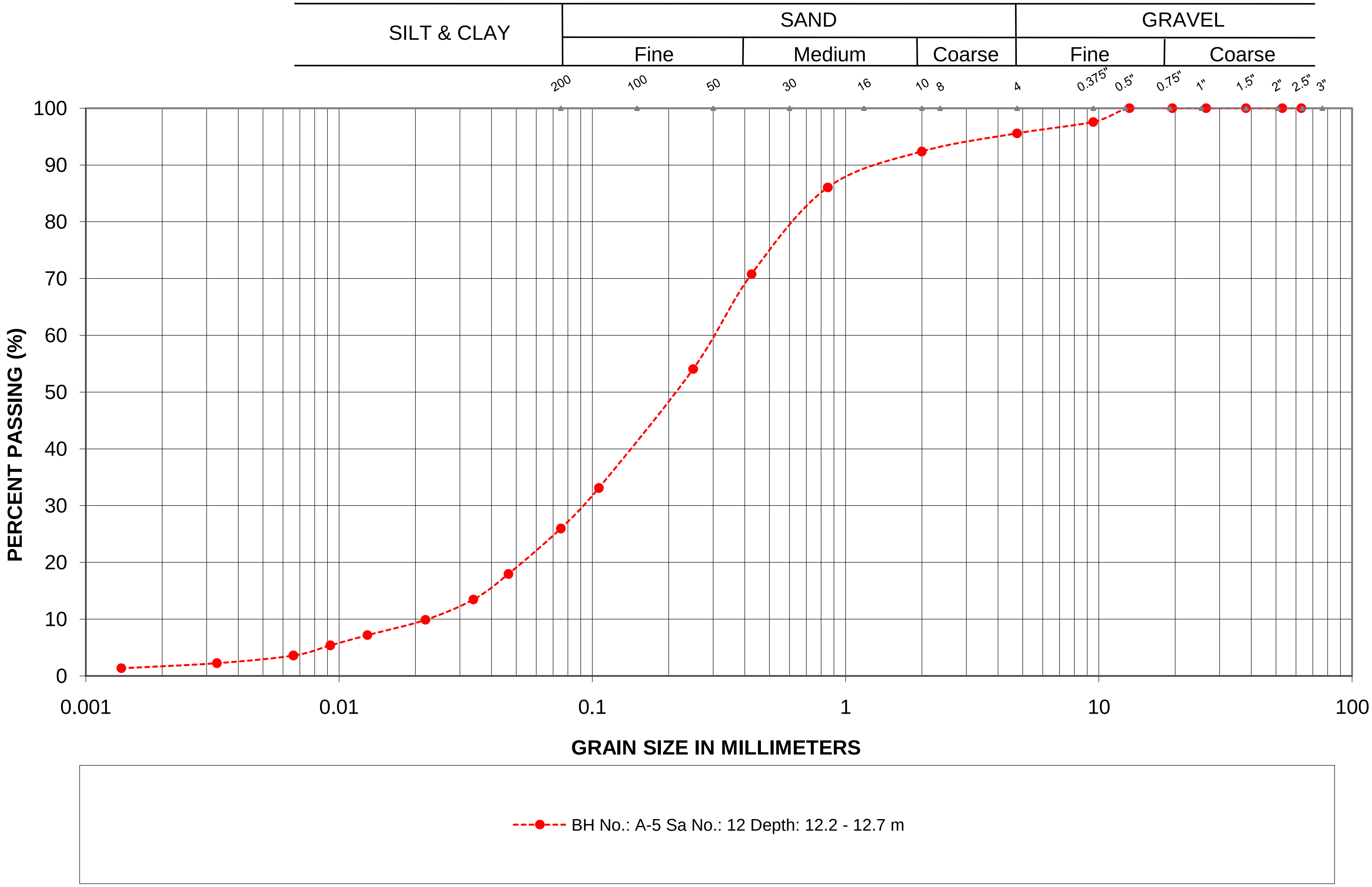
SILTS - Silt, Trace Sand, Trace Clay

MERLEX ENGINEERING LTD.

FIGURE L-5

Reference No.: 10/03/10034A
Date: January 2011

GRAIN SIZE ANALYSIS



PROJECT: G.W.P. 324-00-00
LOCATION: Hwy 518 MEL Site A

SANDS - Sand, With Silt, Trace Gravel, Trace Clay

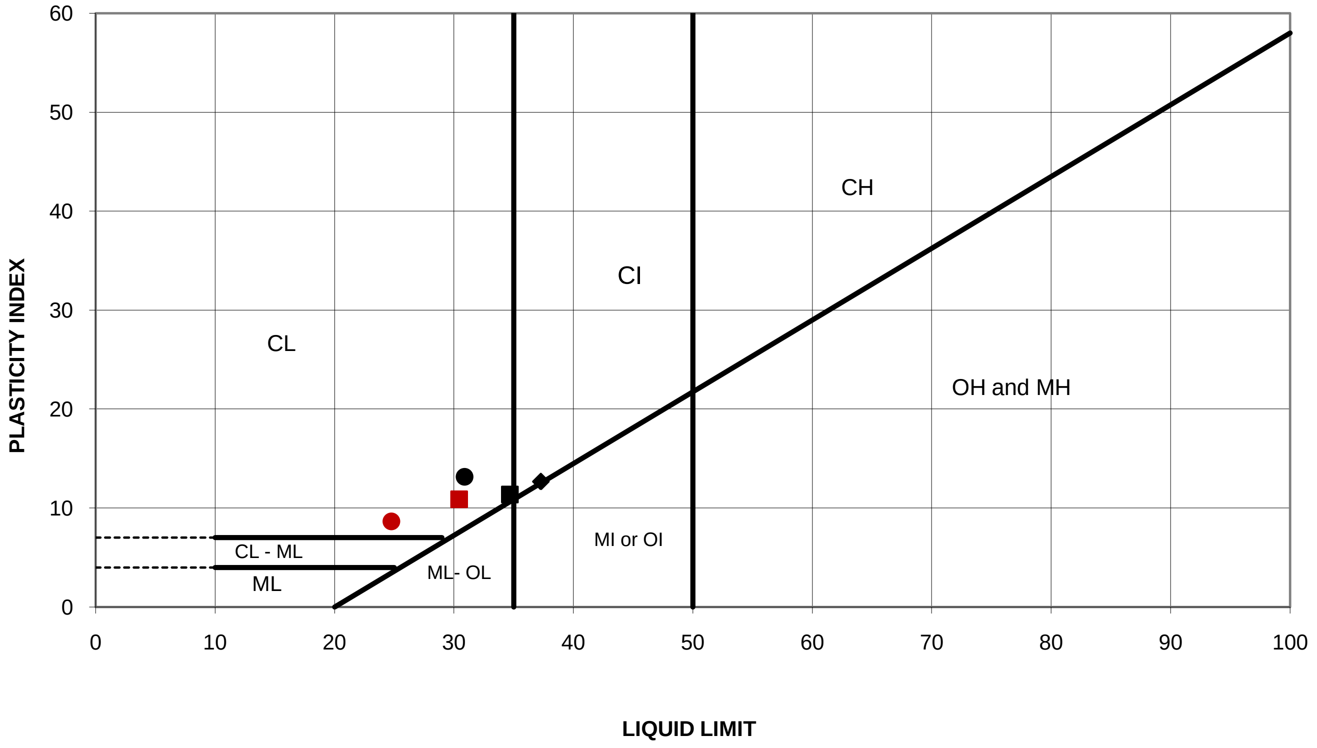
MERLEX ENGINEERING LTD.

FIGURE L-6

ATTERBERG LIMITS TEST RESULTS

FIGURE L- 7

ATTERBERG INDICES



SYMBOL	BH	Sa. No.	Depth(m)	Elev.(m)	Plasticity Index	Plastic Limit	Liquid Limit	NMC %
●	A-1	2	0.8	310.2	13.2	17.7	30.9	28.2
■	A-3	2	0.8	311.2	11.4	23.3	34.7	35.4
◆	A-3	3	1.5	310.5	12.7	24.6	37.3	35.5
🔴	A-5	2	0.8	314.4	8.7	16.1	24.8	24.6
🟥	A-5	7	4.6	310.2	10.9	19.5	30.4	32.6

Date: Jan-11
Project: Hwy 518, MEL Site A

Prep'd: AT
Chkd: MAM
Ref. No.: 10/03/10034A

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APPENDIX D

Photos Nos. 1 and 2:	Culvert Photos
Enclosure No. 10:	Geotechnical Borehole Logs with Abbreviations

Culvert Inlet - Site A	Photo: 1

Culvert Outlet – Site A	Photo: 2

Reference No.: 10/03/10034A Project: Hwy 518 – Township of Perry, Culvert Replacement Station 13+454, MEL Site A	Originated By: JL Date: July, 2010

ABBREVIATIONS FOR BOREHOLE SURVEY DATA SHEETS

Accep	Acceptable	**Gry**	Grey	**Psty**	Polystyrene
Agg	Aggregate	**H**	Heavy	**Poss**	Possible
Amor	Amorphous	**Hi**	Highly	**PST**	Prime & Surface Treated
Asph	Asphalt	**HP**	High Plasticity	**Quant**	Quantity
AP	Auger Probe	**HM**	Hot Mix	**Reinf**	Reinforced
BR	Bedrock	**Lt**	Light	**RSS**	Remoulded Shear Strength
Blk	Black	**Liq**	Liquid	**RF**	Rock Fill
Bl	Blue	W_L	Liquid Limit	**Sa**	Sand
BH	Borehole	**Lo**	Loam	**Sat**	Saturated
Bld (y)	Boulder (y)	**L**	Loose	**SH**	Shale
Blds	Boulders	**Mrl**	Marl	**St**	Sensitivity
BU	Break Up	**Matl**	Material	**SSM**	Select Subgrade Material
Br	Brown	**Max**	Maximum	**Sh Rk**	Shot Rock
CF	Channel Face	**MDD**	Maximum Dry Density	**Si (y)**	Silt (y)
Cl	Clay	**MWD**	Maximum Wet Density	**Sl (y)**	Slight (ly)
Co	Coarse	**Med**	Medium	**SP**	Slight Plasticity
Cob	Cobbles	**MP**	Medium Plasticity	**Stn (y)**	Stoney
Comp	Compact	**Mod**	Moderate	D_R	Relative Density
Conc	Concrete	**Mott**	Mottled	**Stks**	Streaks
Contam	Contaminated	**Mul**	Mulch	**Surf**	Surface
Cord	Corduroy	**NFP**	No Further Progress	**Temp**	Temperature
Cr	Crushed	**NFP (Blds)**	No Further Progress (Boulders)	**TH**	Test Hole
Dk	Dark	**Num**	Numerous	**TP**	Test Pit
Decomp	Decomposed	**Occ**	Occasional	**Tps**	Topsoil
D	Datum	**Wopt**	Optimum Moisture Content	**Tr**	Trace
E	Earth	**Ora**	Orange	**USS**	Undisturbed Shear Strength
Fib	Fibrous	**Org**	Organic	**Unreinf**	Unreinforced
w	Field Moisture Content	**Org M**	Organic Matter	**Varv**	Varved
F	Fine	**Ob**	Overburden	**VF**	Very Fine
Fr Wat	Free Water	**Pavt**	Pavement	**WT**	Water Table
FB	Frost Boil	**Pedo**	Pedological	**Weath**	Weathered
FH	Frost Heave	**Pen Mac**	Penetration Macadam	**W**	With
Gran	Granular	**Wp**	Plastic Limit	**Wd (y)**	Wood (y)
Gr	Gravel (ly)	**Ip**	Plasticity Index	**Yel**	Yellow
Grn	Green				

13+400 3.6 Lt C/L

0 - 50	Asph
50 - 250	Cr Gr
250 - 700	F-Med Sa Tr Gr
700	NFP RF

13+449 3.6 Rt C/L

0 - 50	Asph
50 - 200	Cr Gr
200 - 900	Med Sa W Gr
900	NFP RF

13+450 3.6 Lt C/L

0 - 60	Asph
60 - 280	Cr Gr
280 - 900	F-Med Sa Tr Gr
900	NFP RF

13+459 3.6 Rt C/L

0 - 50	asph
50 - 200	Cr Gr
200 - 900	Med Sa W Gr
900	NFP RF

13+490 3.6 Lt C/L

0 - 50	Asph
50 - 260	Cr Gr
260 - 800	F-Med Sa Tr Gr
800	NFP RF

13+490 3.6 Rt C/L

0 - 50	Asph
50 - 230	Cr Gr
230 - 900	F-Med Sa Tr Gr
900	NFP RF

13+500 4.4 Lt C/L

0 - 150	Cr Gr
150 - 370	F Sa W Si
370 - 700	F-Med Sa Tr Gr
700	NFP RF

13+500 3.6 Lt C/L

0 - 40	Asph
40 - 200	Cr Gr
200 - 1.0	F-Med Sa Tr Gr
1.0	NFP RF

13+500 3.6 Rt C/L

0 - 40	Asph
40 - 200	Cr Gr
200 - 800	F-Med Sa Tr Gr
800	NFP RF

13+500 4.8 Rt C/L

0 - 240	Cr Gr
240 - 900	F-Med Sa W Gr
900	NFP RF

13+500 5.0 Rt C/L

0 - 200	Cr Gr
200 - 750	F-Med Sa Tr Gr
750	NFP RF

13+507 3.6 Lt C/L

0 - 50	Asph
50 - 220	Cr Gr
220 - 400	F Sa W Si
400 - 750	F-Med Sa Tr Gr
750	NFP RF

13+507 3.6 Rt C/L

0 - 40	Asph
40 - 300	Cr Gr
300 - 800	F-Med Sa Tr Gr
800	NFP RF

13+517 3.6 Lt C/L

0 - 50	Asph
50 - 300	Cr Gr
300 - 900	F-Med Sa Tr Gr
900	NFP RF

13+517 3.6 Rt C/L

0 - 50	Asph
50 - 260	Cr Gr
260 - 800	F-Med Sa Tr Gr
800	NFP RF

13+525 3.6 Lt C/L05/03

0 - 40	Asph
40 - 220	Cr Gr
220 - 1.0	F-Med Sa Tr Gr
1.0	NFP RF

13+525 3.6 Rt C/L

0	-	40	Asph
40	-	280	Cr Gr
280	-	800	F-Med Sa Tr Gr
800			NFP RF

13+526 1.4 Lt C/L

0	-	45	Asph
45	-	230	Cr Gr
230	-	1.1	F-Med Sa W Gr
1.1			NFP RF

13+550 3.6 Lt C/L

0	-	50	Asph
50	-	240	Cr Gr
240	-	1.0	F-Med Sa Tr Gr
1.0			NFP RF

13+550 3.6 Rt C/L

0	-	40	Asph
40	-	230	Cr Gr
230	-	1.0	F-Med Sa W Gr
1.0			NFP RF

13+560 3.6 Rt C/L

0	-	50	Asph
50	-	260	Cr Gr
260	-	1.0	F-Med Sa W Gr
1.0			NFP RF

13+575 4.4 Lt C/L

0	-	240	Cr Gr
240	-	1.2	F-Med Sa Tr Gr
1.2			NFP RF

13+575 3.6 Lt C/L

0	-	40	Asph
40	-	260	Cr Gr
260	-	1.1	F-Med Sa Tr Gr
1.1			NFP RF

13+575 3.6 Rt C/L

0	-	50	Asph
50	-	200	Cr Gr
200	-	700	F-Med Sa Tr Gr
700	-	1.1	F-Med Sa Tr Gr & RF Mixed
1.1			NFP RF

13+600 3.6 Lt C/L

0	-	50	Asph
50	-	250	Cr Gr
250	-	1.0	F-Med Sa Tr Gr
1.0			NFP RF

13+600 1.6 Rt C/L

0	-	40	Asph
40	-	260	Cr Gr
260	-	800	F-Med Sa Tr Gr
800			NFP RF

13+600 3.6 Rt C/L

0	-	40	Asph
40	-	200	Cr Gr
200	-	800	F-Med Sa Tr Gr
800			NFP RF

13+600 4.6 Rt C/L

0	-	250	Cr Gr
250	-	900	F-Med Sa Tr Gr
900			NFP RF

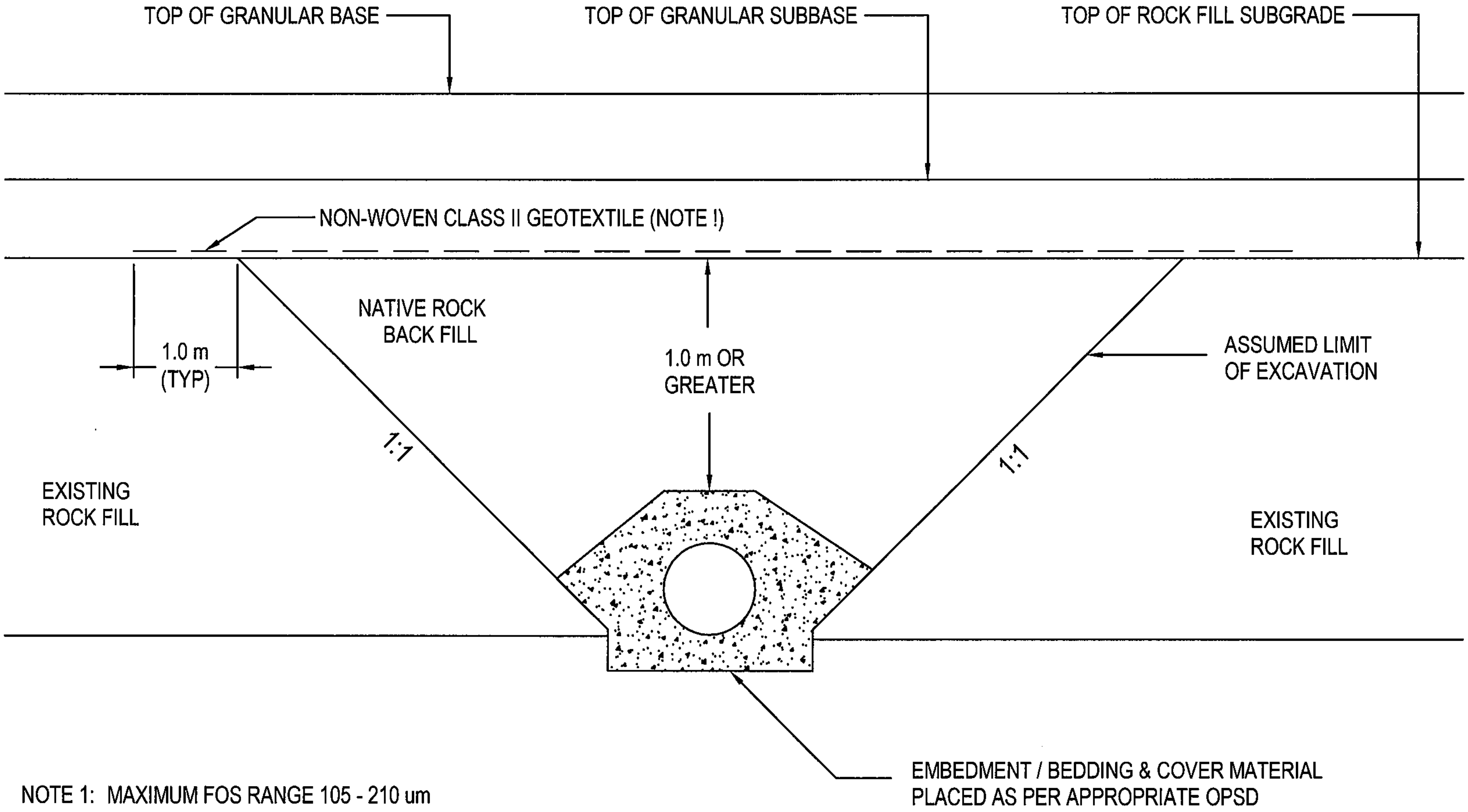
APPENDIX E

Sketch SK-1:	Culvert Replacement in High Rock Fill
Figure No. S-1:	Stability Analysis
Table A:	Culvert Replacement/Installation Methods

NOT TO SCALE

CULVERT REPLACEMENT IN HIGH ROCK FILL

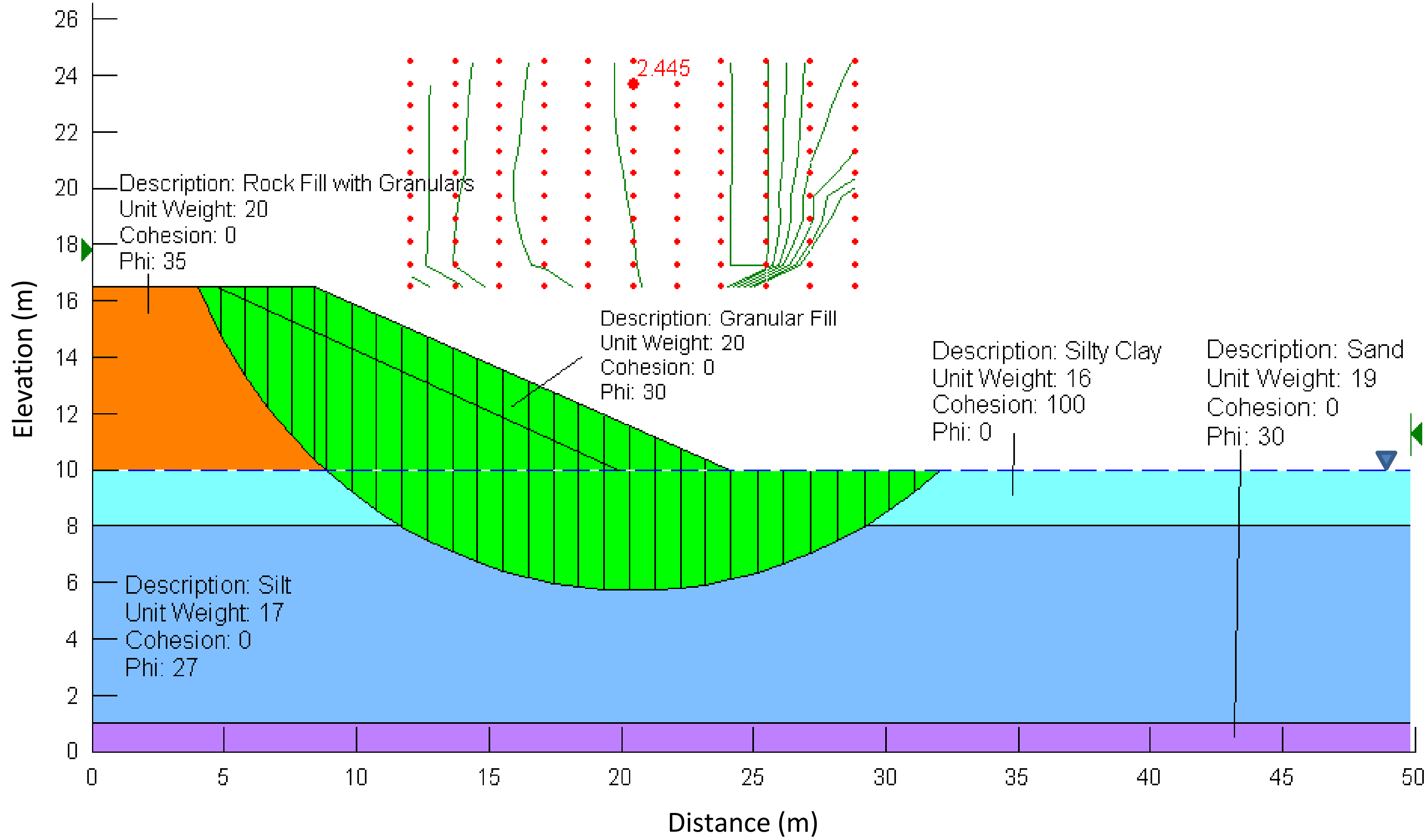
FIGURE SK - 1



NOTE 1: MAXIMUM FOS RANGE 105 - 210 um
MINIMUM FOS RANGE 50 - 100 um
FOS RANGE TO BE SELECTED DURING
DETAIL DESIGN, TO MATCH FOS SPECIFIED
FOR OTHER APPLICATIONS SO THAT ONLY ONE
FOS RANGE IS SPECIFIED IN THE CONTRACT

NOTE 2: NATIVE ROCK FILL SHALL BE
PLACED AS PER OPSS 206.07.08

Reference No.: 10/03/10034A
Date: January 2011



Stability Analysis
Detour for Culvert Replacement
2H:1V

Project: G.W.P 324-00-00
Location: Hwy 518, MEL Site A

Figure No. S-1

Table A – Culvert Replacement/Installation Methods

Method	Advantages	Disadvantages
Open Cut	Generally least cost	Requires wide platform width. Width required increases with depth of excavation
	Can be carried out with conventional excavating equipment	
Open Cut with Roadway Protection and Traffic Signals	Allows open excavation in tight areas	Generally requires specialist sub contractor
		Shoring through rock fill/boulders very high cost
		Increased cost
Open Cut with Detour	Allows open excavation in narrow embankments	Increased cost
Lining	Minimal impact on platform	Decreases interior diameter of culvert but increases flow due to smooth walls
		Requires specialist sub-contractor
Trenchless Techniques		
a) Jack and Bore	Reduces disruption to traffic	Requires specialist sub-contractor
	Actual jacking takes days vs. weeks/months with roadway protection	Cost Escalates if boulder sizes are present
		Moderate number of sub contractors available
		Requires access routes/ launching pad
b) Pipe Ramming	Reduces disruption to traffic	Generally more costly than open cut with shoring
	Effective in soils with cobbles and moderate boulder sizes	Requires specialist sub-contractor
	Can “swallow” existing culvert if sufficient clearance	Only a few firms available in Ontario
	Actual jacking takes days vs. weeks/months with roadway protection	Requires access route/launching pad
c) Horizontal Direction Drilling (HDD)	Reduces disruption to traffic	Requires specialist sub-contractor
	Works well in high water table, no need to dewater (except at launch)	Generally more costly than open excavation with shoring
	Little ground movement, can start bore at grade	Limited to 600 mm φ