

PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT

HIGHWAY 401 STRUCTURE REPLACEMENT

REGIONAL ROAD 25 UNDERPASS

HALTON REGION, ONTARIO

G.W.P. 2188-10-00, SITE No. 10-56

GEOCRES Number: 30M12-375

Report to

AECOM

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TABLE OF CONTENTS

PART 1 FACTUAL INFORMATION

1	INTRODUCTION.....	1
2	SITE DESCRIPTION.....	1
3	SITE INVESTIGATION.....	2
4	LABORATORY TESTING	3
5	SUBSURFACE CONDITIONS	3
5.1	Regional Geology	3
5.2	Site Subsurface Conditions.....	3
5.2.1	Asphalt Pavement.....	3
5.2.2	Topsoil.....	4
5.2.3	Gravelly Sand Fill	4
5.2.4	Silty Clay Fill	4
5.2.5	Clayey Silt to Silty Clay Till	5
5.2.6	Silt and Silty Clay.....	6
5.2.7	Sand and Sand & Gravel (Sand and Gravel Deposit).....	6
5.2.1	Lower Silty Clay Till.....	7
5.2.2	Bedrock	7
5.3	Groundwater Conditions.....	8
6	MISCELLANEOUS.....	8

PART 2 ENGINEERING DISCUSSION AND RECOMMENDATIONS

7	GENERAL	10
8	STRUCTURE FOUNDATION.....	11
8.1	Spread Footings on Native Soil	11
8.2	Spread Footings on Engineered Fill.....	12
8.3	Steel H-Pile Foundations	13
8.3.1	Axial Compression Resistance	13
8.3.2	Pile Tips.....	13
8.3.3	Pile Installation.....	13
8.3.4	Pile Lateral Resistance	14
8.4	Caissons / Drilled Shafts.....	15
8.4.1	Downdrag	16
8.5	Recommended Foundation	16
8.6	Frost Cover	16
9	EXCAVATION AND DEWATERING.....	16
10	RETAINED SOIL SYSTEMS (RSS)	16

11	EMBANKMENT WIDENING	17
12	LATERAL EARTH PRESSURES	18
13	SEISMIC CONSIDERATIONS	19
14	EROSION PROTECTION	19
15	CONSTRUCTION CONCERNS	19
16	INVESTIGATION FOR DETAIL DESIGN	20
17	CLOSURE	21

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 Regional Road 25 Underpass on Highway 401 in the Regional Municipality of Halton, Ontario. This investigation was carried out in support of the preliminary design 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 profiles 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 Regional Road 25 underpass is located approximately 7.5 km west of Trafalgar Road, 1 km north of Steeles Avenue E., 1.9 km south of 5 Side Road and 2.2 km east of Tremaine Road in the Town of Milton, Regional Municipality of Halton, Ontario. As part of the Regional Road 25 Interchange, the underpass structure is bounded by the Highway 401 westbound (WB) and eastbound (EB) on-ramp loops to the northeast and southwest, respectively, a GO-Train Park-and-Ride lot to the southeast, and landscaping areas to the northwest.

The terrain in the area is generally flat. Based on available historic data, the existing road grade of Highway 401 at approximately elevation 209 m is similar to natural grades of the area and Regional Road 25 has been raised. The existing approach embankments for the underpass are to be about 6 to 7 m high with side slopes at 2H: 1V.

The existing underpass was constructed in 1959. It is a two-span structure with a total length of about 42 m and width of 16 m.

3 SITE INVESTIGATION

The site investigation and field testing for the underpass structure and approach embankments included advancement of a total of 8 boreholes (14-29 to 14-36) between July 21 and 25, 2014. Boreholes 14-30 and 14-34 were drilled at the toe of the existing embankment fills near the proposed north and south abutments in the widening portion, respectively, and Boreholes 14-32 and 14-33 at the median of Highway 401 for the proposed pier. To aid the approach embankment design, Boreholes 14-29 and 14-31 were advanced through the existing north approach embankment and Borehole 14-35 at the existing south approach embankment. Borehole 14-36 was completed in green fields west of the existing south embankment fill.

The approximate borehole locations are shown on the attached Borehole Locations and Soil Strata Drawings in Appendix D. Previous boreholes (10-101 and 10-102) from a Preliminary Foundation Investigation and Design Report prepared by Golder Associates (Golder) dated October 2011 (Geocres No. 30M12-325) are included in Appendix C. Borehole location data including northing, easting and surface elevation has been derived based on the preliminary design information provided by AECOM to Thurber.

In general, all boreholes were drilled using continuous flight hollow stem augers, except for Borehole 14-29 where continuous flight solid stem augers were used. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with the Standard Penetration Testing (SPT). For the structure boreholes (14-30 and 14-32 to 14-34), auger and SPT refusal were encountered at depths of 30 to 32.9 m below the existing Highway 401 grade due to the presence of bedrock. The approach embankment boreholes (14-29, 14-31 and 14-35) completed on Regional Road 25 were typically advanced to 15.8 m depth and Borehole 14-36 to 9.8 m depth below the existing Highway 401 road grade.

Upon auger refusal on bedrock at Boreholes 14-30, 14-33 and 14-34, NQ-sized coring equipment was used to obtain 2.5 to 3.8 m of rock core. These boreholes were terminated at depths of 34.7 to 36.7 m below the existing Highway 401 grade. All rock cores were logged, and properties including Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and Fracture Indices (FI) were determined where applicable.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. A standpipe piezometer was installed in Borehole 14-34. However, due to the presence of artesian groundwater conditions, the standpipe piezometer was decommissioned subsequently. Further, artesian groundwater conditions were observed in Borehole 14-30. As such, a vibrating wire piezometer (VWP) was installed at Borehole 14-30 to permit monitoring of the groundwater levels.

A 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.

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 and rock 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 and Atterberg Limits Tests. The results of this laboratory testing program are presented on the Record of Borehole sheets in Appendix A and on the Figures in Appendix B.

Selected rock cores were subjected to Point Load Tests (PLTs). Unconfined compressive strengths (UCS) of rock cores correlated from the PLT results are shown on the Record of Borehole sheets in Appendix A.

5 SUBSURFACE CONDITIONS

5.1 Regional Geology

The site is located within the physiographic region known as the Peel Plain. In general, the Plain slopes gently to the south towards Lake Ontario. The surface topography in the area is typically characterized by a surficial till sheet mainly consisting of clayey silt to silty clay (Halton Till), which overlies discontinuous glacially derived gravel, sand and silt deposit above bedrock. The Upper Ordovician bedrock underlying the area belongs to the Queenston Formation, characterized by thinly-bedded, reddish brown shale.

5.2 Site 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. Borehole information from a previous investigation 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.

Surficial soil conditions typically comprise asphalt over granular fill, topsoil, or existing cohesive embankment fill. Below the surficial soils, native soils comprise clayey silt to silty clay till over sand to sand and gravel deposits underlain by shale bedrock.

5.2.1 Asphalt Pavement

Boreholes 14-29, 14-31 and 14-35 were advanced from the top of pavement level on the driving lanes of Regional Road 25 and Boreholes 14-32 and 14-33 on the median shoulder

of Highway 401. Thicknesses of the asphalt encountered in the boreholes typically ranged from 150 to 200 mm on Regional Road 25 and 50 to 100 mm on the median shoulder of Highway 401.

For reference, Golder's BH 10-102 suggests that asphalt thickness could be in the order of 300 mm.

5.2.2 Topsoil

Topsoil was encountered in Boreholes 14-30, 14-34 and 14-36. The thickness of topsoil typically ranged from about 100 to 125 mm.

5.2.3 Gravelly Sand Fill

Granular fill comprising gravelly sand with some silt to silty was encountered beneath the asphalt pavement in Boreholes 14-29, 14-31 to 14-33 and 14-35, which is part of the existing pavement structure. Thickness of the granular fill in the boreholes ranged from 0.5 to 0.8 m with the base of the fill at elevations varying from 215.6 to 208.8 m.

SPTs were completed at Boreholes 14-32 and 14-35 within the granular fill layer and the recorded SPT 'N' values were 58 and 42 blows per 0.3 m penetration, respectively, indicating dense to very dense relative densities. Grab samples were collected from auger spoil at Boreholes 14-29 and 14-31. The measured natural moisture contents of the granular fill samples ranged from 2 to 6%.

For reference, Golder's Borehole 10-102 suggests that the granular fill could be 1.1 m thick with a compact relative density.

Results of grain size analyses conducted on 4 selected gravelly sand fill samples are presented in Figure B1, and are summarized as follows:

Gravel	25 to 36%
Sand	49 to 55%
Silt & Clay	12 to 23%

5.2.4 Silty Clay Fill

Cohesive fill comprising silty clay with some sand and trace gravel was encountered below the topsoil layer in Boreholes 14-30, 14-34 and 14-36 and below the existing pavement structure on Regional Road 25 in Boreholes 14-29, 14-31 and 14-35 as the existing approach embankment fill. The layer was fully penetrated in all boreholes.

Thickness of the silty clay fill in Boreholes 14-30, 14-34 and 14-36 ranged from 0.7 to 2.1 m with the base of the fill at elevations varying from 208.8 to 206.5 m. SPT 'N' values ranged from 11 to 26 blows per 0.3 m penetration, respectively, indicating a stiff to very stiff consistency. The measured moisture contents of the cohesive fill ranged from 11 to 21%.

Within the existing approach embankment, the thickness of cohesive fill encountered in the boreholes ranged from 6.1 to 6.5 m with the base of the fill at elevations varying from 209.5 to 208 m. SPT 'N' values ranged from 5 to 14 blows per 0.3 m penetration, respectively, indicating a firm to stiff consistency. The measured moisture contents of the cohesive fill within the existing approach embankment ranged from 7 to 24%.

Results of grain size analyses conducted on 8 selected cohesive fill samples are presented in Figures B2A and B2B, and are summarized as follows:

Gravel	0 to 5%
Sand	0 to 27%
Silt	45 to 58%
Clay	21 to 48%

The results of Atterberg Limits tests conducted on 6 selected cohesive fill samples are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B6 of Appendix B. The results indicated that the cohesive fill has plastic limits ranging from 18 to 22% and liquid limits ranging from 34 to 44%, suggesting low to intermediate plasticity.

5.2.5 Clayey Silt to Silty Clay Till

Native soils comprising clayey silt to silty clay till with variable amounts of sand and gravel was encountered below the surficial soils in all boreholes. The layer was fully penetrated in Boreholes 14-30, 14-32, 14-33 and 14-34. Thickness of the layer typically ranged from 10.8 to 22.1 with the base of the layer at elevations varying from 198 to 184.8 m. Boreholes 14-29, 14-31, 14-35 and 14-36 were terminated in this layer at elevations varying from 200.7 to 198.3 m.

SPT conducted within the layer produced 'N' values ranging from were 17 and 100 blows per 0.3 m penetration, indicating a very stiff to hard consistency. The measured moisture contents of the samples typically ranged from 6% and 24%.

Results of grain size analyses conducted on 22 selected clayey silt to silty clay till samples are presented in Figures B3A to B3D, and are summarized as follows:

Gravel	0 to 8%
Sand	12 to 43%
Silt	38 to 60%
Clay	11 to 28%

The results of Atterberg Limits tests conducted on 13 selected clayey silt to silty clay till samples are provided on the Record of Borehole sheets in Appendix A and illustrated in Figures B7A to B7C of Appendix B. The results indicated that the clay till has plastic limits ranging from 13 to 17% and liquid limits ranging from 21 to 28%, suggesting low plasticity.

Glacial till inherently contains cobbles and boulders.

5.2.6 Silt and Silty Clay

Relatively thin silt and silty clay layers with trace sand were encountered within and below the clayey silt to silty clay till in a variable sequence at Boreholes 14-32 to 14-34. Interlayered in the clayey silt to silty clay till in Borehole 14-33, the silt layer was about 1.5 m thick. Below the clayey silt to silty clay till, the silt thickness ranged from 1.4 to 1.7 m and the silty clay thickness from 1.5 to 1.7m.

The SPT 'N' values ranged from 21 to 34 blows per 0.3 m penetration in the silt, indicating compact to dense relative densities, and from 17 to 53 per 0.3 m penetration in the silty clay, indicating a very stiff to hard consistency. The measured natural moisture contents of the samples typically ranged from 13 to 33%.

Results of grain size analyses conducted on 3 selected samples are presented in Figures B4, and are summarized as follows:

Gravel	0%
Sand	0 to 19%
Silt	50 to 77%
Clay	15 to 47%

The results of Atterberg Limits tests conducted on a selected silty clay sample are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B8 of Appendix B. The results indicated that the silty clay has plastic limits of 18% and liquid limits of 34%, suggesting low plasticity.

5.2.7 Sand and Gravel

Below the clayey silt to silty clay till or silt and silty clay layers, a sand and gravel deposit with variable amount of silt was encountered at Boreholes 14-30 and 14-32 to 14-34. Occasional cobbles, possible boulders and shale or limestone fragments were encountered within the sand and gravel deposit. The thickness of the sand and gravel deposit ranged from 2 to 15 m with the base of the layer at elevations varying from 179.7 to 177.2 m.

SPT conducted within the layer produced 'N' values ranging from 20 blows per 0.3 m penetration to 100 blow per 0.075 m penetration (SPT refusal), indicating compact to very dense relative densities. Occasional very low blow counts of 0 and 11 were recorded due to soil disturbance. The deposit is largely in a dense state. The measured natural moisture contents of the samples typically ranged from 2% to 21%.

Results of grain size analyses conducted on 8 selected sand and gravel samples are presented in Figures B5A and B5B, and are summarized as follows:

Gravel	1 to 40%
Sand	39 to 93%
Silt & Clay	3 to 22%

5.2.1 Lower Silty Clay Till

A lower silty clay till was encountered below the sand & gravel deposit at Borehole 14-34. The bottom of the layer appeared to be sandy and gravelly based on drilling actions. The thickness of the layer was 3.9 m and the base of the layer is at elevation 175.8 m.

The recorded SPT 'N' values were typically 100 blows per 0.3 m penetration, indicating a very dense relative density. The measured natural moisture contents of the samples were typically about 9%.

Glacial till inherently contains cobbles and boulders.

5.2.2 Bedrock

Shale bedrock (Queenston formation) was encountered in Boreholes 14-30 and 14-32 to 14-34 below the sand and gravel deposit or the lower silty clay till. NQ coring of 2.5 to 3.8 m was completed in Boreholes 14-30, 14-33 and 14-34. The bedrock was generally described as moderately weathered to fresh, thinly-bedded, fined-grained, reddish brown shale with frequent hard grey limestone interbeds up to about 150 mm in thickness.

TCR of the bedrock generally ranged from 50 to 100%. RQD values ranged from 19 to 95% indicating very poor to excellent rock quality. FI of rock cores typically ranged from 0 to 8 with two values greater than 10 recorded in Run 1 of Borehole 14-34.

The following table summarizes the depth to top of bedrock or inferred bedrock and the bedrock surface elevations encountered in the boreholes.

Foundation Element	Borehole	Top of Borehole Elevation (m)	Depth to Top of Bedrock (m)	Bedrock Elevation (m)
North Abutment	14-30	209.5	32.3	177.2
Pier	14-32	209.7	30.0*	179.7
	14-33	209.6	30.9	178.7
South Abutment	14-34	208.7	32.9	175.8

Note: *Inferred bedrock

The UCS of the intact rock cores was estimated from the results of PLTs conducted on the rock core samples. In general, the UCS values ranged from 19 to 53 MPa, indicating weak to strong intact rock, except for one value of 237 MPa, indicating very strong intact rock. The higher values appear to be associated with thicker limestone interbeds. The UCS values are included on the Record of Borehole sheets in Appendix A.

5.3 Groundwater Conditions

Groundwater were observed in the open boreholes of 14-30, 14-32 and 14-34 during and upon completion of drilling. The measured groundwater levels in the open boreholes, a standpipe piezometer and a vibrating wire piezometer are presented in the table below.

Borehole	Date	Conditions	Groundwater Level	
			Depth (m)	Elevation (m)
14-30	July 24, 2014	Open Borehole	0.9 m above ground	210.4
	July 25, 2014	Vibrating Wire Piezometer	1.0 m above ground	210.5
	July 28, 2014		1.0 m above ground	210.5
	Aug. 11, 2014		1.0 m above ground	210.5
14-32	July 25, 2014	Open Borehole	0.3	209.4
14-34	July 22, 2014	Open Borehole	12.2*	196.4
	July 24, 2014	Piezometer	0.6 m above ground	209.2

Note: *Beginning of second day drilling when borehole at 17.4 m depth.

The shallow groundwater levels appear to be associated with the fill overlying the silty clay till deposit and artesian groundwater conditions correspond to the sand and gravel deposit below. 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 3 subcontractors as follows:

- A track-mounted CME-85 and a track-mounted D-56 drill rig by Walker Drilling Ltd. Of Barrie, Ontario.
- A truck-mounted D-120 and a track-mounted D-120 drill rig by Altech Drilling & Investigative Services of St. Jacobs, Ontario.
- A truck-mounted CME-75 drill rig by Eastern Ontario Diamond Drilling, Hawkesbury, Ontario.

In the present investigation, the borehole locations were staked or marked in the field. Utility clearance was obtained for all borehole locations prior to drilling.

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 Messrs. George Azzopardi, Justin Gray, Stephane Loranger and Sean Petrus of Thurber Engineering Ltd. Overall supervision of the field program was conducted by Mr. Mark Farrant, P.Eng.

The report was prepared by Mr. Charles Ng, 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 Regional Road 25 Underpass on Highway 401.

The abutments and pier of the existing underpass are supported on spread footings with a typical width of 2.3 m. The underside of the footings appeared to be at elevation 207.3 m for the south abutment and pier, and at elevation 207.6 m for the north abutment.

The preliminary General Arrangement (GA) drawing provided by AECOM indicates that the replacement underpass would be a steel box girder structure comprising two, 41 m spans or a total length of 82 m. The length of the replacement underpass will accommodate 12 traffic lanes plus medians, shoulders and merge lanes on Highway 401. The preliminary GA suggests that H-piles at the abutments and a spread footing at the pier are being considered to support the replacement structure to facilitate the use of integral abutments. The proposed abutments will be set back about 20 m from the existing locations on each side and the pier will remain approximately at the current location.

The replacement underpass will be widened about 16 m to the west, resulting in a total structure width of about 32 m, to accommodate 6 traffic lanes plus shoulders on Regional Road 25.

The finished road grades for Highway 401 and Regional Road 25 will be similar to the existing. Accordingly, fill placement in the order of 7 m will be required for the widening section of the approach embankments. Reinforced soil systems (RSS) walls are proposed for the approach embankments.

To maintain traffic on the existing Highway 401 and Regional Road 25, the replacement structure will likely be constructed in 2 stages. Traffic will be maintained on the existing structure during Stage 1 construction of the widening section to the west. The existing structure will be demolished during Stage 2 construction to allow construction of the new structure to be completed.

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 typically consists of very stiff to hard clayey silt to silty clay till over dense to very dense sand and gravel deposit underlain by shale bedrock. For the silty clay till deposits above the sand and gravel layer, the highest groundwater level observed in the open borehole was at about elevation 209.4 m or approximately 0.3 m below the existing Highway 401 grade. For the sand and gravel deposit, artesian groundwater conditions in the order of 1 m above the existing Highway 401 grade were measured.

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 and pier is considered feasible from a geotechnical perspective. Spread footings should be founded on undisturbed, very stiff to hard clayey silt to silty clay till. Table 8.1 summarizes the recommended founding elevations at the abutment and pier locations and the recommended geotechnical resistances assuming a footing width of 2 m subjected to vertical concentric loading. Further, it is assumed that the finished road grade for Highway 401 will be at elevation 209.5 m.

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)
North Abutment	14-30	208.1	Hard Silty Clay Till	600	400
	10-102	208.3	Hard Clayey Silt Till		
Pier	14-32	207.3	Hard Clayey Silt to Silty Clay Till	600	400
	14-33	207.3			
South Abutment	14-34	205.6	Very Stiff Clayey Silt to Silty Clay Till	450	300
	10-101	206.8	Hard Clayey Silt Till	450	300

Any soft, wet or unsuitable materials encountered at bearing surface should be subexcavated and replaced with well compacted granular fill. It should be noted that the native soils are sensitive to changes in moisture content and susceptible to disturbance, especially in freezing or wet weather conditions. Accordingly, equipment traffic on the footing subgrade should be avoided and the subgrade must be protected from deterioration by a 100 mm thick concrete working slab.

For preliminary design purposes, the underside of the new pier footing is assumed to be similar to that of the existing pier footing. However, if the existing spread footing at the pier is situated at or below the recommended highest founding elevations as shown in Table 8.1, the new pier footing should be lowered accordingly.

Where eccentric or inclined loads are applied, the resistances used in design must be reduced in accordance with the Canadian Highway Bridge Design Code 2006 (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 0.45.

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

Construction of a footing will require excavation extending below the upper groundwater level. Dewatering will be required to construct the footings in the dry. Road protection will likely be required to facilitate spread footing construction at the pier.

From a geotechnical perspective, the use of spread footings on competent native soils is recommended for the proposed abutments and pier.

8.2 Spread Footings on Engineered Fill

In principle, footings may be founded on engineered fill constructed over the very stiff to hard clayey silt to silty clay till. The base of the engineered fill pads must be placed at or above 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 SPMD 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 a footing will require excavation below the groundwater level. Hence, dewatering will be required to construct the engineered fill pad in the dry.

8.3 Steel H-Pile Foundations

The ground conditions at the site are considered suitable for the use of driven steel H-piles. The use of H-piles will allow the use of integral abutments.

8.3.1 Axial Compression Resistance

It is recommended that H-piles be driven to refusal on bedrock. Typically, HP 310 x 110 piles can be used. If a higher resistance is required, consideration can be given to using HP 360 x 132 piles. The anticipated pile tip elevations and factored geotechnical resistances at ULS for HP 310 x 110 and HP 360 x 132 piles driven to bedrock 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 (m)	Factored Geotechnical Resistance at ULS (kN)	
			HP 310x110	HP 360x132
North Abutment	14-30	177.4	2,000	2,400
Pier	14-32	179.7	2,000	2,400
	14-33	178.7		
South Abutment	14-34	175.8	2,000	2,400

The geotechnical resistance at SLS will not govern for piles founded on bedrock.

It is noted that the piles will be driven into an aquifer that exhibits a small artesian head with respect to the Highway 401 grade. The final design at this site must be carefully assessed to determine if it may permit a pathway to develop for the flow of groundwater up the pile shafts. If this risk is determined to exist, appropriate geotechnical design must be developed to seal the flow or to control its discharge. Permanent groundwater discharge may require a Permit to Take Water.

8.3.2 Pile Tips

Pile tip protection is recommended for driven H-piles to prevent pile damage when seating on bedrock or encountering cobbles and boulders. 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. The appropriate pile driving note is “Piles to be driven to bedrock”.

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

$$k_s = 67 S_u / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 9 S_u \quad (\text{kPa})$$

Where

S_u = undrained shear strength (kPa)

D = pile width or diameter (m)

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	S_u (kPa)
		Top	Bottom				
North Abutment	Fill	212*	208.8	21	2,500	3.0	-
	Very Stiff to Hard Silty Clay Till	208.8	186.7	11	-	-	200
	Compact to Very Dense Sand	186.7	177.2	12	10,000	4.2	-
Pier	Very Stiff to Hard Silty Clay Till	208.3*	198	11	-	-	200
	Compact Silt and Very Stiff Silty Clay	198	194.7	10	-	-	100
	Dense to Very Dense Sand	194.7	178.7	12	10,000	4.2	-
South Abutment	Fill	212*	206.5	21	2,500	3.0	-
	Very Stiff Silty Clay Till	206.5	184.8	11	-	-	150
	Dense to Very Dense Silt and Sand	184.8	175.8	12	10,000	3.9	-

Note: * Assumed underside of pile cap elevation.

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 a HP 310 x 110 pile should be limited to 160 kN and 65 kN under ULS (factored) and SLS loading conditions, respectively. For a HP 360 x 132 pile, the limiting lateral resistance should be 160 kN and 80 kN under ULS (factored) and SLS loading 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 the clay till into cohesionless soils below the groundwater table with artesian conditions and require the use of a liner to support the caisson sidewalls. Sealing of the caisson liner into the bedrock to prevent inflow of water and cohesionless soils will be problematic. Cobbles and, possibly, boulders are present within the sand and gravel deposit, which may obstruct excavation and advancement of the liner. Further, the depth to bedrock is significant (in the order of 30 m). Cleaning of caisson base and inspection will also be difficult. Accordingly, the use of caissons is not recommended from a geotechnical perspective.

8.4.1 Downdrag

In light of the foundation soil conditions at this site, downdrag on the piles is not considered an issue.

8.5 Recommended Foundation

From a geotechnical and cost perspective, spread footings are the preferred foundation option for this site. However, if an integral abutment design is desired, then the abutments must be founded on driven H-piles and the pier may be founded on spread footings.

8.6 Frost Cover

The depth of frost penetration at this site is 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 existing fills may be classified as Type 3 soils while the stiff to hard clayey silt may be classified as Type 2 soils. 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 well compacted 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.

It is recommended that the RSS walls will generally be founded on well compacted granular fill or very stiff to hard, undisturbed native clayey silt and silty clay till. Walls founded on the above materials should be designed for a Factored Geotechnical Resistance at ULS of 350 kPa and a Geotechnical Reaction at SLS of 225 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 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

Based on the soil conditions encountered, global stability for the proposed widening of the approach embankments using SSM or granular fill is not considered to be an issue with permanent slopes inclined at 2H: 1V or flatter.

Settlement induced by the proposed fill placement is anticipated to be less than 50 mm and the majority of the settlement will be complete at the end of construction.

When placing new fill against the existing embankment, benching will be required for the existing embankment slopes in accordance with OPSD 208.010. 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 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 CHBDC contemplates a 1:475 year design earthquake. The following seismic parameters should be used for design:

- 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.

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.

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.

More detailed investigation of the groundwater is required in order to determine if artesian flow around pile shafts may be a problem.

17 CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Mr. Charles Ng, 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.

Charles Ng, 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

RECORD OF BOREHOLE No 14-29

1 OF 2

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 821 036.6 E 271 974.0 ORIGINATED BY MKE
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.24 - 2014.07.24 CHECKED BY CN

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						
216.0														
0.0	ASPHALT: (150mm)													
0.2	Gravelly SAND, silty Brown Dry (FILL)		1	GS										29 49 22 (SI+CL)
215.3														
0.7	Silty CLAY, some sand (sandy pockets), trace gravel Firm to Stiff Brown to Grey Moist (FILL)		2	SS	9		215							
			3	SS	5		214							5 18 45 32
			4	SS	7		213							
	Becoming grey		5	SS	6		212							
			6	SS	11		211							
			7	SS	8		210							0 16 50 34
208.8							209							
7.2	Silty CLAY, some sand to sandy, trace gravel Hard Grey Dry to Moist (TILL)		8	SS	38		208							
			9	SS	57		207							
	With sandy pockets													

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RECORD OF BOREHOLE No 14-29

2 OF 2

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 821 036.6 E 271 974.0 ORIGINATED BY MKE
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.24 - 2014.07.24 CHECKED BY CN

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	○ UNCONFINED + FIELD VANE	W _P W W _L											
Continued From Previous Page																					
200.2 15.8	Very stiff		10	SS	19		205										3	27	45	25	
	Hard		11	SS	62		204														
			12	SS	59		203														
			13	SS	36		202														
							201														

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RECORD OF BOREHOLE No 14-30

1 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 985.3 E 271 987.6 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.23 - 2014.07.24 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
209.5								20	40	60	80	100					
0.0	TOPSOIL: (125mm)																
0.1	Silty CLAY, trace sand Stiff Brown		1	SS	12		209							○			
208.7	Dry (FILL)																
0.8	Silty CLAY, some sand to sandy, trace gravel Very Stiff to Hard Brown/Reddish Brown Dry (TILL)		2	SS	27		208							○			
			3	SS	31									○			
			4	SS	42		207							○			4 34 43 19
			5	SS	51		206							○			
							205										
			6	SS	24									○			
							204										
			7	SS	41		203							○			2 31 47 20
							202										
			8	SS	28									○			
							201										
			9	SS	38		200							○			

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RECORD OF BOREHOLE No 14-30

2 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 985.3 E 271 987.6 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.23 - 2014.07.24 CHECKED BY CN

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 (%)				
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
	Continued From Previous Page							20 40 60 80 100								GR SA SI CL
			10	SS	35											
			11	SS	36											0 12 60 28
			12	SS	16											
			13	SS	17											
			14	SS	77											6 39 44 11
			15	SS	86											

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Sensitivity

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(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 14-30

3 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 985.3 E 271 987.6 ORIGINATED BY GA
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.23 - 2014.07.24 CHECKED BY CN

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	W _P	W			W _L
SHEAR STRENGTH kPa											WATER CONTENT (%)						
	Continued From Previous Page		16	SS	51/ 0.150												
							189										
							188										
							187										
186.6																	
22.9	SAND , some silt, trace gravel Compact to Very Dense Brown Wet		17	SS	20		186										1 88 11 (SI+CL)
							185										
							184										
			18	SS	89		183										
							182										
							181										
			19	SS	42		180										3 84 13 (SI+CL)

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METRIC

ELEV DEPTH	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 (%)	
	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES									
								SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
	Continued From Previous Page						20 40 60 80 100 20 40 60 80 100 20 40 60 80 100	w _P w w _L 20 40 60					GR SA SI C	

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RECORD OF BOREHOLE No 14-31

1 OF 2

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 821 022.5 E 272 014.2 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.25 - 2014.07.25 CHECKED BY CN

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					
216.5								20 40 60 80 100					
0.0	ASPHALT: (150mm)							20 40 60 80 100					
0.2	Gravelly SAND, silty Compact Brown Moist						216						
215.6													
0.9	Silty CLAY, some sand, trace gravel Firm to Stiff Brown Moist (FILL)		1	SS	11		215						25 52 23 (SI+CL)
			2	SS	8								
			3	SS	8		214						
			4	SS	7		213						0 12 48 40
							212						
			5	SS	5								
							211						
			6	SS	13		210						0 16 54 30
209.5													
7.0	Clayey SILT to Silty CLAY, some sand to sandy, trace gravel Very Stiff to Hard Brown Moist (TILL)						209						
			7	SS	29								
							208						
			8	SS	56		207						

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RECORD OF BOREHOLE No 14-31

2 OF 2

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 821 022.5 E 272 014.2 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.25 - 2014.07.25 CHECKED BY CN

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 (%)		
								20 40 60 80 100									20 40 60		
Continued From Previous Page							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
200.7 15.8							206									8 29 47 16			
			9	SS	21														
			10	SS	26														
			11	SS	49														3 27 52 18

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RECORD OF BOREHOLE No 14-32

1 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 964.3 E 272 018.1 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2014.07.25 - 2014.07.25 CHECKED BY CN

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					
209.7								20 40 60 80 100					
0.0	ASPHALT: (50mm)							20 40 60 80 100					
0.1	Gravelly SAND , some silt Very Dense Brown Moist (FILL)		1	SS	58		209	20 40 60 80 100					36 49 15 (SI+CL)
208.8								20 40 60 80 100					
0.9	Clayey SILT to Silty CLAY , some sand to sandy, trace gravel Very Stiff to Hard Brown Moist (TILL)		2	SS	22		208	20 40 60 80 100					
								20 40 60 80 100					
			3	SS	31		207	20 40 60 80 100					5 27 47 21
								20 40 60 80 100					
			4	SS	47		206	20 40 60 80 100					
								20 40 60 80 100					
			5	SS	58		205	20 40 60 80 100					
								20 40 60 80 100					
			6	SS	27		204	20 40 60 80 100					
								20 40 60 80 100					
			7	SS	31		203	20 40 60 80 100					
								20 40 60 80 100					
			8	SS	59		202	20 40 60 80 100					0 22 54 24
								20 40 60 80 100					
			9	SS	36		201	20 40 60 80 100					
							200	20 40 60 80 100					

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 14-32

2 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 964.3 E 272 018.1 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2014.07.25 - 2014.07.25 CHECKED BY CN

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	20	40	60				
	Continued From Previous Page																						
198.0			10	SS	27																		
11.7	Silty CLAY Very Stiff Grey Moist to Wet		11	SS	17																		
196.4																							
13.3	SILT , some clay Compact Brown Wet		12	SS	29																		
194.7																							
15.0	SAND and GRAVEL , some silt to silty Dense to Very Dense Grey Wet		13	SS	68																		
	Shale fragments Silty		14	SS	73																		
			15	SS	47																		
	Cobbles (150mm) at 19.1m																						

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 14-32

3 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 964.3 E 272 018.1 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2014.07.25 - 2014.07.25 CHECKED BY CN

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		16	SS	60											
187.9							189									
21.8	Gravelly zone with occasional cobbles below 21.8m						188									
			17	SS	42											
185.3							186									
24.4	SAND, trace gravel, trace silt Very Dense Brown Wet						185									
							184									
	Limestone fragments		18	SS	100/ 0.150											4 93 ³ (SI+CL)
							183									
							182									
							181									
	Limestone fragments		19	SS	88											
							180									
179.7			20	SS	100/											

Continued Next Page

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

RECORD OF BOREHOLE No 14-32

4 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 964.3 E 272 018.1 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE NW Casing COMPILED BY AN
 DATUM Geodetic DATE 2014.07.25 - 2014.07.25 CHECKED BY CN

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 (%)				
							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					20 40 60 W P W W L					
30.0	Continued From Previous Page END OF BOREHOLE AT 30.0m ON PROBABLE BEDROCK. BOREHOLE OPEN TO 27.2m AND WATER LEVEL AT 0.3m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.7m, THEN CONCRETE TO 0.1m THEN ASPHALT TO SURFACE.				0.075												

RECORD OF BOREHOLE No 14-33

1 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 993.4 E 272 059.3 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.07.21 - 2014.07.24 CHECKED BY CN

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT 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 (%)				GR	SA	SI	CL			
								<div><div></div><div></div><div></div><div></div><div></div></div> <div>20 40 60 80 100</div>	<div><div></div><div></div><div></div><div></div><div></div></div> <div>20 40 60</div>													
209.6																						
0.0	ASPHALT: (100mm)																					
0.1	Gravelly SAND, some silt Brown Moist (FILL)																					
208.9							209															
0.7	Clayey SILT to Silty CLAY, some sand to sandy, trace gravel Very Stiff to Hard Brown Moist (TILL)		1	SS	28																	
			2	SS	55		208										3	25	52	20		
			3	SS	85		207															
			4	SS	55		206															
205.5																						
4.1	SILT, some clay, some sand Compact Brown to Grey Moist to Wet		5	SS	21		205											0	19	66	15	
204.0							204															
5.6	Clayey SILT to Silty CLAY, some sand, trace gravel Hard Brown Moist (TILL) Shale fragments		6	SS	67		203															
							202												3	17	59	21
	Limestone fragments		7	SS	91		201															
			8	SS	74		200															

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 14-33

2 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 993.4 E 272 059.3 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.07.21 - 2014.07.24 CHECKED BY CN

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 (%)						
							20 40 60						
	Continued From Previous Page												
			9	SS	74								5 14 59 22
			10	SS	83								
196.5													
13.1	Silty CLAY , trace sand Hard Brown Moist		11	SS	53								0 3 50 47
194.8													
14.8	SILT , some clay, trace sand Compact Brown Moist to Wet		12	SS	26								
193.4													
16.2	SAND , some silt, trace gravel Dense to Very Dense Brown Wet		13	SS	0*								
	Boulder from 18.0m to 18.7m												
	Occasional cobbles from 19.0m to 22.5m												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 14-33

3 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 993.4 E 272 059.3 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.07.21 - 2014.07.24 CHECKED BY CN

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 (%)				
							20	40	60	80	100	W _p	W	W _L		
	Continued From Previous Page		14	SS	35											
	Moist						189									
							188									
							187									
			15	SS	100											
							186									
			16	SS	100											
							184									
			17	SS	74											
							183									
							182									
	Gravelly zone with shale and limestone fragments					181										
			18	SS	100/ 0.225											
							180									

Continued Next Page

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

RECORD OF BOREHOLE No 14-33

4 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 993.4 E 272 059.3 ORIGINATED BY SLL
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.07.21 - 2014.07.24 CHECKED BY CN

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						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
								WATER CONTENT (%)						
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT						
								w P w w L						
	Continued From Previous Page													
178.7							179							
30.9	SHALE: , moderately weathered to fresh, very strong over weak, reddish brown with grey limestone interbeds Rubble zone 225mm at 31.2m and 50mm at 31.6m Limestone seam 125mm at 31.8m Fracture zone 50mm at 33.2m Calcite deposit 50mm at 33.5m		1	RUN			178							
			2	RUN			177							
			3	RUN			176							
174.9							175							
34.7	END OF BOREHOLE AT 34.7m. BOREHOLE OPEN TO 26.3m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.9m, THEN CEMENT TO 0.1m, THEN ASPHALT TO SURFACE. * LOW BLOW COUNTS DUE TO SOIL DISTURBANCE.													

ONTMT4S 3896A.GPJ 2012TEMPLATE(MTO).GDT 7/31/14

RECORD OF BOREHOLE No 14-34

1 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 924.4 E 272 039.0 ORIGINATED BY SP/MEF
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.07.21 - 2014.07.24 CHECKED BY CN

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					
208.7													
0.0	TOPSOIL: (100mm)												
0.1	Silty CLAY, trace organics Stiff to Very Stiff Brown (FILL)		1	SS	11								
	With small grey patches		2	SS	21								0 0 52 48
			3	SS	21								
206.5													
2.2	Clayey SILT to Silty CLAY, some sand to sandy, trace gravel Very Stiff Brown Moist (TILL)		4	SS	17								
			5	SS	29								0 31 46 23
			6	SS	24								
			7	SS	17								
	Becoming Grey		8	SS	19								
			9	SS	18								

Continued Next Page

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

RECORD OF BOREHOLE No 14-34

2 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 924.4 E 272 039.0 ORIGINATED BY SP/MEF
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.07.21 - 2014.07.24 CHECKED BY CN

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 (%)				
	Continued From Previous Page							20 40 60 80 100								GR SA SI CL
	Silty															
			10	SS	24		198						o			2 38 47 13
							197									
			11	SS	18		196						oH			5 28 50 17
							195									
			12	SS	27		194						o			
193.9							193									
14.8	Sandy zone		13	SS	100		192						o			4 43 38 15
							191									
192.5			14	SS	51		190						o			
16.2							189									
			15	SS	46								oH			2 18 58 22

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

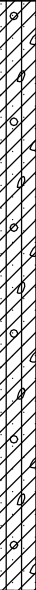




20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 14-34

3 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 924.4 E 272 039.0 ORIGINATED BY SP/MEF
HWY 401 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2014.07.21 - 2014.07.24 CHECKED BY CN

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								
	Continued From Previous Page						20	40	60	80	100					
	Clayey		16	SS	43											
			17	SS	40											
			18	SS	28											
184.8																
23.9	SILT, trace to some sand, trace gravel, trace clay Dense Brown		19	SS	34											
183.2																
25.5	Silty CLAY, trace sand Hard Brown/Grey		20	SS	46											
181.7																
27.0	SAND, some silt, trace gravel Compact to Very Dense Brown/Grey Wet		21	SS	11											
179.7																
29.0	Clayey SILT to Silty CLAY, some sand, trace gravel Hard Brown/Grey (TILL)															

Continued Next Page

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

RECORD OF BOREHOLE No 14-34

4 OF 4

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 924.4 E 272 039.0 ORIGINATED BY SP/MEF
 HWY 401 BOREHOLE TYPE Hollow Stem Augers/NQ Coring COMPILED BY AN
 DATUM Geodetic DATE 2014.07.21 - 2014.07.24 CHECKED BY CN

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 (%)				
								20 40 60 80 100				w _P w w _L				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE								
	Continued From Previous Page															
	Possible sand and gravel zone below 31m		22	SS	100		178									
							177									
			23	SS	100/	0.0625		176								
175.8																
32.9	SHALE , moderately weathered to fresh, medium strong to weak, reddish brown with grey limestone interbeds Silty clay layers (100mm) at 33.2m, (50mm) at 33.4m, (75mm) at 33.6m Limestone interbeds (75mm) at 33.1m, 33.5m Limestone interbeds (175mm) at 34.2m Limestone interbeds (200mm) at 35.6m, (75mm) at 36.4m		1	RUN			175									
			2	RUN			174									
			3	RUN			173									
172.0																
36.7	END OF BOREHOLE AT 36.7m. WATER LEVEL AT 12.2m DEPTH AT THE BEGINING OF SECOND DAY DRILLING, WHEN BOREHOLE WAS AT 17.4m DEPTH. 															

ONTMT4S 3896A.GPJ 2012TEMPLATE(MTO).GDT 7/31/14

METRIC[illegible]

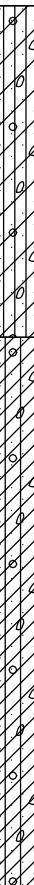
+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 14-35

2 OF 2

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 933.0 E 272 098.6 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.24 - 2014.07.24 CHECKED BY CN

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 x LAB VANE									
							20 40 60 80 100					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT					
							W P W W L					WATER CONTENT (%)					
							20 40 60										
Continued From Previous Page																	
203.1	Silty CLAY , some sand to sandy, trace gravel Very Stiff Brown Moist (TILL)		10	SS	32		205									2 22 54 22	
12.2					11		SS	24	203								
							202										
			12	SS	26		201										
199.4			13	SS	24		200										
15.8	END OF BOREHOLE AT 15.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS AND ASPHALT PATCH TO SURFACE.																

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

RECORD OF BOREHOLE No 14-36

1 OF 2

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 898.3 E 272 053.1 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.24 - 2014.07.24 CHECKED BY CN

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						
208.1														
0.0	TOPSOIL: (120mm)													
0.1	Silty CLAY , some sand to sandy, trace gravel Stiff to Very Stiff Brown Moist (FILL)		1	SS	14									
			2	SS	26									4 27 48 21
206.6														
1.5	Silty CLAY , sandy, trace gravel Very Stiff to Hard Brown Moist (TILL)		3	SS	34									
			4	SS	34									
			5	SS	20									6 34 42 18
			6	SS	18									
			7	SS	20									
			8	SS	22									4 34 44 18
			9	SS	37									
198.3	END OF BOREHOLE AT 9.8m.													
9.8														

Continued Next Page

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

RECORD OF BOREHOLE No 14-36

2 OF 2

METRIC

GWP# 2188-10-00 LOCATION Regional Rd. 25 Underpass N 4 820 898.3 E 272 053.1 ORIGINATED BY JAG
 HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2014.07.24 - 2014.07.24 CHECKED BY CN

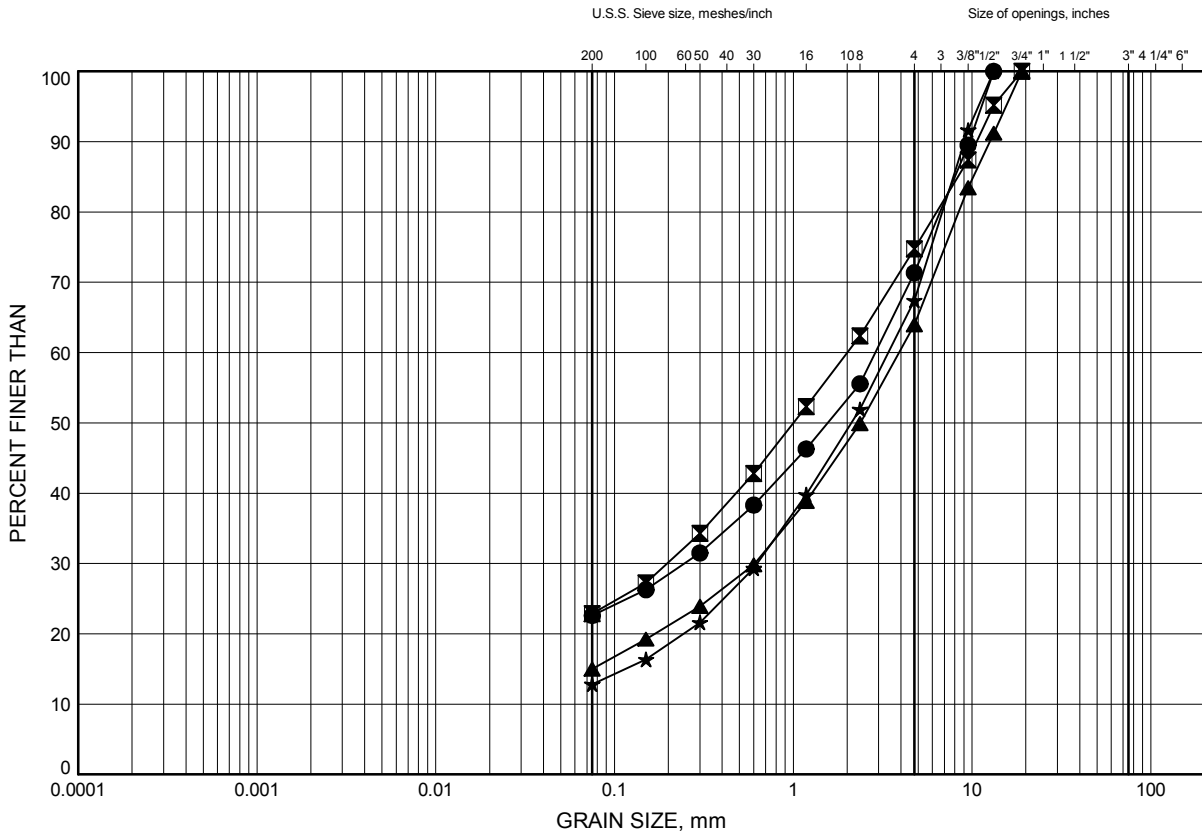
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					20 40 60 W P W W L					
	Continued From Previous Page BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																

Appendix B
Laboratory Test Results

Regional Rd. 25 Underpass
GRAIN SIZE DISTRIBUTION

FIGURE B1

Gravelly SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-29	0.30	215.70
⊠	14-31	0.88	215.62
▲	14-32	0.46	209.29
★	14-35	0.46	214.79

Date July 2014
 GWP# 2188-10-00

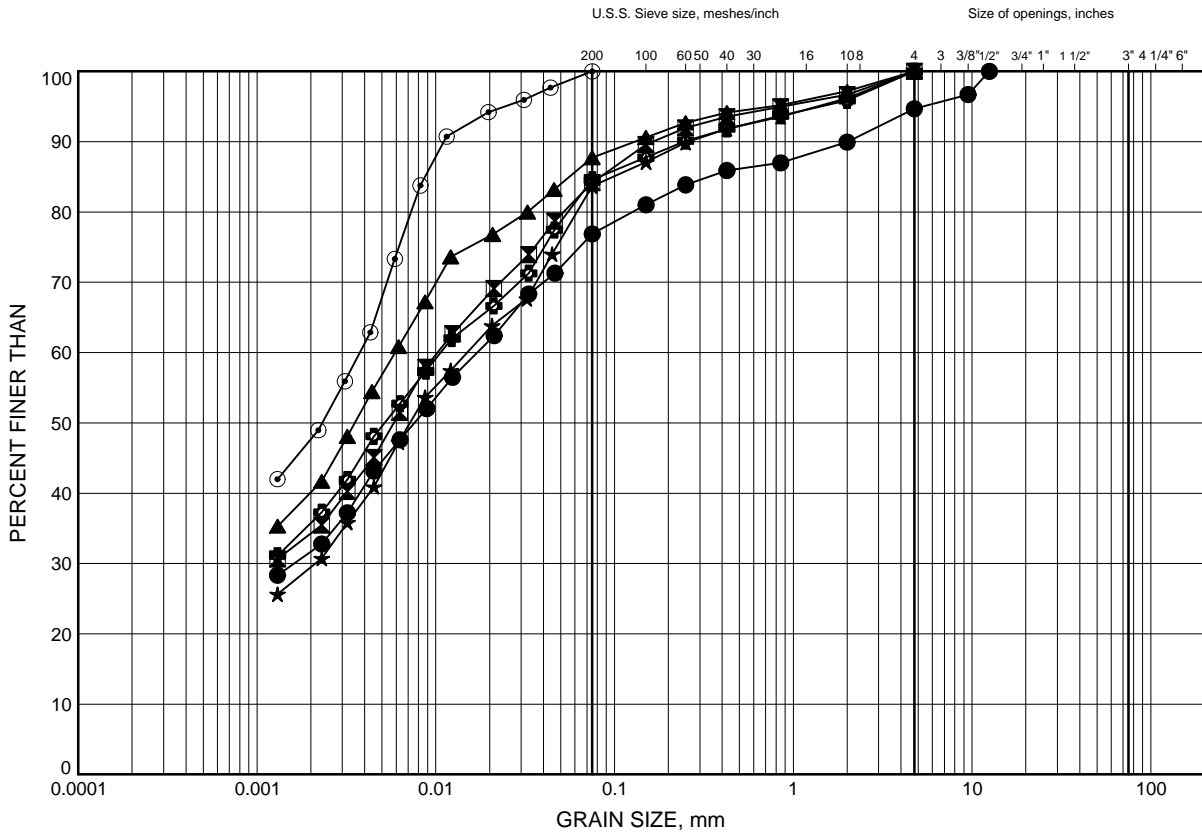


Prep'd AN
 Chkd. SN

Regional Rd. 25 Underpass
GRAIN SIZE DISTRIBUTION

FIGURE B2A

Silty CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-29	1.83	214.17
⊠	14-29	6.40	209.60
▲	14-31	3.35	213.15
★	14-31	6.40	210.10
⊙	14-34	1.07	207.63
⊕	14-35	1.83	213.42

Date July 2014
 GWP# 2188-10-00

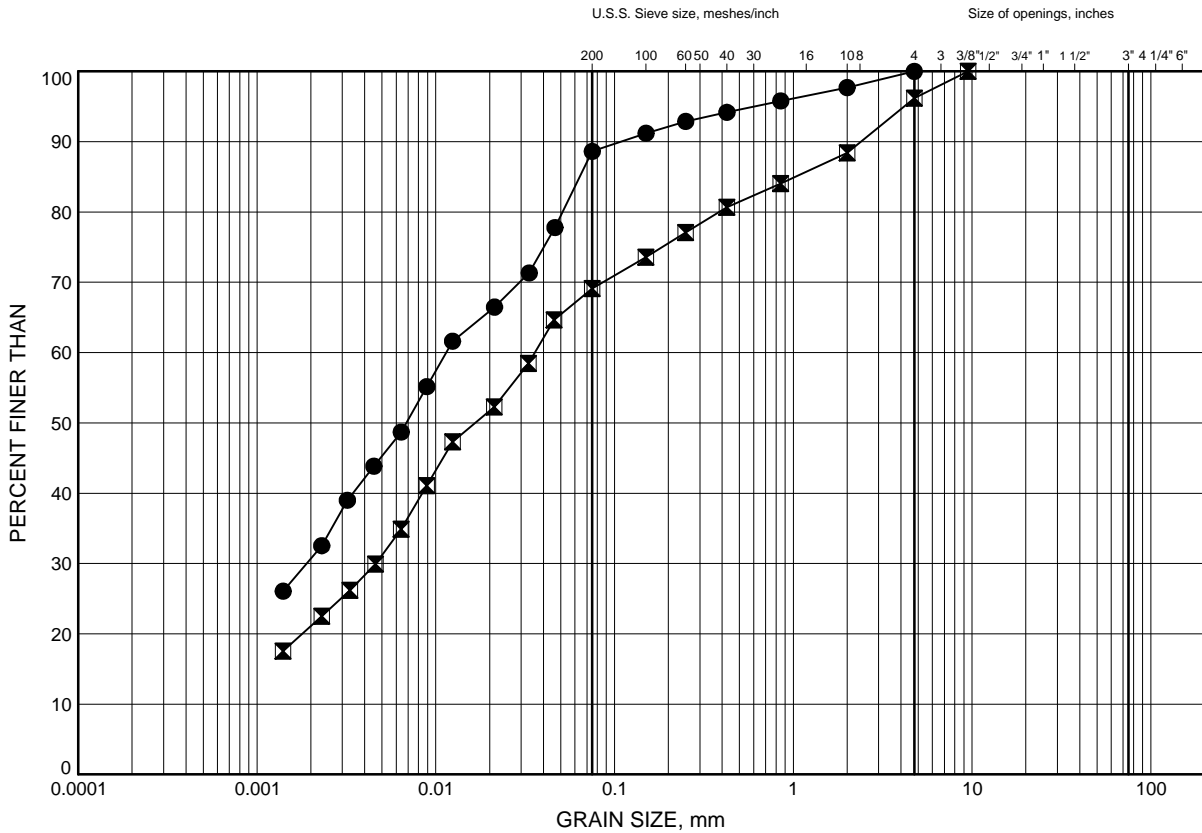


Prep'd AN
 Chkd. SN

Regional Rd. 25 Underpass
GRAIN SIZE DISTRIBUTION

FIGURE B2B

Silty CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-35	6.40	208.85
◻	14-36	1.07	207.03

Date July 2014
 GWP# 2188-10-00



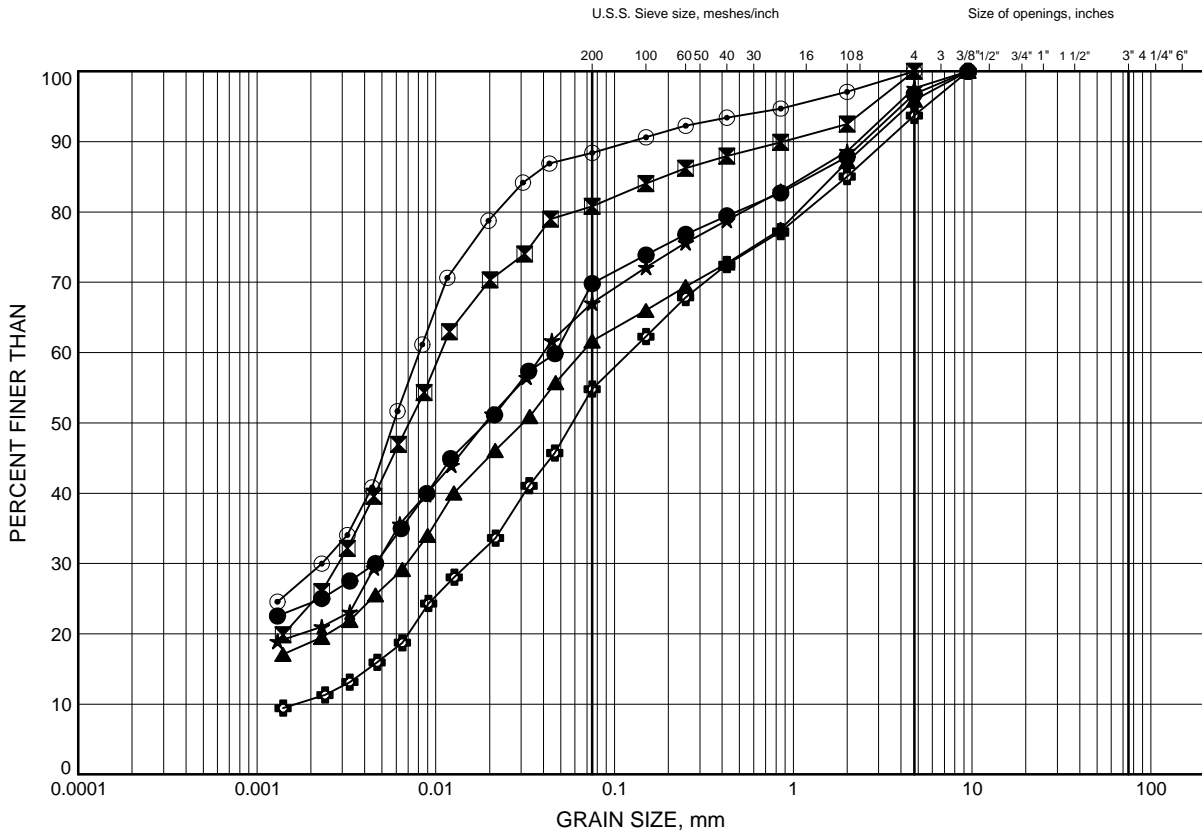
Prep'd AN
 Chkd. SN

Regional Rd. 25 Underpass

GRAIN SIZE DISTRIBUTION

FIGURE B3A

Clayey SILT to Silty CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-29	10.97	205.03
⊠	14-29	15.54	200.46
▲	14-30	2.59	206.91
★	14-30	6.40	203.10
⊙	14-30	12.50	197.00
⊕	14-30	17.07	192.43

Date July 2014

GWP# 2188-10-00



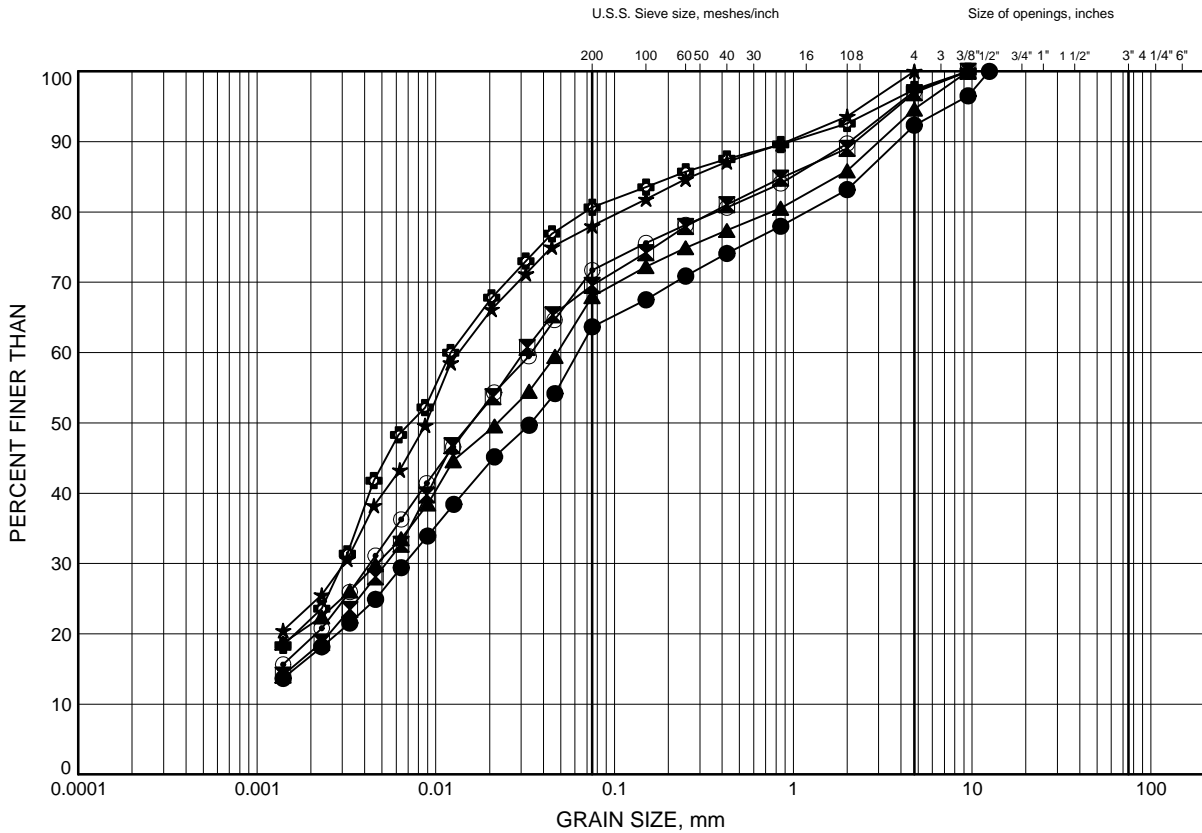
Prep'd AN

Chkd. CN

Regional Rd. 25 Underpass
GRAIN SIZE DISTRIBUTION

FIGURE B3B

Clayey SILT to Silty CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-31	10.97	205.53
⊠	14-31	14.02	202.48
▲	14-32	2.59	207.16
★	14-32	7.92	201.83
⊙	14-33	1.83	207.77
⊕	14-33	7.91	201.69

Date July 2014
 GWP# 2188-10-00

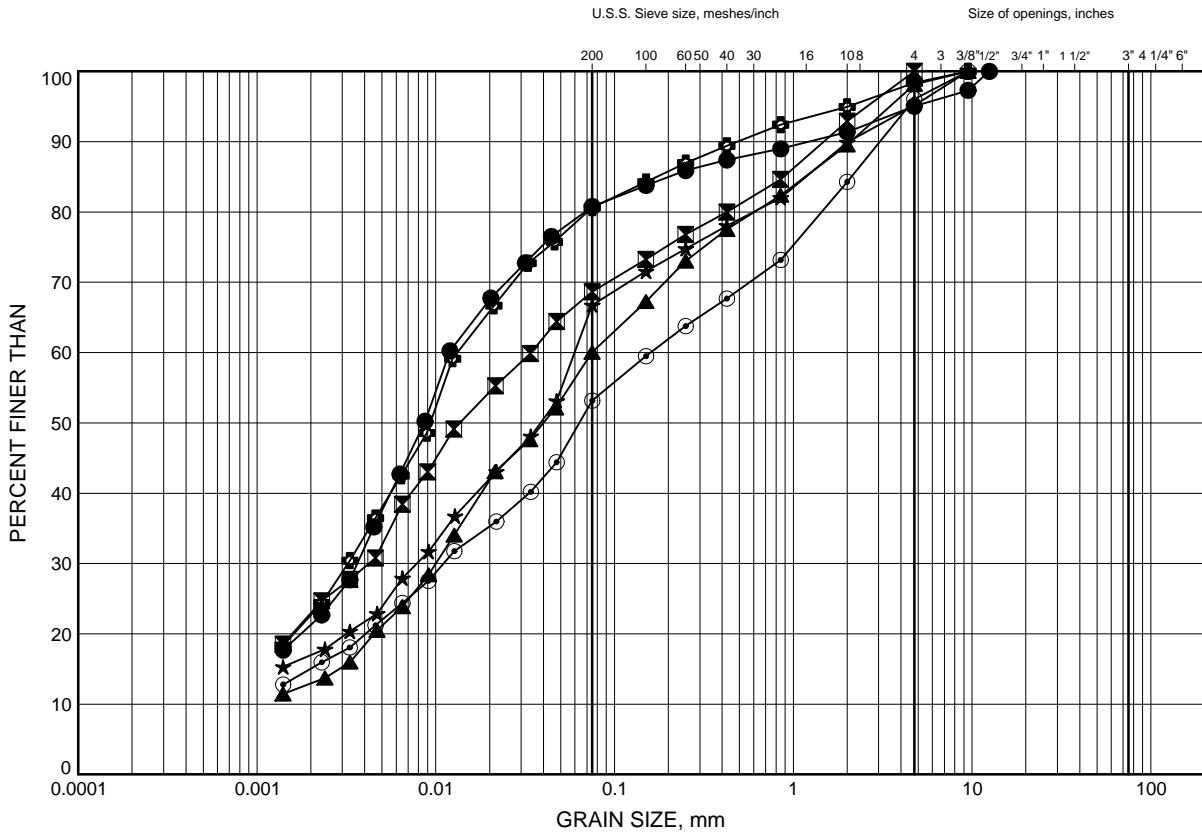


Prep'd AN
 Chkd. CN

Regional Rd. 25 Underpass
GRAIN SIZE DISTRIBUTION

FIGURE B3C

Clayey SILT to Silty CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-33	10.97	198.63
⊠	14-34	3.35	205.35
▲	14-34	10.97	197.73
★	14-34	12.50	196.20
⊙	14-34	15.54	193.16
⊕	14-34	18.59	190.11

Date July 2014

GWP# 2188-10-00



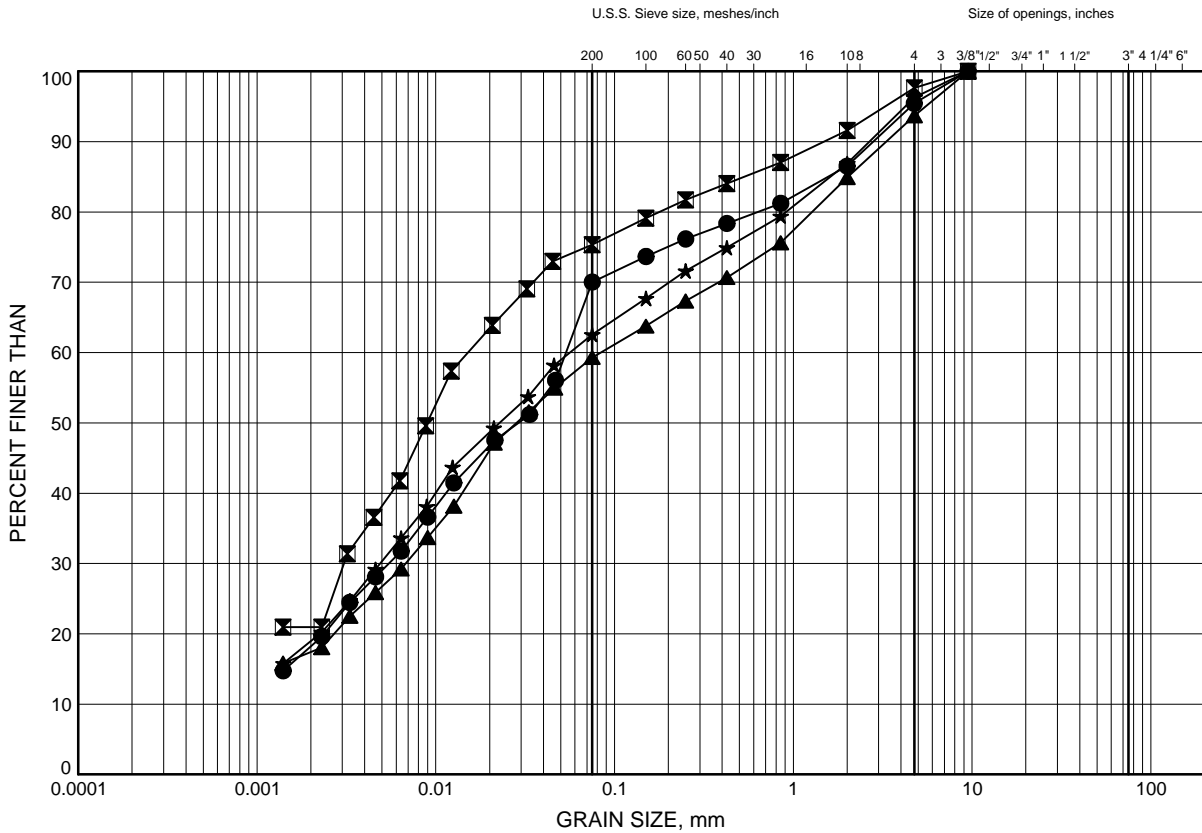
Prep'd AN

Chkd. CN

Regional Rd. 25 Underpass
GRAIN SIZE DISTRIBUTION

FIGURE B3D

Clayey SILT to Silty CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-35	9.45	205.80
⊠	14-35	14.02	201.23
▲	14-36	3.35	204.75
★	14-36	7.92	200.18

Date July 2014
 GWP# 2188-10-00

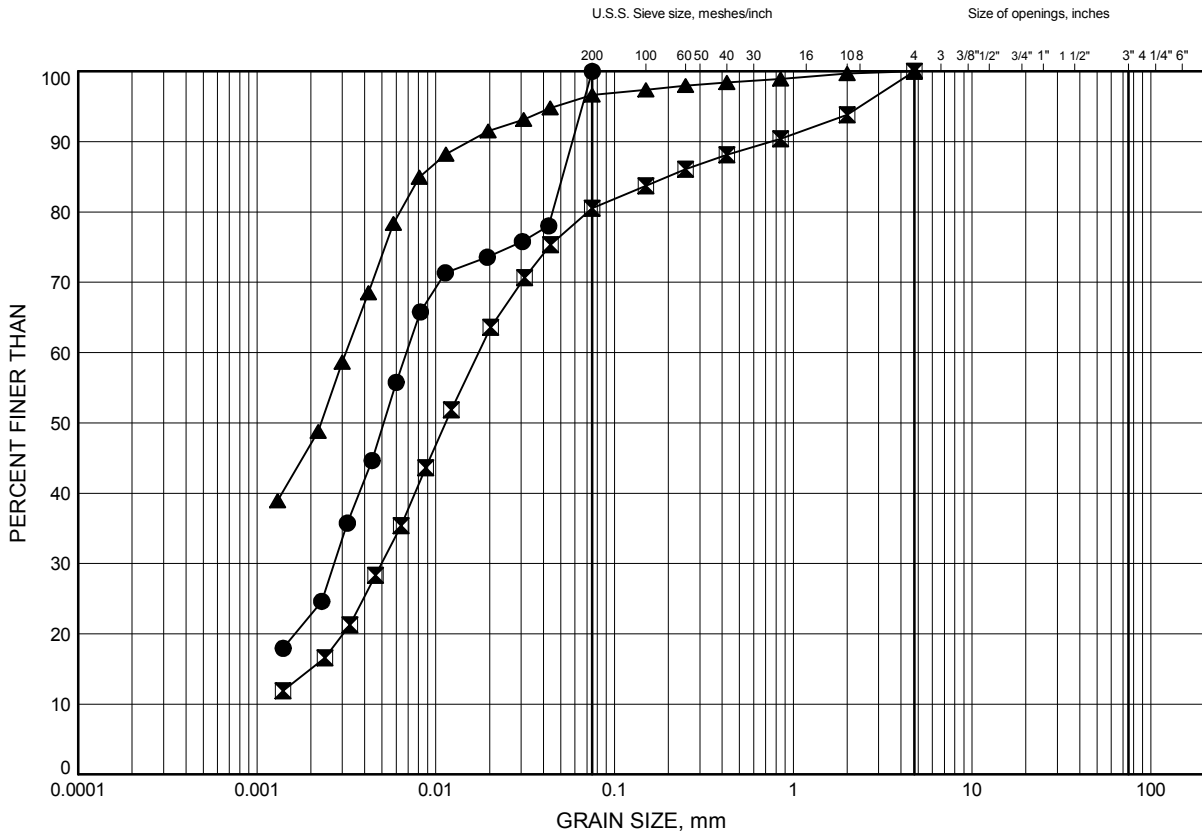


Prep'd AN
 Chkd. CN

Regional Rd. 25 Underpass
GRAIN SIZE DISTRIBUTION

FIGURE B4

SILT & Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-32	14.02	195.73
⊠	14-33	4.88	204.72
▲	14-33	14.02	195.58

Date July 2014
 GWP# 2188-10-00

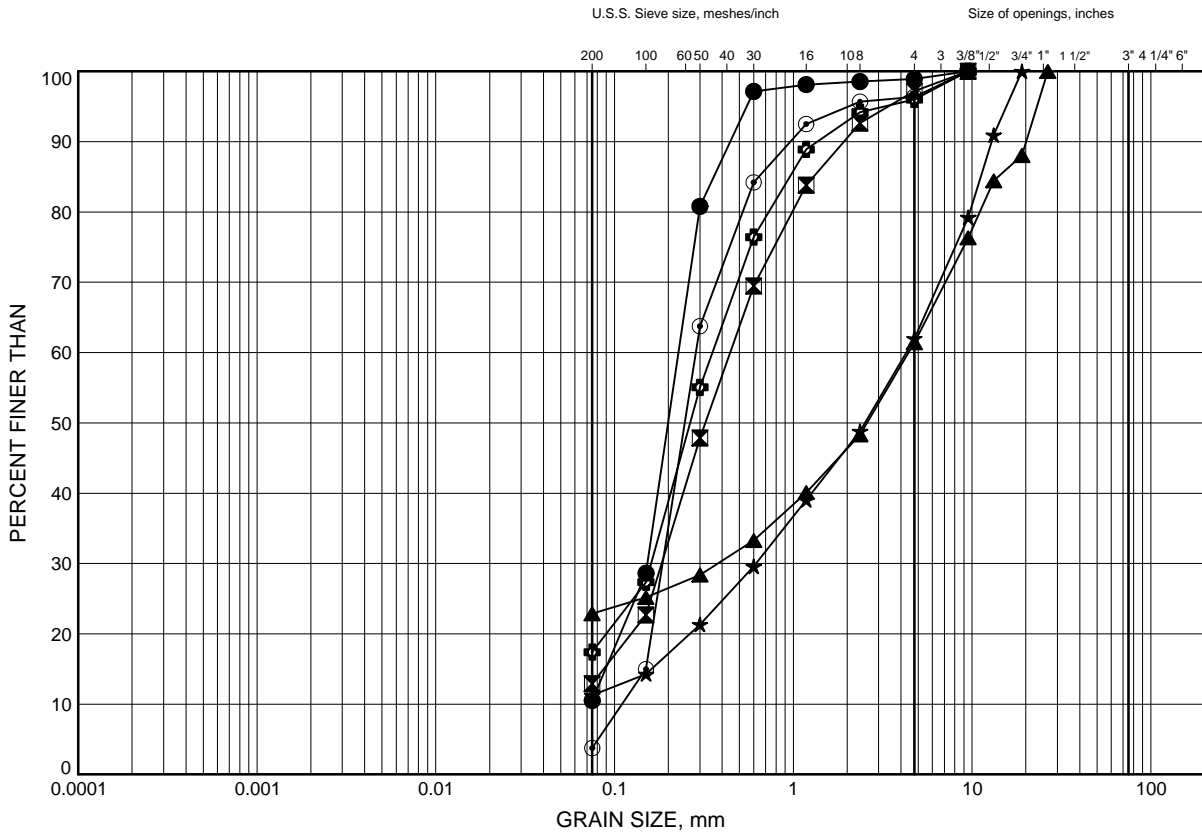


Prep'd AN
 Chkd. CN

Regional Rd. 25 Underpass
GRAIN SIZE DISTRIBUTION

FIGURE B5A

SAND and SAND & GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-30	23.16	186.34
⊠	14-30	29.26	180.24
▲	14-32	15.54	194.21
★	14-32	18.59	191.16
⊙	14-32	25.98	183.77
⊕	14-33	23.09	186.51

Date July 2014
 GWP# 2188-10-00

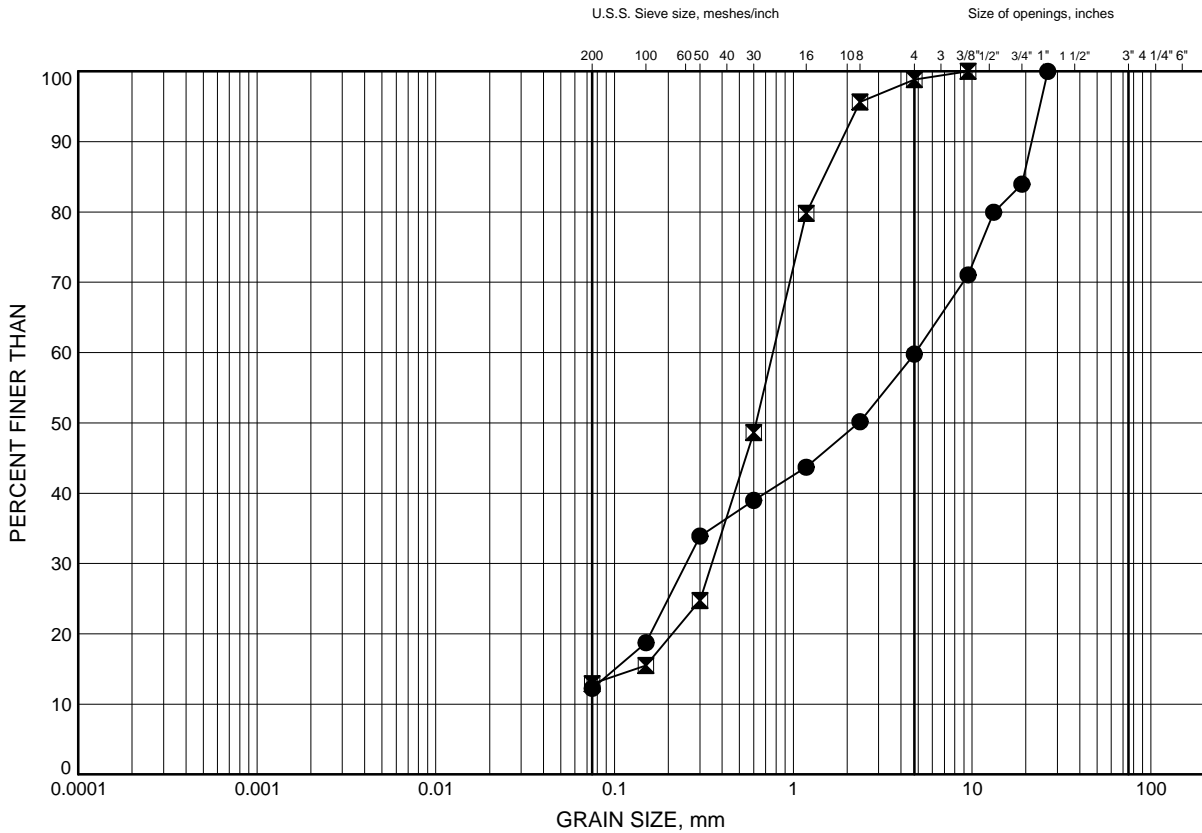


Prep'd AN
 Chkd. CN

Regional Rd. 25 Underpass
GRAIN SIZE DISTRIBUTION

FIGURE B5B

SAND and SAND & GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-33	29.17	180.43
⊠	14-34	27.74	180.96

Date July 2014
 GWP# 2188-10-00

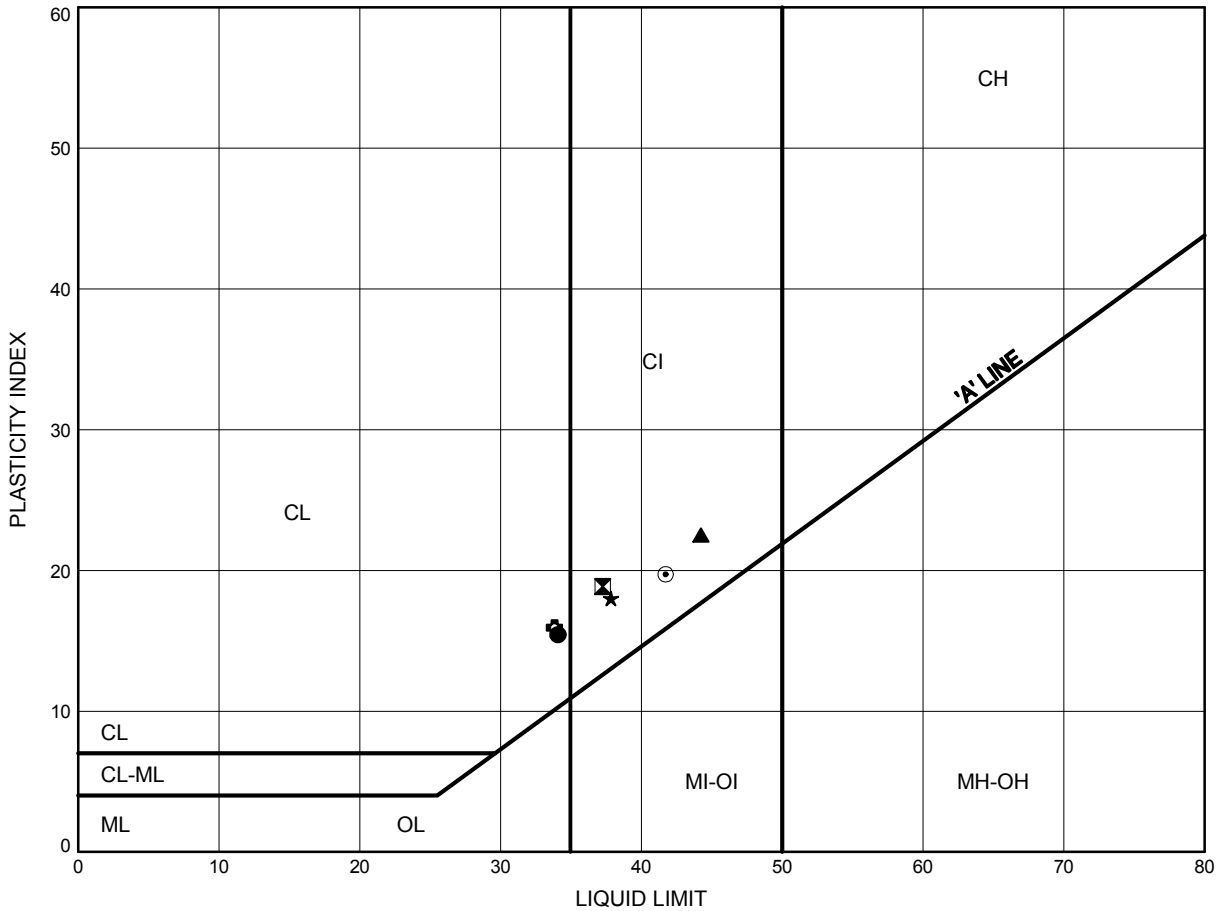


Prep'd AN
 Chkd. CN

Regional Rd. 25 Underpass
ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Silty CLAY FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-29	1.83	214.17
⊠	14-29	6.40	209.60
▲	14-31	3.35	213.15
★	14-31	6.40	210.10
⊙	14-34	1.07	207.63
⊕	14-35	6.40	208.85

Date July 2014
 GWP# 2188-10-00

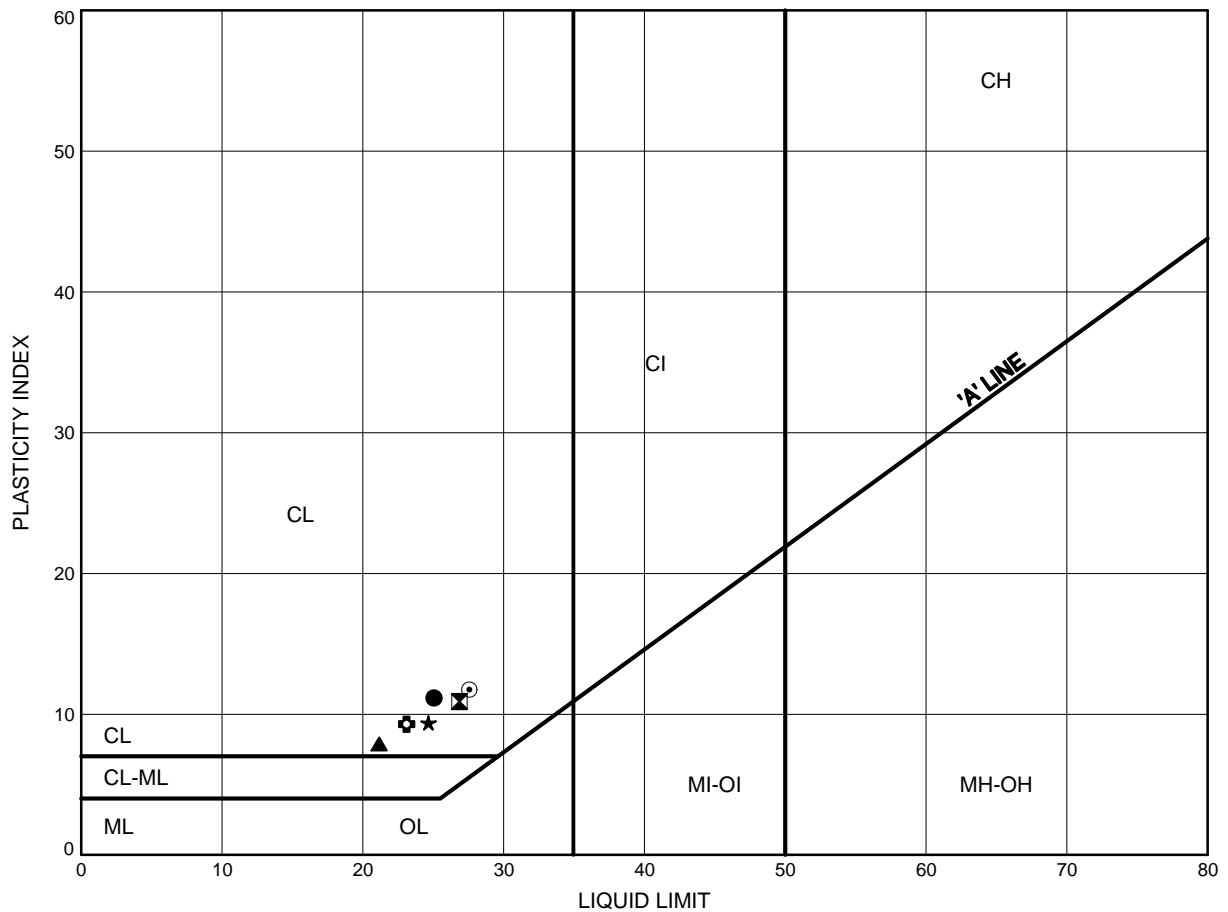


Prep'd AN
 Chkd. CN

Regional Rd. 25 Underpass
ATTERBERG LIMITS TEST RESULTS

FIGURE B7A

Clayey SILT to Silty CLAY TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-29	10.97	205.03
⊠	14-30	2.59	206.91
▲	14-30	6.40	203.10
★	14-30	12.50	197.00
⊙	14-32	2.59	207.16
⊕	14-32	7.92	201.83

Date July 2014
 GWP# 2188-10-00

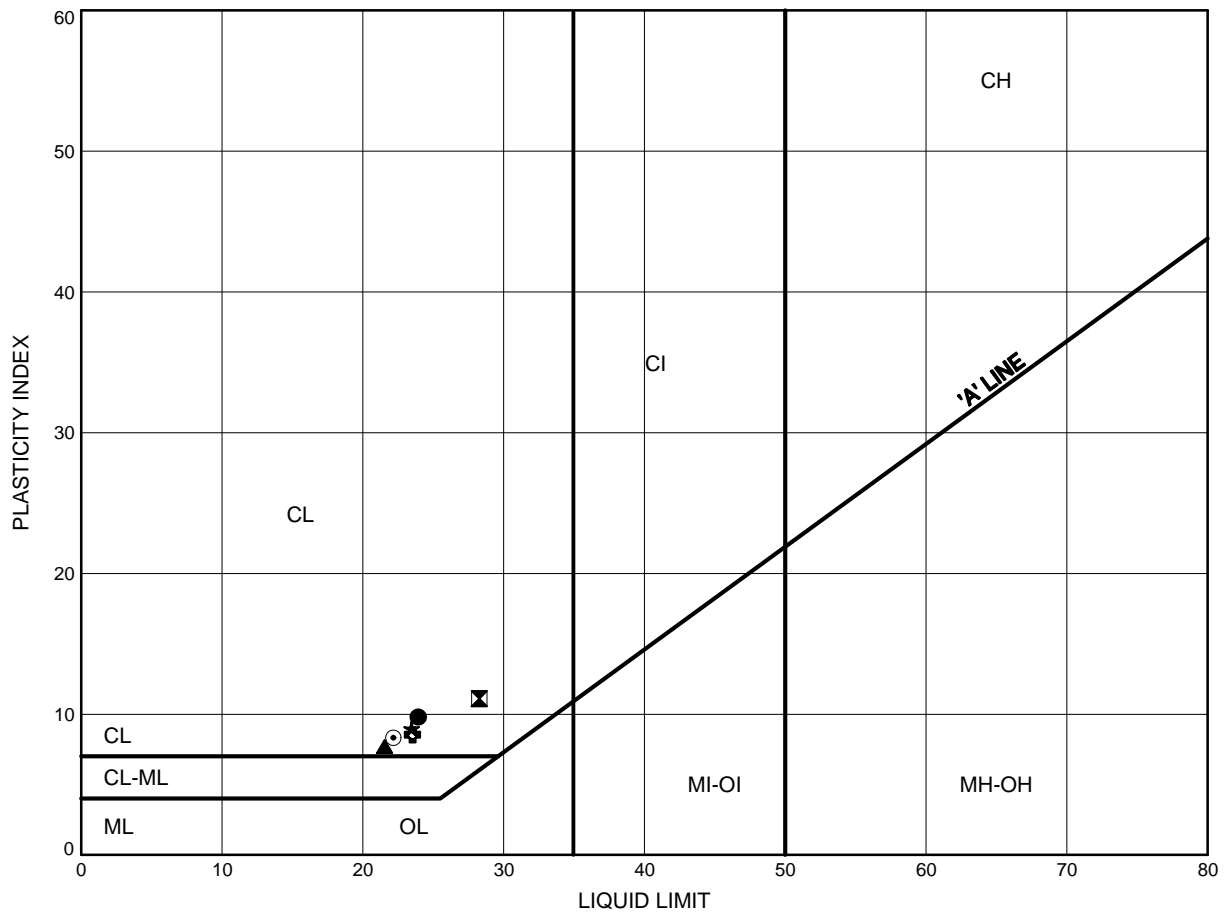


Prep'd AN
 Chkd. CN

Regional Rd. 25 Underpass
ATTERBERG LIMITS TEST RESULTS

FIGURE B7B

Clayey SILT to Silty CLAY TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-33	10.97	198.63
⊠	14-34	3.35	205.35
▲	14-34	12.50	196.20
★	14-34	18.59	190.11
⊙	14-35	14.02	201.23
⊕	14-36	3.35	204.75

Date July 2014
 GWP# 2188-10-00

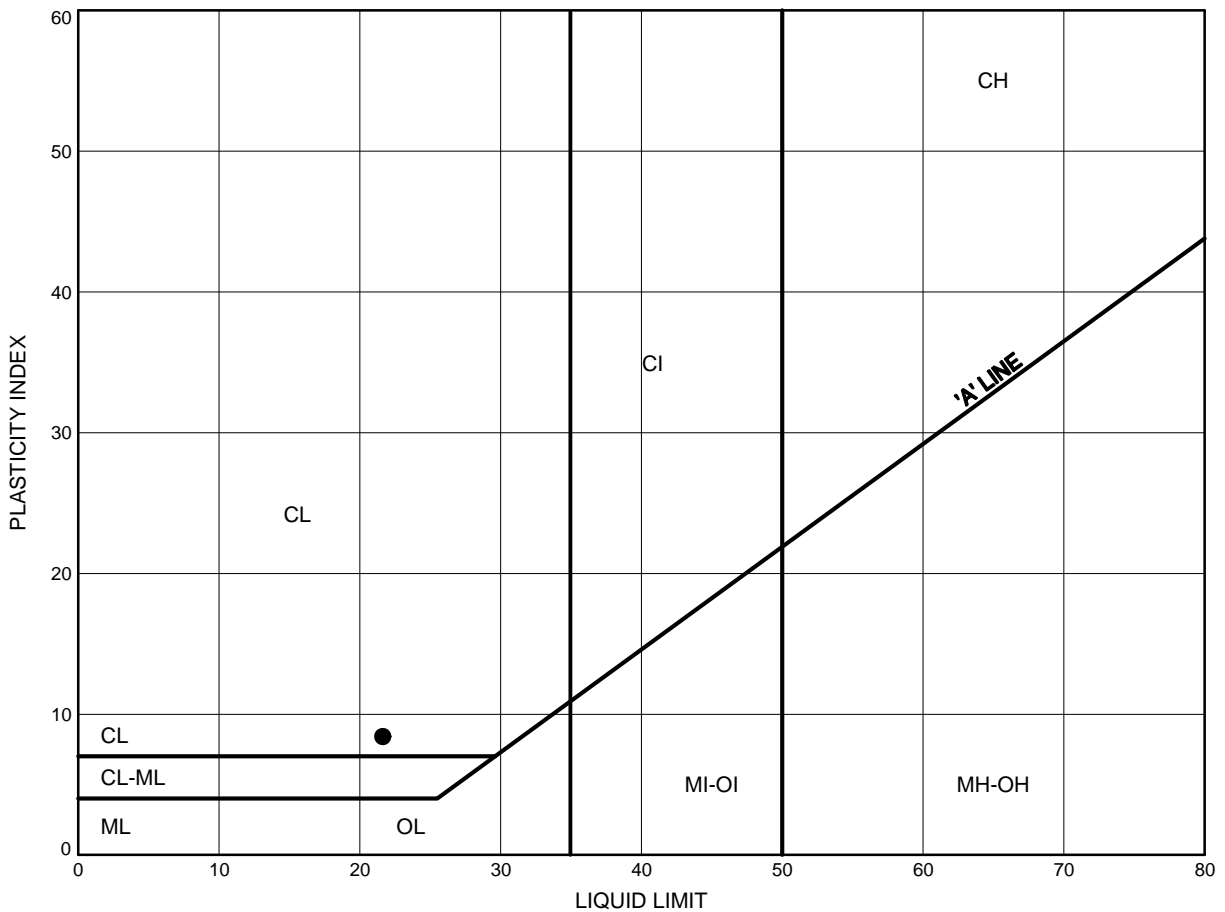


Prep'd AN
 Chkd. CN

Regional Rd. 25 Underpass
ATTERBERG LIMITS TEST RESULTS

FIGURE B7C

Clayey SILT to Silty CLAY TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-36	7.92	200.18

Date July 2014
 GWP# 2188-10-00

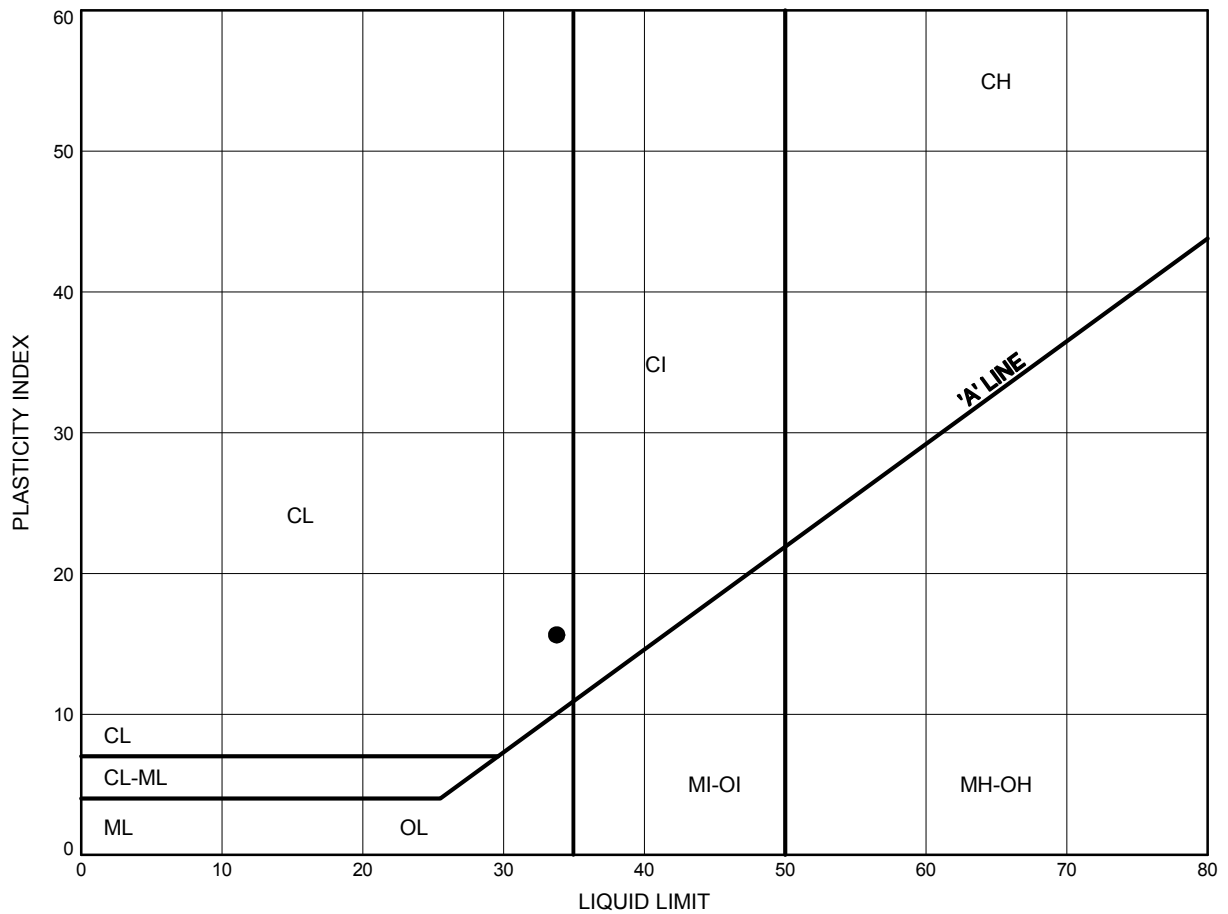


Prep'd AN
 Chkd. CN

Regional Rd. 25 Underpass
ATTERBERG LIMITS TEST RESULTS

FIGURE B8

SILT & Silty CLAY



LEGEND

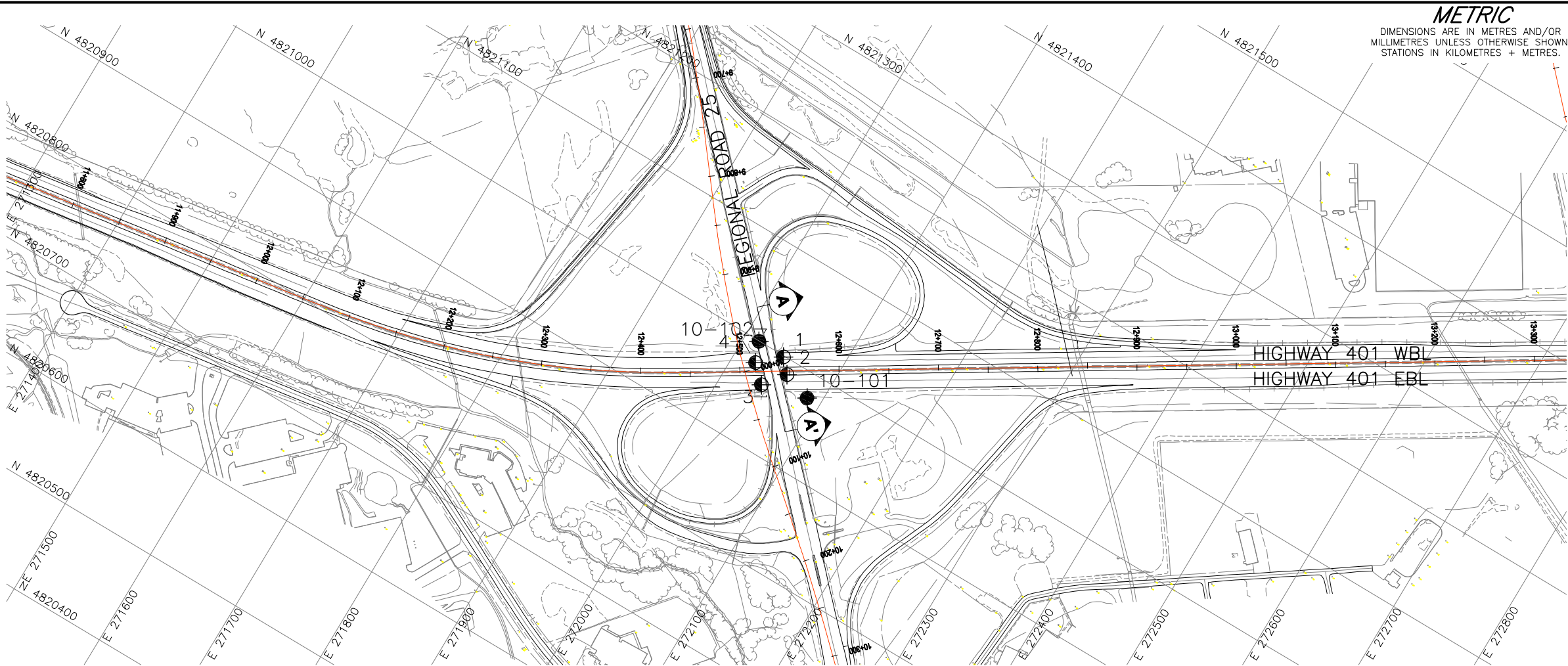
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	14-33	14.02	195.58

Date July 2014
 GWP# 2188-10-00

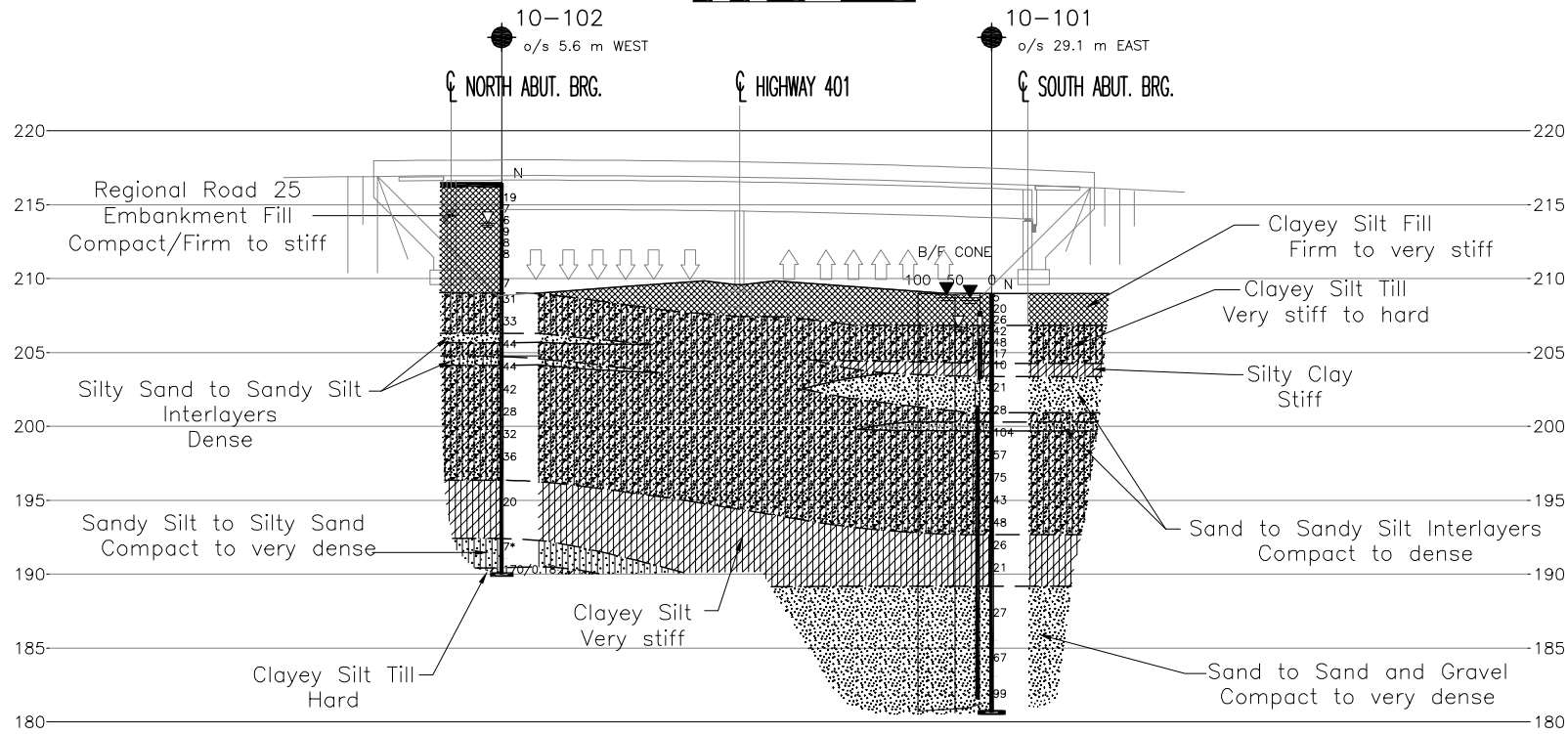
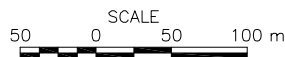


Prep'd AN
 Chkd. CN

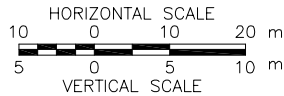
Appendix C
Historical Borehole Information



PLAN



SECTION A-A'



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

CONT No.
WO No. 07-20024

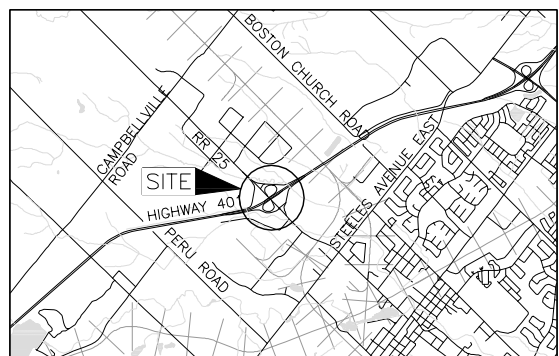
REGIONAL ROAD 25 UNDERPASS
HIGHWAY 401 WIDENING
BOREHOLE LOCATIONS AND SOIL STRATA



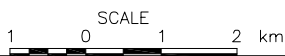
SHEET



Golder Associates Ltd.
MISSISSAUGA, ONTARIO, CANADA



KEY PLAN



LEGEND

- Borehole - Previous Investigation
- Borehole - Current Investigation
- Standard Penetration Test Value
- Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL in piezometer, measured on April 21, 2010
- WL upon completion of drilling

BOREHOLE CO-ORDINATES

No.	ELEVATION	NORTHING	EASTING
1	209.6	4820998.9	272044.1
2	209.6	4820985.5	272056.2
3	209.7	4820963.6	272039.3
4	209.9	4820979.6	272022.9
10-101	209.0	4820975.6	272085.6
10-102	216.5	4820999.7	272014.8

NOTES

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

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

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

REFERENCE

Base plans provided in digital format by URS (Drawing Files X-Align_401.dwg, received March 10, 2011, X-contour.dwg, received August, 2010, and X-Base, received September, 2010).



NO.	DATE	BY	REVISION
NO.	DATE	BY	REVISION
HWY. 401	PROJECT NO. 09-1111-6036	DIST.	
SUBM'D. NK	CHKD. MS	DATE: 10/21/2011	SITE:
DRAWN: JFC	CHKD. NK	APPD. LCC	DWG. 1

RECORD OF BOREHOLE No 10-101

1 OF 3 **METRIC**

PROJECT 09-1111-6036
 W.O. 07-20024 LOCATION N 4820975.6 ; E 272085.6 ORIGINATED BY MS
 DIST Central HWY 401 BOREHOLE TYPE CME 75 Truck-mount, 108 mm I.D. Hollow Stem Power Auger COMPILED BY OK/MS
 DATUM Geodetic DATE June 28, 2010 CHECKED BY LCC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
209.0	GROUND SURFACE							20 40 60 80 100						
0.0	Topsoil		1	SS	5		208							
0.1	Clayey silt, trace sand and gravel, containing organics (Possible FILL, Reworked TILL) Firm to very stiff Brown Moist		2	SS	20									
			3	SS	26		207							
206.9														
2.1	CLAYEY SILT, some to with sand, trace gravel (TILL) Hard Brown Moist		4	SS	42		206							
			5	SS	48									
	Becoming stiff at 3.8 m depth		6	SS	17		205							
204.3														
4.7	SILTY CLAY, trace sand and gravel Stiff Grey Moist		7	SS	10		204							
203.4														
5.6	SAND, trace to some gravel, trace silt and clay Compact Grey Wet		8	SS	21		203							
							202							
200.9			9	SS	28		201							
8.1	CLAYEY SILT, trace sand and gravel (TILL) Very stiff Brown Moist													
200.3							200							
8.7	SAND, trace clay, silt and gravel Very dense Grey Wet		10	SS	104									
199.7							199							
9.3	CLAYEY SILT, some sand, trace gravel (TILL) Hard Brown to grey Moist						198							
			11	SS	57									
							197							
			12	SS	75		196							
			13	SS	43		195							

Continued Next Page

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

PROJECT 09-1111-6036				RECORD OF BOREHOLE No 10-101				2 OF 3 METRIC					
W.O. 07-20024				LOCATION N 4820975.6 ; E 272085.6				ORIGINATED BY MS					
DIST Central HWY 401				BOREHOLE TYPE CME 75 Truck-mount, 108 mm I.D. Hollow Stem Power Auger				COMPILED BY OK/MS					
DATUM Geodetic				DATE June 28, 2010				CHECKED BY LCC					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT		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 ---												
192.7	CLAYEY SILT, some sand, trace gravel (TILL) Hard Brown to grey Moist		14	SS	48								
16.3	CLAYEY SILT, trace sand and gravel Very stiff Grey, becoming brown at 17.8 m depth Moist, becoming wet at 17.8 m depth		15	SS	26								
			16	SS	21								
189.2													
19.8	SAND and GRAVEL, trace silt and clay Compact Grey Wet		17	SS	27								
185.5													
23.5	SAND, some gravel, trace silt Very dense Grey Wet		18	SS	67								
183.1													
25.9	SAND and GRAVEL, some silt, containing cobbles and boulders Very dense Brown Wet		19	SS	99								
181.6													
27.4	END OF BOREHOLE Dynamic Cone Penetration Test												
180.7													
28.4													

Continued Next Page

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

MIS-MTO 001 09-1111-6036.GPJ GAL-MISS.GDT 4/26/11 CD

PROJECT <u>09-1111-6036</u>		RECORD OF BOREHOLE No 10-101		3 OF 3 METRIC	
W.O. <u>07-20024</u>		LOCATION <u>N 4820975.6 ;E 272085.6</u>		ORIGINATED BY <u>MS</u>	
DIST <u>Central</u> HWY <u>401</u>		BOREHOLE TYPE <u>CME 75 Truck-mount, 108 mm I.D. Hollow Stem Power Auger</u>		COMPILED BY <u>OK/MS</u>	
DATUM <u>Geodetic</u>		DATE <u>June 28, 2010</u>		CHECKED BY <u>LCC</u>	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L		GR	SA	SI	CL	
								20	40	60	80	100									
	--- CONTINUED FROM PREVIOUS PAGE ---																				
	END OF DCPT																				
	Notes:																				
	Water levels in piezometer measured as follows:																				
	Shallow																				
	Date Depth (m) Elev. (m)																				
	June 28, 2010 Dry 208.7																				
	April 21, 2011 0.3 208.7																				
	Deep																				
	Date Depth (m) Elev. (m)																				
	June 28, 2010 2.3 206.7																				
	April 21, 2011 0.1 208.9																				

MIS-MTO 001 09-1111-6036.GPJ GAL-MISS.GDT 4/26/11 CD

RECORD OF BOREHOLE No 10-102

1 OF 2 **METRIC**




PROJECT 09-1111-6036
 W.O. 07-20024 LOCATION N 4820999.7 ; E 272014.8 ORIGINATED BY MS
 DIST Central HWY 401 BOREHOLE TYPE CME 75 Truck-mount, 70 mm I.D. Hollow Stem Power Auger COMPILED BY OK/MS
 DATUM Geodetic DATE June 30, 2010 CHECKED BY LCC

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		W _P	W	W _L										
								○ UNCONFINED + FIELD VANE														
						● QUICK TRIAXIAL × REMOULDED																
						WATER CONTENT (%)																
						20 40 60 80 100					10 20 30											
216.5	GROUND SURFACE					▽																
0.0	Asphalt																					
216.2																						
0.3	Sand, trace to some gravel, trace silt (FILL) Compact Brown Moist		1	SS	19		216															
215.1							215															
1.4	Clayey silt to silty clay, some sand, trace gravel, containing organics (FILL) Firm to stiff Brown Moist		2	SS	7																	
			3	SS	6		214												2	20	51	27
			4	SS	9		213															
			5	SS	8		212															
			6	SS	8	211																
</																						

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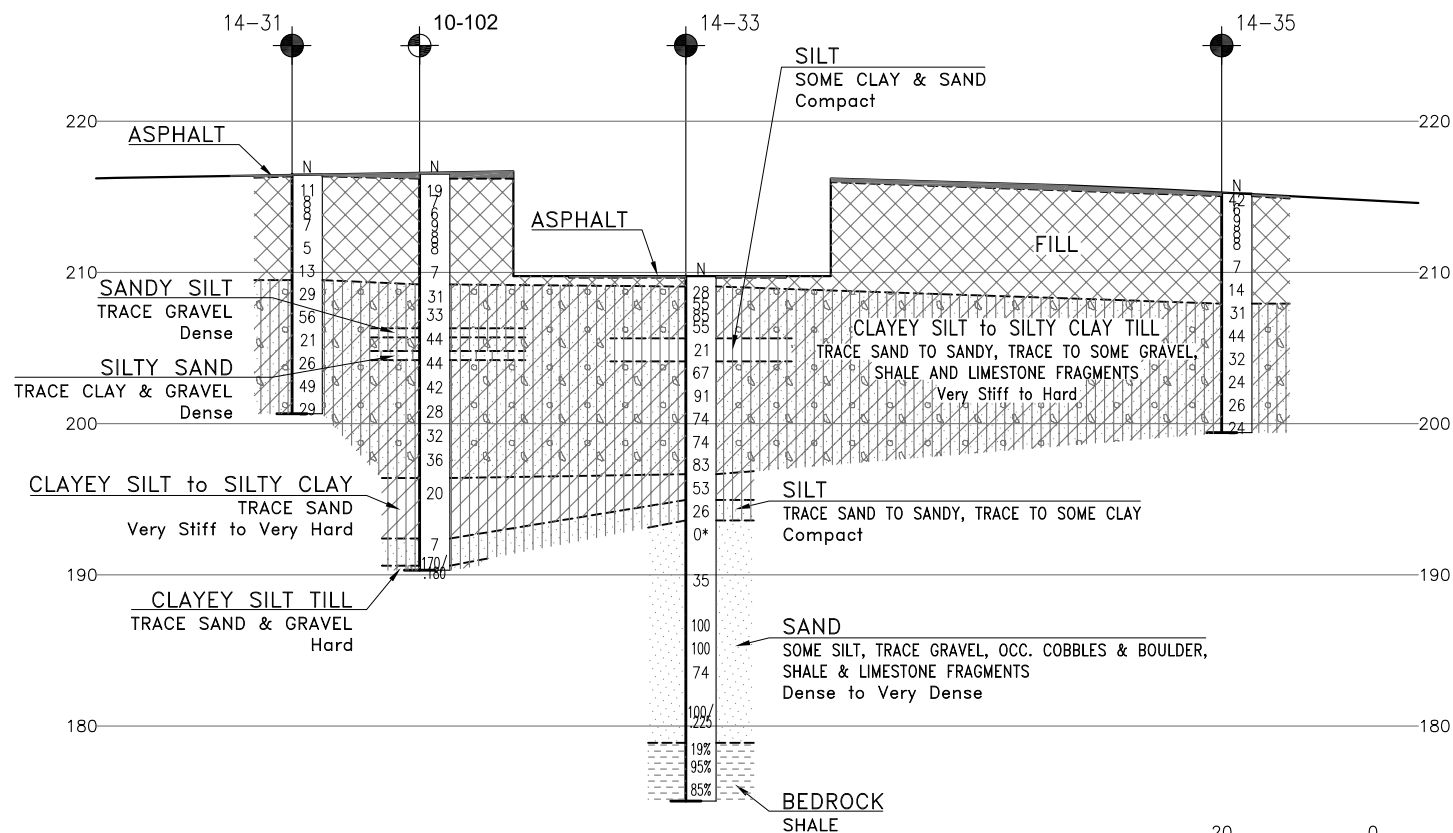
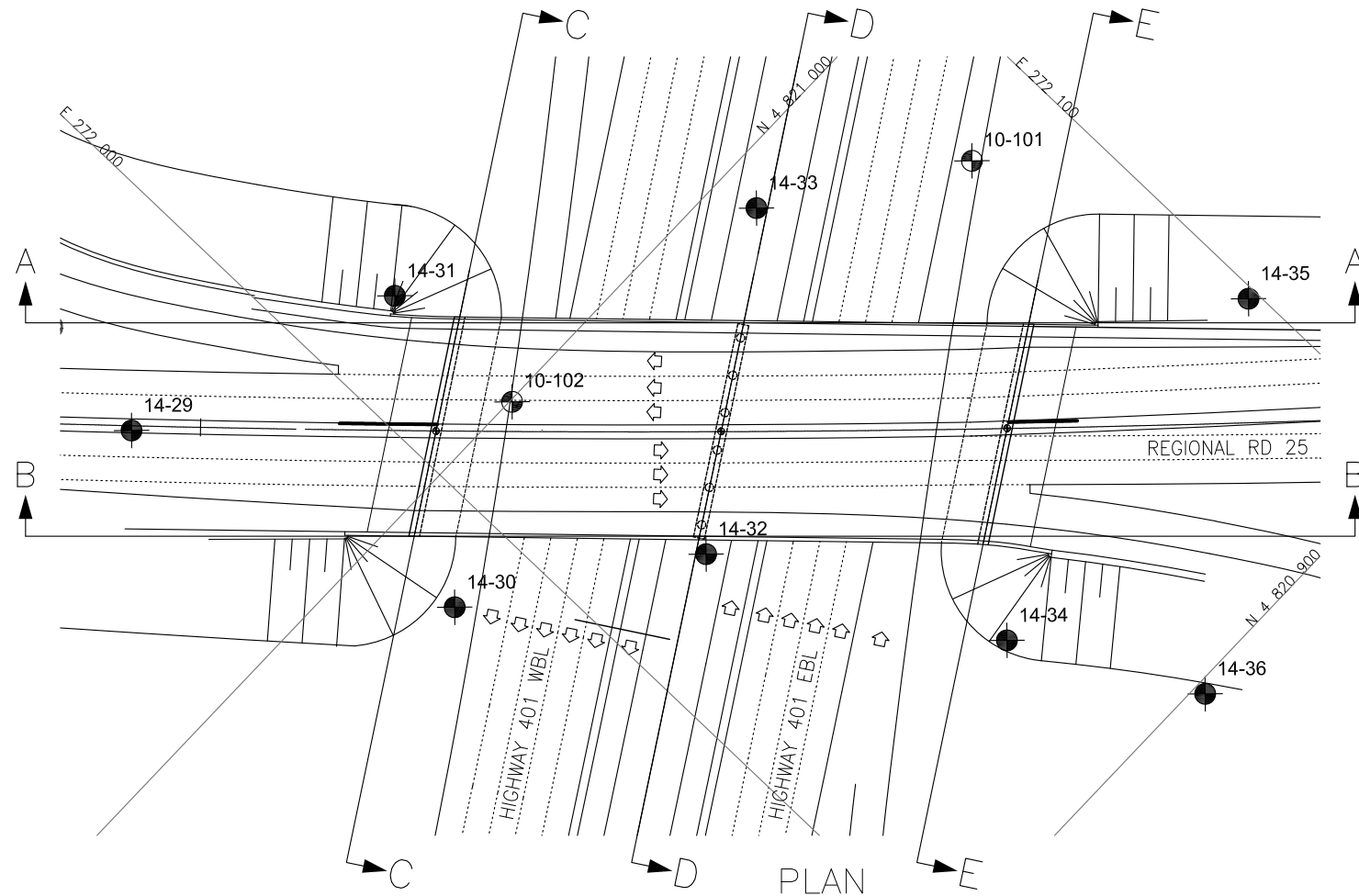
+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

MIS-MTO 001 09-1111-6036.GPJ GAL-MISS.GDT 4/29/11 CD

PROJECT 09-1111-6036			RECORD OF BOREHOLE No 10-102			2 OF 2 METRIC													
W.O. 07-20024			LOCATION N 4820999.7 ; E 272014.8			ORIGINATED BY MS													
DIST Central HWY 401			BOREHOLE TYPE CME 75 Truck-mount, 70 mm I.D. Hollow Stem Power Auger			COMPILED BY OK/MS													
DATUM Geodetic			DATE June 30, 2010			CHECKED BY LCC													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT													
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	20 40 60 80 100 SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED 20 40 60 80 100											
--- CONTINUED FROM PREVIOUS PAGE ---								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _p — W — W _L WATER CONTENT (%) 10 20 30											
								UNIT WEIGHT γ kN/m ³											
								REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL											
196.4	CLAYEY SILT, trace sand and gravel (TILL) Very stiff to hard Brown to grey Moist		13	SS	28		201												
							200												
							199												
							198												
				15	SS	36		197											
20.1	CLAYEY SILT, trace sand Very stiff Grey to brown Moist						196												
							195												
							194												
							193												
				16	SS	20		192											
192.4	Sandy SILT, trace clay Compact Brown Wet						191												
24.1																			
191.1	Silty SAND, trace gravel and clay Very dense Brown Wet																		
190.5																			
26.2	CLAYEY SILT, trace sand and gravel (TILL) Hard Brown Moist END OF BOREHOLE																		
	NOTE: 1. Water level was noted at a depth of approximately 2.7 m (Elevation 213.8 m) when drilling was at a depth of 11.3 m. * SPT "N" values considered to be sample disturbance due to groundwater inflow to borehole.																		

MIS-MTO 001 09-1111-6036.GPJ GAL-MISS.GDT 4/29/11 CD

Appendix D
“Borehole Locations and Soil Strata” Drawings



PROFILE A-A

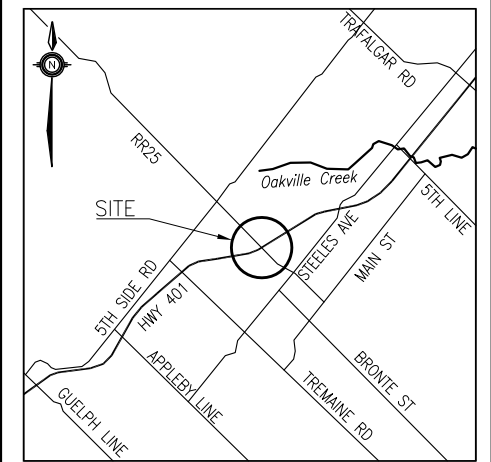
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No
WP No

HIGHWAY 401
REGIONAL ROAD 25
UNDERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

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

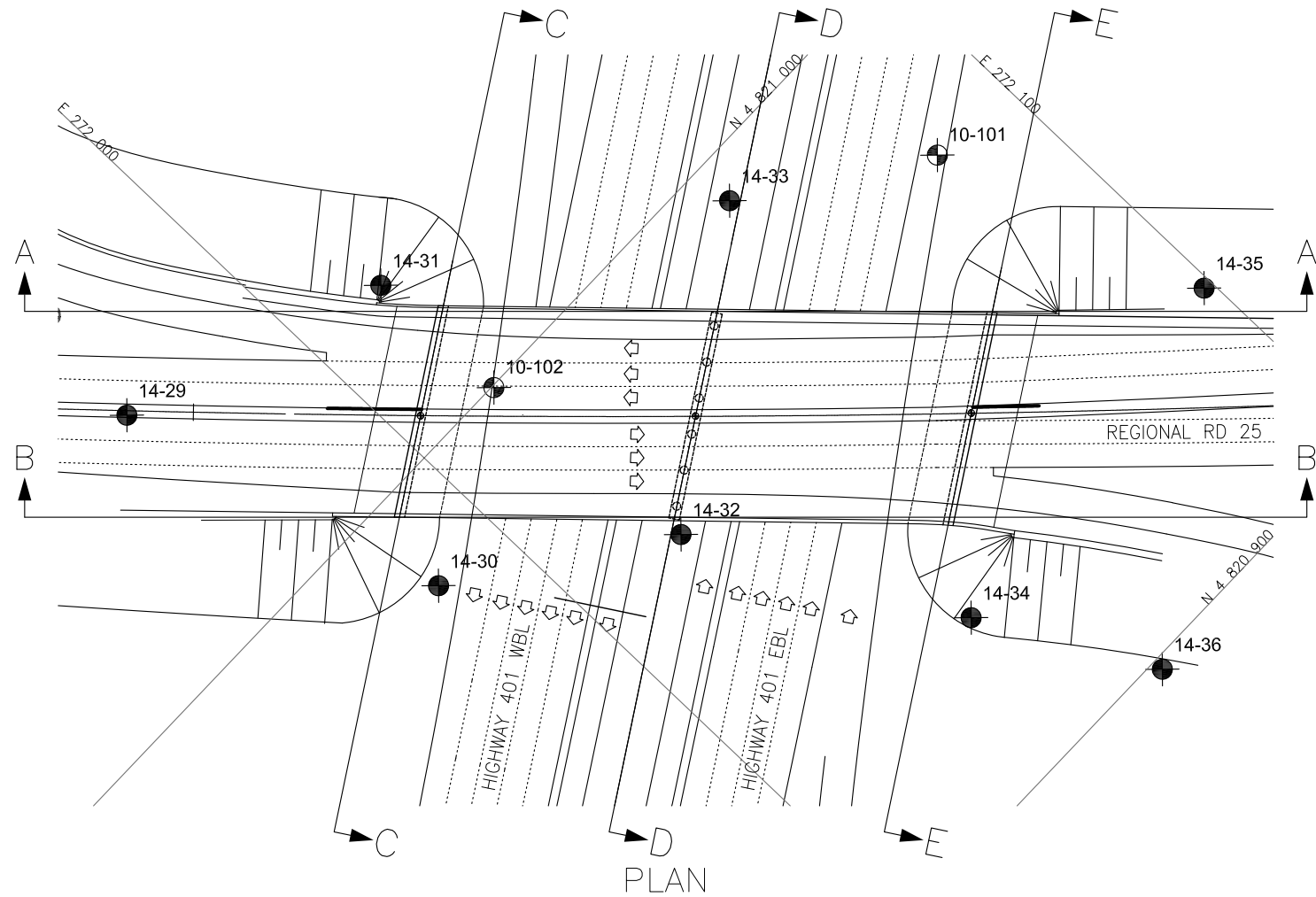
NO	ELEVATION	NORTHING	EASTING
14-29	216.0	4 821 036.6	271 974.0
14-30	209.5	4 820 985.3	271 987.6
14-31	216.5	4 821 022.5	272 014.2
14-32	209.8	4 820 964.3	272 018.1
14-33	209.8	4 820 993.4	272 059.3
14-34	208.7	4 820 924.4	272 039.0
14-35	215.3	4 820 933.0	272 098.6
14-36	208.1	4 820 898.3	272 053.1
10-101	209.0	4 820 975.6	272 085.6
10-102	216.5	4 820 999.7	272 014.8

-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. 30M12-375

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

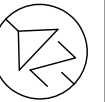


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No
WP No

HIGHWAY 401
REGIONAL ROAD 25
UNDERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

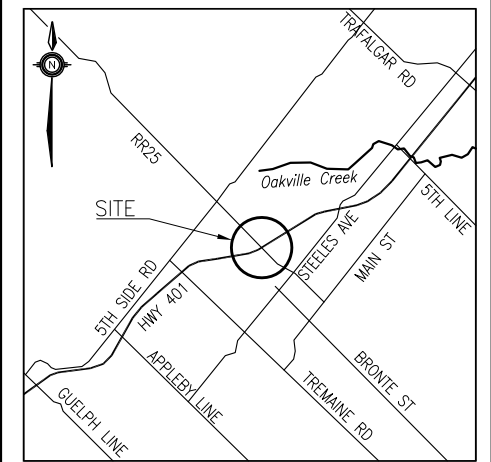


SHEET

AECOM



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

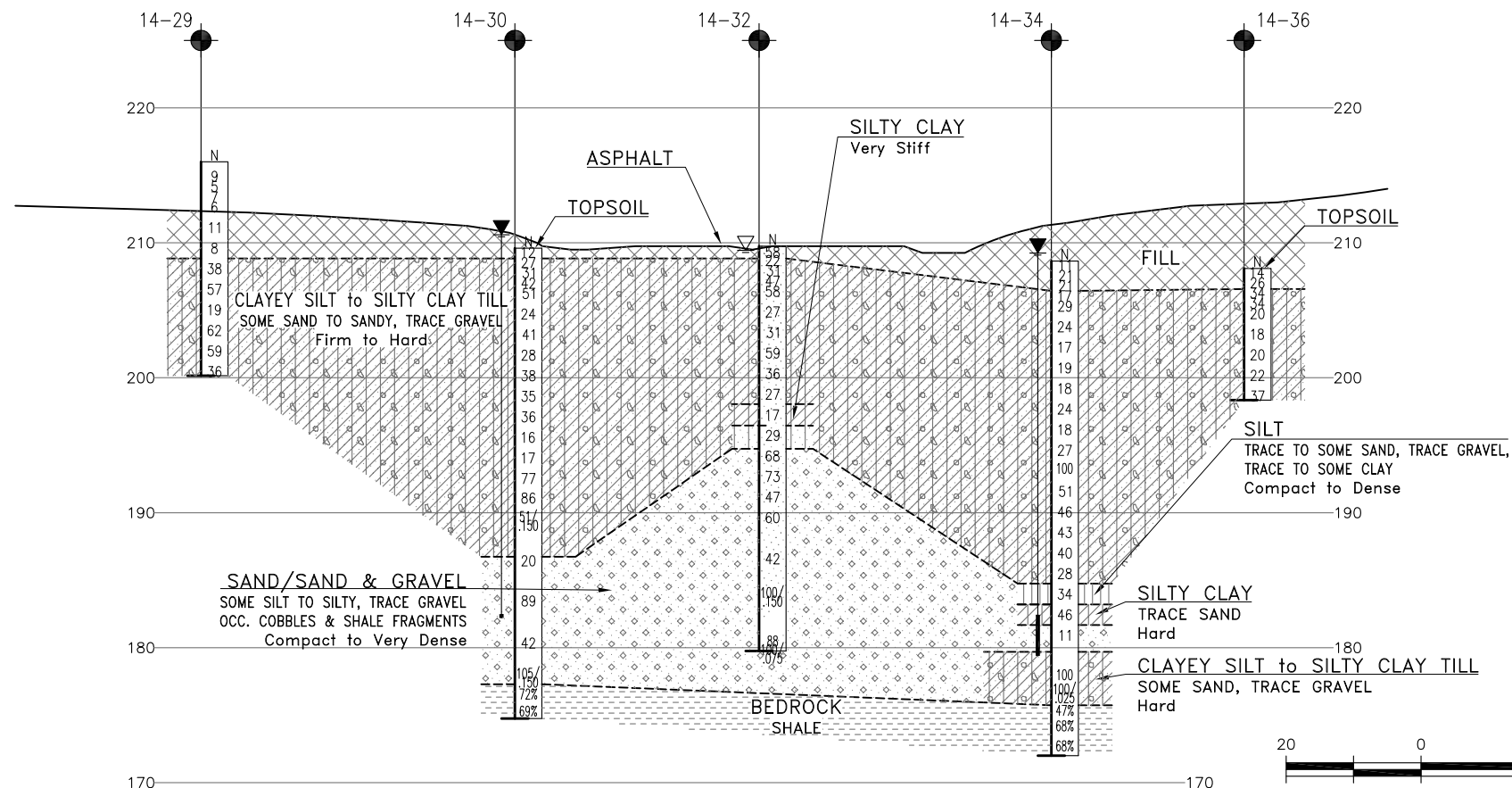
	Borehole (Current Investigation)
	Borehole (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
14-29	216.0	4 821 036.6	271 974.0
14-30	209.5	4 820 985.3	271 987.6
14-31	216.5	4 821 022.5	272 014.2
14-32	209.8	4 820 964.3	272 018.1
14-33	209.8	4 820 993.4	272 059.3
14-34	208.7	4 820 924.4	272 039.0
14-35	215.3	4 820 933.0	272 098.6
14-36	208.1	4 820 898.3	272 053.1
10-101	209.0	4 820 975.6	272 085.6
10-102	216.5	4 820 999.7	272 014.8

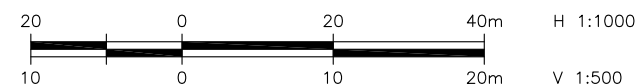
-NOTES-

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GEOCRES No. 30M12-375

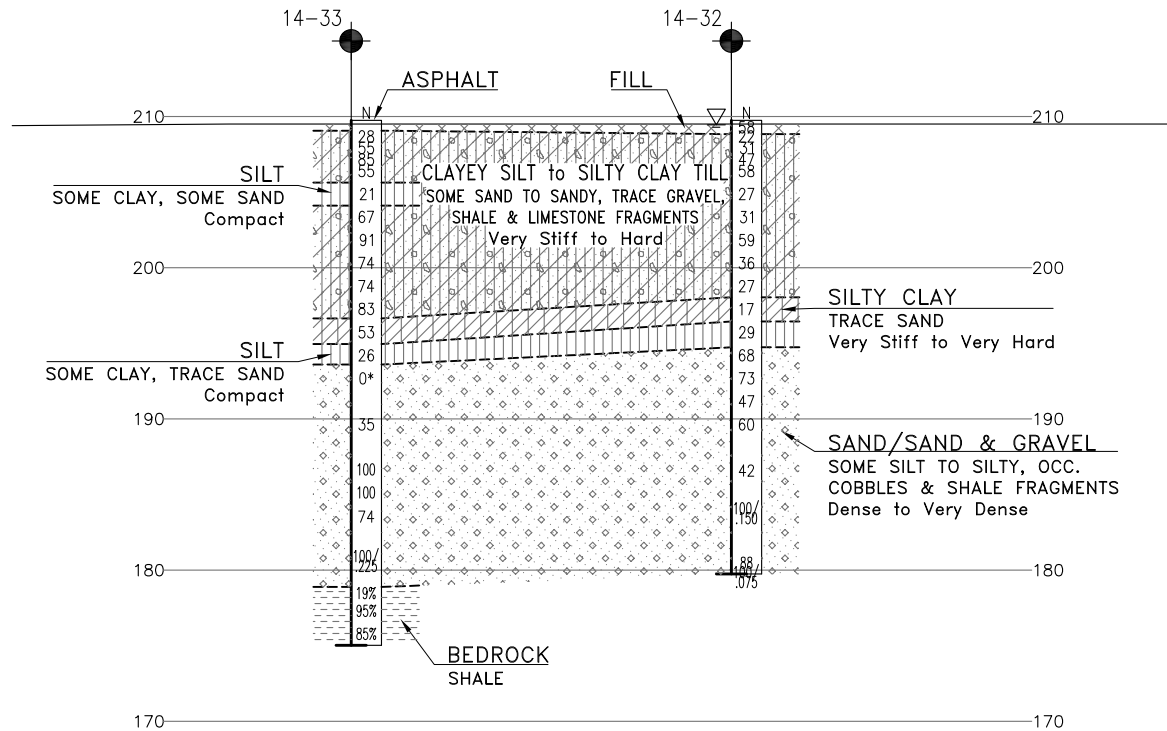


PROFILE B-B

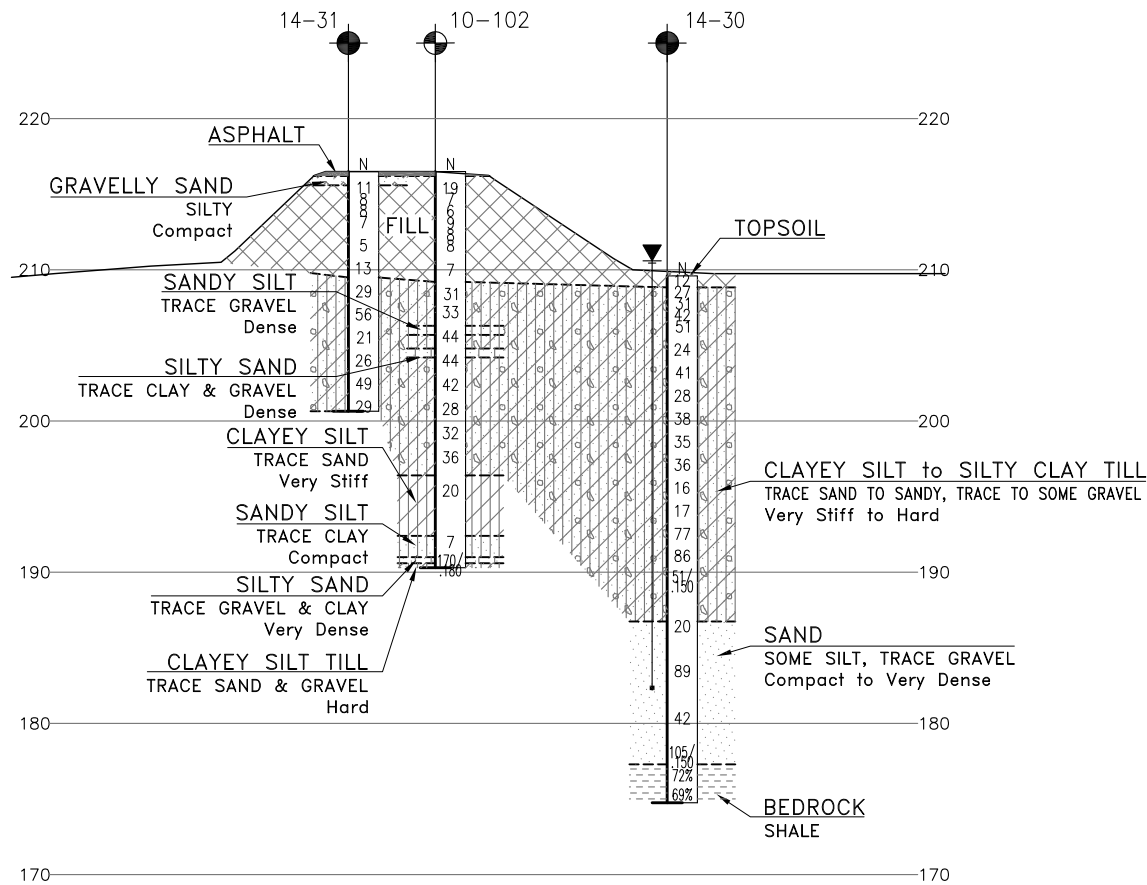


REVISIONS	DATE	BY	DESCRIPTION
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			LOAD
			STRUCT
			DWG 2
			DATE JUL. 2014

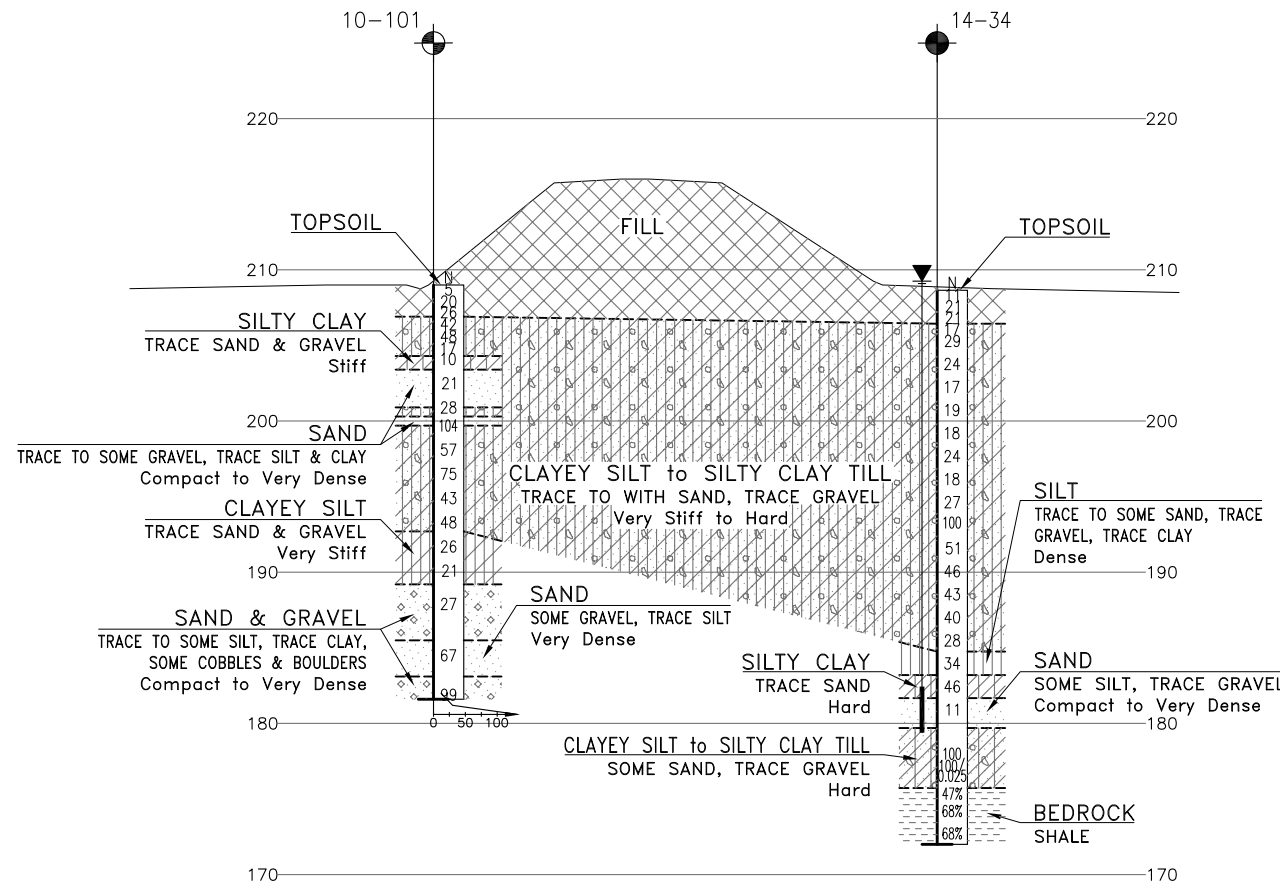
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DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



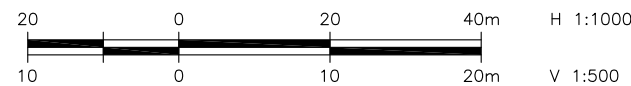
SECTION D-D



SECTION C-C



SECTION E-E

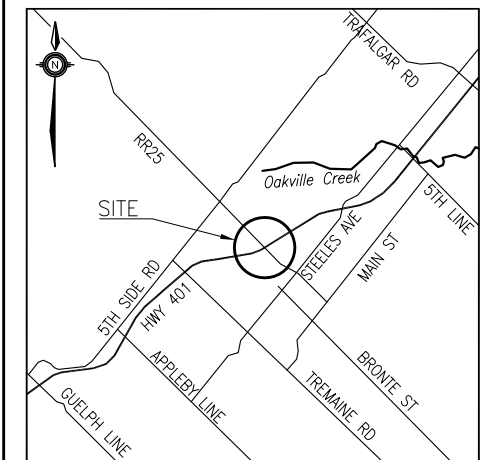


CONT No
WP No

HIGHWAY 401
REGIONAL ROAD 25
UNDERPASS
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
14-29	216.0	4 821 036.6	271 974.0
14-30	209.5	4 820 985.3	271 987.6
14-31	216.5	4 821 022.5	272 014.2
14-32	209.8	4 820 964.3	272 018.1
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14-34	208.7	4 820 924.4	272 039.0
14-35	215.3	4 820 933.0	272 098.6
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NOTES-

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

GEOCRES No. 30M12-375

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	MEF	CHK PKC	CODE
DRAWN	MFA	CHK MEF	SITE
			LOAD
			STRUCT
			DWG 3
			DATE JUL. 2014

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. iii. High geotechnical resistance available on very stiff to hard till. <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 and surface drainage conditions. <p>RECOMMENDED</p>	<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 and surface drainage conditions. <p>NOT RECOMMENDED</p>	<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 native soils. iii. Individual piles within a foundation element may have to be driven to varying elevations to derive required capacity. <p>RECOMMENDED FOR INTEGRAL ABUTMENT</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. High resistance is available for caissons founded bedrock. 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. vi. Significant depth to bedrock vii. Artesian groundwater conditions (1 m) exist. <p>NOT RECOMMENDED</p>