February 26, 2018

FOUNDATION INVESTIGATION AND DESIGN REPORT

Temporary Protection System for Culvert STA 11+622, Highway 11, Blythe Township North Bay, Ontario GWP 5186-14-00

Submitted to:
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REPORT

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morison Hershfield Ltd. (MH), on behalf of the Ministry of Transportation, Ontario (MTO) to provide detail foundation engineering data for the contractor's design of temporary protection systems required for the replacement of the non-structural culvert located at STA 11+622 on Highway 11 in Blythe Township north of North Bay. The key plan showing the general location of this section of Highway 11 and the location of the investigated area and boreholes are shown on Drawing 1.

2.0 SITE DESCRIPTION

The existing culvert at STA 11+622 on Highway 11 consists of a single, 910 mm by 910 mm non-rigid frame box (NRFB) with 1200 mm diameter corrugated steel pipe (CSP) extensions. The invert of this culvert is at approximately Elevation 356.5 m.

It should be noted that the orientation (i.e., north, south, east, west) stated in the text of the report is referenced to project north and therefore may differ from magnetic north shown on the drawing. For the purpose of this report, Highway 11 is oriented in a north-south direction (for this section of roadway) with the culvert perpendicular to the highway in a west-east orientation.

In general, the topography in the area of the culvert is relatively flat with moderate to dense tree cover along the highway right-of-way. At the culvert location, the highway grade is at Elevation 360.4 m. The highway embankment appears to be approximately 3 m to 4 m in height, relative to the surrounding natural ground surface.

3.0 INVESTIGATION PROCEDURES

The field work for this subsurface investigation was carried out on August 23 and 24, 2017, during which time two boreholes (Boreholes 17-12 and 17-13) were advanced at the locations shown on Drawing 1.

Boreholes 17-12 and 17-13 were advanced through the roadway embankment, down chainage and up chainage of the culvert, respectively. Both boreholes were advanced using an ATV-mounted CME 550 drill rig supplied and operated by Landcore Drilling of Chelmsford, Ontario. All boreholes were advanced using NW casing with wash boring techniques, and NQ coring, as required.

Soil samples were obtained in the boreholes at 0.75 m and 1.5 m intervals of depth using 50 mm outer diameter split-spoon samplers driven by an automatic hammer, in accordance with the Standard Penetration Test (SPT) procedures[1]. NQ rock coring was carried out in each of the boreholes, to penetrate cobbles/boulders encountered within the overburden and to core the bedrock. The groundwater level in the open boreholes was observed during the drilling operations as described on the borehole records in Appendix A. The boreholes were backfilled upon completion in accordance with Ontario Regulation 903 (Wells, as amended).

The field work was monitored on a full-time basis by a member of Golder's technical staff who located the boreholes in the field, arranged for the clearance of underground services, supervised the drilling and sampling operations, logged the boreholes, and examined and took custody of the soil samples and rock core. The soil and rock core samples were identified in the field, placed in labelled containers and transported to Golder's geotechnical laboratory in Mississauga for further examination and laboratory testing. Index and classification testing consisting of water content determinations and grain size distributions were carried out on selected soil

[1] ASTM D1586 Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils

samples. The geotechnical laboratory testing was completed according to MTO LS standards. Unconfined compressive strength tests were carried out on selected bedrock samples.

The as-drilled borehole locations and ground surface elevations were measured and surveyed by members of Golder's technical staff, referenced to the highway centreline and the existing culvert and converted into northing/easting coordinates on the plan drawing. The ground surface elevation of the highway centreline was obtained from the profile drawing provided by MH (Drawing B0351144001.dwg). The MTM NAD83 Zone 10 northing and easting coordinates and geographical coordinates, ground surface elevations referenced to Geodetic datum, and borehole depths at each borehole location are presented on the borehole records in Appendix A and summarized below.

Borehole Number	MTM NAD83 Northing (Latitude)	MTM NAD83 Easting (Longitude)	Ground Surface Elevation (m)	Borehole Depth (m), including Rock Coring (Base Elevation, m)
17-12	5151637.2 (46.504392)	303091.3 (-79.522263)	360.3	8.0 (352.3)
17-13	5151650.1 (46.504507)	303078.7 (-79.522427)	360.5	9.2 (351.3)

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

Based on Northern Ontario Engineering Geology Terrain Mapping (NOEGTS)[2] mapping, the culvert site is located within an outwash plain deposit consisting primarily of sand and gravel soils, bordered by bedrock knobs. The area is generally described as undulating to rolling.

Based on geological mapping by the Ontario Ministry of Northern Development and Mines (Map 2543)[3], the site is underlain by strong bedrock consisting of layered biotite gneisses and migmatites, locally including quartzofeldsparic gneisses, orthogneisses and paragneisses.

4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are given on the borehole records contained in Appendix A. The detailed results of geotechnical laboratory testing are contained in Appendix B. The results of the in situ field tests (i.e., SPT 'N' values) as presented on the borehole records and in Section 4.2 are uncorrected. The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profile on Drawing 1 are inferred from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsoil conditions encountered at the site consist of asphalt and granular fill (sand to sand and gravel) underlain by a native deposit of sand to gravelly sand to silt and sand, containing cobbles and boulders.

[2] Northern Ontario Engineering Geology Terrain Study. Ontario Geological Society Electronic Mapping. Map 52KSW.

[3] Ministry of Northern Development of Mines. Bedrock Geology of Ontario – East Central Sheet, Ontario Geological Survey – Map 2543.

Gneiss bedrock was encountered below the native deposits. A more detailed description of the soil deposits, bedrock, and groundwater conditions encountered in the boreholes is provided below.

4.2.1 Asphalt

An approximately 150 mm to 200 mm thick layer of asphalt was encountered at the surface in Boreholes 17-13 and 17-12, respectively, as advanced through Highway 11.

4.2.2 Fill

A layer of fill described as sand to sand and gravel was encountered below the asphalt in Boreholes 17-12 and 17-13 and extended to depths of 2.9 m and 3.7 m. The thickness of this layer in Boreholes 17-12 and 17-13 is 2.7 m to 3.5 m, with the base of the fill at Elevation 357.4 m and 356.8 m, respectively.

In general, the SPT 'N'-values measured in the upper approximately 2 m to 3 m of the fill are between 32 blows and 78 blows per 0.3 m of penetration indicating a dense to very dense relative density, while the lowermost 'N'-values within the fill and above the native deposits are 6 blows and 8 blows per 0.3 m of penetration, indicating a loose relative density. One SPT 'N'-value measured within the upper portion of the fill is 100 blows per 0.1 m of penetration which could be indicative of the presence of gravel, cobble(s) or an obstruction.

The results of grain size distribution tests carried out on two samples of this fill are shown on Figure B1 and Figure B2 in Appendix B. The natural water contents measured on samples of this fill range between about 6 per cent and 9 per cent.

4.2.3 Sand/Gravelly Sand to Silt and Sand Containing Cobbles and Boulders

A non-cohesive deposit was encountered below the fill in Boreholes 17-12 and 17-13 at Elevations of 357.4 m and 356.8 m, respectively. The deposit varies in composition from sand, some gravel to gravelly, trace to some silt, trace clay, trace organics, to silt and sand, trace gravel, trace clay. The deposit extends to depths of 4.8 m and 6.2 m below ground surface in Boreholes 17-12 and 17-13, respectively. Two cobbles and a boulder were cored through and recovered from this deposit, with cored lengths ranging from approximately 200 mm to 540 mm. The thickness of the deposit in Boreholes 17-12 and 17-13 is about 1.9 m and 2.5 m, respectively. This granular deposit immediately overlies the bedrock in both boreholes.

The SPT 'N'-values vary from 11 blows to 39 blows per 0.3 m of penetration, indicating a compact to dense relative density. One SPT 'N'-value of 100 blows for 0.05 m of penetration was measured in both boreholes at the interface of this deposit and the bedrock; however, these values are not considered representative of the relative density of the deposit.

The results of grain size distribution tests carried out on one sample of the sand deposit and one sample of the silt and sand deposit are shown on Figures B3 and B4 in Appendix B. The natural water contents range between about 10 per cent and 18 per cent, with one sample containing trace organics measuring a water content of about 96 per cent. An organic content test carried out on one sample of this deposit indicated an organic content of about 4 per cent.

4.2.4 Bedrock

Bedrock was encountered below the sand/gravelly sand to silt and sand deposit in both boreholes. The approximate depths to top of bedrock below ground surface and corresponding top of bedrock surface elevations are summarized below and are shown on Drawing 2 and on the borehole records in Appendix A.

Location	Borehole Designation	Approximate Depth to Bedrock Surface (m)	Approximate Bedrock Surface Elevation (m)	Remarks
10 m S of culvert centreline	17-12	4.8	355.5	Cored (3.2 m length)
10 m N of culvert centreline	17-13	6.2	354.3	Cored (3.0 m length)

Based on review of the bedrock core samples, the bedrock consists predominantly of gneiss and is generally described as fresh, foliated, pink and black, medium-grained and non-porous. The bedrock details are presented on the drillhole records found in Appendix A. Bedrock core photographs are shown in Appendix B.

The Total Core Recovery (TCR) measured on the recovered rock core samples ranges between 95 per cent and 100 per cent, and the Solid Core Recovery (SCR) ranges between 74 per cent and 88 per cent. The Rock Quality Designation (RQD) measured on the rock core samples ranges from about 71 per cent to 95 per cent, indicating a rock mass of fair to excellent quality as per Table 3.10 of CFEM (2006)[4].

Two unconfined compressive strength (UCS) tests (ASTM D7012)[5] were carried out on selected samples of the gneiss recovered from Boreholes 17-12 and 17-13. The UCS test results are summarized below.

Location	Borehole Designation	Sample Depth (m) (Elevation, m)	UCS (MPa)	Unit Weight (kN/m^3)
10 m S of culvert centreline	17-12	5.06 – 5.17 (355.44 – 355.33)	72.0	25.6
10 m N of culvert centreline	17-13	6.86 – 7.06 (353.44 - 353.24)	79.4	25.7

The test results are also shown on the drillhole records in Appendix A and provided in Appendix B. Based on the laboratory UCS tests and in accordance with Table 3.5 of CFEM (2006), the gneiss bedrock is classified as strong.

4.3 Groundwater Conditions

The water levels were observed inside the casing of Boreholes 17-12 and 17-13 upon completion of wash boring and prior to bedrock coring. The measured depths range from 3.4 m to 3.0 m below ground surface, corresponding to between Elevations 357.1 m and 357.3 m, respectively. These water levels, as noted on the borehole records,

[4] Canadian Geotechnical Society, 2006. Canadian Foundation Engineering Manual, 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.

[5] Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

may not represent the longer-term, stabilized groundwater level at the site due to the addition of water to the boreholes for wash boring and coring.

The groundwater levels are subject to seasonal fluctuations and precipitation events, and are expected to be higher during wet seasons and sustained periods of precipitation.

5.0 CLOSURE

The field work for this investigation was supervised by Mr. Michael Bentley, B.A.Sc. This Foundation Investigation Report was prepared by Ms. Alysha Kobylinski, B.A.Sc. with input from Mr. David Marmor E.I.T. and reviewed by Ms. Sarah Poot, P.Eng., a geotechnical engineer and Associate at Golder. Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact for Golder, conducted an independent quality control review of the report.

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PART B

FOUNDATION DESIGN REPORT
TEMPORARY PROTECTION SYSTEM FOR CULVERT
STA 11+622, HIGHWAY 11, BLYTHE TOWNSHIP
NORTH BAY, ONTARIO
GWP 5186-14-00

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6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides foundation engineering recommendations for temporary protection systems and general design considerations in support of the replacement of the existing culvert located at STA 11+622 on Highway 11 in Blythe Township, north of North Bay. The recommendations are based on interpretation of the factual data obtained from the boreholes advanced during the subsurface investigation at this site. The discussion and recommendations presented are intended to provide the designers with sufficient information to assess the feasible protection system alternatives, develop construction cost estimates, and identify items or issues to be addressed in the Contract Documents. The Foundation Design Report discussion and recommendations are intended for the use of MTO and shall not be used or relied upon for any other purpose or by any other parties, including the contract or Design-Build contractor. The contractor must make their own interpretation based on the factual data in Part A (Foundation Investigation) of the report. 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 the aspects of construction must make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

Based on discussions with MH and MTO and in reviewing the Project Assessment Report (PAR) for GWP 5187-14-00, it is understood that excavations to at least 3.7 m below the roadway surface will be required to reach the invert of the existing culvert, and install the replacement culvert with cut-and-cover methods. The traffic staging plan may require the use of temporary protection systems to facilitate construction while maintaining traffic on Highway 11.

Based on discussion with MH, we understand the proposed traffic staging plan will require temporary barriers to separate traffic from work zones. With respect to MTO memo DCSO#2017-04, dated September 19, 2017 regarding barriers adjacent to excavation, we understand that all temporary barriers will be located a minimum distance of 1.0 m from the edge of all excavations, including those requiring temporary protection systems at this site. Further analysis and recommendations are not required to address MTO memo DCSO#2017-04 in this instance.

6.2 Excavations, Temporary Cut Slopes

The proposed culvert replacement work will require removal of the pavement structure, and excavation through the existing embankment fill material (containing possible obstructions), extending into the sand/gravelly sand to silt and sand deposit containing cobbles and boulders. Based on discussions with MH, it is understood that open cut excavations may be feasible at this site from a traffic staging perspective, based on the existing highway platform width.

Open cut excavation side slopes in the existing embankment fill (i.e., sand to sand and gravel fill) and underlying native sand deposit containing cobbles and boulders should remain stable during construction if the temporary side slopes are cut back no steeper than 1 horizontal to 1 vertical (1H:1V) above the groundwater level; the excavation slopes should be flattened to 3H:1V below the groundwater level.

Based on the subsurface conditions encountered during this investigation, groundwater is expected to be encountered within the proposed excavation depths, near the base of the excavation. The water should be controlled by dewatering, which may be assisted by gravity drainage via local ditching, and sources of surface water should be diverted away from the excavation area prior to beginning the excavation. Some sloughing of excavated slopes due to perched water or surface water runoff may occur and flatter side slopes may become necessary.

During construction, stockpiles should be placed at a distance away from the edge of the excavation not less than 1.5 times the depth of excavation, and their heights should be controlled to prevent surcharging the sides of the excavation and/or overall slope.

All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The existing embankment fill and native soils are classified as Type 3 soils above the groundwater level and Type 4 soils below the groundwater level.

6.3 Temporary Protection Systems (TPS)

Should there be insufficient room for open cuts along the highway centreline, then the use of temporary protection systems (TPS) to facilitate staged construction will likely be required. The advantages, disadvantages, relative costs and risks/consequences associated with different TPS options are compared in Table 1 and the options are discussed in further detail in the sections below. It is imperative that any TPS used at this site be compatible with the presence of cobbles and boulders or other obstructions (see Section 6.3) or that measures are taken to remove/break up all boulders and cobbles prior to the installation of TPS elements. Feasible TPS could consist of either soldier piles and lagging or permeation grouting. Standard TPS such as driven steel sheet piles would not be effective at this site as they will not be able to penetrate the obstructions to achieve sufficient depth. If required at this site, permeation grouting may be more feasible from a foundations perspective than a soldier pile and lagging system, as grouting would likely eliminate the need for coring/socketing into the strong bedrock. However, permeation grouting may pose greater risk to the environment, and is not used as frequently as soldier pile and lagging systems in this application.

6.3.1 Soldier Pile and Lagging System

A braced steel soldier pile and lagging system as a temporary protection method is well suited to the conditions on site for the main reason that the pile installation methods are able to penetrate cobbles, boulders and other obstruction within the fill and native soils. The soldier piles would extend below the cobbles and boulders at this site and be supported on or, more likely, socketted into the bedrock encountered at depths ranging from 4.8 m to 6.2 m below road surface. Coring, down-the-hole (DTH) hammer and/or churn drilling methods and equipment are expected to be required to form soldier pile sockets in the strong gneiss bedrock.

Where boulders and cobbles are removed during installation of the lagging boards, it is recommended that they be replaced with OPSS.PROV 1010 Granular ‘A’ backfill. In the event that perched groundwater or surface water is encountered, it is recommended that a geotextile layer be used to prevent loss of ground behind the lagging. Excess rain or fluctuating groundwater levels may cause sands and fines to wash out from behind the lagging, and the use of geotextile and granular soils would reduce this risk over the limited time period that the shoring system is in place.

6.3.2 Permeation Grouting

Permeation grouting is a soil improvement method that involves injecting low-strength cementitious grout into pilot holes advanced in the area of a proposed excavation or area requiring more strength (as described in Section 59.5 of Essler, *Design Principles for Ground Improvement*, 2012). Suited to granular soils of low fines content, permeation grouting is possible at this location due to the low fines content of the granular fill and underlying granular deposit and would be compatible with the presence of boulders and cobbles provided that the pilot holes are drilled using equipment capable of penetrating the cobbles and boulders. After grouting, excavations at a relatively steep side slope (e.g., near-vertical, depending on the grout strength and grout-soil mixture) could be achieved within the site soils. Where boulders are encountered within the steepened slopes as excavations proceed, they should be removed and replaced with additional grout or granular material, as directed on site, to ensure there are no gaps in the steepened wall where soil loss could occur.

6.3.3 Sheet Piles

Installation of steel sheet piles for a temporary protection system is not considered as a feasible option at this site due to the presence of cobbles and boulders below the existing embankment fill, as well as potential obstructions within the fill. Cobbles and boulders were encountered at depths ranging from 2.9 m to 3.7 m below the highway grade and required NQ coring to advance both boreholes. It is unlikely that sheet piles would be able to be penetrate to the required depth. Further, the sheet piles would not penetrate into the strong bedrock at this site, and therefore may not achieve sufficient depth/toe fixity.

6.3.4 Requirements

The temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (Temporary Protection Systems). Temporary excavation support systems should be designed to Performance Level 2 for any excavation adjacent to existing roadway. Although not anticipated to be an issue at this site, design of the temporary support system should include an evaluation of base stability, soil squeezing and hydraulic uplift stability as defined in the *Canadian Foundation Engineering Manual* (CFEM 2006), as may be required for the site conditions.

The Contractor is responsible for the completed detailed design of the TPS. For MH’s consideration in developing the construction cost estimate for this contract, the TPS may be designed using the following parameters:

Soil Type	Unit Weight	Internal Angle of Friction	Undrained Shear Strength	Coefficient of Lateral Earth Pressure[1]		
	(γ, kN/m^3)	(ϕ, degrees)	(S_u, kPa)	Active K_a	At Rest K_o	Passive K_p [2]
New Granular ‘B’ Type I	21	32	-	0.31	0.47	3.25
New Granular ‘A’ or Granular ‘B’ Type II	21	35	-	0.27	0.43	3.69
Existing sand to sand and gravel fill (loose to very dense)	20	29	-	0.35	0.52	2.88
Sand containing cobbles and boulders (compact)	20	30	-	0.33	0.50	3.00
Silt and sand, containing cobbles and boulders (compact to very dense)	22	30	-	0.33	0.50	3.00

Notes:

1. The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficient of earth pressure should be adjusted accordingly.
2. The total passive resistance below the base of the excavation (i.e. adjacent to the temporary protection system) may be calculated based on the values of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.16 of the CHBDC (2014) to account for the fact that a large strain would be required for mobilization of the full passive resistance.

The design groundwater level may be assumed to be Elevation 357.5 m based on the unstabilized groundwater level as obtained from boreholes 17-12 and 17-13.

Given that the excavations will be on one side of Highway 11 at a time, with the TPS likely used for both halves of the construction, if a cantilever wall is not possible for the proposed wall height, rakers could be used for lateral support with the base of the rakers founded within the native sand/gravelly sand to silt and sand deposit.

Consideration could be given to either partial or full removal of the TPS upon completion of construction or each stage of construction (as required). Where possible, full removal of the temporary shoring system should be considered to mitigate potential impediments to future rehabilitation/reconstruction work at the culvert site, or to the road structure above. If soldier piles and lagging are chosen as the preferred TPS, it will be difficult to fully remove soldier piles if they are founded within the bedrock. Consideration should be given to cutting-off soldier piles near the base of the excavation, if possible, in order to at least partially remove the TPS. If permeation grouting is chosen as the preferred TPS, it will be difficult to remove areas where ground improvement has occurred, and the TPS will likely need to remain in place.

6.4 Obstructions

The contractor should be alerted to the presence of cobbles and boulders encountered in the embankment fill and within the native sand/gravelly sand deposit. A boulder with a minimum dimension of at least 540 mm was cored when advancing Borehole 17-13 through the native granular soil beneath the embankment fill. An NSSP should be included in the contract documents and a sample NSSP is included in Appendix D.

6.5 Groundwater Control

The base of the excavation required for the culvert installation (about 4 m below road surface) will be below the unstabilized groundwater levels of 3.4 m and 3.0 m in Boreholes 17-12 and 17-13, respectively, as measured in the open boreholes upon completion of drilling. It is anticipated that dewatering will be required to maintain a dry and stable subgrade for the culvert replacement works. Dewatering of excavations adjacent to this culvert should be carried out in accordance with MTO Special Provision SP 517F01 which modifies OPSS 517 (Dewatering).

With respect to the required input for SP517F01, the site name/station reference should be 11+622 Highway 11, Blythe Township. Golder recommends a precondition survey distance of 150 m but anticipate that the zone of influence of dewatering will be less than this distance. We recommend that the design engineer and design-checking engineer have a minimum of 5 years of experience designing dewatering systems of similar nature and scope, resulting in the required fill-in being “Yes”. Input for the IDF curve location and return periods should be provided by MH.

Water takings in excess of 50,000 L/day are regulated by the Ministry of the Environment and Climate Change (MOECC). Certain takings of groundwater and stormwater for construction dewatering purposes with a combined total less than 400,000 L/day qualify for self-registration on the MOECC's Environmental Activity and Sector Registry (EASR). Registry on the EASR replaces the need to obtain a PTTW for water taking and a Section 53 approval for discharge of water to the environment. In all cases, discharge under the EASR must be in accordance with a Discharge Plan (to be developed by a qualified professional). The contractor will be responsible for obtaining any required discharge approvals. A Category 3 PTTW would be required for water takings in excess of 400,000 L/day.

An accurate prediction of the groundwater pumping volumes cannot be made at this time, as the flow rate would be dependent on construction methods adopted by the contractor and the size/depth of the excavation. However, based on the soil and groundwater conditions at this site, a Category 3 PTTW is not anticipated to be required.

7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Alysha Kobylinski, B.A.Sc., with input from Mr, David Marmor, E.I.T., and the technical aspects were reviewed by Ms. Sarah Poot, P.Eng. Ms. Lisa Coyne, P.Eng., a Designated MTO Foundations Contact for Golder, conducted an independent quality control review of this report.

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ASTM International:

ASTM D1586	Standard Test Method for Standard Penetration Test and Split-Barrel Sampling of Soils
ASTM D7012	Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures

Ontario Provincial Standard Specifications (OPSS)

OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS 517	Construction Specification for Dewatering
SP517F01	Special Provision No. 517F01 - Amendment to OPSS 517

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)

Table 1: Evaluation of Temporary Protection System Options

Temporary Protection System Option	Advantages	Disadvantages	Relative Costs	Risks / Consequences
Soldier Piles and Lagging	▪ Able to penetrate cobbles and boulders. ▪ Relatively straightforward construction.	▪ Will require pre-drilling through cobbles, boulders or other obstructions as encountered at the site. ▪ Would require socket formation in strong gneiss bedrock, if and where soldier piles are required to penetrate into the bedrock. ▪ Additional time for installation compared to installation of sheet piles. ▪ Groundwater/surface water seepage through lagging boards must be considered to avoid ground loss.	▪ Less than permeation grouting, more than sheet piles especially with equipment required to penetrate obstructions.	▪ Low risk that equipment won't penetrate obstructions in order to achieve required depth. ▪ Low risk of soil loss behind lagging if not adequately controlled.
Permeation Grouting	▪ Allows for steeper (near vertical) excavation side slopes. ▪ Compatible with on-site granular soils that contain cobbles and boulders. ▪ Helps control groundwater flow, if required. ▪ May eliminate the need for socketting into bedrock, compared with a soldier pile and lagging system.	▪ Untraditional approach to this problem in the context of culvert replacements on a highway. ▪ Additional testing may be required. ▪ Requires pilot hole drilling equipment capable of penetrating cobbles and boulders. ▪ May be an issue where cobbles or boulders are encountered during excavation of the wall which will need to be properly removed and backfilled.	▪ Not common in this location; may be relatively expensive for temporary conditions.	▪ Method not commonly used for MTO contracts. ▪ Cobbles and boulders encountered during excavation of wall will require removal and backfilling. ▪ Risk of release of grout into stream during grouting operations.
Sheet Piles (not feasible at this site)	▪ Standard design and construction. ▪ Relatively straight forward installation provided that soil conditions are amenable, which is not the case at this site.	▪ Cannot penetrate cobbles and boulders, or strong bedrock.	▪ Typically least expensive over short distances in appropriate ground conditions; however, this is not the case for the conditions at this site.	▪ High risk of sheet piles encountering obstructions and not achieving required depth.

MINISTRY OF TRANSPORTATION, ONTARIO

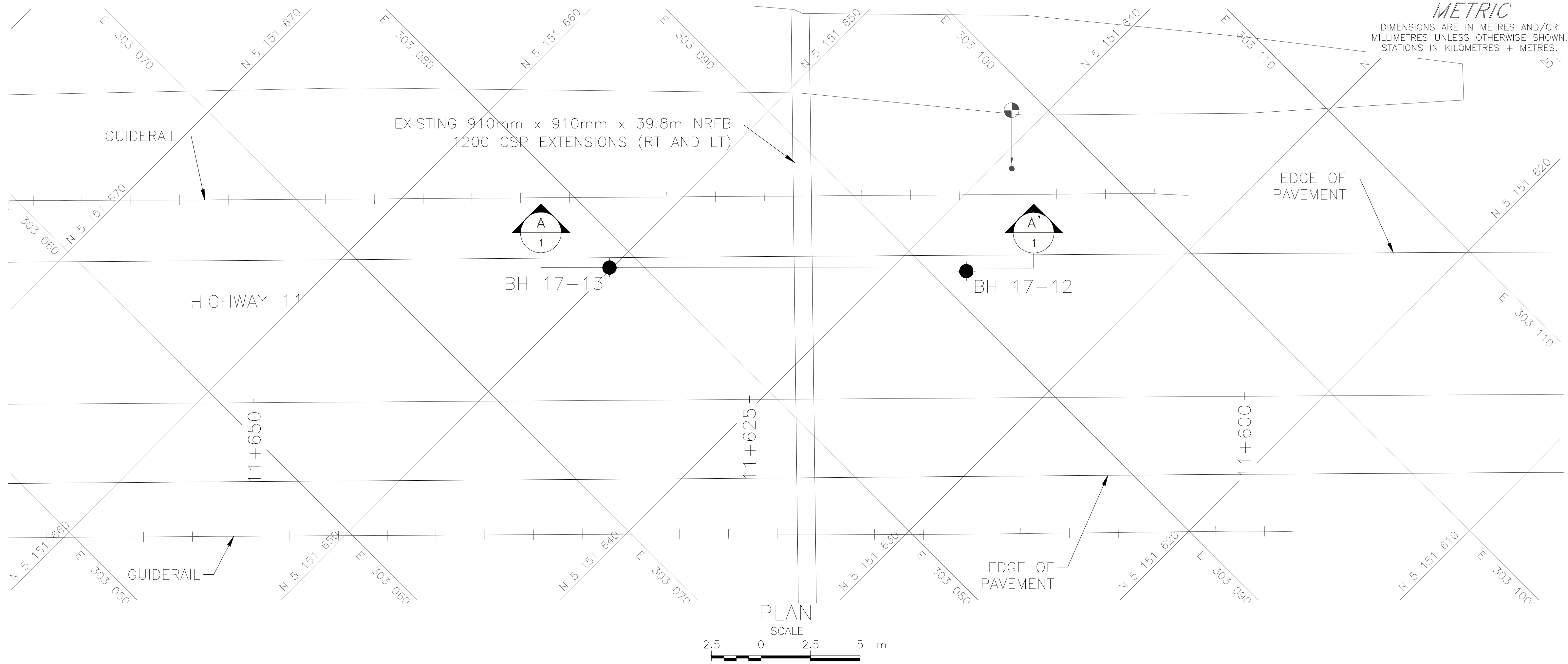
METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

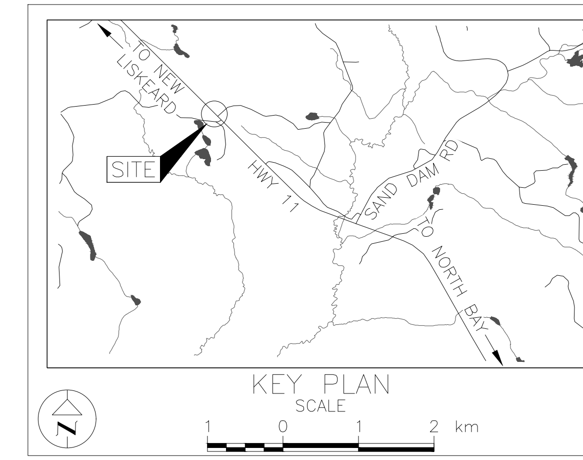
CONT No.
GWP No. 5186-14-00

HIGHWAY 11
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

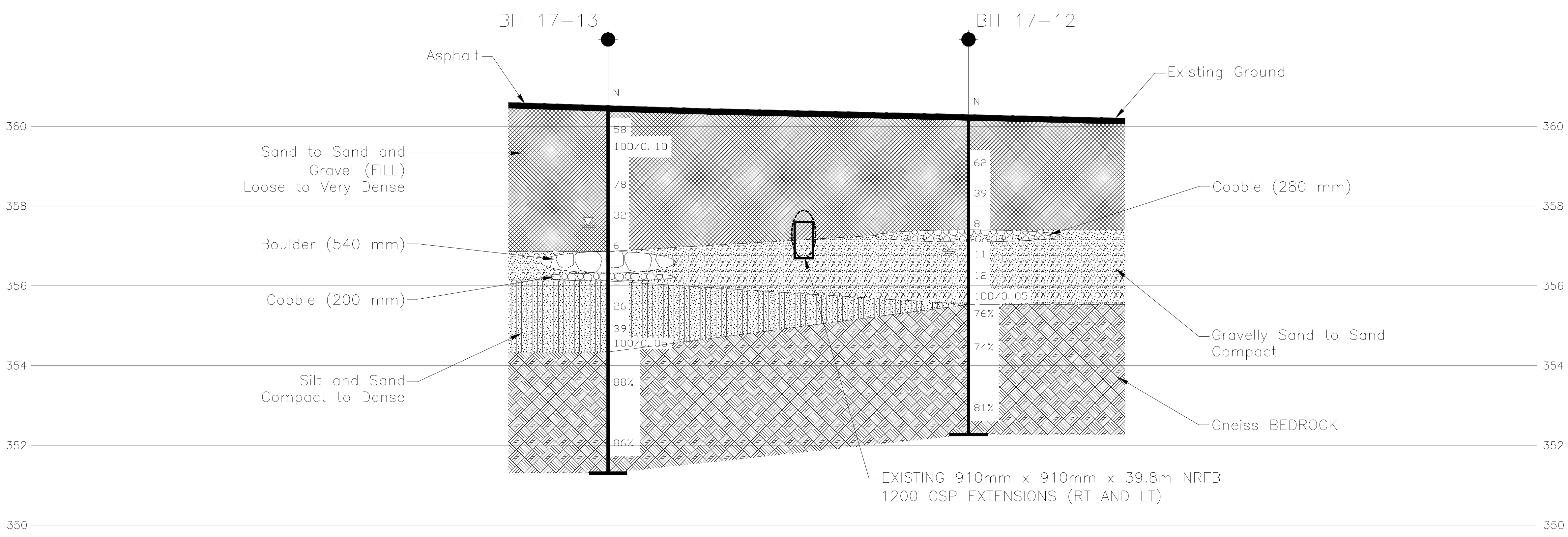
Golder Associates





LEGEND

●	Borehole – Current Investigation
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
100%	Rock Quality Designation (RQD)
▽	WL measured in open borehole upon completion of drilling



A-A / 1 CROSS-SECTION A-A'
TEMPORARY PROTECTION SYSTEM

HORIZONTAL SCALE 2.5 0 2.5 5 m
VERTICAL SCALE 1.25 0 1.25 2.5 m

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
BH 17-12	360.3	5151637.2	303091.3
BH 17-13	360.5	5151650.1	303078.7

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.

REFERENCE

Base plans provided in digital format by Morrison Hershfield, drawing file no. WP51871400SA.dwg, received SEPT. 15, 2017.

LICENSED PROFESSIONAL ENGINEER S.E.M. POOT 90471921 Feb. 26, 2018 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER L.C. COYNE Feb. 26, 2018 PROVINCE OF ONTARIO

NO.	DATE	BY	REVISION

Geocres No. 31L-209

HWY. 11	PROJECT NO. 1671122		DIST. NORTHEAST
SUBM'D. DPM	CHKD. DPM	DATE: 2/26/2018	SITE:
DRAWN: JM	CHKD. SEMP	APPD. LCC	DWG. 1

PLOT DATE: February 26, 2018

APPENDIX A

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
υ	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

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

(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 $= \sigma'_p / \sigma'_{vo}$

(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

Notes:

1. $\tau = c' + \sigma' \tan \phi'$
2. shear strength = (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, 60º 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 cm^2 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 Relative Density	**N 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	Sand and Gravel
	With (cohesive)	Silty Clay with sand / Clayey Silt with sand

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

WEATHERINGS STATE

Fresh: no visible sign of weathering

Faintly weathered: weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.

Completely weathered: rock is wholly decomposed and in a friable condition but the rock and structure are preserved.

BEDDING THICKNESS

Description	Bedding Plane Spacing
Very thickly bedded	Greater than 2 m
Thickly bedded	0.6 m to 2 m
Medium bedded	0.2 m to 0.6 m
Thinly bedded	60 mm to 0.2 m
Very thinly bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	Less than 6 mm

JOINT OR FOLIATION SPACING

Description	Spacing
Very wide	Greater than 3 m
Wide	1 m to 3 m
Moderately close	0.3 m to 1 m
Close	50 mm to 300 mm
Very close	Less than 50 mm

GRAIN SIZE

Term	Size*
Very Coarse Grained	Greater than 60 mm
Coarse Grained	2 mm to 60 mm
Medium Grained	60 microns to 2 mm
Fine Grained	2 microns to 60 microns
Very Fine Grained	Less than 2 microns

Note: * Grains greater than 60 microns diameter are visible to the naked eye.

CORE CONDITION

Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varied from 0% for completely broken core to 100% for core in solid sticks.

DISCONTINUITY DATA

Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

Dip with Respect to Core Axis

The angle of the discontinuity relative to the axis (length) of the core. In a vertical borehole a discontinuity with a 90^{o} angle is horizontal.

Description and Notes

An abbreviation description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces and infillings are also noted.

Abbreviations

JN	Joint	PL	Planar
FLT	Fault	CU	Curved
SH	Shear	UN	Undulating
VN	Vein	IR	Irregular
FR	Fracture	K	Slickensided
SY	Stylolite	PO	Polished
BD	Bedding	SM	Smooth
FO	Foliation	SR	Slightly Rough
CO	Contact	RO	Rough
AXJ	Axial Joint	VR	Very Rough
KV	Karstic Void		
MB	Mechanical Break		

Golder Associates

RECORD OF BOREHOLE No 17-12

SHEET 1 OF 1 **METRIC**

PROJECT 1671122
G.W.P. 5186-14-00
LOCATION N 5151637.2; E 303091.3 MTM ZONE 10 (LAT. 46.504392; LONG. -79.522263)
ORIGINATED BY MB
DIST Northeast HWY 11
BOREHOLE TYPE Wash Boring, NQ Coring
COMPILED BY ZS
DATUM Geodetic
DATE August 23, 2017
CHECKED BY AK

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
360.3	GROUND SURFACE							
0.0	ASPHALT (200 mm)							
0.2	Sand to gravelly sand, some silt (FILL) Loose to very dense Brown Moist to wet	1	SS	62				11 76 (13)
		2	SS	39				
357.4		3	SS	8				
357.1	COBBLE (280 mm)	-	RC	-				
356.8 / 3.5	SAND, some gravel, trace silt, trace clay, trace organics Compact Black Wet	4	SS	11	∇ (Elev. 356.9)		96	OC = 4.1%
	Gravelly SAND to SAND, some silt, trace organics Compact Black to brown Wet	5	SS	12				10 81 5 4
355.5 / 4.8		6	SS	100/0.05				
	Gneiss (BEDROCK) Bedrock cored from depths of 4.8 m to 8.0 m For bedrock coring details refer to Record of Drillhole 17-12.	1	RC	REC 95%				RQD = 71%
		2	RC	REC 100%				RQD = 74%
352.3		3	RC	REC 100%				RQD = 84%
8.0	END OF BOREHOLE							

Notes:

1. "N" Value for sample "SS6" not representative of relative density due to spoon bouncing on bedrock surface.

2. Water level in open borehole after wash boring and prior to rock coring at a depth of 3.4 m below ground surface (Elev. 356.9 m).

ELEVATION SCALE: 360, 359, 358, 357, 356, 355, 354, 353

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED: 20 40 60 80 100
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%): 10 20 30

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

RECORD OF DRILLHOLE: 17-12

PROJECT: 1671122
LOCATION: N 5151637.2 ;E 303091.3
INCLINATION: -90° AZIMUTH: ---

DRILLING DATE: August 23, 2017
DRILL RIG: NQ Coring
DRILLING CONTRACTOR: Landcore

SHEET 1 OF 1
DATUM: Geodetic

NOTE: For abbreviations, symbols and descriptions refer to **LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY**

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	FEATURES
		Refer to previous page	355.53			
5–8	Rotary Drill, NQ Core	Gneiss Fresh Foliated Pink and black Medium grained Non-porous Strong	4.77	1		
				2	FR,PL,RO FR,ST,RO FO,PL,RO JN,PL,RO FO,IR,RO JN,UN,RO FO,PL,RO FR,IR,RO FO,PL,SM FR,IR,RO	UCS = 72.0 MPa
				3	FO,PL,RO FO,PL,RO JN,PL,RO JN,PL,RO JN,IR,RO FO,PL,RO FO,PL,RO	Broken core
8			352.27 8.03			
		END OF DRILLHOLE				

Column headings: DEPTH SCALE METRES; DRILLING RECORD; DESCRIPTION; SYMBOLIC LOG; ELEV. DEPTH (m); RUN No.; FLUSH RETURN; RECOVERY (TOTAL CORE %, SOLID CORE %; 80 60 40 20); R.Q.D. % (80 60 40 20); FRACT. INDEX PER (5 10 15 20); DIP w.r.t. CORE AXIS (0 30 60 90); DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION, Jr, Ja; HYDRAULIC CONDUCTIVITY K, cm/sec (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WEATHERING INDEX (W1 W2 W3 W4 W5 W6); FEATURES

Depth scale: 5, 6, 7, 8, 9, 10, 11, 12, 13, 14

GTA-RCK 031 C:\USERS\JMCCONNELL\DESKTOP\1671122.GPJ GAL-MISS.GDT 2/26/18 ZS

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MB
CHECKED: AK

Golder Associates

RECORD OF BOREHOLE No 17-13

SHEET 1 OF 1

METRIC

PROJECT 1671122			
G.W.P. 5186-14-00	LOCATION N 5151650.1; E 303078.7 MTM ZONE 10 (LAT. 46.504507; LONG. -79.522427)		ORIGINATED BY MB
DIST Northeast HWY 11	BOREHOLE TYPE Wash Boring, NQ Coring		COMPILED BY ZS
DATUM Geodetic	DATE August 24, 2017		CHECKED BY AK

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
360.5	GROUND SURFACE						
0.0	ASPHALT (150 mm)						
0.2	Sand to sand and gravel, some fines (FILL) Loose to very dense Brown to brown mottled black Moist to wet	1	SS	58		360	
		2	SS	100/0.10			
		3	SS	78		359	40 50 9 1
		4	SS	32	⊻	358	
356.9		5	SS	6		357	
3.7	BOULDER (540 mm)	-	RC	-			
356.3	COBBLE (200 mm)	-	RC	-			
4.4	SILT and SAND, trace gravel, trace clay Compact to dense Grey Wet	6	SS	26		356	
354.3		7	SS	39		355	5 39 54 2
		8	SS	100/0.05			
6.2	Gneiss (BEDROCK) Bedrock cored from depths of 6.2 m to 9.2 m For bedrock coring details refer to Record of Drillhole 17-13.	1	RC	REC 98%		354 353	RQD = 89%
351.3		2	RC	REC 100%		352	RQD = 95%
9.2	END OF BOREHOLE						

Notes:

1. "N" Value for sample "SS8" not representative of relative density due to spoon bouncing on bedrock surface.

2. Water level in open borehole after wash boring and prior to rock coring at a depth of 3.0 m below ground surface (Elev. 357.5 m).

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED; 20 40 60 80 100

PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

$+^3, \times^3$: Numbers refer to Sensitivity ○$^{3\%}$ STRAIN AT FAILURE

RECORD OF DRILLHOLE: 17-13

PROJECT: 1671122
SHEET 1 OF 1

LOCATION: N 5151650.1 ;E 303078.7
DRILLING DATE: August 24, 2017
DATUM: Geodetic

INCLINATION: -90° AZIMUTH: ---
DRILL RIG: NQ Coring
DRILLING CONTRACTOR: Landcore

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	ELEV. / DEPTH (m)	RUN No.	DISCONTINUITY DATA – TYPE AND SURFACE DESCRIPTION	FEATURES
		Refer to previous page	354.35			
7, 8, 9	Rotary Drill / NQ Core	Gneiss Fresh Foliated Pink and black Medium grained Non-porous Strong	6.17 … 351.30 / 9.22	1, 2	FR,PL,RO FR,IR,RO FO,PL,RO FO,PL,RO FO,PL,RO FO,PL,RO FO,PL,RO FR,PL,SM FR,ST,SM	Lost core UCS = 79.4 MPa
		END OF DRILLHOLE	9.22			

Column headings also include: SYMBOLIC LOG; FLUSH RETURN; RECOVERY (TOTAL CORE %, SOLID CORE %) 80 60 40 20; R.Q.D. % 80 60 40 20; FRACT. INDEX PER 5 10 15 20; DIP w.r.t. CORE AXIS 0 30 60 90; Jr; Ja; HYDRAULIC CONDUCTIVITY K, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WEATHERING INDEX W1 W2 W3 W4 W5 W6.

Depth scale: 7, 8, 9, 10, 11, 12, 13, 14, 15, 16

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: MB
CHECKED: AK

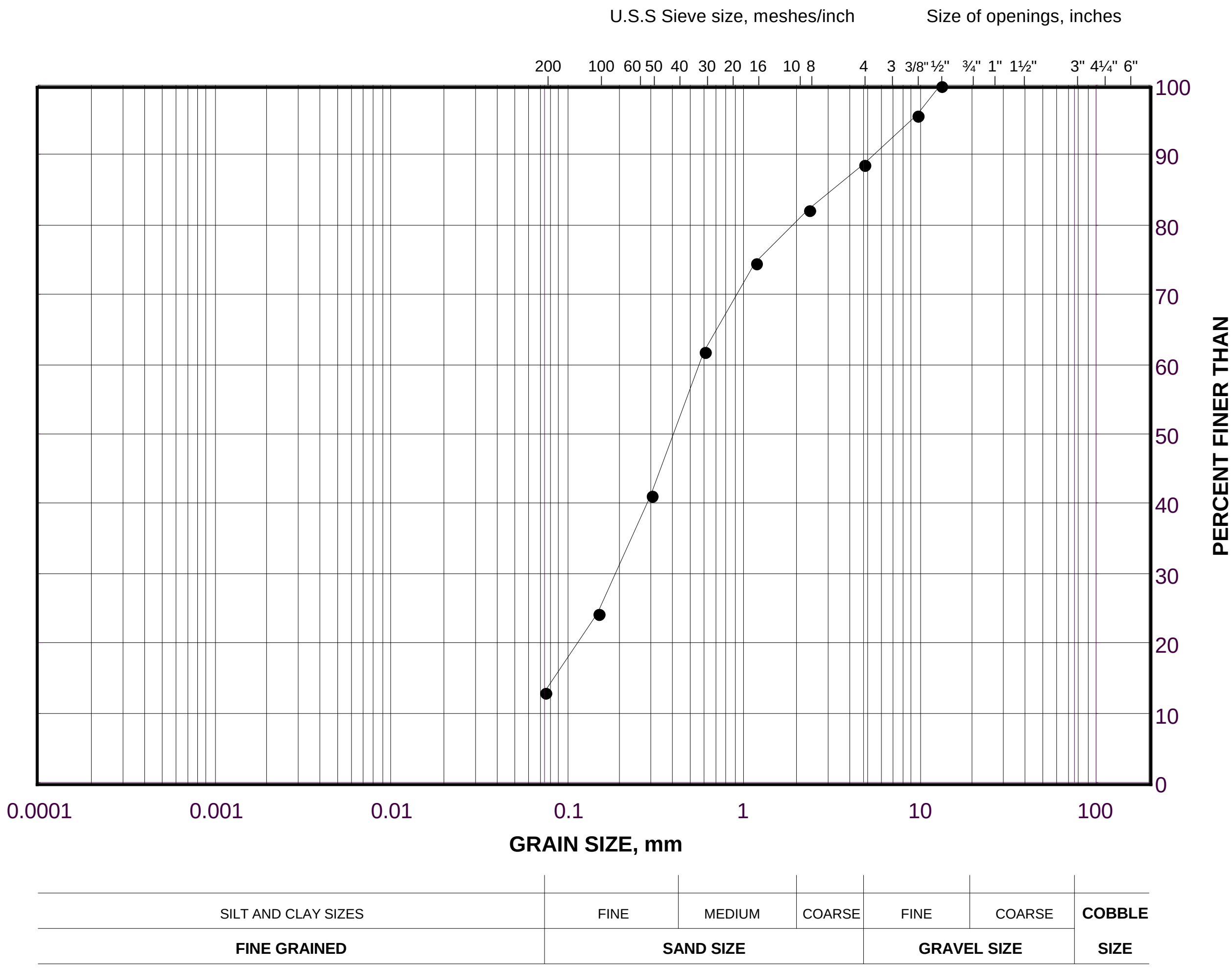
APPENDIX B

Laboratory Test Results

GRAIN SIZE DISTRIBUTION

SAND (FILL)

FIGURE B1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	17-12	1	359.50 - 358.90

Project Number: 1671122 2000/2300

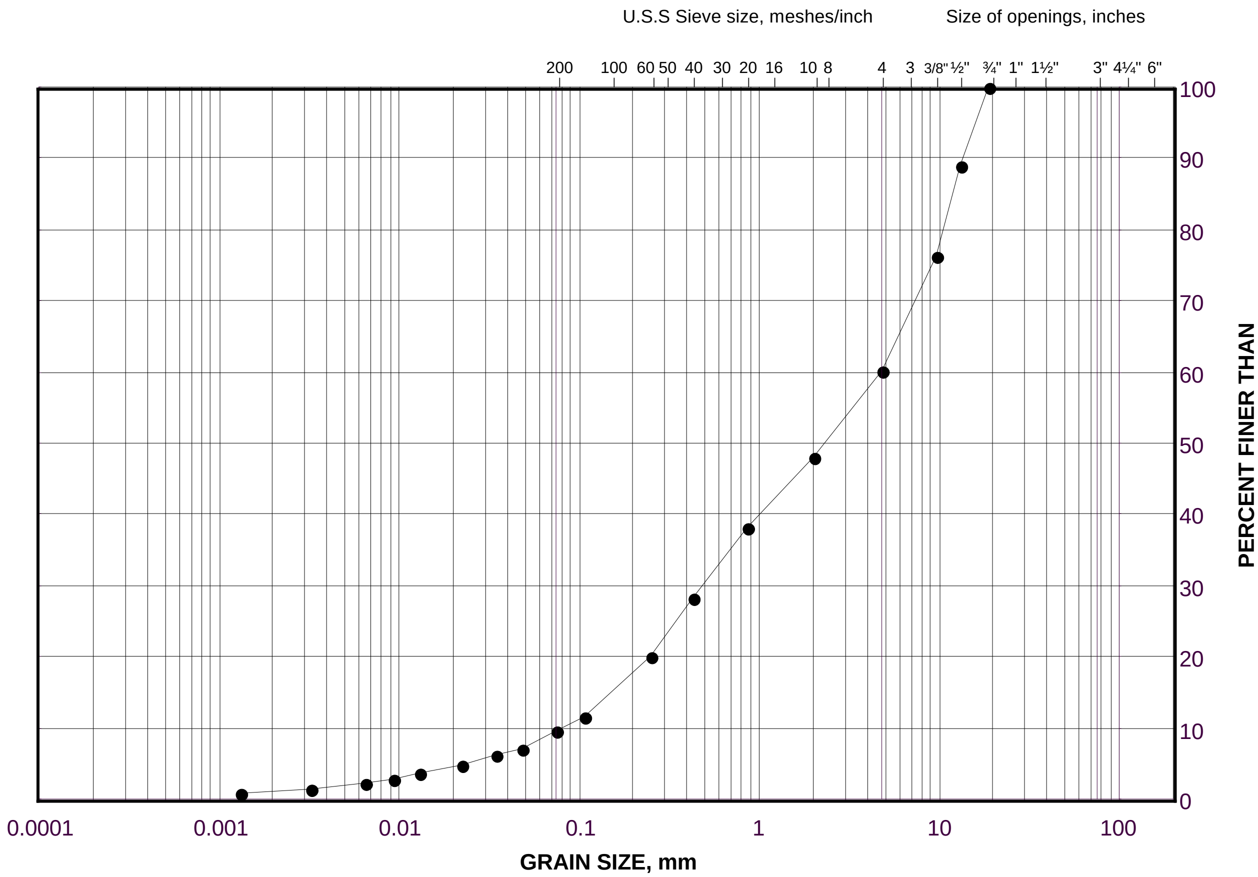
Checked By: JN

Golder Associates

Date: 30-Nov-17

GRAIN SIZE DISTRIBUTION
SAND and GRAVEL (FILL)

FIGURE B2



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	**COBBLE**
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	17-13	3	359.00 - 358.40

Project Number: 1671122 2000/2300

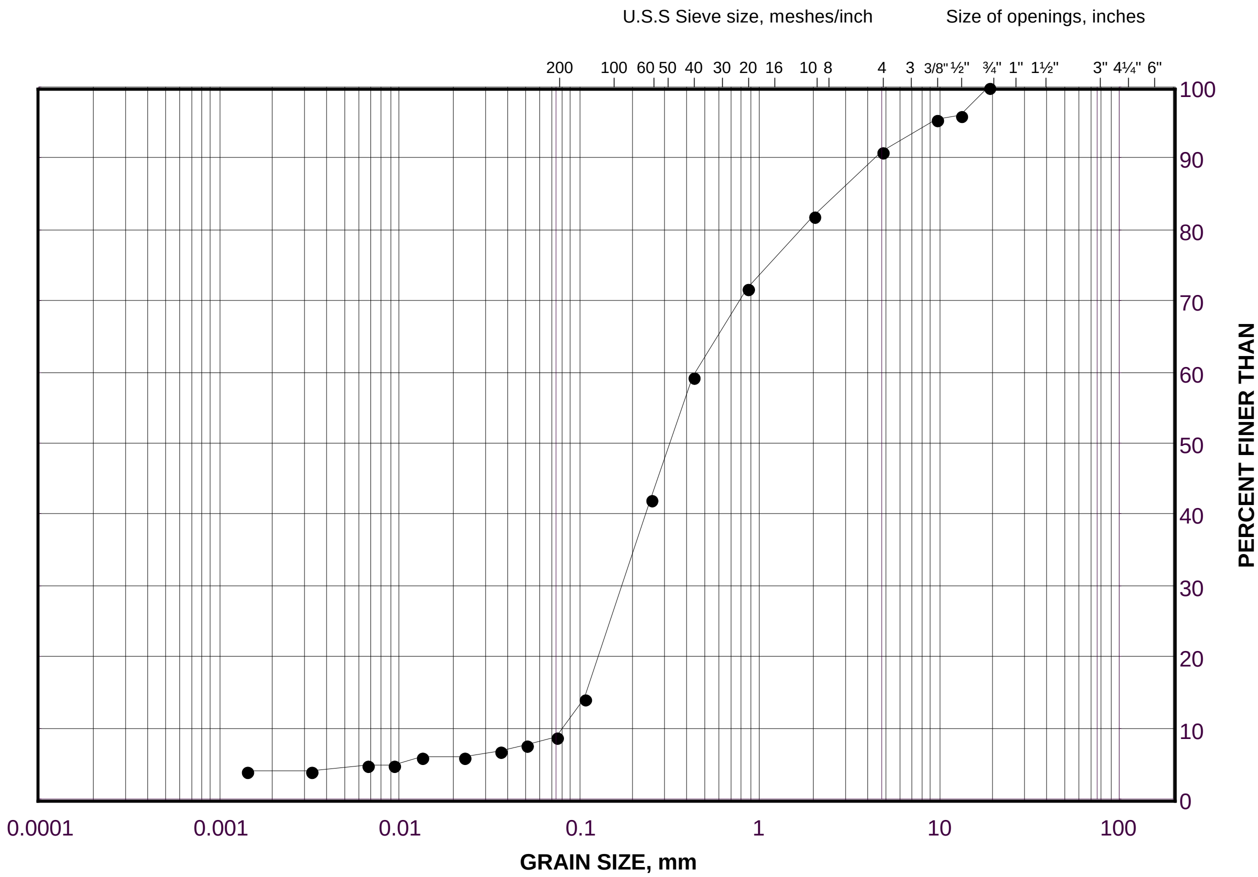
Checked By: JN

Golder Associates

Date: 30-Nov-17

GRAIN SIZE DISTRIBUTION
SAND

FIGURE B3



SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED	**SAND SIZE**			**GRAVEL SIZE**		**SIZE**

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	17-12	5	356.50 - 355.90

Project Number: 1671122 2000/2300

Checked By: JN

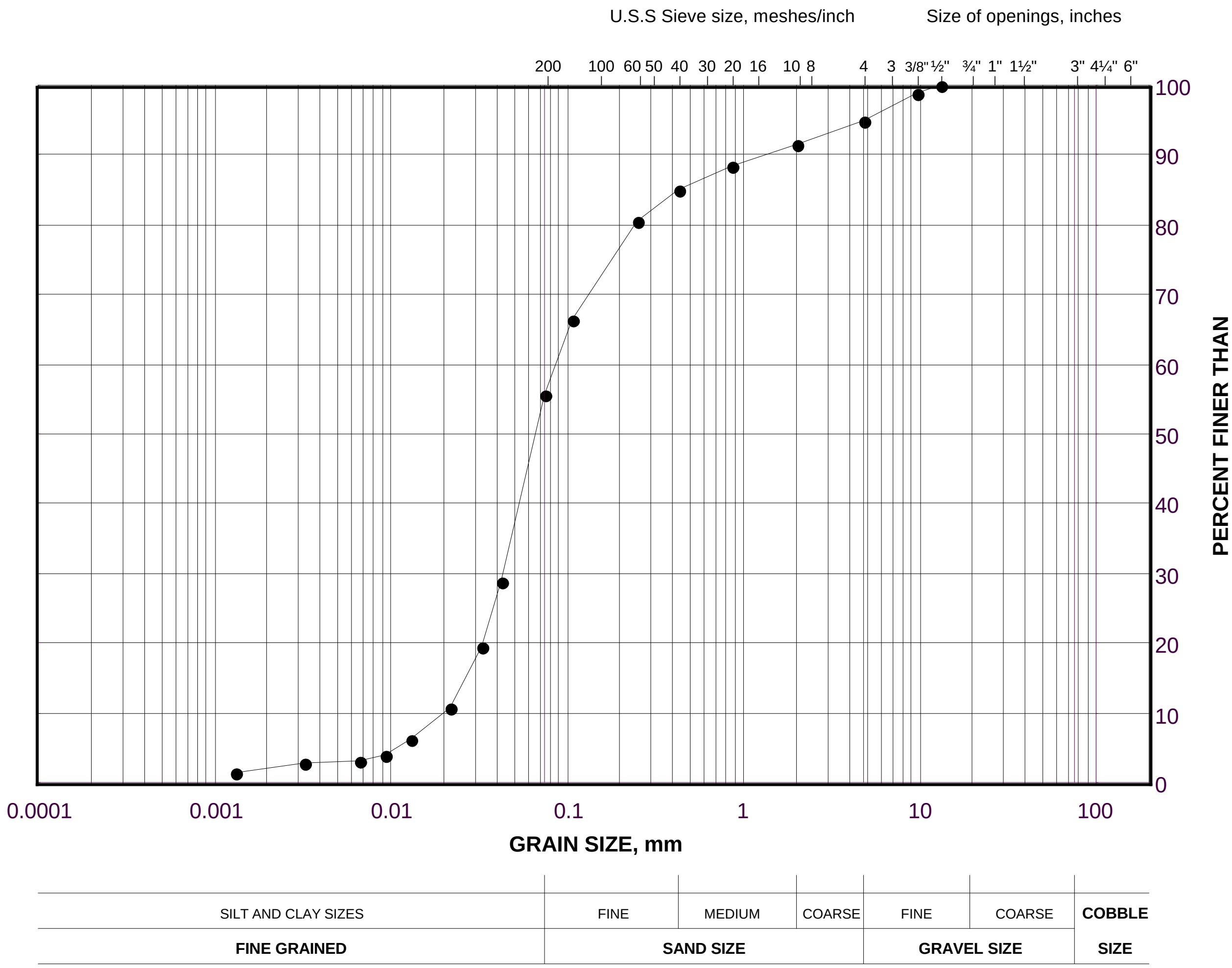
Golder Associates

Date: 30-Nov-17

GRAIN SIZE DISTRIBUTION

SILT and SAND

FIGURE B4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	17-13	7	355.20 - 354.60

Project Number: 1671122 2000/2300

Checked By: JN

Golder Associates

Date: 30-Nov-17

APPENDIX C

Bedrock Core Photographs

Box 1: 4.8 m to 8.0 m

Scale

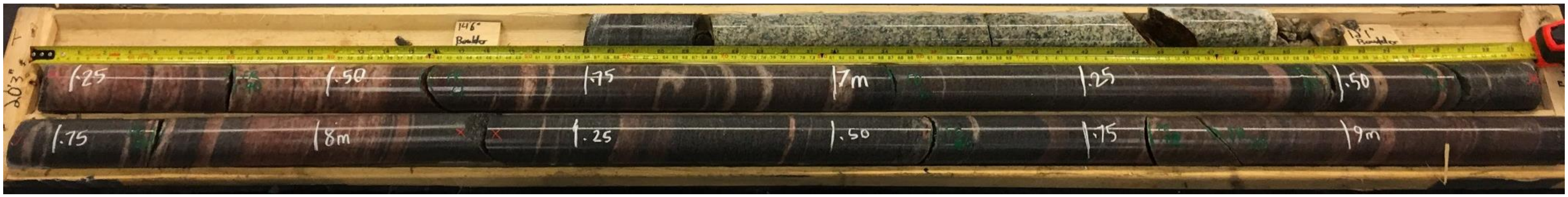
0 m — 0.40 m

0 ft — 1.0 ft — 2.0 ft

PROJECT					
MTO / 5016-E-0031 **Highway 11**					
TITLE: **Bedrock Core Photographs** **Borehole 17-12 6.2 m to 8.0 m**					
Golder Associates	PROJECT No. 1671122			FILE No. ----	
	DESIGN	DJ	20170913	SCALE NTS	VER. 1.
	CADD	--		**FIGURE C1**	
	CHECK	ACK	20180226		
	REVIEW	DPM	20180226		

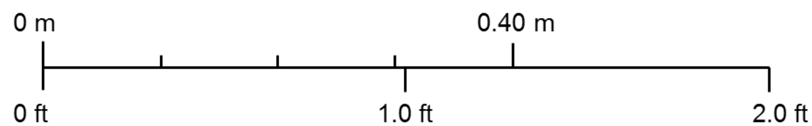
REVISION DATE: December 5, 2017 BY: AK Project: 1671122

Cobble Boulder



Box 1: 4.4 m to 9.2 m

Scale



PROJECT						
MTO / 5016-E-0031 **Highway 11**						
TITLE	**Bedrock Core Photographs** **Borehole 17-13 4.4 m to 9.2 m**					
Golder Associates	PROJECT No. 1671122			FILE No. ----		
	DESIGN	DJ	20170913	SCALE	NTS	VER. 1.
	CADD	--		**FIGURE C2**		
	CHECK	ACK	20180226			
	REVIEW	DPM	20180226			

REVISION DATE: December 5, 2017 BY: AK Project: 1671122

APPENDIX D

Non-Standard Special Provisions

OBSTRUCTIONS

Non-Standard Special Provision

The Contactor shall be alerted to the presence of potential cobbles and boulders within the embankment fill deposits and native sand deposits at this site as encountered during borehole advancement. Considerations of the presence of these obstructions must be made in the selection of appropriate equipment and procedures for excavation and installation of the temporary protection systems.

Basis of Payment

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

END OF SECTION

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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