

PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 401 STRUCTURE REPLACEMENT
CAMPBELL AVENUE EAST OVERPASS
HALTON REGION, ONTARIO
G.W.P. 2188-10-00, SITE No. 10-44/1&2

GEOCRES Number: 30M05-307

Report to

AECOM

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TABLE OF CONTENTS

PART 1 FACTUAL INFORMATION

1	INTRODUCTION.....	1
2	SITE DESCRIPTION.....	1
3	SITE INVESTIGATION AND FIELD TESTING	2
4	LABORATORY TESTING	3
5	DESCRIPTION OF SUBSURFACE CONDITIONS	3
5.1	Asphalt Pavement	3
5.2	Concrete.....	3
5.3	Topsoil	3
5.4	Sandy Gravel to Sand & Gravel Fill	4
5.5	Sand and Gravel.....	4
5.6	Silt and Sand.....	4
5.7	Sand	5
5.8	Silt, some sand.....	5
5.9	Groundwater Conditions.....	6
6	MISCELLANEOUS.....	7

PART 2 ENGINEERING DISCUSSION AND RECOMMENDATIONS

7	GENERAL	8
8	STRUCTURE FOUNDATION.....	8
8.1	Spread Footings on Native Soil	9
8.2	Spread Footings on Engineered Fill.....	10
8.3	Steel H-Pile Foundations	10
8.3.1	Axial Resistance	10
8.3.2	Pile Tips.....	11
8.3.3	Pile Installation.....	11
8.3.4	Pile Lateral Resistance	11
8.4	Caissons / Drilled Shafts.....	12
8.5	Downdrag	12
8.6	Recommended Foundation	12
8.7	Frost Cover	13
9	EXCAVATION AND DEWATERING.....	13
10	RETAINED SOIL SYSTEMS (RSS)	13
11	EMBANKMENT WIDENING	14

12	LATERAL EARTH PRESSURES.....	14
13	SEISMIC CONSIDERATIONS.....	15
14	EROSION PROTECTION.....	16
15	CONSTRUCTION CONCERNS.....	16
16	INVESTIGATION FOR DETAIL DESIGN	17
17	CLOSURE.....	18

Appendices

Appendix A	Record of Borehole Sheets
Appendix B	Laboratory Test Results
Appendix C	Historical Borehole Information
Appendix D	Drawings titled “Borehole Locations and Soil Strata”
Appendix E	List of SPs and OPSS, and Suggested Text for Selected NSSP
Appendix F	Foundation Comparison

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a preliminary foundation investigation carried out at the location of the proposed replacement of the existing Highway 401 Eastbound (EB) and Westbound (WB) Overpass Structure at Campbell Avenue East in the Regional Municipality of Halton, Ontario. This investigation was carried out in support of the preliminary design, environmental assessment and planning for the bridge replacement. These works are part of the project involving preliminary design for Highway 401 Structure Replacement from Trafalgar Road westerly to Halton Region Boundary.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole locations and soil strata drawing, records of boreholes, stratigraphic profile and cross-sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained from the present investigation and selected data from previous investigation.

Thurber was retained by AECOM to carry out the foundation investigation at this site on behalf of the Ministry of Transportation Ontario (MTO) under Consultant Assignment No. 2012-E-0016.

2 SITE DESCRIPTION

The overpass bridges are located approximately 200 m west of Sixteen Mile Creek and 1.5 km east of Guelph Line, and approximately 70 m south of the intersection with Campbellville Road. The terrain in the general area is gently undulating. The land to the north and south of the site is mostly for agricultural use and typically forested. Residential and industrial development areas exist to the west of the site.

The existing Highway 401 EB and WB lanes cross Campbell Avenue East at an approximately 7.3 degree skew angle on an 11 m long single span rigid frame structure. Fill height of the highway embankments at this site is approximately 7.0 m above the surrounding ground.

The site lies in the physiographic region known as the Flamborough Plain, which is bounded by the

Galt Moraine on the northwest and by the silts and sands of glacial Lake Warren on the south. The Plain slopes gently to the south towards Lake Ontario. The surface topography in the area is typically characterized by glacially derived drumlins with overburden soil consisting of glacial till or sand and gravel. The Silurian bedrock underlying the area belongs to the Gasport Member, characterized by thick-bedded, blue-grey, crinoidal limestone to dolostone, of the Lockport Formation.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project consisted of drilling three (3) boreholes through the highway embankment behind the existing abutments, three (3) boreholes on Campbell Avenue East shoulders in close proximity of the existing abutments and two (2) boreholes at the existing ground surface beyond embankment footprint. The field work was carried out between May 22 and July 15, 2014. The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawings in Appendix D. Historical boreholes from a Foundation Investigation Report prepared by Strata Engineering Corp. dated May 21, 1991 (Geocres No. 30M5-182) are included in Appendix C.

In the present investigation, the borehole locations were staked and/or marked in the field. Utility clearance was obtained for all borehole locations prior to drilling. Borehole location data including northing, easting and surface elevation has been derived based on the preliminary design information provided by AECOM to Thurber.

A truck-mounted D-90 drill rig and continuous flight hollow stem augers were used to advance the boreholes through embankment fill and native soils. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with the Standard Penetration Testing (SPT). The boreholes were advanced completely through the embankment fill and into the native soil to establish at least 3 m of soil with a minimum SPT value of 100 blows for 0.3 m of penetration except in CR14-01, CR14-03 and CR14-04 where boreholes were terminated in very dense native sand at approximately 20 m depth below the existing highway grade. Boreholes CR14-01A, CR-02 and CR14-03A were advanced deeper to establish the depth to foundation soils with minimum SPT value of 100 blows for 0.3 m of penetration. Boreholes 14-19 and 14-21 were advanced to approximately 10 m depth.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Standpipe piezometers were installed in Boreholes CR14-01A, CR14-03A, 14-19 and 14-21 to permit monitoring of the groundwater levels. The standpipe piezometer typically consists of 19 mm diameter Schedule 40 PVC pipes with 3.0 m long slotted screen positioned in the soil strata where groundwater fluctuations are to be monitored. The sand screen surrounded the pipe and extended at least 0.3 m above the slotted screen. Bentonite holeplug seals were placed above the sand screen in each installation. Following the final water level reading, the piezometers were decommissioned in general accordance with MOE Regulation 903.

The drilling and sampling operations were supervised on a full-time basis by a member of

Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

4 LABORATORY TESTING

All recovered soil samples were subjected to visual identification and natural moisture content determination. The results of the testing are shown on the Record of Borehole sheets attached in Appendix A. Selected soil samples were subjected to gradation analysis. The results of this testing program are presented on the Record of Borehole sheets in Appendix A and on the Figures in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendix A. Details of the encountered soil stratigraphy are presented in these records and on the "Borehole Locations and Soil Strata" drawings in Appendix D. Historical borehole information is included in Appendix C. A general description of the subsurface conditions encountered in the current investigation is given in the following paragraphs. The factual information established at the borehole locations governs any interpretation of the site conditions.

In general, the subsurface conditions at this site consist of existing highway fill underlain by a sequence of soils composed mainly of silt, sand and gravel. The site lies in an area that once formed part of a glacial spillway and local soil exposures, including gravel pits, have indicated that the soils are highly heterogeneous mixtures of silt through gravel sized material and including many cobbles and boulders. The stratigraphy at the site has been described in broad terms, based on visual examination as well as laboratory test results. However, anomalous test results are seen in each stratum as a result of the heterogeneous nature of the deposits and the limited size of individual SPT samples.

5.1 Asphalt Pavement

Three boreholes CR14-01, CR14-03 and CR14-04 were advanced from the top of pavement level on the outside edge of the driving lanes of Highway 401. Thicknesses of the asphalt encountered in the boreholes were in the order of 125 mm.

5.2 Concrete

Concrete was encountered below the asphalt pavement in boreholes CR14-01, CR14-03 and CR14-04. The concrete was about 450 mm thick.

5.3 Topsoil

Topsoil was encountered at the existing ground surface in Boreholes 14-19 and 14-21. Thickness of the topsoil was about 150 mm.

5.4 Sandy Gravel to Sand & Gravel Fill

Existing fill was encountered beneath the concrete in boreholes CR14-01, CR14-03 and CR14-04 and at surface in boreholes CR14-01A, CR14-02 and CR14-03A advanced through the unpaved Campbell Avenue East shoulders. The composition of the fill ranges from sandy gravel to sand & gravel with trace silt. Thicknesses of the existing fill encountered in the boreholes ranged from 2.2 m on the Campbell Avenue East shoulders to 6.6 m through the highway embankments. The base elevations of the fill varied from 262.4 to 264.6 m.

Standard Penetration Tests (SPT) conducted within the fill gave 'N' values ranging from 10 to 69 blows per 0.3 m penetration, indicating compact to very dense relative densities. The measured natural moisture contents of the fill samples ranged from 3 to 16%.

Results of grain size analyses conducted on selected fill samples are presented in Figures B1a and B1b, and are summarized as follows:

Gravel	44 to 67%
Sand	25 to 45%
Silt & Clay	5 to 14%

5.5 Sand and Gravel

A layer of native sand and gravel was encountered below the embankment fill in boreholes CR14-01, CR14-01A, CR14-02 and CR14-04 and below the topsoil in Boreholes 14-19 and 14-21. The sand and gravel mixture contains trace to some silt. Thickness of this layer ranged from 3.0 to 4.4 m with the base of the layer at elevations varying from 259.0 to 261.9 m.

Standard Penetration Tests (SPT) conducted within the layer produced 'N' values ranging from 3 to 84 blows per 0.3 m penetration, indicating very loose to very dense relative density with typically dense to very dense relative density. One SPT test carried out in borehole CR14-04 recorded 50 blows for 150 mm penetration possibly due to a cobble or boulder. The measured natural moisture contents of the samples ranged from 4 to 16%.

Results of grain size analyses conducted on selected sand & gravel samples are presented in Figures B2a and B2b, and are summarized as follows:

Gravel	19 to 47%
Sand	34 to 58%
Silt & Clay	9 to 23%

5.6 Silt and Sand

A layer of silt and sand was encountered below the sand & gravel in Boreholes CR14-01 and 14-19 and below the existing fill in boreholes CR14-03 and CR14-03A. The layer was fully penetrated in boreholes CR14-01 and CR14-03A, where thicknesses of 6.1 m and

11.5 m were measured with the base of the layer at elevations 255.4 m and 251.3 m, respectively. Boreholes CR14-03 and 14-19 were terminated in the layer at elevations 251.4 m and 256.2 m, respectively.

Standard Penetration Tests (SPT) conducted within the layer produced 'N' values ranging from 12 to 90 blows per 0.3 m penetration, indicating compact to very dense relative densities. The measured natural moisture contents of the samples typically ranged from 14 to 48%.

Results of grain size analyses conducted on selected silt and sand samples are presented in Figures B3a and B3b, and are summarized as follows:

Gravel	0 to 4%
Sand	1 to 77%
Silt	20 to 91%
Clay	3 to 10%

5.7 Sand

A deposit of sand was encountered beneath the silt and sand layer in boreholes CR14-01 and CR14-03A and beneath the sand and gravel layer in boreholes CR14-01A, CR14-02, CR14-04 and 14-21. Boreholes CR14-01A, CR14-02 and CR14-04 were terminated within the sand layer at elevations ranging from 247.5 to 251.4 m. The sand layer was fully penetrated in Borehole 14-21 where thickness of the layer was 3.7 m with the base of layer at elevation 256.4 m.

Standard Penetration Tests (SPT) conducted within the sand deposit produced 'N' values ranging from 19 to greater than 100 blows per 0.3 m penetration, indicating compact to very dense relative densities. The measured natural moisture contents of the sand samples ranged from about 9 to 20%.

Results of grain size analyses conducted on selected sand samples are presented in Figures B4a and B4b, and are summarized as follows:

Gravel	0 to 30%
Sand	48 to 93%
Silt & Clay	7 to 22%

5.8 Silt, some sand

A layer of silt was encountered below the sand deposit in Borehole 14-21. Borehole 14-21 was terminated in the silt at elevation 254.7 m. The silt contains some sand and trace clay.

Standard Penetration Test (SPT) conducted within the silt deposit produced an 'N' value of 38 blows per 0.3 m penetration, indicating a dense relative density. The measured natural moisture contents of the silt samples ranged from about 23 to 24%.

Result of grain size analysis conducted on a silt sample is presented in Figure B3a and

indicates that the silt contains 0% gravel, 17% sand, 76% silt and 7% clay.

5.9 Groundwater Conditions

Groundwater conditions were observed in the open boreholes upon completion of drilling. The measured groundwater levels in the open boreholes and the standpipe piezometers are presented in the table below.

Borehole	Date	Conditions	Groundwater Level	
			Depth (m)	Elevation (m)
CR14-01	May 23, 2014	Open Borehole	12.2	259.5
CR14-01A	June 16, 2014	Open Borehole	6.1	258.5
	July 8, 2014	Piezometer	3.5	261.1
	July 24, 2014		3.8	260.8
	July 28, 2014		3.9	260.7
	Aug. 11, 2014		4.1	260.5
CR14-02	May 30, 2014	Open Borehole	3.8	260.8
CR14-03	May 26, 2014	Open Borehole	12.8	259.0
CR14-03A	June 16, 2014	Open Borehole	5.6	259.4
	July 8, 2014	Piezometer	2.9	262.1
	July 24, 2014		4.0	261.0
	July 28, 2014		4.1	260.9
	Aug. 11, 2014		4.8	260.2
CR14-04	May 27, 2014	Open Borehole	11.8	259.4
14-19	July 15, 2014	Open Borehole	4.6	261.4
	July 24, 2014	Piezometer	1.5	264.5
	July 28, 2014		1.5	264.5
	Aug. 11, 2014		1.8	264.2
14-21	July 24, 2014	Piezometer	3.7	260.8
	July 28, 2014		3.6	260.9
	Aug. 11, 2014		3.7	260.8

It should be noted that all groundwater observations at this site are short term. The groundwater levels are expected to fluctuate seasonally and after severe weather events.

6 MISCELLANEOUS

The drilling and sampling equipment was supplied and operated by Walker Drilling Ltd. of Barrie, Ontario. A truck-mounted D-90 drill rig was used for the duration of the investigation.

Traffic protection during the drilling operation was provided by Direct Traffic Management Inc. of Hamilton, Ontario.

The field work was supervised on a full time basis by Mr. George Azzopardi of Thurber Engineering Ltd. Overall supervision of the field program was conducted by Mr. Weiss Mehdawi, P.Eng.

The report was prepared by Mr. Keli Shi, P. Eng., and reviewed by Mr. Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report provides an interpretation of the geotechnical data in the factual report and presents preliminary foundation design recommendations to assist the design team in the selection and design of a suitable foundation system for the Highway 401 Campbell Avenue East Overpass Bridge.

Based on the preliminary information provided by AECOM, it is understood that the existing 11 m span Campbell Avenue East Overpass Bridge will be replaced by a 13.5 m long span. Existing drawings indicate that the original twin structures are rigid frames supported on spread footings and that a later median infill structure is supported on battered deep foundation elements described as pre-augered steel tube caissons. The preliminary GA received by Thurber indicates that the replacement structure is planned as a rigid frame supported on spread footings.

Deck width of the Highway 401 roadway carried by the overpass bridge will be widened from the current 33.5 m to 48.9 m. Reinforced soil systems (RSS) walls are proposed for the widened approach embankments. There is no grade raise proposed at the overpass bridge.

The discussion and recommendations presented in this report are based on the information provided by AECOM and on the factual data obtained during the course of the current investigation.

8 STRUCTURE FOUNDATION

In general, the stratigraphy below the existing bridge approach embankments consists of a thin layer of compact to very dense sand and gravel underlain by sand deposit. A layer of typically dense to very dense silty sand to sandy silt was encountered above the sand at southwest corner of the bridge site. The highest groundwater level measured in the standpipe piezometers installed close to the existing bridge was at elevation 262.1 m or approximately 2.9 m below the existing Campbell Avenue East grade.

Based on the subsurface conditions, initial consideration was given to supporting the Replacement Bridge on spread footings on native soil or engineered fill, driven steel H-piles, or augered caissons. A comparison of the technical advantages and disadvantages of the alternative foundation schemes is presented in Appendix E.

Recommendations for design of the feasible foundation alternatives are presented in the following sections together with the corresponding geotechnical design parameters. A preferred foundation scheme from a geotechnical perspective is recommended.

8.1 Spread Footings on Native Soil

Based on the subsurface conditions encountered at this site, the use of spread footings to support the abutments is considered feasible from a geotechnical perspective. Spread footings should be founded on compact to dense native silty sand to sand. Table 8.1 summarizes the recommended founding elevations at the abutment locations and the recommended geotechnical resistances assuming a minimum 2 m wide footing subjected to vertical concentric loading.

Table 8.1 – Recommended Founding Elevations and Geotechnical Resistances for Spread Footings

Foundation Element	Borehole No.	Recommended Highest Founding Elevation (m)	Bearing Stratum	Factored ULS (kPa)	SLS (kPa)
West Abutment	CR14-01	263.0	Very dense Gravelly Sand	600	400
	CR14-01A	262.4	Compact Sand & Gravel	500	350
	CR14-03	264.6	Dense Silt & Sand	600	400
	CR14-03A	260.4	Compact Silt & Sand	500	350
East Abutment	CR14-02	262.4	Dense Sand & Gravel	500	350
	CR14-04	263.6	Compact Sand & Gravel	500	350

If the recommended founding elevations are higher than the founding elevation of the existing footings, it is recommended that footings for the replacement bridge be founded no higher than the existing footings.

Where eccentric or inclined loads are applied, the resistances used in design must be reduced in accordance with the CHBDC Clause 6.7.3 and Clause 6.7.4.

The geotechnical resistance at SLS is based on an estimated settlement not exceeding 25 mm. This settlement will be essentially complete by the end of construction.

The lateral resistance developed along the base of concrete footings founded on the above soils may be computed using an ultimate friction coefficient of 0.5.

Excavation and backfilling for the footings must be in accordance with OPSS 902.

Construction of a footing will require excavation extending close to or possibly below the groundwater level. Dewatering may be required.

8.2 Spread Footings on Engineered Fill

The design founding levels may be raised by placing the footings on engineered fill constructed over the native compact to dense silt and sand to sand and gravel. The base of the engineered fill pad must be placed at or below the founding levels provided in Table 8.1. The engineered fill must consist of OPSS Granular 'A' placed in 150 mm lifts and compacted to 100% of its SPMDD at $\pm 2\%$ of optimum moisture content. The fill pad should extend laterally at least 1.0 m beyond the edge of footing.

Provided a minimum footing width of 2 m is maintained, footings bearing on an engineered fill pad at least 2.0 m thick may be designed for the following values:

- Factored Geotechnical Resistance at ULS = 900 kPa
- Geotechnical Resistance at SLS = 350 kPa

The lateral resistance of footings founded on engineered fill may be computed using an unfactored friction coefficient of 0.6.

Construction of the engineered fill will require excavation extending close to or possibly below the groundwater level. Dewatering may be required.

8.3 Steel H-Pile Foundations

The ground conditions at the site are considered to be suitable for the use of driven steel H-piles.

8.3.1 Axial Resistance

It is recommended that H-piles be driven to refusal within the very dense sand layer.

The anticipated pile tip elevations and geotechnical resistances for HP 310x110 piles are presented in Table 8.2.

Table 8.2 – Anticipated Pile Tip Elevation and Recommended Geotechnical Resistance for H-Piles

Foundation Element	Borehole No.	Anticipated Pile Tip Elevation	Factored Geotechnical Resistance at ULS (kN)	Geotechnical Resistance at SLS (kN)
West Abutment	CR14-01 CR14-01A CR14-03 CR14-03A	249.0	1,400	1,200
East Abutment	CR14-02 CR14-04	249.0	1,400	1,200

The pile tips must be driven to the anticipated elevations or deeper if this is necessary to develop the geotechnical resistance.

8.3.2 Pile Tips

Pile tip protection is recommended for driven H-piles to prevent pile damage. The tips of all driven H-piles must be fitted with driving shoes in accordance with OPSD 3000.100.

8.3.3 Pile Installation

Pile installation should be in accordance with OPSS 903.

Pile driving must be controlled in accordance with Standard Drawing SS103-11 (Hiley Formula) and an ultimate pile resistance should be specified by the designer. The Hiley formula need not be used until the piles are within 2.0 m of the design pile tip elevation. The appropriate pile driving note is “Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of “R” kN per pile. “R” must have a minimum value of twice the design load at ULS, but must not exceed 2,800 kN.

8.3.4 Pile Lateral Resistance

The geotechnical lateral resistance acting on a pile in cohesionless soil may be calculated using coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = n_h z / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 3 \gamma' z K_p \quad (\text{kPa})$$

Where

- z = depth of embedment along pile (m)
- D = pile width or diameter (m)
- n_h = coefficient related to soil density (kN/m^3)
- γ' = effective unit weight (kN/m^3)
- K_p = coefficient of passive lateral earth pressure

The parameters recommended for use with the above equations are provided in Table 8.3.

Table 8.3 – Soil Parameters for Lateral Pile Resistance

Location	Soil Unit	Elevation (m)		γ' (kN/m^3)	n_h (kN/m^3)	K_p
		Top	Bottom			
West Abutment	Embankment Fill	271.2	264.5	21	5,000	3.3
	Silt & Sand	264.5	256.0	11	3,500	3.3
	Dense Silty Sand	256.0	252.5	11	5,500	3.5
	Very Dense Sand	252.5	247.5	12	8,000	3.7
East Abutment	Embankment Fill	270.6	264.0	21	5,000	3.3
	Sand & Gravel	264.0	259.0	11	3,500	3.3
	Dense Sand	259.0	252.5	11	5,500	3.5
	Very Dense Sand	252.5	247.5	12	8,000	3.7

The above equations and recommended parameters may be used to analyze the interaction

between a pile and the surrounding soil. The lateral pressures obtained from the analysis must not exceed the ultimate lateral resistance.

The spring constant, K_s , for analysis may be obtained by the expression, $K_s = k_s L D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m³), D is the pile width (m) and L is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance, P_{ult} , may be obtained from the expression, $P_{ult} = p_{ult} L D$. This represents the ultimate load at which geotechnical failure of the pile occurs and will not support any additional load at greater displacement.

According to the CHBDC Clause C6.8.7.1 and Table C6.4, lateral resistance for steel HP310 x 110 piles embedded in compact to very dense cohesionless soils should be limited to 120 kN and 50 kN under ULS (factored) and SLS conditions, respectively.

The coefficient of subgrade reaction and ultimate lateral resistance may have to be reduced, based on the pile spacing. The reduction factors to be used for a pile group oriented perpendicular or parallel to the direction of loading are provided in Table 8.4. Intermediate values may be obtained by linear interpolation.

Consideration may be given to the use of battered piles if lateral pile capacities higher than the available geotechnical lateral resistances are required.

Table 8.4 – Subgrade Reaction Reduction Factors for Pile Spacing

Condition	Pile Spacing (Centre to Centre)	Reduction Factor
Pile group oriented <i>perpendicular</i> to direction of loading	4D	1.0
	1D	0.5
Pile group oriented <i>parallel</i> to direction of loading	8D	1.0
	6D	0.7
	4D	0.4
	3D	0.25

8.4 Caissons / Drilled Shafts

Caisson installation at this site would extend through cohesionless soils below the groundwater table and require the use of a permanent liner to support the caisson sidewalls. Sealing of the caisson liner to prevent inflow of water and cohesionless soils from the base will be problematic. The use of caissons is therefore not recommended and the design recommendations have not been developed.

8.5 Downdrag

In view of the soil conditions at this site, downdrag on the piles is not considered to be an issue.

8.6 Recommended Foundation

From a geotechnical and cost perspective, spread footings are the preferred foundation

option for this site.

8.7 Frost Cover

The depth of frost penetration at this site is approximately 1.2 m. The base of footings or pile caps must be provided with a minimum of 1.2 m of earth cover as protection against frost action.

9 EXCAVATION AND DEWATERING

All excavations must be carried out in accordance with OPSS 902 and the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the approach fill and native silt/sand/gravel within the depth of excavation may be classified as Type 3 soils above the groundwater level and Type 4 soils below the groundwater level. Flatter slopes may be required at locations where water seepage affects stability of an excavation.

The selection of the method of excavation is the responsibility of the Contractor and must be based on his equipment, experience and interpretation of the site conditions. It is anticipated that a hydraulic excavator will be suitable. Provision must be made for the handling of pavement materials, potential obstructions in the fill, and cobbles and boulders.

It is understood that bridge rehabilitation will be carried out in stages to maintain the highway traffic at all times. Roadway protection will be required to facilitate staging. Roadway protection should be provided in accordance with OPSS 539 and designed for Performance Level 2.

The design of any roadway protection or dewatering system that may be required is the responsibility of the Contractor. All shoring systems should be designed by a professional engineer experienced in such design.

10 RETAINED SOIL SYSTEMS (RSS)

Based on the preliminary design information provided by AECOM, both abutments will have RSS wingwalls. The RSS walls will be stepped up at a slope of 2H: 1V along the approaches away from the abutments.

In general, RSS walls used in conjunction with the new abutments must be “High Performance” and “High Appearance”. The contract drawings should include information on the longitudinal alignment of the wall in plan, the top and base elevations of the wall in profile, cross-sectional space constraints and an NSSP for the RSS wall.

To provide an acceptable foundation performance, the RSS mass must be founded on competent soils or engineered fill. The foundation of the entire RSS mass must be considered, i.e. from the face of the wall to the furthest extent of the reinforcement.

The borehole information indicates that the soil conditions at the wall base levels will generally comprise existing embankment fill and compact native sandy silt to gravelly sand. Walls founded on the above materials should be designed for a Factored Geotechnical Resistance at ULS of

320 kPa and a Geotechnical Reaction at SLS of 200 kPa.

The above geotechnical resistance values are estimated for a horizontal ground surface in front of the wall and may have to be reduced for ground surface sloping down in front of the wall.

The geotechnical resistances provided above are for concentric, vertical loading. The effects of load inclination and eccentricity need to be taken into account according to the CHBDC 2006 Section 6.7. The resistance values assume that the RSS wall reinforcement will extend a distance behind the wall face of approximately 70% of the wall height.

A minimum 500 mm thick layer of bedding material conforming to OPSS Granular “A” requirements should be provided under the RSS mass to provide a uniform subgrade condition. Engineered fill placed under the RSS mass to achieve the design founding level should consist of OPSS Granular “A” compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered fill pad must extend at least 500 mm beyond the limits of the RSS mass and levelling strip. Any topsoil and soft/loose fill or native material should be stripped from the footprint of the RSS. All disturbed and new embankment fill must be compacted in accordance with OPSS 501. Suggested text for a NSSP addressing these issues is included in Appendix E.

The reinforced earth block must also be designed against various modes of failure including sliding and overturning. Sliding resistance along the base of the wall on native silty sand and engineered granular fill may be estimated using ultimate friction coefficients of 0.45 and 0.55, respectively. The internal stability of the RSS wall should be analyzed by the supplier/designer of the proprietary product selected for this site.

In view of the soil conditions at this site, the estimated foundation settlement beneath RSS walls is expected to be less than 25 mm and will be essentially complete at the end of construction.

11 EMBANKMENT WIDENING

Widening of the approach embankments will be required to accommodate the replacement structure. Based on the preliminary design information provided by AECOM, the approach embankments will be widened to the north of the existing embankments.

When placing new fill against the existing embankment, benching will be required for the existing embankment slopes in accordance with OPSD 208.010.

The widened portions of embankments with fill height in the order of 7 m are anticipated to be stable at standard side slope inclination of 2H: 1V. A mid-height berm comprising a 2 m wide bench should be incorporated along the length of embankments with fill heights exceeding 8 m.

12 LATERAL EARTH PRESSURES

Backfill to the abutment walls should be in accordance with OPSS 902 and should consist of Granular A or Granular B Type II material. All granular material should meet the specifications of OPSS.PROV 1010. Compaction equipment to be used adjacent to retaining structures should be

restricted in accordance with OPSS 501.

Earth pressures acting on the structure may be assumed to be triangular and to be governed by the characteristics of the backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$p_h = K (\gamma h + q)$$

Where: p_h = horizontal pressure on the wall at depth h (kPa)

K = coefficient of lateral earth pressure (see Table 12.1)

γ = unit weight of retained soil (see Table 12.1)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are given in Table 12.1.

The coefficients provided in Table 12.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.16 in the Commentary to the Canadian Highway Bridge Design Code (CHBDC).

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I, or at a depth of 1.7 m for Granular A or Granular B Type II.

Table 12.1 – Coefficients of Lateral Earth Pressure (K)

Loading Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.39*	0.31	0.47*
At-rest (Restrained Wall)	0.43	-	0.47	-
Passive	3.7	-	3.3	-

* For wing walls.

13 SEISMIC CONSIDERATIONS

The following seismic parameters should be used for design in accordance with the CHBDC for a design earthquake with 475-year return period:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.05

- Acceleration Related Seismic Zone 1
- Zonal Acceleration Ratio 0.05
- Peak Ground Acceleration 0.04 g

The soil profile type at this site has been classified as Type I. Therefore, according to Clause 4.4.6.1 of the CHBDC, a Site Coefficient “S” (ground motion amplification factor) of 1.0 should be used in seismic design.

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. For the design of retaining walls, the coefficients of lateral earth pressure in Table 13.1 may be used.

Table 13.1 – Earth Pressure Coefficient for Earthquake Loading

Loading Condition	Earth Pressure Coefficient (K) for Earthquake Loading			
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)
Active (K_{AE})*	0.29	0.42	0.32	0.51
At-rest (K_{OE})**	0.46	-	0.51	-
Passive (K_{PE})*	3.5	-	3.1	-

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

** After Woods (1973).

Based on review on the SPT data, seismically-induced liquefaction of foundation soils is not anticipated under the design earthquake.

14 EROSION PROTECTION

A vegetation cover should be established on all exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS 804.

15 CONSTRUCTION CONCERNS

During construction, the Contract Administrator (CA) should employ an experienced geotechnical engineer to observe foundation construction activities and to provide advice to the CA regarding any issues that need to be referred to the design team.

Potential construction concerns include, but are not necessarily limited to, the following:

Protection of the Existing Structure and Roadway Remaining in Service

During the staged replacement of the existing structure, portions of the existing structure and travelled lanes must remain in service. The Contractor must provide adequate protection, e.g. shoring, to ensure that the performance of the existing foundations is not compromised and the

roadway is protected.

Removal of the existing battered caissons supporting the median must be carefully planned to avoid conflict with construction of the proposed replacement foundations. It is recommended that this issue be thoroughly reviewed during detail design stage.

Pile Installation

If piles are meeting refusal at higher elevations than anticipated, the issue should be referred to the contract administrator (CA) for comment and guidance.

Excavation and Dewatering

Any excavation carried out below the prevailing groundwater level runs a significant risk of being destabilized due to the inflow of groundwater. Adequate shoring and groundwater control measures must be in place to maintain the stability of the excavation and to prevent loss of ground under the structure or embankment. If the selected foundation option requires excavation below the groundwater level, it is advisable to obtain a Permit to Take Water (PTTW) prior to dewatering.

16 INVESTIGATION FOR DETAIL DESIGN

During the detail design phase, the designers must review the available geotechnical information to determine if it is adequate to support the proposed design. If there are information gaps at the final foundation locations or in the approach embankments, additional investigation must be carried out in accordance with MTO standards.

17 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Mr. Keli Shi, P.Eng. The report was reviewed by Mr. Alastair E. Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

THURBER ENGINEERING LTD.

Keli Shi, P.Eng.
Geotechnical Engineer



Alastair E. Gorman, P.Eng.
Associate, Senior Foundation Engineer



P.K. Chatterji, P.Eng.
Review Principal



Appendix A
Record of Borehole Sheets

METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE
			NUMBER	TYPE	"N" VALUES
271.7					
0.0	ASPHALT: (125mm)				
0.1	CONCRETE: (450mm)				
271.1					
0.6	Sandy GRAVEL, trace silt Dense to Compact Brown Dry (FILL)		1	SS	31
			2	SS	35
			3	SS	26
			4	SS	37
			5	SS	18
			6	SS	69
264.5					
7.2	Gravelly SAND, some silt Compact to Very Dense Brown Dry		7	SS	15
			8	SS	75

+³, ×³: Numbers refer to Sensitivity

ONTMT4S 3896A.GPJ 2012TEMPLATE(MTO).GDT 7/8/14

RECORD OF BOREHOLE No CR14-01

2 OF 3

METRIC

W.P. 2188-10-00 LOCATION Cambellville Rd. Bridge N 4 817 429.1 E 266 765.5 ORIGINATED BY GA
HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2014.05.22 - 2014.05.23 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL LIQUID MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
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												
Continued From Previous Page						▽		20	40	60	80	100		20	40	60	GR SA SI CL			
261.5																				
10.2	SILT to Sandy SILT, trace clay Very Dense Brown Moist		9	SS	84										○				0 1 91 8	
				10	SS		70									○				
			11	SS	60										○				0 31 66 3	
			12	SS	90										○					
255.4																				
16.3	SAND, trace silt Very Dense Brown Wet																			
			13	SS	64										○			0 93 5 2		
				14	SS	82									○					
											</									

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RECORD OF BOREHOLE No CR14-01

3 OF 3

METRIC

W.P. 2188-10-00 LOCATION Cambellville Rd. Bridge N 4 817 429.1 E 266 765.5 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.05.22 - 2014.05.23 CHECKED BY KS


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 (%)					
	Continued From Previous Page		15	SS	104													
251.4	Gravelly																	
20.3	END OF BOREHOLE AT 20.3m. BOREHOLE OPEN TO 20.3m AND WATER LEVEL AT 12.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND GROUT TO 0.6m, CONCRETE TO 0.2m, THEN ASPHALT PATCH TO SURFACE.																	

RECORD OF BOREHOLE No CR14-01A

1 OF 2

METRIC

GWP# 2188-10-00 LOCATION Campbell Ave. East Overpass N 4 817 438.4 E 266 775.8 ORIGINATED BY GA
HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2014.06.16 - 2014.06.16 CHECKED BY KS

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									WATER CONTENT (%)			GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
								20	40	60	80	100					○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL					× LAB VANE	20	40	60																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
264.6	0.0	Sandy GRAVEL , trace silt Very Dense to Dense Brown Dry (FILL)		1	SS	46								○																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										

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RECORD OF BOREHOLE No CR14-01A

2 OF 2

METRIC

GWP# 2188-10-00 LOCATION Campbell Ave. East Overpass N 4 817 438.4 E 266 775.8 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.06.16 - 2014.06.16 CHECKED BY KS

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			20 40 60 80 100	20 40 60 80 100	W _p W W _L	20 40 60					
	Continued From Previous Page															
	SAND, some silt, trace to some gravel Very Dense Brown Wet		10	SS	101		254									
							253									
			11	SS	77		252									
							251									
			12	SS	105		250									
	Gravelly		13	SS	105/		249									
					0.150											
							248									
247.7			14	SS	104/											
16.9	END OF BOREHOLE AT 16.9m. BOREHOLE OPEN TO 6.1m AND WATER LEVEL AT 6.1m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Jul. 08/14 3.5 261.1 Jul. 24/14 3.8 260.8 Jul. 28/14 3.9 260.7 Aug. 11/14 4.1 260.5				0.150											









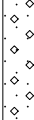


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RECORD OF BOREHOLE No CR14-02

1 OF 2

METRIC

W.P. 2188-10-00 LOCATION Cambellville Rd. Bridge N 4 817 439.9 E 266 788.8 ORIGINATED BY GA
HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2014.05.29 - 2014.05.30 CHECKED BY KS

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 (%)						
								○ UNCONFINED + FIELD VANE					w _p w w _L						
								● QUICK TRIAXIAL × LAB VANE											
264.6	0.0	Sandy GRAVEL , trace silt Dense Brown Dry (FILL)		1	SS	50		264											
				2	SS	45		263											
				3	SS	35		262											
262.4	2.2	SAND and GRAVEL , trace to some silt Dense to Compact Brown Dry to Moist		4	SS	32		261											
				5	SS	31		260											
				6	SS	28		259											
								258											
259.0	5.6	SAND , some silt, trace gravel Dense to Very Dense Brown Wet		7	SS	29		257											
				8	SS	34		256											
				9	SS	54	255												

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RECORD OF BOREHOLE No CR14-03

1 OF 3

METRIC

W.P. 2188-10-00 LOCATION Cambellville Rd. Bridge N 4 817 399.0 E 266 764.4 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.05.26 - 2014.05.26 CHECKED BY KS

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								
271.8							20	40	60	80	100					
0.0	ASPHALT: (125mm)															
0.1	CONCRETE: (450mm)															
271.2																
0.6	Sandy GRAVEL, some silt Dense to Compact Brown Dry (FILL)		1	SS	32											
			2	SS	40											
			3	SS	34											
			4	SS	20											
			5	SS	21											
			6	SS	21											
264.6																
7.2	SILT and SAND, trace clay Dense to Very Dense Brown Moist		7	SS	40											
			8	SS	45											

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RECORD OF BOREHOLE No CR14-03

3 OF 3

METRIC

W.P. 2188-10-00 LOCATION Cambellville Rd. Bridge N 4 817 399.0 E 266 764.4 ORIGINATED BY GA
HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2014.05.26 - 2014.05.26 CHECKED BY KS



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										
								<div><div><div>20406080100</div><div></div></div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>										
Continued From Previous Page																		
251.4			15	SS	48													
20.4	END OF BOREHOLE AT 20.4m. BOREHOLE OPEN TO 20.4m AND WATER LEVEL AT 12.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND GROUT TO 0.4m, CONCRETE TO 0.1m, THEN ASPHALT PATCH TO SURFACE.																	

RECORD OF BOREHOLE No CR14-03A

1 OF 2

METRIC

GWP# 2188-10-00 LOCATION Campbell Ave. East Overpass N 4 817 391.4 E 266 775.3 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.06.16 - 2014.06.16 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL		
								20	40	60	80	100	W _P	W						W _L	
265.0	0.0	SAND and GRAVEL , trace silt Dense Brown Dry (FILL)		1	SS	46															
				2	SS	44															
				3	SS	40															
262.8	2.2	SILT and SAND , trace clay Compact to Very Dense Brown Wet		4	SS	12															
				5	SS	14															
				6	SS	24															
				7	SS	61															
				8	SS	71															
		9	SS	36																	

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CR14-03A

2 OF 2

METRIC

GWP# 2188-10-00 LOCATION Campbell Ave. East Overpass N 4 817 391.4 E 266 775.3 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.06.16 - 2014.06.16 CHECKED BY KS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				GR	SA	SI	CL	
	Continued From Previous Page							20	40	60	80	100	20	40	60					
	SILT and SAND , trace to some gravel Very Dense Reddish Brown Wet		10	SS	53		254													
							253													
			11	SS	88		252													
251.3																				
13.7	SAND , some silt, some gravel Very Dense Brown Wet		12	SS	106		251													
							250													
	Gravelly		13	SS	108		249													
247.9			14	SS	114		248													
17.1	END OF BOREHOLE AT 17.1m. BOREHOLE OPEN TO 17.1m AND WATER LEVEL AT 5.6m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Jul. 08/14 2.9 262.1 Jul. 24/14 4.0 261.0 Jul. 28/14 4.1 260.9 Aug.11/14 4.8 260.2																			





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RECORD OF BOREHOLE No CR14-04

1 OF 3

METRIC

W.P. 2188-10-00 LOCATION Cambellville Rd. Bridge N 4 817 403.4 E 266 800.6 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.05.26 - 2014.05.27 CHECKED BY KS

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												
271.2								20	40	60	80	100								
0.0	ASPHALT: (125mm)						271													
0.1	CONCRETE: (450mm)																			
270.6																				
0.6	SAND and GRAVEL, trace silt Dense to Compact Brown Dry (FILL)		1	SS	41		270													
			2	SS	43		269													
			3	SS	32		268													
			4	SS	30		267													
			5	SS	10		266													
			6	SS	30		265													
264.0							264													
7.2	Gravelly SAND to SAND and GRAVEL, trace silt Dense to Very Dense Brown Dry		7	SS	29		263													
			8	SS	50/ 0.150		262													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No CR14-04

3 OF 3

METRIC

W.P. 2188-10-00 LOCATION Cambellville Rd. Bridge N 4 817 403.4 E 266 800.6 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.05.26 - 2014.05.27 CHECKED BY KS

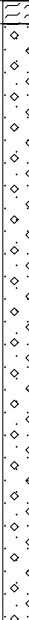
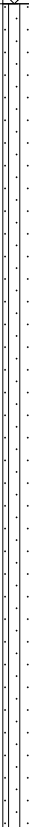
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page		15	SS	113												
251.1																	
20.1	END OF BOREHOLE AT 20.1m. BOREHOLE OPEN TO 20.1m AND WATER LEVEL AT 11.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.5m, CONCRETE TO 0.1m, THEN ASPHALT PATCH TO SURFACE.																

RECORD OF BOREHOLE No 14-19

1 OF 2

METRIC

GWP# 2188-10-00 LOCATION Campbell Ave. East Overpass N 4 817 447.7 E 266 756.2 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.15 - 2014.07.15 CHECKED BY MEF

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									
								20 40 60 80 100									
266.0																	
0.0	TOPSOIL: (150mm)																
0.2	SAND and GRAVEL, some silt Compact to Dense Brown Dry		1	SS	20								○				
			2	SS	33									○			
			3	SS	21										○		
			4	SS	36								○				
			5	SS	31									○			
261.9																	
4.1	SILT and SAND, trace gravel, trace clay Dense to Compact Brown Moist to Wet		6	SS	32									○			
			7	SS	36											○	
			8	SS	28									○			
			9	SS	23									○			
256.2																	
9.8	END OF BOREHOLE AT 9.8m.																

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 14-19

2 OF 2

METRIC

GWP# 2188-10-00 LOCATION Campbell Ave. East Overpass N 4 817 447.7 E 266 756.2 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.15 - 2014.07.15 CHECKED BY MEF

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									
	Continued From Previous Page																
	BOREHOLE OPEN TO 9.1m AND WATER LEVEL AT 4.6m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.																
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2014.07.24 1.5 264.5 2014.07.28 1.5 264.5 2014.08.11 1.8 264.2																

RECORD OF BOREHOLE No 14-21

1 OF 2

METRIC

GWP# 2188-10-00 LOCATION Campbell Ave. East Overpass N 4 817 453.2 E 266 806.5 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.15 - 2014.07.15 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	W _P W W _L	WATER CONTENT (%)	20 40 60	GR SA SI CL				
264.5																	
0.0	TOPSOIL: (150mm)																
0.2	SAND and GRAVEL, some silt Loose to Very Dense Brown Dry to Wet		1	SS	3											47 34 19 (SI+CL)	
			2	SS	30												
			3	SS	61												
			4	SS	35												
			5	SS	31												
260.1																35 55 10 (SI+CL)	
4.4	SAND, some gravel, some silt Compact Brown Wet		6	SS	19												
			7	SS	26												
256.4			8	SS	16											13 76 11 (SI+CL)	
8.1	SILT, some sand, trace clay Dense Reddish Brown Wet																
			9	SS	38												
254.7																0 17 76 7	
9.8	END OF BOREHOLE AT 9.8m.																

Continued Next Page

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

RECORD OF BOREHOLE No 14-21

2 OF 2

METRIC

GWP# 2188-10-00 LOCATION Campbell Ave. East Overpass N 4 817 453.2 E 266 806.5 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.15 - 2014.07.15 CHECKED BY MEF

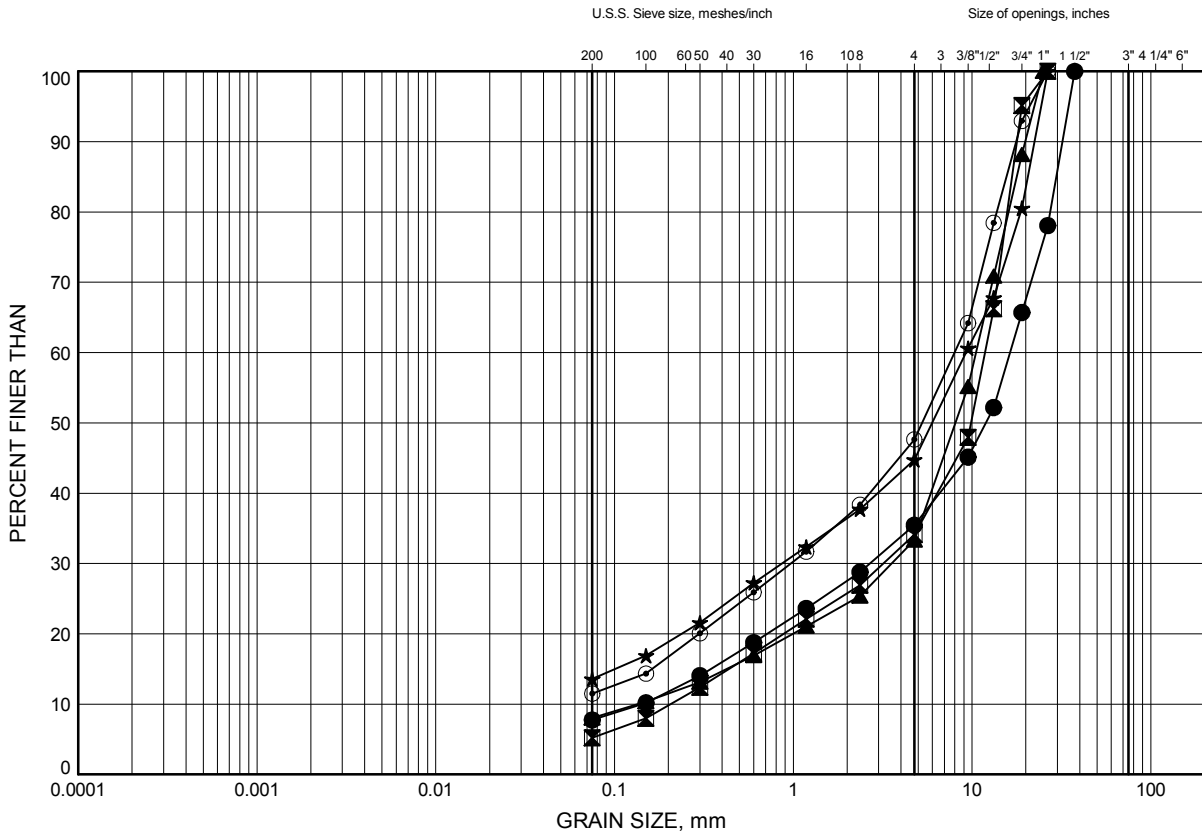
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
	Continued From Previous Page													
	Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2014.07.24 3.7 260.8 2014.07.28 3.6 260.9 2014.08.11 3.7 260.8													

Appendix B
Laboratory Test Results

Campbell Ave. East Overpass
GRAIN SIZE DISTRIBUTION

FIGURE B1a

Sandy GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CR14-01	3.35	268.35
⊠	CR14-01A	1.07	263.53
▲	CR14-02	1.83	262.77
★	CR14-03	1.83	269.97
⊙	CR14-04	1.07	270.13

Date July 2014
GWP# 2188-10-00

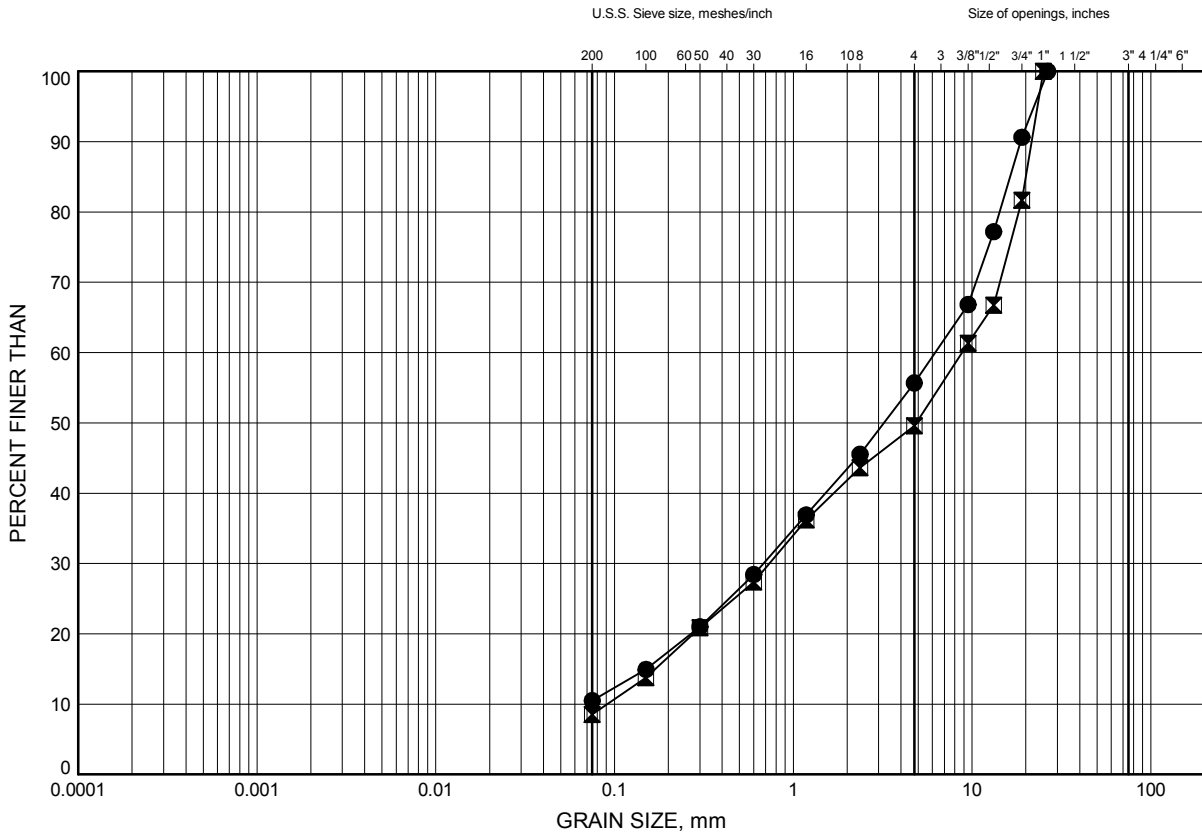


Prep'd AN
Chkd. KS

Campbell Ave. East Overpass
GRAIN SIZE DISTRIBUTION

FIGURE B1b

SAND & GRAVEL FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CR14-03A	1.83	263.17
⊠	CR14-04	4.88	266.32

Date July 2014
 GWP# 2188-10-00

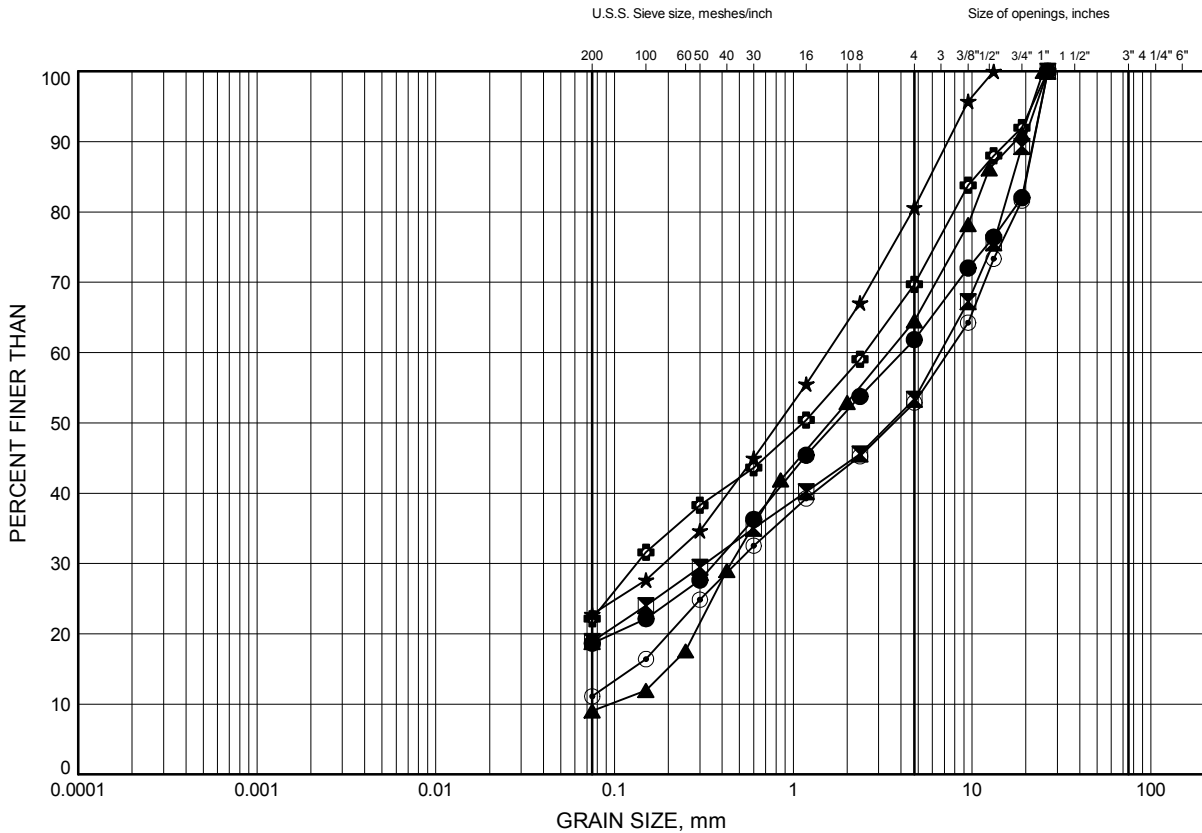


Prep'd AN
 Chkd. KS

Campbell Ave. East Overpass
GRAIN SIZE DISTRIBUTION

FIGURE B2a

SAND & GRAVEL to Gravelly SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-19	2.59	263.41
⊠	14-21	1.07	263.43
▲	14-21	2.59	261.91
★	CR14-01	7.92	263.78
⊙	CR14-01A	3.35	261.25
⊕	CR14-03A	15.54	249.46

Date July 2014

GWP# 2188-10-00



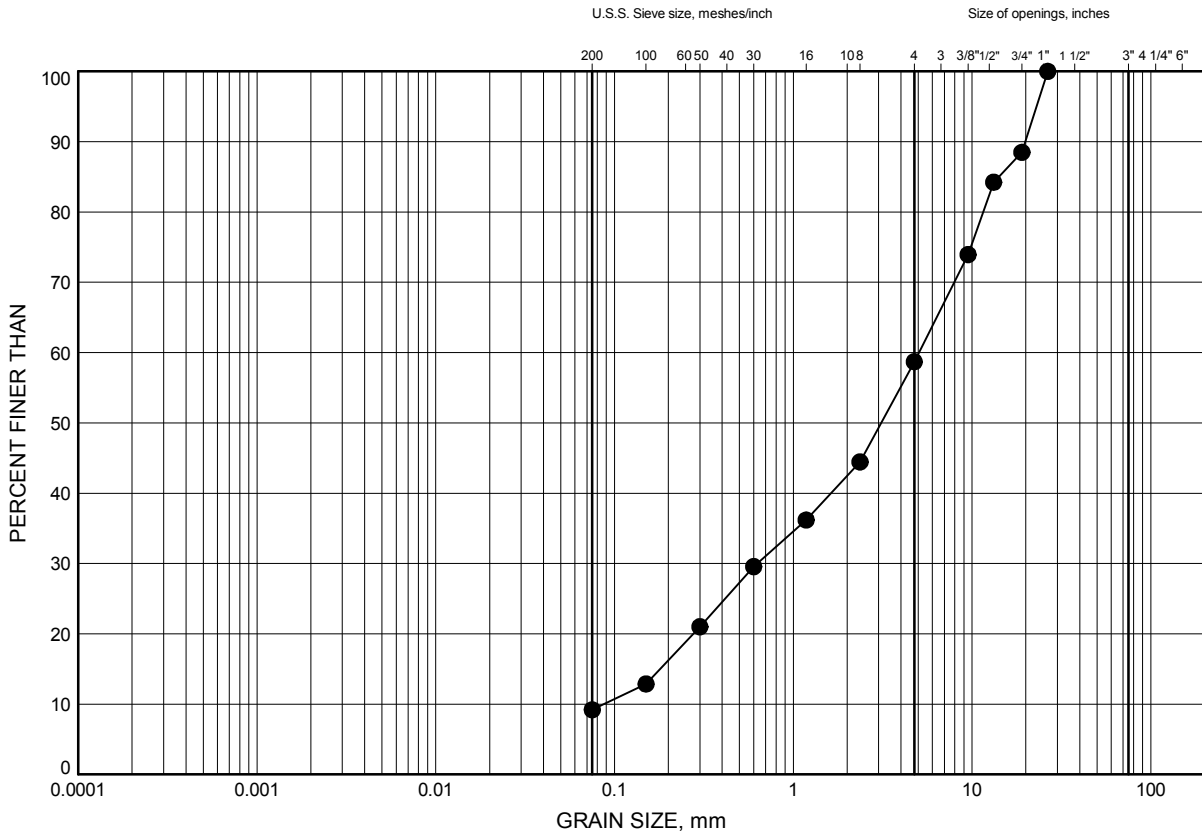
Prep'd AN

Chkd. KS

Campbell Ave. East Overpass
GRAIN SIZE DISTRIBUTION

FIGURE B2b

SAND & GRAVEL to Gravelly SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CR14-04	10.97	260.23

Date July 2014
 GWP# 2188-10-00

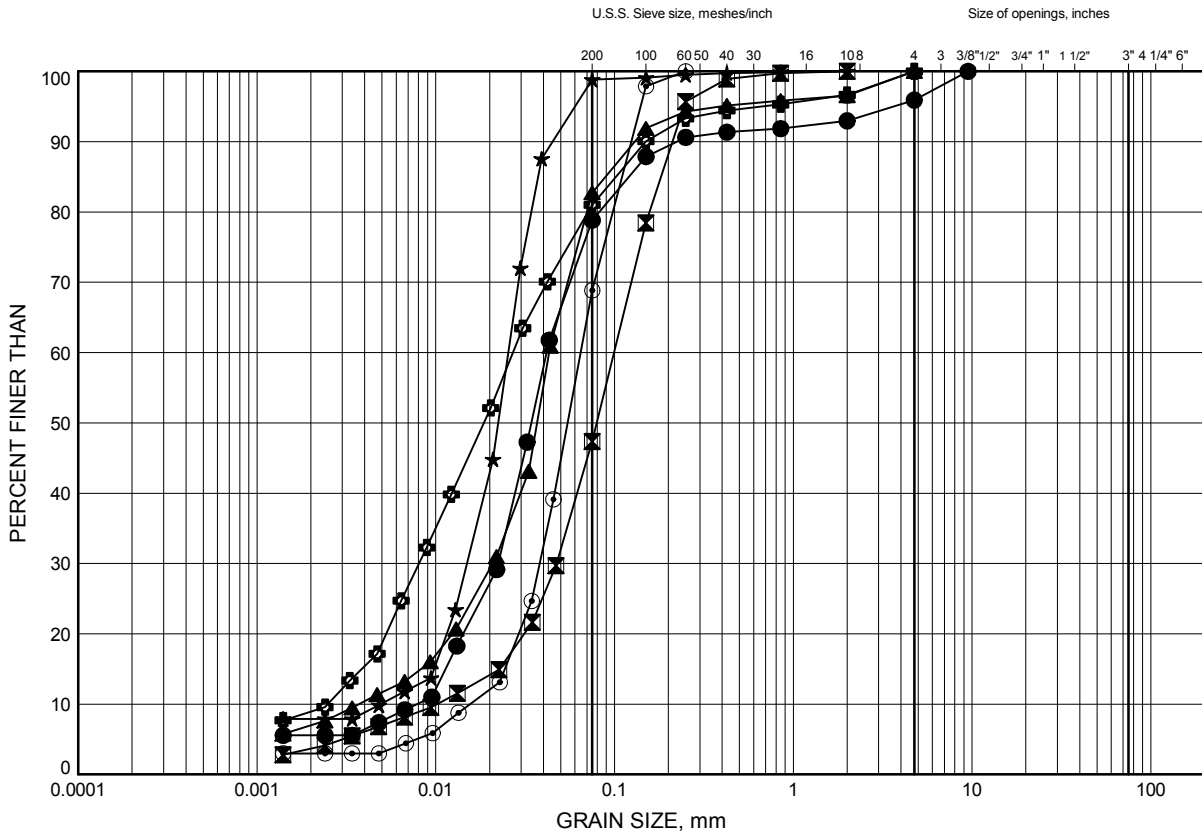


Prep'd AN
 Chkd. KS

Campbell Ave. East Overpass
GRAIN SIZE DISTRIBUTION

FIGURE B3a

SAND & SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-19	6.40	259.60
⊠	14-19	9.45	256.55
▲	14-21	9.45	255.05
★	CR14-01	10.97	260.73
⊙	CR14-01	14.02	257.68
⊕	CR14-03	7.92	263.88

Date July 2014

GWP# 2188-10-00

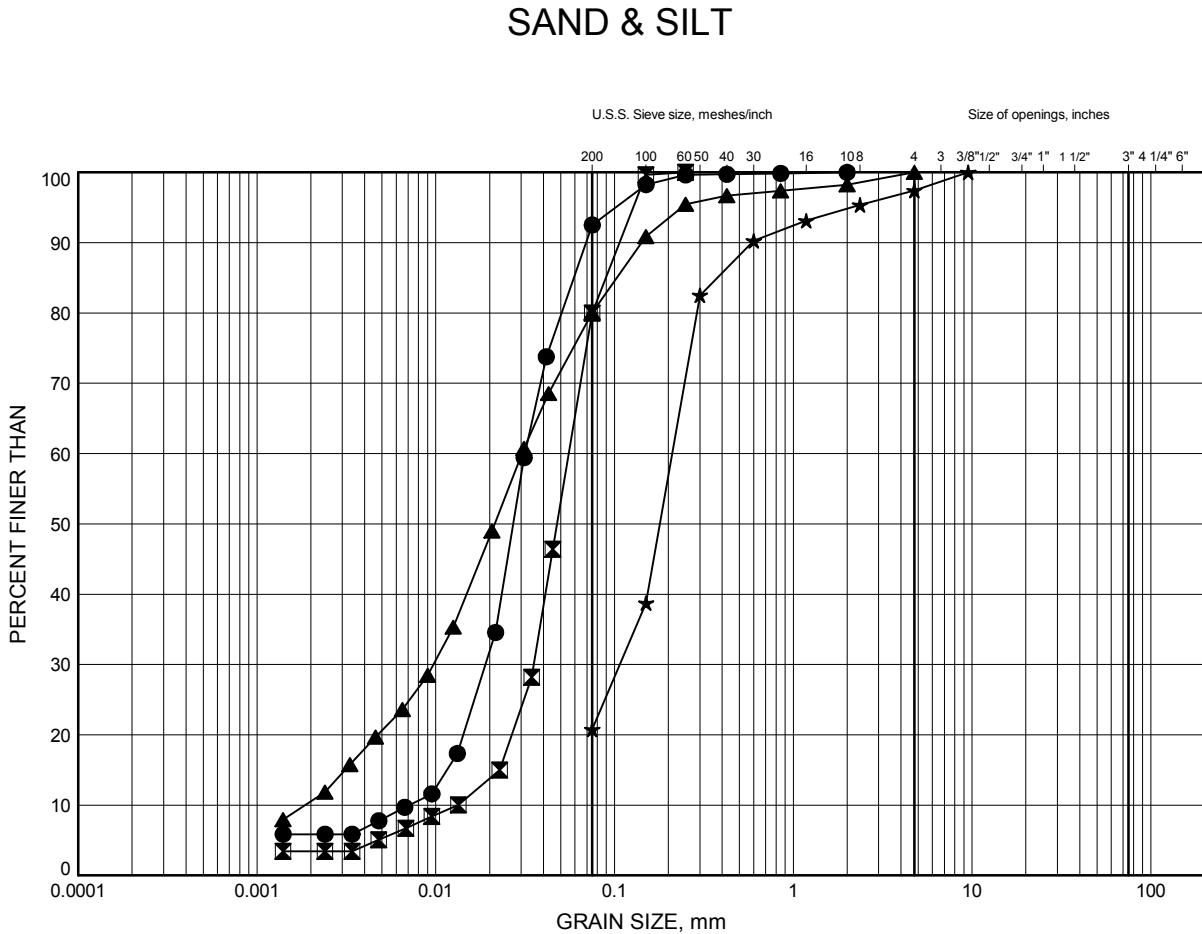


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Campbell Ave. East Overpass
GRAIN SIZE DISTRIBUTION

FIGURE B3b



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CR14-03	12.50	259.30
⊠	CR14-03	15.54	256.26
▲	CR14-03A	2.59	262.41
★	CR14-03A	4.88	260.12

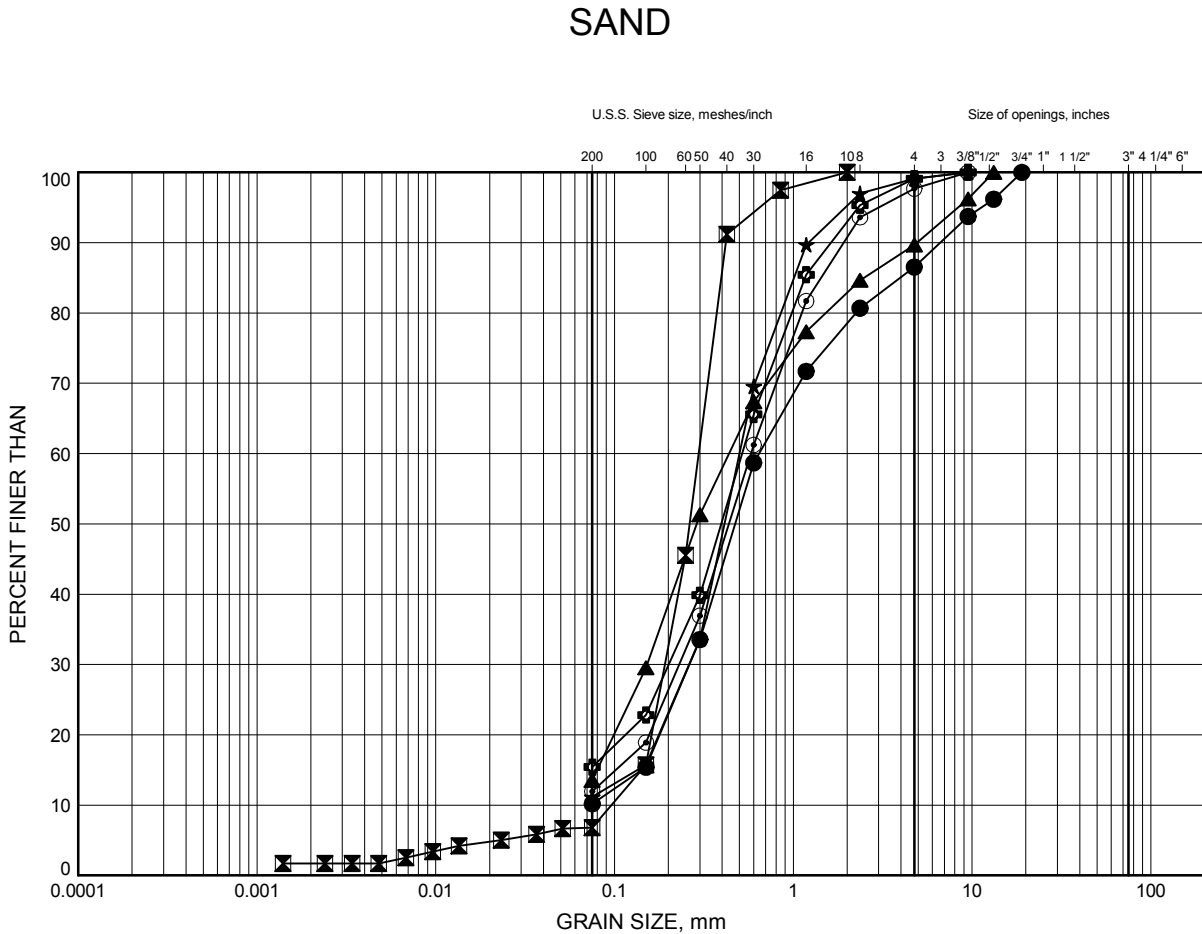
Date July 2014
GWP# 2188-10-00



Prep'd AN
Chkd. KS

Campbell Ave. East Overpass
GRAIN SIZE DISTRIBUTION

FIGURE B4a



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-21	6.40	258.10
⊠	CR14-01	17.07	254.63
▲	CR14-01A	9.45	255.15
★	CR14-02	6.40	258.20
⊙	CR14-02	10.97	253.63
⊕	CR14-02	14.02	250.58

Date July 2014

GWP# 2188-10-00

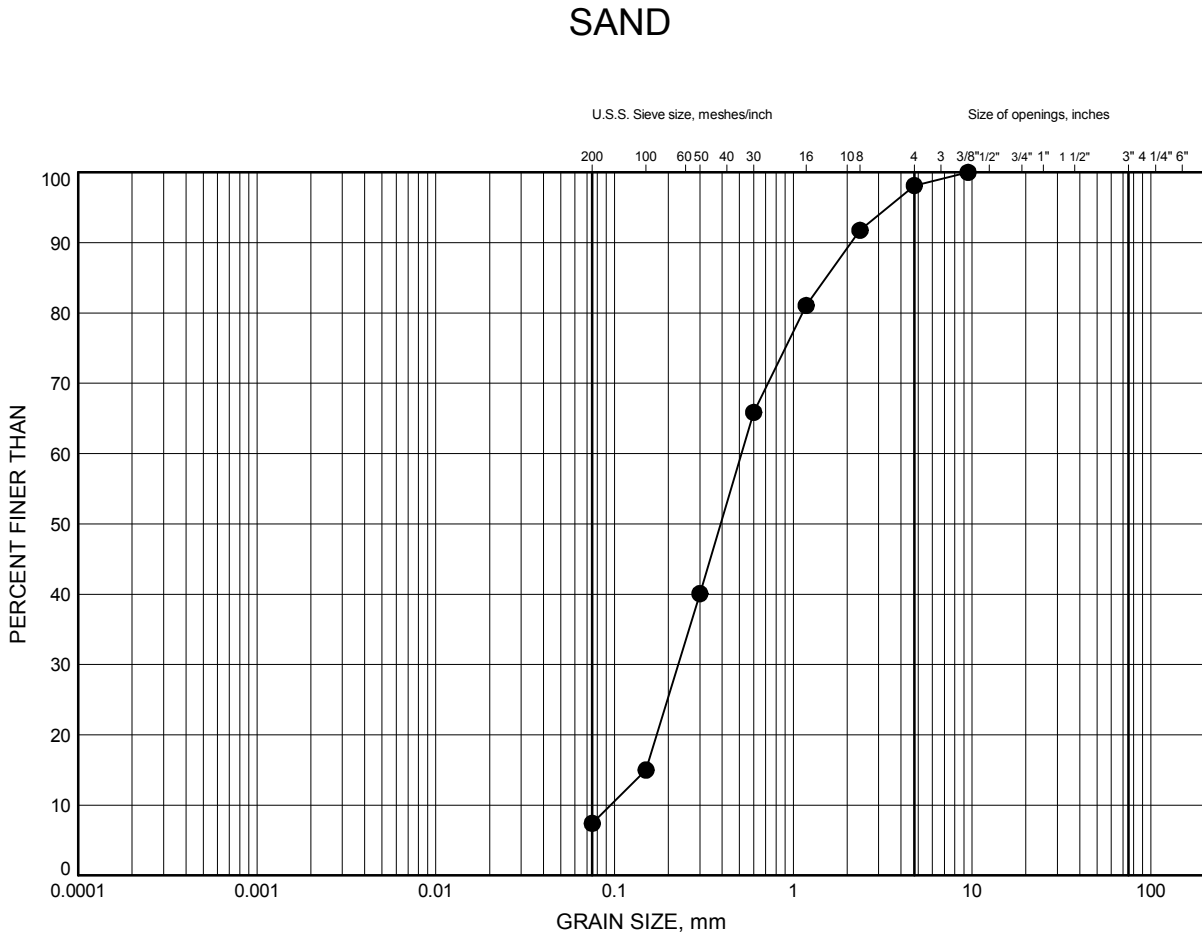


Prep'd AN

Chkd. KS

Campbell Ave. East Overpass
GRAIN SIZE DISTRIBUTION

FIGURE B4b



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

LEGEND

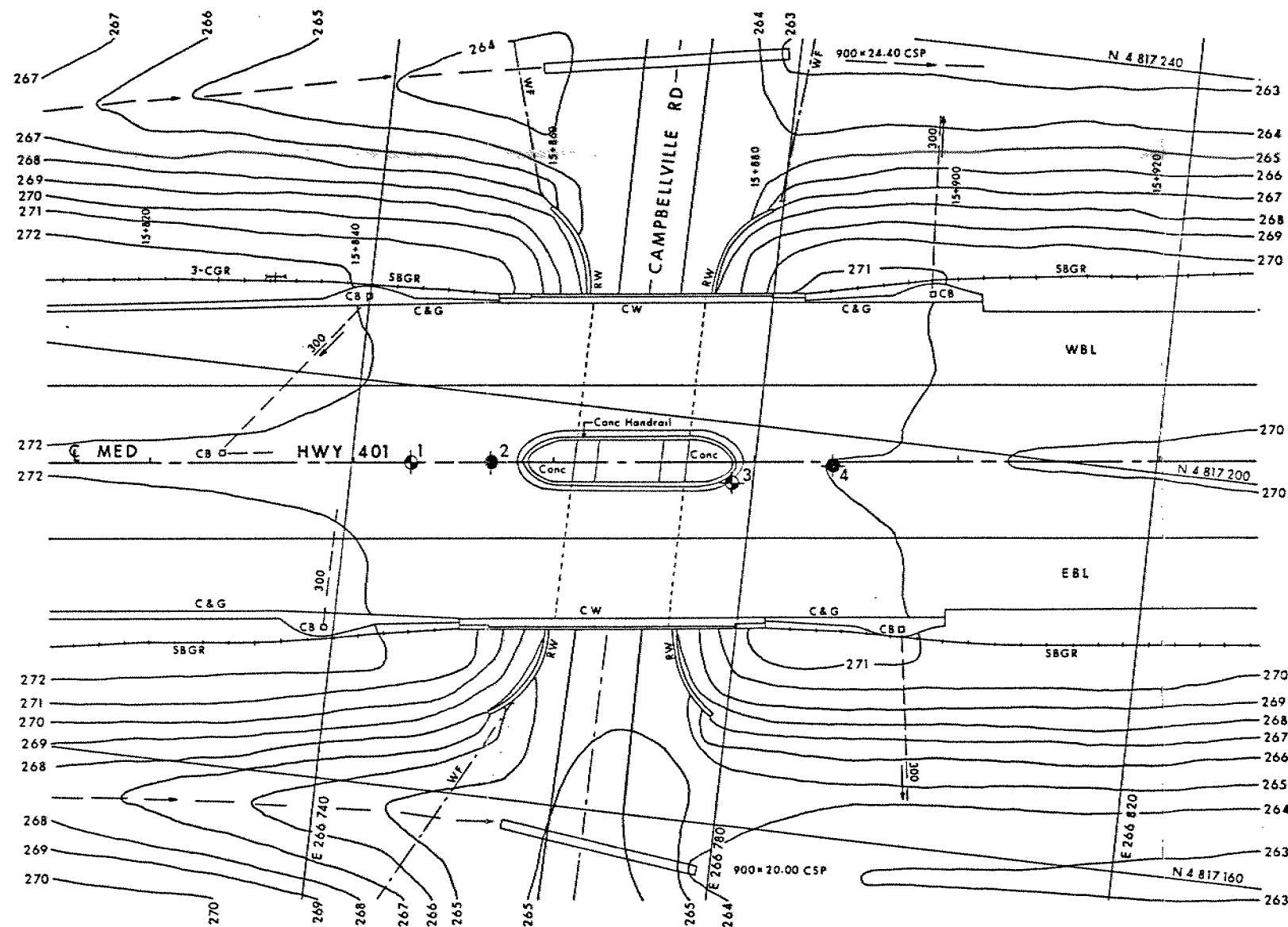
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CR14-04	12.50	258.70

Date July 2014
 GWP# 2188-10-00

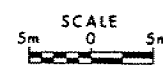


Prep'd AN
 Chkd. KS

Appendix C
Historical Borehole Information

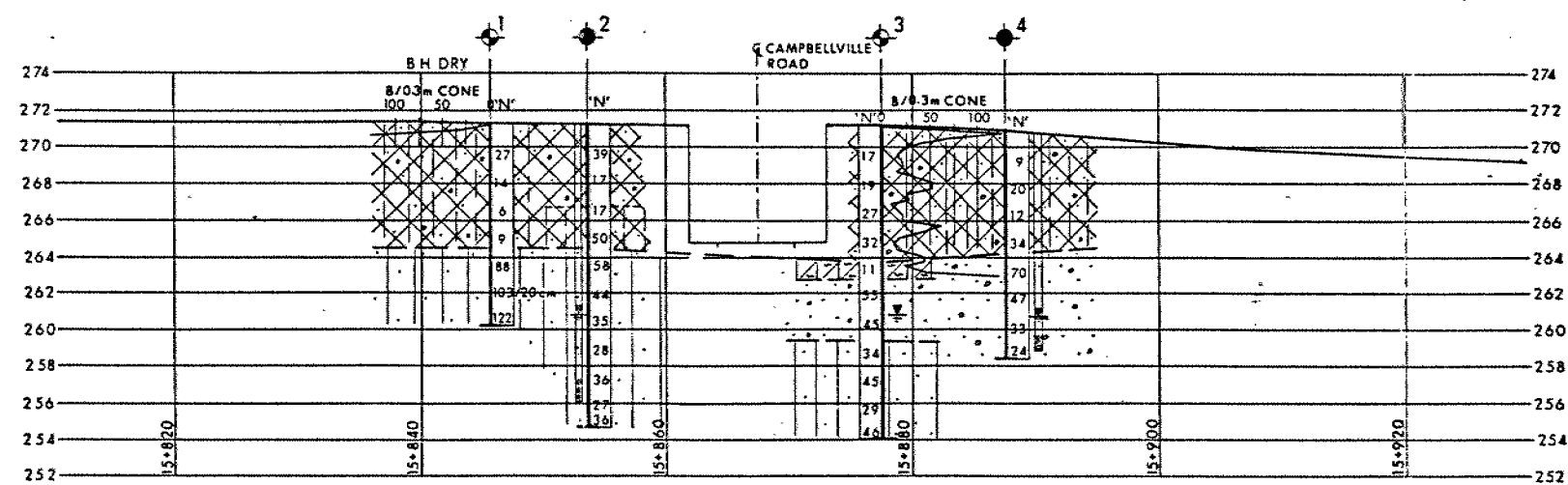


PLAN



SOIL STRATIGRAPHY-LEGEND

- SAND & GRAVEL (ROAD FILL)
Compact to Dense
- HET. MIXTURE OF CLAYEY SILT, SAND & GRAVEL (ROAD FILL)
Loose to Dense
- CLAYEY SILT (COMPRESSED TOPSOIL)
Stiff
- SANDY SILT TO SILTY SAND
Compact to V. Dense
- SAND & GRAVEL
Compact to V. Dense



PROFILE MED HWY 401



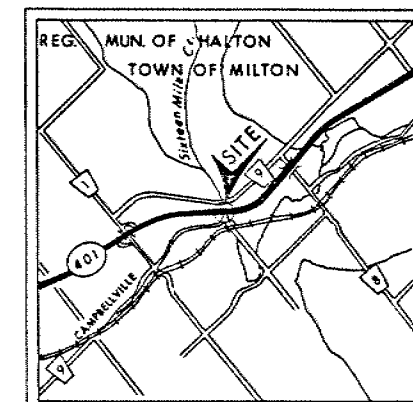
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
IN KILOMETRES + METRES.

CONT No
WP No95&96-90-01

CAMPBELLVILLE RD. OVERPASS

BORE HOLE LOCATIONS & SOIL STRATA

STRATA ENGINEERING CORP.



KEY PLAN



LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation
Jan. & Feb. 1991
- Stand Pipe

No	ELEVATION	CO-ORDINATES NORTH	EAST
1	271.3	4 817 192.4	266 746.0
2	271.3	4 817 193.2	266 753.8
3	271.2	4 817 194.0	266 778.0
4	271.0	4 817 196.8	266 787.8

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV.	DATE	BY	DESCRIPTION
------	------	----	-------------

Geocres No 30M5-182
HWY No 401
SUBMD A A [CHECKED AA] DATE Mar 26 1991 SITE 10-44
DRAWN A K [CHECKED AA] DATE Mar 26 1991 SITE 10-44
DWG 95&96D01A

RECORD OF BOREHOLE No 1

METRIC

W P 95-90-01, 96-90-01 LOCATION N: 4 817 192.4 ; E: 266 746.0 ORIGINATED BY A.A.
 DIST 4 HWY 401 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Test COMPILED BY A.K.
 DATUM Geodetic DATE 1991 01 28 & 29 CHECKED BY C.M.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT Y	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L		
271.3	Ground Surface								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE	WATER CONTENT (%)				
0.0														
	Frozen Zone					*	271							
	Het. Mixture of Clayey Silt, Sand and Gravel (Road Fill)		1	SS	27		270							
							269							
	Compact to Loose		2	SS	14		268							
							267							
	Brown		3	SS	6		266							
							265							0 10 72 18
264.5			4	SS	9		264							
6.8	Sandy Silt to Silty Sand		5	SS	88		263							
							262							
	Very Dense		6	SS	103/20cm		261							
260.2	Brown		7	SS	122									0 19 76 5
11.1	End of Borehole * Borehole dry upon completion													

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2										METRIC					
W P 95-90-01 & 96-90-01			LOCATION N: 4 817 193.2 : E: 266 753.8			ORIGINATED BY A.A.									
DIST 4 HWY 401			BOREHOLE TYPE Hollow Stem Auger,			COMPILED BY A.K.									
DATUM Geodetic			DATE 1991 01 28			CHECKED BY C.M.									
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 Y	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
271.3	Ground Surface														
0.0															
	Frozen Zone		1	SS	-		271								
							270								
	Sand and Gravel (Road Fill)		2	SS	39		269								
							268								
	Dense to Compact		3	SS	17		267								
							266								
	Brown		4	SS	17		265								
	Heterogeneous mixture of Clayey Silt, Sand and Gravel (Road Fill)		5	SS	50		264								
264.5	Compact to Dense Brown						263								
6.8			6	SS	58		262								
	Sandy Silt to Silty Sand						261								
							260								
	V. Dense to Compact		7	SS	44		259								
							258								
			8	SS	35		257								
	Brown		9	SS	28										
			10	SS	36										
256.3															
15.0															

OFFICE REPORT ON SOIL EXPLORATION

Cont. on Sheet 2

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 2 cont'd

METRIC

W P 95-90-01 & 96-90-01 LOCATION N: 4 817 193.2 ; E: 266 753.8 ORIGINATED BY A.A.
 DIST 4 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.K.
 DATUM Geodetic DATE 1991 01 28 CHECKED BY C.M.

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
256.3	Cont. from Sheet 1																
15.0	Sandy Silt to Silty Sand Compact to Dense		11	SS	27		256							o			0 91 (9)
254.7	Brown		12	SS	36		255							o			
16.6	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

RECORD OF BOREHOLE No 3

METRIC

W P 95-90-01 & 96-90-01 LOCATION N: 4 817 194.0 ; E: 266 778.0 ORIGINATED BY Z.D.
 DIST 4 HWY 401 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.
 DATUM Geodetic DATE 1991 01 28 CHECKED BY C.M.

OFFICE REPORT ON SOIL EXPLORATION

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			20 40 60 80 100						
271.2	Ground Surface												
0.0	Frozen Zone		1	SS	-	271							
	Sand and Gravel (Road Fill)		2	SS	17	270							
	Compact to Dense		3	SS	19	269							
	Reddish Brown		4	SS	27	268							44 53 (3)
			5	SS	32	267							
			6	SS	11	266							
263.7	Clayey Silt (Compressed Topsoil)		7	SS	55	265							51 42 (7)
262.8	Stiff Brown		8	SS	45	264							
8.4	Sand and Gravel		9	SS	34	263							
	Very Dense to Dense		10	SS	45	262							51 45 (4)
	Brown					261							W.L. on 1991 01 28
259.4	Sandy Silt to Silty Sand					260							81 17 (2)
11.8	Dense					259							
	Brown					258							
256.2						257							0 96 (4)
15.0	Cont. on Sheet 2												

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 3 cont'd

METRIC

W P 95-90-01 & 96-90-01 LOCATION N: 4 817 194.0 ; E: 266 778.0 ORIGINATED BY Z.D.
DIST 4 HWY 401 BOREHOLE TYPE Hollow Stem Auger, Dynamic Cone Penetration Test COMPILED BY A.K.
DATUM Geodetic DATE 1991 01 28 CHECKED BY C.M.

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			20	40	60	80	100					
256.2	Cont. from Sheet 1																GR SA SI CL
15.0	Sandy Silt to Silty Sand		11	SS	29		256										0 19 (81)
	Compact to Dense						255										
254.0			12	SS	46												
17.2	End of Borehole																

OFFICE REPORT ON SOIL EXPLORATION

+³, x⁵: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

RECORD OF BOREHOLE No 4

METRIC

W P 95-90-01 & 96-90-01 LOCATION N: 4 817 196.8 ; E: 266 787.8 ORIGINATED BY Z.D.
 DIST 4 HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY A.K.
 DATUM Geodetic DATE 1991 01 29 CHECKED BY C.M.

OFFICE REPORT ON SOIL EXPLORATION

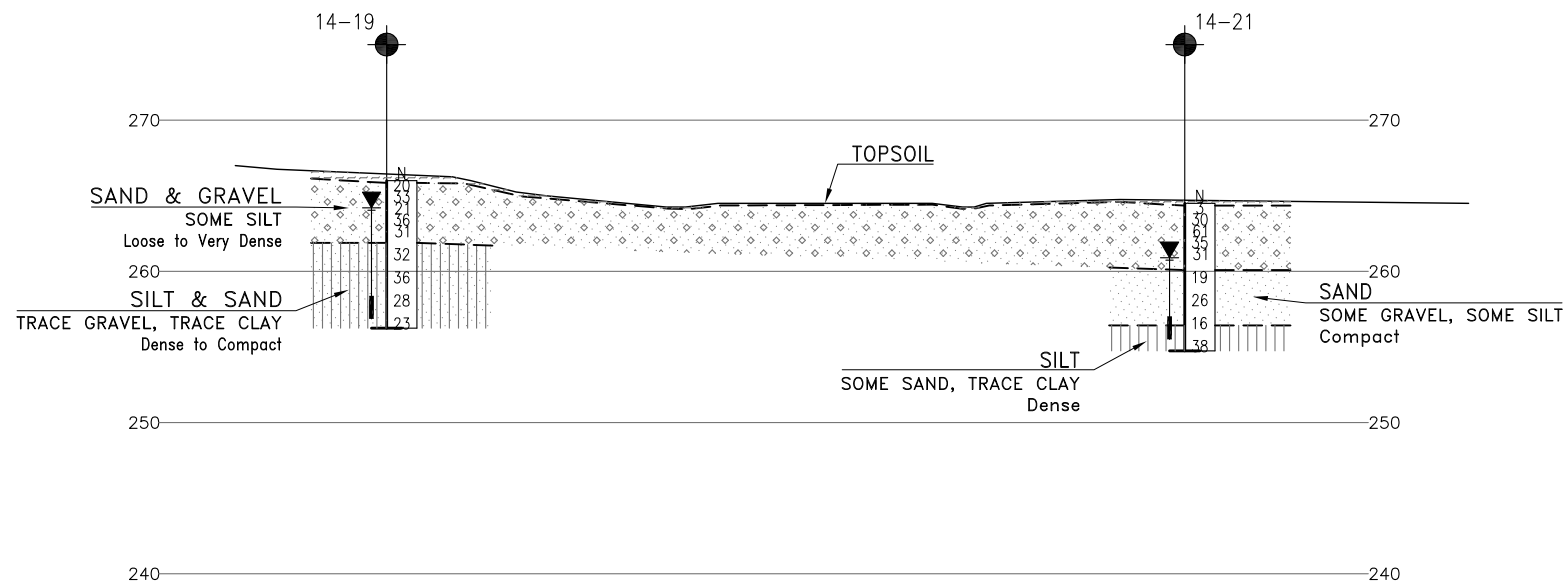
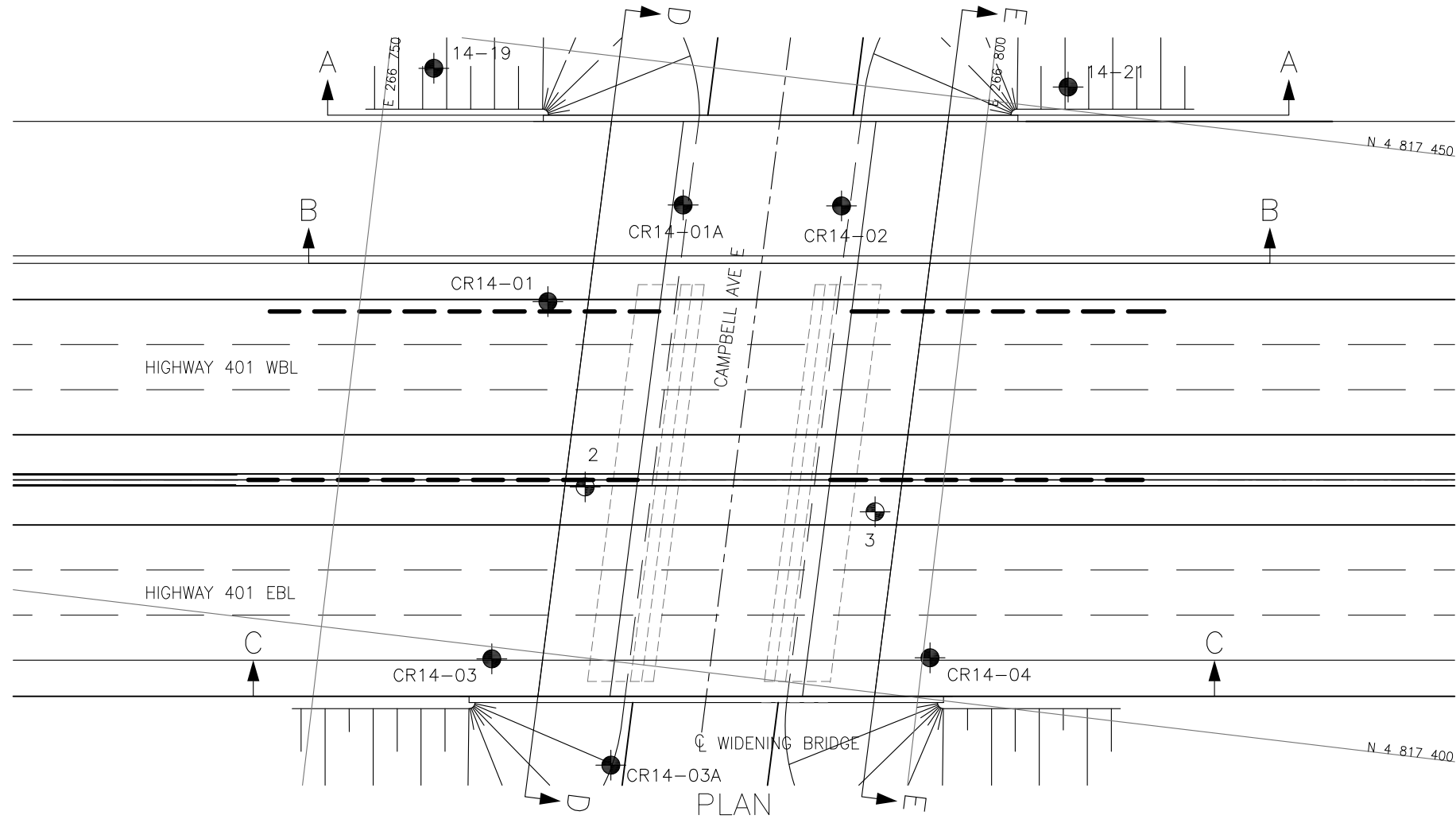
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
271.0	Ground Surface																
0.0	Frozen Zone		1	SS	-												

	Het. mixture of Clayey Silt, Sand and Gravel (Road Fill)		2	SS	9		270										
							269										12 73 (15)
	Loose to Dense		3	SS	20		268										
							267										
			4	SS	12		266										
	Brown						265										
264.2			5	SS	34												
6.8	Sand and Gravel						264										
			6	SS	70		263										
							262										
	V. Dense to Compact		7	SS	47		261										37 59 (4)
							260										W.L. on 1991 02 04
			8	SS	33												10 88 (2)
	Brown						259										
258.4			9	SS	24		Standpipe										40 58 (2)
12.6	End of Borehole																

+3, x5: Numbers refer to
Sensitivity

20
15 5 (%) STRAIN AT FAILURE
10

Appendix D
“Borehole Locations and Soil Strata” Drawings



PROFILE A-A



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



CONT No
WP No 2188-10-00

HIGHWAY 401
CAMPBELL AVENUE EAST
OVERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

AECOM

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole (Current Investigation)
⊙	Borehole (Previous Investigation)
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
2	271.3	4 817 414.1	266 770.4
3	271.2	4 817 414.9	266 794.6
CR14-01	271.7	4 817 429.1	266 765.5
CR14-01A	264.6	4 817 438.4	266 775.7
CR14-02	264.6	4 817 439.9	266 788.8
CR14-03	271.8	4 817 399.0	266 764.4
CR14-03A	265.0	4 817 391.4	266 775.3
CR14-04	271.2	4 817 403.4	266 800.6
14-19	266.0	4 817 447.7	266 756.2
14-21	264.5	4 817 453.2	266 806.5

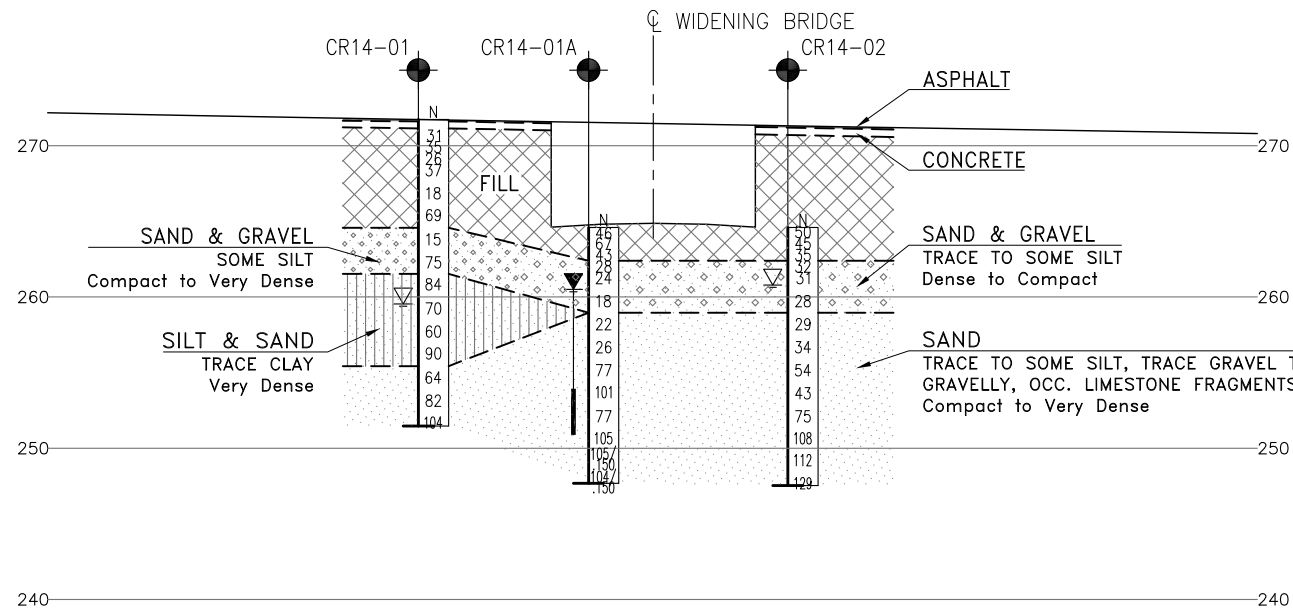
NOTES

- 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.

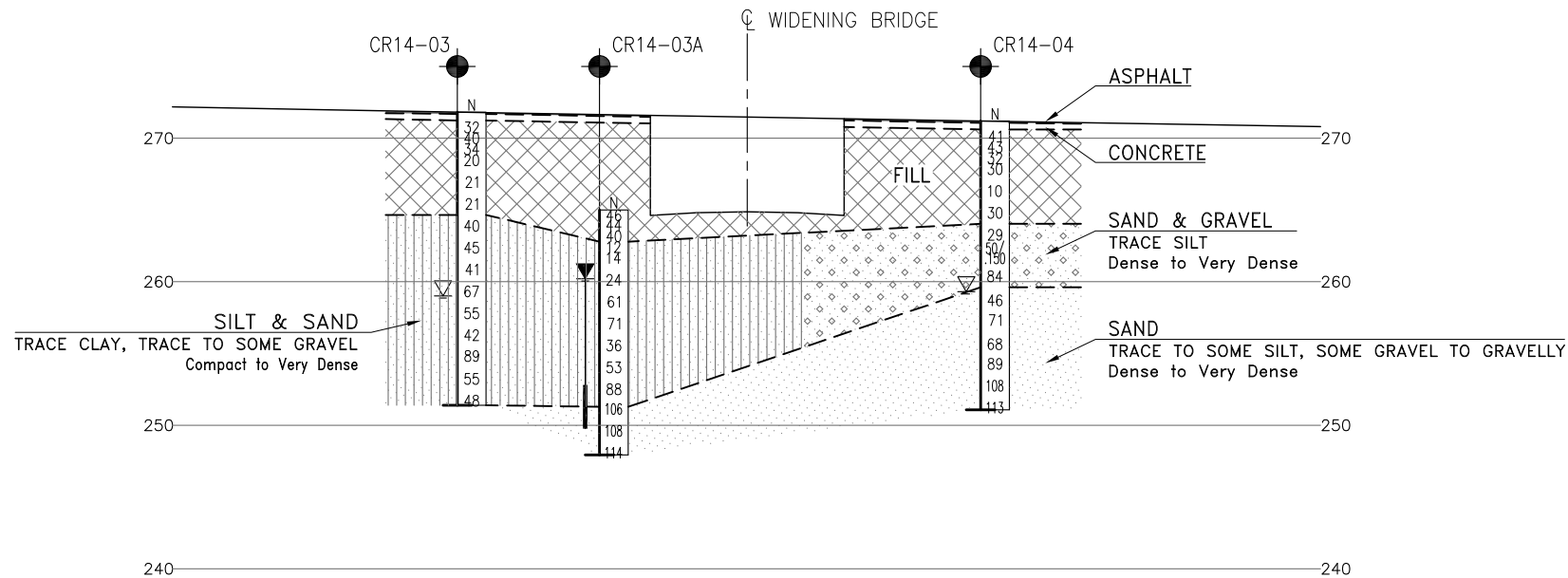
GEOCRES No. 30M05-307

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KS	CHK PKC	CODE LOAD DATE JUL 2014
DRAWN	MFA	CHK KS	SITE STRUCT DWG 1

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



PROFILE B-B



PROFILE C-C



CONT No
WP No 2188-10-00

HIGHWAY 401
CAMPBELL AVENUE EAST
OVERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

AECOM



KEYPLAN

LEGEND

●	Borehole (Current Investigation)
⊙	Borehole (Previous Investigation)
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
2	271.3	4 817 414.1	266 770.4
3	271.2	4 817 414.9	266 794.6
CR14-01	271.7	4 817 429.1	266 765.5
CR14-01A	264.6	4 817 438.4	266 775.7
CR14-02	264.6	4 817 439.9	266 788.8
CR14-03	271.8	4 817 399.0	266 764.4
CR14-03A	265.0	4 817 391.4	266 775.3
CR14-04	271.2	4 817 403.4	266 800.6
14-19	266.0	4 817 447.7	266 756.2
14-21	264.5	4 817 453.2	266 806.5

-NOTES-

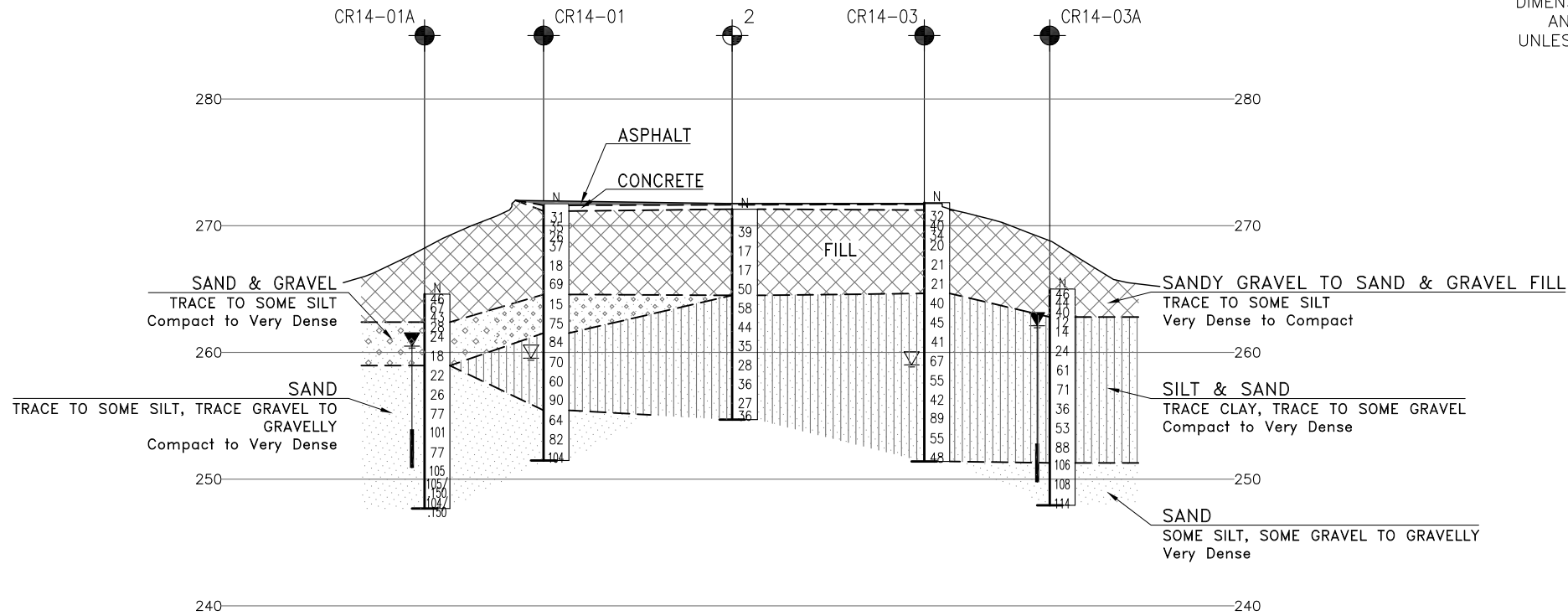
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 30M05-307

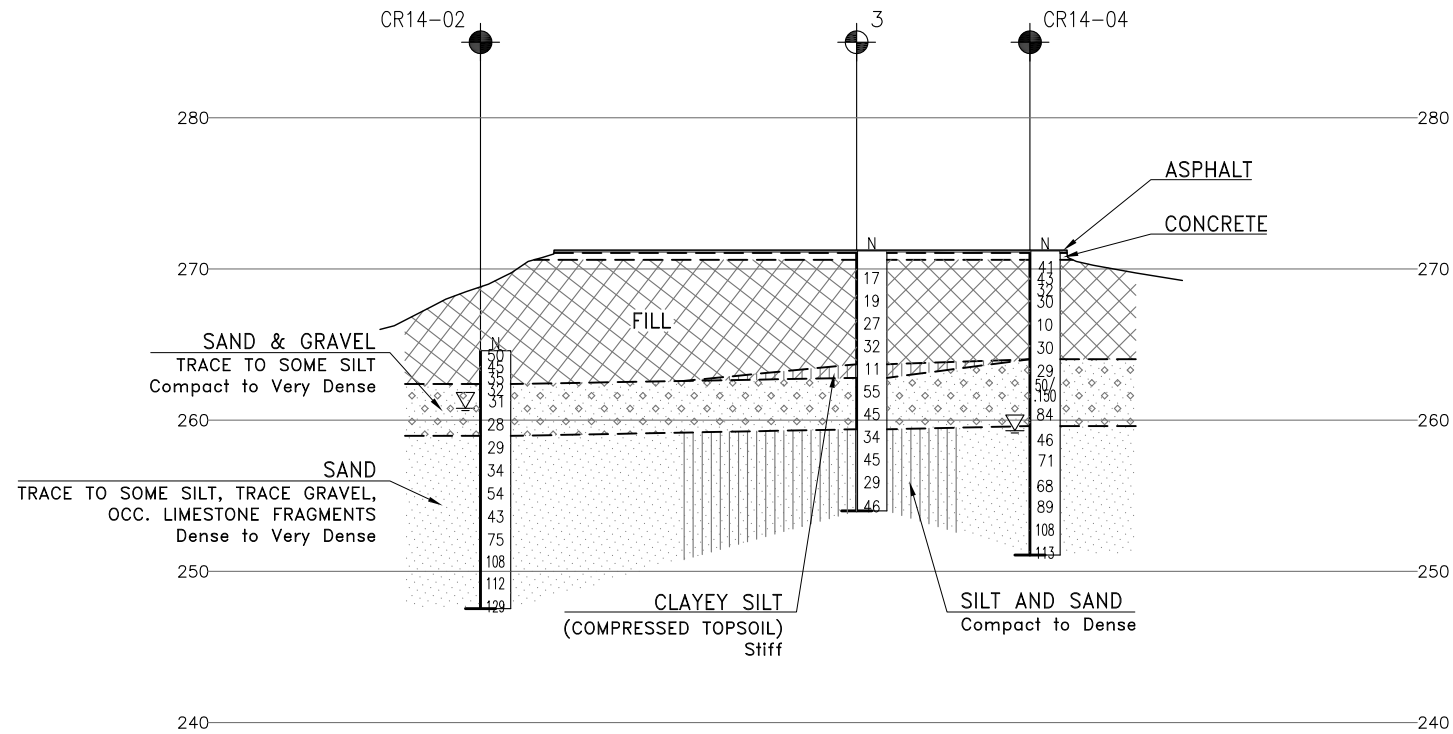


REVISIONS	DATE	BY	DESCRIPTION
DESIGN	KS	CHK	PKC
DRAWN	MFA	CHK	KS
CODE	LOAD	DATE	JUL 2014
SITE	STRUCT	DWG	2

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



SECTION D-D



SECTION E-E



CONT No
WP No 2188-10-00

HIGHWAY 401
CAMPBELL AVENUE EAST
OVERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

AECOM

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole (Current Investigation)
○	Borehole (Previous Investigation)
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
2	271.3	4 817 414.1	266 770.4
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14-21	264.5	4 817 453.2	266 806.5

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. 30M05-307

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Appendix E

List of SPs and OPSS, and Suggested Text for Selected NSSP

1. List of Special Provisions and OPSS Documents Referenced in this Report

- OPSS 501
- OPSS 539
- OPSS 804
- OPSS 902
- OPSS 903
- OPSS.PROV 1010
- OPSD 208.010
- OPSD 3000.100

2. Suggested Text for NSSP on “Subgrade preparation and Engineered Fill Pad for RSS”

Any topsoil, soft/loose native soil or disturbed fill should be stripped from the footprint of the RSS. A minimum 500 mm thick layer of bedding material conforming to OPSS Granular “A” requirements should be provided under the RSS mass to provide a uniform subgrade condition. Engineered fill placed under the RSS mass to achieve the design founding level should consist of OPSS Granular “A” compacted to 100% of its SPMDD at a moisture content within 2% of optimum. The engineered fill pad must extend at least 500 mm beyond the limits of the RSS mass and levelling strip.

Appendix F
Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES

Footings on Native Soil	Footings on Engineered Fill	Driven H-Piles	Caissons / Drilled Shafts
<p>Advantages:</p> <ul style="list-style-type: none"> i. Ease of construction. ii. Lower cost than deep foundations. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Excavation will require temporary shoring. ii. Potential disturbance to the existing footings under service. iii. Dewatering may be required, depending on depth of excavation. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundations. ii. Allows use of perched abutments. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Cost of engineered fill placement. ii. Potential disturbance to the existing footings under service. iii. Dewatering may be required, depending on depth of excavation. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. Piles will develop high geotechnical resistance. ii. Installation of piles could continue in freezing weather. iii. Allows integral abutment design. iv. Requires less excavation than footings. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit costs than footings. ii. Possibility that cobbles and boulders may be encountered in existing fill and native soils. iii. Individual piles within a foundation element may have to be driven to varying elevations to derive required capacity. 	<p>Advantages:</p> <ul style="list-style-type: none"> i. High resistance is available for caissons founded in very dense native soils. ii. Construction of caissons could continue in freezing weather. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher cost than footings. ii. Temporary liners will be required to install caissons in cohesionless gravels/sands/silts below groundwater level. iii. Difficulty in sealing liners at base. iv. Possibility of cobbles and boulders being encountered during augering and liner installation. v. Difficulty in cleaning and inspecting bases.
RECOMMENDED	NOT RECOMMENDED	FEASIBLE BUT NOT RECOMMENDED	NOT RECOMMENDED