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
Bridge Rehabilitation – Site No. 46-175
West Arm Lake Nipissing North Channel Bridge
TWP of Cherriman
GWP 5563-04-00
WP 5323-08-01

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. Nº: 11/04/11046-F9

Geocres No. 41I-280

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

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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 design of a protection system at the West Arm Lake Nipissing North Channel Bridge. This bridge rehabilitation (GWP 5563-04-00, WP 5323-08-01) is located on Highway 535, some 14 km north of Hwy 64, in the Township of Cherriman. The existing bridge is a single span steel plate girder bridge with a total length of 30.5 m and width of 12.2 m.

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 bridge approaches in order to provide design recommendations for a protection system to allow conversion to a semi-integral abutment. 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 West Arm Lake Nipissing North Channel Bridge is located on Highway 535, between Stations 17+502 to 17+532.5, Township of Cherriman (Site No. 46-175). 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 channel flow is from west to east at the bridge location. A visual review of the highway at the north and south approaches indicates that, in general, the bridge approaches have performed well.

The existing 30.5 m single span bridge was constructed in 1971 and rehabilitated in 1991 on the original highway alignment.

Infrastructure at the culvert location consists of overhead power and communication wires on the east (right) 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 silty clay, overlying silts and sands.

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 Metasediments including conglomerate, sandstone, siltstone, chert, and iron formations.

3.0 INVESTIGATION PROCEDURES

The fieldwork for this investigation was carried out between June 21st and September 12th, 2011, during which four (4) sampled boreholes were advanced using an auger drill. Two boreholes were advanced at each end of the bridge: one through the existing approach slab and the second a short distance beyond the end of the approach slab. Unsampled probes were advanced with a Hydrotrack drill rig at the borehole locations in order to further delineate the nature of the shallow auger refusal.

The field investigation was carried out using 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 using a Hydrotrack 300 drill rig.

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 boreholes 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. 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 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 West Arm Lake Nipissing North Channel Bridge, TWP of Cherriman – Site No. 46-175

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, four (4) sampled boreholes were put down at this site, with Borehole Nos. 1 and 2 advanced to the south of the south end of the bridge to the right of centerline, and Borehole Nos. 3 and 4 advanced at the north approach to the bridge to the left of centerline. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1 to 4 were recorded at 200.1, 200.2, 200.5, and 200.6 m, respectively.

4.1.1 Pavement Structure

At surface at Borehole Nos. 1 and 4, a surficial pavement structure consisting of 75 to 100 mm of asphalt overlying 400 to 425 mm of crushed gravel was encountered. At surface at Borehole Nos. 2 and 3, a pavement structure consisting of 75 mm of asphalt overlying a 250 to 285 mm thick concrete approach slab was penetrated.

4.1.2 Fill

Underlying the pavement structure at each borehole, a deposit of fill consisting of crushed gravel occasional cobbles to brown sand trace gravel was penetrated. The natural moisture content measured on samples of this deposit was in the order of 3 to 6%. Gradation analyses were carried out on two (2) samples of this deposit, the results of which indicated 34 to 51% gravel size particles, 42 to 52% sand size particles, and 7 to 14% silt and clay size particles (see Figure No. L-1, Appendix C). Based on SPT 'N' values of 23 to 37 blows per 300 mm penetration, the compactness of this deposit was described as compact to dense. Auger refusal was encountered on cobble/boulder size rock in this deposit at depths of 0.9, 1.4, 1.4, and 1.3 m below ground surface at Borehole Nos. 1 to 4, respectively (elevations 199.2, 198.8, 199.1, and 199.3 m, respectively). DCPT refusal was encountered in this deposit at depths of 3.0, 3.0, 1.2, and 1.3 m below existing grade at Borehole Nos. 1 to 4, respectively (elevations 197.1, 197.2, 199.3, and 199.3 m, respectively).

Unsampled probes advanced at each of the borehole locations indicated that the refusal material likely consists of rock fill, generally extending to bedrock, which was encountered at depths of 7.7, 7.6, 7.9, and 8.5 m below existing grade at Boreholes Nos. 1 to 4, respectively (elevations 192.4, 192.6, 192.6, and 192.3 m, respectively). The unsampled probes were advanced 3 m into the bedrock.

4.1.3 Previous Investigations

Based on a previous foundation investigation, Geocres No. 41I-35, carried out in 1968, the subsurface conditions along the highway alignment generally consisted of free water over bedrock, with gravelly sand encountered to the north of the bridge. It is understood that the approach embankments at the West Arm Lake Nipissing North Channel Bridge along the current alignment were constructed using rock fill under Contract No. 70-166.

4.2 Groundwater Conditions

The water level in the river was measured at an elevation of 195.8 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). Each borehole was dry upon completion and was backfilled immediately upon completion of sampling. The groundwater levels will fluctuate seasonally.

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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 out for the design of a protection system for the proposed rehabilitation of the West Arm Lake Nipissing North Channel Bridge and conversion to a semi integral abutment, as identified in the RFP. The bridge is located between Stations 17+502 to 17+532.5, in the Township of Cherriman, and is identified as Site No. 46-175. The existing bridge is a 30.5 m single span, steel plate girder structure.

The existing highway, at the bridge location, supports two undivided lanes of traffic, running in a north-south direction. A visual review of the highway at the north and south approaches indicates that, in general, the bridge approaches have performed well. Based on data from this foundation investigation, the embankment supporting the existing pavement structure at this site has been constructed using granular materials (pavement structure) over rock fills overlying bedrock encountered at depths of 7.6 to 8.5 m below existing grade (elevations 192.1 to 192.6 m).

The conversion of the bridge to semi-integral abutments will require the removal of the ballast walls. It is anticipated that, to carry out the West Arm Lake Nipissing North Channel Bridge rehabilitation and convert the bridge to a semi-integral abutment, a protection system at the north and south abutments of the bridge will be required to accommodate an anticipated 1 m depth of excavation behind the existing abutments.

Based on the Contract Drawings, 70-166, the abutment footings were founded on rock fill at a depth of 4.0 m (elevation 196.5 m). The protection system is required to support an excavation depth of some ±1 m (i.e. to elevation 199.5 m), extending a sufficient distance back from the abutment to allow modification to the deck and removal of some 850 to 900 mm height of the ballast wall, for conversion to semi-integral abutment. As such, the rehabilitation is unlikely to impact the existing foundation elements.

5.2 Excavation and Dewatering

The fill below the pavement structure and approach slabs is considered a Type 3 soil in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects. As such, side walls of temporary open excavations, above the water table, river elevation 195.8 m, would have to be cut back to a angle of 1H:1V to remain stable. A 1 m deep excavation (i.e. to elevation 199.1 m) will be required to the rear of the abutments to allow the rehabilitation work to be carried out. The existing width of the approaches is insufficient to allow the construction of a 1H:1V slope parallel to the active traffic lane. As such, a vertical excavation adjacent to the active traffic lane will be required and a protection system installed perpendicular to the abutments will be needed to support the active traffic lane. Conceptual shoring locations are illustrated on Figure No. SK-3, Appendix D.

Excavations must be maintained in a dewatered condition during excavation construction. The groundwater was not encountered in the boreholes at the time of investigation (each borehole was dry at the time of the investigation). The water level in the river was recorded at elevation 195.8 m at the time of this investigation. This is below the anticipated depth of excavation (elevation 199.1 m), as such, it is not anticipated that the groundwater table will be encountered during the excavations at the abutments. If an unwatered excavation is required to be advanced below the prevailing groundwater table then groundwater control in accordance with OPSS 517 will have to be carried out.

5.3 Protection System

The results of this investigation indicated that, underlying the pavement structure and approach slabs, a fill consisting of sands trace gravel, trace silt was encountered, in a generally loose to compact state of compactness, to auger refusal on boulder size rock fill at approximately depths of 0.9 to 1.3 m (to elevations 198.8 to 199.3 m).

The required depth of anticipated excavation, directly behind the abutments, will be relatively shallow, in the order of 1.0 m (to elevations 199.2 to 199.5 m). Directly behind both abutments, auger refusal was met at a depth of 1.4 m (elevations 198.8 and 199.1 m), with shallow refusal of 0.9 and 1.3 m just beyond the south and north approach slabs, respectively (elevations 199.2 and 199.3 m). It should be possible to use short sections of steel sheet piling for the vertical protection system parallel to the active lane. The depth of the penetration may be restricted due to rock fill, and, as such, a raker may have to be installed to resist the toe pressure. Alternatively a protection system of H piles (soldier piles) with wood lagging could be considered. Pre-drilling would likely be required to advance the H piles. The H piles are generally installed with a 2 to 2.5 m spacing and the wood lagging should be installed as the excavation progresses.

Driven sheet pile may be considered for the protection system if a sheet pile of sufficiently robust section is used, with tiebacks to provide lateral resistance. The resistance (R) for tiebacks (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):

$\mathbf{R = \sigma_z' A_s L_s} \alpha_g$ 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.

An alternative to using soldier piles would be to install closely spaced micropiles with a reinforced shotcrete face and drilled in tieback anchors could be considered. Depending upon design, the micropiles could be spaced at intervals of 2 to 3 m, with a structurally reinforced shotcrete applied to the excavation face to control ground loss between the micropile locations. Additional lateral restraint can be supplied by drilling in tie-back anchors. Once the first side of the ballast wall has been rehabilitated and backfilling operations commenced, sacrificial deadman anchors with tiebacks could be installed in the backfill with the tieback ends exiting at the area of the micropiles to allow reconnection and stressing during advance of the opposite/second side of the excavation. It is likely that additional reinforced shotcrete will have to be applied as the opposite side of the excavation progresses. It is suggested that, if the excavation will be taken down close to or below the groundwater table, the shoring design incorporate a filtered drainage system below the lower shotcrete panel to prevent the possibility of hydrostatic pressure developing behind the wall.

Anchors, socketed into bedrock, may be required at this location. Bedrock in the area, as indicated on OGS Map 2506, comprises of Metasediments including conglomerate, sandstone, siltstone, chert, and iron formations. If anchors into bedrock are required, an ultimate load transfer of 430 kN/m can be used for pressure grouted anchors of 150 to 200 mm diameter.

Considering the anchor is a deep foundation resisting uplift forces, a factor of safety of 3 should be applied unless a pull out load test is carried out.

See Table A, Appendix E, for comparison of shoring alternatives.

Lateral earth pressures for the protection system can be designed using the following parameters:

Elevation (m)	Soil Type	Unit weight (KN/m^3) ɣ	Angle of Internal Friction (degrees)	Active earth pressure (Ka)	At-rest earth pressure (Ko)
200.2 – 198.8 @ South Abutment 200.6 – 199.1 @ North Abutment	Fill – Crushed gravel	20	32	0.31	0.47
198.8 – 192.6 @ South Abutment 199.1 – 192.6 @ North Abutment	Rock Fill	18.5	43	0.19	0.31
Below 192.6	Bedrock	-	-	-	-

For flexible retaining structures, deflection can occur, as such, the “active” condition (Ka) applies. Considering the cohesionless nature of the fill (granular pavement structure over rock fill), it is recommended that the apparent lateral earth pressure be calculated as a rectangular pressure distribution. As such, the apparent lateral pressure per linear meter of wall is equal to $0.65*K_a*\gamma*H^2$, where:

Ka = active earth pressure,
ɣ = unit weight, and
H = height of wall above the base of excavation.

The temporary protection system should be designed and constructed in accordance with OPSS 539. In consideration of the location of the protection system, a performance level 2 is considered appropriate.

5.4 Backfill and Compaction

The existing backfill at the abutments was generally in a compact condition. Prior to backfilling the excavation, the existing subgrade should be proofrolled with a minimum of five overlapping passes of a hand operated vibratory compactor with a minimum weight of 400 kg (or a centrifugal force of 50 kN). Backfilling should be carried out in accordance with OPSS 902 and compaction should be carried out in accordance with OPSS 501.

5.5 Construction Concerns

Considering the platform widths and the relatively shallow depth of expected excavations, no major construction concerns are anticipated if the works are carried out in general conformance to that discussed herein.

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 truck carrier owned by Chrisdamat Management Ltd., as well as a Hydrotrack drill rig. 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.

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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

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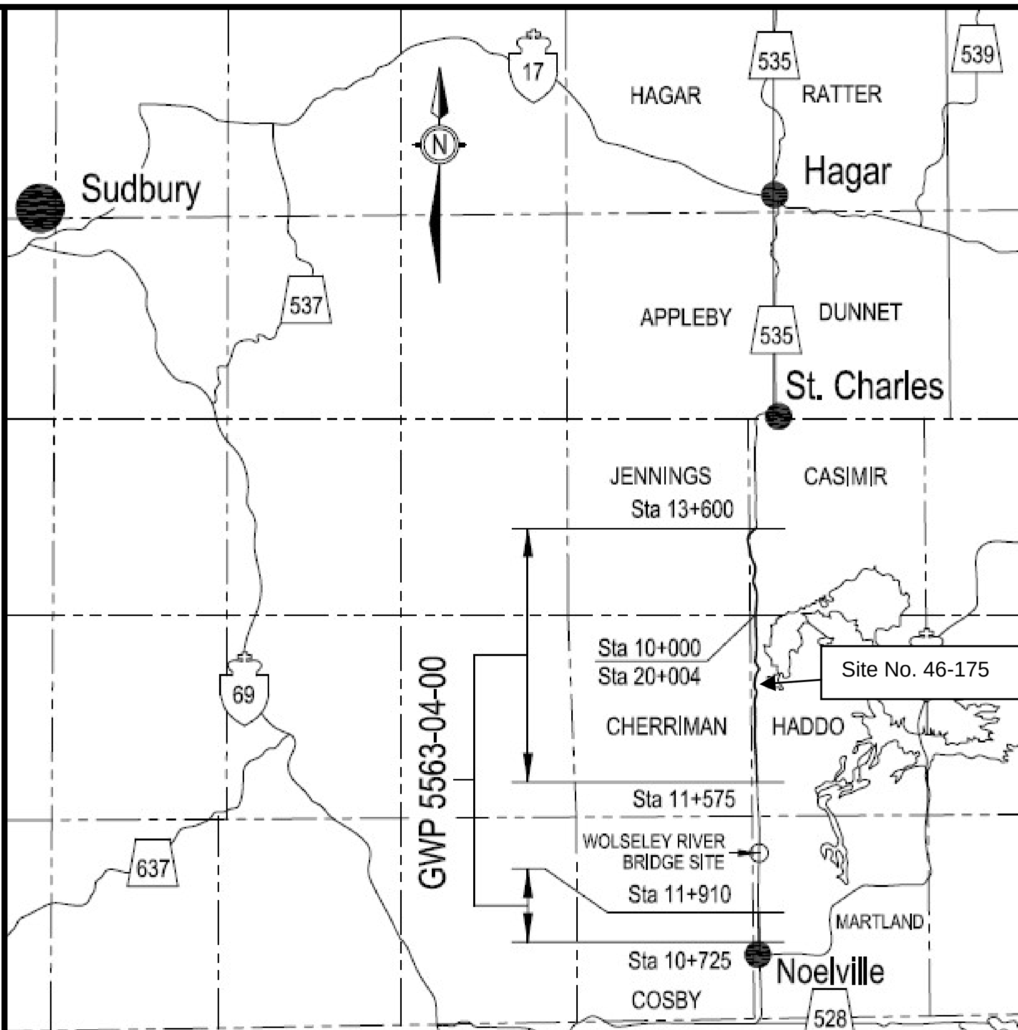
KEY PLAN

Figure No. 1

NOT TO SCALE



FINAL
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Highway 535
From 8.1 km North of Highway 64
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Ref. No.: 11/04/11046-F9 April 2012

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Appendix B Abbreviations
Record of Borehole Sheets

Enclosure No. 1: List of Abbreviations and Symbols
Enclosure Nos. 2 to 5: Record of Borehole Sheets

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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.

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

METRIC

RECORD OF BOREHOLE NO. 1

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REFERENCE 11/04/11046-F9 DATUM Geodetic LOCATION N5124415.6 E348576.9 - Cherriman Twp - W Arm N Channel Bridge ORIGINATED BY JL

PROJECT WP 5323-08-01, Highway 535 - Site No. 46-175 BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

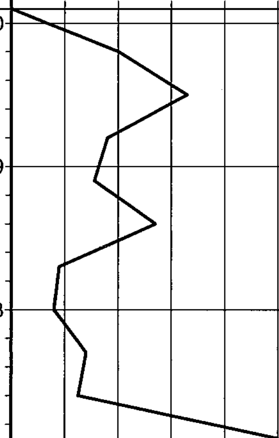
CLIENT AECOM Inc. DATE (Started) June 21, 2011 DATE (Completed) June 21, 2011 TIME (Completed) 2:10:00 PM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT (WATER CONTENT %)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
200.1	Ground Surface							
0.0	75 mm asphalt 400 mm crushed gravel FILL - crushed gravel occasional cobbles	1	AS	N/A		o		
199.2		2	SS	25/25 mm	(symbol)	o		34 52 (14)
0.9	Auger Refusal Hydrotrack probe advanced from surface - unsampled ROCK FILL							
197.1 3.0	DCPT Refusal							
192.4 7.7	BEDROCK							

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)

ELEVATION SCALE: 200, 199, 198, 197, 196, 195, 194, 193, 192, 191



Continued Next Page

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

O 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 6/21/11 2:10:00 PM	DRY	0.9
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS NORTH ARM.GPJ MEL-GEO.GDT 2/16/12

LVM | MERLEX ENGINEERING LTD.

, Phone: Fax: Email:

METRIC

RECORD OF BOREHOLE NO. 1

LVM | MERLEX

REFERENCE 11/04/11046-F9 DATUM Geodetic LOCATION N5124415.6 E348576.9 - Cherriman Twp - W Arm N Channel Bridge ORIGINATED BY JL

PROJECT WP 5323-08-01, Highway 535 - Site No. 46-175 BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) June 21, 2011 DATE (Completed) June 21, 2011 TIME (Completed) 2:10:00 PM CHECKED BY JRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X 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 (Continued from Previous Page)	STRATA PLOT	NUMBER	TYPE	"N" VALUES						
							190				
189.4 / 10.7	End of Hydrotrack Probe End of Borehole										

MEL-GEO 11046 - BH LOGS NORTH ARM.GPJ MEL-GEO.GDT 2/16/12

ENCLOSURE NO.: 3 (Pg. 1 of 2)

METRIC

RECORD OF BOREHOLE NO. 2

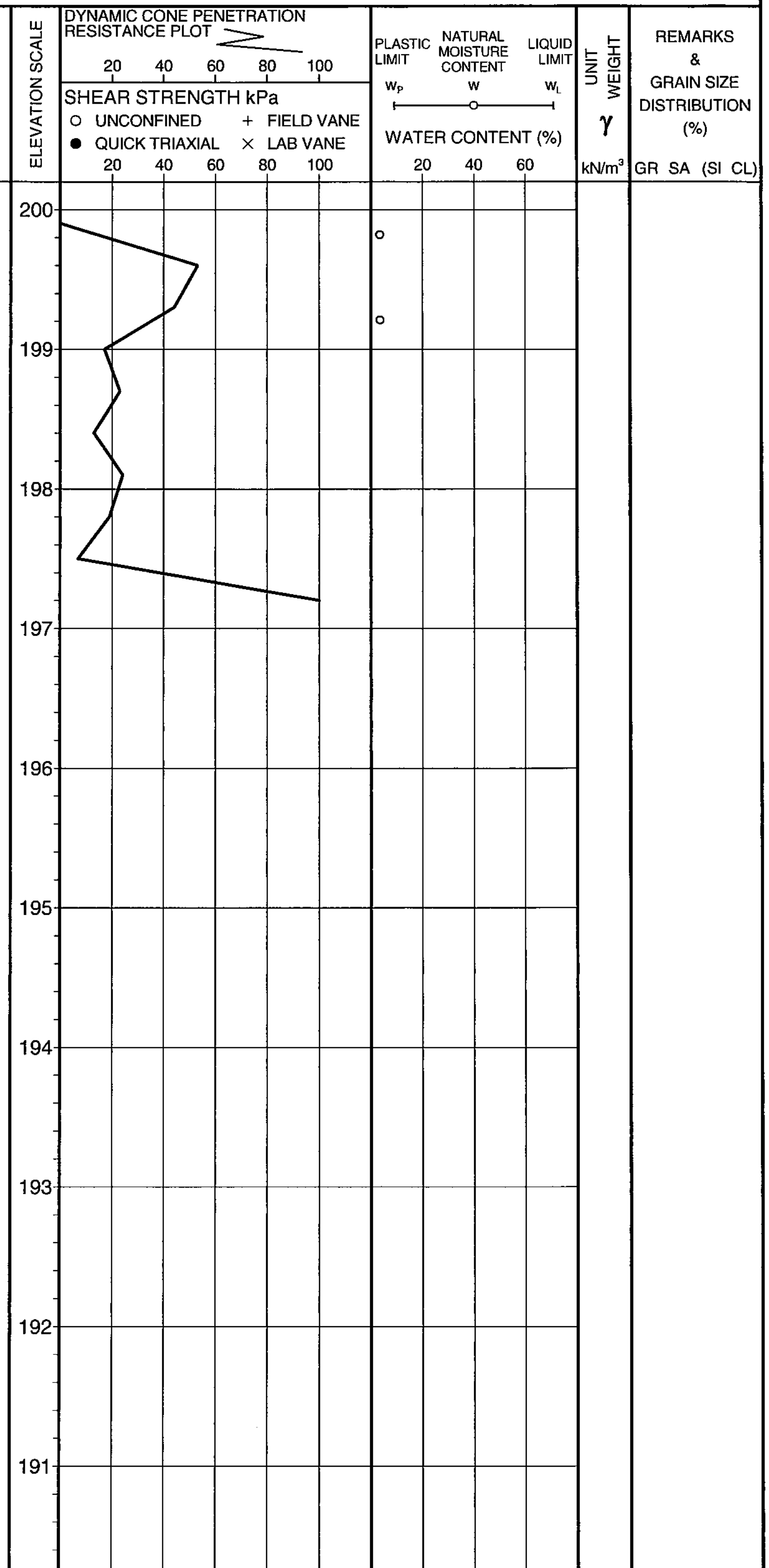
LVM | MERLEX

REFERENCE 11/04/11046-F9 DATUM Geodetic LOCATION N5124422.5 E348576.4 - Cherriman Twp - W Arm N Channel Bridge ORIGINATED BY JL

PROJECT WP 5323-08-01, Highway 535 - Site No. 46-175 BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) June 21, 2011 DATE (Completed) June 21, 2011 TIME (Completed) 12:47:00 PM CHECKED BY JRB

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
200.2	Ground Surface				
0.0	100 mm asphalt 250 mm concrete FILL - crushed gravel occasional cobbles (compact)	1	AS	N/A	
		2	SS	23	
198.8 1.4	Auger Refusal on boulder Hydrotrack probe advanced from surface - unsampled ROCK FILL				
197.2 3.0	DCPT Refusal				
192.6 7.6	BEDROCK				
	Continued Next Page				



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) 6/21/11 12:47:00 PM	DRY	1.1
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS NORTH ARM.GPJ MEL-GEO.GDT 2/16/12

ENCLOSURE NO.: 3 (Pg. 2 of 2)

METRIC

RECORD OF BOREHOLE NO. 2

LVM | MERLEX

REFERENCE 11/04/11046-F9 DATUM Geodetic LOCATION N5124422.5 E348576.4 - Cherriman Twp - W Arm N Channel Bridge ORIGINATED BY JL

PROJECT WP 5323-08-01, Highway 535 - Site No. 46-175 BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) June 21, 2011 DATE (Completed) June 21, 2011 TIME (Completed) 12:47:00 PM CHECKED BY JRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O 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 (Continued from Previous Page)	STRATA PLOT	NUMBER	TYPE	"N" VALUES						
							190				
189.5 / 10.7	End of Hydrotrack Probe End of Borehole										

MEL-GEO 11046 - BH LOGS NORTH ARM.GPJ MEL-GEO.GDT 2/16/12

ENCLOSURE NO.: 4 (Pg. 1 of 2)

METRIC

RECORD OF BOREHOLE NO. 3

LVM | MERLEX

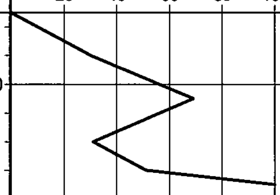
REFERENCE 11/04/11046-F9 DATUM Geodetic LOCATION N5124454.4 E348569.1 - Cherriman Twp - W Arm N Channel Bridge ORIGINATED BY JL

PROJECT WP 5323-08-01, Highway 535 - Site No. 46-175 BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) June 21, 2011 DATE (Completed) June 21, 2011 TIME (Completed) 10:38:00 AM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT (water content %)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
200.5	Ground Surface									
0.0	75 mm asphalt 285 mm concrete FILL - crushed gravel occasional stones (compact)		1	AS	N/A		200	o		
			2	SS	26	▼		o		51 42 (7)
199.3 / 1.2	DCPT Refusal									
199.1 / 1.4	Auger Refusal Hydrotrack probe advanced from surface - unsampled ROCK FILL						199, 198, 197, 196			
195.0 / 5.5	Rapid advance of hydrotrack probe Probably fine rock fill/rock fill with granulars from 5.5 to 7.9 m depth						195, 194, 193			
192.6 / 7.9	BEDROCK						192, 191			
	Continued Next Page									

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)



SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)

WATER CONTENT (%) 20 40 60

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

O 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 6/21/11 10:38:00 AM	DRY	1.1
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS NORTH ARM.GPJ MEL-GEO.GDT 2/16/12

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, Phone: Fax: Email:

ENCLOSURE NO.: 4 (Pg. 2 of 2)

METRIC

RECORD OF BOREHOLE NO. 3

LVM | MERLEX

REFERENCE 11/04/11046-F9 DATUM Geodetic

LOCATION N5124454.4 E348569.1 - Cherriman Twp - W Arm N Channel Bridge

ORIGINATED BY JL

PROJECT WP 5323-08-01, Highway 535 - Site No. 46-175

BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers

COMPILED BY AT

CLIENT AECOM Inc.

DATE (Started) June 21, 2011

DATE (Completed) June 21, 2011

TIME (Completed) 10:38:00 AM

CHECKED BY JRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O 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 (Continued from Previous Page)	STRATA PLOT	NUMBER	TYPE	"N" VALUES						
							190				
189.5 / 11.0	End of Hydrotrack Probe End of Borehole										

MEL-GEO 11046 - BH LOGS NORTH ARM.GPJ MEL-GEO.GDT 2/16/12

ENCLOSURE NO.: 5 (Pg. 1 of 2)

METRIC

RECORD OF BOREHOLE NO. 4

LVM | MERLEX

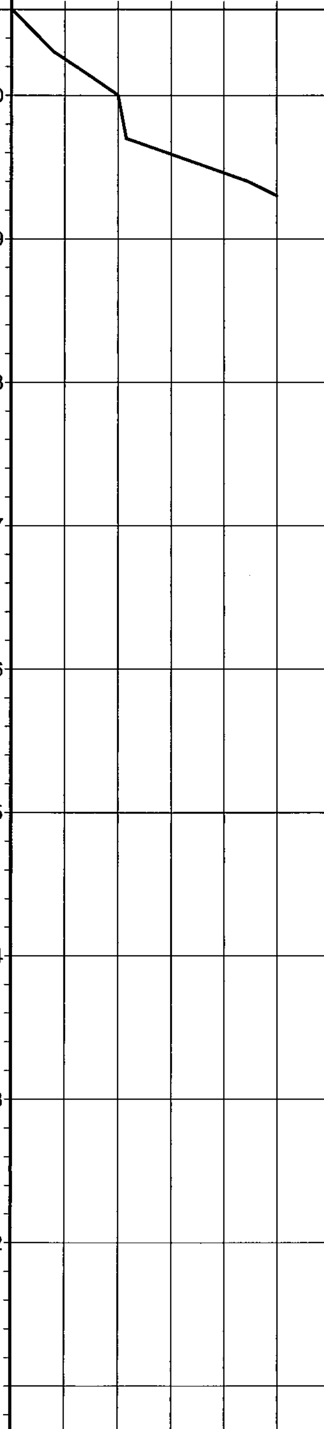
REFERENCE 11/04/11046-F9 DATUM Geodetic LOCATION N5124463.2 E348567.5 - Cherriman Twp - W Arm N Channel Bridge ORIGINATED BY JL

PROJECT WP 5323-08-01, Highway 535 - Site No. 46-175 BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) June 21, 2011 DATE (Completed) June 21, 2011 TIME (Completed) 11:30:00 AM CHECKED BY JRB

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRATA PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
200.6	Ground Surface								
0.0	75 mm asphalt 425 mm crushed gravel FILL - brown sand trace silt trace gravel occasional rock pieces (dense)		1	AS	N/A		o		
			2	SS	37		o		
199.3 / 1.3	Auger Refusal DCPT Refusal Hydrotrack probe advanced from surface - unsampled ROCK FILL								
196.0 / 4.6	Rapid advance of hydrotrack probe Probably fine rock fill/rock fill with granulars from 4.6 to 8.5 m depth								
192.1 / 8.5	BEDROCK								
	Continued Next Page								

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)
SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)
WATER CONTENT (%) 20 40 60
ELEVATION SCALE: 200, 199, 198, 197, 196, 195, 194, 193, 192, 191



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

O 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 6/21/11 11:30:00 AM	DRY	1.1
2)	-	-
3)	-	-

MEL-GEO 11046 - BH LOGS NORTH ARM.GPJ MEL-GEO.GDT 2/16/12

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METRIC

RECORD OF BOREHOLE NO. 4

LVM | MERLEX

REFERENCE 11/04/11046-F9 DATUM Geodetic
LOCATION N5124463.2 E348567.5 - Cherriman Twp - W Arm N Channel Bridge
ORIGINATED BY JL

PROJECT WP 5323-08-01, Highway 535 - Site No. 46-175
BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers
COMPILED BY AT

CLIENT AECOM Inc.
DATE (Started) June 21, 2011
DATE (Completed) June 21, 2011
TIME (Completed) 11:30:00 AM
CHECKED BY JRB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O 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 Continued from Previous Page	STRATA PLOT	NUMBER	TYPE	"N" VALUES						
							190				
189.0 11.6	End of Hydrotrack Probe End of Borehole						189				

MEL-GEO 11046 - BH LOGS NORTH ARM.GPJ MEL-GEO.GDT 2/16/12

Appendix C Borehole Location Plan Labwork

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

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METRIC

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

SITE No 46–175
WP No 5323–08–01
GEOCRES No 41I–280

HWY NO. 535 – Township of Cherriman

West Arm Lake Nipissing North Channel Bridge

BOREHOLE LOCATIONS & SOIL STRATA

Figure 2

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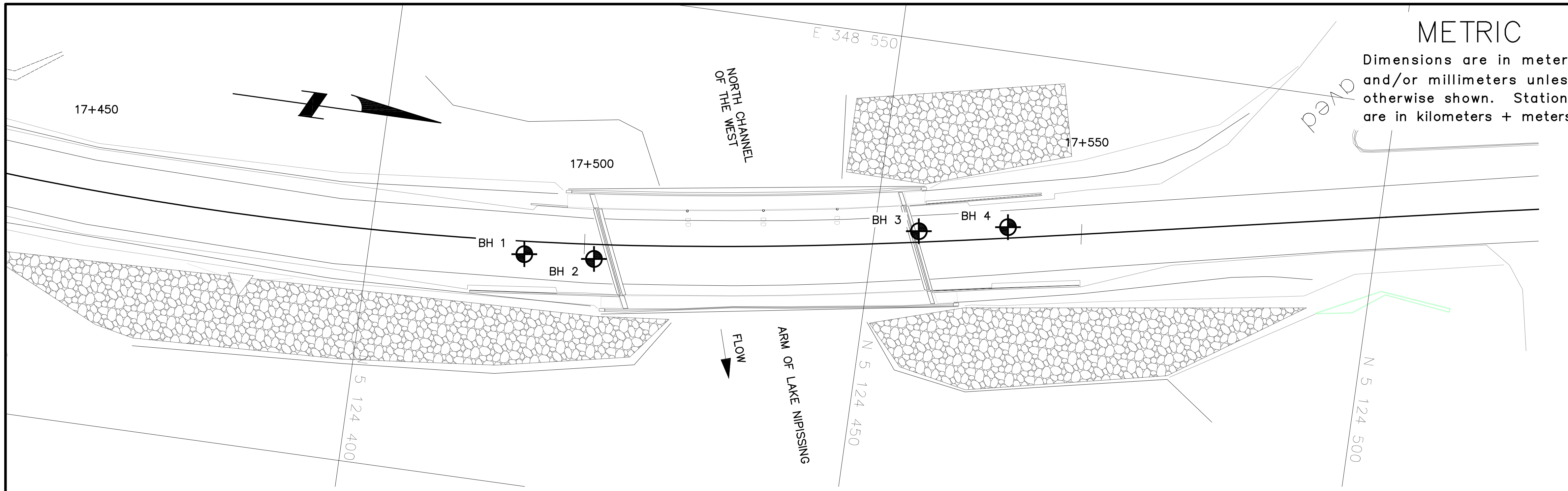
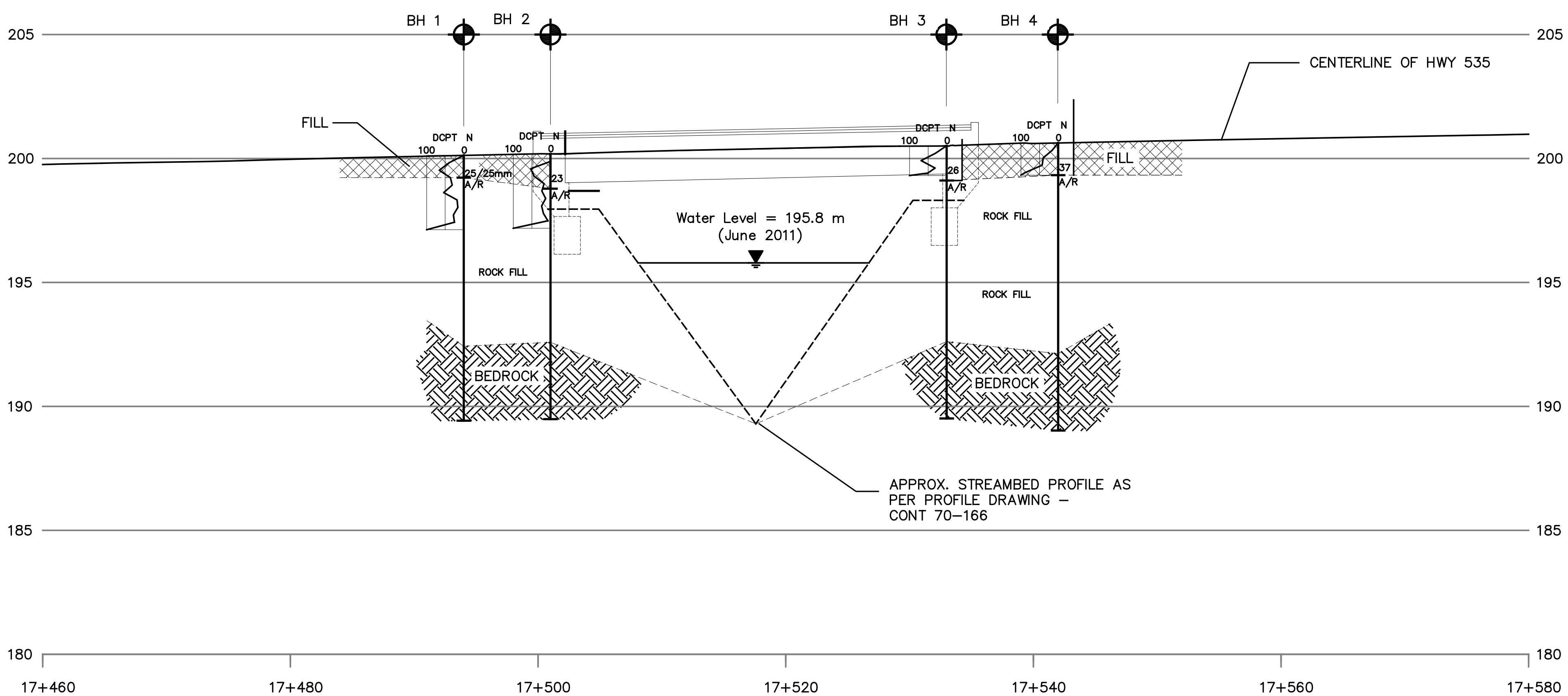


PLAN

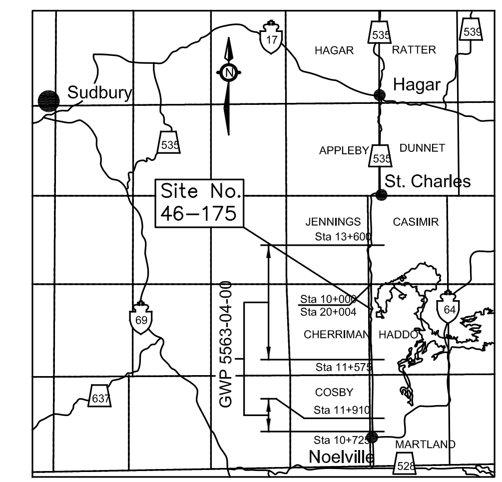
SCALE 5m 0 10m



PROFILE

SCALE 5m 0 10m HOR

2.5m 0 5m VER



KEY PLAN – NOT TO SCALE

LEGEND

- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole & DCPT
- 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.	Elev.	O/S	Station	Co–ordinates Northerly	Co–ordinates Easterly
Borehole No. 1	200.1	1.3m Rt	17+494	5124415.6	348576.9
Borehole No. 2	200.2	1.5m Rt	17+501	5124422.5	348576.4
Borehole No. 3	200.5	1.1m Lt	17+533	5124454.4	348569.1
Borehole No. 4	200.6	1.1m Lt	17+542	5124463.2	348567.5

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.

This drawing is for subsurface information only. Surface details and features are for conceptual illustration. The proposed structure location is shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contract Documents.

REVISIONS	DATE	BY	DESCRIPTION

HWY No. 535 – Cherriman – West Arm North Channel	REF: 11046
SUBM'D	SITE 46–175
DRAWN RG / CHK MAM / DATE September 2011	FIG 2

Reference No.: 11/04/11046-F9
Date: April 2012

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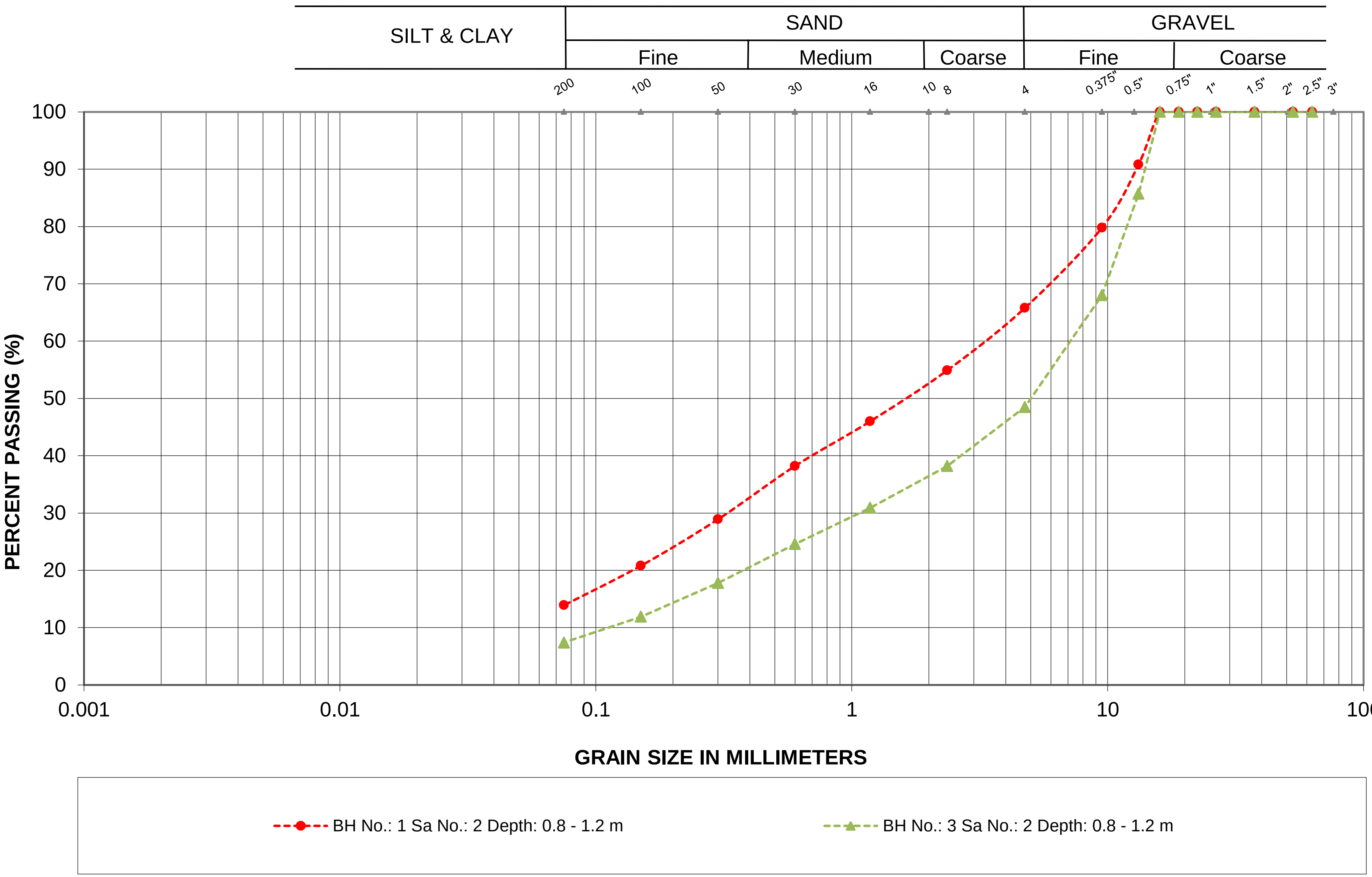
GRAIN SIZE ANALYSIS



G.W.P.: 5563-04-00
LOCATION: Hwy 535
SITE: 46-175

EMBANKMENT FILL

Reference No.: 11/04/11046-F9
Date: April 2012

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Laboratory Tests - Summary Sheet

Borehole No.	Sample No.	Depth	Grain Size Analysis				NMC	Atterberg Limits			SPT 'N'	USCS	Unit Weight (kN/m3)	Remarks
			Gravel Size (%)	Sand Size (%)	Silt Size (%)	Clay Size (%)		LL (%)	PL (%)	IP (%)				
1	1	0.0					4.4				N/A			
	2	0.8	34	52	14		3.5				25/25mm			
2	1	0.0					3.3				N/A			
	2	0.8					3.4				23			
3	1	0.0					3.8				N/A			
	2	0.8	51	42	7		4.1				26			
4	1	0.0					3.7				N/A			
	2	0.8					6.1				37			

Project: Hwy 535
Location: West Arm Lake Nippising North Channel Bridge

Figure No. L-2

Appendix D Photo Essay

Enclosure No. 6: Photo Essay

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Top: Embankment, east side, looking north Bottom: Embankment, west side, looking north	Photo: 1 - 2

Reference Number: 11/04/11046-F9 Project: Hwy 535 – West Arm Lake Nipissing North Channel Bridge – Site No. 46-175	Provided By: LVM | MERLEX Date: May 2011

LVM | MERLEX

Bridge surface, looking north	Photo: 3

Reference Number: 11/04/11046-F9	Provided By: LVM | MERLEX
Project: Hwy 535 – West Arm Lake Nipissing North Channel Bridge – Site No. 46-175	Date: May 2011

Appendix E Protection System

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

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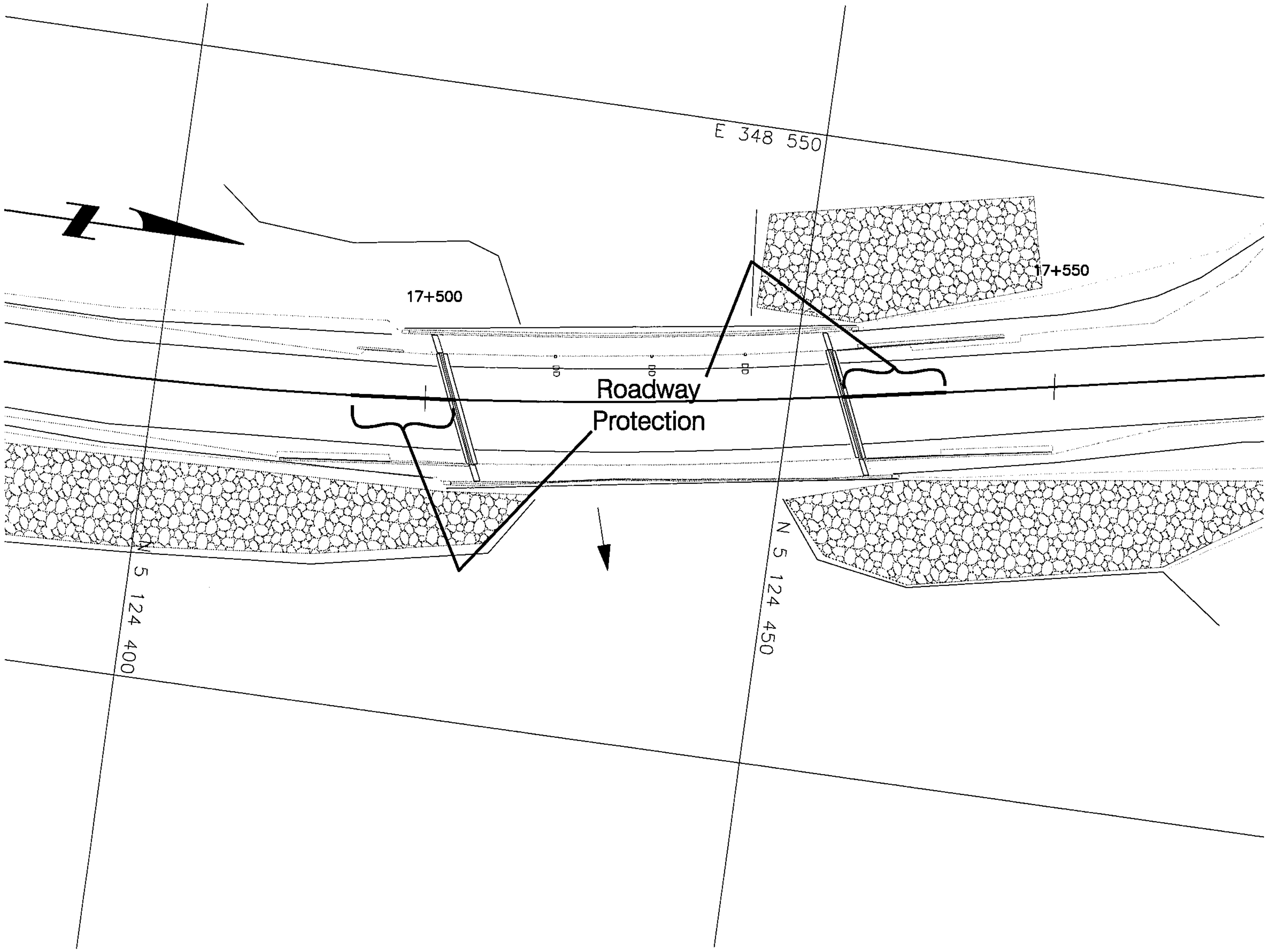

HWY 535 - Township of Cheeriman - Site 46-175 Conceptual Shoring Locations - West Arm Lake Nipissing North Channel Bridge	FIGURE SK-3

LVM | MERLEX

Table A – Comparison of Shoring Alternatives

Method	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 due to ground conditions	$650/m^2
Steel Sheet Piles	5 – 21	-High strength, continuous, -Readily available	-Limited by soil conditions (i.e. obstructions)	Considered for shallow excavations at this site	$650/m^2
Pre-cast concrete panels	3 – 10	-Durable -Assists in minimizing seepage	-Limited depths -Can be damaged during installation -Limited by soil conditions (i.e. obstructions)	Not considered due to ground conditions and higher cost	
Soldier piles	5 – 25	-Easy installation -Readily available -Adaptable to various ground conditions	-Pre-drilling may be required -Possible ground loss	Recommended for excavations at this site	$725/m^2 Predrilled $1,500/m^2
Tangent/ Secant/ Staggered Drilled Piles	10 – 18	-Readily available -Adaptable to various ground conditions	-Possible ground loss and/or seepage -Poor alignment tolerance	Nor considered due to 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	
Micropiles with reinforced shotcrete face		-Can be installed in various ground conditions -High strength -Good tolerance	-High Cost -Requires specialized equipment	Considered for excavations at this site	$ 1,200 – 1,500/m^2