



MERLEX ENGINEERING LTD.

CONSULTING GEOTECHNICAL ENGINEERS

FINAL

FOUNDATION INVESTIGATION AND DESIGN REPORT

FOUNDATION AREA 1

W.P. 309-00-00

Highway 63 Drainage Improvements,
Site 43-83, Four Mile Creek Culvert
Station 19+360 Widdifield Township

District 54 Sudbury

Merlex Reference No. 00/11/00135

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Submitted to:

Stantec Consulting Ltd.
1400 Rymal Road East
Hamilton, ON
L8W 3N9

Prepared by:

MERLEX ENGINEERING LTD.

2-120 Progress Court
North Bay, Ontario
P1B 8G4
Tel: (705) 476-2550
Fax: (705) 476-8882

GEOCRES 31L-82

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1.0 INTRODUCTION

Merlex Engineering Ltd. (MEL) has been retained by Stantec Consulting Ltd., on behalf of the Ministry of Transportation, to carry out a foundation investigation for Work Project 309-00-00. The work project is located along a section of Highway 63 at Four Mile Creek (Twp. of Widdifield). Highway 63 connects the City of North Bay with the Town of Temiscaming at the Ontario – Quebec border.

The purpose of this investigation was to determine subsurface conditions in the vicinity of the large corrugated steel plate culvert at this location. This report addresses Foundation Area 1, MTO Site 43-83, Four Mile Creek Culvert (see Key Location Plan). The investigation was initiated via detailed site reconnaissance by a senior geotechnical engineer from MEL, followed by drilling and sampling boreholes, carrying out Dynamic Cone Penetration Tests (DCPT), and performing a series of laboratory analyses on selected samples from the subject locations. Based on the information recovered from this program and our interpretation of the conditions that were encountered at the subject site, we have provided recommendations on the geotechnical aspects of the culvert replacement, along with discussions on excavations, fills and embankment design.

The plan and profile information for Foundation Area 1 is presented in Figure A-1. Stantec Consulting Ltd. provided the base drawing, coordinates, and reference elevations for the borehole locations. Stratigraphic information contained on the above noted figure is based on our evaluation of conditions encountered in the field.

Specific terms of reference for this project are contained in MEL Proposal No. P-00-83, dated August 17, 2000. The work was carried out in compliance with our Quality Control Plan dated November 30, 2000.

2.0 SITE DESCRIPTION

The section of Highway 63 addressed within this report commences at Station 19+330 and extends to approximately Station 19+380 in the Twp. of Widdifield, northeast of the City of North Bay. The actual location of the Four Mile Creek culvert at highway centerline is Station 19+360.

The site is steeply sloping to the south. The valley is narrow and heavily forested with deciduous and coniferous trees. To the left (or west), the creek runs almost parallel to the highway embankment over a distance of approximately 30 m. The existing culvert is constructed of corrugated steel plate arch sections supported on cast in place concrete footings. There is excessive corrosion at the concrete to steel interface and signs of minor sloughing of the embankment fills in the immediate vicinity of the inlet and outlet.

3.0 INVESTIGATION PROCEDURES

All drilling operations were performed with a Bombardier mounted CME 45 drilling unit under the guidance of experienced staff, during the period of April 4th to 6th, 2001 and on April 25th, 2001. Boreholes were advanced with 150 mm hollow stem continuous flight augers. Samples were retrieved at regular intervals of depth or as deemed necessary by our field staff. Disturbed samples were retrieved with 50 mm OD Split Spoon Samplers and Standard Penetration Test (SPT) "N" values were recorded in conjunction with this sampling technique. Typical sampling depth was to equivalent fill height, 2 to 3 times structure height, or auger refusal.

Where encountered, groundwater conditions have been recorded on the attached Record of Borehole Logs.

All samples from this project were identified in the field and placed in airtight sample jars prior to careful transport to our laboratory in North Bay. All samples received a confirmatory inspection in our laboratory and select samples were tested to determine natural water content and grain size distributions.

The results of our testing program for Foundation Area 1 are presented on the attached Record of Borehole Logs for borings 23, 28, 34, and 34A which also include DCPT results at each location. A Summary of Laboratory Testing is presented in Table 1. Specific laboratory test results are presented on Figures L83-1 and L83-2.

4.0 SUBSURFACE CONDITIONS

Details of subsurface conditions revealed by the investigation program are presented on the Record of Borehole Logs and on the Summary of Laboratory Testing. Please note that stratigraphic delineations presented on the borehole records are the result of non-continuous sampling, response to drilling progress, the results of SPTs, and values obtained from DCPTs. Typically, such boundaries represent transitions from one zone to another and 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 or beyond any specific boring location.

At Four Mile Creek (Foundation Area 1) the Borehole Locations & Soil Strata drawing (Figure A-1) shows borehole layouts and their respective stratigraphy. Three boreholes were put down at this site. Borehole No. 23 is located near the inlet of the culvert where it was advanced to a depth of 1.5 m with hollow stem augers and to 3.3 m by DCPT. An additional attempt at advancing a borehole was made with solid stem augers at a distance of 1.5 m south of Borehole No. 23. Refusal was encountered at 2.0 m. Borehole No. 28 is located near the outlet of the culvert. In this case, the hole was advanced to a depth of 3.2 m with hollow stem

augers and 3.4 m with a DCPT. Auger probes AP 28A through AP 28C, located 1.5 m south, 1.5 m north, and 3.0 m south of Borehole No. 28 respectively, could not be advanced to more than a 2.9 m depth. The natural ground elevation across the two borehole locations varies between 247.1 m and 246.2 m. The centerline elevation of the road located between the two boreholes is 251.58 m.

Subsurface conditions at Borehole No. 23 were found to consist of 100 mm of organic silt that was underlain by a 500 mm layer of fine fibrous peat with a natural moisture content recorded at 155%. Below this horizon, a stratum of dense to very dense, fine to medium brown sand was encountered, in which cobbles and boulder sizes are inferred from response to drilling and sampling operations. Trace to some silt is inferred to be present within this deposit based on natural moisture content values in the 18% to 25% range. Standard Penetration Test "N" values recorded across the various sub strata of this zone were found to vary from 32 to 77 per 0.3 m test length, indicating a compact to very dense condition.

The stratigraphic sequence at Borehole No. 28 was more complex, comprising 500 mm of silty sand with some organics at depth. Below this a 400 mm stratum of dense gravelly sand was encountered ($M_c=12\%$) which was in turn underlain by a thin layer of organic silt and silt equally divided at 50 mm each. A stratum of gravelly sand, trace silt ranging from fine to medium sand some gravel some silt to trace silt with depth and occasional cobbles throughout was found to underlay the silt layer. Natural moisture content values of 8 to 16% were recorded within this fluvial stratum. Dynamic Cone Penetration Test values oscillated significantly with depth, confirming the presence of cobble sizes. Standard Penetration Test "N" values throughout these fluvial deposits varied between 17 to 66 blows per 0.3 m penetration indicating a compact to very dense (generally compact) condition of relative density.

Borehole No. 34 was put down through the embankment fill at Station 19+360 and at a distance of 3.9 m right of highway centreline. Refusal was encountered at a depth of 1.7 m in sand and cobble fill. Borehole No. 34A was put down at Station 19+352, 3.9 m right of centerline. At this location, the fill was penetrated to an estimated depth of 6.7 m and was found to consist of compact brown sand and/some gravel, trace silt with occasional cobbles throughout. The fill was generally dry, changing to moist with depth. Refusal to further advance of the augers was encountered at a depth of 6.7 m. Dynamic Cone Penetration Test advance in an inferred continuation of this stratum was achieved to a depth of 8.4 m. A relative density of compact to very dense (generally compact) is inferred based on advance of the dynamic cone and the Standard Penetration Test "N" values recorded at 11 to greater than 100 blows per 0.3 m within the cohesionless granular fill deposit.

Water level observations during the drilling of Borehole No. 23 (inlet) and Borehole No. 24 (outlet) indicate that the water table was at a depth of approximately 150 mm below natural ground level at the time of investigation.

MERLEX ENGINEERING LTD.

M. A. Merleau, P. Eng.
Principal

Dennis Netherton, P. Eng.

5.0 DESIGN COMMENTS AND RECOMMENDATIONS

5.1 General

The Four Mile Creek Culvert section is to be replaced and raised in order to accommodate widening of the highway shoulders in accordance with a RAU 100 design criteria. The highway grade will remain the same at this location. The existing culvert section is a corrugated steel multi-plate arch 3200 mm high by 6100 mm wide, 21750 mm long at top of arch and 28950 mm at existing footing level. Preliminary design details place the final length of the proposed culvert at 27000 mm. As indicated on the attached Preliminary General Arrangement Details (see Figure P-83), a new larger span open footing concrete culvert is planned. End and wing walls will be provided for fill stability and training of the creek flow.

The new culvert will be constructed over the existing structure so that the latter serves as protection for sensitive fish habitat and a rare species (Atlantic Salmon) known to exist in this reach of Four Mile Creek. Extreme care is to be taken with all aspects of construction activities in or near the creek so as to minimize damage to the fish habitat.

In order to insure this, positive groundwater control methods must be employed so that the new foundations can be installed to a depth of 1.2 m below river bed at their location just outside of the existing footings. The existing footings are to be left in place to insure that the current limits of fish habitat within the immediate culvert area are preserved.

5.2 Foundations

5.2.1 Culvert Replacement, Integral Headwall and Wing Walls

Current plans are for the establishment of 1 m wide footings at a depth of 1.2 m below river bottom (elevation 244.3 m) along the new culvert alignment. Positive ground water control methods must be employed to insure that the foundations are excavated, prepared and poured in the “dry”, and in such a manner that the existing foundations supporting the steel plate arch remain stable and provide the degree of fish habitat protection required. Dewatering and ground water control methods, to insure the above measures are met, will include sand bag coffer dams, seepage diaphragms or vacuum well point dewatering, transfer pumps, and suitably located discharge piping. If ground freezing methods are considered by the contractor he must ensure that frost lenses do not develop below footing grade. To the outside of the new footing, vacuum well points might be installed to sufficient depth so that their influence covers all of the work site below the new footing area. However, due to the strong resistance to dynamic cone penetration tests encountered in the course of our investigations at this site, this may prove difficult. If this should prove to be impractical, it is judged that placement of a heavy polyethylene sheet that extends into the creek bed for a transverse distance of 1 m and carries up and over the existing footing wall will adequately allow for the installation of additional well points for the dewatering system. As the well points are installed, the section on the creek side would be sandbagged with a single row of bags placed length ways (approximately 1 m into creek) and two courses high. The best point of application for the creek side well point dewatering, if they are required, would be tight against the existing foundation wall. However, considering the boulders and cobbles present at depth, spacing along the wall and out from the wall will probably have to be varied or pilot holes run in with an air track or suitable drive mandrel. All discharge water would be pumped to a filter fabric protected holding pond located to the downstream of the work site and 1 to 2 m above creek level at that location. Water discharging from the holding pond to the river course proper should be via adequately sized

tubing or a shallow channel built up on natural ground, comprising a filter fabric for erosion protection and rock fill for flow and scour control.

The actual details for water and ground water control at this project are understood to be the responsibility of the Contractor, subject to review and acceptance by MTO and MNR personnel.

As a minimum, creek side backfill to structure should consist of rock fill that meets hydraulic and fish habitat requirements.

5.2.2 Design Bearing Resistance

Based on the above noted soil conditions and the founding elevations shown on the Preliminary General Arrangement Details (Figure P-83) we have determined a factored bearing capacity value at ULS of 500 kPa. A SLS bearing capacity of 300 kPa has been applied to reflect the establishment of new larger footings at greater depth in soils where bearing capacity increases appreciably with depth and bedrock or an extremely competent stratum exists at shallow depth. The factored values can be used by the design team to carry out final section choice and optimization. Review and/or adjustment will be required if founding elevation or structural configuration is changed.

5.2.3 Lateral Earth Pressure

A free draining granular material such as Granular B Type I (OPSS 1010) is recommended as appropriate backfill to the wing walls. In order to insure the prevention of hydrostatic pressure build-up, a drainage system must be provided (i.e. weep holes and/or perforated drainage tile with suitable porous surround) behind the wall.

Lateral earth pressures should be computed in accordance with OHBDC. The design parameters are as follows:

	<u>Granular A</u>	<u>Granular B Type I</u>	<u>Rock Fill</u>
Angle of Internal Friction (degrees)	35	30	43
Unit weight (kN/m ³)	22	20	18.5
Active earth pressure (Ka)	0.27	0.33	0.19
At-rest earth pressure (Ko)	0.43	0.50	0.32

An active condition (Ka) may be assumed to apply for a yielding structure, which will require an outward deflection of up to 0.5 percent of the wall height, measured from passive support line to the top of the wall. For rigid structures such deflection cannot occur, so the “at rest” condition (Ko) applies. The actual magnitude of force and location of application will be controlled by final structure geometry and siting. The relevant lateral pressure calculations involved in an assessment of the force will incorporate surcharge loading whether line, point, or area, hydrostatic effects, and the proper evaluation of such general formulae as:

$$P_a = K_a (\gamma' H^2 / 2 + q) \quad \text{Where: } K_a = \text{active earth pressure}$$

$$\gamma' = \text{unit weight (kN/m}^3\text{)}$$

$$H = \text{total height of supported soils}$$

$$q = \text{the effect of any form of surcharge loading}$$

Cohesive soils and soils that exhibit both cohesion and friction require different evaluation, as do assessments of at rest and passive earth pressure.

5.2.4 Embankment Fills

Embankment widening in the vicinity of the structure is in the order of 3 m. Prior to placing the fill beyond the immediate culvert limits and behind the new wing wall construction area, the existing slope should be stripped to at least 300 mm within the plan limits of the culvert work area in order to provide a uniform and stable base for wing wall backfill. Beyond the immediate culvert area, the benching dimensions, as per OPSD 208.010, shall be a height of 500 mm and a width of 900 mm. The sub-excavated material, from behind the retaining wall, will be replaced with a granular fill of the same origin as the widening material. Temporary excavations should be inclined at 2:1 (horizontal to vertical) or flatter in the vicinity of saturated zones or flowing water. The embankment widening fill can be placed at 2:1 (horizontal to vertical) provided the backfill material meets OPSS for Granular B Type I.

5.2.5 Roadway Protection

Roadside protection at this site will involve traffic lights and single lane access. To facilitate this, a shoring system will be used for traffic diversion, support of soils above the culvert obvert and down to the underside of the new footing elevation. It must be noted that embedment depth below footing is not considered adequate to develop sufficient lateral resistance. Therefore additional means such as rock anchors, bracing and/or tie-back anchorage systems will have to be considered. Over the top of the circular culvert barrel, the sheeting would be carried down to top of culvert grade behind a suitably sized and anchored whaler(s) and fixed at the base as required. The upper extension of this sheeting can be held in place with whalers carried across the full span of the barrel (6500 mm) or with a combination of whalers and counter fort type supports. Up and down chainage of the culvert barrel, the full depth piling sections should extend to a depth of 2 m below underside of the existing culvert footing before encountering refusal and extend up above highway surface. Depending on the section properties of the sheeting, whalers and bracing struts or ground anchor support systems will be required. Lateral earth pressure design parameters are provided in Subsection 5.2.4 for this purpose. The line of

application for the top set of whalers would be highway grade and additional whalers and tiebacks may be required as the excavation depth increases.

5.2.6 Safety

Care should be given to ventilation of the culvert barrel whenever workers may be present, especially if any welding or cutting of zinc plated steel may be required. Pumping for dewatering of foundations and/or bypassing stream flow around work areas within the culvert should be carried out with electric submersible pumps, energized from a remote and well ventilated power source.

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.

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.

MERLEX ENGINEERING LTD.

M. A. Merleau, P. Eng.
Principal

Dennis Netherton, P. Eng.

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