MERLEX ENGINEERING LTD.

CONSULTING GEOTECHNICAL ENGINEERS

FINAL
FOUNDATION INVESTIGATION AND DESIGN REPORT

GWP 356-97-00

Highway 144, From the Highway 17/144 Interchange Northerly 14.6 km

MTO Sudbury Area

07/01/07002 June 8, 2009

Submitted to:

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GEOCRES Number: 41I-234

TABLE OF CONTENTS

APPENDICES

APPENDIX A

Figure No. 1	Key Plan

APPENDIX B

Enclosure No. 1	List of Abbreviations and Symbols
Enclosure Nos. 2 to 8	Record of Borehole Sheets (Borehole Nos. 1 to 7)

APPENDIX C

Figures A1 & A2	Borehole Locations & Soil Strata (Area A and Area B)
Figure L-1 to L-3	Summary Grain Size Analysis Graph
Figure L-4	Summary of Atterberg Limits Test Results

APPENDIX D

Photo Essay	
Figures S-1 & S-2	Slope Stability Cross Sections A-A and B-B

1.0 INTRODUCTION

Merlex Engineering Ltd. (MEL) has been retained by AECOM Inc., on behalf of the Ministry of Transportation of Ontario (MTO), to carry out a foundation investigation along a section of embankment, on Highway 144, directly north of the north abutment to the existing Levey Creek bridge.

Highway 144 is a rural arterial, undivided two lane King's Highway. This 271 km long north/south thoroughfare intersects with Highway 17 at its south end, in the Regional Municipality of Sudbury, and with Highway 101 in the City of Timmins at its north end. The highway also serves several small communities along its route. The draft Design Criteria (DC), provided by the Ministry, states that Highway 144 within the limits of this project is presently classified as an undivided two lane rural arterial highway (RAU110). The posted speed on this highway is 90 km per hour.

The foundation investigation locations were established with the MTO in correspondence of October 6, 2008 for Change Order No. 4 for Agreement No. 5006-E-0008. The purpose of the investigation was to determine the subsurface conditions at the location of embankment widening, north of Levey Creek Bridge, where foundation design recommendations are required. MEL investigated the foundation area by the drilling of boreholes, carrying out in-situ tests and performing laboratory testing on selected samples.

Foundation investigation work was undertaken at the embankment located directly north of the Levey Creek Bridge, at Area A, Station 18+140 to 18+153, on the right, and Area B, Station 18+187 to 18+202.5 (see Borehole Location Plan - Figures A1 and A2, Appendix C). The foundation investigation was carried out to obtain sufficient subsurface information to verify

design assumptions and provide adequate subsurface descriptions to permit planning of the construction of the proposed embankment widening.

The contract sheets and proposed cross sections, in the area of the foundation investigations, were provided by AECOM Inc. Prior to commencing the fieldwork, stations and offsets in the area of the foundation investigations were surveyed by others and this field data was incorporated in preparation of the plans and profiles presented in this report.

2.0 SITE DESCRIPTION

There are two foundation areas covered in this report, herein referred to as Area A and Area B which are described as follows:

Area A:

Widening of the Levey Creek Bridge is proposed. To accommodate the proposed structure work, widening of the existing embankment on the right side of the highway on the north approach fill is required between Stations 18+140 and 18+153, in Creighton Township. The existing embankment is approximately 3.0 m high and the existing rockfill embankment slope is at an angle of ± 56o, based on recently compiled cross sections (see Cross Section A-A, Figure A1, Appendix C). The bridge structure will be widened by cantilevering the widened sections of the deck off the existing bridge deck. No work is proposed for the existing abutment or foundation system (piles and pile cap supporting the abutment). The abutment on the right is at Station 18+139.

An available document, Geocres No. 41I-123 titled “Proposed New Structure of the Crossing of Levey Creek & King’s Highway 144 NWBP, District 17, Sudbury, WP 132-77-02, Site 46-310” prepared by Trow Group Limited and dated December 7, 1978, indicates that prior to the

construction of the existing highway, there was approximately 1.0 to 2.5 m of peat, on centerline, overlying silts and clays. Contract 82-200 drawings indicate that the organic materials were excavated to a width of 16.0 m left and right of centerline and SSM used as swamp backfill. Boreholes advanced during MEL's June 2007 geotechnical site investigations and the Contract 82-200 drawings indicate that rock fill was used to construct the embankment over the SSM. There has been no reported history of settlement of the existing abutment fill at the north approach.

Site investigations were carried out to confirm the existing conditions adjacent to the existing approach embankment. The foundation investigation consisted of one (1) borehole put down in the area of widening at Station 18+155 offset 15 m Rt (Borehole No. 7).

Area B:

Widening of the existing highway embankment to construct a steel beam guiderail terminus, on both left and right, is required between Stations 18+187 and 18+202.5, in Creighton Township. The existing embankment is approximately 3.0 m high and the existing embankment fore slope is at an angle of ± 69^{o} off the horizontal on the right (see Cross Section B-B, Figure A1, Appendix C). The offset to the new toe of the embankment slopes will be 18.0 to 20.0 m from centerline. As discussed for Area A, historical documents indicate that approximately 1.0 to 2.5 m of peat was excavated to 16.0 m left and right of centerline and SSM was used as swamp backfill. The north limit of the swamp excavation was Station ± 18+195. Contract 82-200 drawings indicate that rock fill was used to construct the embankment over the SSM.

Site investigations were carried out to confirm the existing conditions adjacent to the existing approach embankment. The foundation investigation consisted of six (6) boreholes, three on each side of the highway, at the terminus locations. Boreholes were located at offsets of 15.0 m

and 19.0 m, both left and right of centerline at Station 18+190 (Borehole Nos. 2, 3, 5, and 6), and one borehole located 15.0 m left and right of centerline at Station 18+205 (Borehole Nos. 1 and 4).

2.1 Physiography and Surficial Geology

This Highway 144 project falls within the limits of the geomorphic sub-province known as the North Shore - Sudbury Ridges and Pockets. The topography at the site is generally flat to rolling. There are numerous exposed bedrock ridges throughout the project. At many locations, relatively thin layers of earth overlay the bedrock. Areas with organic terrain are also present. Within the project area overburden conditions consist primarily of silty earth containing varying amounts of sand and clay.

Based on the Northern Ontario Highway Geological Map, Highway144 transverses through an area developed during the late to middle Precambrian period, comprising of mafic igneous rocks.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out during the period of November 18 to 20, 2008, in Area B, with Borehole No. 7 (Area A) advanced on January 12, 2009, after the ground had sufficiently froze. The field investigation was carried out using a Bombardier mounted CME 45 drilling rig equipped with hollow stem augers and all routine geotechnical sampling equipment. The boreholes were advanced using 165 mm O.D. continuous flight hollow stem augers or 110 mm O.D. continuous flight standard augers. Soil samples were obtained at regular intervals of depth using the standard 50 mm O.D. split spoon sampler advanced in accordance with the Standard Penetration Test (SPT) procedures, or a 75 mm OD thin walled open Shelby tube sampler advanced either manually or hydraulically, if soft cohesive deposits

were encountered. The boreholes were advanced to auger or Dynamic Cone Penetration Test (DCPT) refusal. In-situ vane testing, using an MTO "N" size vane, was carried out where appropriate and possible. Maximum exploration depth was 9.9 m by auger (Borehole No. 6) with DCPT advanced to a maximum depth of 13.7 m. Auger probes were advanced using either 165 mm O.D. continuous flight hollow stem augers or 110 mm O.D. continuous flight standard augers.

The soil/bedrock interface was determined by geological definition and, where necessary, by advancing additional adjacent borings through the overburden to practical auger refusal.

Groundwater conditions in the open boreholes were observed during and immediately following completion of the individual boreholes and a set of water level observations were taken during the last day of the investigation. All open boreholes were backfilled upon completion with the auger cuttings in the order they were removed, using reverse augering techniques. Where necessary, imported bentonite was used to seal the hole at grade.

The field work for this investigation was under the full time direction of a senior member of our engineering staff, who was responsible for locating the boreholes, clearing the borehole locations of underground services, in-situ sampling and testing operations, logging of the boreholes, labeling and preparation of samples for transport to our North Bay laboratory, plus overall drill supervision. All samples received a visual confirmatory inspection in our laboratory. Laboratory testing of select samples included natural water content determination, Atterberg Limits determination, grain size analysis, and specific gravity testing. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix B) with a summary of select results presented on the laboratory sheets in Appendix C (Figures L-1 to L-4).

The location of the individual boreholes were established in the field using highway chainage and offset from centerline.

4.0 SUBSURFACE CONDITIONS

Details of subsurface conditions revealed by the investigation program are presented on the enclosed Record of Borehole Logs (Enclosure Nos. 2 to 8) and on the Borehole Locations & Soil Strata (Figures A1 & A2). 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, and the results of SPT, plus field observations. Typically such boundaries represent transitions from one zone to another and are not an exact demarcation of specific geological unit. Additional consideration should be given to the fact that subsurface conditions may vary markedly between adjacent boreholes and beyond any specific boring location.

4.1 Area A: Station 18+140 to 18+153, 15 m Rt

A plan and cross-section showing the borehole locations and stratigraphic sequences is shown on Figure A1. During the course of our exploration program, one (1) sampled borehole was advanced at the toe of the north-east embankment. At Borehole No. 7, a 200 mm thick layer of ice was initially penetrated followed by 700 mm of black/dark brown fine fibrous peat and sand, some gravel. The natural moisture content of the fibrous peat portion of this deposit was measured at 184%.

Between a depth of 0.9 and 5.2 m, a deposit of grey silt, trace of fine sand and trace of clay was penetrated. SPT “N” values recorded in conjunction with split spoon sampling within this stratum returned values of 17 to 61 blows/0.3 m penetration, indicating a compactness of compact to very dense. Natural moisture content determinations carried out on samples from this stratum indicated values of 19 to 29%.

Between a depth of 5.2 and 9.9 m (end of sampling), a deposit of grey silty clay was encountered. The deposit exhibited a varved structure. Based on in-situ vane shear strength test values, which returned values between 76 to greater than 100 kPa, between elevations 259.4 and 256.4 m, the consistency of the deposit is described as stiff to very stiff. The natural moisture contents varied between 38 and 56%. Sampling was terminated in this deposit at a depth of 9.9 m. Adjacent to the borehole a DCPT was advanced to refusal which occurred at a depth of 13.7 m.

In 1978, a foundation investigation covered under Geocres No. 41I-123 titled "Proposed New Structure of the Crossing of Levey Creek & King's Highway 144 NWBP, District 17, Sudbury, WP 132-77-02, Site 46-310" prepared by Trow Group Limited advanced Borehole No. 1 at Station 18+134 on centerline. This historical borehole is the closest (10 m west) to the area under investigation and identifies 2.29 m thickness of fibrous peat underlain by compact deposit of silt some 3 m thick, followed by a firm clay deposit in which in-situ shear vane tests returned values of 30 kPa and 23 kPa at approximately elevations 258.6 and 257.0 m, respectively. The field vane results are slightly higher, ranging from 25 kPa to 40 kPa, at the south approach along the centerline. A one dimensional consolidation test was carried out on a representative sample from Borehole No. 3 (south approach), which indicated the clay was over-consolidated by approximately 75 kPa and had a coefficient of consolidation (M_v) of 0.345 MPa^{-1}.

4.2 Area B: Station 18+187 to Station 18+202.5

A plan and profile showing the borehole locations and stratigraphic sequences is shown on the enclosed Borehole Locations & Soil Strata, Figures A1 and A2. During the course of our exploration program, six (6) sampled boreholes and accompanying DCPT were put down at this site. Boreholes Nos.1 to 3 were put down to the left side, whereas Borehole Nos. 4 to 6 were

advanced to the right side of the highway embankment. Information from the previously referenced 1978 investigation for Borehole No. 2 (on centerline) is also included.

Borehole No. 1 encountered bedrock at existing grade and the bedrock was protruding above grade to the north. At Borehole No. 2, a surficial layer of organics, some 50 mm thick, was underlain by a thin layer of silt some clay fill with organics and trace of sands and gravels, which extended to a depth 0.8 m. The fill at Borehole No. 2, as well as the thin 200 mm thick surficial layer of organics at Borehole No. 3, was underlain by a silt. The silt deposit consisted of a grey silt with fine sand and a trace of gravel and trace of clay and contained occasional cobble sizes. At Borehole No. 2, the silt had a higher fine sand and gravel content than at Borehole No. 3. This can be seen from the gradation analysis for Borehole No. 2 (Figure L-3) compared to the gradation results at Borehole No. 3 (Figure L-1). Based on the SPT values, which ranged from 10 to 43 blows per 300 mm penetration, with several samples encountering refusal on cobble sizes before penetrating the full 300 mm penetration, the compactness of this deposit was described as compact to dense. Natural moisture content determinations carried out on samples from this stratum indicated values of 22 to 25%. Three grain size determinations were carried out on select samples from this stratum and it was found that the general envelope contains 0 to 19% gravel sized particles, 2 to 27% sand sized particles, 37 to 79% silt sized particles, and 10 to 34% clay sized particles. Borehole Nos. 2 and 3 were terminated in the silt deposit at depths of 3.1 and 2.0 m respectively, where auger refusal was met. Auger probes were advanced adjacent to the borehole locations and met refusal at similar depths to the boreholes indicating the auger refusal is probably due to bedrock (see record of borehole logs for auger probe results).

Borehole Nos. 4, 5, and 6 were advanced to the right of the embankment (see the Borehole Location Plan & Soil Strata, Figure No. A1). At Borehole Nos. 4 and 5, 100 mm of free water

was encountered at the ground surface. The free water was underlain by a thin (100 mm thick) layer of grass and organics at Borehole No. 4 and a deposit of fine fibrous peat mixed with sand and gravel at Borehole No. 5, which extended to a depth of 1.2 m. At Borehole No. 6, a deposit of fine fibrous peat was encountered from existing grade to a depth of 1.2 m. The peat was mixed with approximately 50% sand and gravel with cobble/boulder sizes mixed in with the peat at Borehole Nos. 5 and 6.

The above surface deposits, at all three boreholes, was underlain by a deposit of silt to depths varying between 4.4 and 5.2 m below grade. The silt deposit is described as grey silt with some clay. Natural moisture content determinations carried out on samples from this stratum indicated values of 24 to 26%. A total of three grain size determinations were carried out on select samples from this stratum and it was found that the general envelope contains 0% gravel sized particles, 0 to 1% sand sized particles, 76 to 80% silt sized particles, and 20 to 24% clay sized particles. Atterberg Limits determinations carried out on one sample from this stratum indicated a ML-CL designation with Plastic Limit of 22% and Liquid Limit 28%. Grain size distribution curves and Atterberg Limits test results can be found on the Summary of Laboratory Testing sheets (Appendix C, Figure Nos. L-1 and L-4). The specific gravity of three samples of this deposit was measured at an average of 2.74. SPT “N” values, recorded in conjunction with split spoon sampling within this stratum, returned values of 17 to 88 blows per 300 mm penetration, indicating a compactness of compact to very dense.

At depths of 4.4 to 5.2 m in Borehole Nos. 4, 5, and 6, a deposit of grey varved silty clay was penetrated. Natural moisture content values were found to vary between 34 and 59%, and the stratum was found to be saturated. Atterberg Limits determinations carried out on four samples from this stratum indicate a CL to CH designation with Plastic Limits ranging from 19 to 24% and Liquid Limits ranging from 37 to 54%. Atterberg Limits test results can be found on the

Summary of Laboratory Testing sheets (Appendix C, Figure No. L-4). SPT "N" values recorded, in conjunction with split spoon sampling within this stratum, returned values of 0 (weight of hammer or pushed manually). Field vane shear tests in this stratum returned values of 40 to 58 kPa with sensitivity values in the order of 4. Overall, a firm to stiff consistency is inferred for this stratum. Based on the results of the vane shear strength data, and the relationship of the moisture content to liquid limit, this clay deposit is judged to be normally consolidated to moderately over-consolidated. Sampling was terminated in this deposit at depths varying between 9.6 and 9.9 m. Adjacent to Borehole Nos. 4, 5, and 6, DCPTs were advanced to refusal which occurred at depths ranging from 12.6 to 13.7 m.

Borehole No. 2, from the previously referenced 1978 investigation, indicates that from ground surface (elevation 265.4 m) a 200 mm thick layer of topsoil was underlain by a stratum of compact silt down to elevation 262.1 m, where a firm clay was encountered, which extended to elevation 258.6 m. The in-situ shear strengths in the clay returned values from approximately 21 to 30 kPa. The clay was underlain by a dense silty sand till down to a depth of 7.6 m, where refusal, on the casing shoe, was encountered on boulders or bedrock, at elevation 257.8 m.

4.3 Groundwater Conditions

Groundwater levels in the open boreholes were taken during the advance of the individual borings and upon completion. Groundwater levels and cave-in depths are summarized on the individual Record of Borehole Log Sheets (Appendix B).

At Borehole Nos. 2, 3, 4, 5, 6, and 7, the stabilized groundwater level was at, or within 600 mm of, the existing ground surface shortly after completion of the boreholes.

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