



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

Highway 144 Rehabilitation
Bridge Rehabilitation – Site No. 46-256
Moncrieff Creek Bridge
Twp. of Moncrieff
GWP 5046-05-00

Highway 144
From Cartier West Entrance (Centre Street),
Northerly 24.8 km

FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

Date: September 21, 2012
Ref. N^o: 11/06/11101-F3

Geocres No. 42I-289

LVM | MERLEX

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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 to supply subsurface information to support the design of a protection system to be implemented during the rehabilitation of the Moncrieff Creek Bridge. This bridge is located on Highway 144, some 9.6 km north of Cartier (Center Street), in the Township of Moncrieff. The existing bridge is a 24.4 m single span steel girder bridge with a width of 9.4 m.

The foundation investigation location was specified by the MTO in the RFP/TPM documentation Agreement No. 5010-E-0012. The terms of reference for the scope of work are outlined in MEL's proposal P-10-177, dated January 2011. The purpose of this investigation was to determine the subsurface conditions in the areas of the bridge approached in order to provide design recommendations for a protection system during rehabilitation and conversion to semi-integral abutments. 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 Moncrieff Creek Bridge is located on Highway 144, between Stations 36+227 to 36+251.4, Township of Moncrieff (Site No. 46-256). 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. Moncrieff Creek flows from east to west at the bridge location. A visual review of the highway at the north and south approaches indicates that, in general, the bridge approaches are in fair condition.

The existing 24.4 m single span steel girder bridge was constructed in 1969 and rehabilitated in 1984 on the original highway alignment. The structure is in fair condition with deterioration of the concrete in some elements, including the wing walls and abutments and ruptured expansion joint seals.

Infrastructure at the bridge 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 Eastern Sandy Uplands. The topography on this section of Highway 144 is generally rolling. There are 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 sand and gravel containing varying amounts of silt and clay.

Bedrock in the area, as indicated on OGS Map 2506, is of the Early Precambrian Era. At the location of this foundation investigation, the bedrock comprises of Metavolcanics including: rhyolitic, dacitic, and andesitic flows, tuffs, and breccias.

3.0 INVESTIGATION PROCEDURES

The fieldwork for this investigation was carried out between September 18th and November 1st, 2011, during which six (6) sampled boreholes were advanced. Three boreholes were advanced at each end of the bridge: two through the existing approach slab and the second a short distance beyond the end of the approach slab.

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.

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. Oversize particles, greater than the internal diameter of the split spoon (I.D. 37.5 mm), could not be sampled and as such have not been included in the particle size analysis. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix B), with a summary of results presented on the laboratory sheets in Appendix C (Figure Nos. L-1 to L-4).

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 Historical Background Subsurface Information

In 1967, during the review of possible alignments for Hwy 144, a subsurface investigation was carried out for the Ministry (known as the Department of Highways at the time). The subsurface

information was recorded in Report No. 67-F-63. For information purposes, a copy of the Plan and Stratigraphic Profile has been included as Enclosure No. 8, Appendix D.

The historical data indicated the overburden at this site generally consisted of organic silts overlying silts underlain by sands with gravel occasional boulders, with bedrock proven at elevations 369.8 to 371.2 m. Based on information obtained from Contract No. 69-30, Drawing No. 67-F-63A, the organic silts were removed during construction and replaced with fill.

4.2 Moncrieff Creek Bridge, TWP of Moncrieff – Site No. 46-256

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, six (6) sampled boreholes were put down at this site. Borehole Nos. 2 and 3 were advanced at the south abutment of the bridge to the right and left of centerline, respectively, and Borehole No. 1 was advanced at the south end of the approach slab, right of centerline. Borehole Nos. 4 and 5 were advanced through the approach slab at the north abutment to the right and left of centerline, respectively, and Borehole No. 6 was advanced to the north of the approach slab, left of centerline. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1 to 6 were recorded at 389.5, 389.5, 389.5, 389.6, 389.6, and 389.6 m, respectively.

4.2.1 Pavement Structure

At surface at Borehole Nos. 1 and 6, a surficial pavement structure consisting of 125 mm of asphalt overlying 100 to 175 mm of crushed gravel was encountered. At Borehole No. 6, a second layer of asphalt and crushed gravel, 75 and 100 mm thick respectively, was encountered underlying the first crushed gravel layer. At surface at Borehole Nos. 2 to 5, a

pavement structure consisting of 100 to 125 mm of asphalt, a 250 to 275 mm thick concrete approach slab, and 300 to 450 mm of crushed gravel was penetrated.

4.2.2 Fill

Underlying the pavement structure at each borehole, a deposit of granular fill consisting of brown gravel and sand trace to some silt was penetrated. Occasional cobbles and boulder size rock was encountered in this deposit. The natural moisture content measured on samples of this deposit was in the order of 2 to 8%. Gradation analyses were carried out on twelve (12) samples of this deposit, the results of which indicated 13 to 73% gravel size particles, 24 to 66% sand size particles, and 2 to 21% silt and clay size particles (Figure Nos. L-1 and L-2, Appendix C). Based on SPT 'N' values of 9 to 71 blows per 300 mm penetration, the compactness of this deposit was described as loose to very dense, generally compact. Auger refusal was encountered on cobble/boulder size rock in this deposit at depths of 4.9, 5.0, 3.8, 4.0, and 4.0 m below grade at Borehole Nos. 2 to 6, respectively (elevations 384.6, 384.5, 385.8, 385.6, and 385.6 m, respectively). DCPT refusal was encountered in this deposit at a depth of 5.8 m below existing grade at Borehole No. 3 (elevation 383.7 m).

At Borehole Nos. 1, 2, 4, 5, and 6, DCPT were advanced past the cobbles and boulders. However the hollow stem augers could not penetrate beyond the cobbles/boulder obstructions in the lower part of the fill, except at Borehole No. 1.

4.2.3 Sand

At Borehole No. 1, a transition into sand was encountered at a depth of 6.1 m below grade (elevation 383.4 m). The natural moisture content measured on samples of the sand deposit was in the order of 13 to 24%. A gradation analysis was carried out on one (1) sample of this deposit, the results of which indicated 1% gravel size particles, 97% sand size particles, and 2%

silt and clay size particles (Figure No. L-3, Appendix C). Based on SPT 'N' values of 4 to 18 blows per 300 mm penetration, the compactness of this deposit was described as loose to compact. This deposit was encountered to a depth of 8.5 m below grade (elevation 381.0 m).

4.2.4 Silt

Underlying the sand at Borehole No. 1, a deposit of grey silt some sand was penetrated. The natural moisture content measured on samples of this deposit was in the order of 16 to 24%. A hydrometer analysis was carried out on one (1) sample of this deposit, the results of which indicated 0% gravel size particles, 14% sand size particles, 80% silt size particles, and 6% clay size particles (Figure No. L-4, Appendix C). Based on SPT 'N' values of 0 (static weight of hammer) to 13 blows per 300 mm penetration, the compactness of this deposit was described as very loose to compact. Sampling was terminated in this deposit at a depth of 15.7 m below grade (elevation 373.8 m).

DCPT refusal was encountered at depths of 21.2, 17.3, 17.3, 15.5, and 15.1 m below grade at Borehole Nos. 1, 2, 4, 5, and 6, respectively (elevations 368.3, 372.2, 372.3, 374.1, and 374.5 m, respectively).

4.3 Groundwater Conditions

The water level in the creek was measured at an elevation of 384.8 m, at the time of this investigation. It is noted that based on Drawing 67-F-63A, the water level in the creek was recorded at elevation 385.2 m. 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 elevation 384.1 m at Borehole No. 1 at the time of sampling. Borehole Nos. 2 to 6 were dry upon completion and were backfilled immediately upon completion of sampling. The groundwater levels will fluctuate seasonally.

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5.0 DESIGN COMMENTS AND RECOMMENDATIONS

5.1 General

A foundation investigation was carried out to support the design of a protection system for the proposed conversion to semi-integral abutment at the Moncrieff Creek Bridge, as identified in the RFP. The bridge is located between Stations 36+227 to 36+251.4, in the Township of Moncrieff, and is identified as Site No. 46-256. The existing bridge is a 24.4 m single span, steel plate girder structure with a reinforced concrete deck.

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 granular fill, occasional cobbles/boulders (rock fill), underlain by native sands and silts with bedrock proven in previous investigations between elevations 369.8 to 371.2 m.

Based on Contract No. 69-30, drawing D-6363-1, the abutments are founded on piles with pile caps established at approximately elevation 383.8 m. The conversion to semi-integral abutments will require the removal of the ballast walls. It is anticipated that, to carry out the bridge rehabilitation and convert the Moncrieff Creek Bridge to a semi-integral abutment an excavation, some 1 m deep, will be required behind the existing abutments. As such, a protection system will be required at the north and south abutments of the bridge to support an excavation some 1 m deep behind the abutments and maintain an active lane of traffic. Based on data from this foundation investigation, the fill behind the abutments supporting the approach slabs and pavement structure generally consist of sands and gravel trace silt, occasional

cobbles/boulders with auger refusal on the cobble/boulders (rock fill) at depths of approximately 3.8 to 5.0 m below grade (elevations 385.8 to 384.5 m), except at Borehole No 1.

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, would have to be cut back to a angle of 1H:1V to remain stable. A 1 m deep excavation (i.e. to elevations 388.5 to 388.6 m) will be required to the rear of the abutments to allow the rehabilitation work to be carried out on the ballast walls. The existing width of the approaches is insufficient to allow the construction of a 1H:1V temporary 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 E.

Excavations must be maintained in an unwatered condition during excavation and foundation construction, and every reasonable effort must be made to prevent disturbing the founding subgrade. The groundwater level was encountered at elevation 384.1 m at Borehole No. 1. The water level in the creek was recorded at elevation 384.8 m. These levels are below the anticipated depth of excavation (elevations 388.5 to 388.6 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 sand and gravel, trace silt, occasional cobbles/boulders (rock fill) is present, in generally a loose to compact state of compactness, with auger refusal on cobbles/boulders (rock fill) at approximately depths of 3.8 to 5.0 m at Boreholes Nos. 2 to 6 (elevations 385.8 to 384.5 m). At Borehole No. 1, the augers were advanced beyond the cobble/boulder (rock fill) obstructions. The DCPT's at all boreholes were also advanced beyond the obstructions, except at Borehole No. 3.

The required depth of anticipated excavation, directly behind the abutments to remove the existing ballast walls for conversion to a semi-integral abutment, will be relatively shallow, in the order of 1.0 m (i.e. to elevations 388.5 to 388.6 m). As discussed in Section 5.2, a protection system will be required to carry out this excavation. A table outlining the possible protection systems and their relative advantages, disadvantages, and costs, as well as comments on the viability of the methods is provided in Table A, Appendix E.

In consideration of the soil conditions within the anticipated depth of excavation, steel sheet piles or timber sheeting may be considered for use as the protection system, once the approach slab has been removed. The steel sheet piles or timber sheeting can be advanced vertically to the required depth below the base of the excavation to provide adequate support. Alternatively, toe resistance can be supplied with a strut type member. If refusal is met before the required penetration depth, then the excavation would have to be locally advanced to remove the obstruction. A system of walers and rakers would have to be installed as the depth of the excavation progresses. Once the excavation has reached a sufficient depth to allow work on the ballast wall, the sheets can be tied into the existing approach slab and final waler and raker installed to supply lateral resistance.

Upon completion of the first side (lane) a system of buried anchors could be installed, as the backfilling operation progresses, to tie in the steel sheet piles or timber sheeting and allow the use of the same system while carrying out the excavation for the second side (lane).

It is not anticipated that an excavation greater than 1 m depth will be required. However, should a deeper excavation be required, penetration of cobble and boulder size rock would have to be undertaken. Successfully driving steel sheet piles or timber sheeting through these obstructions would be difficult. As such, a system of H piles (soldier piles) and lagging, probably requiring predrilling, or micropiles with a reinforced shotcrete face, to retain the fill between piles would probably be required. 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 buried anchors with tiebacks could be installed in the backfill, with the tieback ends exiting at the area of the excavation face to allow reconnection and stressing during advance of the opposite/second side (section) of the excavation. If micropiles with a reinforced shotcrete face are used, it is likely that additional reinforced shotcrete will have to be applied as the second side of the excavation progresses.

If tiebacks are required, 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):

$$R = \sigma_z' A_s L_s \alpha_g \text{ Where: } \sigma_z' = \text{effective vertical stress at the midpoint of the load carrying length}$$

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.

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

Elevation (m)	Soil Type	Unit weight (KN/m ³) γ	Angle of Internal Friction (degrees)	Active earth pressure (Ka)	At-rest earth pressure (Ko)
Borehole No.1 389.5 – 383.4 South Abutment 389.5 – 384.6 North Abutment 389.6 – 385.8	Fill – Sand and gravel trace silt occasional cobbles/boulders	20	32	0.31	0.47
Borehole No.1 383.4 – 381.0	Sand – trace silt trace gravel	18.5	30	0.33	0.50
Borehole No. 1 381.0 – 373.8	Silt – Silt some sand trace clay	18	27	0.38	0.55

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 granular 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 metre of wall is equal to $0.65 \cdot K_a \cdot \gamma \cdot H^2$, where:

Ka = active earth pressure,
 γ = 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 new excavation, the subgrade subsurface of the base of the excavation 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 relatively shallow depths of expected excavation, no major construction concerns are anticipated if carried out in general conformance to that discussed above.

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.

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

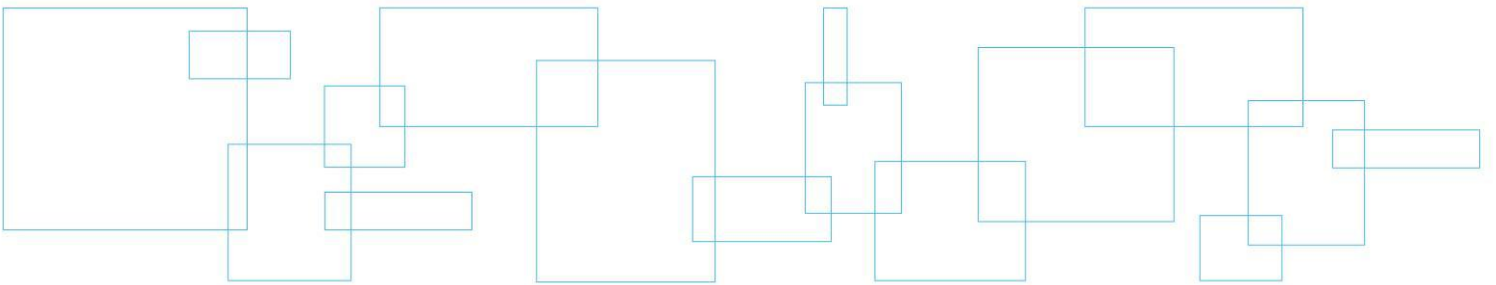
J. R. Berghamer, P. Eng.
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Appendix A

Key Plan

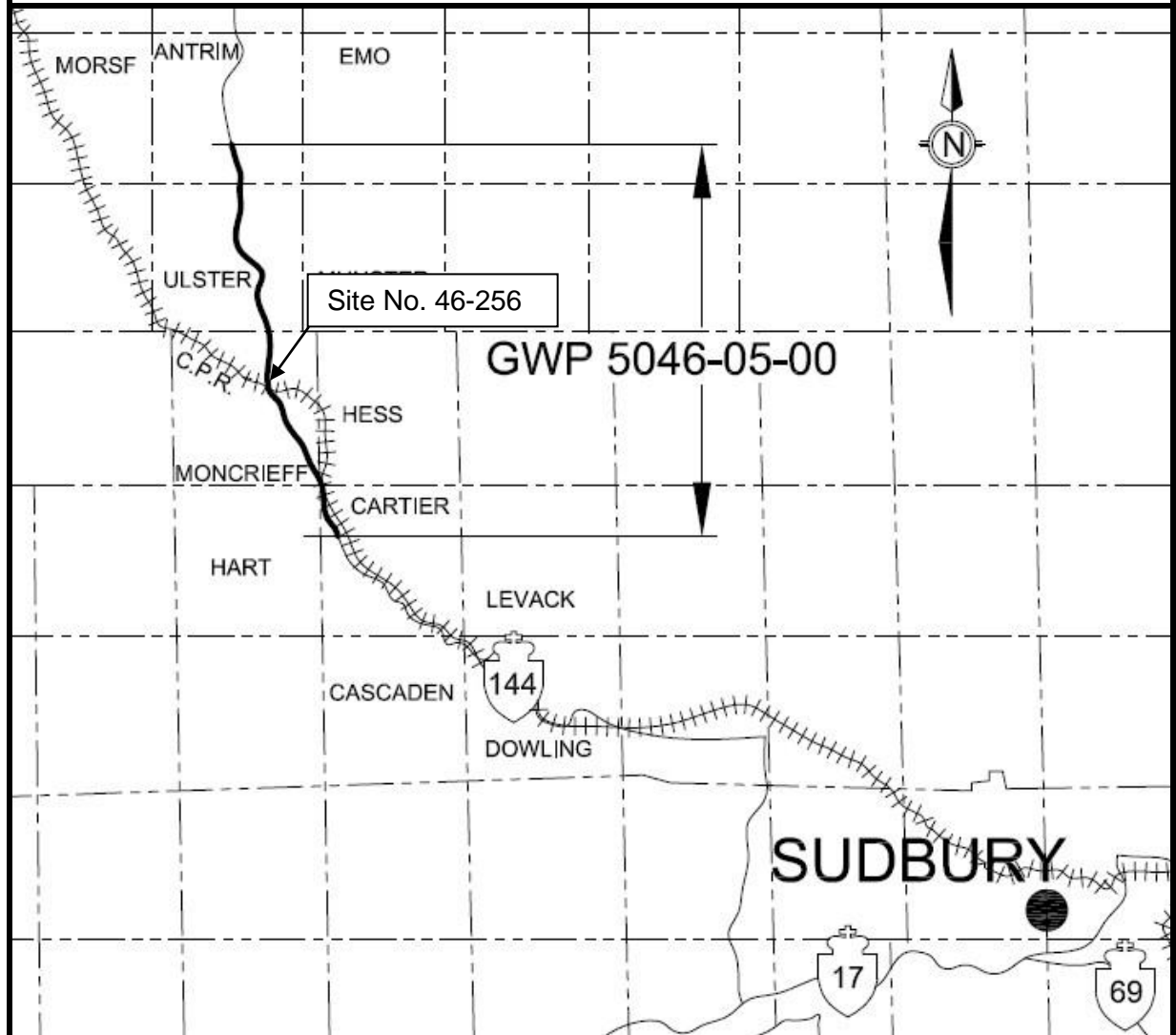
Figure No. 1: Key Plan



KEY PLAN

Figure No. 1

NOT TO SCALE



**FINAL
FOUNDATION INVESTIGATION
AND DESIGN REPORT
GWP 5046-05-00**

Highway 144

From Cartier West Entrance (Centre Street)
Northerly 24.8 km

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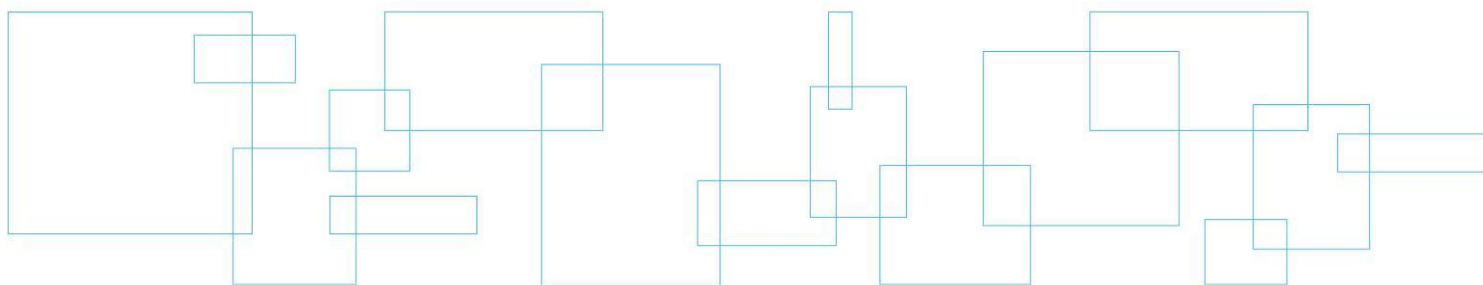
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September 2012

Appendix B

Abbreviations Record of Borehole Sheets

Enclosure No. 1: List of Abbreviations and Symbols
Enclosure Nos. 2 to 7: Record of Borehole Sheets



LIST OF ABBREVIATIONS & DESCRIPTION OF TERMS

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

1. ABBREVIATIONS

AS	Auger Sample
CS	Chunk Sample
DS	Denison type sample
FS	Foil Sample
NFP	No Further Progress
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
RC	Rock core with size & percentage of recovery
SS	Split Spoon
ST	Slotted Tube
TO	Thin-walled, open
TP	Thin-walled, piston
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

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

3. SOIL DESCRIPTION (Cont'd)

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%

Terminology for cobbles and boulders is based on auger response and field observations:

Occasional	Obstructions encountered in borehole, however advance is not impeded
Numerous	Obstructions are essentially continuous over drilled length

5. LABORATORY TESTS

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

SAMPLE DESCRIPTION NOTES:

1. **FILL:** The term fill is used to designate all man-made deposits of natural soil and/or waste materials. The reader is cautioned that fill materials can be very heterogeneous in nature and variable in depth, density and degree of compaction. Fill materials can be expected to contain organics, waste materials, construction materials, shot rock, rip-rap, and/or larger obstructions such as boulders, concrete foundations, slabs, abandoned tanks, etc.; none of which may have been encountered in the borehole. The description of the material penetrated in the borehole therefore may not be applicable as a general description of the fill material on the site as boreholes cannot accurately define the nature of fill material. During the boring and sampling process, retrieved samples may have certain characteristics that identify them as 'fill'. Fill materials (or possible fill materials) will be designated on the Borehole Logs. If fill material is identified on the site, it is highly recommended that testpits be put down to delineate the nature of the fill material. However, even through the use of testpits defining the true nature and composition of the fill material cannot be guaranteed. Fill deposits often contain pockets or seams of organics, organically contaminated soils or other deleterious material that can cause settlement or result in the production of methane gas. It should be noted that the origins and history of fill material is frequently very vague or non-existent. Often fill material may be contaminated beyond environmental guidelines and the material will have to be disposed of at a designated site (i.e. registered landfill). Unless requested or stated otherwise in this report, fill material on this site has not been tested for contaminants however, environmental testing of the fill material can be carried out at your request. Detection of underground storage tanks cannot be determined with conventional geotechnical procedures.
2. **TILL:** The term till indicates a material that is an unstratified, glacial deposit, heterogeneous in nature and, as such, may consist of mixtures and pockets of clay, silt, sand, gravel, cobbles and/or boulders. These heterogeneous deposits originate from a geological process associated with glaciation. It must be noted that due to the highly heterogeneous nature of till deposits, the description of the deposit on the borehole log may only be applicable to a very limited area and therefore, caution must be exercised when dealing with a till deposit. When excavating in till, contractors may encounter cobbles/boulders or possibly bedrock even if they are not indicated on the borehole logs. It must be appreciated that conventional geotechnical sampling equipment does not identify the nature or size of any obstruction.
3. **BEDROCK:** Auger refusal may be due to the presence of bedrock, but possibly could also be due to the presence of very dense underlying deposits, boulders or other large obstructions. Auger refusal is defined as the point at which an auger can no longer be practically advanced. It must be appreciated that conventional geotechnical sampling equipment does not differentiate between nature and size of obstructions that prevent further penetration of the boring below grade. Bedrock indicated on the borehole logs will be labeled 'possibly' or 'probable' etc. based on the response of the boring and sampling equipment, surrounding topography, etc. Bedrock can be proven at individual borehole locations, at your request, by diamond core drilling operations or, possibly, by testpits. It must also be appreciated that bedrock surfaces can be, and most times are, very erratic in nature (i.e. sheer drops, isolated rock knobs, etc.) and caution must be used when interpreting subsurface conditions between boreholes. A bedrock profile can be more accurately estimated, at the clients' request, through a series of closely positioned unsampled auger probes combined with core drilling.
4. **GROUNDWATER:** Although the groundwater table may have been encountered during this investigation and the elevation noted in the report and/or on the record of boreholes, it must be appreciated that the elevation of the groundwater table will fluctuate based upon seasonal conditions, localized changes, erratic changes in the underlying soil profile between boreholes, underlying soil layers with highly variable permeabilities, etc. These conditions may affect the design and type and nature of dewatering procedures. Cave-in levels recorded in borings give a general indication of the groundwater level in cohesionless soils however, it must be noted that cave-in levels may also be due to the relative density of the deposit, drilling operations etc.

METRIC

RECORD OF BOREHOLE NO. 1



REFERENCE 11/06/11101-F3 DATUM Geodetic LOCATION N5182035.2 E258402.2 - Moncrieff Township ORIGINATED BY JL
 PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-256 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT
 CLIENT AECOM Inc. DATE (Started) 2011 September 18 TIME
 DATE (Completed) 2011 September 18 (Completed) 1:30:00 PM CHECKED BY MAM

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	"N" VALUES								
389.5	Ground Surface												
0.0	125 mm Asphalt 100 mm Crushed Gravel FILL - brown sand and gravel trace silt occasional cobble/boulder (compact/very dense)		1	AS	N/A								
			2	SS	51								45 48 (7)
			3	SS	31								
			4	SS	14								
			5	SS	17								45 51 (4)
			6	SS	27								
			7	SS	50								31 62 (7)
383.4													
6.1	SAND - grey sand trace gravel trace silt (loose/compact)		8	SS	18								
			9	SS	4								1 97 (2)
381.0													
8.5	SILT - grey silt some sand trace clay (very loose/compact)		10	SS	13								
			11	SS	5								
			12	SS	4								0 14 80 6
			13	SS	WH								
373.8			14	SS	10								
15.7	End of Sampling												
	Continued Next Page												
COMMENTS							+ 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) 11/9/18 1:30:00 PM 5.4 5.7 2) - - 3) - -						
The stratification lines represent approximate boundaries. The transition may be gradual.													

MEL-GEO 11101 - AREA 8 - BOREHOLE LOGS - MONCRIEFF RIVER.GPJ MEL-GEO.GDT 12/9/21



METRIC

RECORD OF BOREHOLE NO. 1



REFERENCE 11/06/11101-F3 DATUM Geodetic LOCATION N5182035.2 E258402.2 - Moncrieff Township ORIGINATED BY JL
 PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-256 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT
 CLIENT AECOM Inc. DATE (Started) 2011 September 18 TIME 1:30:00 PM
 DATE (Completed) 2011 September 18 CHECKED BY MAM

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															
368.3						369										
21.2	DCPT Refusal End of Borehole															

MEL-GEO 11101 - AREA 8 - BOREHOLE LOGS - MONCRIEFF RIVER.GPJ MEL-GEO.GDT 12/9/21



LIVIM
120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@lvm.ca

METRIC

RECORD OF BOREHOLE NO. 3



REFERENCE 11/06/11101-F3 DATUM Geodetic LOCATION N5182043.6 E258397.5 - Moncrieff Township ORIGINATED BY JL
 PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-256 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT
 CLIENT AECOM Inc. DATE (Started) 2011 November 1 TIME
 DATE (Completed) 2011 November 1 (Completed) 9:40:00 AM CHECKED BY MAM

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	"N" VALUES								
389.5	Ground Surface												
0.0	100 mm Asphalt 275 mm Concrete 300 mm Crushed Gravel FILL - gravel and sand to gravel some sand trace silt occasional cobble/boulder (compact)		1	AS	N/A		389						
			2	SS	16		388						50 45 (5)
			3	SS	18		387						59 36 (5)
			4	SS	23		386						
			5	SS	14		385						
			6	SS	13		384						
384.5	Auger Refusal		7	SS	64/225 mm								72 24 (4)
5.0													
383.7													
5.8	DCPT Refusal End of Borehole												
COMMENTS								+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE					
The stratification lines represent approximate boundaries. The transition may be gradual.								WATER LEVEL RECORDS					
								Date (dd/mm/yy)/Time		Water Depth (m)		Cave In (m)	
								1) 11/11/1 9:25:00 AM		DRY		1.2	
								2) -		-		-	
3) -		-		-									

MEL-GEO 11101 - AREA 8 - BOREHOLE LOGS - MONCRIEFF RIVER.GPJ MEL-GEO.GDT 12/9/21



METRIC

RECORD OF BOREHOLE NO. 5



REFERENCE	11/06/11101-F3	DATUM	Geodetic	LOCATION	N5182071.9 E258395.7 - Moncrieff Township	ORIGINATED BY	JL
PROJECT	GWP 5046-05-00, Highway 144 - Site No. 46-256			BOREHOLE TYPE	Track Mounted CME 45B - Hollow Stem Augers	COMPILED BY	AT
CLIENT	AECOM Inc.	DATE (Started)	2011 November 1	DATE (Completed)	2011 November 1	CHECKED BY	MAM
					(Completed) 12:25:00 PM		

[illegible]

MEL-GEO 11101 - AREA 8 - BOREHOLE LOGS - MONCRIEF RIVER.GPJ MEL-GEO.GDT 12/9/21

METRIC

RECORD OF BOREHOLE NO. 6



REFERENCE 11/06/11101-F3 DATUM Geodetic LOCATION N5182080.8 E258394.8 - Moncrieff Township ORIGINATED BY JL
 PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-256 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT
 CLIENT AECOM Inc. DATE (Started) 2011 October 19 TIME (Completed) 2:30:00 PM CHECKED BY MAM
 DATE (Completed) 2011 October 19

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								
389.6	Ground Surface											
0.0	125 mm Asphalt		1	AS	N/A							
	175 mm Crushed Gravel		2	SS	25							
	75 mm Asphalt		3	SS	16							
	100 mm Crushed Gravel		4	SS	9							
	FILL - sand some gravel with silt (loose/compact)		5	SS	11							
385.6	Auger Refusal		6	SS	30/150mm							
4.0												
374.5	DCPT Refusal											
15.1	End of Borehole											
COMMENTS						+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE						
The stratification lines represent approximate boundaries. The transition may be gradual.						WATER LEVEL RECORDS						
						Date (dd/mm/yy)/Time		Water Depth (m)		Cave In (m)		
						1) 11/10/19 2:30:00 PM		DRY		2		
						2)						
						3)						

MEL-GEO 11101 - AREA 8 - BOREHOLE LOGS - MONCRIEFF RIVER.GPJ MEL-GEO.GDT 12/9/21



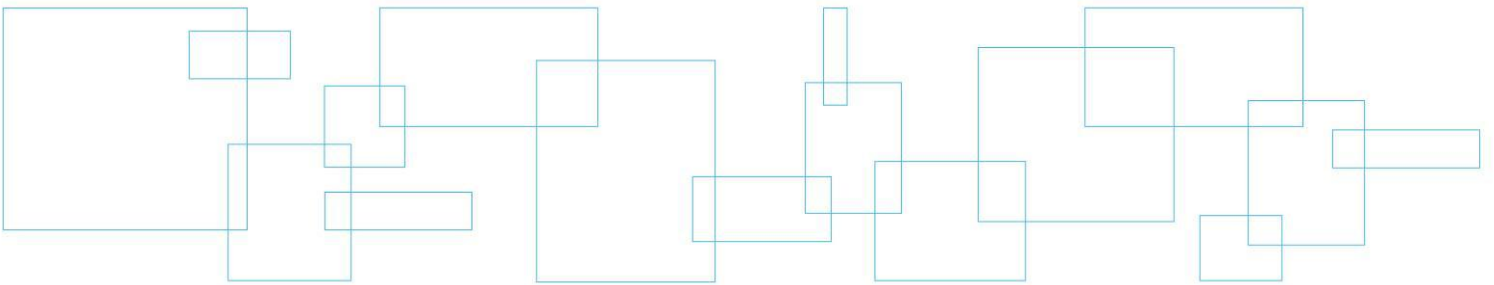
Appendix C

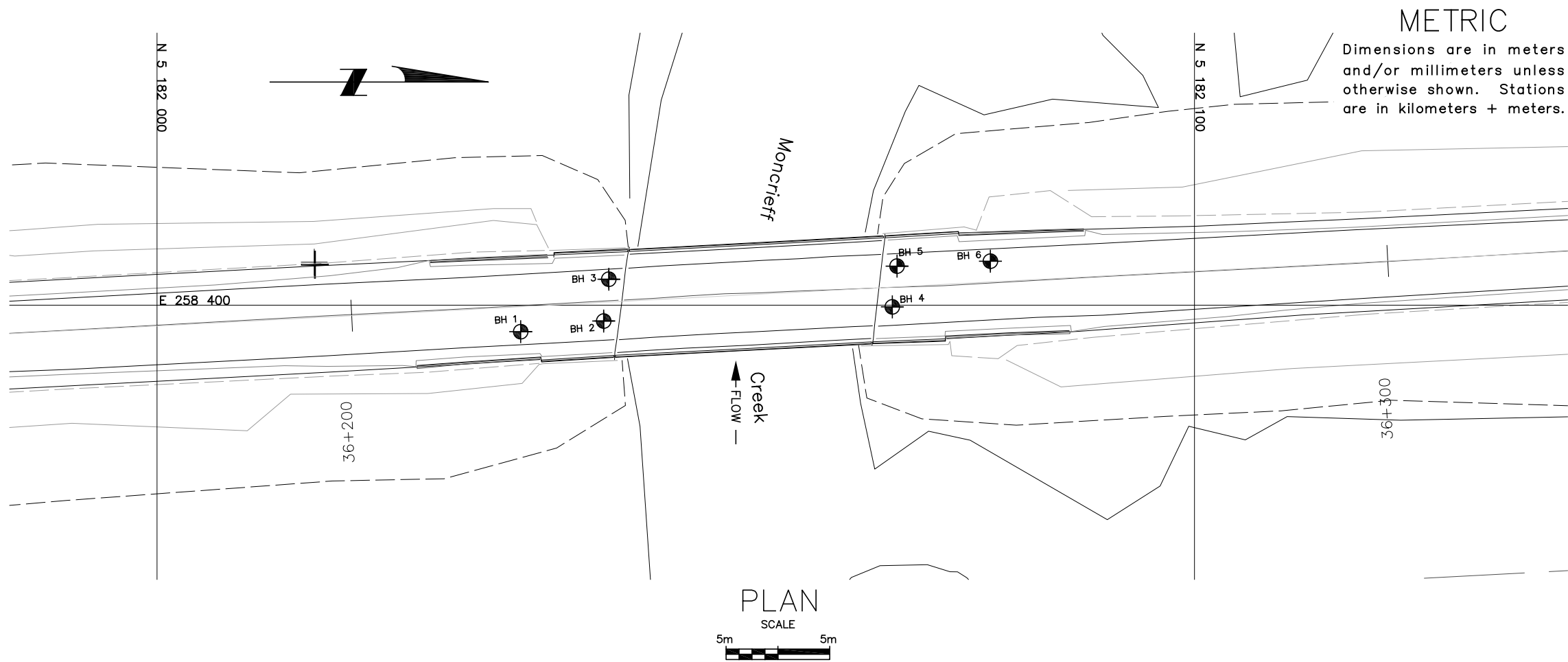
Borehole Location Plan Labwork

Figure No. 2: Borehole Location and Soil Strata

Figure No. L-1 to L-4: Summary Grain Size Analysis Graph

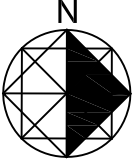
Figure No. L-5: Lab Test Summary Sheet





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

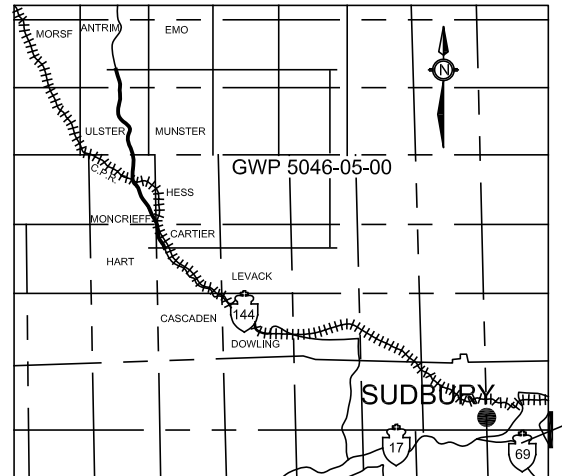
SITE No 46-256
WP No 5046-05-00
Geocres 421-289



HWY NO. 144 - Township
of Moncrief
Moncrief Creek Bridge Protection System
BOREHOLE LOCATIONS & SOIL STRATA

Figure
2

LVM | MERLEX

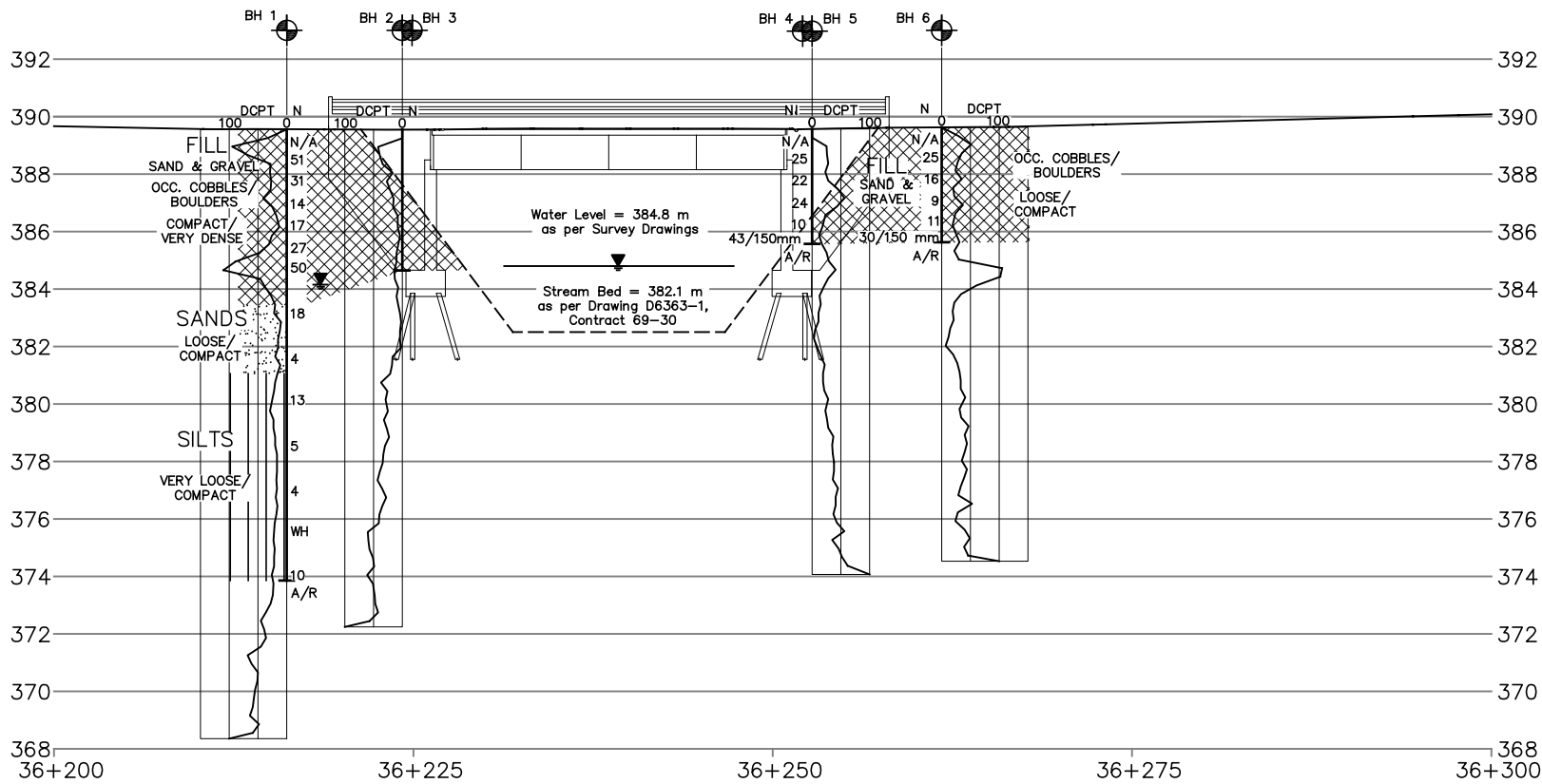


KEY PLAN - NOT TO SCALE
LEGEND

- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole and 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	Co-ordinates	
			Northerly	Easterly
Borehole No. 1	389.6	2.4m Rt	5182035.1	285402.6
Borehole No. 2	389.5	1.8m Rt	5182043.1	285401.5
Borehole No. 3	389.5	2.2m Lt	5182043.6	285397.5
Borehole No. 4	389.6	1.9m Rt	5182070.9	285400.2
Borehole No. 5	389.6	2.0m Lt	5182071.3	285396.2
Borehole No. 6	389.6	2.6m Lt	5182080.3	285395.8

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

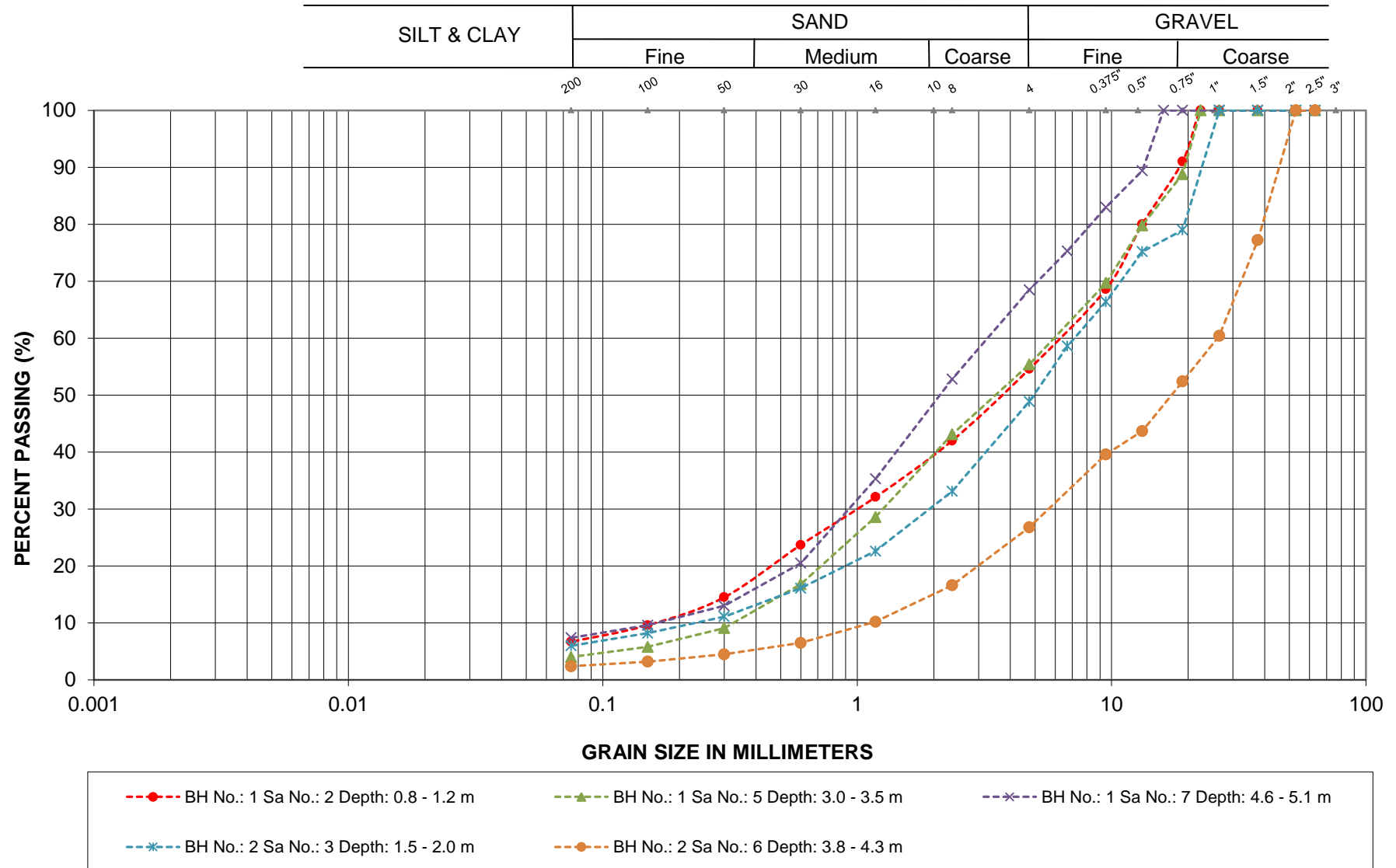


PROFILE
SCALE
5m 5m HOR
2.5m 2.5m VER

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	
	AUG 2012	RG	FINAL	
HWY No. 101 - Moncrief Twp - Moncrief Creek Bridge			REF 11101	
SUBM'D			SITE 46-256	
DRAWN MCM			CHK MAM	DATE JANUARY 2012
			FIG 2	

GRAIN SIZE ANALYSIS

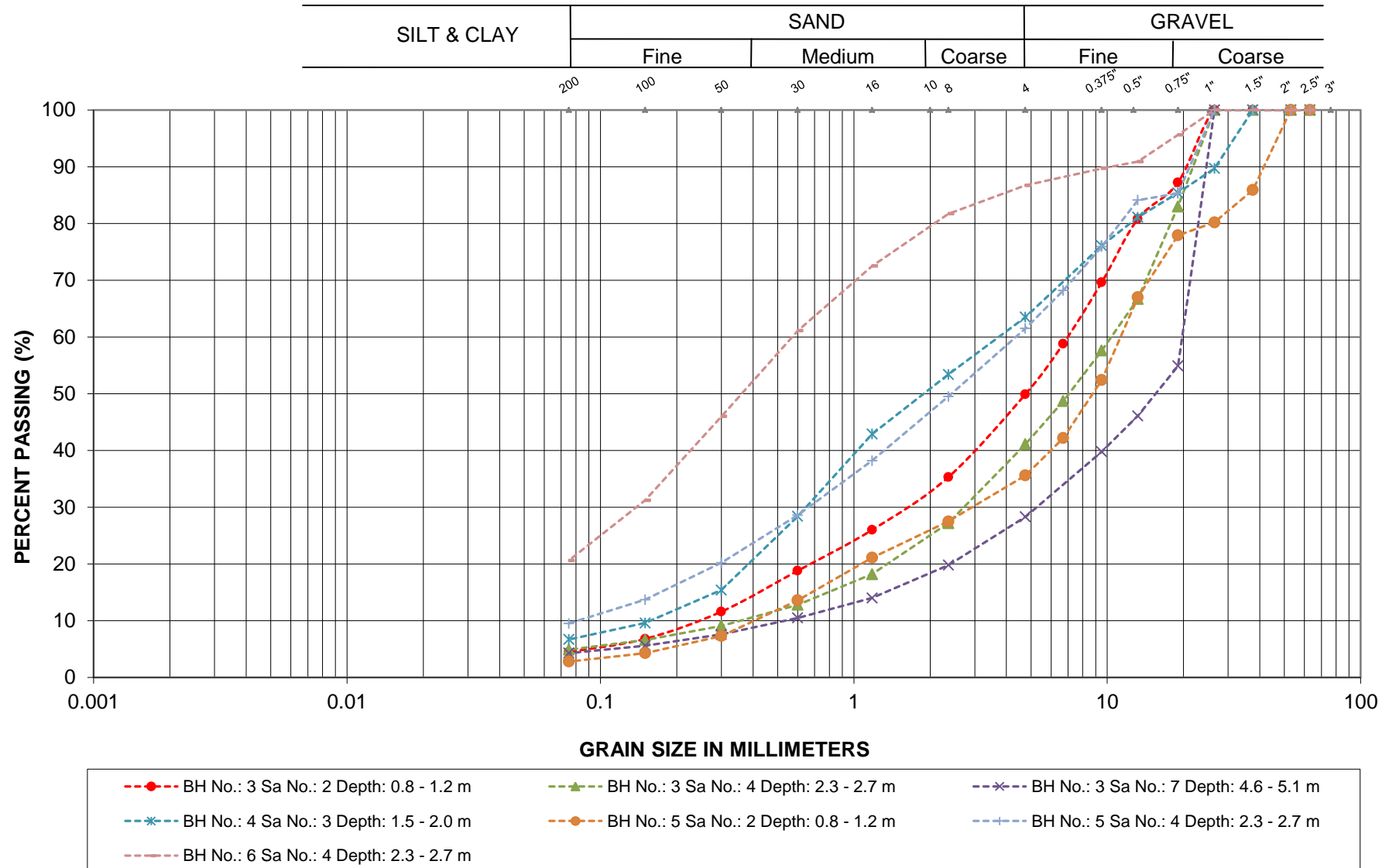


G.W.P.: 5046-05-00
LOCATION: Hwy 144
SITE: 46-4256

FILL
LVM | MERLEX

FIGURE L-1

GRAIN SIZE ANALYSIS



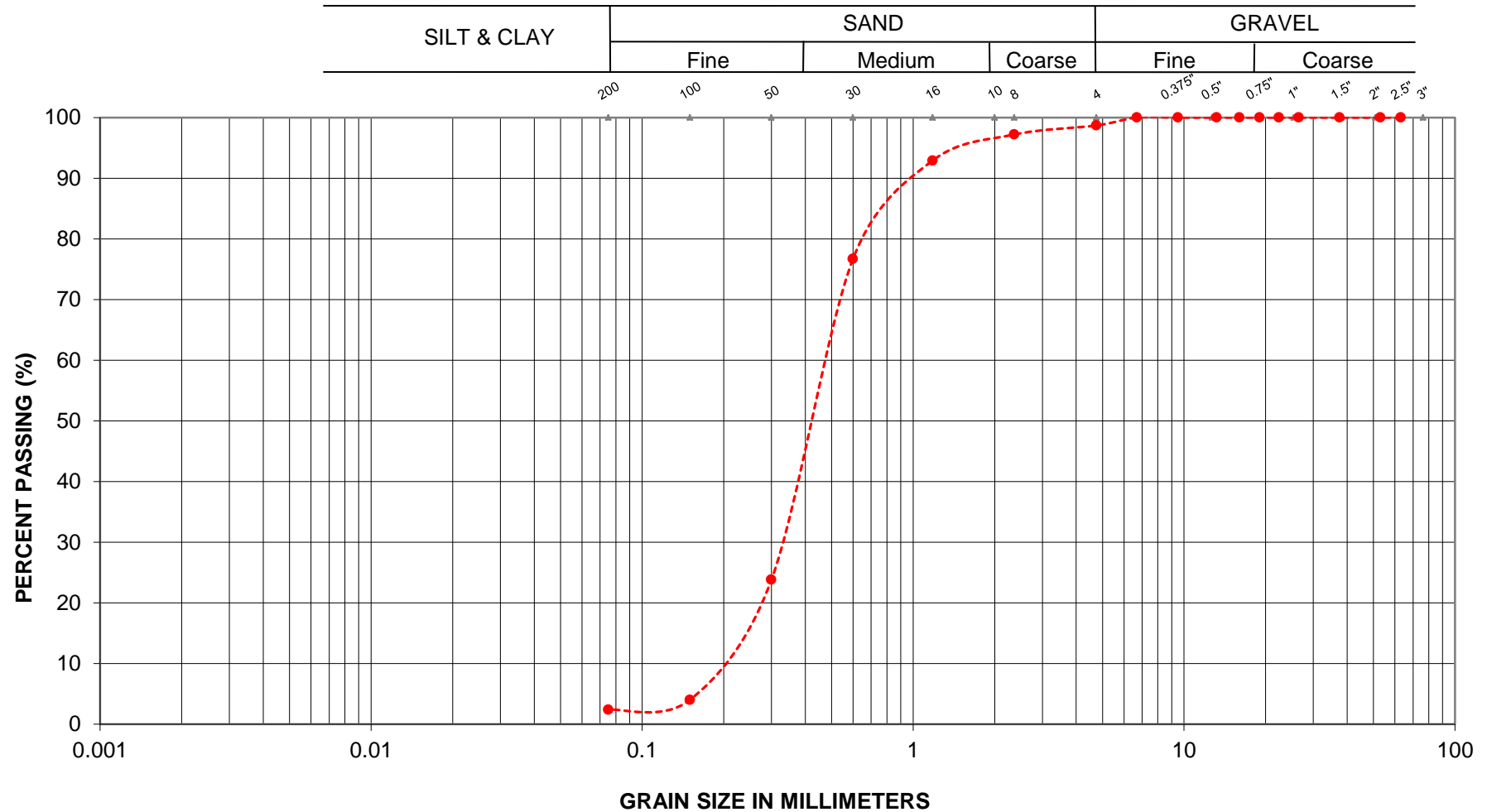
G.W.P.: 5046-05-00
LOCATION: Hwy 144
SITE: 46-256

FILL

LVM | MERLEX

FIGURE L-2

GRAIN SIZE ANALYSIS



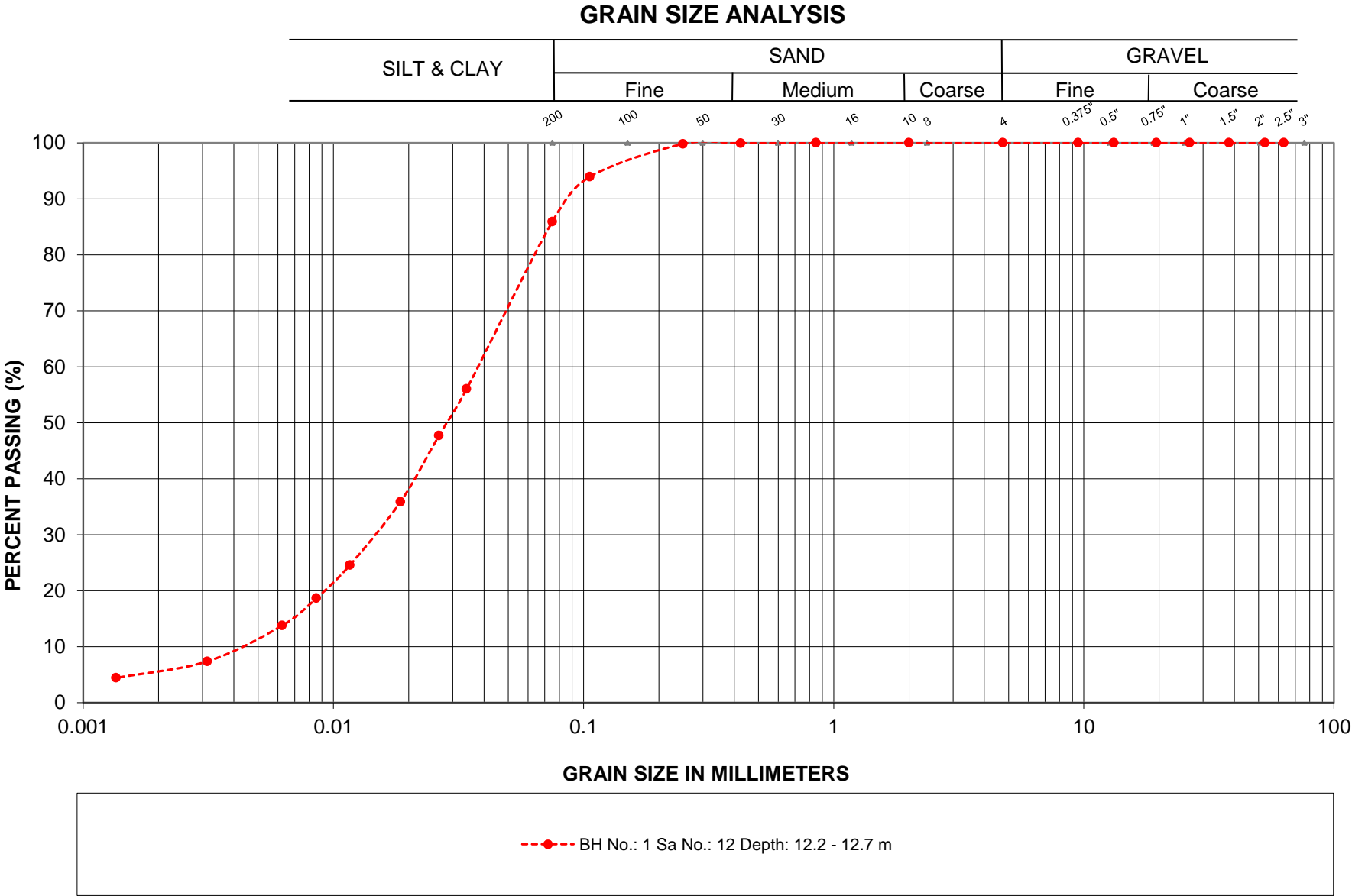
---●--- BH No.: 1 Sa No.: 9 Depth: 7.6 - 8.1 m

G.W.P.: 5046-05-00
LOCATION: Hwy 144
SITE: 46-256

SAND FILL

LVM | MERLEX

FIGURE L-3



G.W.P.: 5046-05-00
LOCATION: Hwy 144
SITE: 46-256

SILT
LVM | MERLEX

FIGURE L-4

Laboratory Tests - Summary Sheet

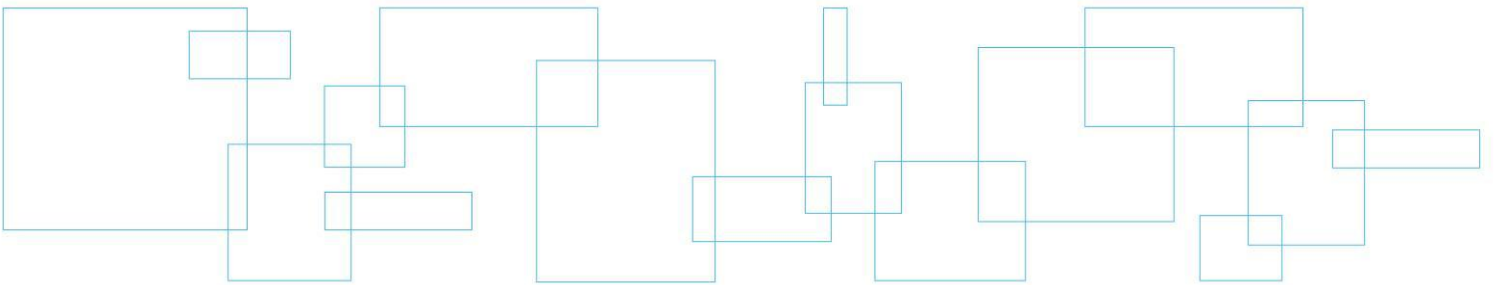
Borehole No.	Sample No.	Depth	Grain Size Analysis				NMC	Atterberg Limits			SPT 'N'	USCS	Unit Weight (kN/m3)	Remarks
			Gravel Size (%)	Sand Size (%)	Silt Size (%)	Clay Size (%)		LL (%)	PL (%)	IP (%)				
1	1	0.0					2.1				N/A			
	2	0.8	45	48	7		2.2				51			
	3	1.5					1.8				31			
	4	2.3					2.9				14			
	5	3.0	45	51	4		3.0				17			
	6	3.8					2.5				27			
	7	4.5	31	62	7		3.9				50			
	8	6.1					13.5				18			
	9	7.6	1	97	2		24.1				4			
	10	9.1					23.1				13			
	11	10.7					21.7				5			
	12	12.2	0	14	80	6	24.3				4			
	13	13.7					16.0				WH			
	14	15.2					18.6				10			
2	1	0.0					4.2				N/A			
	2	0.8					3.9				25			
	3	1.5	51	43	6		2.8				15			
	4	2.3					2.9				18			
	5	3.0					2.5				37			
	6	3.8	73	25	2		2.3				11			
	7	4.5					3.3				37/175 mm			
3	1	0.0					4.2				N/A			
	2	0.76	50	45	5		3.3				16			
	3	1.5					3.0				18			
	4	2.3	59	36	5		2.3				23			
	5	3.04					2.3				14			
	6	3.8					2.3				13			

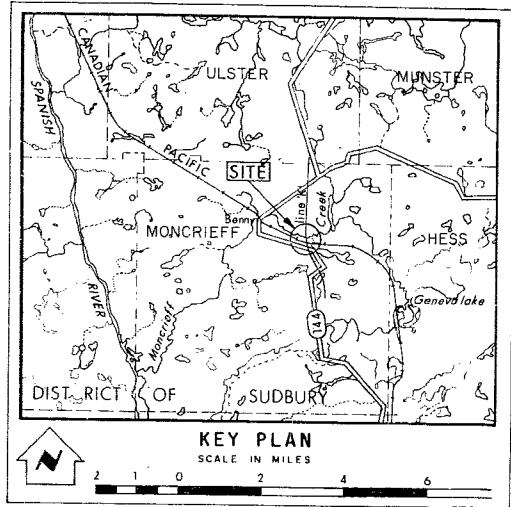
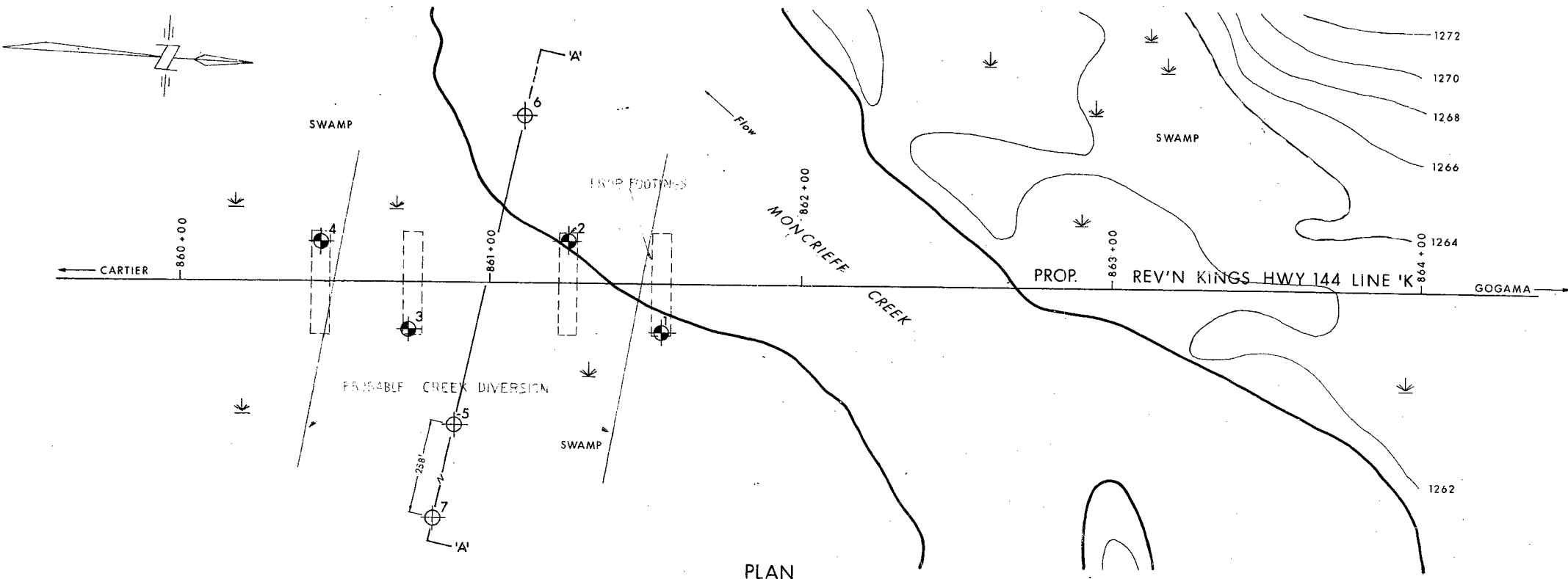
Laboratory Tests - Summary Sheet

[illegible]

Appendix D Historical Information

Enclosure No. 8: Historical Plan and Profile



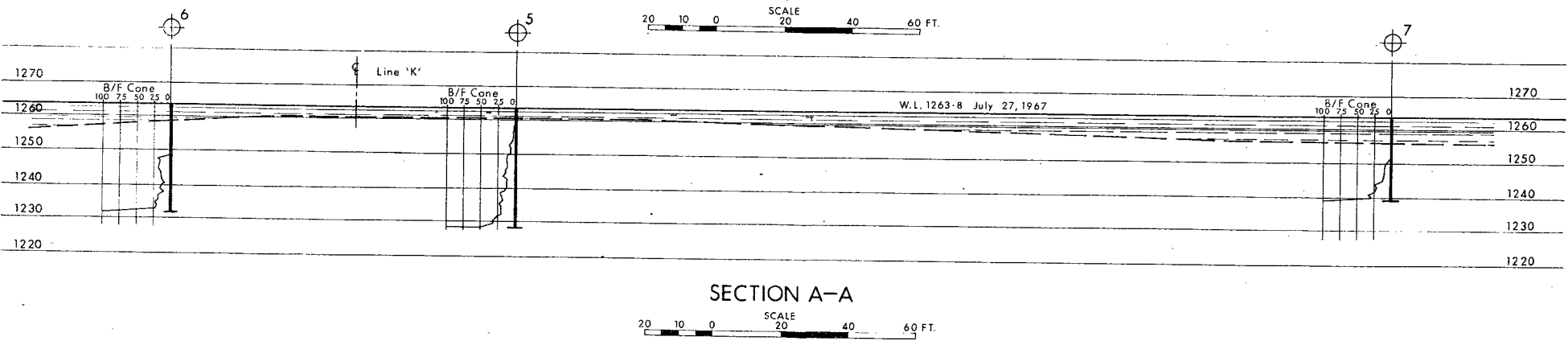
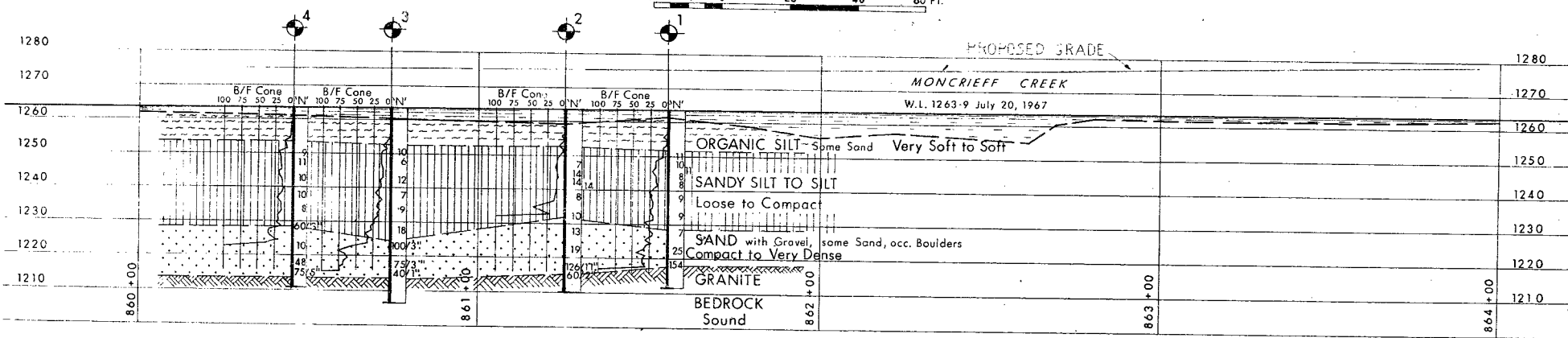


LEGEND			
	Bore Hole		
	Cone Penetration Hole		
	Bore & Cone Penetration Hole		
	Water Levels established at time of field investigation.		

NO.	ELEVATION	STATION	OFFSET
1	1263.9	861+55	18' RT
2	1263.9	861+25	14.5' LT
3	1263.8	860+74	14.5' RT
4	1263.8	850+45	14' LT
5	1263.8	860+89	45' RT
6	1263.8	861+10.5	55' LT
7	1263.8	860+39	298' RT

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.



REVISIONS	DATE	BY	DESCRIPTION

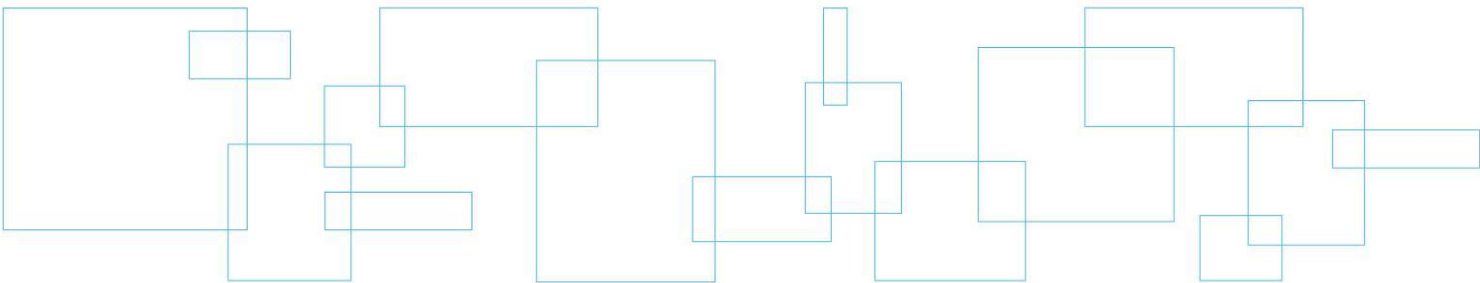
DEPARTMENT OF HIGHWAYS - ONTARIO			
MATERIALS & TESTING DIVISION - FOUNDATION SECTION			
MONCRIEFF CREEK			
KING'S HIGHWAY NO. 144 LINE 'K'		DIST. NO. 17	
60- DIST. SUDBURY			
TWP. MONCRIEFF		LOT. CON.	
BORE HOLE LOCATIONS & SOIL STRATA			
SUB'D. R.R.T. CHECKED <input checked="" type="checkbox"/>	W.P. NO. 273-64	M.B.T. DRAWING NO.	
DRAWN S.V. CHECKED <input checked="" type="checkbox"/>	JOB NO. 67-F-63	67-F-63 A	
DATE 18 SEPT. 1967	SITE NO.	BRIDGE DRAWING NO.	
APPROVED <i>[Signature]</i>	CONT. NO.		

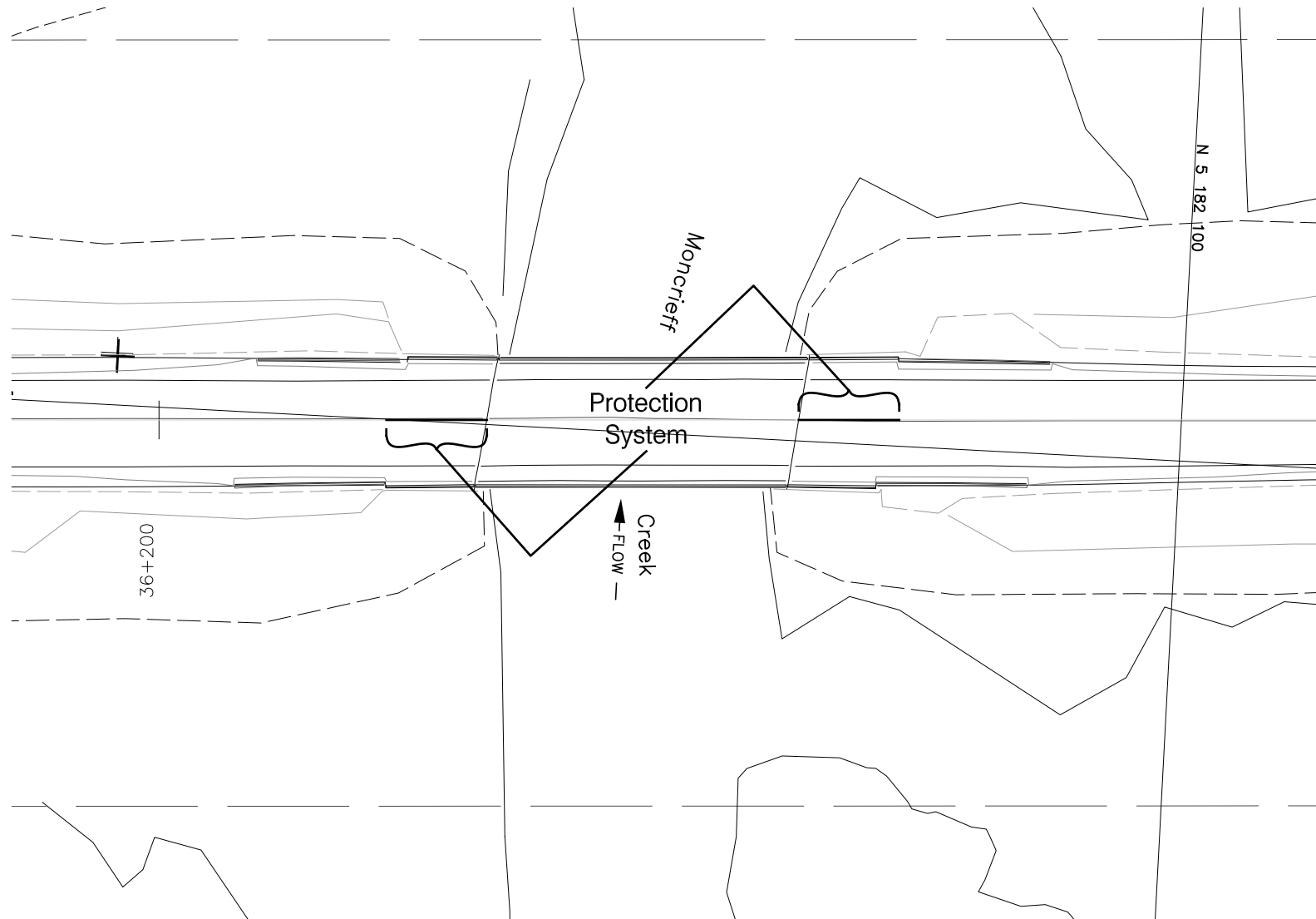
Appendix E

Design Data

Sketch Nos. SK-3:
Table A:

Conceptual Shoring Sketch
Comparison of Shoring Alternatives





HWY 144 - Township of Moncrief - Site 46-256
Conceptual Shoring Locations - Moncrief Creek Bridge

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	Considered for protection system	\$ 650/m ²
Steel Sheet Piles	5 – 21	-High strength, continuous, -Readily available	-Limited by soil conditions (i.e. obstructions)	Recommended for shallow excavations at this site (i.e. 2 m or less)	\$ 650/m ²
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	
Soldier piles With lagging	5 – 25	-Easy installation -Readily available -Adaptable to various ground conditions	-Pre-drilling may be required -Possible ground loss	Considered for deep excavations at this site	\$ 725/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	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	
Micropiles with reinforced shotcrete face		-Can be installed in various ground conditions -High strength -Good tolerance	-High Cost -Requires specialized equipment	Considered for deep excavations at this site	\$ 900/m ²