



**Submitted To AECOM Canada Ltd.
189 Wyld Street Suite 103, North Bay, Ontario P1B 1Z2
On Behalf of the Ontario Ministry of Transportation**

**Highway 535 Rehabilitation
Culvert Replacement – Site No. 46-380/C
Maskinonge Creek Culvert
Station 12+957 - TWP of Jennings
GWP 5563-04-00
WP 5536-05-01**

**Highway 535
From 8.1 km North of Highway 64 (Noelville) Northerly 12.1 km;
And, 0.6 km North of Highway 64 Northerly 1.4 km
District of Sudbury**

FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

Date: April 9, 2012
Ref. N^o: 11/04/11046-F6

Geocres No. 41I-283

LVM | MERLEX

2-120 Progress Court, North Bay (Ontario) Canada P1A 0C2 – T 705.476.2550 | F 705.476.8882 – northbay@lvm.ca - www.lvm.ca

TABLE OF CONTENTS

		PAGE
1.0	INTRODUCTION.....	1
2.0	SITE DESCRIPTION.....	1
2.1	Site Physiography and Surficial Geology	2
3.0	INVESTIGATION PROCEDURES.....	2
4.0	SUBSURFACE CONDITIONS.....	4
4.1	Maskinonge Creek Culvert, Station 12+957, TWP of Jennings – Site No. 46-380/C	5
4.1.1	Surficial Layers	5
4.1.2	Fill	5
4.1.3	Embankment Fill	5
4.1.4	Peat	6
4.1.5	Organic Silt	6
4.1.6	Sand	7
4.2	Groundwater Conditions.....	8
5.0	DESIGN COMMENTS AND RECOMMENDATIONS	9
5.1	General.....	9
5.2	Foundation Considerations	9
5.3	Culvert Design, Bedding and Embedment	10
5.4	Culvert Installation and Construction Staging Considerations	11
5.4.1	Protection System.....	12
5.5	Lateral Earth Pressures.....	14
5.6	Excavation, Dewatering and Embankment Reconstruction.....	14
5.7	Construction Concerns	16
6.0	CLOSURE.....	17

1.0 INTRODUCTION

LVM | MERLEX has been retained by AECOM Canada Ltd., on behalf of the Ministry of Transportation of Ontario (MTO), to carry out a foundation investigation for the proposed replacement of an existing culvert and design of a protection system. This culvert replacement (GWP 5563-04-00, WP 5536-05-01) is located on Highway 535, some 18.5 km south of Hwy 17, in the Township of Jennings.

The foundation investigation location was specified by the MTO in the RFP/TPM documentation Agreement No. 5010-E-0015. The terms of reference for the scope of work are outlined in MEL's proposal P-10-169, dated December, 2010. The purpose of this investigation was to determine the subsurface conditions in the areas of the culvert in order to provide design recommendations. LVM | MERLEX investigated the foundation areas by the drilling of boreholes, carrying out in-situ tests, and performing laboratory testing on select samples.

2.0 SITE DESCRIPTION

The foundation investigation for this culvert is located at Station 12+957, Township of Jennings (Site No. 46-380/C). The topography at the site is generally of low relief. The existing highway embankment currently supports two undivided lanes of highway, running in a north south direction. The existing highway, at the culvert location, is constructed on a fill embankment some 5.0 m in height, with centerline elevation at 201.2 m at the culvert location. The culvert at this location is a 5.5 x 3.6 m SPCSPA culvert, some 18.4 m in length at the top of the pipe with the culvert invert at elevation 196.7 m (see Photo Essay, Appendix D). Flow through the culvert is from west to east.

The Maskinonge Creek drains a relatively large low lying swamp (wetland area) located directly to the west (left) of the highway embankment. The creek flows east where the channel width is constricted by bedrock ridges to the north and south of the culvert location.

Infrastructure at the culvert location consists of overhead power and communication wires on the west (left) side of the highway.

2.1 Site Physiography and Surficial Geology

This project is located in the Geomorphic Sub-province known as the North Shore - Sudbury Ridges and Pockets. The topography on this section of Highway 535 is generally rolling. There are a few exposed bedrock ridges. At many locations, significant layers of earth overlay the bedrock. Organic terrain was also observed. Within the project area, overburden consists primarily of sands. The Maskinonge Creek at the culvert location is a wetland area.

Bedrock in the area, as indicated on OGS Map 2506, is of the Late to Middle Precambrian Era. At the location of this culvert foundation investigation, the bedrock comprises of Felsic Igneous Rocks including; granitic rocks, syenite, pegmatite, derived gneisses, and migmatites.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between May 25th and September 12th, 2011, during which five (5) sampled boreholes were advanced. For the purposes of foundation design for the culvert replacement, one borehole was advanced through the embankment slightly down chainage from the culvert, and one borehole was advanced at each the inlet and outlet end of the culvert. Two boreholes were advanced through the embankment, one up and one down chainage from the culvert, for the purposes of design of a protection system. Shallow refusal was encountered at one borehole (Borehole No. 2), as such, one unsampled probe was

advanced beyond the obstruction with a Gardner Denver 300 hydraulic rock drill in order to determine the nature of shallow refusal.

The field investigation was carried out using a Bombardier and a truck mounted CME drilling rig equipped with hollow stem augers, standard augers, and routine geotechnical sampling equipment. Soil samples were obtained at the borehole locations 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). The SPT method involves advancing a 50 mm O.D. 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 field 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. The unsampled probes were advanced with a Gardner Denver hydraulic rock drill rig. Access to the east end of the culvert was flooded and, as such, a light weight barrel raft and Mobile B-24 drill rig were used to advance the borehole using wash boring techniques. Soil samples were taken using the SPT method.

Groundwater conditions in the open boreholes were observed during the advancement of 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. At the borehole(s) through the embankment, the upper portion of the hole, where necessary, was backfilled with an asphalt cold patch to seal the existing asphalt surface. 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, as well as specific gravity. 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 summary sheet and in Appendix C (Figures Nos. L-1 and L-2).

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. 2 (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 a 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 illustration purposes only.

4.1 Maskinonge Creek Culvert, Station 12+957, TWP of Jennings – Site No. 46-380/C

A plan and profile illustrating the borehole locations and stratigraphic sequences is shown on Figure No. 2, Appendix C. During the course of the exploration program, five (5) sampled boreholes were put down at this site, with Borehole Nos. 1 to 3 advanced through the existing embankment, and Borehole Nos. 4 and 5 advanced at either end of the culvert. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1, 2, 3, and 5 were recorded at 201.1, 201.4, 201.1, and 199.0 m, respectively. Borehole No. 4 was advanced at the culvert end, with a raft mounted drill, located in the creek. The surface water level at Borehole No. 4 was recorded at elevation 198.6 m.

4.1.1 Surficial Layers

At surface at Borehole Nos. 1 to 3, a surficial pavement structure consisting of 150 to 175 mm of asphalt and 175 to 200 mm of crushed gravel was encountered. An additional 50 mm of asphalt was encountered underlying the crushed gravel at Borehole No. 3. At surface at Borehole No. 4, free water was encountered to elevation 197.1 m. A 200 mm thick layer of silty organics was encountered at the surface at BH No. 5.

4.1.2 Fill

Underlying the layer of surficial silty organics at Borehole No. 5, a deposit of fill consisting of brown silt trace sand trace clay was penetrated. The natural moisture content measured on samples of this deposit was in the order of 21%. This deposit was encountered to a depth of 0.8 m below grade (elevation 198.2 m).

4.1.3 Embankment Fill

Underlying the surficial pavement structure at Borehole Nos. 1, 2, and 3, and underlying the silt fill at Borehole No. 5, a deposit of embankment fill consisting of brown sand trace to some

gravel trace to with silt, occasional cobbles was penetrated. The natural moisture content measured on samples of this deposit was in the order of 5 to 21%. Gradation analyses were carried out on six (6) samples of this deposit, the results of which indicated 6 to 14% gravel size particles, 60 to 83% sand size particles, and 9 to 33% silt and clay size particles (see Figure No. L-1, Appendix C). Based on SPT 'N' values of 3 to 29 blows per 300 mm penetration, the compactness of this deposit was described as very loose to compact, generally compact.

DCPT refusal was encountered at a depth of 1.3 m below grade at Borehole No. 2 (elevation 200.1 m). Auger refusal was encountered on a boulder size rock at depth of 3.4 m below ground surface at Borehole No. 2 (elevations 198.0 m). This obstruction was bypassed using the hydraulic rock drill. This fill deposit was encountered to depths of 5.0, 5.0, and 2.3 m below grade at Borehole Nos. 1, 3, and 5 (elevations 196.1, 196.1, and 196.7 m, respectively).

4.1.4 Peat

Underlying the embankment fill at Borehole No. 5, a deposit of black fine fibrous peat with wood inclusions was encountered. The natural moisture content measured on samples of this deposit was in the order of 309 to 323%. This deposit was encountered to a depth of 3.5 m below grade (elevation 195.5 m).

4.1.5 Organic Silt

Underlying the free water at Borehole No. 4, and underlying the peat at Borehole No. 5, a deposit of black organic silt was penetrated. The natural moisture content measured on samples of this deposit was in the order of 83 to 141%. This deposit was encountered to depths of 2.2 and 4.0 m below grade at Borehole Nos. 4 and 5, respectively (elevations 196.4 and 195.0 m, respectively).

4.1.6 Sand

Underlying the embankment fill at Borehole Nos. 1, 2 and 3, and underlying the organic silt at Borehole Nos. 4 and 5, a deposit of grey sand trace to with gravel trace to some silt trace gravel was penetrated. The natural moisture content measured on samples of this deposit was in the order of 9 to 24%. Gradation analyses were carried out on five (5) samples of this deposit the results of which indicated 0 to 30% gravel size particles, 55 to 99% sand size particles, 2 to 25% silt and clay size particles (see Figure No. L-2, Appendix C). Based on SPT 'N' values of 4 to 29 blows per 300 mm penetration, the compactness of this deposit was described as loose to compact, generally compact. Auger refusal was encountered in this deposit at depths of 10.4, 10.3, 6.0, and 8.8 m below grade at Borehole Nos. 1, 3, 4, and 5, respectively (elevations 190.7, 190.8, 192.6, and 190.2 m, respectively). DCPT refusal was encountered at depths of 9.9, 10.7, 6.2, and 8.4 m below grade at Borehole Nos. 1, 3, 4, and 5, respectively (elevations 191.2, 190.4, 192.4, and 190.6 m, respectively). Bedrock (based on drill response) was encountered at a depth of 9.4 m (elevation 192.0 m) in the hydraulic rock drill probe hole advanced at Borehole No. 2.

4.2 Groundwater Conditions

Surface water was encountered in the culvert at an elevation of 198.6 m, at the time of this investigation. Measurements of the groundwater table and cave-in levels were undertaken, where possible, in the open boreholes during the advance of the individual borings and upon completion. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix B). The water level was recorded at elevations 198.8, 198.9, 199.2, and 198.6 m at Borehole Nos. 1, 2, 3, and 5, respectively. Borehole No. 4 was advanced at the culvert end, in the creek, and as such the water level was that of the creek at the time of this investigation (elevation 198.6 m). The groundwater levels will fluctuate seasonally. The creek water level in June 1966 was recorded at elevation 197.75 m.

LVM | MERLEX

M. A. Merleau, P. Eng.
Principal Engineer
MTO Designate

J. R. Berghamer, P. Eng.
Regional Manager

5.0 DESIGN COMMENTS AND RECOMMENDATIONS

5.1 General

A foundation investigation was carried for the proposed replacement of an existing culvert and for a protection system, as identified in the RFP. This 5.5 x 3.6 m SPCSPA culvert is identified as Site No. 46-380/C, at Station 12+957 in the Township of Jennings.

The existing culvert is 5.5 x 3.5 m diameter SPCSPA some 24.4 m long. The existing highway embankment currently supports two undivided lanes of highway, running in a north south direction. Flow through the culvert is from west to east with an average summer flow of 0.2 m³/s and a one in ten year daily flow of 3.2 m³/s. Based on data from this foundation investigation, the embankment supporting the existing pavement structure at this site has been constructed using granular fill containing occasional cobble/boulder size pieces of rock. The native material underlying the fill generally consisted of compact sands with refusal varying between elevations 190.2 and 192.6 m, at the borehole locations.

It is understood that a 3.6 m concrete box culvert is the preferred type of culvert to replace the existing 5.5 x 3.6 m SPCSPA culvert. The precast box culvert will likely be constructed at a similar alignment and skew to the existing culvert.

5.2 Foundation Considerations

The founding native compact sands present below the existing embankment are considered adequate for support of a Rigid Frame Box culvert and for a conventional highway embankment of this height. Bearing resistance should not be a major issue provided the natural bearing surface is not disturbed during construction and groundwater is controlled during construction, as discussed in Section 5.6.

Based on the characteristics of the native loose to compact sand subgrade present below the culvert foundation, the response of the existing embankment, and a founding elevation similar to that of the existing culverts, a factored bearing resistance at ULS of 650 kPa can be used, for a concrete frame **box** culvert. A geotechnical resistance at SLS of 100 kPa can be used for design, in consideration of 25 mm settlement. If a concrete frame **open** culvert is considered, then a factored bearing resistance at ULS of 100 kPa and at SLS of 50 kPa should be used.

The existing embankment has preloaded the soils at the culvert locations and since there will be no change in the height of the embankment, and therefore no increase in embankment load, no appreciable settlement of the embankment is anticipated. As such, installing the culvert on a camber will not be required at this site.

5.3 Culvert Design, Bedding, and Embedment

The embankment consists of granular soils (pavement structure) overlying granular fill. The results of this investigation indicate that, below the culvert invert, the native soils at Borehole Nos. 1 to 3 consist of generally compact sands. A review of the condition of the pavement surface, at the culvert locations, revealed a minor transverse asphalt crack, however, in general, the embankment appears to have performed well (see Photo Essay, Appendix D).

It is understood that the preferred type of replacement culvert will be a precast Rigid Frame Box culvert. Bedding for a rigid frame box culvert shall consist of Granular A with a thickness of 300 mm. The bedding under the middle third of the box unit base should be loosely placed and uncompacted. The upper 75 mm portion of the Granular A bedding should be uncompacted throughout the length/width of the box and incorporated as the top levelling course in conformance with OPSS 422. During backfilling the embankment fill should be placed in a

balanced manner on both sides of the box unit. Cover material for concrete box culverts should consist of 300 mm of Granular A.

It is understood that frost tapers will be required to both sides (south and north) of the proposed culvert, as per the geotechnical report also by LVM | MERLEX, Ref No. 11/14/11046-P2. The frost tapers shall commence at the frost depth of 2.0 m and taper upward from the sides of the culvert at a 10H:1V slope to the bottom of the Granular A base, taken as 0.5 m deep at this location. Provide a 1 m long taper through the 0.5 m depth of granular. The backfill below the frost tapers should be constructed to match the existing embankment, and the existing embankment fill can be used as backfill, outside the frost taper zone, and below the pavement structure, provided it is properly placed in lifts and compacted.

The joints between precast box units should be covered with a strip of Non-Woven Class II Geotextile 600 mm in width, centered over the joint, covering the top of the culvert and extending halfway down the sides of the culvert to prevent the infiltration of fines.

Apron (cut-off) walls, 1.2 m deep, must be added to the ends of the rigid frame box culvert in accordance with the MTO Concrete Culvert Design Manual. It is anticipated that wing walls will also be added at the concrete box culvert ends. An apron of rock protection would be required at the culvert ends, for a distance of 5 m either side of the culvert, if wing walls are not used. Clay seals are not considered necessary.

5.4 Culvert Installation and Construction Staging Considerations

The existing culverts are established in an earth fill embankment some 5 m in height. The invert elevation of the existing culvert is at 196.7 m, with the top of the embankment at elevation 201.2 m at centerline. As such, the embankment at this location is some 4.5 m in height above the

culvert invert at the centerline. Therefore, a 5.1 m deep excavation (i.e. to elevation 196.1 m) will be required, with the invert of the box placed a distance equal to 10% of the box height below the stream bed level and allowing for a minimum of 300 mm of bedding and leveling course below the culvert. The present platform width at this location is some 9 m as can be seen on the cross section on Figure No. 2. The platform width at this location, as is, will not be sufficient in width to carry out an open excavation using staged construction. At this culvert location, sliver widening and/or locally lowering the grade will be insufficient to allow for an open excavation. As such, a protection system must be used to carry out the excavation at this culvert location and maintain a single lane of traffic.

5.4.1 Protection System

The installation of a protection system for use in the culvert replacement operation will require penetration through some 5.0 m of earth embankment fill. The embankment fill is underlain by compact sands. Obstructions were not encountered in the embankment, except at Borehole No. 2. As such, it is anticipated that a conventional shoring system consisting of driven sheet piles can be considered for a protection systems at this culvert. See Table A, Appendix E, for advantages and disadvantages for the different type of protection system considered for this site. Conceptual shoring locations are illustrated on Figure No. SK-3, Appendix E.

Considering the cohesionless nature of the embankment fills (granular pavement structure over earth fills) a rectangular pressure distribution over the height of the cut would be appropriate for design of temporary shoring. The width of the apparent rectangular pressure distribution, over the height of excavation, can be considered equal to $0.65 \cdot K_a \cdot \gamma \cdot H$, where $K_a=0.30$, and $\gamma=20.0$ kN/m³.

Considering the depth of excavation and provided a sheet pile of sufficiently robust cross section is used, a whaler and raker system may be used to span the width of the culvert, however, a tieback system may also be chosen by the contractor. If tiebacks are used, the resistance (R) for grouted anchors, located outside the active failure wedge, in cohesionless soils can be estimated from the following equation as supplied in the Canadian Foundation Manual (4th Edition):

$$R = \sigma_z' A_s L_s \alpha_g$$

Where: σ_z' = effective vertical stress at the midpoint of the load carrying length

A_s = effective unit surface area of the anchor

L_s = effective embedment length of the anchor

α_g = anchorage coefficient
use 1.0 for granular backfill

Unless the pull-out resistance (capacity) of the anchor is proven with a load test program, the allowable anchor load (as suggested by the Canadian Foundation Engineering Manual, 4th Edition), is commonly obtained by dividing the computed capacity of the anchor by a factor of safety of 3. Alternatively, proprietary anchor systems can be used.

The temporary protection system should be designed and constructed to comply with OPSS 539. In consideration of the location of the protection system and traffic volume, a performance level 2 is considered appropriate. However, a detailed monitoring system must be implemented by the contractor in order to guarantee the serviceability of the half of the structure which is carrying traffic, specifically during critical stages of construction. The monitoring system shall include scaled survey targets attached to the protection system, surveyed by a registered land surveyor or professional engineer as identified in OPSS 539, to ensure that the horizontal displacement and angular distortion do not exceed the limits as outlined in 539.04.02.01.

5.5 Lateral Earth Pressures

Lateral earth pressures should be computed in accordance with the Canadian Highway Bridge Design Code (CHBDC). The design parameters for the bedding/embedment and backfill materials are as follows:

	<u>Granular A</u>	<u>Granular B Type I</u>	<u>SSM/ Existing Embankment Material</u>
Angle of Internal Friction (degrees)	35	30	30
Unit weight (KN/m ³)	22	20	18
Active earth pressure (Ka)	0.27	0.33	0.33
At-rest earth pressure (Ko)	0.43	0.50	0.50

For rigid structures, such as a precast concrete box culvert, 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.

5.6 Excavation, Dewatering, and Embankment Reconstruction

All excavations greater than 1.2 m in depth must, at a minimum, be sloped or shored in accordance with the Occupational Health and Safety Act Regulations for Construction Projects. The embankment material, above the water table, is considered a Type 3 soil as defined in the Occupational Health and Safety Act and Regulations for Construction Projects. Temporary open excavations above the groundwater table, could be cut back at an angle of 1H:1V, however, below the groundwater table, the side slopes will have to be cut back to an angle of 2H:1V, possibly shallower, dependent upon the Contractors’ chosen method of controlling the groundwater. Final (permanent) embankment side slopes in earth fills should be established at the standard angle of 2H:1V.

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 a dewatered condition during excavation and foundation construction and every reasonable effort must be made to prevent disturbing (piping/boiling) at the founding subgrade. The water level was recorded at elevation 198.6 m, at the time of this investigation. Groundwater control, in accordance with OPSS 517 and 518, will be required to maintain a stable subgrade during culvert installation.

The water level in the creek was recorded at elevation 198.6 m at the time of this investigation and excavations to elevation 196.1 m would be required to install the culvert and bedding. As such, a 2.5 m head of water must be controlled during excavation and culvert installation.

A positive method of controlling the groundwater would be to enclose the full excavation with closed steel sheet piling, driven to an adequate depth below the excavation to maintain the groundwater exit gradient below the critical value where piping would develop. Generally, at a minimum, the sheet piling would have to penetrate a depth below the base of the excavation equal to the head of water above the excavation base.

Ultimately, the method of excavation, dewatering, and stream flow diversion will be the choice of the contractor; however the importance of maintaining the subgrade in a dewatered stable condition during excavation and foundation construction cannot be stressed enough.

5.7 Construction Concerns

The high water level in the creek, which is fed from a relatively large wet land area directly to the west, could result in groundwater control issues which would subsequently result in unstable subgrade conditions during excavation and installation of the culvert. See Section 5.6 for recommendations on dewatering. No other major construction concerns are anticipated if construction is carried out in general conformance with the above discussion.

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.

LVM | MERLEX

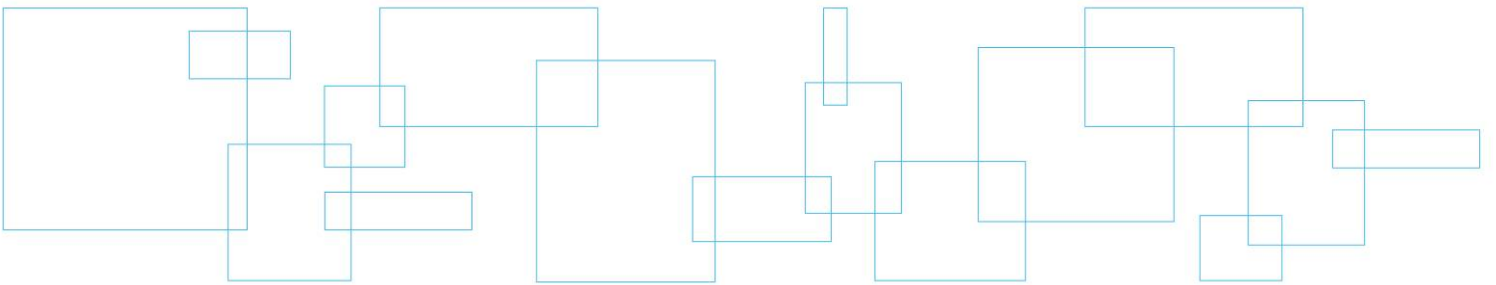
M. A. Merleau, P. Eng.
Principal Engineer
MTO Designate

J. R. Berghamer, P. Eng.
Regional Manager

Appendix A

Key Plan

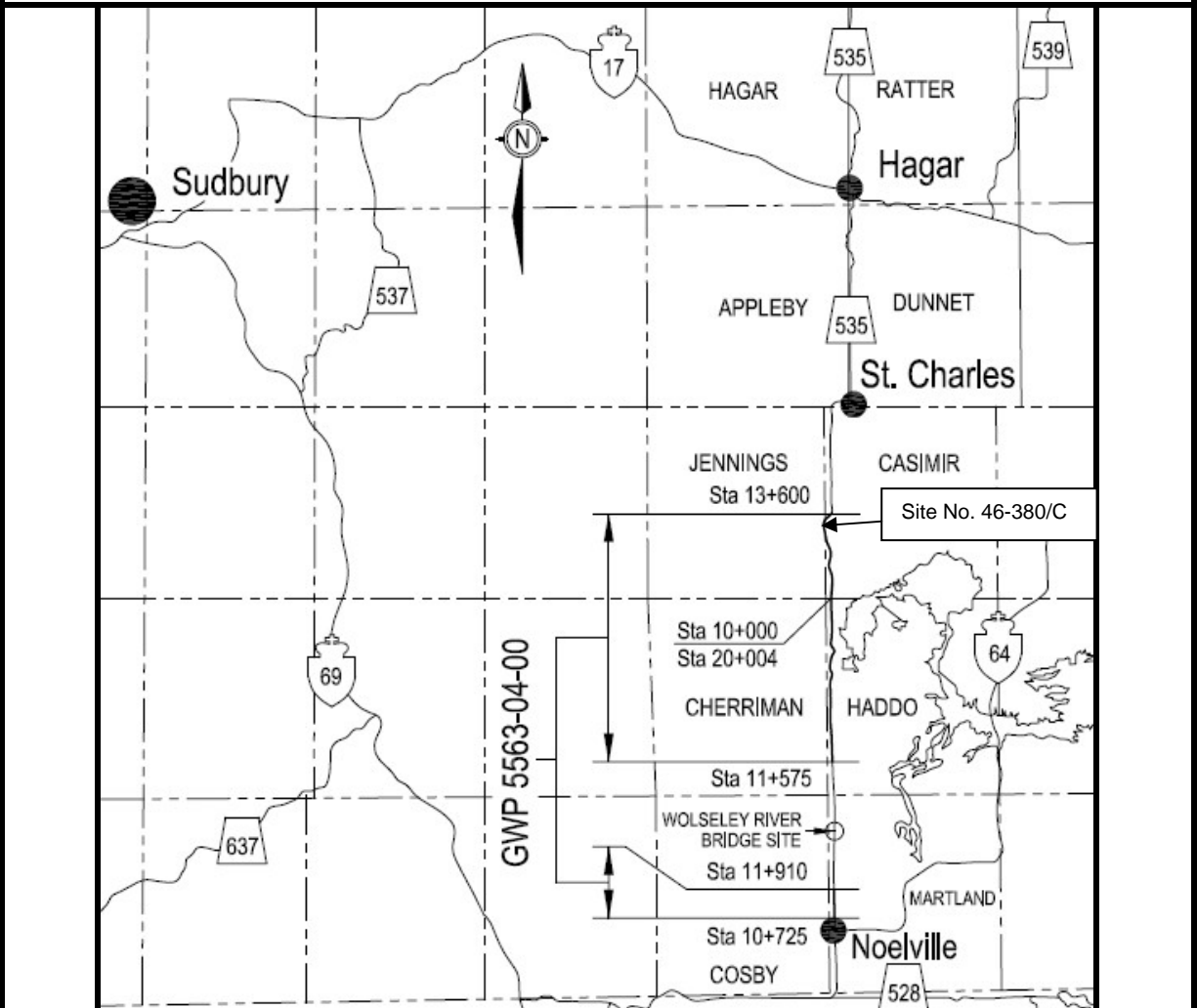
Figure No. 1: Key Plan



KEY PLAN

Figure No. 1

NOT TO SCALE



FINAL FOUNDATON INVESTIGATION AND DESIGN REPORT GWP 5563-04-00

Highway 535
From 8.1 km North of Highway 64
(Noelville) Northerly 12.1 km;
And, 0.6 km North of Highway 64
Northerly 1.4 km
District of Sudbury

LVM | MERLEX

Ref. No.: 11/04/11046-F6

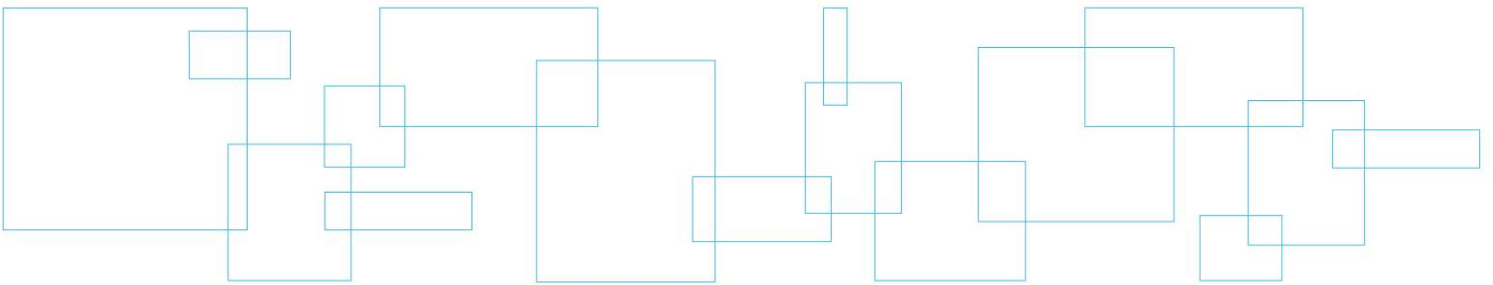
April, 2012

Appendix B

Abbreviations Record of Borehole Sheets

Enclosure No. 1: List of Abbreviations and Symbols

Enclosure Nos. 2 to 6: Record of Borehole Sheets



LIST OF ABBREVIATIONS AND 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:

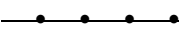
1. ABBREVIATIONS

AS	Auger Sample
CS	Chunk Sample
DS	Denison type sample
FS	Foil Sample
NP	Non Plastic
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
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 60° cone attached to AW rod 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

LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

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.

METRIC

RECORD OF BOREHOLE NO. 1



REFERENCE 11/04/11046-F6 DATUM Geodetic LOCATION N5129807.6 E348166.0 - Township of Jennings - Maskinonge Cree ORIGINATED BY JL
 PROJECT WP 5536-05-01, Highway 535 - Site No. 46-380/C BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT
 CLIENT AECOM Inc. DATE (Started) May 25, 2011 TIME
 DATE (Completed) May 25, 2011 (Completed) 2:20:00 PM CHECKED BY JRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE								
201.1	Ground Surface											
0.0	175 mm asphalt 200 mm crushed gravel FILL - brown sand trace to some gravel trace to with silt (compact/very loose)		1	AS	N/A							
			2	SS	17							13 60 (27)
			3	SS	13							
			4	SS	3							14 66 (20)
			5	SS	5							
	brown grey		6	SS	6							
	50 mm asphalt pieces		7	SS	9							8 83 (9)
196.1	SAND - grey sand some to with gravel some silt trace clay (loose/compact)		8	SS	6							
5.0			9	SS	9							16 59 20 5
			10	SS	5							
			11	SS	29							30 55 13 2
191.2	Continued Next Page											

COMMENTS	+ 3, X 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) 5/25/11 2:20:00 PM	2.3 3.1
		2)	- -
		3)	- -

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

MEL-GEO 11046 - BH LOGS MASKINONGE.GPJ MEL-GEO.GDT 4/12/12

METRIC

RECORD OF BOREHOLE NO. 1



REFERENCE 11/04/11046-F6 DATUM Geodetic LOCATION N5129807.6 E348166.0 - Township of Jennings - Maskinonge Cree ORIGINATED BY JL
 PROJECT WP 5536-05-01, Highway 535 - Site No. 46-380/C BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT
 CLIENT AECOM Inc. DATE (Started) May 25, 2011 TIME
 DATE (Completed) May 25, 2011 (Completed) 2:20:00 PM CHECKED BY JRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80					
9.9	DCPT Refusal					191										
190.7																
10.4	Auger Refusal End of Borehole															

MEL-GEO 11046 - BH LOGS MASKINONGE.GPJ MEL-GEO.GDT 4/12/12

METRIC

RECORD OF BOREHOLE NO. 2



REFERENCE 11/04/11046-F6 DATUM Geodetic LOCATION N5129819.1 E348162.6 - Township of Jennings - Maskinonge Cree ORIGINATED BY JL
 PROJECT WP 5536-05-01, Highway 535 - Site No. 46-380/C BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT
 CLIENT AECOM Inc. DATE (Started) May 25, 2011 TIME
 DATE (Completed) May 25, 2011 (Completed) 5:30:00 PM CHECKED BY JRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE								
201.4	Ground Surface											
0.0	150 mm asphalt 200 mm crushed gravel FILL - silty sand trace gravel occasional cobbles		1	AS	N/A							
200.1			2	SS	10							
1.3	DCPT Refusal		3	SS	12							
			4	SS	29							
			5	SS	36/200 mm							
198.0	Auger Refusal on boulders Hydraulic rock drill probe advanced from surface - unsampled Occasional cobbles/boulders in sands from 3 m to 9.4 m depth											6 61 (33)
3.4												
192.0	BEDROCK (based on drill response) Continued Next Page											
9.4												

COMMENTS
 Borehole advanced beyond auger refusal with Gardner Denver 300 hydraulic rock drill
 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) 5/25/11 5:30:00 PM	2.5	3.2
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS MASKINONGE.GPJ MEL-GEO.GDT 4/12/12

METRIC

RECORD OF BOREHOLE NO. 2



REFERENCE 11/04/11046-F6 DATUM Geodetic LOCATION N5129819.1 E348162.6 - Township of Jennings - Maskinonge Cree ORIGINATED BY JL

PROJECT WP 5536-05-01, Highway 535 - Site No. 46-380/C BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) May 25, 2011 TIME
 DATE (Completed) May 25, 2011 (Completed) 5:30:00 PM CHECKED BY JRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80					
	Continued from Previous Page															
	BEDROCK															
188.9																
12.5	End of Hydraulic Rock Drill Probe End of Borehole															

MEL-GEO 11046 - BH LOGS MASKINONGE.GPJ MEL-GEO.GDT 4/12/12

METRIC

RECORD OF BOREHOLE NO. 3



REFERENCE 11/04/11046-F6 DATUM Geodetic LOCATION N5129796.0 E348179.2 - Township of Jennings - Maskinonge Cree ORIGINATED BY JL
 PROJECT WP 5536-05-01, Highway 535 - Site No. 46-380/C BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT
 CLIENT AECOM Inc. DATE (Started) May 26, 2011 TIME
 DATE (Completed) May 26, 2011 (Completed) 5:20:00 PM CHECKED BY JRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE								
201.1	Ground Surface											
0.0	150 mm asphalt 175 mm crushed gravel 50 mm asphalt		1	AS	N/A							
	FILL - brown sand some to with silt trace to some gravel		2	SS	21							8 73 (19)
	(loose/compact)		3	SS	15							
			4	SS	4							
	brown		5	SS	15							14 62 (24)
	grey		6	SS	20							
	asphalt and gravel mix		7	SS	12							
196.1												
5.0	SAND - grey sand trace to some silt trace gravel		8	SS	6							1 99 (0)
	(loose/compact)		9	SS	24							
			10	SS	29							

Continued Next Page

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) 5/26/11 5:20:00 PM	1.9	3.8
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS MASKINONGE.GPJ MEL-GEO.GDT 4/12/12

METRIC

RECORD OF BOREHOLE NO. 3



REFERENCE 11/04/11046-F6 DATUM Geodetic LOCATION N5129796.0 E348179.2 - Township of Jennings - Maskinonge Cree ORIGINATED BY JL

PROJECT WP 5536-05-01, Highway 535 - Site No. 46-380/C BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) May 26, 2011 TIME
 DATE (Completed) May 26, 2011 (Completed) 5:20:00 PM CHECKED BY JRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 	PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
ELEV. DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE						
	Continued from Previous Page									
190.8			11	AS	N/A	191				4 79 (17)
10.3	Auger Refusal									
190.4										
10.7	DCPT Refusal End of Borehole									

MEL-GEO 11046 - BH LOGS MASKINONGE.GPJ MEL-GEO.GDT 4/12/12

METRIC

RECORD OF BOREHOLE NO. 4



REFERENCE 11/04/11046-F6 DATUM Geodetic LOCATION N5129804.1 E348179.2 - Township of Jennings - Maskinonge Cree ORIGINATED BY JL
 PROJECT WP 5536-05-01, Highway 535 - Site No. 46-380/C BOREHOLE TYPE Raft and Mobile B24 COMPILED BY AT
 CLIENT AECOM Inc. DATE (Started) August 23, 2011 TIME _____
 DATE (Completed) August 23, 2011 (Completed) _____ CHECKED BY JRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)												
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE									"N" VALUES	SHEAR STRENGTH kPa	WATER CONTENT (%)									
198.6 0.0	Water Level Water																							
197.1 1.5	ORGANIC SILT - black organic silt trace sand																							
196.4 2.2	SAND - grey sand trace silt trace gravel (compact)		1	SS	4						83.2													
			2	SS	18																			
			3	SS	21																			
			4	SS	11							0 98 (2)												
192.6 6.0	Auger Refusal		5	SS	70/100 mm																			
192.0 6.2	DCPT Refusal End of Borehole																							
COMMENTS							+ 3, X 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE																	
							WATER LEVEL RECORDS <table border="1"> <thead> <tr> <th>Date (dd/mm/yy)Time</th> <th>Water Depth (m)</th> <th>Cave In (m)</th> </tr> </thead> <tbody> <tr> <td>1)</td> <td>-</td> <td>-</td> </tr> <tr> <td>2)</td> <td>-</td> <td>-</td> </tr> <tr> <td>3)</td> <td>-</td> <td>-</td> </tr> </tbody> </table>						Date (dd/mm/yy)Time	Water Depth (m)	Cave In (m)	1)	-	-	2)	-	-	3)	-	-
Date (dd/mm/yy)Time	Water Depth (m)	Cave In (m)																						
1)	-	-																						
2)	-	-																						
3)	-	-																						
The stratification lines represent approximate boundaries. The transition may be gradual.																								

MEL-GEO 11046 - BH LOGS MASKINONGE.GPJ MEL-GEO.GDT 4/12/12

METRIC

RECORD OF BOREHOLE NO. 5



REFERENCE 11/04/11046-F6 DATUM Geodetic LOCATION N5129793.1 E348155.3 - Township of Jennings - Maskinonge Cree ORIGINATED BY JL
 PROJECT WP 5536-05-01, Highway 535 - Site No. 46-380/C BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT
 CLIENT AECOM Inc. DATE (Started) June 29, 2011 TIME
 DATE (Completed) June 29, 2011 (Completed) 6:30:00 PM CHECKED BY JRB

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			"N" VALUES	20					
199.0	Ground Surface												
0.0	200 mm Silty Organics												
	FILL - brown silt trace sand trace clay		1	AS	N/A								
198.2													
0.8	FILL - grey sand some gravel trace silt		2	SS	14								
	occasional cobbles and boulders		3	SS	45/150mm								
196.7													
2.3	PEAT - black fine fibrous peat with wood inclusions		4	SS	4							323	
			5	SS	2							309	
195.5													
3.5	ORGANIC SILT - black organic silt		6	SS	5							141	
195.0													
4.0	SAND - grey sand trace silt (loose/compact)		7	SS	4								0 96 (4)
			8	SS	12								
			9	SS	18								
190.6													
8.4	DCPT Refusal												
190.2													
8.8	Auger Refusal End of Borehole												

COMMENTS: + 3, X 3 : Numbers on right refer to Sensitivity. Numbers on left refer to values greater than 120 kPa. O 3% STRAIN AT FAILURE.

WATER LEVEL RECORDS	
Date (dd/mm/yy)Time	Water Depth (m) Cave In (m)
1) 6/29/11 2:30:00 PM	0.4 3.3
2)	- -
3)	- -

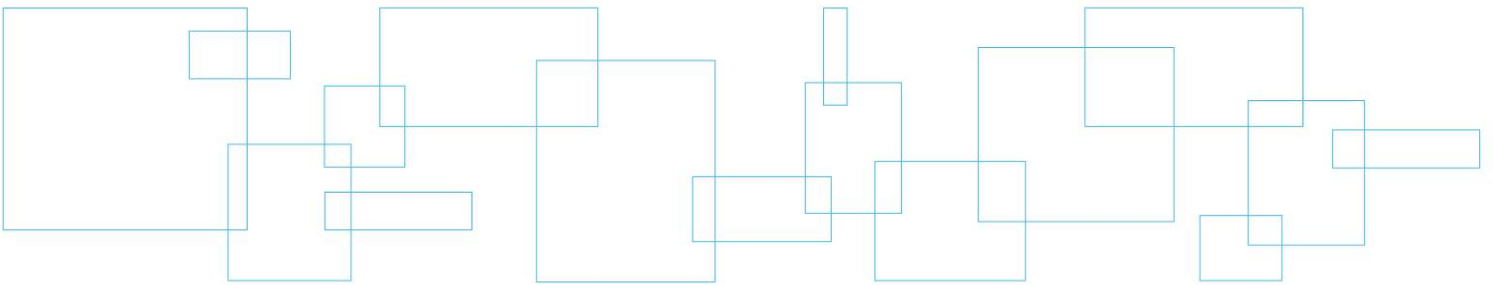
The stratification lines represent approximate boundaries. The transition may be gradual.

MEL-GEO 11046 - BH LOGS MASKINONGE.GPJ MEL-GEO.GDT 4/12/12

Appendix C

Borehole Location Plan Labwork

Figure No. 2: Borehole Location and Soil Strata
Figure Nos. L-1 and L-2: Summary Grain Size Analysis
Figure No. L-3: Lab Test Summary Sheet



METRIC

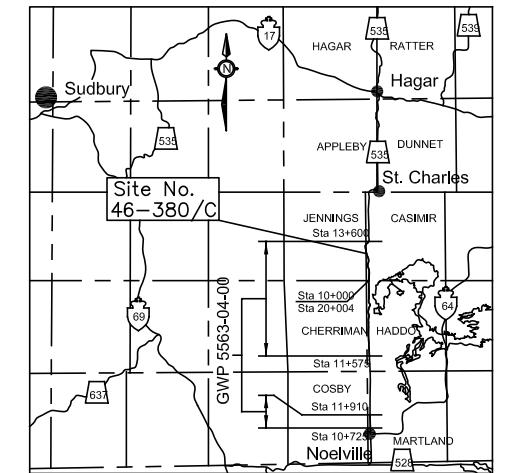
Dimensions are in meters and/or millimeters unless otherwise shown. Stations are in kilometers + meters.

SITE No 46-380/C
GWP No 5563-04-00
GEOCRES No 411-283



HWY NO. 535 - Township of Jennings Figure 2
Maskinonge Creek
Culvert Replacements- Station 12+957
BOREHOLE LOCATIONS & SOIL STRATA

LVM | MERLEX



KEY PLAN - NOT TO SCALE

LEGEND

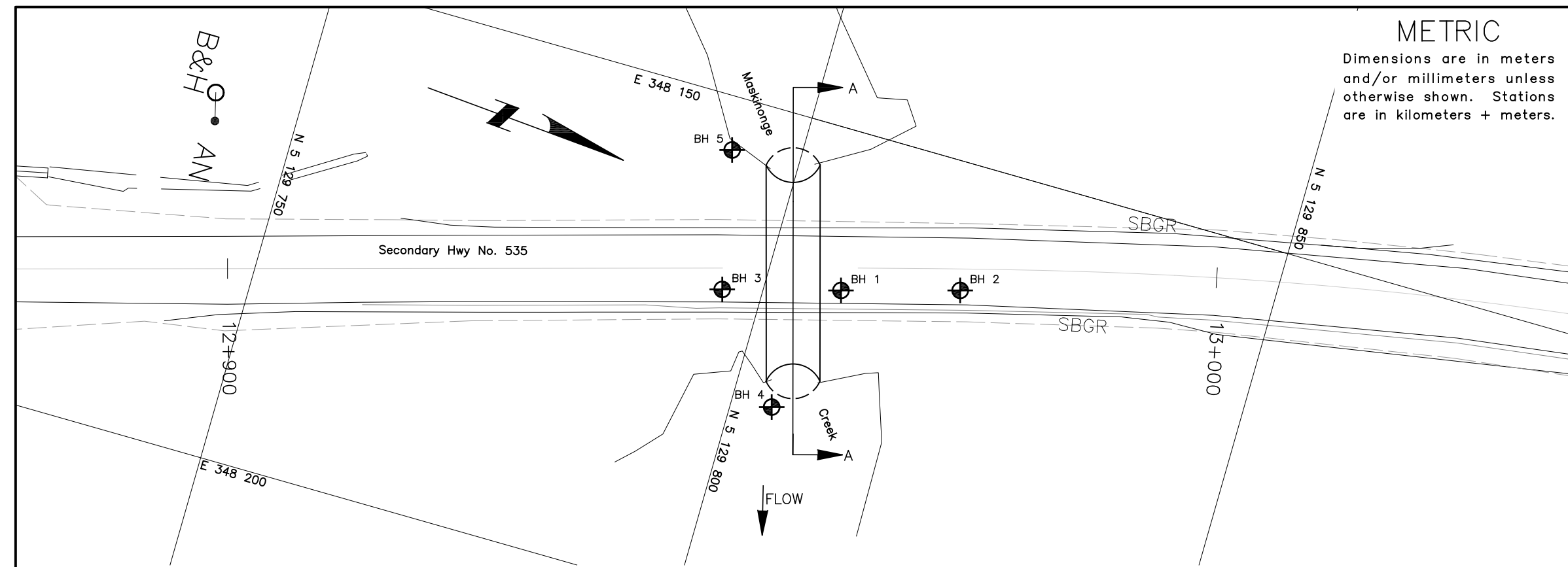
- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole & DCPT
- Blows/0.3 m (Std Pen Test, 475 J/blow)
- DCPT Blows/0.3 m (60' Cone, 475 J/blow)
- Water Level at Time of Investigation
- Auger Refusal at Elevation
- End of Sampling

Borehole No.	Elev.	O/S	Co-ordinates	
			Northerly	Easterly
Borehole No. 1	201.1	2.2m Rt	5129807.6	348166.0
Borehole No. 2	201.4	2.1m Rt	5129819.1	348162.6
Borehole No. 3	201.1	2.1m Rt	5129796.0	348169.2
Borehole No. 4	198.6	14.0m Rt	5129804.1	348179.2
Borehole No. 5	199.0	12.0m Lt	5129793.1	348155.3

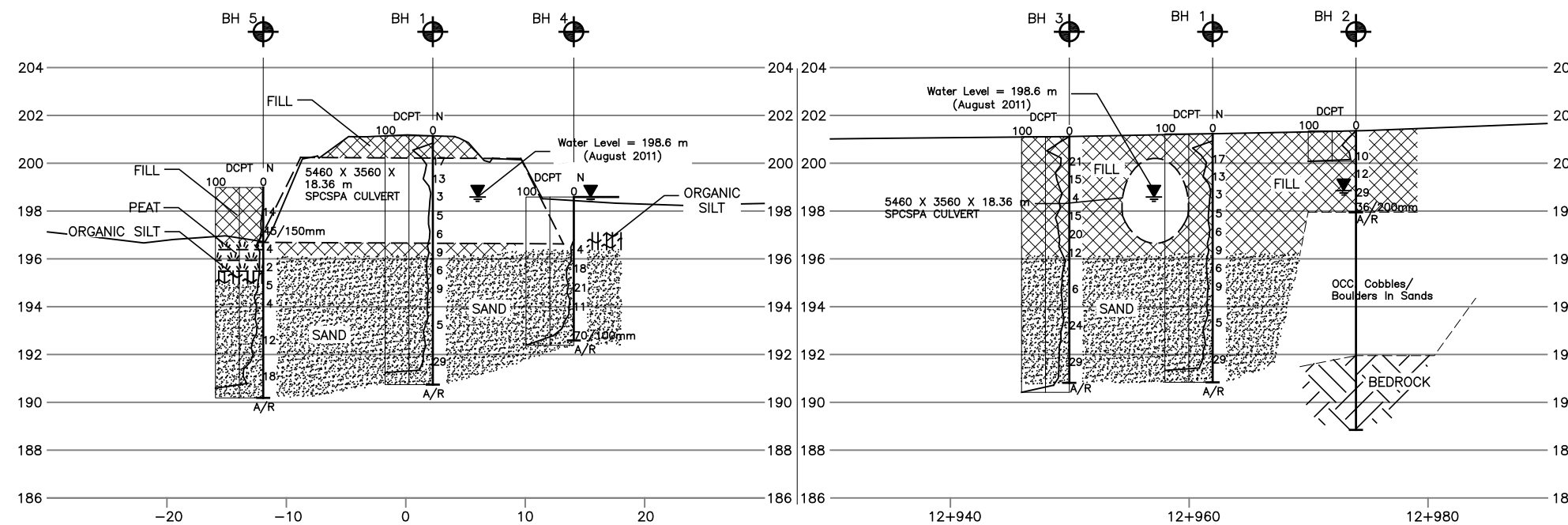
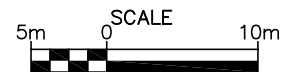
NOTE:
The boundaries between soil strata have been established at the borehole locations only. The boundaries illustrated and stratigraphy between boreholes on this drawing are assumed based on borehole data and may vary. They are intended for design only.

REVISIONS	DATE	BY	DESCRIPTION

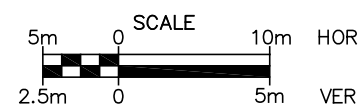
HWY No. 535 - Jennings Twp - Maskinonge Creek		REF: 11046
SUBM'D		SITE 46-380/C
DRAWN MCM	CHK MAM	DATE September 2011
		FIG 2



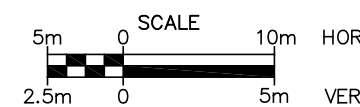
PLAN



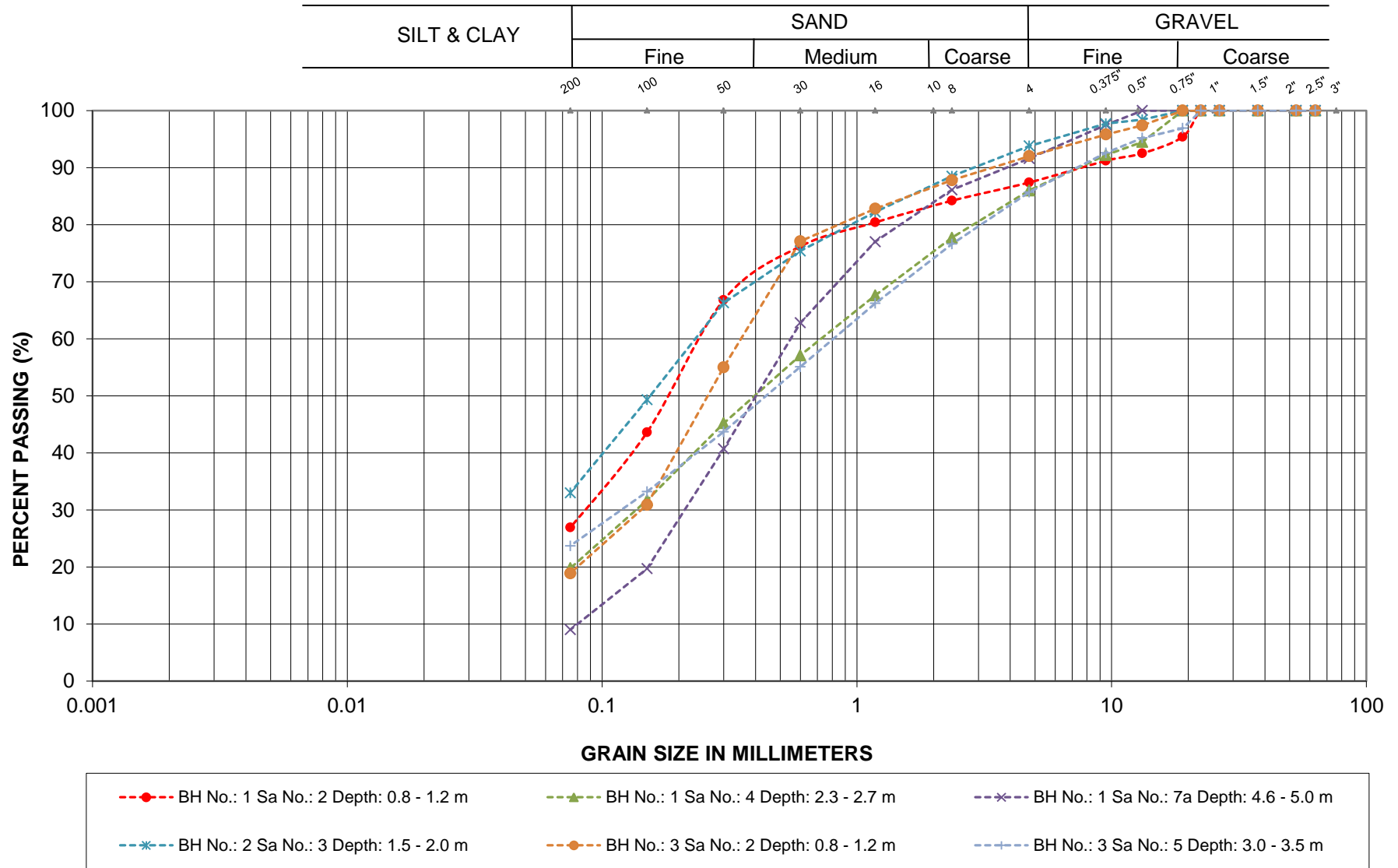
CROSS SECTION A - A



PROFILE



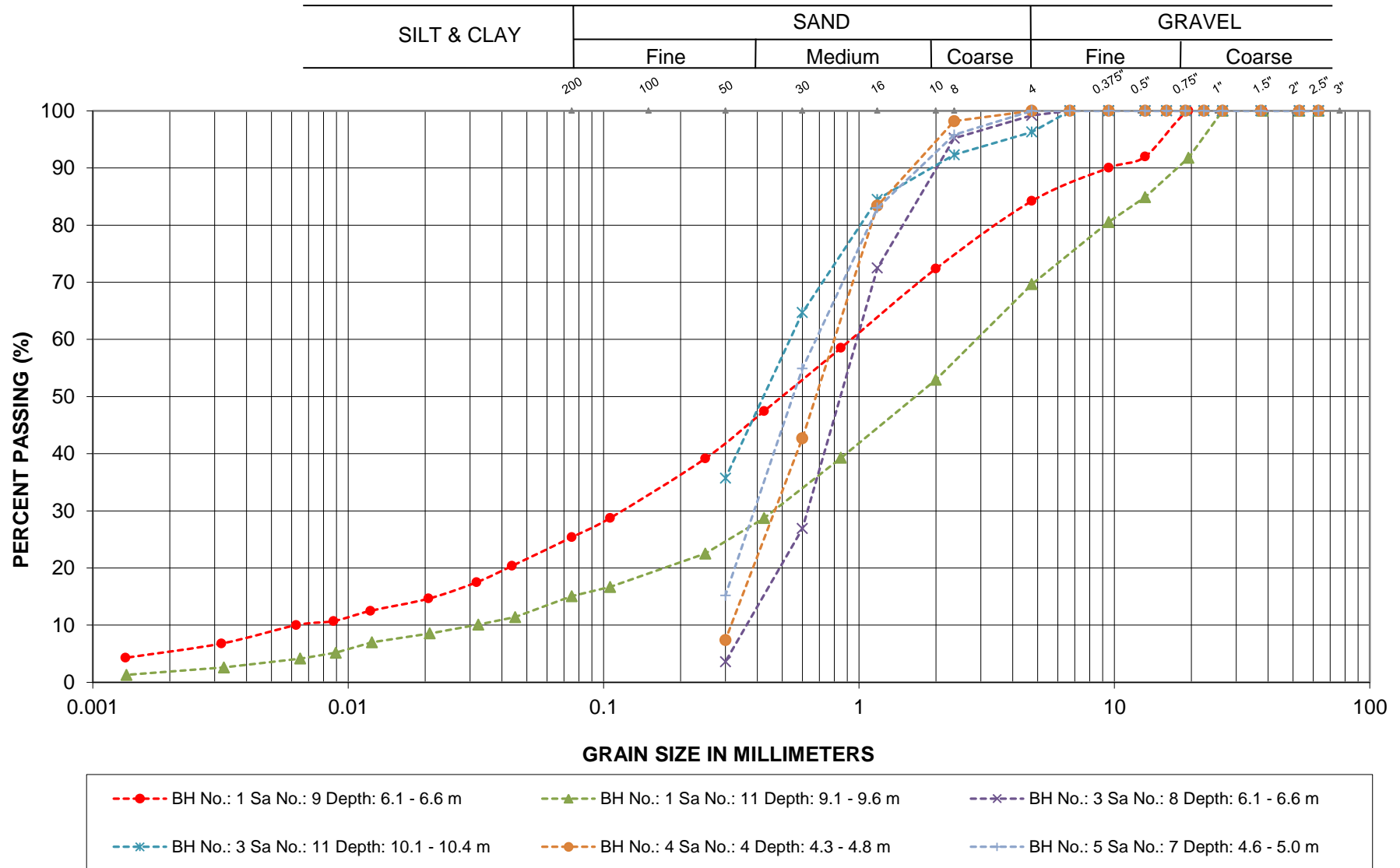
GRAIN SIZE ANALYSIS



G.W.P.: 5563-04-00
 LOCATION: Hwy 535
 SITE: 46-380/C

EMBANKMENT FILL

GRAIN SIZE ANALYSIS



G.W.P.: 5563-04-00
 LOCATION: Hwy 535
 SITE: 46-380/C

SAND

Date: April 2012

Laboratory Tests - Summary Sheet

Borehole No.	Sample No.	Depth	Grain Size Analysis				NMC	Atterberg Limits			SPT 'N'	USCS	Unit Weight (kN/m ³)	Remarks
			Gravel Size (%)	Sand Size (%)	Silt Size (%)	Clay Size (%)		LL (%)	PL (%)	IP (%)				
1	1	0.0					5.4				N/A			
	2	0.8	13	60		27	7.2				17			
	3	1.5					8.2				13			
	4	2.3	14	66		20	9.9				3			
	5	3.0					13.8				5			
	6	3.8					13.1				6			
	7a	4.6	8	83		9	14.1				9			
	7b	4.6					9.5				9			
	7c	4.6					13.5				9			
	8	5.3					11.6				6			
	9	6.1	16	59		20	14.5				9			
	10	7.6					11.2				5			
	11	9.1	30	55		13	8.5				29			
2	1	0.0					9.4				N/A			
	2	0.8					10.7				10			
	3	1.5	6	61		33	13.6				12			
	4	2.3					15.0				29			
	5	3.0					14.8				36/200mm			
3	1	0.0					5.9				N/A			
	2	0.8	8	73		19	6.5				21			
	3	1.5					7.6				15			
	4	2.3					12.9				4			
	5	3	14	62		24	10.4				15			
	6a	3.8					10.9				20			
	6b	3.8					6.5				20			
	7	4.6					8.0				12			
	8	6.1	1	99		0	18.9				6			

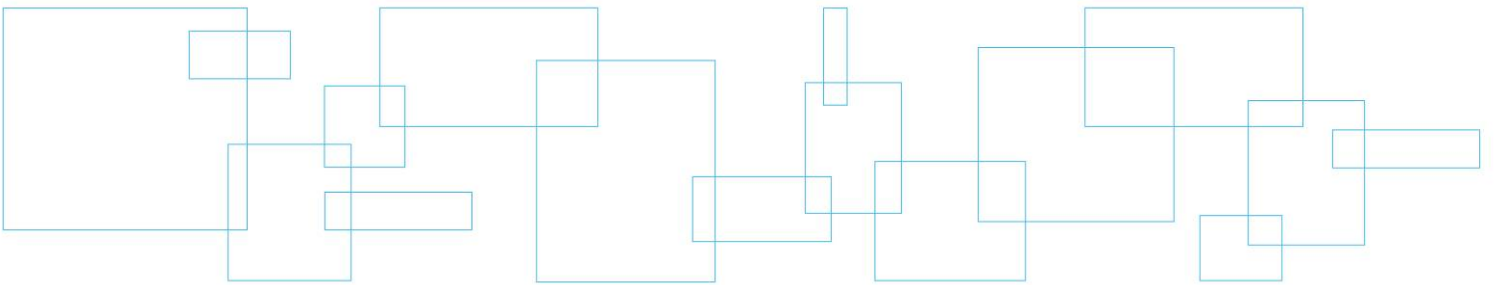
Date: April 2012

Laboratory Tests - Summary Sheet

Borehole No.	Sample No.	Depth	Grain Size Analysis				NMC	Atterberg Limits			SPT 'N'	USCS	Unit Weight (kN/m ³)	Remarks
			Gravel Size (%)	Sand Size (%)	Silt Size (%)	Clay Size (%)		LL (%)	PL (%)	IP (%)				
3	9	7.6					18.1				24			
	10	9.1					19.0				29			
	11	10.1	4	79	17		11.0				N/A			
4	1a	1.9					83.2				4			
	1b	1.9					16.8				4			
	2	2.7					12.2				18			
	3	3.5									21			
	4	4.3	0	98	2		21.5				11			
	5	5.8									70/100mm			
5	1	0									N/A			
	2	0.8									14			
	3	1.5									45/150mm			
	4	2.3									4			
	5	3									2			
	6	3.8									5			
	7	4.6	0	96	4						4			
	8	6.1									12			
	9	7.6									18			

Appendix D Photo Essay

Enclosure No. 7: Photo Essay



Top: Embankment at culvert outlet, looking north
Bottom: Embankment at culvert inlet, looking north

Photo: 1 - 2



Reference Number: 11/04/11046-F6

Project: Hwy 535 – Maskinonge Creek Culvert – Site No. 46-380/C

Provided By: LVM | MERLEX

Date: May 2011

Top: Stream at culvert outlet, looking east
Bottom: Stream at culvert inlet, looking west

Photo: 3 - 4



Reference Number: 11/04/11046-F6

Project: Hwy 535 – Maskinonge Creek Culvert – Site No. 46-380/C

Provided By: LVM | MERLEX

Date: May 2011

Top: Culvert site, looking north
Bottom: Culvert barrel, looking west

Photo: 5 - 6



Reference Number: 11/04/11046-F6

Project: Hwy 535 – Maskinonge Creek Culvert – Site No. 46-380/C

Provided By: LVM | MERLEX

Date: May/August 2011

Top: Drilling Borehole No. 4, looking east

Photo: 7



Reference Number: 11/04/11046-F6

Project: Hwy 535 – Maskinonge Creek Culvert – Site No. 46-380/C

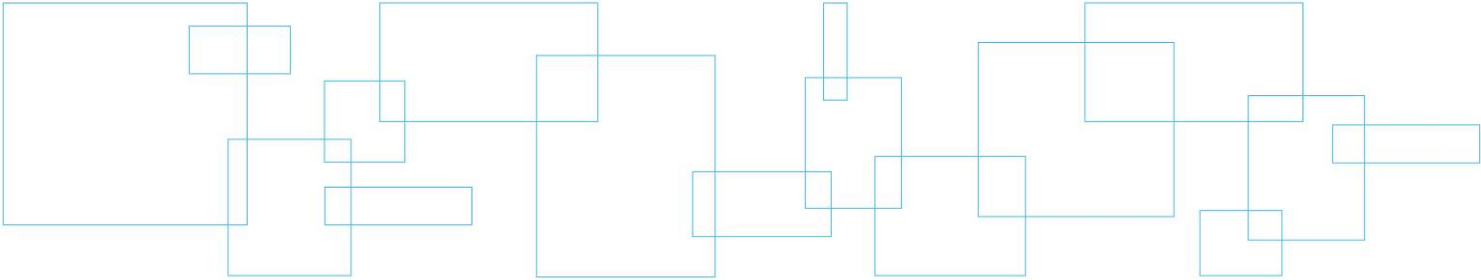
Provided By: LVM | MERLEX

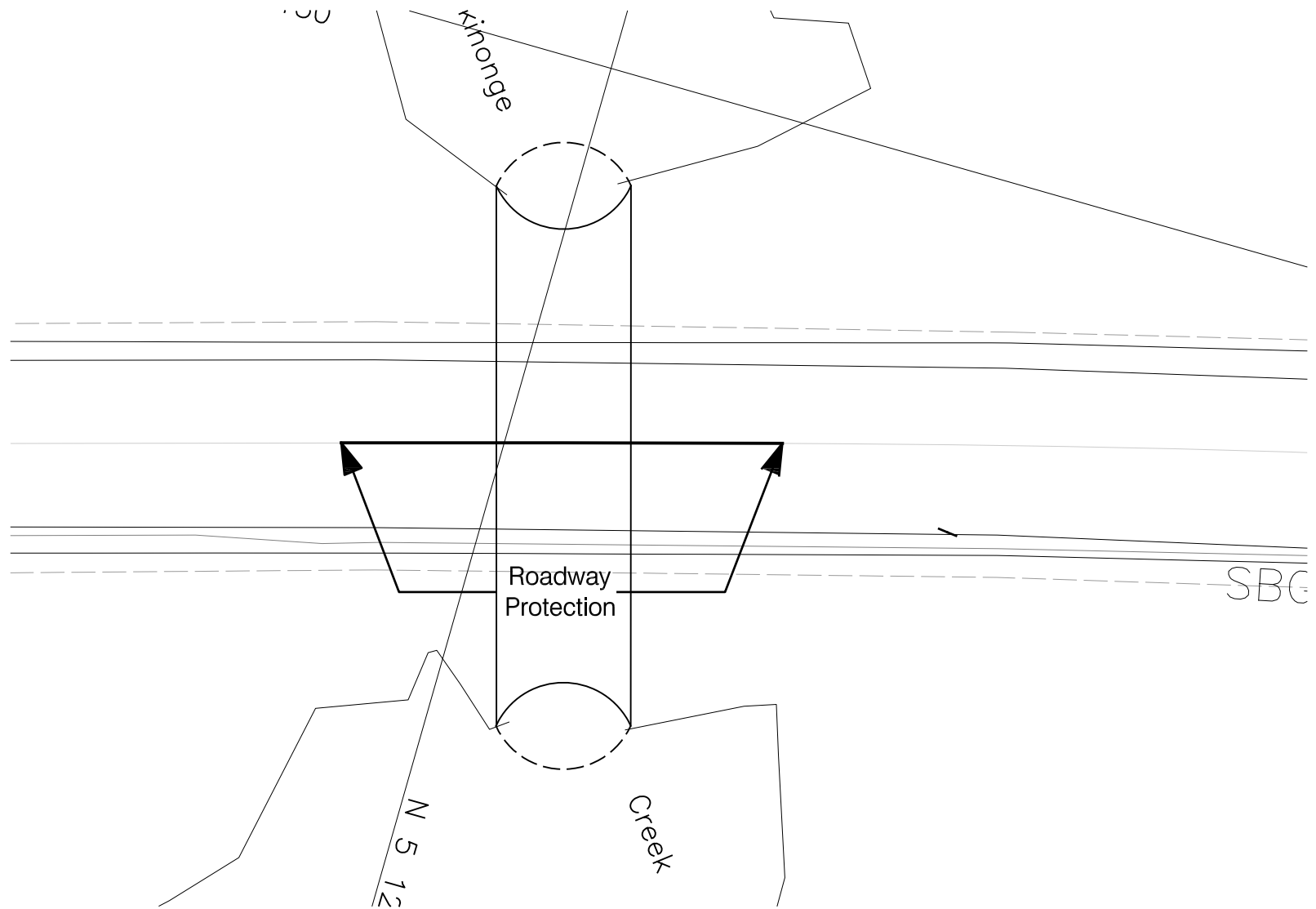
Date: August 2011

Appendix E

Design Data

Sketch Nos. SK-3: Conceptual Shoring Location
Table A: Comparison of Shoring Alternatives





NOT TO SCALE

HWY 535 - Township of Jennings - Site 46-380/C
Conceptual Shoring Locations- Maskinonge Creek

FIGURE SK-3

Table A – Protection Systems

Retaining System	Depth Range (m)	Advantages	Disadvantages	Remarks	Estimated Costs
Wood Sheeting	1.5 – 5	-Low cost, -Easily installed in good ground conditions	-Limited by soil conditions, -Limited depth of installation, -Low strength, -discontinuous	Not considered for protection system due to high water level	
Steel Sheet Piles	5 – 21	-High strength, continuous, -Readily available	-Limited by soil conditions (i.e. obstructions)	Recommended for excavations at this site	\$ 650/m ²
Soldier piles	5 – 25	-Easy installation -Readily available -Adaptable to various ground conditions	-Pre-drilling may be required -Possible ground loss	Not Considered due to limited depths required and higher costs	
Pre-cast concrete panels	3 – 10	-Durable -Assists in minimizing seepage	-Limited depths -Can be damaged by driving -Limited by soil conditions (i.e. obstructions)	Not considered due to limited depth required and higher costs	
Micropiles with reinforced shotcrete face		-Can be installed in various ground conditions -High strength -Good tolerance	-High Cost -Requires specialized equipment	Not considered due to limited depth required and higher costs	
Tangent/ Secant/ Staggered Drilled Piles	10 – 18	-Readily available -Adaptable to various ground conditions	-Possible ground loss and/or seepage -Poor alignment tolerance	Not Considered due to limited depths required and higher costs	
Concrete Diaphragm	10 – 30	-High Strength -Durable -Can be permanent	-High cost -Requires specialized equipment/control	Not Considered due to limited depths required and higher costs	