

**FOUNDATION INVESTIGATION REPORT
HIGHWAY 416 - FALLOWFIELD ROAD
CULVERT REPLACEMENTS
OTTAWA, ON
GWP 4096-16-00
4015-E-0013
ASSIGNMENT #13**

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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

This section of the report presents the factual findings obtained from a foundation investigation completed for the proposed replacement of five CSP culverts at the Highway 416 Fallowfield Road Interchange within the City of Ottawa. Thurber Engineering Limited (Thurber) carried out the investigation as a sub-consultant to WSP | MMM Group (WSP | MMM) under MTO Agreement Number 4015-E-0013.

The purpose of this investigation was to explore the subsurface conditions at the sites and, based on the data obtained, to provide borehole location plans, records of boreholes, stratigraphic profiles, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction was developed in the course of the current investigation. No previous foundation investigation information was available for the subject culverts within the Geocres library.

2 SITE DESCRIPTION

The Highway 416 and Fallowfield Road interchange has an existing underpass structure that carries Fallowfield Road over Highway 416. For the purpose of this report, Highway 416 is assumed to run north-south and Fallowfield Road is assumed to run west-east. Fallowfield Road consists of two lanes of traffic in each direction, and Highway 416 is a four-lane (two lanes in each direction) rural divided freeway. The interchange also includes an off-ramp from each highway direction (S-E/W, N-E/W ramps) and two on-ramps for each highway direction (E-S, W-S, E-N, and W-N ramps).

The existing culverts are non-structural corrugated steel pipe (CSP) culverts with reported diameters ranging from 610 mm to 1105 mm and lengths between 23.1 m and 88.0 m.

The site lies within the physiographic region known as the Ottawa Valley Clay Plains. Locally, the bedrock is exposed at several locations along the ramps in the north-west quadrant of the interchange.

Culvert 1 conveys storm water beneath the E-N ramp and is located approximately 240 m north from the bullnose of the ramp/Fallowfield Road. The existing culvert is a non-structural corrugated steel pipe culvert. The culvert is reported to be 610 mm in diameter and approximately 31.0 m long with a generally south to north alignment. The invert of the existing culvert is reported to be at elevation 106.07 m and 105.14 m at the inlet and outlet respectively. The embankment fill height is in the order of 3.9 m with the road surface at

approximate elevation 110.10 m. The embankment sides are sloped at approximately 2H:1V and are vegetated with wild grass and brush. No evidence of settlement or stability concerns were noted.

Culvert 3B conveys storm water beneath the W-S ramp and is located approximately 360 m south of the bullnose of the ramp and Fallowfield Road underpass structure. The Culvert 3B outlet is in close proximity to the inlet of Culvert 3A. The existing culvert is a non-structural corrugated steel pipe culvert. The culvert is reported to be 800 mm in diameter and approximately 30.0 m long with a generally west to east alignment. The invert of the existing culvert is reported to be at elevation 109.23 m and 107.60 m at the inlet and outlet respectively. The embankment fill height is in the order of 4.0 m with the road surface at approximate elevation 112.70 m. The embankment sides are sloped at approximately 2H:1V and are vegetated with wild grass or brush. At the time of the investigation it was noted that there was some erosion of the slopes above the outlet.

Culvert 3A conveys storm water beneath the Highway 416 and the W-N ramp and is located approximately 120 m south of the Fallowfield Road underpass structure. Culvert 3A is constructed of two separate runs of non-structural corrugated steel pipe culvert connected at a catch basing located in the median ditch. The culverts are reported to be 660 mm in diameter at the inlet and 1105 mm at the outlet and approximately 77.8 m long in total with a generally west to east alignment. The invert of the existing culvert is reported to be at elevation 107.32 m and 105.34 m at the inlet and outlet respectively. The embankment fill height is in the order of 2.8 to 3.2 m with the road surface at approximate elevation 109.80 m. The embankment sides are sloped at approximately 2H:1V and are vegetated with wild grass. No evidence of settlement or stability concerns were noted.

Culvert 4 conveys storm water beneath the W-N ramp and S-E/W ramp and is located approximately 40 m south of the centreline of Fallowfield Road. Culvert 4 is constructed of two separate runs of non-structural corrugated steel pipe culvert connected at a catch basin located in the ditch between the two ramps. The culverts are reported to be 900 mm in diameter at the inlet and 1105 mm in diameter at the outlet and approximately 88.0 m in combined length with a generally west to east alignment. The invert of the existing culvert is reported to be at elevation 104.57 m and 102.22 m at the inlet and outlet respectively. The embankment fill heights are in the order of 6.0 to 6.5 m with the road surface at approximate elevation 109.30 m to 110.70 m. The embankment sides are sloped at approximately 2H:1V and are vegetated with wild grass.

Culvert 6 conveys storm water beneath the southbound Highway 416 to the median and is located approximately 180 m north of the centreline of Fallowfield Road underpass structure. The existing culvert is a non-structural corrugated steel pipe culvert. The culvert is reported to be 610 mm in diameter and approximately 23.1 m long with a generally west to east alignment. The invert of the existing culvert is reported to be at elevation 109.43 m and 109.08 m at the inlet and outlet respectively. The embankment fill height is in the order of 1.4 m with the road surface at approximate elevation 110.90 m. A rock cut approximately 2 m in height is present near the culvert inlet.

Select photographs showing the existing conditions in the area of the culverts are included in Appendix D for reference.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing program was carried out between March 27th and April 11th, 2017. The field investigation consisted of advancing sixteen boreholes identified as 1 through 16. The drilling was carried out using a combination of CME 45 track mounted drill and portable equipment for off-road boreholes, and a truck mounted CME 55 drill rig for the on-road boreholes. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). The boreholes were sampled to depths ranging from 4.1 to 10.7 m (elev. 98.2 to 105.5 m) below the existing ground surface.

The drilling and sampling operations were supervised on a full time basis by a member of Thurber's technical staff. The drilling supervisor logged the boreholes and processed the recovered soil samples for transport for further laboratory examination and testing.

To allow for measurements of the groundwater level after completion of drilling, a 19 mm diameter standpipe piezometer was installed in every inlet and outlet borehole, with the exception of Borehole 16. The piezometer installation details are illustrated on the respective Record of Borehole sheet, provided in Appendix B. Following completion of the field investigation the remaining boreholes were backfilled in general accordance with MOEE requirements (O.Reg. 903). Boreholes through the embankments were topped with cold patch asphalt to reinstate the traveling surface.

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawings included in Appendix A. The coordinates and elevation of the boreholes are provided on these drawings and on the individual Record of Borehole sheets. The following table summarizes which boreholes were drilled at which culvert locations.

| Culvert | Inlet Borehole | Embankment Borehole(s) | Outlet Borehole |
|---------|----------------|------------------------|-----------------|
| 1 | 1 | 2 | 3 |
| 3A | 9 | 4 and 5 | 6 |
| 3B | 7 | 8 | 9 |
| 4 | 10 | 11 and 12 | 13 |
| 6 | 14 | 15 | 16 |

4 LABORATORY TESTING

The recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to gradation analysis (hydrometer and/or sieve) and Atterberg Limit testing. The results of these tests are summarized on the Record of Borehole sheets included in Appendix B. Five samples of soil recovered from within the boreholes were selected and submitted for analytical testing of corrosivity parameters and sulphate content. All laboratory test results from the field investigation are provided in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata drawings included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following sections for each culvert site. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations.

5.1 Culvert 1 (E-N Ramp): Boreholes 1, 2 and 3

5.1.1 Pavement Structure and Embankment Fill

Asphalt:

Borehole 2 was drilled through the existing E-N Ramp embankment and encountered a surficial layer of asphalt with a thickness of 140 mm.

Rootmat:

A 75 mm thick layer of rootmat was encountered at surface near the inlet and outlet in Boreholes 1 and 3. Recorded moisture contents ranged from 32 to 48%.

Rockfill: Gravel/Cobbles with Sand and Silt:

Below the asphalt pavement in Borehole 2 was a layer of rockfill consisting of gravel and cobbles with sand and silt. The underside of the fill was at 4.7 m below the existing roadway surface (elev. 105.4 m).

The SPT tests conducted in the fill gave N-values ranging from 18 to 52 blows indicating a relative density of compact to very dense. Recorded moisture contents ranged from 3 to 8%. The results of grain size analyses conducted on two samples of the fill are summarized below and are illustrated on Figure C1 in Appendix C. It is noted that the recovered samples do not include cobbles and boulders and the results of grain size analyses only reflect the gradation of the recovered portion of the fill material

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel | 67 and 51 |
| Sand | 22 and 33 |
| Silt and Clay | 11 and 16 |

5.1.2 Silty Sand with Gravel (Till)

A native deposit of silty sand with gravel was encountered below the fill layers in Borehole 2 and below the surficial rootmat Boreholes 1 and 3. All three boreholes were terminated within this layer at elevations ranging from of 100.8 to 102.0 m. The SPT N-values ranged from 9 to greater than 100 blows per 300 mm and, in general, the layer is compact to very dense. In Borehole 1 and 2 this layer was noted to contain occasional to frequent cobbles. A clayey zone was encountered from 3.0 m to 3.8 m in Borehole 3.

The moisture content of the samples tested ranged from 14% to 19%. The results of grain size analyses conducted on four samples of the till are summarized below and are illustrated on Figure C2 in Appendix C.

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel | 15 - 30 |
| Sand | 43 - 52 |
| Silt and Clay | 24 - 33 |

Glacial tills inherently contain cobbles and boulders.

5.1.3 Bedrock

Bedrock was not encountered within the depth of investigation at this culvert site.

5.1.4 Groundwater

Water was flowing through the culvert at the time of the field investigation. Following the completion of drilling, a standpipe piezometer was installed in Boreholes 1 and 3. During a site visit on April 25, 2017 the groundwater in the standpipes were observed at the ground surface (elevation 106.4 m) and 0.2 m (elevation 105.1 m) below the ground surface in Boreholes 1 and 3 respectively.

These observations are considered short term and it should be noted that the groundwater level at the time of construction may vary and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

5.2 Culvert 3A (W-N Ramp and Highway 416): Boreholes 4, 5, 6 and 9

5.2.1 Pavement Structure and Embankment Fill

Asphalt:

Boreholes 4 and 5 were drilled through the existing Southbound and Northbound 416 embankment, respectively. A surficial layer of asphalt with a thickness of 200 mm was recorded in each roadway borehole.

Rootmat:

A 100 mm and 50 mm thick layer of rootmat was encountered at surface near the inlet and outlet in Boreholes 9 and 6, respectively. Recorded moisture contents ranged from 29 to 36%.

Silty Gravel with Sand Fill:

Below the asphalt pavement in Boreholes 4 and 5 was a layer of fill consisting of silty gravel with sand. In both boreholes, the underside of the silty gravel fill was 1.4 m below the existing roadway surface (elev. 108.4 m).

The SPT tests conducted in the gravel fill gave N-values ranging from 29 to 57 blows indicating a relative density of compact to very dense. Recorded moisture contents ranged from 2 to 6%. The results of grain size analyses conducted on two samples of the silty gravel with sand fill are summarized below and are illustrated on Figure C3 in Appendix C.

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel | 59 and 49 |
| Sand | 29 and 37 |
| Silt and Clay | 12 and 14 |

Rockfill:

Below the silty gravel fill in Boreholes 4 and 5 and below the rootmat in Borehole 6 was a layer of rockfill containing variable amounts of gravel, cobbles, sand and silt. The underside of the rockfill was at 2.7 m and 3.0 m (elev. 107.1 m and 106.7) below the existing roadway surfaces in Boreholes 4 and 5, respectively.

The SPT tests conducted in the rockfill gave N-values ranging from 35 to greater than 100 blows indicating a relative density of dense to very dense. Due to the presence of cobbles and boulders, Boreholes 5 and 6 were advanced with casing and coring techniques. Boulders as large as 360 mm were cored within the rockfill. Recorded moisture contents ranged from 7 to 11%. The results of grain size analyses conducted on three samples of the rockfill are summarized below and are illustrated on Figure C3 in Appendix C. It is noted that the recovered samples do not include cobbles and boulders and the results of grain size analyses only reflect the gradation of the recovered portion of the fill material

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel | 46 - 88 |
| Sand | 10 - 33 |
| Silt and Clay | 2 - 22 |

5.2.2 Sand with Gravel and Silt

A 0.3 m thick deposit of native sand with gravel and silt was encountered below the rockfill layer in Borehole 5 and below the rootmat in Borehole 9. The underside of the sand was at 3.3 m (elev. 106.5 m) below the existing roadway surface in Borehole 5 and at 0.4 m (elev. 107.3 m) below the ground surface in Borehole 9.

Recorded moisture contents were 7 and 9%. A single gradation analysis was completed on the sand with gravel and silt, and indicated a material with 39% gravel, 48% sand and 13% fines. The results of the grain size analysis are illustrated on Figure C5 in Appendix C.

5.2.3 Bedrock

The overburden materials were underlain by limestone bedrock. Boreholes 4, 5, 6 and 9 were advanced into the bedrock by coring. The bedrock surface ranges from elevation 105.2 to 107.3 m.

The Total Core Recovery (TCR) ranged from 94 to 100%, the Solid Core Recovery (SCR) ranged from 45 to 100% and the Rock Quality Designation (RQD) ranged from 22 to 100%. Based on the RQD value the bedrock is classified as poor to excellent quality. Unconfined Compressive Strength tests indicated a compressive strength of 159 to 162 MPa. Unconfined Compressive Strengths interpreted from point load tests indicate a very strong rock.

5.2.4 Groundwater

The culvert outlet was partially submerged at the time of the field investigation. Following the completion of drilling a standpipe piezometer was installed in Borehole 6. During a site visit on April 25, 2017 the groundwater in the standpipe was observed at 0.02 m (elevation 106.4 m) below the ground surface.

These observations are considered short term and it should be noted that the groundwater level at the time of construction may vary and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

5.3 Culvert 3B (E-S Ramp): Boreholes 7, 8 and 9

5.3.1 Pavement Structure and Embankment Fill

Asphalt:

Borehole 8 was drilled through the existing E-S Ramp embankment and encountered a surficial layer of asphalt with a thickness of 150 mm.

Rootmat:

A 50 mm and 100 mm thick layer of rootmat was encountered at surface near the inlet in Borehole 7 and outlet in Borehole 9. The moisture content of a single sample was recorded at 29%.

Sand with Gravel Fill:

Below the asphalt pavement in Borehole 8 was a layer of fill consisting of sand with gravel. The underside of the sand with gravel fill was at 0.8 m depth below the existing roadway surface (elev. 111.9 m).

A single SPT test conducted in the sand with gravel fill gave a N-value of 58 blows indicating a very dense relative density. A single moisture content was recorded at 5%.

Gravel with Sand and Silt Fill:

Below the sand with gravel fill in Borehole 8 was a layer of fill consisting of gravel with sand and silt. The underside of the gravel fill was 2.1 m (elev. 110.5 m) below the existing roadway surface.

The SPT tests conducted in the fill gave N-values of 21 and 33 blows indicating a relative density of compact to dense. Recorded moisture contents were 7 and 8%. A single gradation analysis was completed on the gravel fill and indicated a material with 72% gravel, 22% sand and 6% fines. The results of the grain size analysis is illustrated on Figure C4 in Appendix C.

Gravel/Cobbles Fill with Sand:

Below the gravel fill in Borehole 8 and below the rootmat in Borehole 7 was a layer of fill consisting of silty gravel and cobbles with sand. The underside of the gravel and cobble fill was at 4.4 m (elev. 108.3 m) below the existing roadway surface in Borehole 8 and at 1.0 m (elev. 108.7 m) below the ground surface in Borehole 7.

The SPT tests conducted in the fill gave N-values ranging from 5 to 26 blows indicating a relative density of compact. Recorded moisture contents ranged from 9 to 13%. The results of grain size analyses conducted on two samples of the gravel and cobble fill are summarized below and are illustrated on Figure C4 in Appendix C. It is noted that the recovered samples did not include cobbles and boulders and the results of grain size analyses only reflect the gradation of the recovered portion of the fill material

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel | 47 and 48 |
| Sand | 33 and 34 |
| Silt and Clay | 20 and 18 |

5.3.2 Gravel with Sand and Silt to Sand with Gravel and Silt

A deposit of gravel with sand and silt to sand with gravel and silt was encountered below the fill in Boreholes 7 and 8 and below the rootmat in Borehole 9. This layer has a thickness ranging from 0.3 m to 1.5 m with an underside elevation of 106.7 to 107.7 m. Due to the presence of cobbles and boulders, Boreholes 7, 8 and 9 were advanced through this material with casing and coring techniques. Boulders as large as 250 mm were cored within the this layer.

The SPT tests conducted in the fill gave N-values of greater than 100 blows indicating a relative density of very dense. Recorded moisture contents ranged from 7 to 8%. A single gradation analysis was completed on the sand with gravel and silt and indicated a material with 39% gravel, 48% sand and 13% fines. The results of the grain size analysis is illustrated on Figure C5 in Appendix C.

5.3.3 Bedrock

The overburden materials were underlain by limestone bedrock. Boreholes 7, 8 and 9 were advanced into the bedrock by coring. The bedrock surface ranges from elevation 106.7 to 107.7 m.

The Total Core Recovery (TCR) ranged from 96 to 100%, the Solid Core Recovery (SCR) ranged from 85 to 100% and the Rock Quality Designation (RQD) ranged from 59 to 100%. Based on the RQD value the bedrock is classified as fair to excellent quality.

5.3.4 Groundwater

Water was flowing through the culvert at the time of the field investigation. Following the completion of drilling, a standpipe piezometer was installed in Boreholes 7 and 9. During a

site visit on April 25, 2017 the groundwater in the standpipes were observed at 0.25 m below the ground surface (elevation 109.5m) and 0.14 m above the ground surface (elevation 107.8 m) in Boreholes 7 and 9 respectively.

These observations are considered short term and it should be noted that the groundwater level at the time of construction may vary and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

5.4 Culvert 4 (W-N Ramp and S-E/W Ramp): Boreholes 10, 11, 12 and 13

5.4.1 Pavement Structure and Embankment Fill

Asphalt:

Boreholes 11 and 12 were drilled through the existing W-N Ramp and S-E/W ramp embankments and encountered a surficial layer of asphalt with a thickness of 175 mm and 125 mm, respectively.

Rootmat:

A 50 mm thick layer of rootmat was encountered at the surface near the inlet and outlet in Boreholes 10 and 13.

Gravel with Sand and Silt to Silty Gravel with Sand Fill:

Below the asphalt pavement in Borehole 11 and 12 was a fill material consisting of predominantly gravel. This fill layer contained occasional cobbles. The underside of the fill was at 7.8 m and 6.9 m depths (elev. 102.9 m and 102.5) below the existing roadway surface in Boreholes 11 and 12 respectively.

The SPT tests conducted in the fill gave N-values ranging from 8 to greater than 100 blows indicating a relative density of loose to very dense, although most of the fill is in a compact to dense state. Recorded moisture contents ranged from 2 to 22%. The results of grain size analyses conducted on five samples of the gravel fill are summarized below and are illustrated on Figure C6 in Appendix C.

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel | 38 - 76 |
| Sand | 19 - 39 |
| Silt and Clay | 5 - 23 |

5.4.2 Clay

A native deposit of clay with variable amounts of sand and gravel was encountered below the fill in Borehole 12 and below the surficial rootmat in Borehole 13. This layer has a thickness of 2.2 m with an underside elevation of 100.2 to 100.3 m.

The SPT tests conducted in the clay gave N-values ranging from 3 to 22 blows indicating a soft to very stiff state. One N-value of greater than 100 blows was encountered in Borehole 13 likely due to the presence of occasional cobbles within the stratum. Recorded moisture

contents ranged from 18 to 37%. The results of grain size analyses conducted on two samples of the clay are summarized below and are illustrated on Figure C7 in Appendix C.

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel | 3 and 19 |
| Sand | 33 and 18 |
| Silt | 42 and 32 |
| Clay | 22 and 31 |

Atterberg Limit testing was completed on two samples of the clay. The results are summarized on the Record of Borehole sheets in Appendix B and the Atterberg Limit graphs are included in Figure C10 of Appendix C. The laboratory results are summarized below and indicate that the clay exhibits low to intermediate plasticity (CL to CI).

| Parameter | Value |
|------------------|-----------|
| Liquid Limit | 29 and 42 |
| Plastic Limit | 16 and 20 |
| Plasticity Index | 22 and 13 |

5.4.3 Silty Sand

A native deposit of Silty Sand with variable amounts of gravel, cobbles, and boulders was encountered in all boreholes. Boulder sizes ranged from 510 to 685 mm. This layer was found below the fill in Borehole 11, and below the clay in Borehole 12 and 13, and below the surficial rootmat in Boreholes 10. All four boreholes were terminated within this layer at elevations of 98.2 to 100.9 m. The SPT N-values ranged from 3 to greater than 100 blows per 300 mm. The deposit is generally dense to very dense.

The moisture content of the samples tested ranged from 8% to 22%. The results of grain size analyses conducted on four samples of the native silty sand are summarized below and are illustrated on Figure C8 in Appendix C.

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel | 17 - 37 |
| Sand | 40 - 49 |
| Silt and Clay | 23 - 34 |

5.4.4 Bedrock

Bedrock was not encountered within the depth of investigation at this culvert site.

5.4.5 Groundwater

Water was flowing through the culvert at the time of the field investigation. Following the completion of drilling, a standpipe piezometer was installed in Boreholes 10 and 13. During a site visit on April 25, 2017 the groundwater in the standpipes were observed at 0.27 m

below the ground surface (elevation 102.3m) and 0.09 m above the ground surface (elevation 105.2 m) in Boreholes 13 and 10 respectively.

These observations are considered short term and it should be noted that the groundwater level at the time of construction may vary and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

5.5 Culvert 6 (Highway 416 Southbound): Boreholes 14, 15 and 16

5.5.1 Pavement Structure and Embankment Fill

Asphalt:

Borehole 15 was drilled through the existing southbound median paved shoulder encountered a surficial layer of asphalt with a thickness of 50 mm.

Silty Sand with Gravel Fill:

Below the asphalt pavement in Borehole 15 was a layer of fill consisting of silty sand with gravel. The underside of the silty sand fill was at 0.9 m depth below the existing roadway surface (elev. 110.0 m).

The SPT tests conducted in the silty sand fill gave N-value of 24 blows indicating a relative density of compact. A single moisture content was recorded at 4%. A single gradation analysis was completed on the silty sand fill and indicated a material with 40% gravel, 48% sand and 12% fines. The results of the grain size analysis is illustrated on Figure C9 in Appendix C.

Rock Shatter Fill:

Below the silty sand fill in Borehole 15 and at surface in Borehole 14 was a layer of rock shatter fill containing gravel and cobble sized particles. This layer has a thickness ranging from 0.9 m to 1.3 m with an underside elevation of 108.6 to 108.7 m.

The SPT tests conducted in the rock shatter fill gave N-values of 13 to greater than 100 blows indicating a relative density of compact to very dense. Recorded moisture contents ranged from 9 to 11%. The results of grain size analyses conducted on two samples of the rock shatter fill are summarized below and are illustrated on Figure C9 in Appendix C. It is noted that the recovered samples did not include cobbles and boulder sizes and the results of grain size analyses only reflect the gradation of the recovered portion of the fill material

| Soil Particle | Percentage (%) |
|---------------|----------------|
| Gravel | 68 and 69 |
| Sand | 28 and 28 |
| Silt and Clay | 4 and 3 |

5.5.2 Clay with Gravel

A 0.5 m thick deposit of clay with gravel was encountered at surface in Borehole 16. This material was noted to contain frequent cobbles and boulders. A single SPT test conducted in the clay with gravel gave a N-value of greater than 100 blows. The N-value of greater than 100 blows was due to the presence of cobbles and boulder within the stratum. A single moisture content was recorded at 36%.

5.5.3 Bedrock

The overburden materials were underlain by limestone bedrock. Boreholes 14, 15 and 16 were advanced into the bedrock by coring. The bedrock surface ranges from elevation 108.6 to 109.0 m.

The Total Core Recovery (TCR) ranged from 94 to 100%, the Solid Core Recovery (SCR) ranged from 81 to 100% and the Rock Quality Designation (RQD) ranged from 26 to 95%. Based on the RQD value the bedrock is classified as poor to excellent quality. Unconfined Compressive Strength tests indicated a compressive strength of 143 to 168 MPa. Unconfined Compressive Strengths interpreted from point load tests indicate a very strong rock.

5.5.4 Groundwater

Following the completion of drilling, a standpipe piezometer was installed in Borehole 14. During a site visit on April 25, 2017 the groundwater in the standpipe was observed at 0.13 m below the ground surface (elevation 109.4m).

These observations are considered short term and it should be noted that the groundwater level at the time of construction and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation events.

5.6 Analytical Testing

Four samples of soil were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate and chloride concentrations, and resistivity. The analysis results are summarized in the table below:

| Borehole | Sample | Depth (m) | Sulphate (µg/g) | pH (-) | Resistivity (Ohm-cm) | Chloride (µg/g) |
|----------|--------|-----------|-----------------|--------|----------------------|-----------------|
| 1 | SS2 | 0.8 – 1.4 | 33 | 7.7 | 2960 | 120 |
| 7 | SS1B | 0.1 – 0.6 | 9 | 7.8 | 2700 | 148 |
| 13 | SS1 | 0 – 0.6 | 47 | 7.7 | 1350 | 239 |
| 16 | SS1 | 0 – 0.4 | 36 | 7.5 | 1760 | 189 |

6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features and the anticipated foundation locations. The as-drilled locations and ground surface elevation were surveyed by MMM following completion of the field program.

Marathon Drilling of Greely, Ontario supplied and operated the drilling equipment to conduct the drilling, soil sampling, in-situ testing and borehole decommissioning. The field investigation was supervised on a full time basis by Mr. Chris Murray, E.I.T., Justin Gray, E.I.T., Mr. Nick Weil, and Mr. Sean O'Bryan of Thurber. Overall supervision of the investigation program was conducted by Mr. Shawn Lapain, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa, Ontario. Interpretation of the factual data and preparation of this report were carried out by Mr. Justin Gray, E.I.T. and Mr. Paul Carnaffan P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundation Projects.



Justin Gray, E.I.T.
Geotechnical Engineer-In-Training



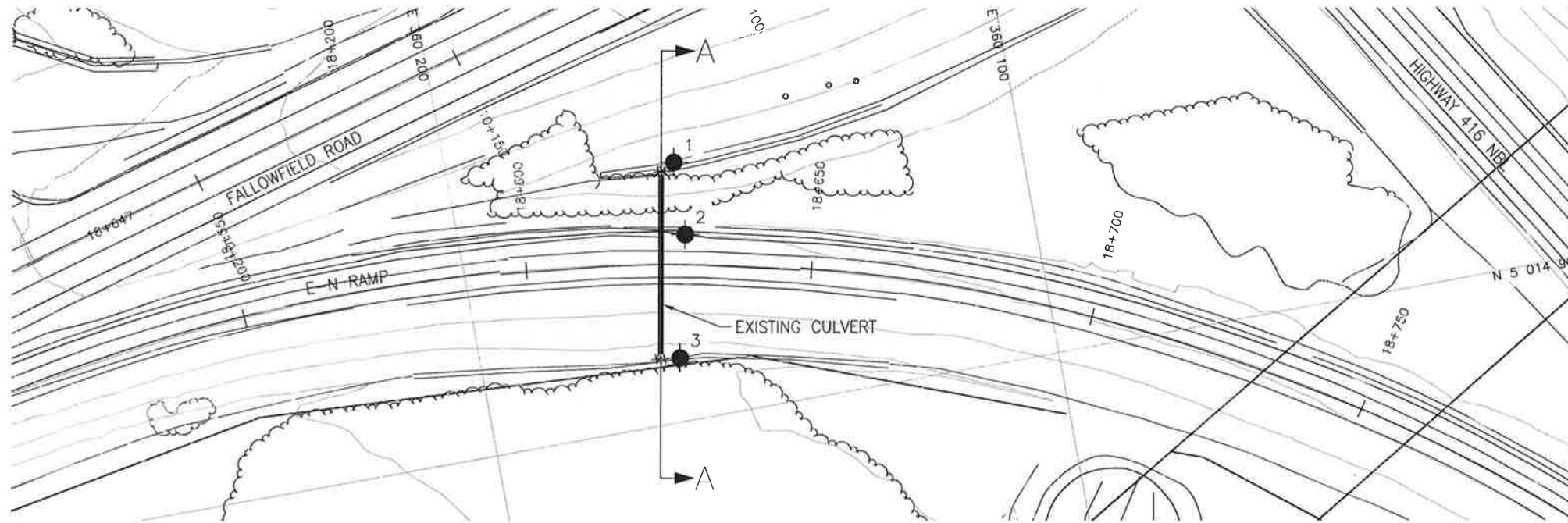
Paul Carnaffan, P.Eng.
Principal
Senior Geotechnical Engineer



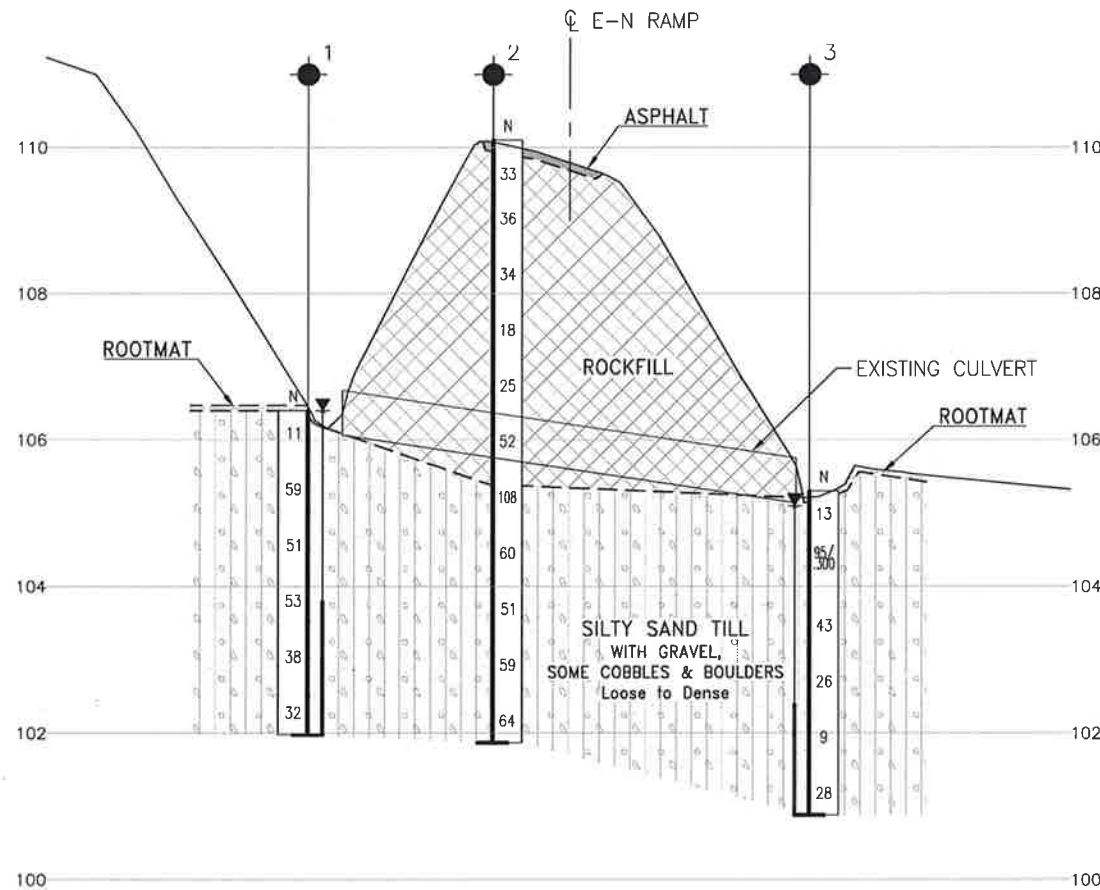
Dr. P.K. Chatterji, P.Eng.
Review Principal
Senior Geotechnical Engineer

Appendix A.

Borehole Location Plan and Stratigraphic Drawings



PLAN
SCALE 1:1000



SECTION A-A

SCALE 1:500
SCALE 1:100



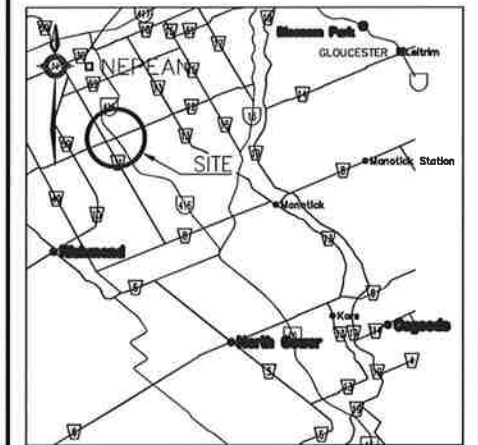
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 4096-16-00

HWY 416/FALLOWFIELD RD
E-N RAMP
CULVERT C1
BOREHOLE LOCATIONS AND SOIL STRATA



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

| | |
|------|---------------------------------------|
| ● | Borehole |
| ⊙ | Borehole and Cone |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
| ▽ | Water Level |
| ▽ | Head Artesian Water |
| ⊥ | Piezometer |
| 90% | Rock Quality Designation (RQD) |
| A/R | Auger Refusal |

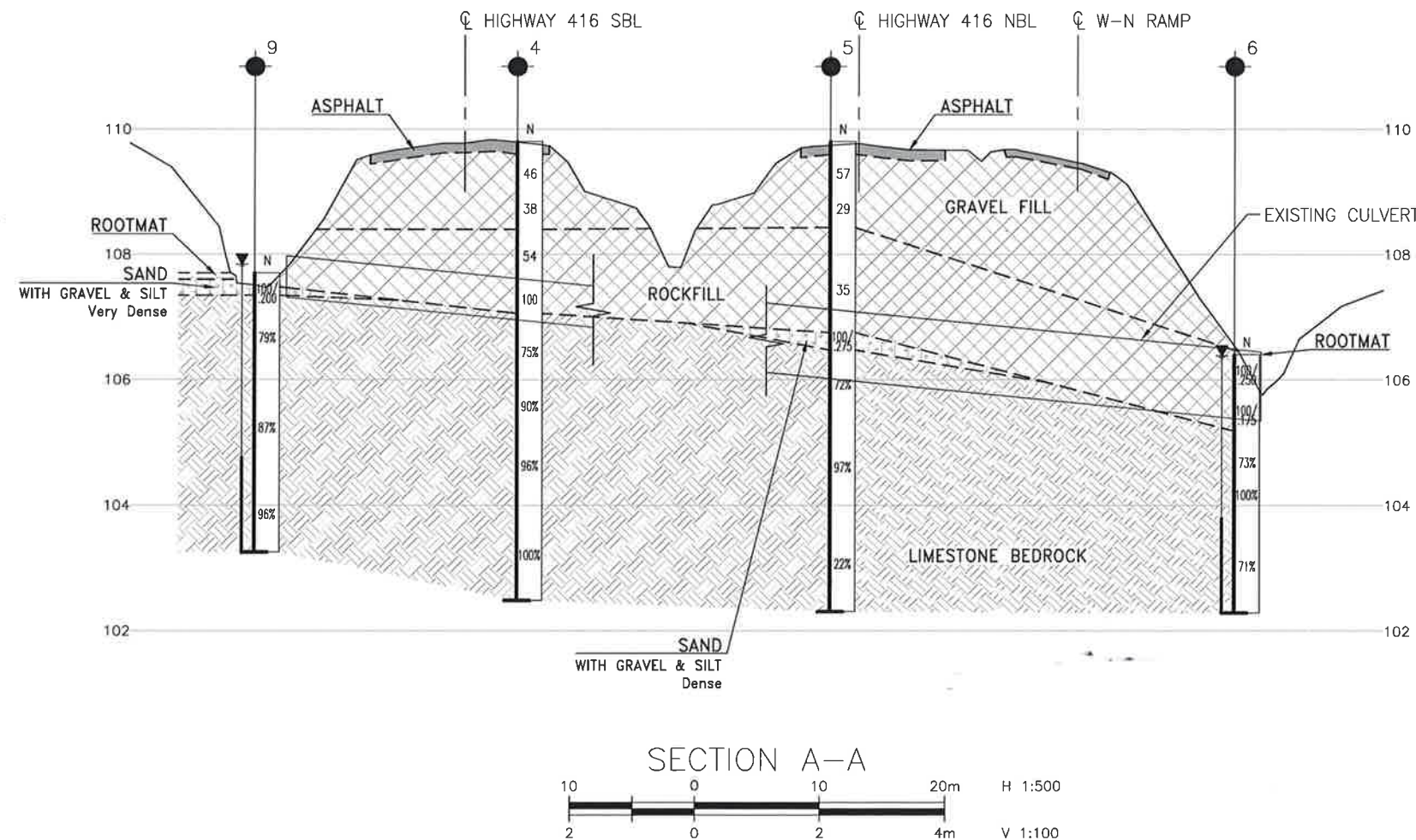
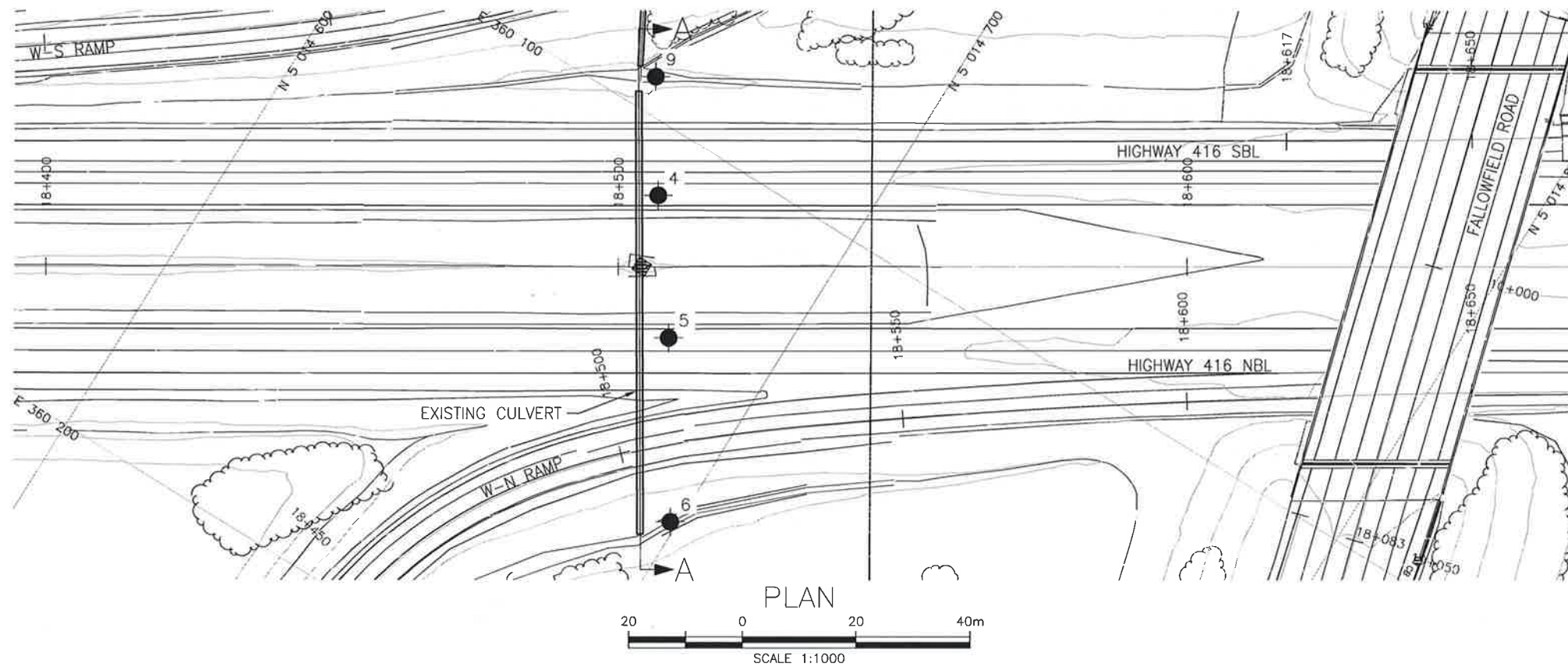
| NO | ELEVATION | NORTHING | EASTING |
|----|-----------|-------------|-----------|
| 1 | 106.4 | 5 014 854.9 | 360 160.5 |
| 2 | 110.1 | 5 014 867.7 | 360 160.7 |
| 3 | 105.3 | 5 014 888.9 | 360 165.5 |

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31G5-281

| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|--------|---------------|
| DESIGN | JG | CHK PC | CODE |
| DRAWN | MFA | CHK JG | SITE |
| | | | LOAD |
| | | | STRUCT |
| | | | DWG 1 |
| | | | DATE AUG 2017 |



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 4096-16-00

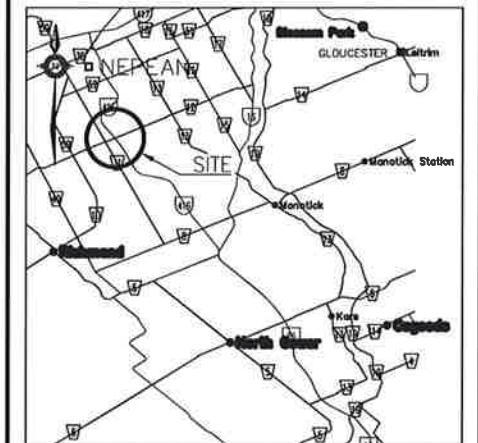
HWY 416/FALLOWFIELD RD
SBL, NBL AND W-N RAMP
CULVERT C3A
BOREHOLE LOCATIONS AND SOIL STRATA



MMM GROUP



THURBER ENGINEERING LTD.



LEGEND

| | |
|------|---------------------------------------|
| ● | Borehole |
| ⊕ | Borehole and Cone |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60' Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
| ▽ | Water Level |
| ▽ | Head Artesian Water |
| ⊥ | Piezometer |
| 90% | Rock Quality Designation (RQD) |
| A/R | Auger Refusal |

| NO | ELEVATION | NORTHING | EASTING |
|----|-----------|-------------|-----------|
| 4 | 109.8 | 5 014 666.7 | 360 111.3 |
| 5 | 109.8 | 5 014 681.5 | 360 131.6 |
| 6 | 106.4 | 5 014 698.8 | 360 158.8 |
| 9 | 107.7 | 5 014 655.3 | 360 093.8 |

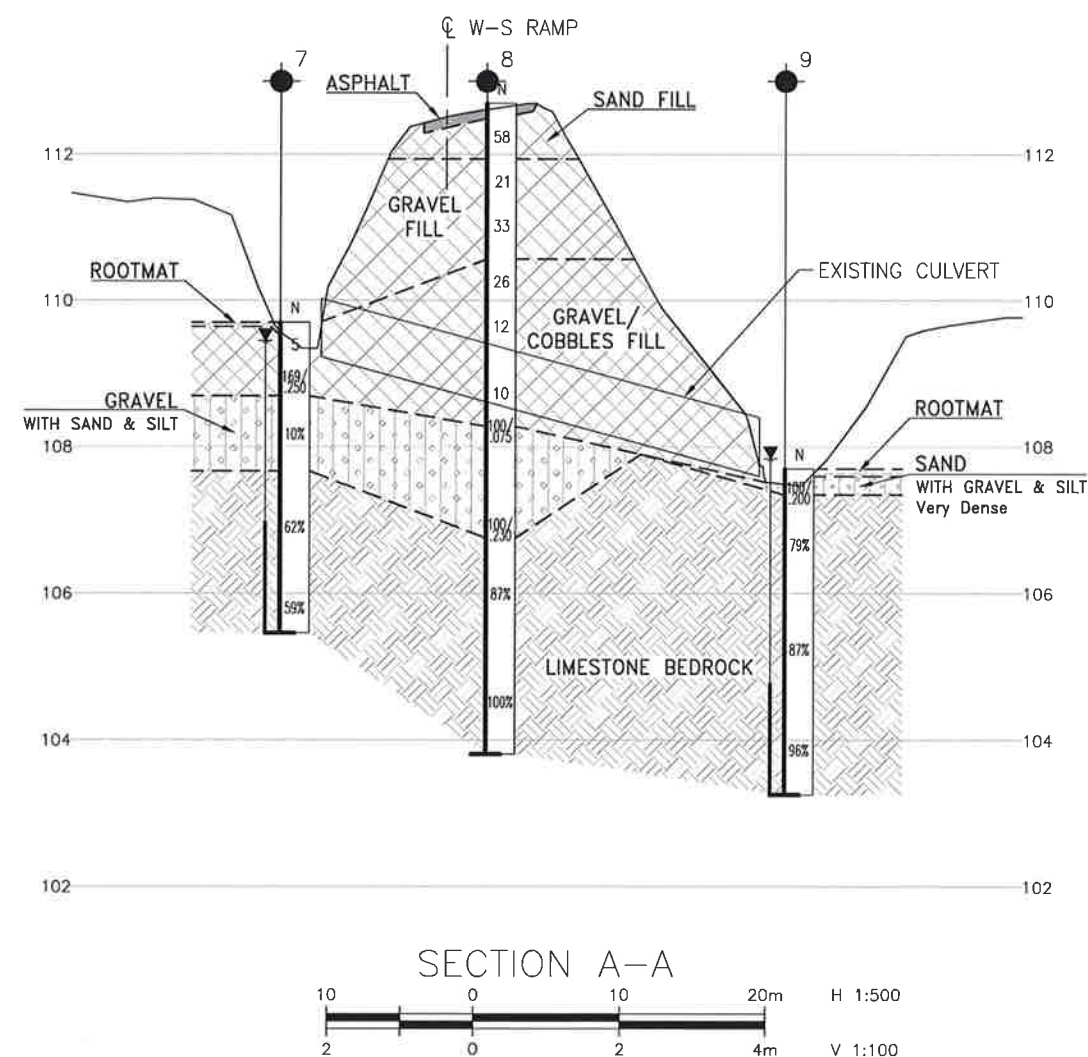
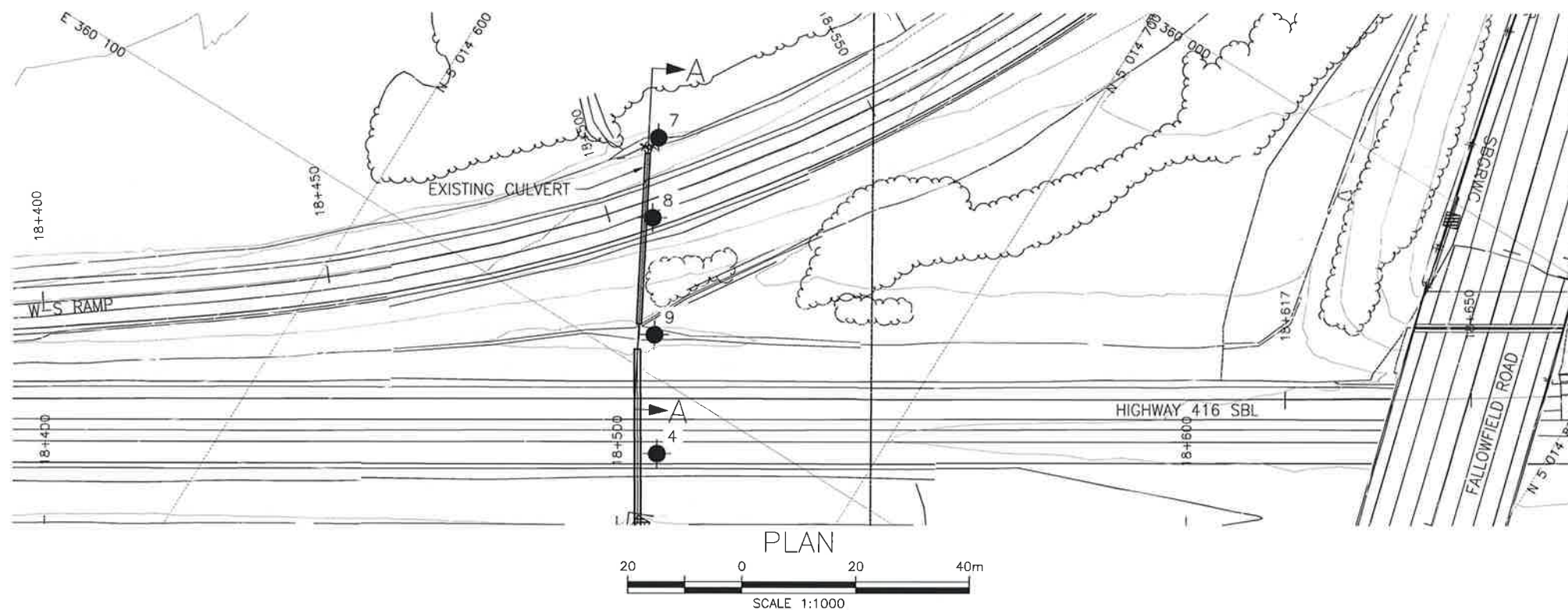
NOTES-

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- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31G5-281



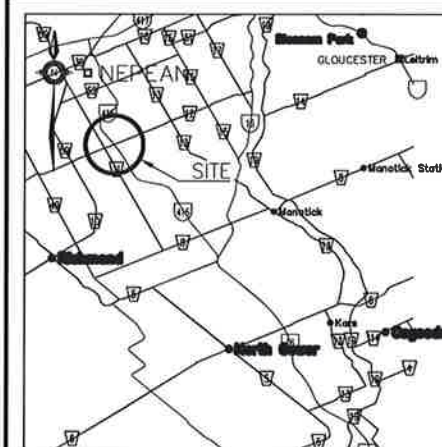
| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|--------|-------------|
| DESIGN | JG | CHK PC | CODE |
| DRAWN | MFA | CHK JG | SITE |
| | | | STRUCT |
| | | | DWG 1 |








METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 4096-16-00

HWY 416/FALLOWFIELD RD
W-S RAMP
CULVERT C3B
BOREHOLE LOCATIONS AND SOIL STRATA



KEYPLAN
LEGEND

| | |
|---|---------------------------------------|
|  | Borehole |
|  | Borehole and Cone |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60' Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
|  | Water Level |
|  | Head Artesian Water |
|  | Piezometer |
| 90% | Rock Quality Designation (RQD) |
| A/R | Auger Refusal |

[illegible]

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31G5-281



| | | | | | | | | | |
|-----------|------|-----|-------------|------|--------|------|----------|--|--|
| REVISIONS | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | DATE | BY | DESCRIPTION | | | | | | |
| DESIGN | JG | CHK | PC | CODE | LOAD | DATE | AUG 2017 | | |
| DRAWN | MFA | CHK | JG | SITE | STRUCT | IDWG | 1 | | |

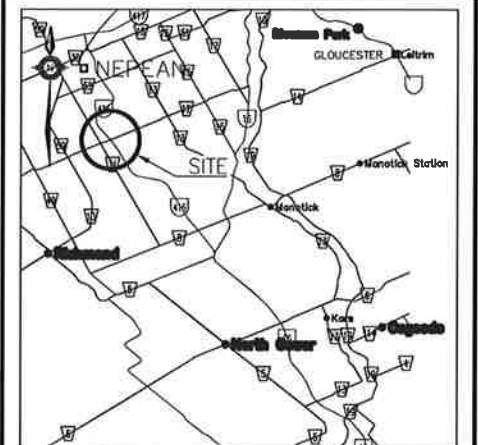
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 4096-16-00

HWY 416/FALLOWFIELD RD
W-N AND S-EW RAMP
CULVERT C4
BOREHOLE LOCATIONS AND SOIL STRATA



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

| | |
|------|---------------------------------------|
| ● | Borehole |
| ⊕ | Borehole and Cone |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60' Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
| ▽ | Water Level |
| ⌵ | Head Artesian Water |
| ⌵ | Piezometer |
| 90% | Rock Quality Designation (RQD) |
| A/R | Auger Refusal |

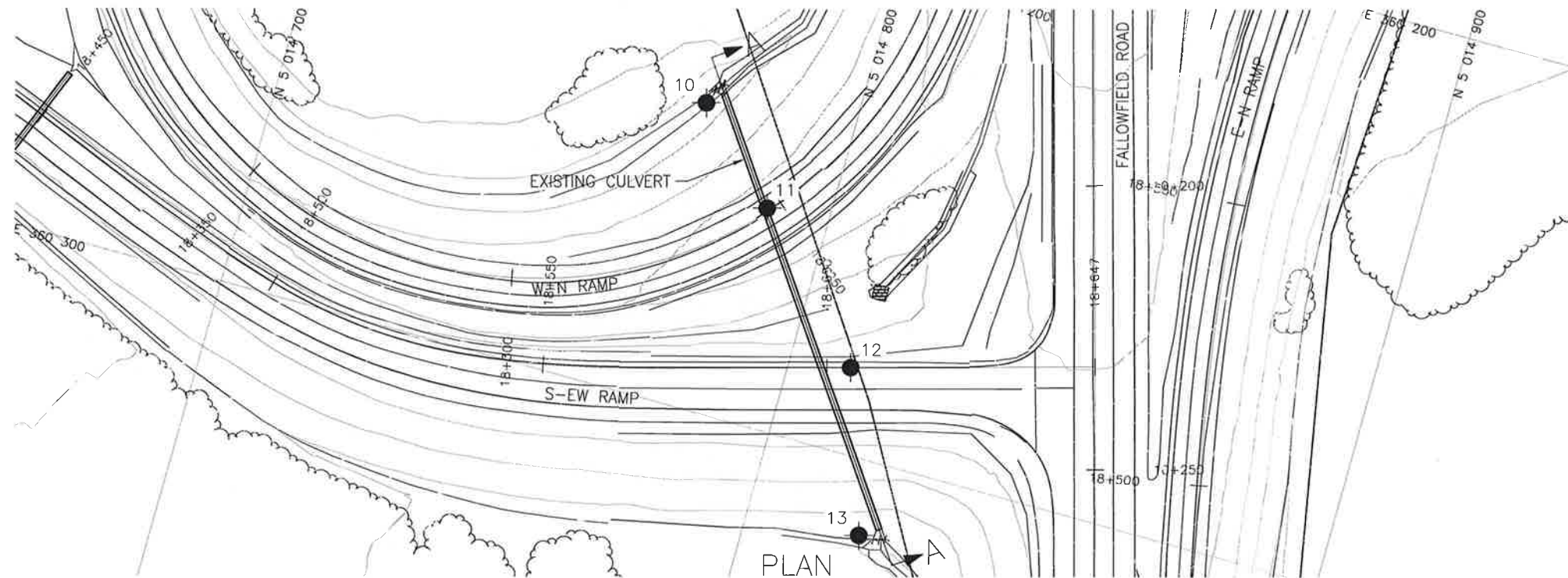
| NO | ELEVATION | NORTHING | EASTING |
|----|-----------|-------------|-----------|
| 10 | 105.1 | 5 014 773.6 | 360 246.9 |
| 11 | 110.7 | 5 014 789.0 | 360 261.9 |
| 12 | 109.3 | 5 014 810.7 | 360 285.0 |
| 13 | 102.6 | 5 014 820.0 | 360 313.1 |

-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

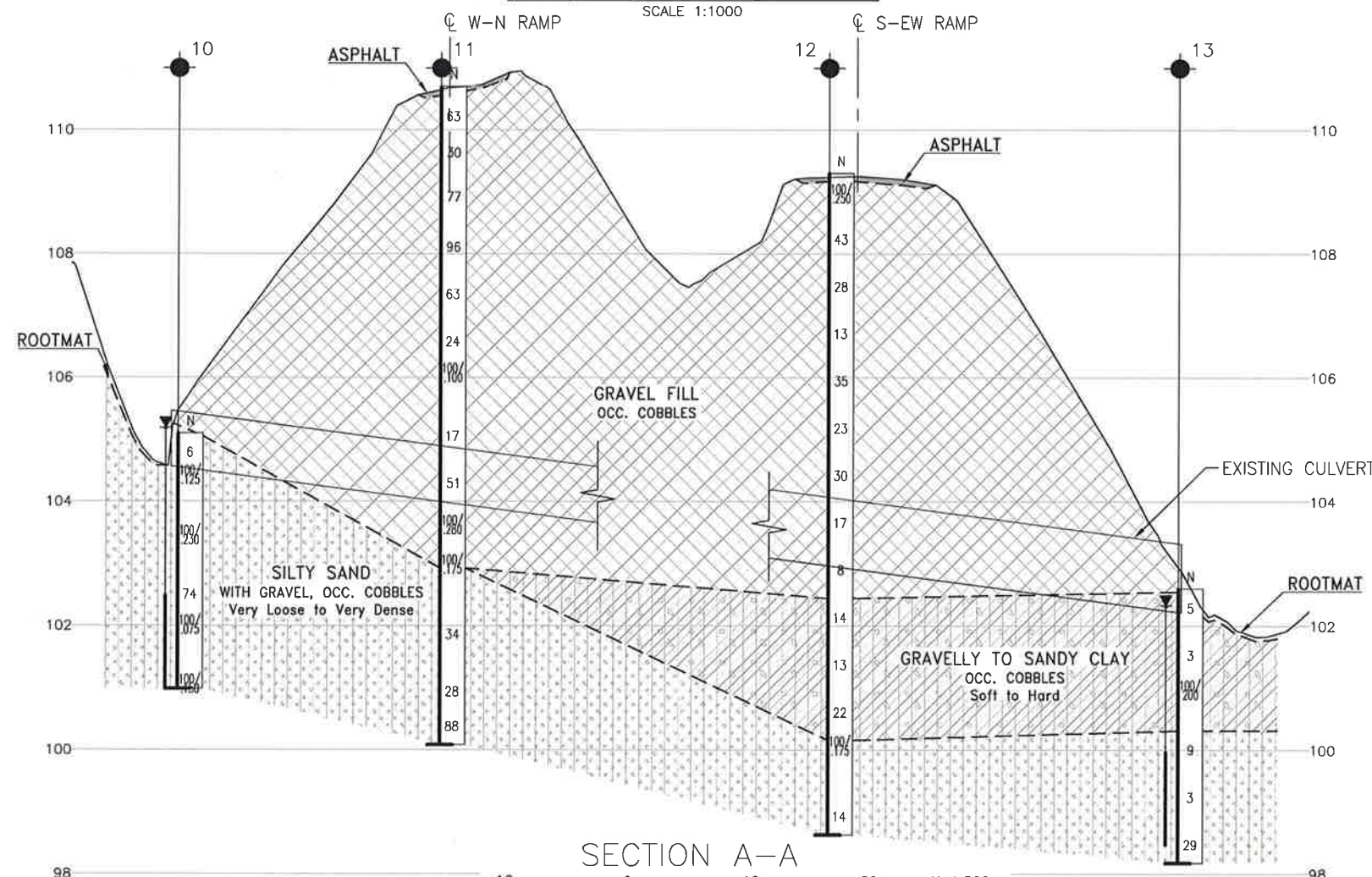
GEOCREs No. 31G5-281

| REVISIONS | DATE | BY | DESCRIPTION |
|-----------|------|--------|-------------|
| DESIGN | JG | CHK PC | CODE |
| DRAWN | MFA | CHK JG | SITE |
| | | | LOAD |
| | | | DATE |
| | | | STRUCT |
| | | | DWG 1 |



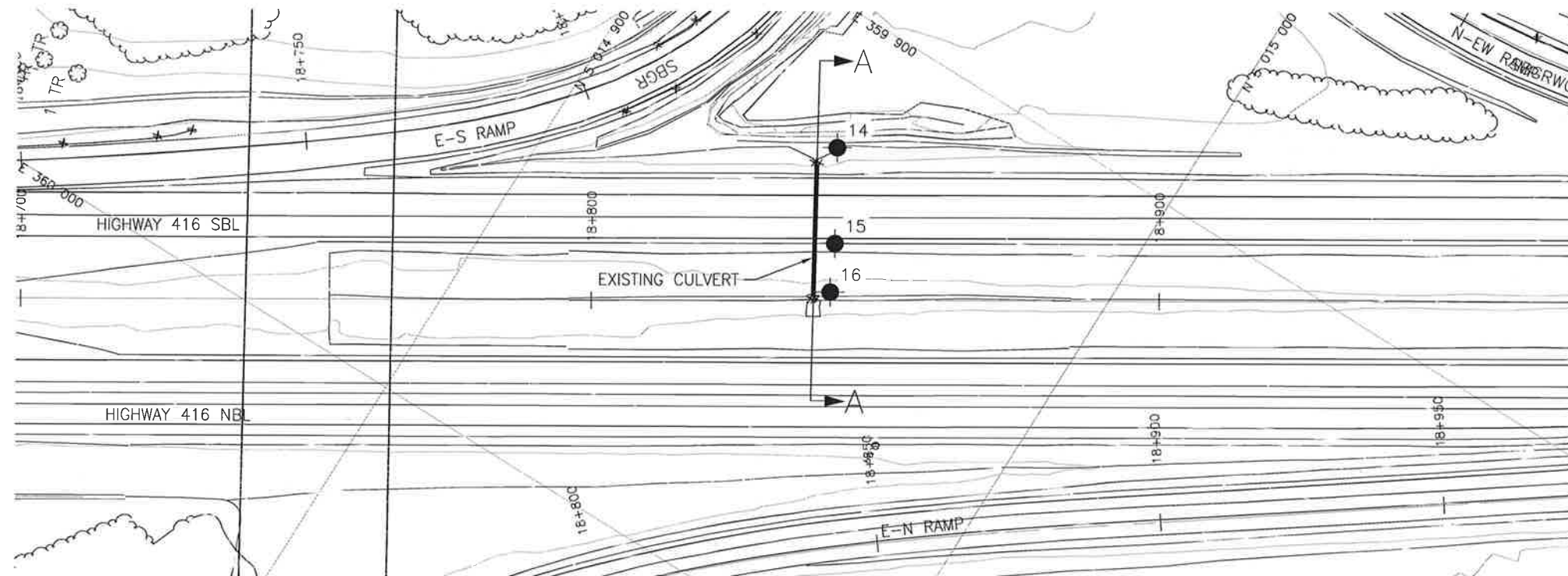
PLAN

SCALE 1:1000

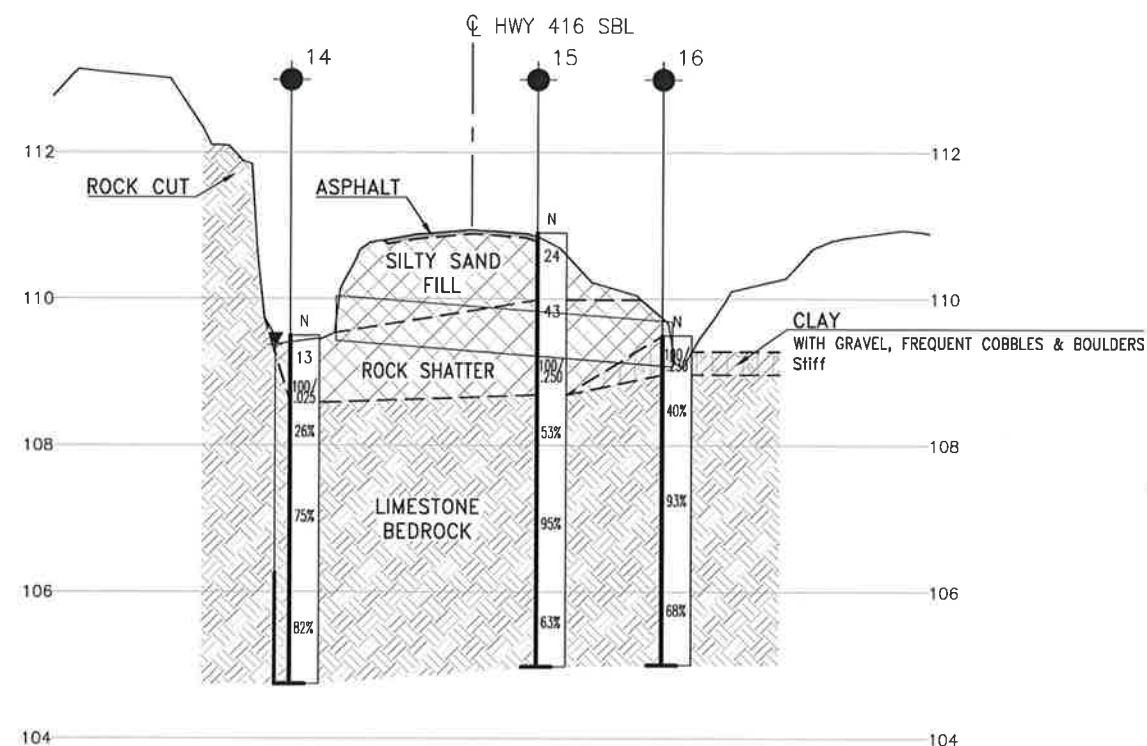


SECTION A-A

H 1:500
V 1:100



PLAN



SECTION A-A



H 1:500

V 1:100

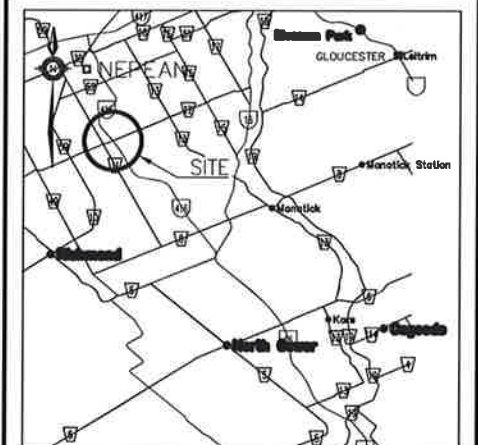
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 4096-16-00

HWY 416/FALLOWFIELD RD
SOUTHBOUND LANES
CULVERT C6
BOREHOLE LOCATIONS AND SOIL STRATA








THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

| | |
|---|---------------------------------------|
|  | Borehole |
|  | Borehole and Cone |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
|  | Water Level |
|  | Head Artesian Water |
|  | Piezometer |
| 90% | Rock Quality Designation (RQD) |
| A/R | Auger Refusal |

[illegible]

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 31G5-281

[illegible]

Appendix B.

**Symbols, Abbreviations and Terms Used on Test Hole Records
Record of Borehole Sheets**

SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

| | |
|---------|--|
| Topsoil | mixture of soil and humus capable of supporting vegetative growth |
| Peat | mixture of fragments of decayed organic matter |
| Till | unstratified glacial deposit which may include particles ranging in sizes from clay to boulder |
| Fill | material below the surface identified as placed by humans (excluding buried services) |

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

| | |
|------------|---|
| Desiccated | having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc. |
| Fissured | having cracks, and hence a blocky structure |
| Varved | composed of alternating layers of silt and clay |
| Stratified | composed of alternating successions of different soil types, e.g. silt and sand |
| Layer | > 75 mm in thickness |
| Seam | 2 mm to 75 mm in thickness |
| Parting | < 2 mm in thickness |

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

N-VALUE:

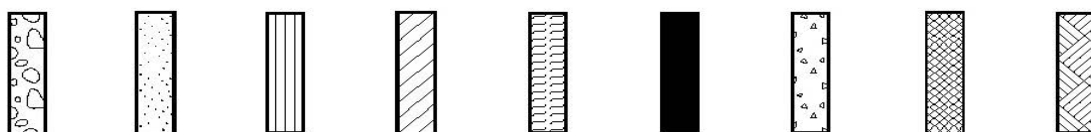
Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an "A" size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.

STRATA PLOT:

Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



Boulders
Cobbles
Gravel

Sand

Silt

Clay

Organics

Asphalt

Concrete

Fill

Bedrock

TEXTURING CLASSIFICATION OF SOILS

| Classification | Particle Size |
|----------------|---------------------|
| Boulders | Greater than 200 mm |
| Cobbles | 75 – 200 mm |
| Gravel | 4.75 – 75 mm |
| Sand | 0.075 – 4.75 mm |
| Silt | 0.002 – 0.075 mm |
| Clay | Less than 0.002 mm |

SAMPLE TYPES

| | |
|-----------------|--|
| SS | Split spoon samples |
| ST | Shelby tube or thin wall tube |
| DP | Direct push sample |
| PS | Piston sample |
| BS | Bulk sample |
| WS | Wash sample |
| HQ, NQ, BQ etc. | Rock core sample obtained with the use of standard size diamond coring equipment |

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

| Descriptive Term | Undrained Shear Strength (kPa) |
|------------------|--------------------------------|
| Very Soft | 12 or less |
| Soft | 12 – 25 |
| Firm | 25 – 50 |
| Stiff | 50 – 100 |
| Very Stiff | 100 – 200 |
| Hard | Greater than 200 |

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

| Descriptive Term | SPT “N” Value |
|------------------|-----------------|
| Very Loose | Less than 4 |
| Loose | 4 – 10 |
| Compact | 10 – 30 |
| Dense | 30 – 50 |
| Very Dense | Greater than 50 |

MODIFIED UNIFIED SOIL CLASSIFICATION

| Major Divisions | | Group Symbol | Typical Description |
|----------------------|--|--------------|--|
| COARSE GRAINED SOIL | GRAVEL AND GRAVELLY SOILS | GW | Well-graded gravels or gravel-sand mixtures, little or no fines. |
| | | GP | Poorly-graded gravels or gravel-sand mixtures, little or no fines. |
| | | GM | Silty gravels, gravel-sand-silt mixtures. |
| | | GC | Clayey gravels, gravel-sand-clay mixtures. |
| | SAND AND SANDY SOILS | SW | Well-graded sands or gravelly sands, little or no fines. |
| | | SP | Poorly-graded sands or gravelly sands, little or no fines. |
| | | SM | Silty sands, sand-silt mixtures. |
| | | SC | Clayey sands, sand-clay mixtures. |
| FINE GRAINED SOILS | SILT AND CLAY SOILS $W_L < 35\%$ | ML | Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. |
| | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. |
| | | OL | Organic silts and organic silty-clays of low plasticity. |
| | SILT AND CLAY SOILS $35\% < W_L < 50\%$ | MI | Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts. |
| | | CI | Inorganic clays of medium plasticity, silty clays. |
| | | OI | Organic silty clays of medium plasticity. |
| | SILT AND CLAY SOILS $W_L > 50\%$ | MH | Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts. |
| | | CH | Inorganic clays of high plasticity, fat clays. |
| | | OH | Organic clays of high plasticity, organic silts. |
| HIGHLY ORGANIC SOILS | | Pt | Peat and other organic soils. |

Note - W_L = Liquid Limit

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

| | |
|---------------------------|--|
| Fresh (FR) | No visible signs of weathering. |
| Fresh Jointed (FJ) | Weathering limited to surface of major discontinuities. |
| Slightly Weathered (SW) | Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials. |
| Moderately Weathered (MW) | Weathering extends throughout the rock mass, but the rock material is not friable. |
| Highly Weathered (HW) | Weathering extends throughout the rock mass and the rock is partly friable. |
| Completely Weathered (CW) | Rock is wholly decomposed and in a friable condition, but the rock texture and structures are preserved. |

TERMS

| | |
|--|--|
| Total Core Recovery: (TCR) | Core recovered as a percentage of total core run length. |
| Solid Core Recovery: (SCR) | Percent ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run. |
| Rock Quality Designation: (RQD) | Total length of sound core recovered in pieces 0.1 m in length or larger, as a percentage of total core length |
| Unconfined Compressive Strength: (UCS) | Axial stress required to break the specimen. |
| Fracture Index: (FI) | Frequency of natural fractures per 0.3 m of core run. |

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

| Rock Strength | Approximate Uniaxial Compressive Strength (MPa) |
|------------------|---|
| Extremely Strong | Greater than 250 |
| Very Strong | 100 – 250 |
| Strong | 50 – 100 |
| Medium Strong | 25 – 50 |
| Weak | 5 – 25 |
| Very Weak | 1 – 5 |
| Extremely Weak | 0.25 – 1 |

RECORD OF BOREHOLE No 1

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 1 - Inlet N 5 014 854.9 E 360 160.5 ORIGINATED BY CAM
 HWY 416 BOREHOLE TYPE HSA COMPILED BY SML
 DATUM Geodetic DATE 2017.04.03 - 2017.04.03 CHECKED BY PC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | 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 (%) | | | | | | |
| | | | | | | | | | | | | | | |
| 106.4 | | | | | | | | | | | | | | |
| 0.0 | | | | | | | | | | | | | | |
| 0.1 | ROOTMAT (75 mm) | | 1 | SS | 11 | | | | | | | | | 15 52 33 (SI+CL) |
| | SILTY SAND with gravel, TILL Compact to very dense Wet | | 2 | SS | 59 | | | | | | | | | |
| | | | 3 | SS | 51 | | | | | | | | | 28 44 28 (SI+CL) |
| | - Frequent Cobbles/Boulders from 2.0 m to 2.6 m | | 4 | SS | 53 | | | | | | | | | |
| | | | 5 | SS | 38 | | | | | | | | | |
| | | | 6 | SS | 32 | | | | | | | | | |
| 102.0 | | | | | | | | | | | | | | |
| 4.4 | End of Borehole Groundwater in piezometer at Elev. 106.4 m on 25.04.2017 | | | | | | | | | | | | | |

ONTMT4S HWY 416 CULVERTS.GPJ 2012TEMPLATE(MTO).GDT 25/7/17

RECORD OF BOREHOLE No 2

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 1 - Embankment N 5 014 867.7 E 360 160.7 ORIGINATED BY JAG/NNW
 HWY 416 BOREHOLE TYPE HSA/NW Casing/NQ Coring COMPILED BY SML
 DATUM Geodetic DATE 2017.04.03 - 2017.04.10 CHECKED BY PC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | 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 | | | | | | | |
| | | | | | | | | ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | | |
| | | | | | | | | WATER CONTENT (%) P L W L | | | | | | | |
| 110.1 | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | |
| 0.0 | ASPHALT (140 mm) | | | | | | | | | | | | | | |
| 0.2 | ROCKFILL (GRAVEL/COBBLES with sand and silt) Very dense to compact Grey to brown Moist - occasional to frequent cobbles from 0.9 m to 4.4 m, difficult augering | | 1 | SS | 33 | | | | | | | | | | |
| | | | 2 | SS | 36 | | | | | | | | | | |
| | | | 3 | SS | 34 | | | | | | | | | | 67 22 11 (SI+CL) |
| | | | 4 | SS | 18 | | | | | | | | | | |
| | | | 5 | SS | 25 | | | | | | | | | | |
| | | | 6 | SS | 52 | | | | | | | | | | 51 33 16 (SI+CL) |
| 105.4 | | | 7 | SS | 108 | | | | | | | | | | |
| 4.7 | SILTY SAND with gravel, frequent to occasional cobble/boulder TILL Dense Brown Moist - borehole advanced from 4.7 m to 8.2 m using casing/coring techniques - 430 mm boulder at 4.7 m - 380 mm boulder at 7.0 m | | 8 | SS | 60 | | | | | | | | | | |
| | | | 9 | SS | 51 | | | | | | | | | | 30 43 27 (SI+CL) |
| | | | 10 | SS | 59 | | | | | | | | | | |
| | | | 11 | SS | 64 | | | | | | | | | | |
| 101.9 | | | | | | | | | | | | | | | |
| 8.2 | End of Borehole | | | | | | | | | | | | | | |

ONTMT4S HWY 416 CULVERTS.GPJ 2012TEMPLATE(MTO).GDT 25/7/17





+³, ×³: Numbers refer to
Sensitivity 20
15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 3

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 1 - Outlet N 5 014 888.9 E 360 165.5 ORIGINATED BY CAM/JAG
 HWY 416 BOREHOLE TYPE HSA COMPILED BY SML
 DATUM Geodetic DATE 2017.04.03 - 2017.04.03 CHECKED BY PC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | 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 | | | | | | |
| | | | | | | | | 20 40 60 80 100 | | | | | | |
| | | | | | | | | ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | |
| | | | | | | | WATER CONTENT (%) | | | | | | | |
| | | | | | | | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p W W _L | | | | | | | |
| 105.3 | | | | | | | | | | | | | | |
| 0.0 | | | | | | | | | | | | | | |
| 0.1 | ROOTMAT (75 mm) |  | 1 | SS | 13 |  | 105 | | | | | | | 26 50 24 (SI+CL) |
| | SILTY SAND with gravel, TILL loose to dense Brown to Brownish Grey Wet |  | 2 | SS | 95/ 300mm | | 104 | | | | | | | |
| | | | 3 | SS | 43 | | 103 | | | | | | | |
| | | | 4 | SS | 26 | | 102 | | | | | | | |
| | - clayey from 3.0 m to 3.8 m |  | 5 | SS | 9 | | 101 | | | | | | | |
| 100.8 | | | 6 | SS | 28 | | | | | | | | | |
| 4.4 | End of Borehole Groundwater in piezometer at Elev. 105.1 m on 25.04.2017 | | | | | | | | | | | | | |

ONTMT4S HWY 416 CULVERTS.GPJ 2012TEMPLATE(MTO).GDT 25/7/17

RECORD OF BOREHOLE No 4

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 3A - Embankment N 5 014 666.7 E 360 111.3 ORIGINATED BY NNW
 HWY 416 BOREHOLE TYPE HSA/NQ Coring COMPILED BY SML
 DATUM Geodetic DATE 2017.04.10 - 2017.04.10 CHECKED BY PC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|--|------------|---------|------|------------|----------------------------|-----------------|---|--|--|--|--|---|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | |
| 109.8 0.0 | ASPHALT 200 mm | | | | | | | | | | | | | |
| 0.2 | GRAVEL, silty with sand FILL Dense Grey Dry | | 1 | SS | 46 | | | | | | | | | |
| | | | 2 | SS | 38 | | | | | | | | | |
| 108.4 | ROCKFILL (GRAVEL/COBBLES, silty with sand) Dense to Very Dense Brown Moist | | 3 | SS | 54 | | | | | | | | | |
| 1.4 | | | | | | | | | | | | | | |
| | | | 4 | SS | 100 | | | | | | | | | |
| 107.1 | BEDROCK Limestone Fresh Moderately Bedded Very Strong Grey | | 1 | NQ | | | | | | | | | | |
| 2.7 | | | | 2 | NQ | | | | | | | | | |
| | | | | 3 | NQ | | | | | | | | | |
| | | | | 4 | NQ | | | | | | | | | |
| | | | | | | | | | | | | | | |
| 102.5 | | | | | | | | | | | | | | |
| 7.3 | End of Borehole | | | | | | | | | | | | | |

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 5 10 15 20 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 5

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 3A - Embankment N 5 014 681.5 E 360 131.6 ORIGINATED BY NNW
 HWY 416 BOREHOLE TYPE HSA/NW Casing/NQ Coring COMPILED BY SML
 DATUM Geodetic DATE 2017.04.10 - 2017.04.10 CHECKED BY PC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | 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 | | | | | |
| | | | | | | | | 20 40 60 80 100 | | PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT | | | |
| 109.8 | | | | | | | | | | | | | |
| 0.0 | ASPHALT 200 mm | | | | | | | | | | | | |
| 0.2 | GRAVEL, silty with sand FILL Dense Grey Dry | | 1 | SS | 57 | | | | | | | | |
| | | | 2 | SS | 29 | | | | | | | | 49 37 14 (SI+CL) |
| 108.4 | | | | | | | | | | | | | |
| 1.4 | ROCKFILL (GRAVEL/COBBLES, silty with sand) Compact to dense Brown to Grey Moist - auger refusal at 1.5 m, borehole advanced with casing/coring techniques from 1.5 m to 3.3 m - frequent cobbles from 1.5 m to 2.1 m - 360 mm boulder at 2.7 m | | 3 | SS | 35 | | | | | | | | 46 32 22 (SI+CL) |
| 106.7 | | | | | | | | | | | | | |
| 3.0 | SAND with gravel and silt | | 4 | SS | 100/ | | | | | | | | |
| 106.5 | Dense Grey Wet | | | | 275 mm | | | | | | | | |
| 3.3 | BEDROCK Limestone Fresh Moderately Bedded Very Strong Grey | | 1 | NQ | | | | | | | | | RUN #1 TCR=100% SCR=100% RQD=72% UCS=162MPa RUN #2 TCR=100% SCR=100% RQD=97% |
| | | | 2 | NQ | | | | | | | | | |
| | | | 3 | NQ | | | | | | | | | RUN #3 TCR=100% SCR=45% RQD=22% |
| 102.3 | | | | | | | | | | | | | |
| 7.5 | End of Borehole | | | | | | | | | | | | |

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 6

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 3A - Outlet N 5 014 698.8 E 360 158.8 ORIGINATED BY NNW
 HWY 416 BOREHOLE TYPE Portable/NQ Casing/BX Coring COMPILED BY SML
 DATUM Geodetic DATE 2017.04.04 - 2017.04.04 CHECKED BY PC

| 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 (%) | |
|---------------|---|------------|---------|------|------------|----------------------------|-----------------|--|----|----|------------------------------------|-------------------------------------|-----------------------------------|---|---|-------------------|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | | | WATER CONTENT (%) |
| 106.4 | | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | |
| 0.0 | | | | | | | | | | | | | | | | |
| 0.1 | ROOTMAT (50 mm) | | 1 | SS | 100/250 mm | | | | | | | | | | | |
| | ROCKFILL (GRAVEL/COBBLES some sand) Very Dense - 360 mm boulder at 0.3 m | | | | | | | | | | | | | | | |
| 105.2 | | | 2 | SS | 100/175 mm | | | | | | | | | | | |
| 1.2 | BEDROCK Limestone Fresh Moderate to thinly bedded Grey | | 1 | BX | | | | | | | | | | | | |
| | | | 2 | BX | | | | | | | | | | | | |
| | | | 3 | BX | | | | | | | | | | | | |
| | | | 4 | BX | | | | | | | | | | | | |
| 102.3 | | | | | | | | | | | | | | | | |
| 4.1 | End of Borehole Groundwater in piezometer at Elev. 106.4 m on 25.04.2017 | | | | | | | | | | | | | | | |

+³, ×³: Numbers refer to Sensitivity
 20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 7

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 3B - Inlet N 5 014 637.7 E 360 064.0 ORIGINATED BY CAM
 HWY 416 BOREHOLE TYPE Portable/NQ Casing/BX Coring COMPILED BY SML
 DATUM Geodetic DATE 2017.03.27 - 2017.03.27 CHECKED BY PC

| 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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | | | | WATER CONTENT (%) |
| 109.7 | | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | |
| 0.0 | ROOTMAT (50mm) | | | | | | | | | | | | | | | | |
| | GRAVEL/COBBLES, silty with sand FILL Loose to Very Dense Brown Wet | | 1 | SS | 5 | | | | | | | | ○ | | | | |
| 108.7 | | | 2 | SS | 169/ 250 mm | | | | | | | | ○ | | | | 48 34 18 (SI+CL) |
| 1.0 | GRAVEL with sand and silt - frequent cobbles/boulders cored from 1.0 m to 2.0 m | | 1 | BX | | | | | | | | | | | | | RUN #1 TCR=60% SCR=33% RQD=10% |
| 107.7 | | | | | | | | | | | | | | | | | |
| 2.0 | BEDROCK Limestone Fresh Moderately bedded Grey | | 2 | BX | | | | | | | | | | | | | RUN #2 TCR=100% SCR=95% RQD=62% |
| | | | | | | | | | | | | | | | | | |
| 105.5 | | | 3 | BX | | | | | | | | | | | | | RUN #3 TCR=96% SCR=85% RQD=59% |
| 4.2 | End of Borehole Groundwater in piezometer at Elev. 109.5 m on 25.04.2017 | | | | | | | | | | | | | | | | |

+³, ×³: Numbers refer to Sensitivity
 20
15
10
5
0
5
10
15
20
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 8

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 3B - Embankment N 5 014 644.2 E 360 076.5 ORIGINATED BY SOB
 HWY 416 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY SML
 DATUM Geodetic DATE 2017.03.27 - 2017.03.27 CHECKED BY PC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | | | | | |
|---------------|---|------------|---------|------|-----------------|----------------------------|-----------------|---|----|----|----|---|---|--|--|--|--|--|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | | | | | |
| 112.7 | | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | | | |
| 0.0 | ASPHALT 150 mm | | | | | | | | | | | | | | | | | | | |
| 0.2 | SAND with gravel FILL Very Dense Brown Moist | | 1 | SS | 58 | | 112 | | | | | | | | | | | | | |
| 111.9 | | | | | | | | | | | | | | | | | | | | |
| 0.8 | GRAVEL with sand and silt FILL Compact to dense Brown | | 2 | SS | 21 | | 111 | | | | | | | | | | | | | |
| | | | 3 | SS | 33 | | | | | | | | | | | | | | | |
| 110.5 | | | | | | | | | | | | | | | | | | | | |
| 2.1 | GRAVEL/COBBLES, silty with sand FILL - occasional cobbles 2.1 m to 4.4 m Compact to Very Dense Brown | | 4 | SS | 26 | | 110 | | | | | | | | | | | | | |
| | | | 5 | SS | 12 | | | | | | | | | | | | | | | |
| | | | | | | | 109 | | | | | | | | | | | | | |
| | | | 6 | SS | 10 | | | | | | | | | | | | | | | |
| 108.3 | | | | | | | | | | | | | | | | | | | | |
| 4.4 | GRAVEL with sand and silt - frequent cobbles/boulders cored from 4.4 m to 5.9 m - 150 mm cobble at 4.9 m - 250 mm boulder at 5.2 m - 250 mm boulder at 5.5 m | | 7 | SS | 100 / 75 mm | | 108 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | 107 | | | | | | | | | | | | | |
| 106.7 | | | 8 | SS | 100 / 230 mm | | | | | | | | | | | | | | | |
| 5.9 | BEDROCK Limestone Fresh Moderately Bedded Grey | | 1 | NQ | | | 106 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | 2 | NQ | | | 105 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| 103.8 | | | | | | | 104 | | | | | | | | | | | | | |
| 8.9 | End of Borehole | | | | | | | | | | | | | | | | | | | |

ONTMT4S HWY 416 CULVERTS.GPJ 2012TEMPLATE(MTO).GDT 25/7/17

+³, ×³: Numbers refer to Sensitivity
 20
 15
 10
 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 9

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 3B - Outlet N 5 014 655.3 E 360 093.8 ORIGINATED BY CAM
 HWY 416 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY SML
 DATUM Geodetic DATE 2017.04.11 - 2017.04.11 CHECKED BY PC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | PLASTIC LIMIT W _P NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 107.7 | | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 10

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 4 - Inlet N 5 014 773.6 E 360 246.9 ORIGINATED BY CAM
 HWY 416 BOREHOLE TYPE Portable/NQ Casing COMPILED BY SML
 DATUM Geodetic DATE 2017.03.28 - 2017.04.04 CHECKED BY PC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | 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 | | | | | | |
| | | | | | | | | 20 40 60 80 100 | | | | | | |
| 105.1 | | | | | | | | 20 40 60 80 100 | | | | | | |
| 0.0 | ROOTMAT (50 mm) | | | | | | | 20 40 60 80 100 | | | | | | |
| 0.1 | SILTY SAND with gravel, occasional cobbles Very Dense Grey Wet | | 1 | SS | 6 | | | 20 40 60 80 100 | | | | | | |
| | | | 2 | SS | 100/ 125 mm | | | 20 40 60 80 100 | | | | | | 25 46 29 (SI+CL) |
| | - frequent cobbles from 0.7 m to 2.3 m | | 3 | SS | 100/ 230 mm | | | 20 40 60 80 100 | | | | | | |
| | | | 4 | SS | 74 | | | 20 40 60 80 100 | | | | | | 37 40 23 (SI+CL) |
| | - 685 mm boulder cored at 3.1 m | | 5 | SS | 100/ 75 mm | | | 20 40 60 80 100 | | | | | | |
| 100.9 | | | 6 | SS | 100/ 150 mm | | | 20 40 60 80 100 | | | | | | |
| 4.1 | End of Borehole Groundwater in piezometer at Elev. 105.2 m on 25.04.2017 | | | | | | | | | | | | | |


ONTMT4S HWY 416 CULVERTS.GPJ 2012TEMPLATE(MTO).GDT 25/7/17

RECORD OF BOREHOLE No 11

1 OF 2

METRIC

GWP# 4068-13-00 LOCATION Culvert 4 - Embankment N 5 014 789.0 E 360 261.9 ORIGINATED BY SOB
 HWY 416 BOREHOLE TYPE NW Casing COMPILED BY SML
 DATUM Geodetic DATE 2017.03.28 - 2017.03.28 CHECKED BY PC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | 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 (%) | | | |
| | | | | | | | | ○ UNCONFINED + FIELD VANE | | | | | | | w P w w L | | | |
| | | | | | | | | ● QUICK TRIAXIAL × LAB VANE | | | | | | | | | | |
| 110.7 | | | | | | | 20 | 40 | 60 | 80 | 100 | | | | | | | |
| 0.0 | ASPHALT 175 mm | | | | | | | | | | | | | | | | | |
| 0.2 | GRAVEL, silty with sand FILL, occasional cobbles Compact to Very Dense Brown |  | 1 | SS | 63 | | | | | | | | | | | | | |
| | | | 2 | SS | 30 | | | | | | | | | | | | | |
| | | | 3 | SS | 77 | | | | | | | | | | | | | |
| | | | 4 | SS | 96 | | | | | | | | | | | | | |
| | | | 5 | SS | 63 | | | | | | | | | | | | | |
| | | | 6 | SS | 24 | | | | | | | | | | | | | |
| | | | 7 | SS | 100 / | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| | | | 8 | SS | 17 | | | | | | | | | | | | | |
| | | | 9 | SS | 51 | | | | | | | | | | | | | |
| | | | 10 | SS | 100 / | | | | | | | | | | | | | |
| | - cobble | | | | | | | | | | | | | | | | | |
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Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 11

2 OF 2

METRIC

GWP# 4068-13-00 LOCATION Culvert 4 - Embankment N 5 014 789.0 E 360 261.9 ORIGINATED BY SOB
 HWY 416 BOREHOLE TYPE NW Casing COMPILED BY SML
 DATUM Geodetic DATE 2017.03.28 - 2017.03.28 CHECKED BY PC

| 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 (%) GR SA SI CL |
|---------------|------------------------------|------------|---------|------|------------|----------------------------|-----------------|--|----|----|-----|----|---|----|--|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | WATER CONTENT (%) W P W W L | | | | |
| | | | | | | | 20 | 40 | 60 | 80 | 100 | 20 | 40 | 60 | | | |
| | Continued From Previous Page | | 14 | SS | 88 | | | | | | | | | | | | |
| 100.1 | | | | | | | | | | | | | | | | | |
| 10.6 | End of Borehole | | | | | | | | | | | | | | | | |

ONTMT4S HWY 416 CULVERTS.GPJ 2012TEMPLATE(MTO).GDT 25/7/17

RECORD OF BOREHOLE No 12

1 OF 2

METRIC

GWP# 4068-13-00 LOCATION Culvert 4 - Embankment N 5 014 810.7 E 360 285.0 ORIGINATED BY SOB
 HWY 416 BOREHOLE TYPE NW Casing COMPILED BY SML
 DATUM Geodetic DATE 2017.03.29 - 2017.03.29 CHECKED BY PC

| 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 | REMARKS & GRAIN SIZE DISTRIBUTION (%) |
|---------------|---|------------|---------|------|--------------|----------------------------|-----------------|---|--|------------------------------------|-------------------------------------|-----------------------------------|-------------------------|---|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | |
| 109.3 | | | | | | | | 20 40 60 80 100 | | | | | | |
| 0.0 | ASPHALT 125 mm | | 1 | SS | 100 / 250 mm | | 109 | | | | | | | |
| 0.1 | GRAVEL with sand and silt, occasional cobbles FILL Very dense to loose Brown | | 2 | SS | 43 | | 108 | | | | | | | 56 37 7 (SI+CL) |
| | | | 3 | SS | 28 | | 107 | | | | | | | |
| | | | 4 | SS | 13 | | 106 | | | | | | | |
| | | | 5 | SS | 35 | | 105 | | | | | | | 76 19 5 (SI+CL) |
| | -poor sample recovery | | 6 | SS | 23 | | 104 | | | | | | | |
| | | | 7 | SS | 30 | | 103 | | | | | | | |
| | | | 8 | SS | 17 | | 102 | | | | | | | |
| | | | 9 | SS | 8 | | 101 | | | | | | | |
| 102.5 | | | 10 | SS | 14 | | 100 | | | | | | | |
| 6.9 | CLAY (Cl), gravelly with sand Stiff to very stiff Brown | | 11 | SS | 13 | | | | | | | | | 19 18 32 31 |
| | | | 12 | SS | 22 | | | | | | | | | |
| 100.2 | | | 13 | SS | 100 / 175 mm | | | | | | | | | |
| 9.1 | SILTY SAND with gravel, occasional cobbles Very dense Brown | | | | | | | | | | | | | |

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

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15
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(%) STRAIN AT FAILURE

ONTMT4S HWY 416 CULVERTS.GPJ 2012TEMPLATE(MTO).GDT 25/7/17

RECORD OF BOREHOLE No 12

2 OF 2

METRIC

GWP# 4068-13-00 LOCATION Culvert 4 - Embankment N 5 014 810.7 E 360 285.0 ORIGINATED BY SOB
 HWY 416 BOREHOLE TYPE NW Casing COMPILED BY SML
 DATUM Geodetic DATE 2017.03.29 - 2017.03.29 CHECKED BY PC

| 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 (%) GR SA SI CL |
|---------------|---|------------|---------|------|------------|--|-----------------|---|--|--|-------------------|---|------------------|--------------------------------|-----------------|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | | |
| | | | | | | ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | WATER CONTENT (%) | | | | | | |
| | | | | | | 20 40 60 80 100 20 40 60 80 100 | | | | | W P | W | W L | | | | |
| | Continued From Previous Page | | | | | | | | | | | | | | | | |
| 98.6 | SILTY SAND with gravel, occasional cobbles Very dense Brown | | 14 | SS | 14 | | 99 | | | | | | | | | | |
| 10.7 | End of Borehole | | | | | | | | | | | | | | | | |

ONTMT4S HWY 416 CULVERTS.GPJ 2012TEMPLATE(MTO).GDT 25/7/17

RECORD OF BOREHOLE No 13

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 4 - Outlet N 5 014 820.0 E 360 313.1 ORIGINATED BY JAG
 HWY 416 BOREHOLE TYPE HSA COMPILED BY SML
 DATUM Geodetic DATE 2017.04.05 - 2017.04.05 CHECKED BY PC

| 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 (%) | |
| | | | | | | | | ○ UNCONFINED ● QUICK TRIAXIAL | + FIELD VANE × LAB VANE | | | | | | | | | |
| 102.6 | | | | | | | 20 40 60 80 100 | | | | | | | | | | | |
| 0.0 | ROOTMAT (50 mm) | | 1 | SS | 5 | | | | | | | | | | | | | |
| | CLAY (CL), sandy | | | | | | | | | | | | | | | | | |
| | Soft to hard | | | | | | | | | | | | | | | | | |
| | Grey | | 2 | SS | 3 | | | | | | | | | | | 3 33 42 22 | | |
| | Wet | | | | | | | | | | | | | | | | | |
| | - occasional cobble | | 3 | SS | 100 / 200 mm | | | | | | | | | | | | | |
| 100.3 | | | | | | | | | | | | | | | | | | |
| 2.3 | SILTY SAND with gravel | | 4 | SS | 9 | | | | | | | | | | | 17 49 27 7 | | |
| | Very loose to compact | | | | | | | | | | | | | | | | | |
| | Greyish brown | | 5 | SS | 3 | | | | | | | | | | | | | |
| | Wet | | | | | | | | | | | | | | | | | |
| | | | 6 | SS | 29 | | | | | | | | | | | | | |
| 98.2 | | | | | | | | | | | | | | | | | | |
| 4.4 | End of Borehole | | | | | | | | | | | | | | | | | |
| | Groundwater in piezometer at Elev. 102.3 m on 25.04.2017 | | | | | | | | | | | | | | | | | |




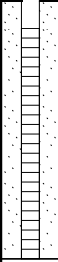
+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 14

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 6 - Inlet N 5 014 945.1 E 359 922.2 ORIGINATED BY CAM
 HWY 416 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY SML
 DATUM Geodetic DATE 2017.04.11 - 2017.04.11 CHECKED BY PC

| 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 (%) GR SA SI CL | | | | |
|---------------|--|--|---------|------|------------|--|-----------------|--|--|--|--|---|---|--|-------------------|--|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | WATER CONTENT (%) | | | |
| 109.5 | | | | | | | | 20 40 60 80 100 | | | | | | | W P W L | | | |
| | | | | | | | | ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | | | | | | | | | | |
| 0.0 | ROCK SHATTER FILL (GRAVEL with frequent cobbles/boulders) Compact Grey Wet |  | 1 | SS | 13 |  | 109 | | | | | | ○ | | | | 68 28 4 (SI+CL) | |
| 108.6 | | | 2 | SS | 100/25mm | | | | | | | | | | | | | |
| 0.9 | BEDROCK Limestone Fresh Moderately Bedded Very Strong Grey |  | 1 | NQ | | | 108 | | | | | | | | | | RUN #1 TCR=100% SCR=81% RQD=26% UCS=143MPa | |
| | | | 2 | NQ | | | 107 | | | | | | | | | | RUN #2 TCR=100% SCR=100% RQD=75% | |
| | - occasional shale seams from 3.2 m to 4.7 m | | 3 | NQ | |  | 106 | | | | | | | | | | RUN #3 TCR=100% SCR=93% RQD=82% | |
| 104.7 | | | | | | | 105 | | | | | | | | | | | |
| 4.7 | End of Borehole Groundwater in piezometer at Elev. 109.4 m on 25.04.2017 | | | | | | | | | | | | | | | | | |

ONTMT4S HWY 416 CULVERTS.GPJ 2012TEMPLATE(MTO).GDT 25/7/17

RECORD OF BOREHOLE No 15

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 6 - Embankment N 5 014 953.7 E 359 936.7 ORIGINATED BY CAM
 HWY 416 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY SML
 DATUM Geodetic DATE 2017.04.10 - 2017.04.10 CHECKED BY PC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | PLASTIC LIMIT NATURAL MOISTURE LIMIT | | | 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 (%) | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 110.9 | | | | | | | | | | | | | | | | |
| 0.0 0.1 | ASPHALT (50 mm) | | 1 | SS | 24 | | | | | | | | | | | |
| | SILTY SAND with gravel FILL Compact Brown Moist | | | | | | | | | | | | | | 40 48 12 (SI+CL) | |
| 110.0 | | | 2 | SS | 43 | | 110 | | | | | | | | 69 28 3 (SI+CL) | |
| 0.9 | ROCK SHATTER FILL (GRAVEL/COBBLES with sand) Very dense Grey - 100 mm cobble cored at 1.4 m - 125 mm cobble cored at 1.5 m | | | | | | | | | | | | | | | |
| | | | 3 | SS | 100 / 250 mm | | 109 | | | | | | | | | |
| 108.7 | | | | | | | | | | | | | | | | |
| 2.2 | BEDROCK Limestone Fresh Moderately Bedded Grey | | 1 | NQ | | | 108 | | | | | | | | RUN #1 TCR=100% SCR=93% RQD=53% | |
| | | | 2 | NQ | | | 107 | | | | | | | | RUN #2 TCR=100% SCR=97% RQD=95% | |
| | - occasional shale seams from 4.7 m to 5.9 m | | 3 | NQ | | | 106 | | | | | | | | RUN #3 TCR=94% SCR=94% RQD=63% | |
| 105.0 | | | | | | | 105 | | | | | | | | | |
| 5.9 | End of Borehole | | | | | | | | | | | | | | | |


ONTMT4S HWY 416 CULVERTS.GPJ 2012TEMPLATE(MTO).GDT 25/7/17

RECORD OF BOREHOLE No 16

1 OF 1

METRIC

GWP# 4068-13-00 LOCATION Culvert 6 - Outlet N 5 014 957.5 E 359 944.4 ORIGINATED BY CAM
 HWY 416 BOREHOLE TYPE HSA/NW Casing/NQ Coring COMPILED BY SML
 DATUM Geodetic DATE 2017.04.10 - 2017.04.10 CHECKED BY PC

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT | | | | | UNIT WEIGHT γ kN/m ³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) | | |
|---------------|---|--|---------|------|--------------|----------------------------|-----------------|---|--|--|--|--|---|--|--|--|
| ELEV DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | SHEAR STRENGTH kPa | | | | | | | | |
| 109.5 | CLAY with gravel, frequent cobbles/boulders Stiff Brown Wet - auger refusal at 0.4 m BEDROCK Limestone Fresh Moderately bedded Very Strong Grey - occasional shale seams from 3.0 m to 4.5 m |  | 1 | SS | 100 / 230 mm | | | | | | | | | RUN #1 TCR=100% SCR=97% RQD=40% UCS=168MPa | | |
| 109.0 | | | | | | | | | | | | | | | | |
| 0.5 | | | 1 | NQ | | | | | | | | | | | | |
| | | | 2 | NQ | | | | | | | | | | | | |
| | | | 3 | NQ | | | | | | | | | | | | |
| 105.0 | End of Borehole | | | | | | | | | | | | | | | |
| 4.5 | | | | | | | | | | | | | | | | |

ONTMT4S HWY 416 CULVERTS.GPJ 2012TEMPLATE(MTO).GDT 25/7/17

Appendix C.

Laboratory Testing

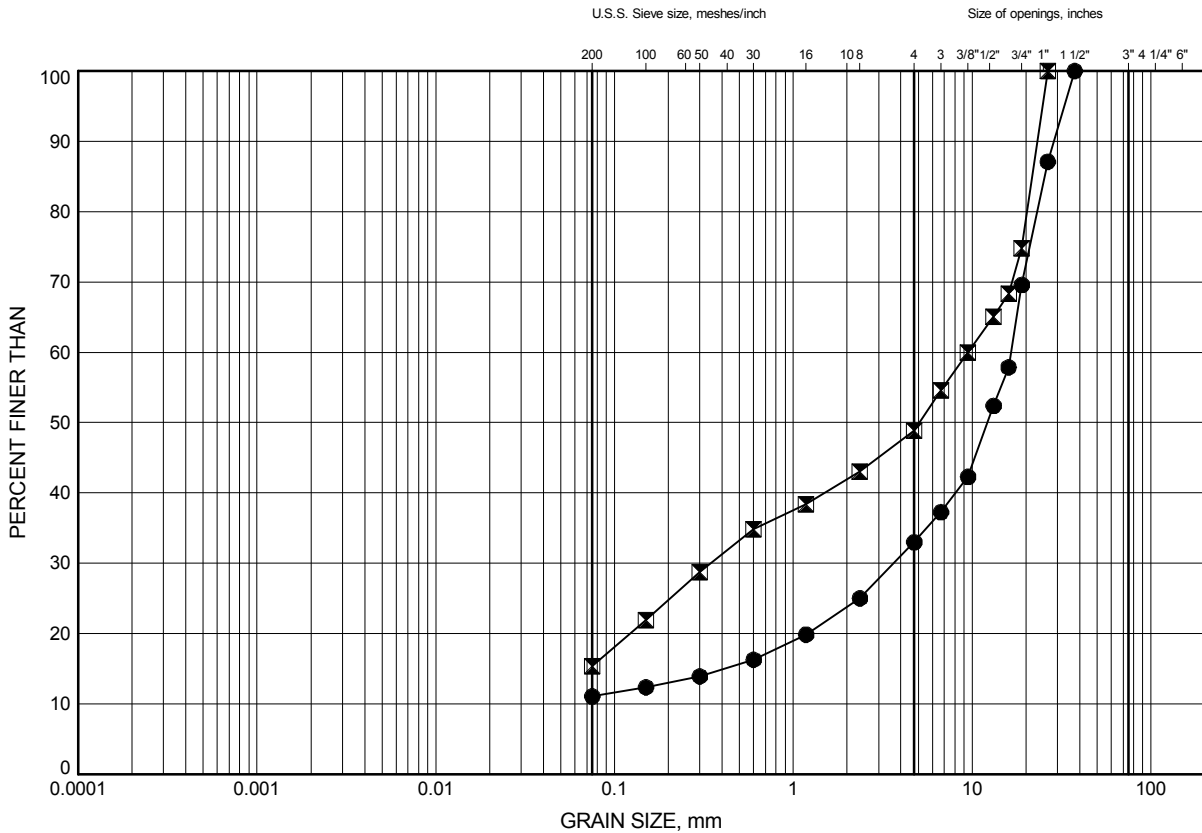
Appendix C.1
Particle Size Analysis Figures

Highway 416 Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C1

Culvert 1, Fill



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | 2 | 1.83 | 108.26 |
| ⊠ | 2 | 4.11 | 105.98 |

Date June 2017
GWP# 4068-13-00



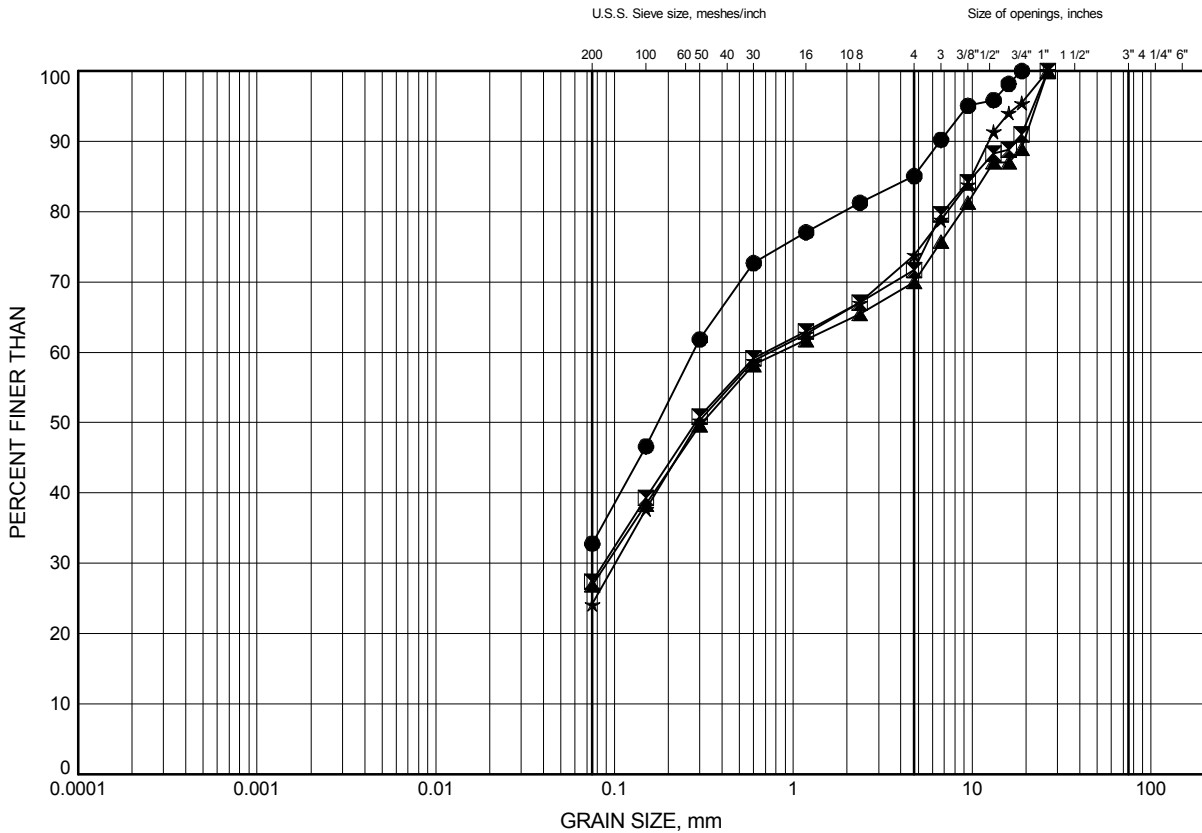
Prep'd JAG
Chkd. PC

Highway 416 Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C2

Culvert 1, Silty Sand with Gravel (Till)



LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | 1 | 0.30 | 106.08 |
| ⊠ | 1 | 1.83 | 104.55 |
| ▲ | 2 | 6.40 | 103.69 |
| ★ | 3 | 0.30 | 104.96 |

Date June 2017

GWP# 4068-13-00



Prep'd JAG

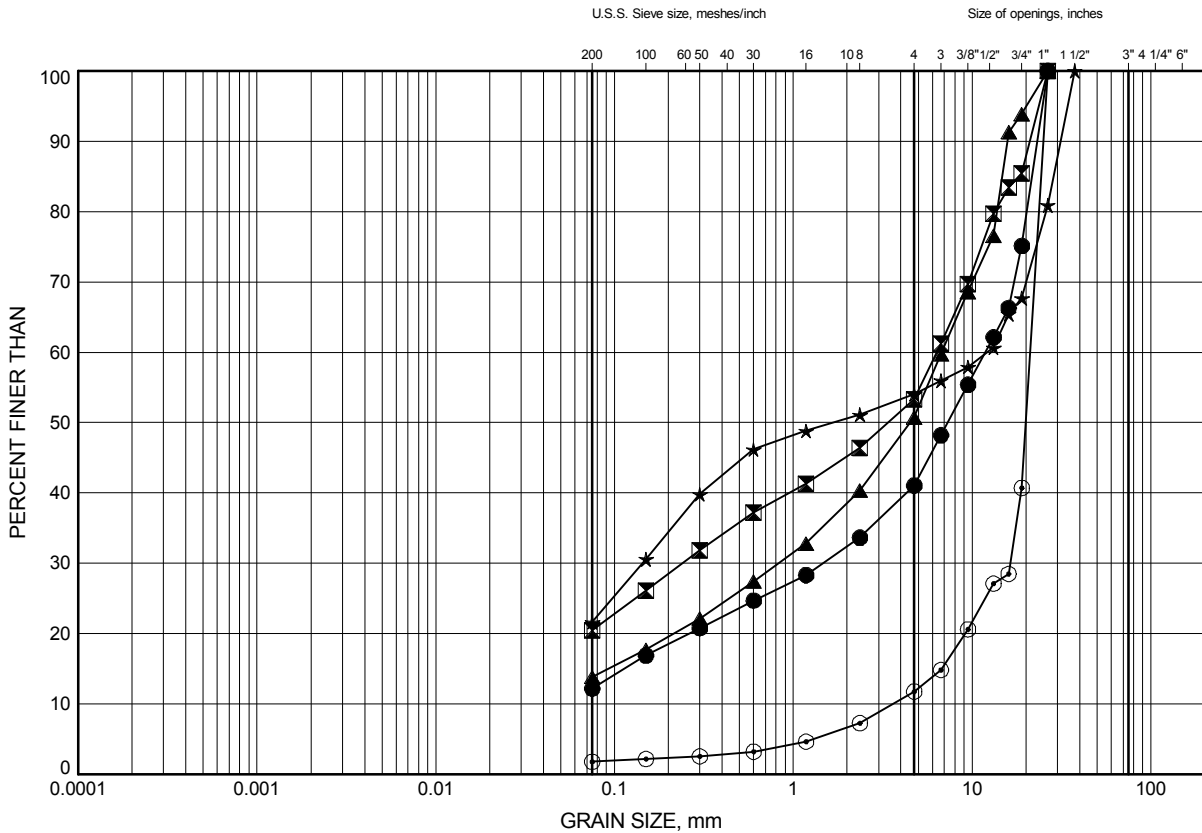
Chkd. PC

Highway 416 Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C3

Culvert 3A, Fill



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | 4 | 1.07 | 108.75 |
| ⊠ | 4 | 2.59 | 107.23 |
| ▲ | 5 | 1.07 | 108.71 |
| ★ | 5 | 2.34 | 107.44 |
| ⊙ | 6 | 1.07 | 105.36 |

Date June 2017
GWP# 4068-13-00



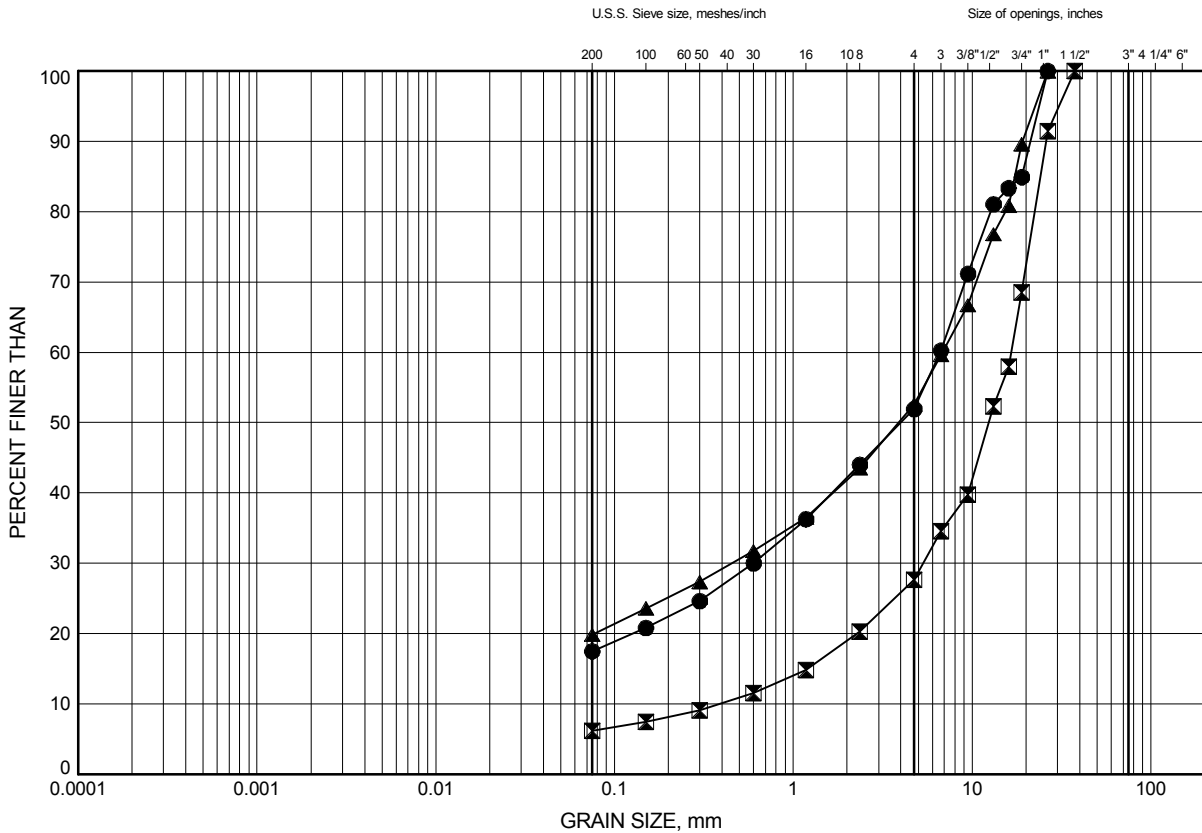
Prep'd JAG
Chkd. PC

Highway 416 Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C4

Culvert 3B, Fill



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | 7 | 0.91 | 108.80 |
| ⊠ | 8 | 1.60 | 111.08 |
| ▲ | 8 | 3.96 | 108.72 |

Date June 2017
GWP# 4068-13-00



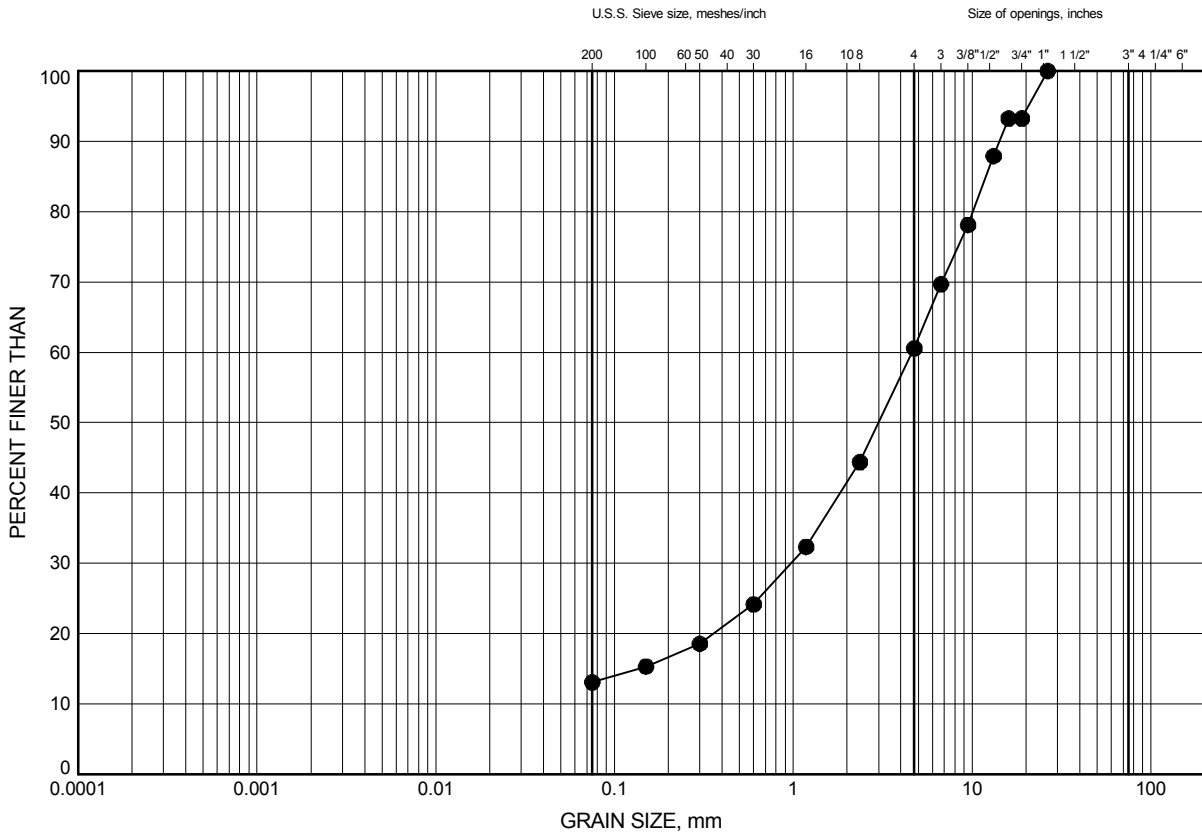
Prep'd JAG
Chkd. PC

Highway 416 Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C5

Culvert 3A/3B, Sand with Gravel and Silt



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | 9 | 0.23 | 107.44 |

Date June 2017
GWP# 4068-13-00



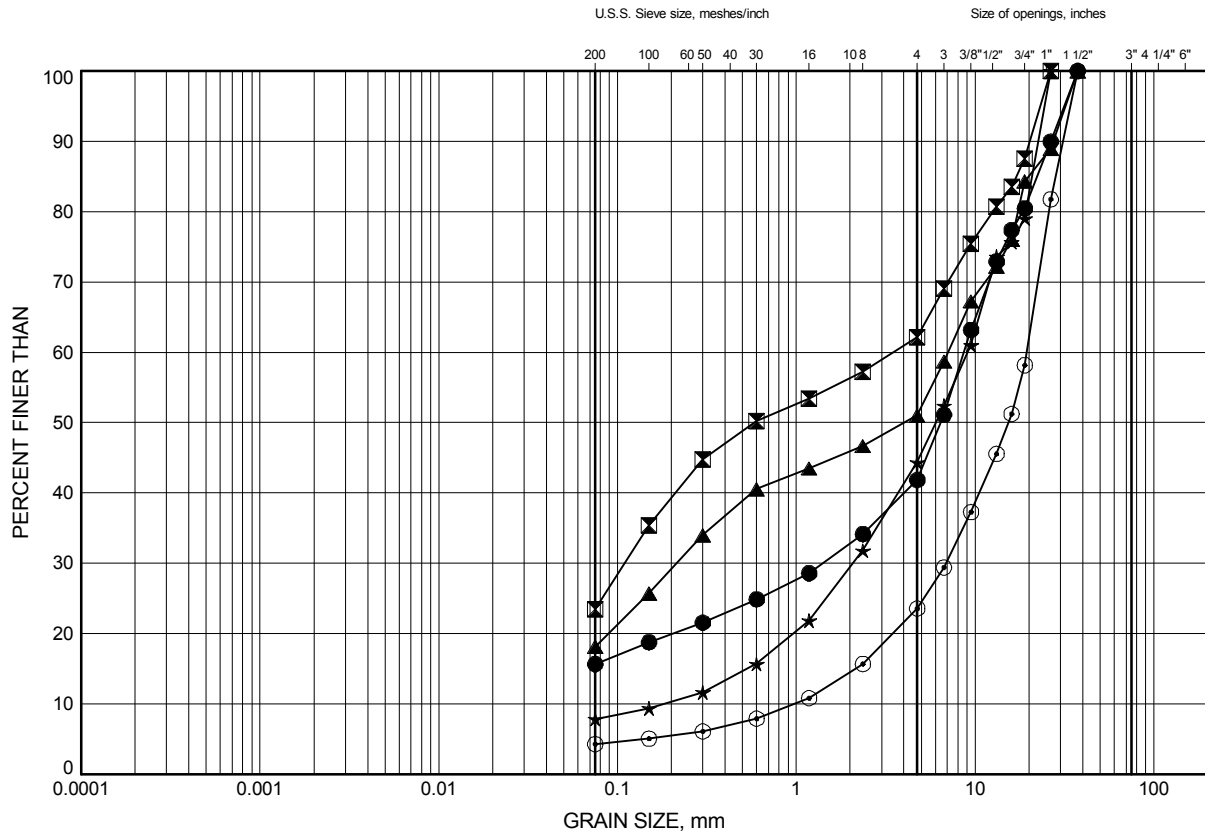
Prep'd JAG
Chkd. PC

Highway 416 Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C6

Culvert 4, Fill



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | 11 | 1.80 | 108.89 |
| ⊠ | 11 | 4.11 | 106.57 |
| ▲ | 11 | 6.40 | 104.29 |
| ★ | 12 | 1.07 | 108.24 |
| ⊙ | 12 | 4.11 | 105.19 |

Date June 2017
GWP# 4068-13-00



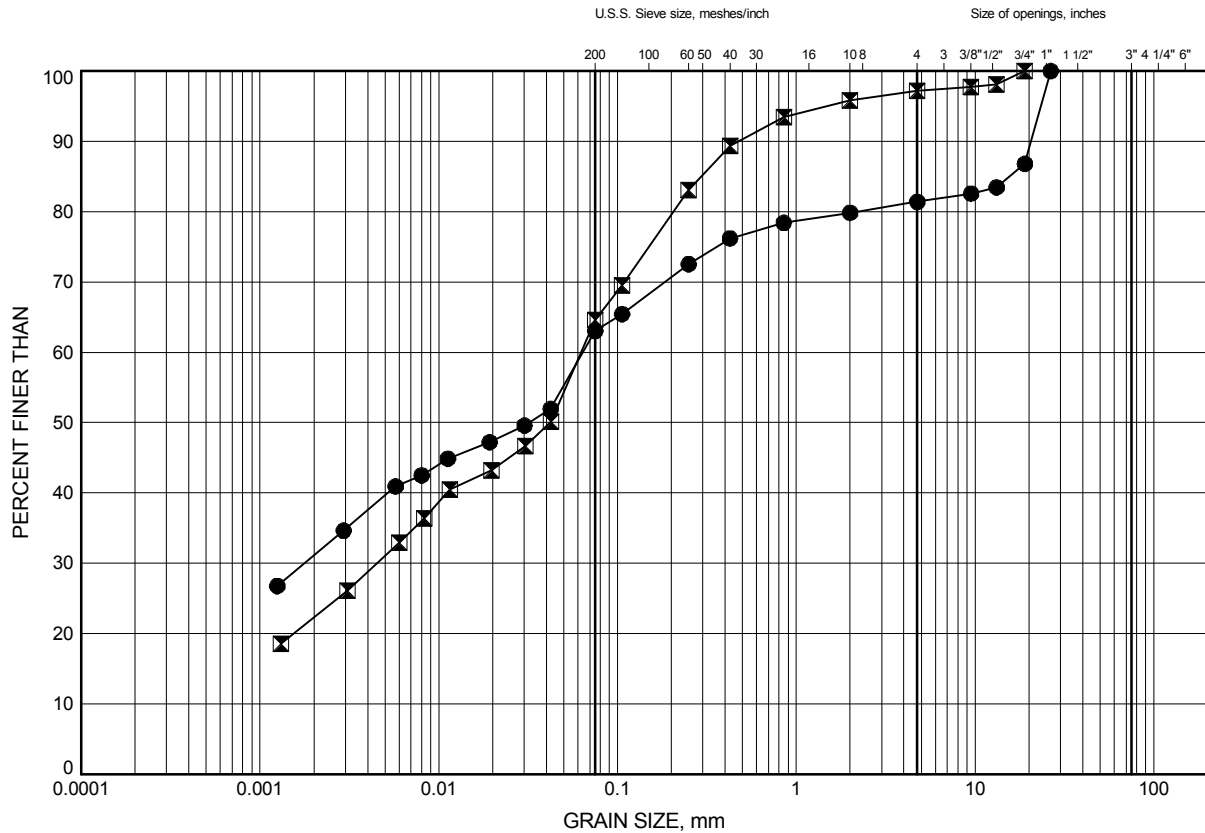
Prep'd JAG
Chkd. PC

Highway 416 Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C7

Culvert 4, Clay



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | 12 | 7.16 | 102.15 |
| ⊠ | 13 | 1.07 | 101.50 |

Date June 2017
GWP# 4068-13-00



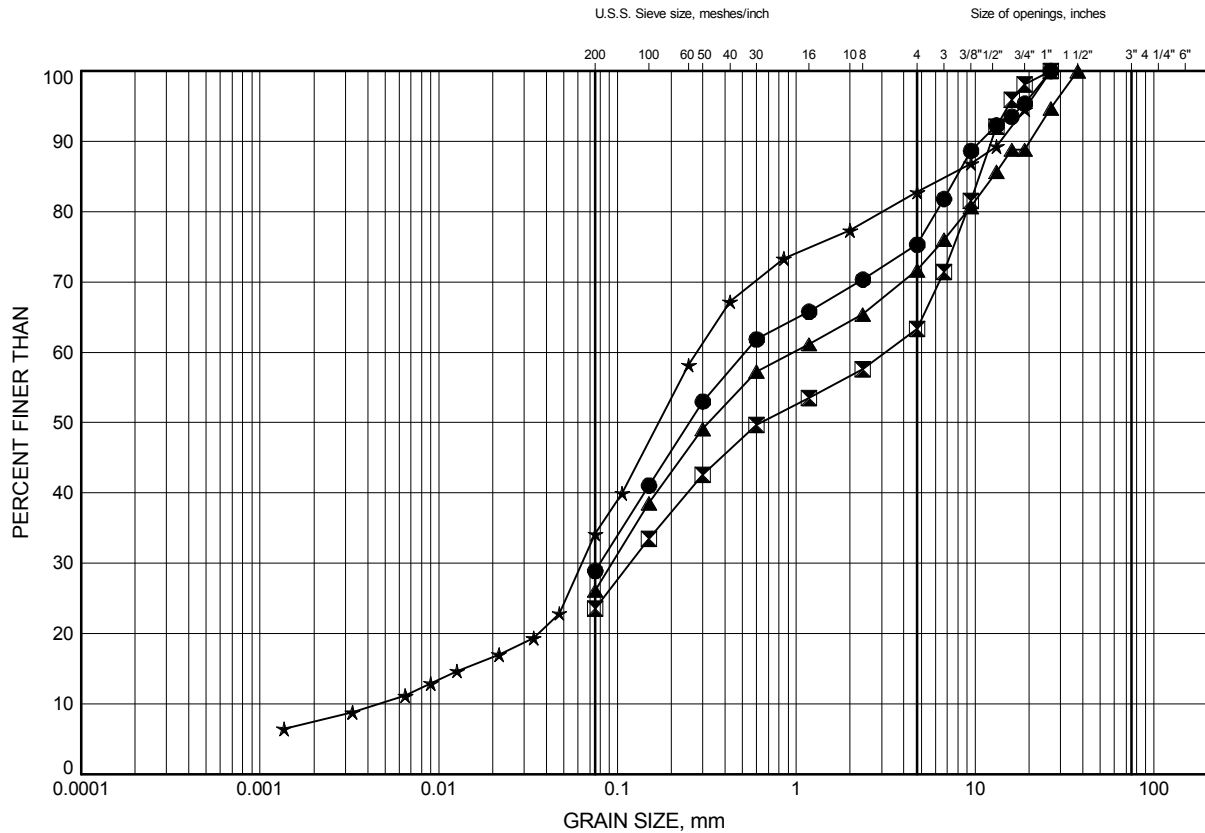
Prep'd JAG
Chkd. PC

Highway 416 Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C8

Culvert 4, Silty Sand with Gravel



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | 10 | 0.69 | 104.38 |
| ⊠ | 10 | 2.59 | 102.47 |
| ▲ | 11 | 9.75 | 100.94 |
| ★ | 13 | 2.59 | 99.98 |

Date June 2017
GWP# 4068-13-00



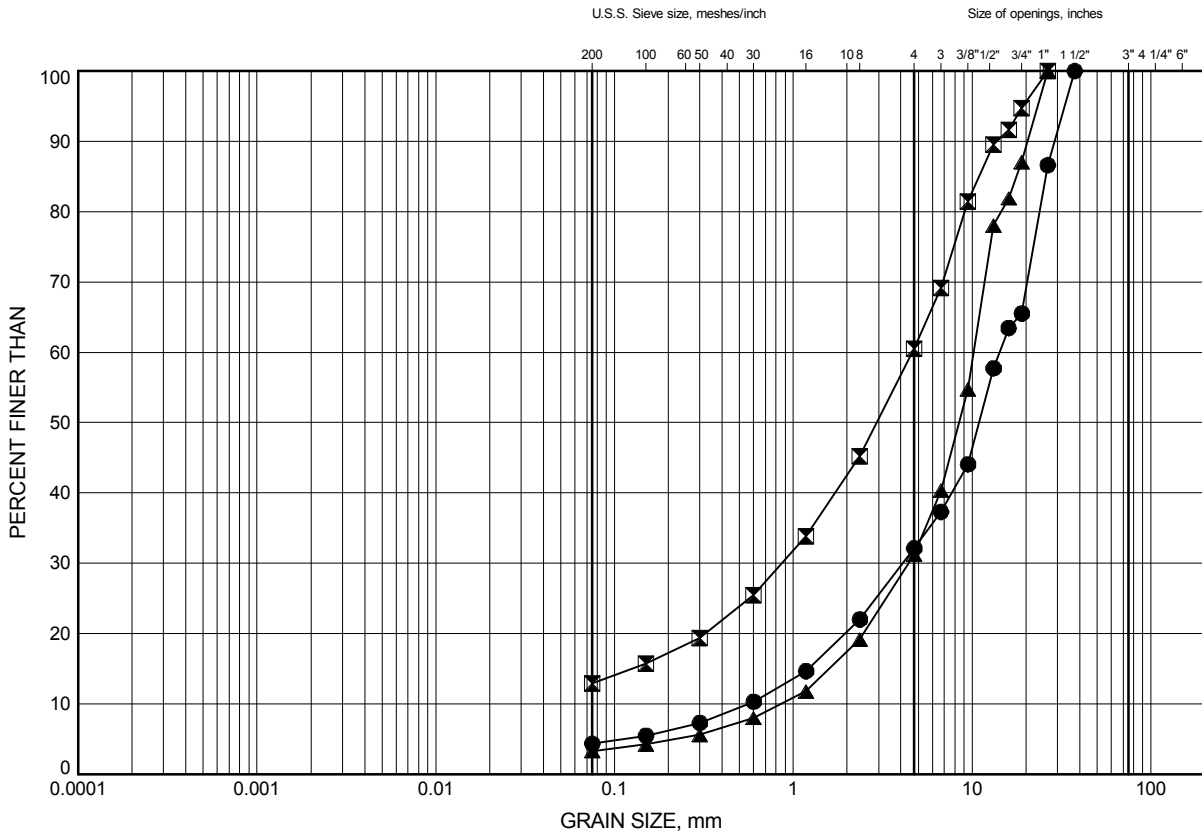
Prep'd JAG
Chkd. PC

Highway 416 Culverts

GRAIN SIZE DISTRIBUTION

FIGURE C9

Culvert 6, Fill



| | | | | | | |
|---------------|------|--------|--------|--------|--------|-------------|
| SILT and CLAY | FINE | MEDIUM | COARSE | FINE | COARSE | COBBLE SIZE |
| FINE GRAINED | SAND | | | GRAVEL | | |

LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | 14 | 0.30 | 109.16 |
| ◻ | 15 | 0.30 | 110.58 |
| ▲ | 15 | 1.07 | 109.82 |

Date June 2017
GWP# 4068-13-00



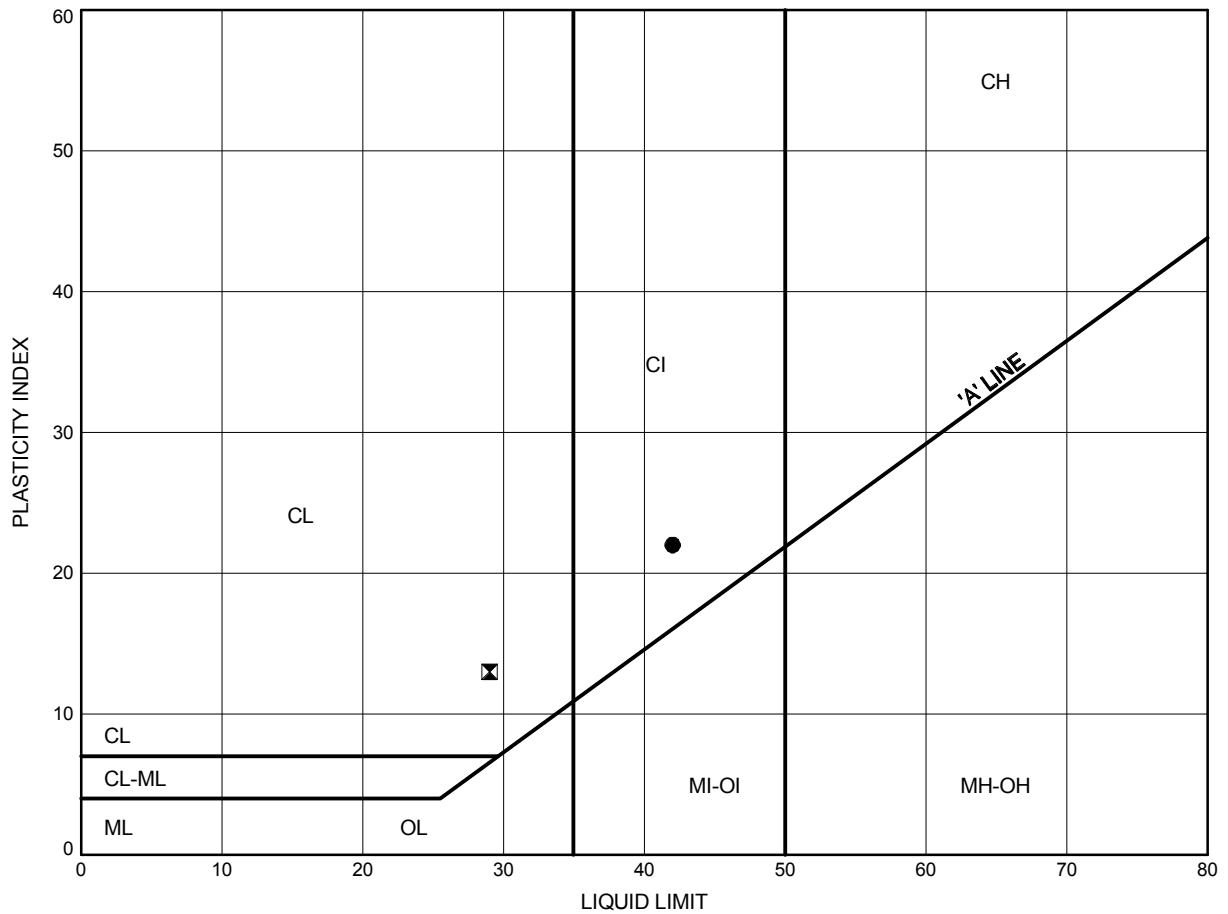
Prep'd JAG
Chkd. PC

Appendix C.2

Atterberg Limit Analysis Figures

Highway 416 Culverts ATTERBERG LIMITS TEST RESULTS

FIGURE C10



LEGEND

| SYMBOL | BOREHOLE | DEPTH (m) | ELEV. (m) |
|--------|----------|-----------|-----------|
| ● | 12 | 7.16 | 102.15 |
| ⊠ | 13 | 1.07 | 101.50 |

Date . June 2017

GWP# . 4068-13-00



Prep'd JAG

Chkd. PC

Appendix C.3
Analytical Testing Results

Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B 4S5
Attn: Justin Gray

Client PO: 16498
Project: 416 Fallowfield
Custody: 14052

Report Date: 9-May-2017
Order Date: 3-May-2017

Order #: 1718305

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

| Paracel ID | Client ID |
|------------|---------------------|
| 1718305-01 | BH1, SS2, 2'6"-4'6" |
| 1718305-03 | BH7, SS1B, 0'2"-2' |
| 1718305-04 | BH13, SS1, 0'-2' |
| 1718305-05 | BH16, SS1, 0'-1'3" |

Approved By:



Dale Robertson, BSc
Laboratory Director

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 16498

Report Date: 09-May-2017

Order Date: 3-May-2017

Project Description: 416 Fallowfield

Analysis Summary Table

| Analysis | Method Reference/Description | Extraction Date | Analysis Date |
|-------------|--|-----------------|---------------|
| Anions | EPA 300.1 - IC, water extraction | 4-May-17 | 4-May-17 |
| pH, soil | EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext. | 4-May-17 | 5-May-17 |
| Resistivity | EPA 120.1 - probe, water extraction | 5-May-17 | 5-May-17 |
| Solids, % | Gravimetric, calculation | 9-May-17 | 9-May-17 |

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 16498

Report Date: 09-May-2017

Order Date: 3-May-2017

Project Description: 416 Fallowfield

| | | | | |
|---------------------|---------------------|--------------------|------------------|--------------------|
| Client ID: | BH1, SS2, 2'6"-4'6" | BH7, SS1B, 0'2"-2' | BH13, SS1, 0'-2' | BH16, SS1, 0'-1'3" |
| Sample Date: | 03-Apr-17 | 27-Mar-17 | 05-Apr-17 | 09-Apr-17 |
| Sample ID: | 1718305-01 | 1718305-03 | 1718305-04 | 1718305-05 |
| MDL/Units | Soil | Soil | Soil | Soil |

Physical Characteristics

| | | | | | |
|----------|--------------|------|------|------|------|
| % Solids | 0.1 % by Wt. | 90.7 | 91.3 | 76.4 | 73.2 |
|----------|--------------|------|------|------|------|

General Inorganics

| | | | | | |
|-------------|---------------|----------|----------|------|------|
| pH | 0.05 pH Units | 7.71 [1] | 7.76 [1] | 7.67 | 7.47 |
| Resistivity | 0.10 Ohm.m | 29.6 | 27.0 | 13.5 | 17.6 |

Anions

| | | | | | |
|----------|------------|---------|---------|-----|-----|
| Chloride | 5 ug/g dry | 120 [1] | 148 [1] | 239 | 189 |
| Sulphate | 5 ug/g dry | 33 [1] | 9 [1] | 47 | 36 |

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 16498

Report Date: 09-May-2017

Order Date: 3-May-2017

Project Description: 416 Fallowfield

Method Quality Control: Blank

| Analyte | Result | Reporting Limit | Units | Source Result | %REC | %REC Limit | RPD | RPD Limit | Notes |
|---------------------------|--------|-----------------|-------|---------------|------|------------|-----|-----------|-------|
| Anions | | | | | | | | | |
| Chloride | ND | 5 | ug/g | | | | | | |
| Sulphate | ND | 5 | ug/g | | | | | | |
| General Inorganics | | | | | | | | | |
| Resistivity | ND | 0.10 | Ohm.m | | | | | | |

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 16498

Report Date: 09-May-2017

Order Date: 3-May-2017

Project Description: 416 Fallowfield

Method Quality Control: Duplicate

| Analyte | Result | Reporting Limit | Units | Source Result | %REC | %REC Limit | RPD | RPD Limit | Notes |
|---------------------------------|--------|-----------------|----------|---------------|------|------------|-----|-----------|-------|
| Anions | | | | | | | | | |
| Chloride | 19.8 | 5 | ug/g dry | 19.9 | | | 0.2 | 20 | |
| Sulphate | 15.1 | 5 | ug/g dry | 14.8 | | | 2.4 | 20 | |
| General Inorganics | | | | | | | | | |
| pH | 7.71 | 0.05 | pH Units | 7.70 | | | 0.1 | 10 | |
| Resistivity | 29.8 | 0.10 | Ohm.m | 29.6 | | | 0.5 | 20 | |
| Physical Characteristics | | | | | | | | | |
| % Solids | 59.4 | 0.1 | % by Wt. | 58.2 | | | 2.0 | 25 | |

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 16498

Report Date: 09-May-2017

Order Date: 3-May-2017

Project Description: 416 Fallowfield

Method Quality Control: Spike

| Analyte | Result | Reporting Limit | Units | Source Result | %REC | %REC Limit | RPD | RPD Limit | Notes |
|---------------|--------|-----------------|-------|---------------|------|------------|-----|-----------|-------|
| Anions | | | | | | | | | |
| Chloride | 129 | 5 | ug/g | 19.9 | 109 | 78-113 | | | |
| Sulphate | 115 | 5 | ug/g | 14.8 | 100 | 78-111 | | | |

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO: 16498

Report Date: 09-May-2017
Order Date: 3-May-2017
Project Description: 416 Fallowfield

Qualifier Notes:

Login Qualifiers :

Sample - One or more parameter received past hold time -
Applies to samples: BH1, SS2, 2'6"-4'6", BH7, SS1B, 0'2"-2'

Sample Qualifiers :

1 : Holding time had been exceeded upon receipt of the sample at the laboratory.

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Appendix D.

Site Photographs



Photo 1. Culvert 1, Looking north towards inlet and side slope.



Photo 2. Culvert 1, Looking north at culvert crossing.



Photo 3. Culvert 1, Looking north at outlet and side slope



Photo 4. Culvert 3B, Looking north at inlet and side slope



Photo 5. Culvert 3B, Looking south at culvert crossing



Photo 6. Culvert 3A/3B, Looking south towards outlet of 3B



Photo 7. Culvert 3A/3B, Looking south towards inlet of 3A and outlet of 3B



Photo 8. Culvert 3A, Looking south toward outlet



Photo 9. Culvert 4, Looking southeast towards inlet



Photo 10. Culvert 4, Looking north towards mid length junction between W-N and S-EW ramps



Photo 11. Culvert 4, Looking west towards outlet



Photo 12. Culvert 6, Looking north towards inlet and rock cut



Photo 13. Culvert 6, Looking north towards inlet