



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

**Highway 654 Rehabilitation
Culvert Replacement
Station 16+927 - TWP of North Himsworth
GWP 5090-05-00**

**Highway 654
From Highway 534 Easterly 23.1 km to Highway 11**

FINAL FOUNDATION INVESTIGATION REPORT

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LVM | MERLEX



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Attention: **Mr. Al Rose**

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1 INTRODUCTION

LVM | MERLEX has been retained by AECOM Canada Ltd., on behalf of the Ministry of Transportation of Ontario (MTO), to carry out a foundation investigation for the proposed replacement of an existing culvert and the associated temporary protection system required for the culvert replacement. This culvert replacement is located on Highway 654, some 4.0 km West of Highway 11, in the Township of North Himsforth.

The foundation investigation location was specified by the MTO in the RFP/TPM documentation Agreement No. 5010-E-0028. The terms of reference for the scope of work are outlined in LVM | MERLEX's Proposal P-11-151, dated October, 2011. The purpose of this investigation was to determine the subsurface conditions in the area of the culvert in order to provide design recommendations. LVM | MERLEX investigated the foundation area by the drilling of boreholes, carrying out in-situ tests, and performing laboratory testing on select samples.

2 SITE DESCRIPTION

The foundation investigation for this Corrugated Steel Pipe (CSP) culvert is located at Station 16+927, Township of North Himsforth. The topography at the site is slightly rolling with low terrain and a stream flowing adjacent to the left (north) toe of the embankment. The existing highway embankment currently supports two undivided lanes of highway, running in an east-west direction. The existing highway, at the culvert location, is constructed on a fill embankment some 5.4 m in height above the surrounding grade, with centerline elevation of 216.4 m at the culvert location. The culvert at this location is an 800 mm diameter CSP culvert, some 33.1 m in length. Flow through the culvert is from right to left (i.e. south to north) (see Photo Essay, Appendix 4).

Infrastructure at the culvert location consists of overhead wires on the left (north) side of the highway.

2.1 SITE PHYSIOGRAPHY AND SURFICIAL GEOLOGY

This project is located in the Geomorphic Sub-province known as the Muskoka Ridges and Pockets. The general topography on this section of Highway 654 is slightly 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 silt and clay containing varying amounts of sand and gravel.

Bedrock in the area, as indicated on OGS Map 2506, is of the Late Precambrian Era. At the location of this culvert foundation investigation, the bedrock comprises of granitic to syenitic rocks and derived gneisses.

3 INVESTIGATION PROCEDURES

The field work for this investigation was carried out during the period of April 5th to May 22nd, during which five (5) sampled boreholes, and DCPTs, were advanced. For the purposes of foundation design for the culvert replacement, one borehole was advanced through the embankment slightly up chainage from the culvert and one borehole was advanced at each the inlet and outlet ends of the culvert. Two boreholes were advanced through the embankment up and down chainage from the culvert, to provide subsurface data to support the design of a protection system.

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

Groundwater conditions in the open boreholes were observed during the advancement of and immediately following, completion of the individual boreholes. All open boreholes were backfilled upon completion with compacted auger cuttings in the general order they were removed and, where necessary, bentonite pellet backfill was added to the boreholes to bring them up to grade. At the borehole(s) through the embankment, the upper portion of the hole was backfilled where necessary with an asphalt cold patch to seal the existing asphalt surface.

The field work for this investigation was under the full time direction of a senior member of our engineering staff, who was responsible for locating the boreholes, clearing the borehole locations of underground services, in-situ sampling and testing operations, logging of the boreholes, labeling and preparation of samples for transport to our North Bay laboratory, plus overall drill supervision. All samples received a visual confirmatory inspection in our laboratory. Laboratory testing of select samples included routine testing for natural moisture content determination and particle size analysis, as well as specific gravity testing. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix 2), with a summary of results presented on the laboratory sheets in Appendix 3 (Figures Nos. L-1 to L-7).

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

4 SUBSURFACE CONDITIONS

Details of the subsurface conditions revealed by the investigation program are presented on the enclosed Record of Borehole Logs (Appendix 2) and on Figure No. 2 (Appendix 3). Please note that stratigraphic delineation presented on the borehole logs and soil strata plot are the results of non-continuous sampling, response to drilling progress, the results of SPT and Dynamic Cone Penetration Test (DCPT) plus field observations. Typically such boundaries represent transitions from one zone to another and are not an exact demarcation of specific geological unit. Additional consideration should be given to the fact that subsurface conditions may vary markedly between adjacent boreholes and beyond any specific boring location, and are shown on the drawings for illustration purposes only.

4.1 CULVERT, STATION 16+927, TWP OF NORTH HIMSWORTH

A plan and profile illustrating the borehole locations and stratigraphic sequences is shown on Figure No. 2, Appendix 3. During the course of the exploration program, five (5) sampled boreholes were put down at this site, with Borehole Nos. 1, 2, and 3 advanced through the embankment and Borehole Nos. 4 and 5 advanced at the culvert ends. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1 to 5 were recorded at 216.4, 216.5, 216.3, 212.8, and 213.9 m, respectively.

4.1.1 Pavement Structure

At Surface at Borehole Nos. 1 and 2, a pavement structure consisting of 50 mm of asphalt and 175 to 200 mm crushed gravel was penetrated. At Borehole No. 3, a pavement structure consisting of 75 mm of asphalt was encountered.

4.1.2 Surficial Organics

At surface at BH No. 4, a layer of surficial organics, some 50 mm thick, was penetrated.

4.1.3 Embankment Fill

Underlying the pavement structure at Borehole Nos. 1 to 3, a deposit of fill consisting of brown sand some silt to silty, trace gravel to gravelly, was penetrated. Occasional cobbles were encountered in this deposit. A buried asphalt layer was encountered in this deposit at Borehole No. 1. The natural moisture content measured on samples of this deposit was in the order of 3 to 17%. Gradation analyses were carried out on five (5) samples of this deposit, the results of which indicated 4 to 39% gravel size particles, 49 to 69% sand size particles, and 10 to 35% silt and clay size particles (Figure No. L-1, Appendix 3). Based on SPT 'N' values of 7 to 61 blows per 300 mm penetration, the compactness of this deposit was described as loose to very

dense, generally compact. This deposit was encountered to depths of 5.3, 4.6, and 2.9 m below grade at Borehole Nos. 1 to 3, respectively (elevations 211.1, 211.9, and 213.4 m, respectively).

4.1.4 **Fill**

Underlying the surficial organics at Borehole No. 4, and at surface at Borehole No. 5, a deposit of fill consisting of brown sand some silt trace gravel was penetrated. Occasional cobbles were encountered in this deposit. The natural moisture content measured on samples of this deposit was in the order of 14 to 21%. Based on SPT 'N' values of 16 to 21 blows per 300 mm penetration, the compactness of this deposit was described as compact. This deposit was encountered to depths of 0.3 and 2.1 m below grade at Borehole Nos. 4 and 5, respectively (elevations 212.5 and 211.8 m, respectively). DCPT refusal, likely on a boulder size rock piece, was encountered in this deposit at a depth of 1.9 m at Borehole No. 5 (elevation 212.0 m).

4.1.5 **Silty Clay**

Underlying the embankment fill at Borehole Nos. 1 and 3, and underlying the fill at Borehole Nos. 4 and 5, a deposit of grey silty clay trace to with sand trace gravel was penetrated. The natural moisture content measured on samples of this deposit was in the order of 23 to 31%. Hydrometer analyses were carried out on two (2) samples of this deposit, the results of which indicated 0 to 9% gravel size particles, 10 to 25% sand size particles, 32 to 62% silt size particles, and 28 to 34% clay size particles (Figure No. L-2, Appendix 3). Atterberg Limits testing was carried out on two (2) samples of this deposit, the results of which indicated a Plastic Limit in the order of 19% and a Liquid Limit in the order of 33 to 34% (Figure No. L-6, Appendix 4). Based on the results of the Atterberg Limits testing, this deposit was described as a silty clay of low plasticity (CL). Based on SPT 'N' values, the consistency of this deposit was estimated as stiff. This deposit was encountered to depths of 6.1, 3.8, 0.9, and 3.2 m below grade at Borehole Nos. 1, 3, 4, and 5, respectively (elevations 210.3, 212.5, 211.9, and 210.7 m, respectively).

4.1.6 **Sand and Silt**

Underlying the silty clay at Borehole No. 1 and underlying the embankment fill at Borehole No. 2, a deposit of grey sand and silt some to with gravel was penetrated. The natural moisture content measured on samples of this deposit was in the order of 16 to 17%. A hydrometer analysis was carried out on one (1) sample of this deposit, the results of which indicated 21% gravel size particles, 38% sand size particles, 34% silt size particles, and 7% clay size particles (Figure No. L-3, Appendix 3). Atterberg Limits testing was carried out on one (1) samples of this deposit, the results of which indicated a Plastic Limit in the order of 16% and a Liquid Limit in the order of 20% (Figure No. L-6, Appendix 4). Based on the results of the Atterberg Limits testing, this deposit was described as an inorganic sandy silt of slight plasticity (ML). Based on SPT 'N' values of 5 blows per 300 mm penetration, the compactness of this deposit was described as loose. Auger refusal was encountered in this deposit at depths of 6.9 and 6.0 m

below grade at Borehole Nos. 1 and 2 respectively (elevations 209.5 and 210.5 m, respectively).

4.1.7 Silt

Underlying the silty clay at Borehole No. 3, a deposit of grey silt trace gravel trace clay was penetrated. The natural moisture content measured on samples of this deposit was in the order of 22 to 28%. A hydrometer analysis was carried out on one (1) sample of this deposit, the results of which indicated 21% gravel size particles, 38% sand size particles, 34% silt size particles, and 7% clay size particles (Figure No. L-4, Appendix 3). Based on STP 'N' values of 17 to 18 blows per 300 mm penetration, this deposit was described as compact. Auger refusal was encountered in this deposit at a depth of 5.6 m below grade (elevation 210.7 m).

4.1.8 Sand

Underlying the silty clay at Borehole Nos. 4 and 5, a deposit of grey sand some silt some to with gravel was penetrated. Occasional cobbles were encountered in this deposit at Borehole No. 5. The natural moisture content of measured on samples of this deposit was in the order of 8 to 23%. A gradation analyses was carried out on one (1) sample of this deposit, the results of which indicated 26% gravel size particles, 42% sand size particles, and 16% silt and clay size particles (Figure No. L-5, Appendix 3). Based on STP 'N' values of 16 to 52 blows per 300 mm penetration, this deposit was described as compact to dense. Auger refusal was encountered in this deposit at depths of 1.8 and 4.0 m below grade at Borehole Nos. 4 and 5, respectively (elevations 211.0 and 209.9 m, respectively).

4.1.9 Bedrock

Underlying the sand and silt at Borehole No. 1, auger refusal was encountered at a depth of 6.9 m (elevation 209.5 m). Coring was undertaken to determine the nature of auger refusal, which proved to be bedrock. The bedrock was described as a pink to grey gneiss. Based on an RQD of 40 to 77% the bedrock was described as poor to good quality. The borehole was terminated at a depth of 11.4 m below grade (elevation 205.0 m).

4.2 GROUNDWATER DATA

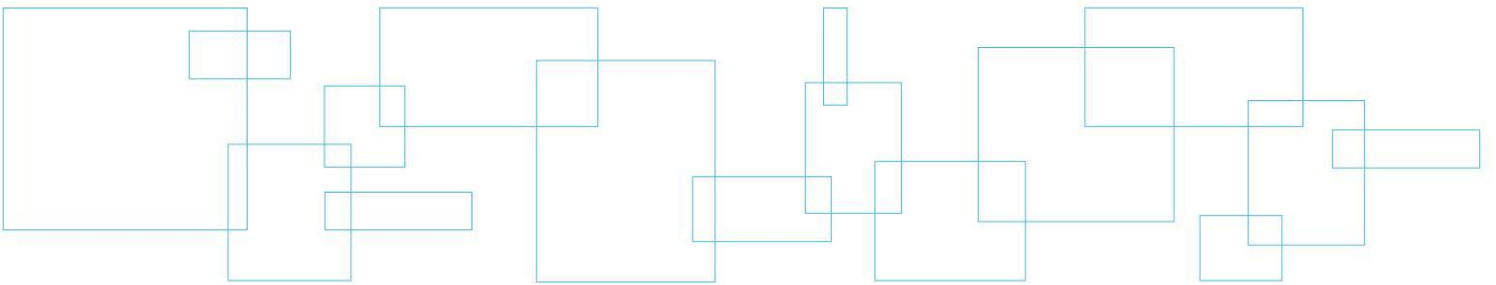
Measurements of the groundwater table and cave-in levels were undertaken, where possible, in the open boreholes during the advance of the individual borings and upon completion. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix B). The groundwater levels in Borehole Nos. 1 to 4 inclusive were measured to vary between elevations 211.4 to 212.2 m, upon completion. Borehole No. 5 was dry upon completion.

The groundwater and stream water levels will fluctuate seasonally.

Appendix 1 Key Plan

Drawing No. 1

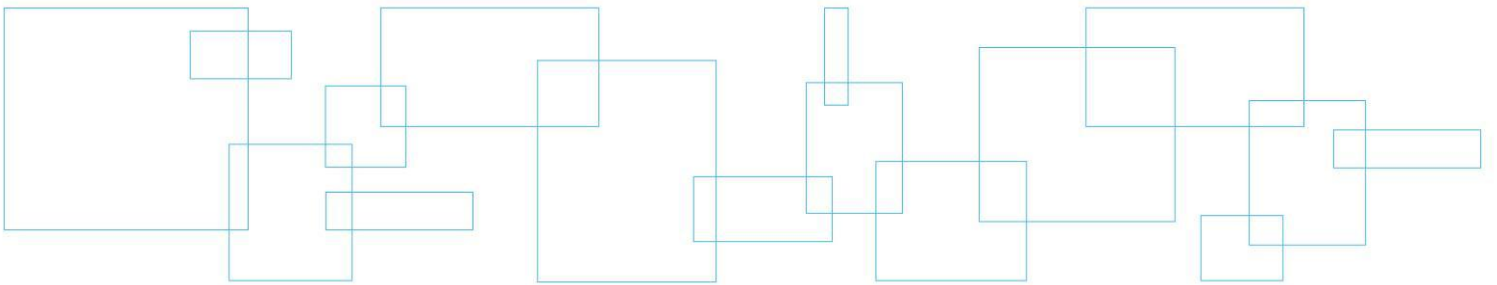
Key Plan



Appendix 2 Subsurface Data

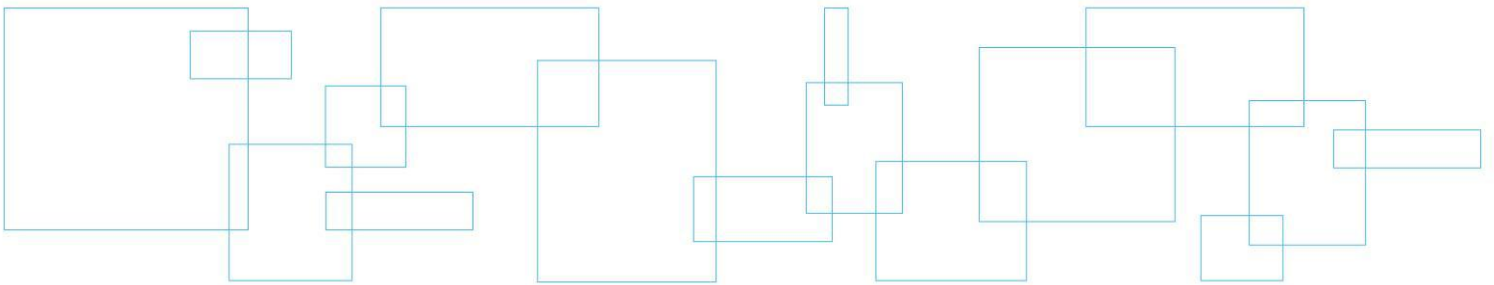
Enclosure No. 1
Enclosure Nos. 2 to 6

List of Abbreviations and Symbols
Record of Borehole Sheet



Appendix 3 Borehole Plan and Lab Data

Drawing No. 2: Borehole Location and Soil Strata
Figure Nos. L-1 to L-5: Grain Size Distribution Curves
Figure No. L-6: Atterberg Limits Summary
Figure No. L-7: Lab Test Summary Sheet



Appendix 4 Photo Essay

Enclosure No. 7:

Photo Essay

