



November 24, 2014

FOUNDATION INVESTIGATION AND DESIGN REPORT

REPLACEMENT OF OLSON ROAD CULVERT
OLSON ROAD, 75 M NORTHWEST OF HIGHWAY 621, TOWNSHIP OF PRATT
MINISTRY OF TRANSPORTATION, ONTARIO
ASSIGNMENT 6011-E-0039, W.O. 2014-11017

Submitted to:

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Pavements and Foundations Section
Foundations Group
Building "C", Room 223
1201 Wilson Avenue, 2nd Floor,
Downsview, ON M3M 1J8



REPORT

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PART A

FOUNDATION INVESTIGATION REPORT
REPLACEMENT OF OLSON ROAD CULVERT
OLSON ROAD, 75 m NORTHWEST OF HIGHWAY 621,
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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by the Ministry of Transportation, Ontario (MTO), to provide foundation engineering services for the replacement of a culvert located on Olson Road approximately 75 m northwest of Highway 621 and about 33 km northeast of Rainy River, Ontario.

The Terms of Reference and Scope of Work for the foundation investigation are outlined in MTO's Request for Quotation for Assignment, dated April 28, 2014, and subsequent Work Item Order by Golder, number 12-1191-0005/2700 dated April 30, 2014. This work item is part of Retainer Assignment 6011-E-0039. Available information for this site was provided to Golder by MTO and includes:

- field sketch of the culvert; and
- site photographs.

The purpose of this investigation is to establish the subsurface conditions at the proposed culvert by borehole drilling, in situ testing and laboratory testing on selected soil samples.

2.0 SITE DESCRIPTION

The existing structure is a three cell timber culvert approximately 7 m long and 7 m wide (3 by 2.3 m cells) by about 1 m high and is oriented in a southwest-northeast in the creek flow direction. The site is located approximately 75 m northwest of the intersection of Olson Road and Highway 621 in the Township of Pratt, approximately 33 km northeast of Rainy River, Ontario.

Olson Road is a rural gravel surface road (as shown on the photographs contained in Appendix A), intersecting the meandering creek in an almost perpendicular orientation at the culvert location. The creek flows in a southwest to northeast direction and the water level was noted to be near the underside of the top of culvert as observed at the time of drilling (May 2014). The topography in the general vicinity of the site consists of rolling terrain, including sparsely to densely populated tree covered areas, separated by valleys, rivers and swamps containing areas of standing water and various types of vegetation.

Due to the high water level at the time of the site visit, Golder was unable to thoroughly assess the condition of the surrounding embankments. However, based on photographs provided by MTO we understand that the existing approach embankments are heavily vegetated with various types of grasses with side slopes generally at approximately 3 horizontal to 1 vertical (3H:1V) and as steep as 1H:1V near the culvert.

The top of the culvert was measured to be approximately 0.5 m above the creek water level, which was surveyed at Elevation 99.5 m on May 14, 2014, local datum.

3.0 INVESTIGATION PROCEDURES

The field investigation was carried out on May 13 and 14, 2014, at which time a total of four (4) boreholes (O1 to O4) and two (2) probe holes (P1 and P2) were advanced at the locations shown on Drawing 1.



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The boreholes were drilled using a CME 750 buggy rig, while the probe holes were drilled using a portable Pionjar unit, both supplied and operated by RPM Drilling Inc. of Thunder Bay, Ontario. The boreholes were advanced using 108 mm inner diameter continuous flight hollow-stem augers. In the boreholes, soil samples were obtained at intervals of depth of about 0.75 m to 1.5 m, using a 50 mm outer diameter (O.D.) split-spoon sampler driven by an automatic hammer on the drill rig, in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586). In the probe holes, continuous samples were obtained to a depth of 3.0 m below ground surface using a 50 mm O.D. split-spoon sampler advanced using the portable Pionjar unit. Field vane shear tests were conducted in cohesive soils for determination of undrained shear strengths (ASTM D2573) using an MTO Standard 'N' size vane and a calibrated torque wrench. All boreholes were backfilled upon completion in accordance with Ontario Regulation 903 Wells (as amended).

The boreholes were advanced to a depth of 9.8 m below ground surface, while the probe holes were advanced to a depth of 3.0 m below ground surface. The groundwater conditions and water levels in the open boreholes and probe holes were observed during the drilling operations and are described on the Record of Borehole sheets in Appendix B.

The fieldwork was supervised throughout by a member of our technical staff, who located the boreholes, arranged for the clearance of underground services at the borehole locations, supervised the drilling and sampling operations, logged the boreholes and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to our Sudbury Geotechnical Laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected samples.

The location and ground surface elevation of the as-drilled boreholes and probe holes were surveyed by Golder field staff on May 15, 2014. The borehole locations were referenced to the corners of the existing culvert and the ground surface elevations are referenced to local datum. The local Temporary Benchmark consists of a metal spike driven into the northeast corner of the timber culvert (as shown in Photograph 7 in Appendix A) and assigned Elevation 100.0 m local datum. Approximate northing and easting coordinates of the boreholes were obtained through Google Earth. The locations, elevations and borehole depths are presented on the Record of Borehole sheets in Appendix B and are summarized below.

Borehole	Culvert Corner Reference	Offset (m)	Ground Surface Elevation (m)	MTM NAD 82 COORDINATES		Borehole Depth (m)
				Approximate Northing	Approximate Easting	
O1	Northeast	1.3 m North, 1.5 m West	100.4	5 418 662.3	396 712.5	9.8
O2	Northwest	3.6 m North, 1.2 m East	100.4	5 418 662.1	396 707.3	9.8
O3	Southeast	3.0 m South, 1.2 m West	100.5	5 418 652.3	396 717.8	9.8
O4	Southwest	1.0 m South, 1.9 m East	100.4	5 418 651.9	396 712.9	9.8



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Borehole	Culvert Corner Reference	Offset (m)	Ground Surface Elevation (m)	MTM NAD 82 COORDINATES		Borehole Depth (m)
				Approximate Northing	Approximate Easting	
P1	Southwest	3.0 m South, 2.0 m West	100.0	5 418 648.3	396 710.4	3.0
P2	Northeast	2.0 m North, 1.0 m East	99.7	5 418 664.2	396 714.4	3.0

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on NOEGTS¹ Mapping, the topography in the vicinity of the Olson Road culvert is generally characterized as a glaciolacustrine plain comprised mainly of clayey soils with low relief and dry drainage conditions. Bordering the site to the northeast, the topography consists of organic terrain comprised mainly of peat with low relief and wet conditions.

Based on geological mapping by the Ministry of Natural Resources (Map 2542)², the site is underlain by bedrock of the Paleoproterozoic Era, comprised of sedimentary rocks primarily wacke, shale and limestone as well as iron formations and minor volcanics.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions as encountered in the boreholes and probe holes advanced during this investigation, together with the results of the laboratory tests carried out on selected soil samples, are presented on the Record of Borehole sheets in Appendix B. Detailed results of the laboratory testing of the soil samples are provided in Appendix C. The results of the in situ field tests (i.e., SPT 'N'-values and undrained shear strengths from the field vanes) as presented on the Record of Borehole sheets and in Section 4 are uncorrected. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and observations of drilling progress and cuttings. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Further, subsurface conditions will vary between and beyond the borehole locations. The inferred soil stratigraphy based on the results of the boreholes is shown in profile and cross-sections on Drawing 1.

In general, the subsoils in the immediate area of the culvert consist of sand to silty sand fill constituting the roadway embankment. Underlying the embankment fill in the boreholes or from ground surface in the probe holes, a deposit of silty clay to clay was encountered, underlain by a silty clay till deposit or, in one borehole, a gravelly sand to sand and silt deposit. The water level of the creek at the Olson Road Culvert location was measured at Elevation 99.5 m on May 14, 2014, local datum.

¹ Northern Ontario Engineering Geology Terrain Study, Ontario Geological Society Map Reference Number 52DNE.

² Ministry of Natural Resources. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey - Map 2542



A more detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

4.2.1 Fill

A fill deposit comprised of brown sand, trace to some gravel to silty sand, some clay was encountered from ground surface between Elevation 100.4 m and 100.5 m in Boreholes O1 to O4 and ranging in thickness from 0.7 m to 1.1 m. Trace organics was encountered within the fill.

SPT 'N'-values measured within the sand to silty sand fill range from 2 blows to 12 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

The natural water content measured on a sample of the sand to silty sand fill is about 7 per cent.

4.2.2 Silty Clay to Clay

In all boreholes, a deposit of dark brown transitioning to grey silty clay to clay was encountered beneath the fill in Boreholes O1 to O4 and from ground surface in probe holes P1 and P2. The top of the silty clay to clay deposit was encountered between Elevation 100.0 m and 99.3 m and the deposit is between 3.6 m and 5.9 m thick, where fully penetrated. In all boreholes, the deposit is generally comprised of an upper silty clay to clay containing trace organics/rootlets, trace to some sand, trace gravel and a lower portion comprised of wet, grey clay, trace sand.

SPT 'N'-values measured within the silty clay to clay deposit range from 0 blows (weight of hammer) to 21 blows per 0.3 m of penetration, where the silty clay to clay was not frozen, typically less than 4 blows in the non-frozen zone. In situ field vane tests carried out within this deposit measured undrained shear strengths ranging from about 24 kPa to 57 kPa, with the sensitivity calculated to range from about 1 to 3. In one borehole a field vane undrained shear strength greater than 100 kPa was measured within the deposit. The field vane test results indicate that the silty clay to clay deposit has a soft to very stiff consistency, typically firm to stiff.

The grain size distributions of three samples of the silty clay to clay are shown on Figure C1 in Appendix C.

Atterberg limits tests were carried out on ten samples of the silty clay to clay deposit and measured liquid limits ranging from about 38 per cent to 62 per cent, plastic limits ranging from about 16 per cent to 24 per cent and plasticity indices ranging from about 21 per cent to 39 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure C2 in Appendix C, and indicate the material to be silty clay of intermediate plasticity to clay of high plasticity.

The natural water content measured on eleven samples of the silty clay to clay deposit ranges from about 24 per cent to 51 per cent.



4.2.3 Gravelly Sand to Sand and Silt

In Boreholes O3 and O4 a deposit of gravelly sand to sand and silt was encountered underlying the silty clay to clay deposit. The surface of the deposit was encountered at Elevation 96.2 m and 95.2 m and the thickness of the deposit is 5.3 m and 0.6 m, in Boreholes O3 and O4, respectively.

SPT 'N'-values measured within the gravelly sand to sand and silt deposit range from 5 blows to 17 blows per 0.3 m of penetration, indicating a loose to compact relative density.

The grain size distribution of one sample of the gravelly sand deposit is shown on Figure C3 in Appendix C.

The natural water content measured on two samples of the gravelly sand to sand and silt deposit are about 14 per cent and 15 per cent.

4.2.4 Silty Clay (Till)

A till deposit comprised of grey silty clay, some sand, trace to some gravel was encountered beneath the silty clay to clay deposit in Boreholes O1 and O2 and underlying the gravelly sand to sand and silt in Boreholes O3 and O4. The top of the silty clay till deposit was encountered between Elevation 94.8 m and 90.9 m and the thickness of the deposit ranges from 3.6 m and 4.0 m, where fully penetrated. In Boreholes O2 and O3 the silty clay till was not penetrated after exploring for 3.2 m and 0.2 m, respectively.

SPT 'N'-values measured within the silty clay till deposit range from 10 blows to 16 blows per 0.3 m of penetration, suggesting a stiff to very stiff consistency.

The grain size distributions of two samples of the silty clay till deposit are shown on Figure C4 in Appendix C.

Atterberg limits tests were carried out on three samples of the silty clay till deposit and measured liquid limits ranging from about 47 per cent to 49 per cent, plastic limits ranging from about 17 per cent to 19 per cent and plasticity indices ranging from about 29 per cent to 30 per cent. The results of the Atterberg limits tests are shown on the plasticity chart on Figure C5 in Appendix C, and indicate the material to be silty clay of intermediate plasticity.

The natural water content measured on three samples of the silty clay till deposit ranges from about 22 per cent to 27 per cent.

4.2.5 Silt

In Boreholes O1 and O4, a deposit of grey silt, trace to some sand was encountered below the silty clay till deposit at a depth of 9.6 m below ground surface and was explored for a thickness of 0.2 m in both boreholes.

4.2.6 Groundwater Conditions

In general, the soil samples taken in the boreholes were moist to wet. Groundwater levels observed upon completion of drilling were measured at depths ranging from ground surface to 1.5 m below ground surface



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corresponding to between Elevation 100.0 m and Elevation 98.9 m. It should be noted that the groundwater levels in the area are subject to seasonal fluctuations and will vary due to precipitation events and snowmelt.

The creek water level at the Olson Road Culvert was measured at Elevation 99.5 m on May 14, 2014, near the underside of the top of the culvert. Photographs provided by MTO show the creek water level lower than the underside of the top of culvert.

5.0 CLOSURE

The field drilling program was supervised by Mr. Mathew Riopelle. This report was prepared by Mr. Adam Core, E.I.T., and the technical aspects were reviewed by Ms. Sarah E.M. Poot, P.Eng., Associate. An independent quality control review of the report was provided by Mr. Jorge M.A. Costa, P.Eng., Principal and Golder's Designated MTO Contact for this assignment.



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Report Signature Page

GOLDER ASSOCIATES LTD.



Adam Core, E.I.T.

Geotechnical Engineering Intern



Sarah E.M. Poot, P.Eng.
Senior Geotechnical Engineer, Associate



Jorge M.A. Costa, P.Eng.
Designated MTO Contact, Principal

AC/SEMP/JMAC/kp

[http://capws.golder.com/sites/p211910005mtonwretainerthunderbay/2700 olson road culvert/5reporting/final/12-1191-0005-2700 rpt 14nov24 olson rd culvert fdr.docx](http://capws.golder.com/sites/p211910005mtonwretainerthunderbay/2700%20olson%20road%20culvert/5reporting/final/12-1191-0005-2700%20rpt%2014nov24%20olson%20rd%20culvert%20fdr.docx)



PART B

FOUNDATION DESIGN REPORT
REPLACEMENT OF OLSON ROAD CULVERT
OLSON ROAD, 75 m NORTHEAST OF HIGHWAY 621
TOWNSHIP OF PRATT
MINISTRY OF TRANSPORTATION, ONTARIO
ASSIGNMENT 6011-E-0039, W.O. 2014-11017



6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides foundation design recommendations for the proposed replacement of the culvert on Olson Road. The recommendations are based on interpretation of the factual data obtained from the boreholes and probe holes advanced during the subsurface investigation at the site.

The interpretation of the subsurface information and recommendations presented are intended to provide the designer with sufficient information to assess the feasible foundation alternatives and to design the proposed culvert. As such, where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project. Those requiring information on construction aspects should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 General

The existing Olson Road structure conveying the local creek consists of a three cell timber culvert approximately 7 m long and 7 m wide (3 m by 2.3 m cells) and is oriented in a southwest-northeast direction. The site is located approximately 75 m northwest of the intersection of Olson Road and Highway 621 in the Township of Pratt, approximately 33 km northeast of Rainy River, Ontario. The creek flows in a southwest to northeast direction and the water level was noted to be near the underside of the top of culvert as observed at the time of drilling on May 14, 2014.

It is assumed that there will be no grade raise of the roadway embankment at the culvert location; a grade raise will induce time dependant settlement of the subsoils which would require mitigation.

The subsurface conditions at the culvert location generally consist of sand to silty sand embankment fill underlain by a silty clay to clay deposit in turn underlain by a gravelly sand to sand and silt deposit or a silty clay till deposit.

The geometry of the proposed culvert replacement is not known at the time of preparation of this report, however, it is understood that the new culvert may be approximately the same size and placed at approximately the same elevation as the existing structure.

6.2 Culvert Types

Foundation design recommendations are provided for an open footing culvert, circular pipe culvert and concrete box culvert. From a foundations perspective a box culvert is the preferred option.

6.2.1 Geotechnical Resistance

For an open footing culvert, the footings should be placed at least 2.3 m (as discussed in Section 6.2.3) below the creek bed or culvert invert for protection from frost penetration. Footings would therefore be founded within the generally firm to stiff silty clay to clay deposit. The factored geotechnical axial resistance at ULS and the



geotechnical reaction at SLS (for 25 mm settlement) for a 1 m wide footing founded on the properly prepared native silty clay to clay subgrade may be taken as 100 kPa.

If a box culvert is selected to replace the existing culvert, the concrete box culvert (pre-cast or cast-in-place) should be founded within the generally firm to stiff silty clay to clay deposit. The factored geotechnical axial resistance at ULS and the geotechnical reaction at SLS (for 25 mm settlement) for a 7 m wide concrete box culvert founded on the properly prepared native silty clay to clay subgrade may be taken as 100 kPa and 40 kPa, respectively.

The geotechnical resistances are applicable for loads that will be applied perpendicular to the base of the culvert. Where loads are not applied perpendicular to the base of the culvert, inclination of the loads should be taken into account in accordance with Section 6.7.4 and Section C6.7.4 of the Canadian Highway Bridge Design Code (CHBDC) and its Commentary.

6.2.2 Resistance to Lateral Loads/Sliding Resistance

Resistance to lateral forces/sliding resistance between the base of a box culvert and the granular fill/bedding placed following sub-excavation of organic deposits if present within the culvert footprint should be calculated in accordance with Section 6.7.5 of the CHBDC. The following summarizes the coefficient of friction for the interface materials:

Interface Materials	Coefficient of Friction ($\tan \delta$)
Cast-in-Place Concrete Box Culvert on soft to very stiff native clayey silt to silty clay to clay	$\tan \delta = 0.30$
Cast-in-Place Concrete Box Culvert on compacted Granular 'A' or Granular 'B' Type II	$\tan \delta = 0.55$
Precast Concrete Box Culvert on Granular 'A'	$\tan \delta = 0.45$

These values represent unfactored values.

6.2.3 Frost Protection

The estimated frost penetration depth north of Rainy River, Ontario is approximately 2.3 m, as per OPSP 3090.100 (Foundation, Frost Penetration Depths for Northern Ontario).

Spread footings for an open footing culvert should be provided with a minimum of 2.3 m of conventional soil cover for frost protection.

Box culverts are typically not provided with frost protection where water flows year-round through the culvert. Where the creek freezes in winter and frost protection may extend to 2.3 m below the invert, it would be prudent/recommended that the subsoils from below the proposed culvert be sub-excavated to a depth of 2.3 m below the culvert invert and replaced with non-frost susceptible OPSS.PROV 1010 Granular 'B' Type II material (Aggregates).



6.3 Stability, Settlement and Horizontal Strain

We understand that the existing roadway grade will not be raised at the Olson Road culvert location. Provided that the re-instated embankment side slopes are constructed of granular material at 2H:1V and well vegetated, then stability should not be an issue. Time-dependant settlement of the firm to stiff silty clay to clay deposit will not be an issue provided that the grade is not raised beyond a nominal amount (less than 0.3 m for surface grading purposes). Since there is no post-construction settlement anticipated, horizontal strain and culvert cambering need not be considered in the structural design. However, if the designer requires a grade raise to suit design conditions, then additional analysis should be carried out and recommendations for mitigation of stability, post-construction settlement and horizontal strain should be provided, as appropriate.

The analyses are based on the construction condition that all organic soils (if encountered) beneath the culvert footprint will be removed prior to construction as discussed in Section 6.5.1 and that approved granular fill (i.e., sand and gravel material such as OPSS.PROV 1010 Granular 'B' Type II) will be used for replacement of sub-excavated material, if required.

6.4 Lateral Earth Pressures

If a box culvert is selected for this site, the lateral earth pressures acting on the walls of the culvert will depend on the type and method of placement of backfill materials, the nature of the soils/embankment fill behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls.

The following recommendations are made concerning the design of the culvert walls. It should be noted that these design recommendations and parameters are for level backfill and ground surface behind the walls. Where there is sloping ground behind the walls, the coefficient of lateral earth pressure must be adjusted to account for the slope.

- Select, free draining granular fill meeting the specifications of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II but with less than 5 per cent passing the No. 200 (0.075 mm) sieve should be used as backfill behind the culvert walls, and on top of the culvert for a thickness of up to 300 mm. Backfill should be placed in a maximum of 200 mm loose lift thickness and nominally compacted. Weep holes should be installed in the walls to provide positive drainage of the granular backfill. Compaction (including type of equipment, target densities, etc.) should be carried out in accordance with OPSS 501 (Compacting) as amended by Special Provision (SP) 105S21 (Compacting).
- For a box culvert, granular fill should be placed in a zone with the width up to 2.3 mm behind the back of the culvert. The pressures are based on the proposed embankment fill materials and the following parameters (unfactored) may be used:

Fill Type	Soil Unit Weight	Coefficients of Static Lateral Earth Pressure	
		At-Rest, K_o	Active, K_a
Granular 'A'	22 kN/m ³	0.43	0.27
Granular 'B' Type II	21 kN/m ³	0.43	0.27



If the culvert structure allows for lateral yielding, active earth pressures may be used in the foundation design. If the culvert structure does not allow lateral yielding, at-rest earth pressures should be assumed for foundation design. The movement to allow active pressures to develop within the backfill, and thereby assume a restrained structure, may be taken as per Table C6.6 of the Commentary to the CHBDC.

6.5 Constructions Considerations

6.5.1 Excavations and Subgrade Preparation

Prior to the placement of any bedding material or granular fill, all organic soils (if encountered) should be stripped from the plan limits of the proposed works.

All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects and good construction practice. Existing fill and the native soft to very stiff silty clay to clay material would be classified as Type 3 soil, according to the OHSA. Temporary excavations (i.e., those that are open for a relatively short period of time) should be made with side slopes no steeper than 1H:1V above the water table and 3H:1V below the water table.

The open footing culvert may be placed directly on the properly prepared native silty clay to clay material provided that all soft or loosened soils within the footprint at the founding level are removed. The base of the excavation should be free of water and softened/loosened soil prior to placing concrete. We recommend that the prepared subgrade be protected using a 150 mm thick working slab comprised of a minimum 20 MPa concrete as per the attached Non Standard Special Provision (NSSP) in Appendix D. Alternatively, a minimum 300 mm thick granular working pad consisting of compacted OPSS.PROV 1010 (Aggregates) Granular 'B' Type II or Granular 'A' may be used as subgrade protection.

The box culvert may be placed on a properly prepared bedding/levelling pad (as described further in Section 6.5.2) overlying the properly prepared native silty clay to clay subgrade provided that all soft or loosened soils within the footprint and founding level are removed.

For both the box culvert and the open footing culvert the working slab/pad should be placed along the bottom of the excavation immediately upon completion of the excavation and after the subgrade has been approved. The excavation would have to extend below the intended invert level by the amount required for the slab or granular protection pad. This is recommended to limit the degradation of the clayey subgrade soils as they are susceptible to disturbance from construction and foot traffic and ponded water.

All excavations should be carried out in accordance with OPSS 902 (Excavation and Backfilling for Structures) and must be carried out in accordance with Ontario Regulation 213 Ontario Occupational Health and Safety Act for Construction Projects (as amended).

6.5.2 Culvert Bedding and Backfill

6.5.2.1 Open Footing Culvert

As discussed above, for footings of an open footing culvert founded on the native subgrade, a bedding layer is not required. Granular fill or a mud slab may be placed as discussed above in Section 6.5.1, to protect the



subgrade. If required, a levelling pad consisting of Granular 'A' (OPSS.PROV 1010 – Aggregates) may be placed in-the-dry above the mud slab or granular protective layer. The levelling pad should be placed in lifts not exceeding 200 mm in loose thickness, and compacted to at least 98 per cent of the Standard Proctor maximum dry density of the material as specified in OPSS 501/SP 105S21 (Compacting).

6.5.2.2 Box Culvert

As discussed above in Section 6.5.1, for a box culvert, a bedding and levelling pad is required overlying the native silty clay to clay subgrade soils. The levelling pad should be comprised of a 300 mm thick layer of Granular 'B' Type II (OPSS.PROV 1010 – Aggregates) followed by a 150 mm thick bedding layer of Granular 'A'. The Granular 'B' Type II should be nominally compacted and can be placed sub-aqueously. The Granular 'A' material should be placed in-the-dry and in loose lifts not exceeding 200 mm thickness and compacted to at least 98 per cent of the Standard Proctor maximum dry density of the material as specified in OPSS 501/SP 105S21 (Compacting).

6.5.2.3 Circular Culvert

Should a circular culvert be considered, the bedding, levelling pad and backfill for a circular concrete pipe or CSP culvert should be in accordance with OPSD 802.034 (Rigid Pipe Bedding and Cover in Embankment) or OPSD 802.010 (Flexible Pipe Embedment and Backfill – Earth Excavation), respectively, and culvert construction should be in accordance with OPSS 421 (Pipe Culvert Installation in Open Cut). It is important that the backfill at the haunches be well compacted. The circular culvert should be constructed on a minimum 300 mm thick layer of OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II material for bedding purposes.

6.5.2.4 Precast Culvert

Should a precast box culvert be considered, the bedding, levelling pad and granular backfill requirements should be in accordance with OPSS 422 (Precast Reinforced Concrete Box Culverts) and OPSD 803.010 (Backfill and Cover for Concrete Culverts with Spans Less Than or Equal to 3 m). A minimum 75 mm thick uncompacted levelling pad consisting of OPSS.PROV 1010 Granular 'A' material or concrete fine aggregate (meeting the grading requirements specified in OPSS.PROV 1002 (Aggregates - Concrete)) should be provided as shown on OPSD 803.010 for culvert construction in dry conditions.

6.5.2.5 General

Backfill behind the culvert walls, should consist of granular fill meeting the specifications for OPSS.PROV 1010 (Aggregates) Granular 'A' or Granular 'B' Type II, but with less than 5 per cent passing the No. 200 (0.075 mm) sieve. The granular backfill should be placed and compacted in accordance with OPSS 501/SP 105S21 (Compacting). The fill should also be placed concurrently on both sides of the culvert walls, ensuring that the backfill depth on one side does not exceed the other side by more than 400 mm.



The culvert should be designed for the full overburden stress and appropriate live loads, assuming a fill unit weight of 22 kN/m³ for Granular 'A' and 21 kN/m³ for Granular 'B' Type II placed above and surrounding the culvert.

Inspection and field density testing should be carried out by qualified geotechnical personnel during all engineered fill placement operations to ensure that appropriate materials are used, and that adequate levels of compaction have been achieved.

6.5.3 Erosion Protection

Side slopes of the reconstructed granular fill embankments adjacent to the culvert should be no steeper than 2H:1V or constructed to match the existing slopes. To reduce erosion on the embankment side slopes due to surface water/runoff, topsoil and seeding as per OPSS 802 (Topsoil) and OPSS 804 (Seed and Cover) should be placed on the slope surfaces as soon as possible after construction of the embankments.

Provisions should be made for scour and erosion protection at the culvert location. We understand that clay seals are typically required for culverts of significant length, steep horizontal gradient or where there is a significant flow rate anticipated through the culvert. At this site, the requirement for a clay seal should be assessed by a hydraulics design engineer to assess if the flow rate through the culvert is sufficiently high to warrant the installation of the clay seal. A clay seal provided at the upstream end of the culvert would prevent surface water from flowing either beneath the culvert (potentially causing undermining and scouring) or around the culvert (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles).

If a clay seal is adopted, the clay material should meet the requirements of OPSS 1205 (Clay Seal), and the seal should be a minimum 1 m thick if constructed of natural clay or soil-bentonite mix and extend from a depth of 1 m below the scour level to a minimum horizontal distance of 2 m on either side of the culvert inlet opening, and a minimum vertical height equivalent to the high water level including along the embankment slope. Alternatively, a 0.6 m thick clay blanket (if constructed of natural clay or a soil-bentonite mix) may be constructed, extending upstream of the culvert inlet for a length of three times the culvert height and along the adjacent slopes to a height of two times the culvert height or the high water level, whichever is greater.

The requirements for and design of erosion protection measures for the inlet and outlet of the culvert should be assessed by the hydraulics design engineer. As a minimum, rip-rap treatment for the outlet of the culvert should be consistent with OPSS 810.010 (Rip-Rap Treatment for Sewer and Culvert Outlets). Erosion protection for the inlet of the culvert should generally follow the standard presented in OPSS 810.010, with the rip-rap placed up to the toe of slope level, in combination with the cut-off measures noted above. Similarly, R10 size rip-rap (OPSS.PROV 1004 – Miscellaneous) should be provided over the full extent of the clay blanket, including the creek side slopes and fill slope over the culvert.

6.5.4 Control of Groundwater and Surface Water

Since the bottom of the culvert will be at approximately 2.3 m below the existing ground surface, dewatering will be required to carry out construction in-the-dry. The type of dewatering, if required, will depend on the time of



year that construction work is carried out and the culvert invert elevation. Since the depth of the excavation below the water level is expected to be about 2 m (time of year dependant), it is anticipated that groundwater inflow may be controlled locally by pumping from properly filtered sumps below the base of the excavation, provided a suitable cut-off is provided to prevent water inflow from the creek.

Creek/ditch flows at the time of construction of the replacement culvert will need to be diverted/piped away from the excavation areas during the construction period. Surface water should be directed away from the excavation areas to prevent ponding of water that could result in disturbance and weakening of the foundation subgrade.

7.0 CLOSURE

This Detail Foundation Design Report was prepared by Mr. Adam Core, E.I.T. and the technical aspects were reviewed by Ms. Sarah E.M. Poot, P.Eng., Associate. An independent quality control review of the report was provided by Mr. Jorge M.A. Costa, P.Eng., Principal and Golder's Designated MTO Contact for this assignment.



FOUNDATION REPORT REPLACEMENT OF OLSON ROAD CULVERT

Report Signature Page

GOLDER ASSOCIATES LTD.


Adam Core, E.I.T.

Geotechnical Engineering Intern



Sarah E.M. Poot, P.Eng.
Senior Geotechnical Engineer, Associate



Jorge M.A. Costa, P.Eng.
Designated MTO Contact, Principal

[http://capws.golder.com/sites/p211910005mtonwretainerthunderbay/2700 olson road culvert/5reporting/final/12-1191-0005-2700 rpt 14nov24 olson rd culvert fidr.docx](http://capws.golder.com/sites/p211910005mtonwretainerthunderbay/2700%20olson%20road%20culvert/5reporting/final/12-1191-0005-2700%20rpt%2014nov24%20olson%20rd%20culvert%20fidr.docx)



REFERENCES

Canadian Highway Bridge Design Code (CHBDC) and Commentary on CAN/CSA S6-06, 2006. CSA Special Publication, S6.1-06. Canadian Standard Association.

Ministry of Natural Resources. Bedrock Geology of Ontario – West Central Sheet, Ontario Geological Survey - Map 2542

Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Map Reference Number 52DNE

Occupational Health and Safety Act and Regulation for Construction Projects, January 2006.

ASTM International

ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

ASTM D2573 Standard Test Method for Field Vane Shear Test in Cohesive Soil

Ministry of Transportation Ontario Special Provisions

SP 105S21 Amendment to OPSS 501, November 2010 – Water Requirements and Quality Control for Compaction – Method B.

Ontario Provincial Standard Drawings

OPSD 802.010 Flexible Pipe Embedment and Backfill, Earth Excavation

OPSD 802.034 Rigid Pipe Bedding and Cover in Embankment

OPSD 803.010 Backfill and Cover for Concrete Culverts With Less Than or Equal to 3.0 m

OPSD 810.010 Rip-Rap Treatment for Sewer and Culvert Outlets

OPSD 3090.100 Foundation, Frost Penetration Depths for Northern Ontario

Ontario Provincial Standard Specifications

OPSS 421 Construction Specification for Pipe Culvert Installation in Open Cut

OPSS 422 Construction Specification for Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut

OPSS 501 Construction Specification for Compacting

OPSS 802 Construction Specification of Topsoil

OPSS 804 Construction Specification for Seed and Cover

OPSS 902 Construction Specification for Excavating and Backfilling - Structures

OPSS 1205 Material Specification for Clay Seal

OPSS.PROV 1002 Aggregates – Concrete

OPSS.PROV 1004 Material Specification for Aggregates - Miscellaneous

OPSS PROV 1010 Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material



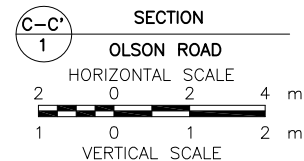
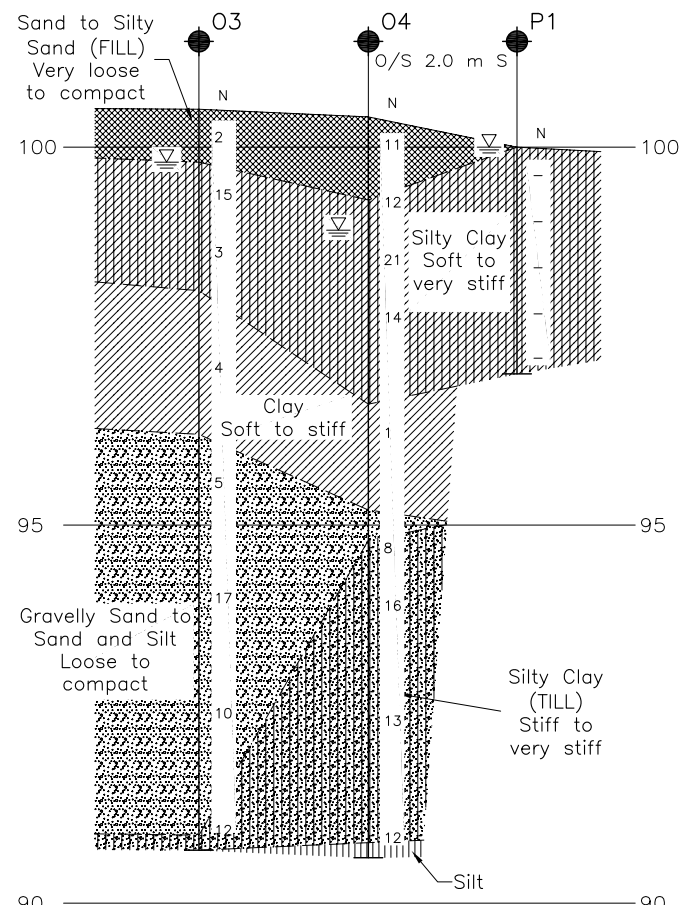
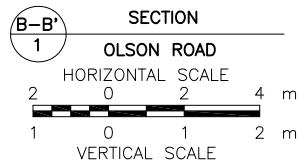
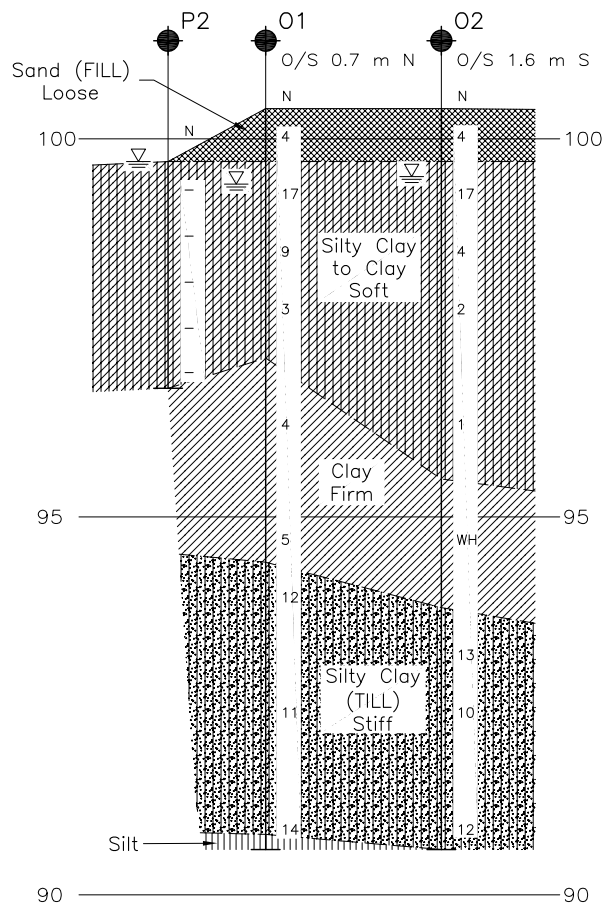
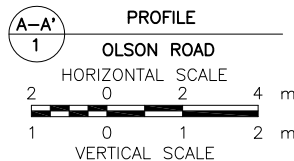
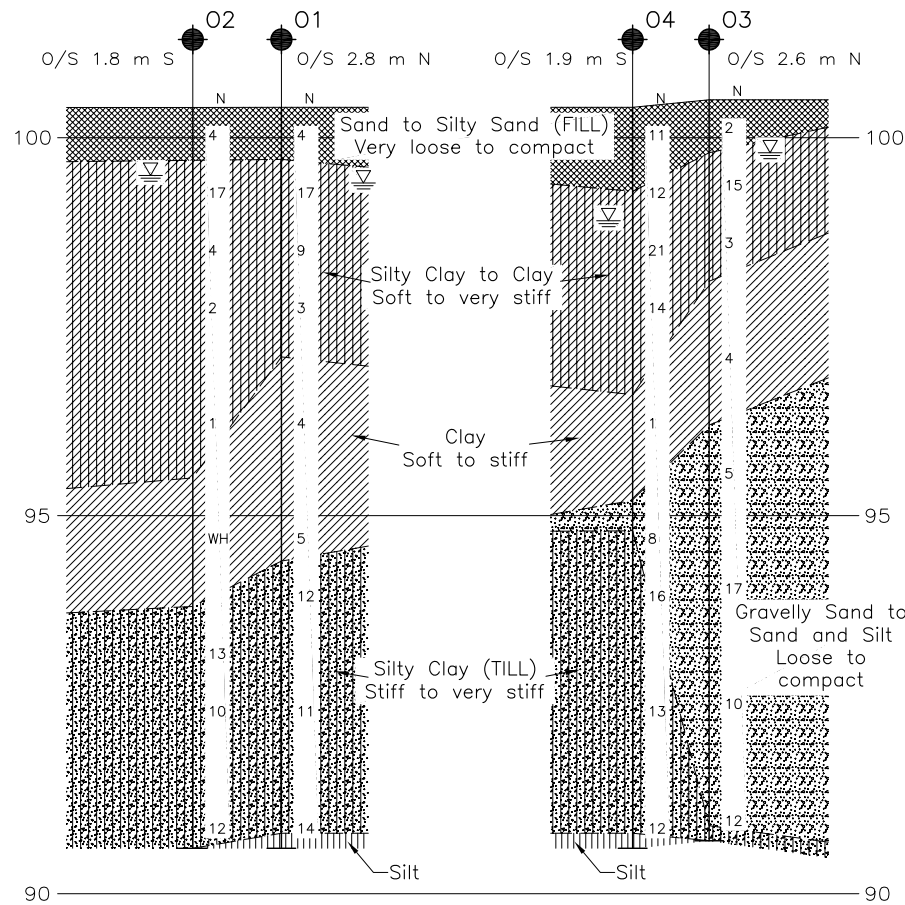
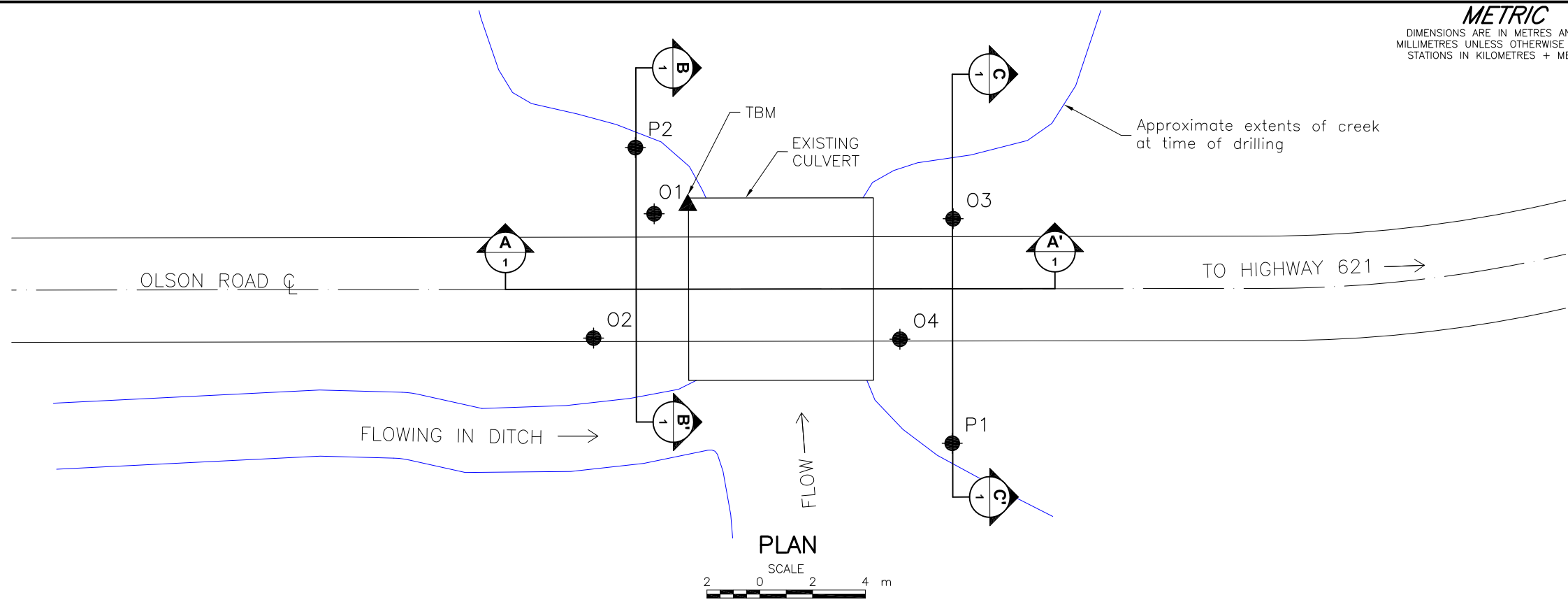
FOUNDATION REPORT REPLACEMENT OF OLSON ROAD CULVERT

Ontario Water Resources Act

Ontario Regulation 903/90 Wells: O. Reg. 468/10 Amendment to Ontario Regulation 903

Ontario Occupational Health and Safety Act

Ontario Regulation 213 (Construction Projects)

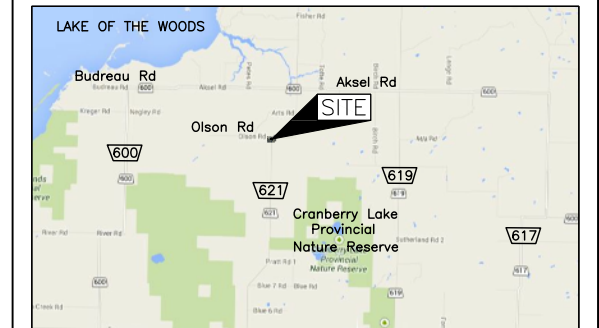


CONT No.
WO No. 2014-11017

OLSON ROAD
Olson Road Culvert
BOREHOLE LOCATIONS PLAN AND
SOIL STRATA



Golder Associates Ltd.
SUDBURY, ONTARIO, CANADA



LEGEND

- Borehole
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ∇ WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
O1	100.4	5418662.3	396712.5
O2	100.4	5418662.1	396707.3
O3	100.5	5418652.3	396717.8
O4	100.4	5418651.9	396712.9
P1	100.0	5418648.3	396710.4
P2	99.7	5418664.2	396714.4

NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contracts Documents.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section GC 2.01 of OPS General Conditions.

REFERENCE

Key plan by Google Maps. Approximate Northing and Easting coordinates obtained from Google Earth.



NO.	DATE	BY	REVISION
Geocres No. 52D-17			
HWY. OLSON ROAD		PROJECT NO. 12-1191-0005	DIST.
SUBM'D. AC	CHKD.	DATE: NOV 2014	SITE:
DRAWN: TB	CHKD. SEMP	APPD. JMAC	DWG. 1



APPENDIX A

Photographs



PHOTOGRAPHS

Photograph 1: Looking North at Olson Rd. Culvert (May 2014)



Photograph 2: Looking South at Olson Rd. Culvert (May 2014)





PHOTOGRAPHS

Photograph 3: Looking West from West Side of Culvert (May 2014)



Photograph 4: Looking South at West Side of Olson Rd. Culvert – Inlet (May 2014)





PHOTOGRAPHS

Photograph 5: Looking North at East Side of Olson Rd. Culvert Outlet (May 2014)



Photograph 6: Looking Northeast from East Side of Olson Rd. Culvert (May 2014)





PHOTOGRAPHS

Photograph 7: Temporary Benchmark on Northeast Corner - Spike on Top of Culvert (May 2014)



Photograph 8: View from South East Corner (Photo provided by MTO – taken November 2013)





APPENDIX B

Record of Boreholes



LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a)	Index Properties
$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = $\tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

* Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$



LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Density Index	N
Relative Density	Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils Consistency

	C_u, S_u	
	kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000





IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

PROJECT		12-1191-0005/2700		RECORD OF BOREHOLE No 01		1 OF 1 METRIC									
W.P.		2014-11017		LOCATION		N 5418662.3; E 396712.5									
DIST		Northwest HWY		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers									
DATUM		LOCAL		DATE		May 14, 2014									
				ORIGINATED BY		MR									
				COMPILED BY		AC									
				CHECKED BY		SEMP									
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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
100.4	GROUND SURFACE							20 40 60 80 100	20 40 60						
0.0	Sand, some gravel, trace organics (FILL)		1	SS	4		100								
99.7	Loose Brown Wet		2	SS	17		99								
0.7	SILTY CLAY, trace to some sand, trace organics		3	SS	9		98								
	Soft Frozen from 0.7 m to 2.1 m depth, then wet		4	SS	3		97								
97.1	CLAY Firm Grey Wet						97								
3.3															
94.4															
6.0	SILTY CLAY, some sand, trace gravel (TILL)		5	SS	4		96								
	Stiff Grey Wet		6	SS	5	95									
			7	SS	12	94									
			8	SS	11	93									
90.8															
9.8	SILT, some sand, some clay Grey Wet		9	SS	14		91								
	END OF BOREHOLE														
	Note: 1. Water level at a depth of 1.0 m below ground surface (Elev. 99.4 m) upon completion of drilling.														

SUD-MTO 001 12-1191-0005 OLSON.GPJ GAL-MISS.GDT 24/11/14 DATA INPUT:

PROJECT		12-1191-0005/2700		RECORD OF BOREHOLE No 02		1 OF 1 METRIC								
W.P.		2014-11017		LOCATION		N 5418662.1; E 396707.3								
DIST		Northwest HWY		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers								
DATUM		LOCAL		DATE		May 14, 2014								
				ORIGINATED BY		MR								
				COMPILED BY		AC								
				CHECKED BY		SEMP								
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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
100.4	GROUND SURFACE													
0.0	Sand, trace gravel, trace organics (FILL)		1	SS	4		100							
99.7	Loose Brown Wet						99							
0.7	CLAY, trace organics, trace sand Soft Dark brown to grey Frozen from 0.7 m to 1.4 m then, wet		2	SS	17		98							
			3	SS	4		97							
			4	SS	2		96							
		5	SS	1	95									
95.5	CLAY Firm Grey Wet	6	SS	WH	94									
4.9					93									
93.8	SILTY CLAY, some sand, trace gravel (TILL) Stiff Grey Wet	7	SS	13	92									
6.6		8	SS	10	91									
		9	SS	12										
90.6	END OF BOREHOLE													
9.8	Note: 1. Water level at a depth of 0.9 m below ground surface (Elev. 99.5 m) upon completion of drilling.													

SUD-MTO 001 12-1191-0005 OLSON.GPJ GAL-MISS.GDT 24/11/14 DATA INPUT:

PROJECT		12-1191-0005/2700		RECORD OF BOREHOLE No 03		1 OF 1		METRIC							
W.P.		2014-11017		LOCATION		N 5418652.3; E 396717.8		ORIGINATED BY							
DIST		Northwest HWY		BOREHOLE TYPE		108 mm I.D. Continuous Flight Hollow Stem Augers		COMPILED BY							
DATUM		LOCAL		DATE		May 13, 2014		CHECKED BY							
SEMP															
SOIL PROFILE		SAMPLES		GROUND WATER CONDITIONS		ELEVATION SCALE		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100	20 40 60	W _p W W _L	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
100.5	GROUND SURFACE														
0.0	Silty sand, trace organics, some clay (FILL) Very loose Brown Wet		1	SS	2		100								
99.8															
0.7	SILTY CLAY, trace to some sand, trace gravel, trace rootlets Soft Dark brown to grey Frozen from 0.7 m to 1.5 m depth then wet		2	SS	15		99								
			3	SS	3		98								
97.9	CLAY Firm to stiff Grey Wet						97								
2.6			4	SS	4		96								
							95								
96.2	Gravelly SAND to SAND and SILT Loose to compact Grey Wet		5	SS	5		94								
4.3			6	SS	17		93								
			7	SS	10		92								
90.9	SILTY CLAY, some sand, trace gravel (TILL) Grey Wet		8	SS	12		91								
9.8	END OF BOREHOLE														
Note: 1. Water level at a depth of 0.7 m below ground surface (Elev. 99.8 m) upon completion of drilling.															

+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

[illegible]

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>12-1191-0005/2700</u>		RECORD OF BOREHOLE No P1		1 OF 1 METRIC	
W.P. <u>2014-11017</u>		LOCATION <u>N 5418648.3; E 396710.4</u>		ORIGINATED BY <u>MR</u>	
DIST <u>Northwest</u> HWY <u></u>		BOREHOLE TYPE <u>Pionjor - Portable Equipment</u>		COMPILED BY <u>AC</u>	
DATUM <u>LOCAL</u>		DATE <u>May 13, 2014</u>		CHECKED BY <u>SEMP</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT			LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					GR	SA	SI	CL
100.0	GROUND SURFACE																			
0.0	SILTY CLAY, trace organics, trace sand Brown Wet		1	SS	-															
			2	SS	-															
			3	SS	-															
			4	SS	-															
			5	SS	-															
97.0	END OF BOREHOLE																			
3.0	Note: 1. Water level at ground surface (Elev. 100.0 m) upon completion of drilling.																			

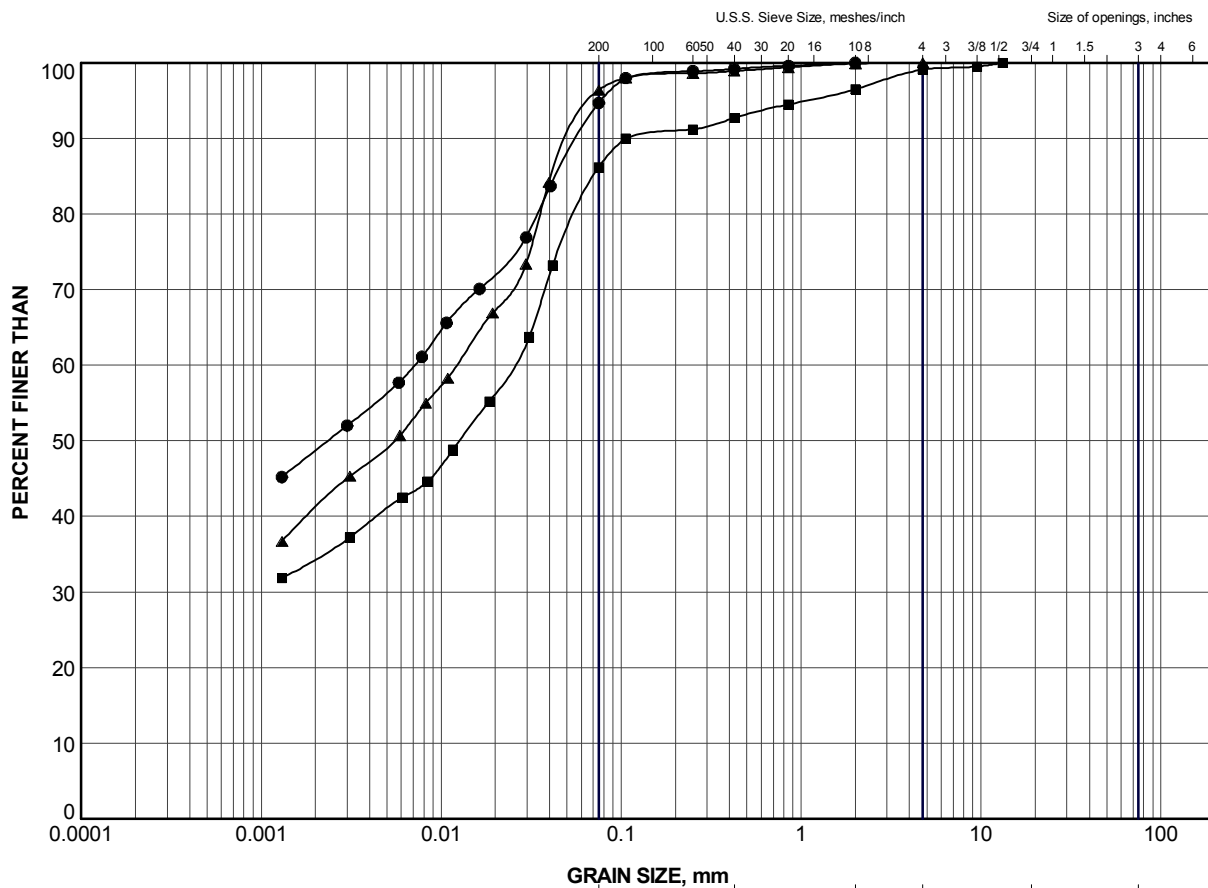
PROJECT		12-1191-0005/2700		RECORD OF BOREHOLE No P2				1 OF 1 METRIC									
W.P.		2014-11017		LOCATION		N 5418664.2; E 396714.4		ORIGINATED BY		MR							
DIST		Northwest HWY		BOREHOLE TYPE		Pionjor - Portable Equipment		COMPILED BY		AC							
DATUM		LOCAL		DATE		May 13, 2014		CHECKED BY		SEMP							
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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
99.7	GROUND SURFACE																
0.0	SILTY CLAY to CLAY, trace organics Dark brown to grey Wet		1	SS	-												
			2	SS	-												
			3	SS	-												
			4	SS	-												
			5	SS	-												
96.7	END OF BOREHOLE																
3.0	Note: 1. Water level at ground surface (Elev. 99.7 m) upon completion of drilling.																

SUD-MTO 001 12-1191-0005 OLSON.GPJ GAL-MISS.GDT 24/11/14 DATA INPUT:



APPENDIX C

Laboratory Test Results



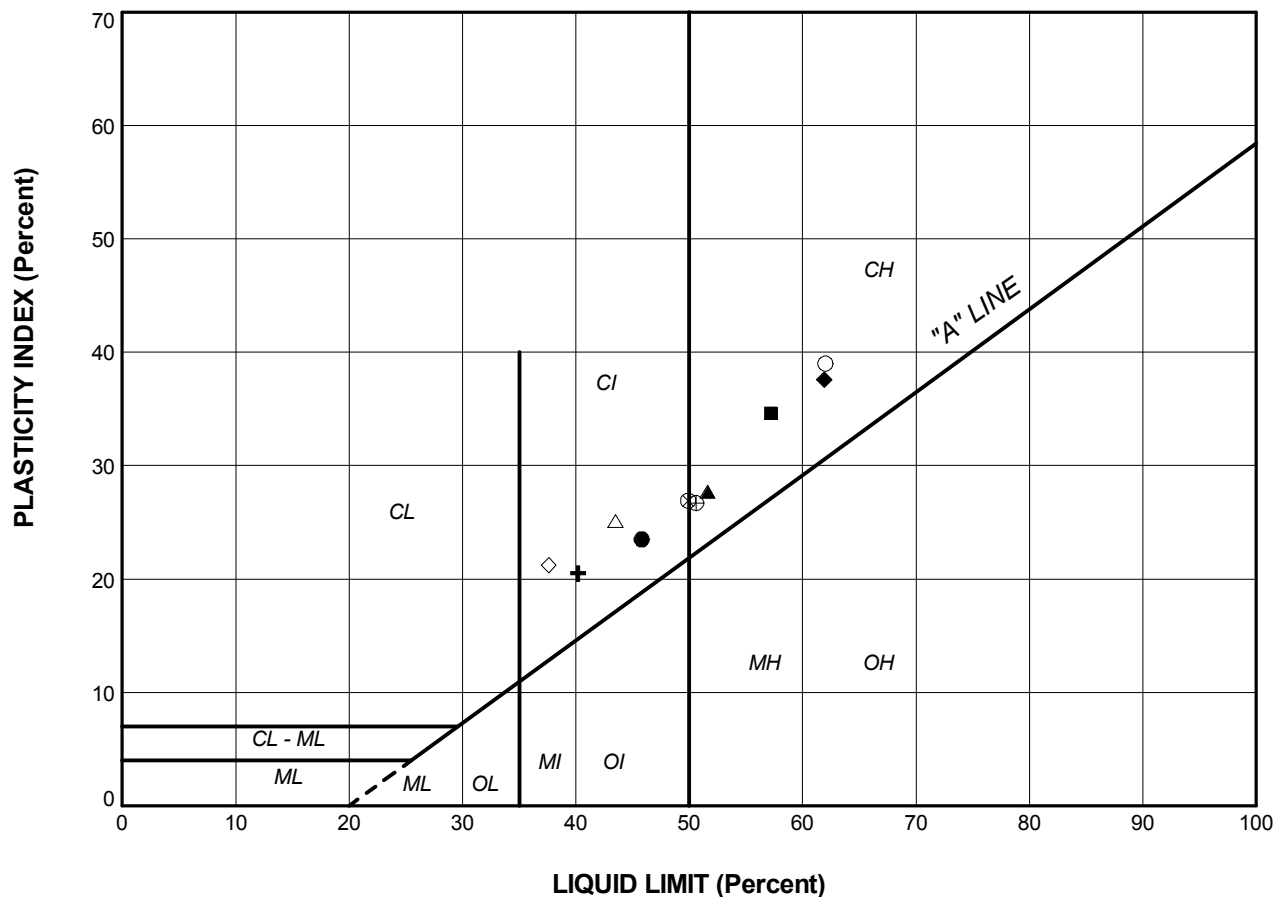
		GRAVEL SIZE, mm					
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size	
	SAND SIZE			GRAVEL SIZE			

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	O1	5	96.3
■	O4	3	98.6
▲	P1	4	97.9

PROJECT					
OLSON ROAD CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION					
SILTY CLAY to CLAY					
PROJECT No. 12-1191-0005/2700			FILE N02-1191-0005 OLSON.GPJ		
DRAWN	TB	Nov 2014	SCALE	N/A	REV.
CHECK	SEMP	Nov 2014			
APPR	JMAC	Nov 2014			
			FIGURE 1		



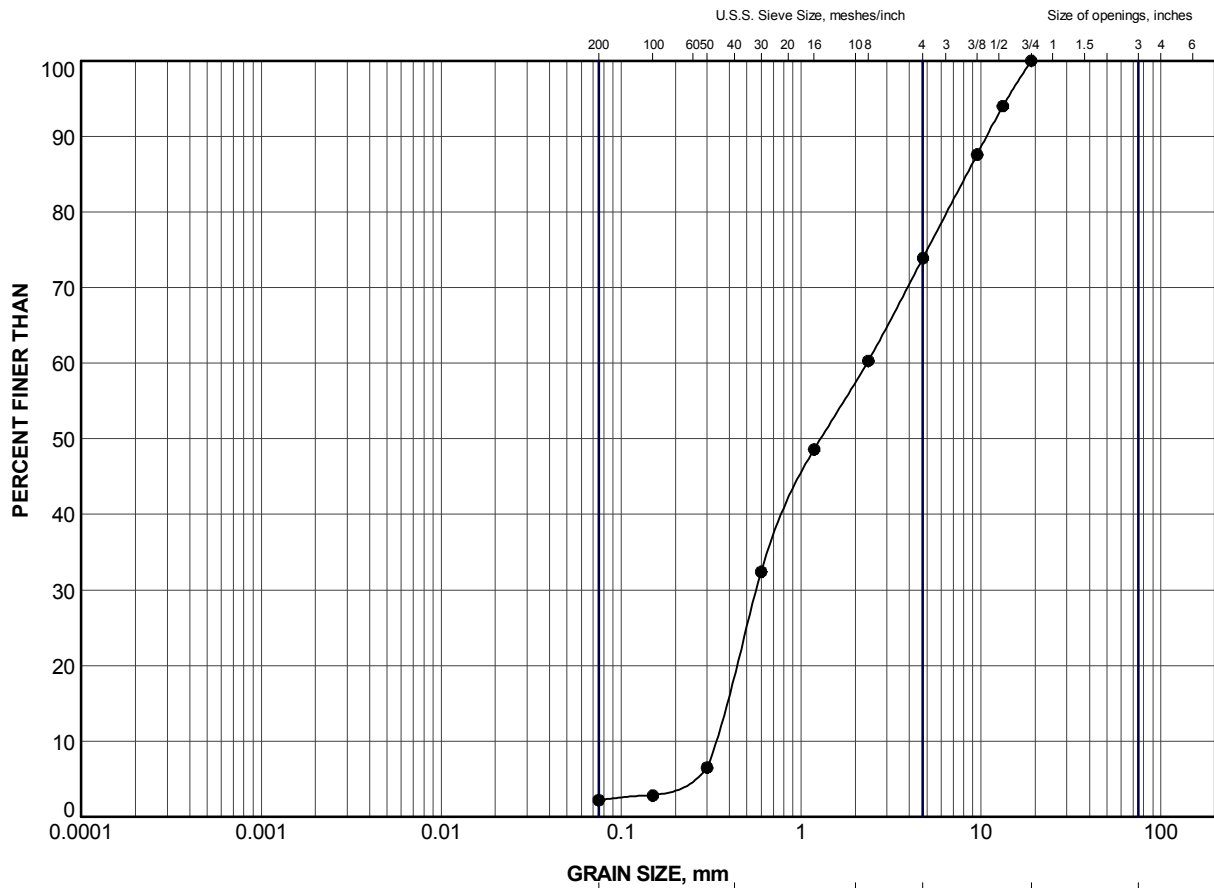


LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	O1	3	45.8	22.3	23.5
■	O1	5	57.2	22.6	34.6
▲	O2	4	51.6	23.9	27.7
+	O3	2	40.2	19.7	20.5
◆	O3	4	61.9	24.3	37.6
◇	O4	3	37.6	16.4	21.2
○	O4	5	62.0	23.0	39.0
△	P1	4	43.5	18.4	25.1
⊗	P2	2	49.9	23.0	26.9
⊕	P2	5	50.6	23.9	26.7

PROJECT					
OLSON ROAD CULVERT					
TITLE					
PLASTICITY CHART					
SILTY CLAY to CLAY					
PROJECT No. 12-1191-0005/2700			FILE No. 12-1191-0005 OLSON.GPJ		
DRAWN	TB	Nov 2014	SCALE	N/A	REV.
CHECK	SEMP	Nov 2014	FIGURE 2		
APPR	JMAC	Nov 2014			




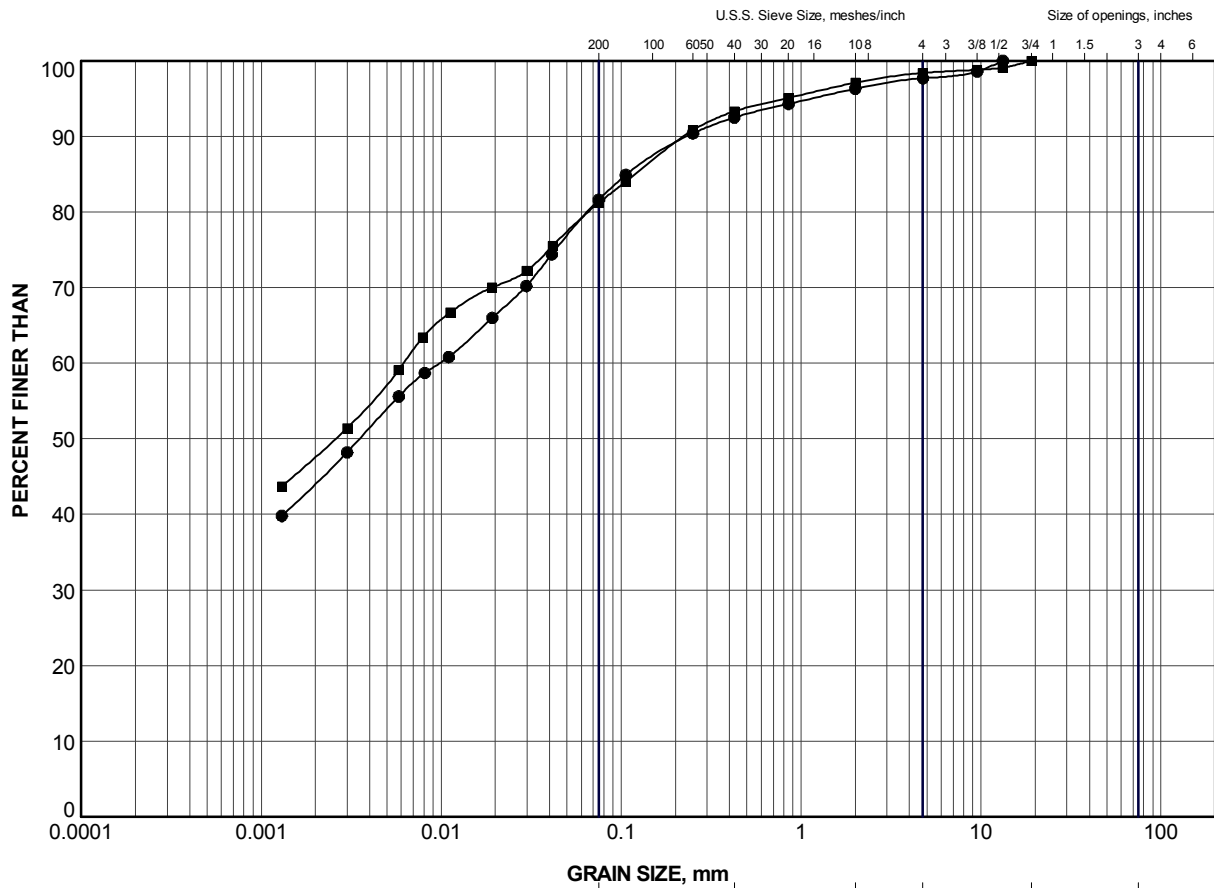


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	O3	5	95.6

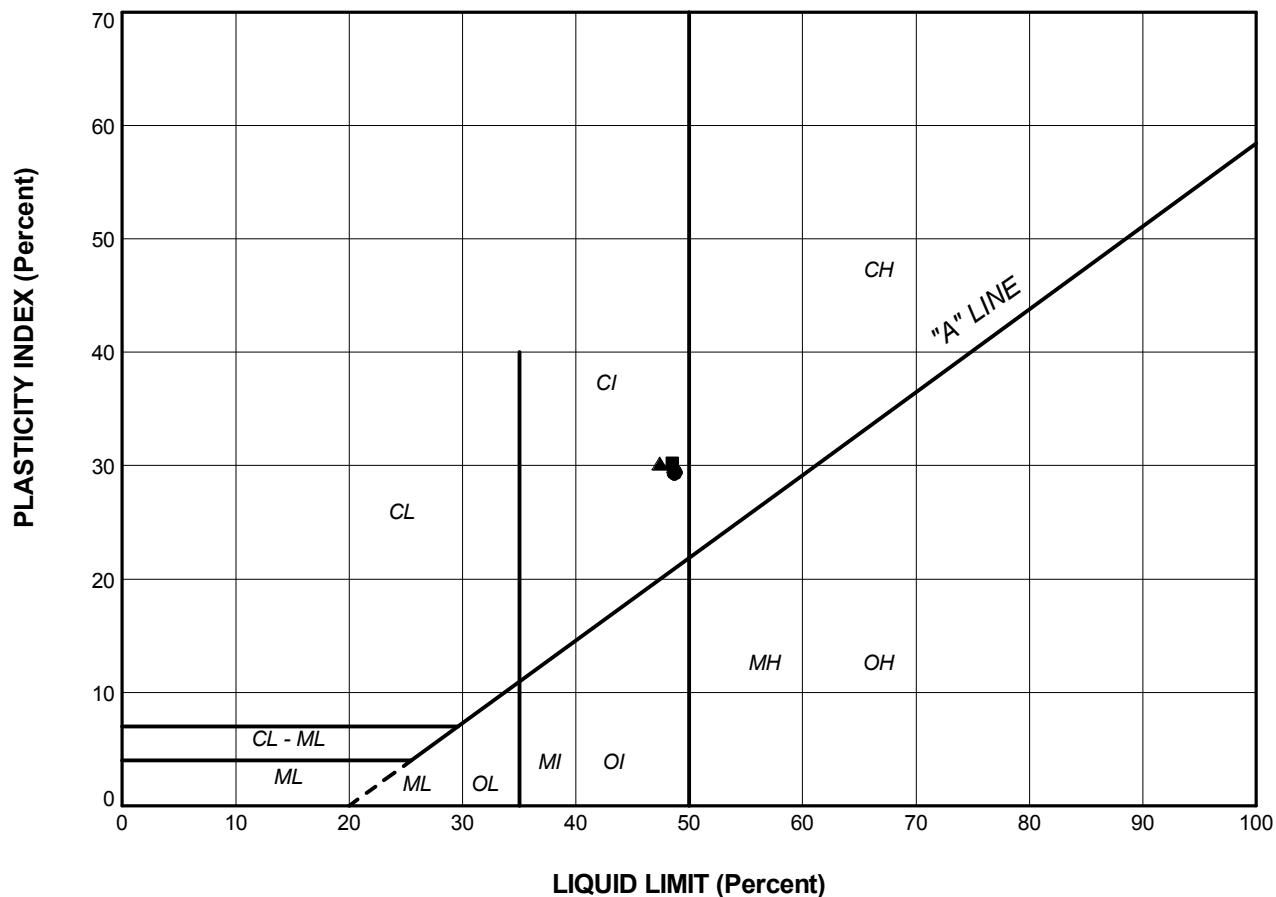
PROJECT					
OLSON ROAD CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION					
GRAVELLY SAND					
 Golder Associates SUDBURY, ONTARIO		PROJECT No. 12-1191-0005/2700		FILE N02-1191-0005 OLSON.GPJ	
		DRAWN	TB	Nov 2014	SCALE N/A
		CHECK	SEMP	Nov 2014	REV.
		APPR	JMAC	Nov 2014	
		FIGURE 3			



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	O2	7	93.2
■	O4	8	92.5

PROJECT					
OLSON ROAD CULVERT					
TITLE					
GRAIN SIZE DISTRIBUTION					
SILTY CLAY (TILL)					
PROJECT No.		12-1191-0005/2700		FILE N02-1191-0005 OLSON.GPJ	
DRAWN	TB	Nov 2014	SCALE	N/A	REV.
CHECK	SEMP	Nov 2014			
APPR	JMAC	Nov 2014			
 Golder Associates SUDBURY, ONTARIO			FIGURE 4		




SOIL TYPE
 C = Clay
 M = Silt
 O = Organic

PLASTICITY
 L = Low
 I = Intermediate
 H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
●	O1	8	48.7	19.3	29.4
■	O2	7	48.5	18.3	30.2
▲	O4	8	47.4	17.2	30.2

PROJECT					
OLSON ROAD CULVERT					
TITLE					
PLASTICITY CHART					
SILTY CLAY (TILL)					
PROJECT No. 12-1191-0005/2700			FILE No. 12-1191-0005 OLSON.GPJ		
DRAWN	TB	Nov 2014	SCALE	N/A	REV.
CHECK	SEMP	Nov 2014			
APPR	JMAC	Nov 2014			
 Golder Associates SUDBURY, ONTARIO			FIGURE 5		



APPENDIX D

Non-Standard Special Provisions

WORKING SLAB – Item No.

Non-Standard Special Provision

Scope of Work

This Special Provision covers the requirements for the supply and placement of a concrete working slab on a soil subgrade under the structure foundations for the Olson Road Culvert. The purpose of the working slab is to protect the subgrade from disturbance and loosening due to construction traffic and ponded water and also to provide a level working surface.

Construction

Protection of Founding Soil

- Following inspection and approval of the prepared soil subgrade by the Quality Verification Engineer, a working slab, with a minimum thickness of 150 mm shall be placed on the foundation subgrade as per the contract drawings and documents. The concrete shall have a minimum 28 day compressive strength of 20 MPa.

Unwatering carried out for the footing or pile cap excavation shall be done in such a manner as to prevent any disturbance to the surrounding original soil.

Basis of Payment

Payment at the Contract Price for the above tender item includes full compensation for all labour, equipment and material to do the required work.

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1010 Lorne Street
Sudbury, Ontario, P3C 4R9
Canada
T: +1 (705) 524 6861

