



THURBER ENGINEERING LTD.

**PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 401 WIDENING, HIGHWAY 16 TO MAITLAND ROAD
HWY 416 SB CONNECTOR N-E REHABILITATION, SITE NO. 16X-0308
GWP 4024-20-00 / ASSIGNMENT NO. 4019-E-0010.2**

Geocres No.: 31B-105

Report to:

MTO c/o AECOM Canada Ltd.

Latitude: 44.760707°
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PART 1. FACTUAL INFORMATION

1 INTRODUCTION

Thurber Engineering Ltd. (Thurber) has been retained by AECOM Canada Ltd. (AECOM) on behalf of the Ministry of Transportation Ontario (MTO) under Assignment No. 4019-E-0010, Work Item No. 2, to carry out Foundation Investigations to support the Preliminary Design and Environmental Assessment for the widening of Highway 401 from Highway 16 to Maitland Road. The overall scope of work comprises replacement or rehabilitation of 14 existing structures, including ten bridges and four structural culverts.

This report addresses the proposed rehabilitation of the Highway 416 underpass ramp bridge connecting traffic coming from the north on Highway 416 to traffic traveling east on Highway 401 (416N-401E) and southbound Highway 16. The bridge, Site No. 16-308, is located approximately 1.5 km north of the Highway 401 and Highway 416 intersection, near the town of Prescott, Ontario.

This section of the report presents the factual findings obtained from a foundation investigation completed at the site, as well as data from existing subsurface information pertinent to the site, obtained from the MTO's Foundation Library and included:

- Report prepared by Jacques, Whitford Limited titled, "*Report on Foundation Investigation, W.P. 177-89-02, Site 16-308, Ramp 416 SB Connection Over Ramps W-N & N-W, Hwy. 401-416 Interchange, District 9, Ottawa*", dated April, 1992 (Geocres No. 31B-73).

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and rehabilitation of the structure was developed during the current investigation.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.



2 SITE DESCRIPTION

Highway 416 is generally oriented north to south and the bridge is oriented roughly northwest to southeast. For project purposes, Highway 416 and the bridge are herein described as oriented north-south and west-east, respectively.

The land adjacent to the site generally consists of forested lands and agricultural fields. The terrain is relatively flat, apart from the existing highway embankment and associated drainage ditches. Near the bridge, Highway 416 is in a nominal cut section. In this area, Highway 416 consists of a four-lane divided freeway, and the 416N-401E ramp consists of a single travelled lane with paved inside and outside shoulders. The existing bridge is a three span structure with an overall length of approximately 161.5 m. The two piers are located in the median which is approximately 68 m wide from centreline to centreline.

Within the vicinity of the bridge, the embankment side slopes are sloped at approximately 2H:1V and are generally covered with bushes and small trees growing around the abutments. At the time of the field work, the embankments did not show any visible signs of distress or other performance issues. The available structural drawings (Cont. No. 97-68, Sheets 186 to 192) identify the abutment wingwalls as RSS walls that tie into the earth approach embankments as much as 19 m behind the abutments.

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies near the southeastern extent of the physiographic region known as the Glengarry Till Plain. The area is characterized by an undulating surface consisting of morainic ridges and intervening clay flats and swamps, overlying till and similar glaciofluvial deposits containing many cobbles and boulders. The Glengarry Till Plain is known to be underlain by limestone and sandstone bedrock.

Photographs showing the existing conditions at the site at the time of the field investigation are included in Appendix D for reference.

3 SITE INVESTIGATIONS AND FIELD TESTING

The original foundation investigation for design of the 416N-401E ramp bridge was carried out in April 1991 and March 1992, prior to its construction. The current investigation was carried out in April/May 2021 to collect additional subsurface information near the existing bridge abutments. Summaries of the investigations are provided in the following sections.

3.1 Original (1991/1992) Investigations

A total of 11 boreholes were put down at the site as part of the original investigation. Boreholes 91-1 to 91-8 were put down at the proposed approach embankment and foundation element locations between April 17 and 29, 1991. Boreholes 92-1 to 92-3 were put down near the then-revised foundation locations on March 30, 1992. The locations of the 1991/1992 boreholes are within the as-constructed alignment near the west approach and abutment but are up to about 15 m south of the as-constructed alignment near the east abutment.



The 1991/1992 boreholes were advanced to depths ranging from 2.3 m to 18.4 m below the existing ground surface at the time of the investigation (prior to construction of the ramp bridge). A standpipe piezometer or monitoring well was installed in each of the boreholes (91-1 to 91-8 and 92-1 to 92-3).

The locations of the 1991/1992 boreholes were surveyed by others prior to the initiation of the field work, unless they were subsequently relocated due to site constraints, in which case the as-drilled borehole location was re-surveyed.

The northing, easting and elevation of the boreholes used in this investigation are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A and in Table 3-1, below. The site is located within MTM Zone 9. Note that the borehole locations were originally surveyed relative to NAD27 horizontal datum and have been converted relative to NAD83 in the drawing, on the Record of Borehole Sheets (where appropriate), and in Table 3-1, below.

Table 3-1: Borehole Summary

Borehole No.	Drilled Location	Northing¹ (Latitude)	Easting¹ (Longitude)	Ground Surface² Elevation (m)	Termination Depth (m)
91-1	West Approach Embankment	4 958 406.3 (44.761249)	384 191.4 (-75.497145)	93.4	4.8
91-2	West Abutment	4 958 374.3 (44.760957)	384 230.6 (-75.496655)	96.7	7.9
91-3	West of West Pier	4 958 354.1 (44.760773)	384 251.1 (-75.496399)	97.5	8.9
91-4	South of West Pier	4 958 330.8 (44.760559)	384 283.9 (-75.495989)	98.4	18.4
91-5	South of Ramp, between East and West Piers	4 958 313.2 (44.760397)	384 315.9 (-75.495587)	98.0	8.6
91-6	South of East Pier	4 958 297.7 (44.760254)	384 348.1 (-75.495183)	98.3	12.0
91-7	Southeast of East Abutment	4 958 284.8 (44.760134)	384 385.8 (-75.494709)	97.7	5.2
91-8	South of East Approach Embankment	4 958 277.5 (44.760065)	384 414.4 (-75.494349)	97.5	3.3
92-1	South of East Approach Embankment	4 958 282.1 (44.760108)	384 396.5 (-75.494574)	98.0	10.3
92-2	South of West Abutment	4 958 376.0 (44.760973)	384 223.6 (-75.496743)	96.7	2.3
92-3	West of West Abutment	4 958 387.2 (44.761075)	384 213.9 (-75.496864)	96.2	3.5

Notes: 1) Boreholes were surveyed relative to NAD27; coordinates listed above were converted relative to NAD83.

2) Boreholes were put down prior to construction of the existing ramp and bridge.

The Borehole Locations and Soil Strata drawing included in the 1997 structural design drawing package shows three additional boreholes numbered 97-4, 97-5, and 97-6 that were put down



within the as-constructed alignment near the east abutment, centre pier, and west abutment, respectively. The drawing indicates that the boreholes were added in December 1997; however, Record of Borehole sheets for these 1997 boreholes were not included in the available Geocres information and are, therefore, not discussed in the current report.

3.2 Current (2021) Investigation

The current site investigation was carried out in the Spring of 2021. Two boreholes were put down at the 416N-401E ramp bridge site: one near the west abutment on April 28 and 29, 2021 (Borehole 308-21-1) and one near the east abutment on May 3 and 4, 2021 (Borehole 308-21-2). The boreholes were put down from truck-mounted CME 55 drill rig.

The locations of 2021 boreholes were surveyed by Thurber for both location and elevation with a Trimble Catalyst DA1 antenna with centimeter accuracy. The northing, easting and elevation of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A, the individual Record of Borehole sheets in Appendix B, and in Table 3-2 below. The site is located within MTM Zone 9.

Table 3-2: Borehole Summary

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface ² Elevation (m)	Termination Depth (m)
308-21-1	West Abutment	4 958 382.2 (44.761036)	384 220.6 (-75.496783)	104.0	25.1
308-21-2	East Abutment	4 958 297.8 (44.760258)	384 386.8 (-75.494698)	105.1	25.2

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). A standpipe piezometer was installed in Borehole 308-21-1 following completion of the drilling to allow for subsequent groundwater level measurements. Borehole 308-21-2 was abandoned by backfilling with bentonite and drill cuttings.

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

4 LABORATORY TESTING

Geotechnical laboratory testing carried out as part of the current investigation included natural moisture content determination and visual identification of all retained soil samples. Testing for grain size distribution was also carried out on selected samples to MTO and ASTM standards. All rock cores were photographed and their total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were measured.



The 1991/1992 investigation included natural moisture content determination, grain size distribution testing, and Atterberg Limit determinations.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and the laboratory test results are presented on the figures included in Appendix C.

5 GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy based on the conditions encountered in the boreholes is given in the following sections. However, the factual data presented on the Borehole Records takes precedence over the Soil Strata Drawing and the general description. It must be recognized that the soil and groundwater conditions may vary between and beyond borehole locations. Soil classification on the 2021 Record of Borehole sheets is in accordance with ASTM D2487. Description of cohesive soils and secondary components of all deposits from the 2021 borehole are described as outlined in the MTO Guideline for Foundation Engineering Services Manual, Version 2 (October 2020). Terminology from the historic Geocres information may vary from current.

In general terms, the site was found to have granular fill over a layer of clayey silt (present at the time of the 1991/1992 investigations) overlying glacial till at relatively shallow depth. The till is, in turn, underlain by interlayered limestone and dolostone bedrock.

It is noted that the conditions reported on the 1991 and 1992 borehole records may not reflect current conditions due to construction or other activities in the area subsequent to those investigations.

5.1 Embankment Fill

Boreholes 308-21-1 and 308-21-2 were advanced behind the west and east abutments, respectively. The asphalt surface was 200 mm thick in both boreholes. Granular fill was encountered beneath the asphalt surface in both boreholes and extended to depths of 9.1 m (Elevation 94.9 m) and 7.8 m (Elevation 97.3 m) behind the west and east abutments, respectively.

The fill within approximately 1.4 m of top of pavement consisted of gravel with silt and sand to silty sand with gravel. Below this depth, the fill consisted predominantly of sand to sand some silt.

Standard Penetration Tests (SPTs) conducted in the embankment fill gave N-values from 8 to 50 blows per 0.3 m of penetration, but generally ranged between about 20 and 45 blows per 0.3 m of penetration, indicating a compact to dense relative density.

The moisture content of the fill samples tested ranged from about 2 to 16%. The results of grain size analysis testing conducted on four samples of the embankment fill are summarized below and are illustrated on Figures C1 and C2 in Appendix C.

Table 5-1: Summary of Grain Size Distribution Testing – Fill

Soil Particle	Percentage (%)	
	Upper Fill	Lower Fill
Gravel	27 – 49	0 – 2
Sand	42 – 58	89 – 92
Silt and Clay	9 – 15	6 – 11

5.2 Native Surficial Deposits

Surficial deposits consisting of layers of topsoil, sand, sand and gravel, and clayey silt were encountered at the ground surface of the boreholes put down as part of the 1991/1992 investigations that were carried out in the planning stages, prior to construction of the bridge in 1998. It is noted that some of these surficial materials may have been removed during construction of the piers, abutments, approach embankments or during grading/ditching for the new Highway 416 lanes. These deposits were not encountered in the 2021 investigation boreholes but have been described below for informational purposes.

5.2.1 Topsoil

A surficial layer of topsoil was observed in all historic boreholes. It ranged in thickness from 0.1 m to 0.3 m.

5.2.2 Sand, some Silt

A near surface deposit of sand with trace to some silt was observed in Boreholes 91-1, 91-4, 91-5, 91-6, 91-7, 91-8, 92-1, and 92-3 put down near the location of the then-proposed east pier and abutment during the 1991/1992 investigations. The sand deposit ranged from 0.1 to 1.6 m thick at these locations. N-values from 1 to 20 blows per 0.3 m of penetration, indicating a very loose to compact relative density.

5.2.3 Sand and Gravel

A deposit of sand and gravel was encountered at the ground surface in Borehole 91-1 within the footprint of the then-proposed west approach embankment. The deposit extended to approximately 3.9 m below the existing ground surface (Elevation 89.5 m). SPTs conducted in the sand and gravel gave N-values ranging from 33 to 52 blows per 0.3 m of penetration, indicating a compact to dense relative density.

The results of a grain size analysis test conducted on a sample of this material are summarized below and are illustrated on Figure C4 in Appendix C.

Table 5-2: Summary of Grain Size Distribution Testing – Sand and Gravel

Soil Particle	Percentage (%)
Gravel	49
Sand	40
Silt and Clay	11

5.2.4 Clayey Silt

A deposit of clayey silt was encountered near the then-proposed west abutment in Boreholes 91-1, 91-2, 91-3, and 92-2. The deposit was generally encountered near the original ground surface (Elevations 96.7 m to 97.5 m) however was noted to be deeper in Borehole 91-1 (Elevation 89.5 m). It ranged from 0.2 m to 1.6 m thick.

SPTs conducted within this layer gave N-values generally ranging from 2 to 3. In situ shear vane tests were not carried out in any of the boreholes put down at the time but, based on the in-situ testing, was described as having a soft to firm consistency.

The moisture content of the samples tested ranged from about 25 to 35%. The results of an Atterberg Limit test carried out on a sample of the clayey silt gave a Liquid Limit of 35% and a Plastic Limit of 22 %. The results are illustrated on Figure C5 Appendix C and indicate a soil of low to intermediate plasticity (CL).

The results of a grain size analysis test conducted on a sample of this material are summarized below and are illustrated on Figure C6 in Appendix C.

Table 5-3: Summary of Grain Size Distribution Testing – Clayey Silt

Soil Particle	Percentage (%)
Gravel	0
Sand	0
Silt	75
Clay	25

5.3 Glacial Till

A glacial till deposit consisting of a heterogeneous mixture of silty sand, sand, gravel, and clayey silt was encountered beneath the embankment fill or surficial clayey silt or sand at all boreholes. Cobbles and boulders were encountered in the glacial till in all boreholes. The glacial till was encountered at Elevations ranging from 89.3 m to 98.2 m. In the boreholes which fully penetrated this layer (91-4, 308-21-1 and 308-21-2), the thickness ranged from 12.3 m to 15.8 m.

SPTs conducted in this layer gave N-values ranging from 21 to greater than 100 blows for 100 mm of penetration, but were generally greater than 100 blows for 100 mm of penetration or effective refusal of the sampler below about Elevation 93 m, indicating a very dense relative density. Refusals within this deposit are likely due to the presence of cobbles and boulders. Penetration through this layer often required the use of coring techniques.



The moisture content of this unit ranged from 6 to 17%. The results of grain size distribution testing carried out on 13 samples of the till are summarized below and are illustrated on Figures C7 and C3 in Appendix C.

Table 5-4: Summary of Grain Size Distribution Testing – Glacial Till

Soil Particle	Percentage (%)
Gravel	7 – 31
Sand	15 – 68
Silt	14 – 55
Clay	7 – 14

The results of Atterberg Limits testing carried out on the fines of four samples of the glacial till from the 1991 boreholes are summarized below and are illustrated on Figure C7 in Appendix C. The laboratory results indicate that the fines are non-plastic to low plastic (ML to CL-ML to CL).

Table 5-5: Summary of Atterberg Limit Testing – Glacial Till Fines

Parameter	Value
Liquid Limit	15 – 23
Plastic Limit	11 – 14
Plasticity Index	3 – 9

5.4 Bedrock

Bedrock was proven by coring in Boreholes 308-21-1, 308-21-2, and 91-4. The bedrock encountered consisted of fresh, very strong, interbedded sandstone and dolostone. Photographs of the bedrock cores are provided in Appendix C. The following table summarizes the rock core quality:

Table 5-6: Summary of Rock Core Quality

Parameter	Range
Total Core Recovery (TCR), %	95 to 100
Solid Core Recovery (SCR), %	52 to 100
Rock Quality Designation (RQD), %	48 to 96
Fracture Index	0 to 3

The RQD values encountered in the upper 0.5 m of bedrock at Boreholes 308-21-1 and 308-21-2 were 48% and 52%, but below that in all boreholes the RQD ranged from about 85% to 96%, indicating a bedrock of good to excellent quality.

Unconfined compressive strength (UCS) testing was carried out on a sample of the bedrock from Borehole 308-21-1. The results indicated a UCS value of 217 MPa, indicating a very strong rock. The results of the UCS testing are included in Appendix C.

A summary of the bedrock surface information is provided in Table 5-7 below:

Table 5-7: Summary of Bedrock Depth/Elevation

Borehole No.	Depth to Bedrock Surface (mbgs)	Bedrock Surface Elevation (m)
91-4	16.0	82.4
308-21-1	21.4	82.6
308-21-2	21.5	83.6

5.5 Groundwater

Standpipe piezometers or monitoring wells were installed in many of the boreholes put down as part of the 1991/1992/investigations, and in Borehole 308-21-1 put down as part of the current investigation. Groundwater levels recorded are presented in Table 5-8. The observations are considered short term and it should be noted that the groundwater level may vary with season and fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant and/or prolonged precipitation.

Table 5-8: Summary of Groundwater Levels

Borehole No.	Bottom of Screen Elev. (m)	Screened Unit	Depth (mbgs)¹	Groundwater Elevation (m)	Date of Measurement
91-1	88.7	Overburden	0.4	93.0	May 10, 1991
			0.5	92.9	March 30, 1992
91-2	89.1	Glacial Till	0.2	96.5	May 10, 1991
			0.2	96.5	March 30, 1992
91-3	88.6	Glacial Till	0.4	97.1	May 10, 1991
			0.3	97.2	March 30, 1992
91-4	94.5	Glacial Till	0.2	98.2	May 10, 1991
			1.2	97.2	March 30, 1992
91-4	80.0	Bedrock	2.1	96.3	May 10, 1991
			2.1	96.3	March 30, 1992
91-5	89.6	Glacial Till	0.1	97.9	May 10, 1991
			-0.1	98.1	March 30, 1992
91-6	86.9	Glacial Till	0.3	98.0	May 10, 1991
			0.4	97.9	March 30, 1992
91-7	93.4	Glacial Till	0.0	97.7	May 10, 1991
			-0.2	97.9	March 30, 1992
91-8	94.2	Glacial Till	0.0	97.5	May 10, 1991
			0.0	97.5	March 30, 1992
92-1	87.7	Glacial Till	-	-	May 10, 1991
			5.6	92.4	March 30, 1992
92-2	94.4	Glacial Till	-	-	May 10, 1991
			2.0	94.7	March 30, 1992
308-21-1	85.7	Glacial Till	9.9	94.1	July 1, 2021
			9.4	94.6	December 23, 2022

Note: 1) Depths below ground surface at the time of reading; ground surface may have changed since.



6 MISCELLANEOUS

It is noted that the conditions reported on the 1991 and 1992 borehole records may not reflect current conditions due to construction or other activities in the area subsequent to those investigations.

The 2021 borehole locations were selected by Thurber relative to existing site features. The as-drilled locations and ground surface elevations of the boreholes were surveyed by Thurber following completion of the field program. The elevation survey of the boreholes was carried out with reference to geodetic elevation benchmarks provided by the MTO. Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, and borehole decommissioning.

The field investigation was supervised on a full-time basis by Jamil Pirani of Thurber. Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. Unconfined Compressive Strength Testing of the bedrock was carried out by Stantec's laboratory in Ottawa.

Overall project management and direction of the field investigation was provided by Matt Kennedy, P.Eng. Interpretation of the factual data and preparation of this report was carried out by Matt Kennedy, P.Eng. The report was reviewed by Paul Carnaffan, P.Eng. and Fred Griffiths, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



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PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

This report presents the interpretation of the factual data obtained from a foundation investigation and a desktop review of the available subsurface information conducted by Thurber for the rehabilitation of the existing Highway 416 underpass ramp bridge connecting traffic coming from the north on Highway 416 to traffic traveling east on Highway 401 (416N-401E).

The site is located approximately 1.5 km north of the intersection of Highway 416 and Highway 401. Highway 401 is generally oriented north to south and the 416N-401E ramp bridge is oriented roughly northwest to southeast. For project purposes, Highway 416 and the bridge are herein described as oriented north-south and west-east, respectively.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. Contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The following sections provide geotechnical recommendations for the design of the foundation elements as part of the structural assessment and rehabilitation. The discussions and recommendations presented in this report are based on the information provided by the Ministry of Transportation of Ontario (MTO) and on the factual data obtained throughout this investigation.

7.1 Existing Structure

The existing 416N-401E ramp bridge is a three-span structure with a cast-in-place, post-tensioned concrete deck and non-integral abutments and a total length of 161.5 m. It is curved, with a 420 m radius to the north, and crosses the lanes of the northbound and southbound Highway 416 at skew angles of about 48 and 34 degrees, respectively.

Based on the available structural drawings (Cont. No. 97-68, Sheets 180 and 182, included in Appendix F), the abutments are supported on steel HP 310x110 piles up to about 12 m long,



driven to the dense to very dense glacial till at about Elevation 89 m. There are two rows of five and six vertical piles at each abutment. The abutment pile caps are perched within the existing embankments which are nominally sloped down to the north due to curve superelevation. The underside of the pile cap is at approximate Elevation 100.9 m and 99.8 m for the east and west abutments respectively.

The piers are supported on concrete spread footings founded within the upper compact to very dense glacial till. The east pier is 7.8 m square, 2.1 m thick, and founded at approximate Elevation 94.1 m. The west pier is 7.6 m square, 2.0 m thick, and founded at about Elevation 93.6 m.

7.2 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the existing foundations and ground conditions and in accordance with the Canadian Highway Bridge Design Code, version CSA S6:19 (CHBDC).

In accordance with CHBDC, the analysis and design of the structure takes into consideration the importance of the structure and the consequence associated with exceeding limit states. The importance category and consequence classification are defined by the Regulatory Authority, which in this case is the Ministry of Transportation, Ontario (MTO).

It is understood that the structure is classified as being part of the “Major Route” importance category.

This project has been assigned Typical Consequence Classification, in accordance with Section 6.5.1 of the CHBDC. Accordingly, a consequence factor (Ψ) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing the factored geotechnical resistances. If the consequence classification changes, the geotechnical assessment and recommendations provided within this report will need to be reviewed and revised.

The degree of site and prediction model understanding for this site has been assessed to be typical understanding (Section 6.5.3 of CHBDC).

8 SEISMIC CONSIDERATIONS

8.1 Spectral and Peak Acceleration Hazard Values

The seismic hazard data for the CHBDC is based on the fifth-generation seismic model developed by the Geological Survey of Canada (GSC). Seismic hazard data for this site has been obtained from the GSC’s seismic hazard calculator. The data includes peak ground acceleration (PGA), peak ground velocity (PGV), and the 5% damped spectral response acceleration values ($S_a(T)$) for the reference ground condition (Site Class C) for a range of periods (T) and for a range of return periods including the 475-year, 975-year and 2475-year events. The GSC seismic hazard calculation data sheet for this site is presented in Appendix E.



The site coefficients used to determine the design spectral acceleration and displacement values are a function of the Site Class, the peak ground acceleration (PGA) and $S_a(0.2)$. The PGA for this location for a *reference* Site Class C with a 2% probability of exceedance in 50 years is 0.25 g (1 in 2475 year). This value is to be scaled by the $F(PGA)$ based on the site-specific Site Class as per Section 4.4.3.3 (Table 4.8) of the CHBDC (see Section 8.2).

8.2 CHBDC Seismic Site Classification

In accordance with the CHBDC, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy below the reference elevation of the foundation element. As outlined in Section 4.4.3.2 of the CHBDC, if the shear wave velocity of the site soil and bedrock is not known, as is the case at this site, the seismic site class may be determined by the harmonic mean of the energy-corrected SPT-N values (N_{60}) and/or the undrained shear strength (s_u) encountered below the foundation element(s).

Boreholes 91-3, 91-4, 91-5, and 91-6 were put down near the piers. At each of these borehole locations the N_{60} values below the undersides of the piers (Elevations 94.1 m and 93.6 m at the east and west piers, respectively) were greater than 100 blows per 0.3 m of penetration. These high values are likely influenced by the presence of cobbles and boulders but are still considered to represent a generally very dense deposit. As such, seismic site class at the piers may be taken as Site Class C.

At the abutments, the seismic Site Class was assessed based on the N_{60} values recorded in Boreholes 308-21-1 and 308-21-2, which were put down at the west and east abutments, respectively. The assessments considered the N_{60} values recorded below the undersides of the pile caps (approximate Elevations 99.8 m and 100.9 m at the west and east abutments, respectively) that are perched within the embankment fill. The average N_{60} values in the embankment fill ranged from 8 to 25 blows per 0.3 m of penetration and were greater than 50 blows per 0.3 m of penetration (or effective refusal) in the underlying glacial till. Based on the relative thicknesses of embankment fill, glacial till, and proximity of the bedrock (approximately 17.6 m and 16.9 m below the pile caps at the east and west abutments, respectively) the seismic site class at the abutments may be taken as Site Class C.

The site classification should be confirmed with measurement of the shear wave velocity in the 30 m below the foundation elements at subsequent design stages.

8.3 Seismic Performance Category

In consideration of the Site Class C spectral values for the site and the designated *Major Route* importance category, the bridge structure would fall into either Seismic Performance Category 2, if the bridge has a fundamental period greater than or equal to 0.5 seconds, or Seismic Performance Category 3, if the bridge has a fundamental period less than 0.5 seconds, as per Section 4.4.4 (Table 4.10) of the CHBDC.

8.4 Liquefaction Potential

The susceptibility of the embankment fill and glacial till at the site to experience liquefaction was assessed using the SPT data following the simplified method for cohesionless soil as outlined in Boulanger and Idriss (2014)ⁱ. The cohesionless soils at the site are not considered to be susceptible to liquefaction.

9 FOUNDATION DESIGN RECOMMENDATIONS

9.1 Existing Spread Footings

Based on the available 1997 structural design drawings for the structure (Cont. No. 97-68, Sheets 180 and 182), the existing pier foundations consist of spread footings founded on the very dense glacial till. The footing dimensions and founding elevations are summarized in Table 9-1, below.

Table 9-1: Summary of Pier Foundation Footings

	East Pier (Pier #1)	West Pier (Pier #2)
Plan Dimensions (m)	7.8 x 7.8	7.6 x 7.6
Footing Thickness (m)	2.1	2.0
Top of Footing Elevation (m)	96.2	95.6
Underside of Footing Elevation (m)	94.1	93.6

Based on the pier footing dimensions and founding elevations, and the assumption that the footings were cast-in-place atop a leveling pad of nominal thickness consisting of Granular A engineered fill, the following factored geotechnical resistance values may be considered:

- Factored Geotechnical Resistance at ULS of 750 kPa
- Factored Geotechnical Resistance at SLS of 500 kPa

The geotechnical resistances presented are for vertical concentric loading only on cast-in-place footings and would need to be adjusted for the effects of inclined or eccentric loadings, where applicable, in accordance with CHBDC Clause 6.10.5. The geotechnical SLS resistance values given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to have been completed by the end of original construction. Differential settlement is not expected to have exceeded 15 mm across the width of the structure for subgrades prepared with good workmanship.

The horizontal resistance against sliding between the cast-in-place concrete footings founded on engineered fill or glacial till can be computed using a unfactored coefficient of friction factor of 0.5. Appropriate resistance factors should be applied for the design.

9.2 Existing Driven Steel Piles

Based on the available 1997 structural design drawings for the structure (Cont. No. 97-68, Sheets 180 and 182), the existing abutment foundations consist of perched pile caps supported on

vertical steel HP 310x110 piles driven to the dense to very dense glacial till, arranged in two rows of five and six vertical piles at each abutment.

The 1997 design drawings also indicate that the portion of the piles between the underside of pile cap and the existing ground surface at the time of construction were cased in a concrete-filled, 500 mm diameter Corrugated Steel Pipe (CSP). The abutment foundation dimensions are summarized in Table 9-2, below.

Table 9-2: Summary of Abutment Foundations

	East Abutment	West Abutment
Overall Plan Dimensions (m)	2.7 x 11.1	3.1 x 11.1
Pile Cap Thickness (m)	Up to 1.45 m	
Top of Pile Cap Elevation (m)	102.0 to 102.6	101.0 to 101.6
Underside of Pile Cap Elevation (m)	100.6 to 101.2	99.6 to 100.2
Estimated Bottom of CSP Elevation (m)	98.2	96.5

9.2.1 Axial Geotechnical Resistance

The boreholes put down behind the abutments as part of the current investigation encountered as much as 4.6 m of embankment fill beneath the pile caps. The embankment fill is underlain by glacial till, over bedrock.

The 1997 design drawings indicate that the steel HP 310x110 piles at the east and west abutments were anticipated to be 11.7 m and 10.7 m long, respectively. These lengths assumed that the piles, fitted with driving shoes, would have hung up in the very dense glacial till prior to reaching the anticipated penetration lengths. For capacity assessment, it has been assumed that the piles reached refusal at these depths in the glacial till, which correlates to Elevations of 88.8 m to 89.5 m at the east and west abutments, respectively.

Based on the subsurface conditions encountered at the abutment boreholes and tip Elevations of 88.8 m to 89.5 m, the existing steel HP 310x110 piles may be considered to have a factored ULS resistance of 1,600 kN and a factored SLS resistance of 1,400 kN. The structural resistance of the pile under static and seismic conditions must be checked by a structural engineer. The factored geotechnical resistances include the following factors:

- Consequence factor (Ψ) of 1.0
- Geotechnical resistance factors (CHBDC Table 6.2) of $\phi_{gu} = 0.4$ (static analysis; typical degree of understanding)

As outlined in Section 6.11.3.2 of the Commentary to the CHBDC, the group efficiency of driven piles in cohesionless soils are typically taken as 1.0.

9.2.2 Downdrag

The results of the current investigation indicate that the glacial till is directly overlain by granular embankment fill at the abutments. It has been assumed that the native, soft to firm clayey silt



encountered at the ground surface at several abutment boreholes put down as part of the original (pre-construction) investigation was removed prior to placement of embankment fill behind the abutments. The embankment fill and underlying glacial till is practically non-compressible and, therefore, downdrag loads need not be considered acting on the piles.

9.2.3 Uplift Resistance

The glacial till and embankment fill at the abutments will provide uplift resistance to the piles. Shaft friction of the embankment fill along the concrete filled CSPs at the upper portion of the piles and of the glacial till along the lower portion of the piles were calculated, assuming the piles met effective refusal to driving between Elevation 88.8 m and 89.5 m.

The factored geotechnical tensile resistance for a single HP 310x110 pile at either abutment may be taken as 500 kN under static conditions and 1,600 kN under seismic conditions. These values include the following factors:

- Consequence factor (Ψ) of 1.0
- Geotechnical resistance factors (CHBDC Table 6.2) of $\phi_{gu} = 0.3$ (static analysis; typical degree of understanding)
- Geotechnical resistance factors (CHBDC Table 6.3) of $\phi_{gu} = 1.0$ (seismic analysis; typical degree of understanding, performance-based design)

9.2.4 Lateral Geotechnical Resistance

The lateral response of the existing pile foundations can be analyzed considering the soil-structure interaction between the pile(s) and the surrounding soils or bedrock using the load transfer method. The lateral load-displacement behaviour of the soils and bedrock developed on the face of a given pile can be modeled using P-y curves as described in Section C6.11.2.2.1 of the Commentary to the CHBDC. Thurber can provide P-y curves, if required.

9.3 Backfill and Lateral Earth Pressures

The lateral earth pressures acting on the abutment walls will depend on the type and method of placement of the backfill behind the abutment, the nature of the soils behind the backfill, the magnitude of surcharge including construction loadings, the freedom of lateral movement of the structure, and the drainage conditions behind the walls.

The 1997 design drawings show two options for RSS wall design. Both options suggest that the retained earth be a Select Backfill material with unit weight of 22 kN/m³ and friction angle of 35 degrees (similar to that of OPSS Granular A or Granular B Type II). Based on the results of the current investigation, the overall embankment fill at Boreholes 308-21-1 and 308-21-2 is generally a clean sand or sand and gravel mix with SPT N-values generally ranging between about 20 and 45 blows per 0.3 m of penetration. The boreholes were put down at a sufficient distance from the expansion joints to avoid penetration of the approach slabs or the RSS wall reinforcement.



It has been assumed that a filter fabric wrapped subdrain was constructed at the base of the walls, as noted on the 1997 design drawings.

Lateral earth pressure parameters provided in Table 9-3 and Table 9-4 in the sections below consider that the wall is vertical and the backfill is fully drained so that there are no unbalanced hydrostatic pressures above the permanent groundwater level. Where back slopes are horizontal, the corresponding coefficients provided in Table 9-3 and Table 9-4 should be used. If other backfill and wall geometries are to be considered, Thurber will need to calculate the appropriate earth pressure coefficients.

9.3.1 Static Lateral Earth Pressure

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC. Under drained conditions the lateral earth pressure is generally given by the following expression:

$$\sigma_h = K * (\gamma h + q)$$

where:

σ_h	=	horizontal pressure on the wall at depth h (kPa)
K	=	earth pressure coefficient (see table below) (K_a for yielding walls, K_o for non-yielding walls)
γ	=	unit weight of retained soil (see table below), use submerged unit weight below groundwater level
h	=	depth below top of fill where pressure is computed (m)
q	=	value of any surcharge (kPa)

A lateral earth pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Clause 6.12.3 of the CHBDC. Typical earth pressure coefficients for backfill are shown in Table 9-3.

Table 9-3 Static Earth Pressure Coefficients

Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22 \text{ kN/m}^3$	Existing Embankment Fill $\phi = 32^\circ, \gamma = 22 \text{ kN/m}^3$
Active, K_A (Yielding Wall)	0.27	0.31
At Rest, K_O (Non-Yielding Wall)	0.43	0.47
Passive, K_P (Movement towards Soil Mass) in front of wall	3.7	3.3

The parameters in the table correspond to full mobilization of active and passive earth pressures and require certain relative movements between the wall and adjacent soil to produce these

conditions. The movement required can be assessed from Table C6.12 of the Commentary to the CHBDC. Active earth pressures should be used for unrestrained walls. For rigid structures, at-rest horizontal earth pressures would apply for design.

9.3.2 Combined Static and Seismic Lateral Earth Pressure

In accordance with Clause 6.14.7.2 of the CHBDC, retaining structures should be designed using dynamic earth pressure coefficients that incorporate the effects of earthquake loading. The following recommendations are per Section C6.14.7.2 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using the Mononobe-Okabe Method with:

- $k_h = \frac{1}{2} * F(PGA) * PGA$, for structures that allow 25 to 50 mm of movement, and
- $k_h = F(PGA) * PGA$, for non-yielding walls

The coefficients of horizontal earth pressure for combined static and seismic loading presented in Table 9-4 may be used. The provided earth pressure coefficients are calculated using a site-adjusted PGA of 0.25 g, based on a Seismic Site Class C and a 2% probability of exceedance in 50 years.

Table 9-4 Combined Static and Seismic Earth Pressure Coefficients

Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22 \text{ kN/m}^3$	Existing Embankment Fill $\phi = 32^\circ, \gamma = 22 \text{ kN/m}^3$
Active, K_{AE} Yielding Wall	0.34	0.38
Active, K_{AE} Non-Yielding Wall	0.43	0.48

The total pressure due to combined static and seismic loads acting at a specific depth below the top of the wall may be determined using the following equation that includes consideration of material properties and the soils profile.

$$\sigma_h = K * \gamma * d + (K_{AE} - K_A) * \gamma * (H - d)$$

where:

σ_h	=	lateral earth pressure at depth d (kPa)
d	=	depth below the top of the wall (m)
K	=	static earth pressure coefficient (K_A for yielding walls, K_o for non-yielding walls)
γ	=	unit weight of retained soil, use submerged unit weight below groundwater level
K_{AE}	=	combined static and seismic earth pressure coefficient
H	=	total height of the wall (m)

9.4 Embankment Stability

Based on the available original structure drawings and observations during the 2021 field investigation, the grade of the travelled lanes ranges from about 104.0 m to 105.0 m with embankments on the order of up to 8.0 m above the existing ground surface at the abutments. The embankments are sloped at about 2H:1V, extending as much as 16 m horizontally at the abutments.

Table 6.2 of the CHBDC for embankment fills with a typical degree of understanding and a Ψ of 1.0 generates minimum Factors of Safety of 1.5 and 1.3 for static permanent and static temporary conditions respectively.

For seismic analysis, Table 6.3 in Section 6.14.4.1 of the CHBDC indicates a minimum resistance factor of 0.95 ($\phi_{gu, static(temporary)} = 0.75 + 0.2$) for force-based design and 1.0 for performance-based design. Based on these values and Ψ of 1.0, a target Factor of Safety of 1.1 for this temporary condition with a typical degree of understanding is appropriate for the pseudo-static seismic analysis. However, as is stated in Section 6.14.9.1, some embankment displacement can occur where the pseudo-static Factor of Safety is less than 1.3. In that case, the bridge foundations must be designed to withstand the permanent deformations and/or slope stabilizing measures shall be incorporated into the design. Where the pseudo-static Factor of Safety is at least 1.3, the slope is considered to be seismically stable with deformations of less than 50 mm.

Typically, where the initial 1 in 2475 year pseudo-static analyses generates a Factor of Safety less than 1.3, a screening level deformation check should be completed where there are potential implications to the bridge foundations or embankment slopes.

In addition, Sections 6.14.2.1 and 6.14.2.3 of the CHBDC present performance criteria requirements for Major Route geotechnical systems (embankments) inside and outside the bridge interface zone, respectively. Based on Clause 6.14.2.2, the bridge interface zone at this site extends to 20 m behind the abutment (based on a fill height of 8.5 m). The performance criteria for Major Route embankments are as follows:

- Within the bridge interface zone (bridge approaches): 100% of the travelled lanes shall be available for use following a ground motion event with a return period of at least 475 years.
- Outside the bridge interface zone (beyond bridge approaches): sites that fall within Seismic Performance Category 2 or 3 (See Section 8.3) shall have at least 50% of travelled lanes, but not less than one, available for use following ground motions with a return period of at least 475 years.

Slope stability assessments of the typical embankment slope, considered to be the south slope of the eastern embankment near the abutment, have been carried out. Embankment slope stability was evaluated using GeoStudio 2020 Slope/W software for limit equilibrium analysis. Input parameters for the analysis are based on the SPT N-values encountered in the 2021 boreholes and the results of laboratory testing. The following additional parameters were used in the analysis:

- Estimated soil stratigraphy based on the existing ground surface contours and nearest boreholes;
- Embankment maximum fill height of 8.5 m;
- Site adjusted PGA value of 0.12 g, equal to ½ of the site adjusted PGA value (0.25 g) was used for seismic analysis, as per Section 4.4.3.3, of the CHBDC and outlined in Sections 8.1 and 8.2 above; and,
- A traffic surcharge of 17 kPa applied as a temporary load.

The output from the stability analyses are provided on the figures presented in Appendix G. Each output figure shows the slope geometry, groundwater conditions, soil stratigraphy and soil strength parameters utilized in the analysis.

The stability analyses generated the following factor of safety values for the critical embankment design:

Table 9-4 Slope Stability Analysis Results

Condition	Case	Factor of Safety
Permanent (no traffic loading)	Long Term Static (Drained)	1.7 (Fig G1)
Temporary (includes seismic)	Pseudo-Static Seismic (Undrained)	1.3 (Fig G2)
Temporary (traffic loading)	Short Term Static (Undrained)	1.7 (Fig G3)

All of the static results presented in the Table 9-4 achieve the target Factors of Safety described above. In addition, the pseudo-static analysis for a 1 in 2475 year seismic event yields a value of 1.3 which achieves the target stability value and indicates that a screening level deformation check is not required. Furthermore, the 1 in 2475 year pseudo-static results suggest that the performance criteria requirements for this embankment (which would be based on a 1 in 475 year event) are also achieved.

10 RECOMMENDED SCOPE FOR DETAIL DESIGN

The recommendations provided above are in support of the preliminary design of the proposed rehabilitation of the Highway 416N-401W Ramp Overpass (Site No. 16X-0308) as part of the overall Preliminary Design and Environmental Assessment for the widening of Highway 401 from Highway 416 to Maitland Road. Depending on the scope of the design rehabilitation works, additional foundation investigation will be required following the selection of the Technically Preferred Alternative (TPA). Additional field investigation should be carried out to provide additional foundation design input to the following:

- Shear wave velocity measurements in the 30 m below the foundation elements to confirm Seismic Site Classification



- Testing of soil and/or groundwater at the site to determine degree of corrosiveness of the sub-surface environment and potential for sulphate attack on steel and concrete elements in contact with the soil and groundwater at the site

The required supplementary foundation field investigation scope should be reviewed following the selection of the TPA.



11 CLOSURE

Engineering analysis and preparation of this report was carried out by Mr. Matt Kennedy, P.Eng. The report was reviewed by Paul Carnaffan, P.Eng. and Fred Griffiths, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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REFERENCES

ⁱ Boulanger, R. W., and Idriss, I. M. (2014). CPT and SPT based liquefaction triggering procedures, Report No. UCD/CGM-14/01, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, CA, 134 pp.

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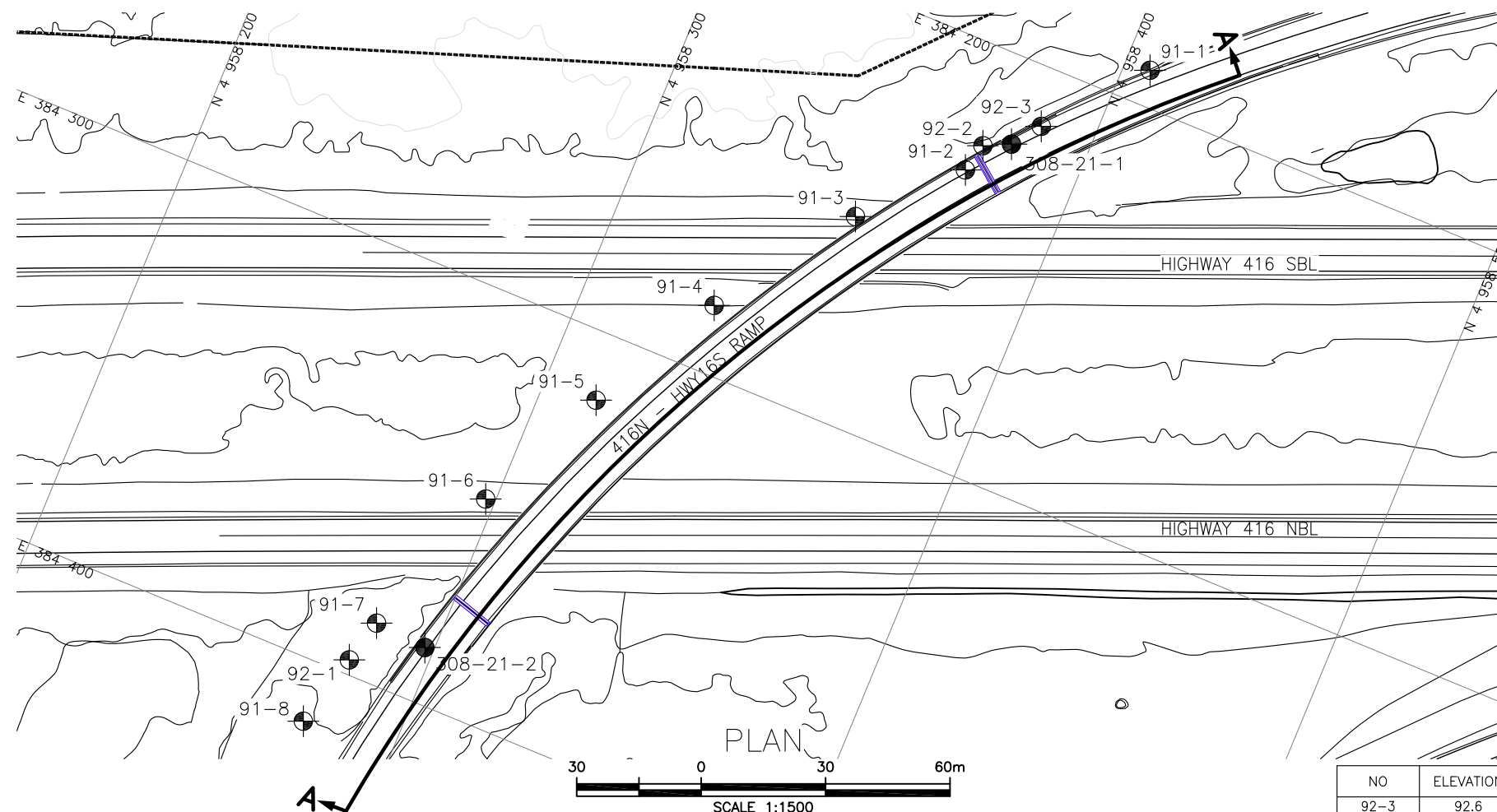
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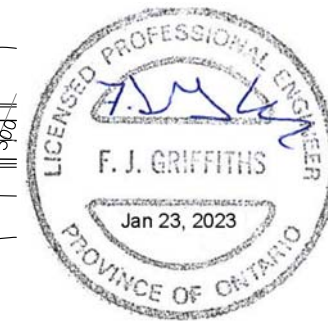


Appendix A.

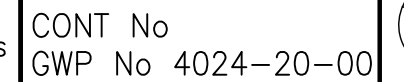
Borehole Location Plan and Stratigraphic Drawings



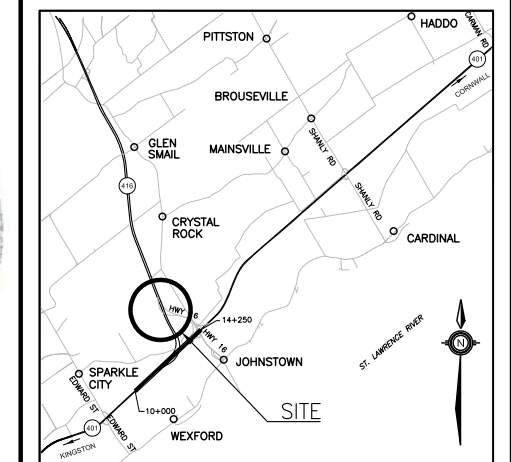
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



NO	ELEVATION	NORTHING	EASTING
92-3	92.6	4 958 387.2	384 213.9








HIGHWAY 416 416N - HIGHWAY 16S RAMP REHABILITATION BOREHOLE LOCATIONS AND SOIL STRATA	
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KEYPLAN

LEGEND

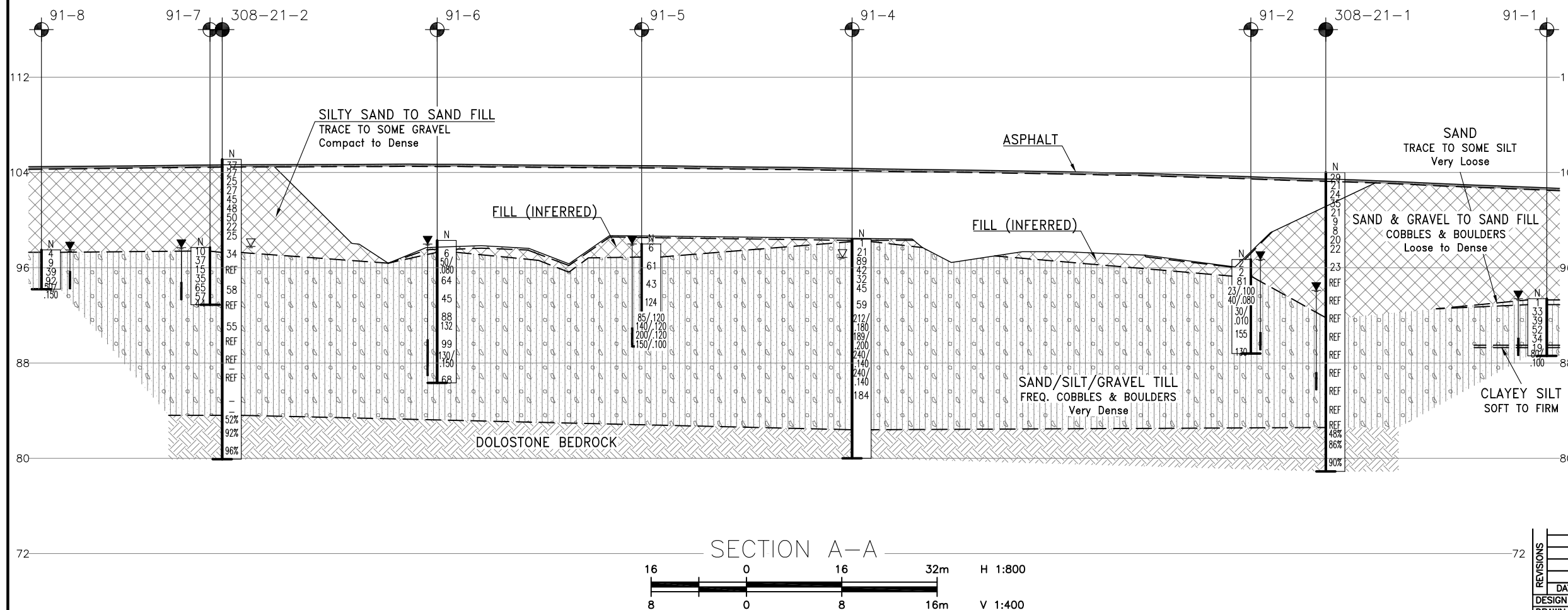
- | | |
|---|---------------------------------------|
|  | Borehole (Current Investigation) |
|  | Borehole (Previous Investigation) |
| N | Blows /0.3m (Std Pen Test, 475J/blow) |
| CONE | Blows /0.3m (60° Cone, 475J/blow) |
| PH | Pressure, Hydraulic |
|  | Water Level |
|  | Head Artesian Water |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

NO	ELEVATION	NORTHING	EASTING
308-21-1	104.0	4 958 382.2	384 220.6
308-21-2	105.1	4 958 297.8	384 386.8
91-1	93.4	4 958 406.3	384 191.4
91-2	96.7	4 958 374.3	384 230.6
91-3	97.5	4 958 354.1	384 251.1
91-4	98.4	4 958 330.8	384 283.9
91-5	98.0	4 958 313.2	384 315.9
91-6	98.3	4 958 297.7	384 348.1
91-7	97.7	4 958 284.8	384 385.8
91-8	97.5	4 958 277.5	384 414.4
92-1	98.0	4 958 282.1	384 396.5
92-2	96.7	4 958 376.0	384 223.6

-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.
- 3) Coordinate system is MTM NAD 83 Zone 9.

GEOCRES No. 31B-105

[illegible]



Appendix B.

Record of Borehole Sheets



Appendix B.1

Current (2021) Investigation



SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

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

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

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

RECOVERY:

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

N-VALUE:

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

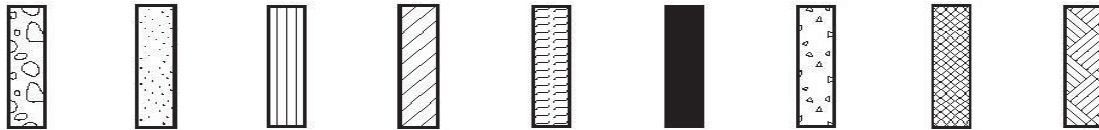
DYNAMIC CONE PENETRATION TEST (DCPT):

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



STRATA PLOT:

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



Boulders
Cobbles
Gravel Sand Silt Clay Organics Asphalt Concrete Fill Bedrock

TEXTURING CLASSIFICATION OF SOILS

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

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

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

SAMPLE TYPES

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

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

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

MODIFIED UNIFIED SOIL CLASSIFICATION

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

Note - W_L = Liquid Limit



EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

TERMS

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

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

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

RECORD OF BOREHOLE No 308-21-1

1 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.761036°, Long: -75.496784° N 4 958 382.2 E 384 220.6 ORIGINATED BY JP
 HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
 DATUM Geodetic DATE 2021.04.28 - 2021.04.29 CHECKED BY MJK

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			20	40	60	80	100		
104.0														
0.0	ASPHALT (200 mm)													
0.2	SAND and GRAVEL to Gravelly SAND, trace to some fines Grey-brown to brown Compact FILL		1	SS	29									49 42 9 (SI+CL)
102.6			2	SS	21		103							27 58 15 (SI+CL)
1.4	SAND Brown Loose to dense FILL		3	SS	24		102							
			4	SS	35		101							
			5	SS	21		100							
			6	SS	9		99							2 92 6 (SI+CL)
			7	SS	8		98							
			8	SS	20		97							
			9	SS	22		96							
			10	SS	23		95							
94.9														
9.1	GRAVELLY SILTY SAND to SILT, some gravel and sand Grey-brown to grey Very dense Frequent cobbles/boulders GLACIAL TILL		11	SS	REF									18 68 14 (SI+CL)

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+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

RECORD OF BOREHOLE No 308-21-1

2 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.761036°, Long: -75.496784° N 4 958 382.2 E 384 220.6 ORIGINATED BY JP
HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2021.04.28 - 2021.04.29 CHECKED BY MJK

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																
	GRAVELLY SILTY SAND to SILT, some gravel and sand Very dense Frequent cobbles/boulders GLACIAL TILL		12	SS	REF												
			13	SS	REF												
			14	SS	REF												
			15	SS	REF												
			16	SS	REF												
			17	SS	REF												
			18	SS	REF												

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

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

RECORD OF BOREHOLE No 308-21-1

3 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.761036°, Long: -75.496784° N 4 958 382.2 E 384 220.6 ORIGINATED BY JP
 HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
 DATUM Geodetic DATE 2021.04.28 - 2021.04.29 CHECKED BY MJK

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			20	40	60	80	100		
	Continued From Previous Page							SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
								WATER CONTENT (%)						
								20	40	60	80	100		
82.6	GRAVELLY SILTY SAND to SILT, some gravel and sand Grey-brown to grey Very dense Frequent cobbles/boulders GLACIAL TILL		19	SS	REF		83						FI	
21.4	Interbedded LIMESTONE and DOLOSTONE Fresh Grey Fine grained Very strong		1	RUN			82						3	RUN #1 TCR=100% SCR=70% RQD=48%
			2	RUN			81						3	UCS = 217 MPa
			3	RUN			80						1	RUN #2 TCR=100% SCR=100% RQD=86%
78.9							79						2	RUN #3 TCR=100% SCR=100% RQD=90%
25.1	End of Borehole Flushmount 19 mm diameter PVC monitoring well installed. Well Readings: Date: Depth (m): Elev. (m): 2021/07/01 9.9 94.1 2022/12/20 9.4 94.6													

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

RECORD OF BOREHOLE No 308-21-2

1 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.760258°, Long: -75.494698° N 4 958 297.8 E 384 386.8 ORIGINATED BY JP
 HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
 DATUM Geodetic DATE 2021.05.03 - 2021.05.04 CHECKED BY MJK

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			20	40	60	80	100		
105.1														
0.0	ASPHALT (200 mm)						105							
0.2	SILTY SAND, some gravel Grey-brown to brown Compact to dense FILL		1	SS	37									
			2	SS	27		104							
103.7														
1.4	SAND, some silt Grey-brown to brown Compact to dense FILL		3	SS	25		103							
			4	SS	27									
							102							
			5	SS	45									
			6	SS	48		101							
			7	SS	50		100							
			8	SS	22		99							
			9	SS	25		98							
							97							
97.3			10	SS	34									
7.8	SILTY SAND some gravel Brown to grey Dense to very dense Frequent cobbles/boulders GLACIAL TILL													
							96							
			11	SS	REF									

Continued Next Page

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

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

RECORD OF BOREHOLE No 308-21-2

2 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.760258°, Long: -75.494698°
N 4 958 297.8 E 384 386.8 ORIGINATED BY JP
HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2021.05.03 - 2021.05.04 CHECKED BY MJK

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			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
	Continued From Previous Page													
	SILTY SAND some gravel Brown to grey Dense to very dense Frequent cobbles/boulders GLACIAL TILL Grey below 10.7 m		12	SS	58		95							18 38 32 12
							94							
			13	SS	REF		93							
							92							
			14	SS	55		91							26 37 29 8
							90							
			15	SS	REF		89							
			16	SS	REF		88							
			1	NQ	-		87							
			17	SS	REF		86							

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+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

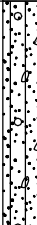

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22

RECORD OF BOREHOLE No 308-21-2

3 OF 3

METRIC

GWP# 4024-20-00 LOCATION Lat: 44.760258°, Long: -75.494698°
N 4 958 297.8 E 384 386.8 ORIGINATED BY JP
HWY 401 BOREHOLE TYPE CME 55 Truckmount, HSA/NQ Coring COMPILED BY SH
DATUM Geodetic DATE 2021.05.03 - 2021.05.04 CHECKED BY MJK

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
								WATER CONTENT (%)									
	Continued From Previous Page						20 40 60 80 100										
83.6	SILTY SAND some gravel Brown to grey Dense to very dense Frequent cobbles/boulders GLACIAL TILL		2	NQ	-		85										7 34 49 10
			3	NQ	-		84										
21.5	Interbedded LIMESTONE and DOLOSTONE Fresh Grey Fine grained Very strong Vertical fracture 21.5 to 21.7 m		1	RUN			83										RUN #1 TCR=100% SCR=52% RQD=52% RUN #2 TCR=100% SCR=98% RQD=92% RUN #3 TCR=100% SCR=100% RQD=96%
			2	RUN			82										
			3	RUN			81										
79.9								80									
25.2	End of Borehole																

DOUBLE LINE 29381 BOREHOLE LOGS REHAB SITES.GPJ 2012TEMPLATE(MTO).GDT 12-23-22



Appendix B.2

Original (1991/1992) Investigation

RECORD OF BOREHOLE No 91-1

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 406.3 E: 384 191.4 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE April 21, 1991 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40					
93.4	Ground Surface													
0.1	Topsoil													
0.5	Sand trace to some silt Very Loose Reddish-Brown		1	SS	1									
	Sand and Gravel, some silt Dense to Very Dense Brown		2	SS	33									
			3	SS	39									
			4	SS	52									
			5	SS	34									
89.5	Clayey Silt													
4.1	Soft to Firm Brown		6	SS	19									
88.6	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till) Compact Grey		7	SS	80/10cm									
4.8	End of Borehole													



RECORD OF BOREHOLE No 91-2

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 374.3 E: 384 230.6 ORIGINATED BY Y.L.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing COMPILED BY C.K.K.
DATUM Geodetic DATE April 23, 1991 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
96.7	Ground Surface																GR SA SI CL
0.1	Topsoil		1	SS	2		May 10, 1991, March 30, 1992										
	Clayey Silt		2	SS	2		96										0 0 75 25
95.3	Soft to Firm Brown																
1.4	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till) Very Dense		3	SS	81		95 Native Backfill						o				
			4	SS	23	0 cm	94						o				16 44 (40)
			5	SS	40	8 cm	93						o				
	Brown Grey						92 Seal										
			6	SS	30	cm	91						o				
							90 Sand Backfill										
			7	SS	155		90 Piezometer						o				
88.8			8	SS	130		89						o				
7.9	End of borehole																

RECORD OF BOREHOLE No 91-3

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 354.1 E: 384 251.1 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing COMPILED BY C.K.K.
 DATUM Geodetic DATE April 23, 24, 1991 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
97.5	Ground Surface																GR SA SI CL
97.2	Topsoil																
0.3	Clayey Silt Soft to Firm						May 10, 1991, March 30, 1992										
96.5	Brown						Seal										
1.0	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till) Compact to Very Dense		1	SS	27												
			2	SS	59												
			3	SS	60	10 cm											
			4	SS	161												
			5	SS	50/8	10 cm											
			6	SS	100/	10 cm											
			7	Ss	120/	10 cm											
88.6																	
8.9	End of borehole																

RECORD OF BOREHOLE No 91-4

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 330.8 E: 384 283.9 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing, Rock Coring COMPILED BY C.K.K.
 DATUM Geodetic DATE April 17 to 19, 1991 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
98.4	Ground Surface														GR SA SI CL
98.1	Topsoil														
0.2	Sand trace to some silt, Very Loose Brown	1	SS	1		Seal									
	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till) Compact to Very Dense Brown Grey	2	SS	21		Native Backfill									
		3	SS	89		March 30, 1992									
		4	SS	42		Seal									
		5	SS	32		May 10, 1991, March 30, 1992									
		6	SS	45		96 Sand Backfill									
		7	SS	59		Piezometer									
		8	SS	202/ 18 cm		Seal									
		9	SS	189/ 20 cm		94									
		10	SS	240/ 14 cm		93 Native Backfill									
		11	SS	240 14 cm		92									
		12	SS	184		91									
						90 Seal									
						89									
						88 Native Backfill									
						87									
						86									
						85									
						84									
						83									
82.4						Seal									
16.0	Bedrock Limy Dolostone Good to Excellent	13	NQ RC	REC 95%		Sand 82 Backfill									RQD = 85%
		14	NQ RC	REC 96%		Piezometer 81									RQD = 96%
80.0															
18.4	End of borehole														



RECORD OF BOREHOLE No 91-5

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 313.2 E: 384 315.9 ORIGINATED BY Y.L.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing COMPILED BY C.K.K.
DATUM Geodetic DATE April 24 to 26, 1991 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
98.0	Ground Surface																GR SA SI CL
0.1	Topsoil		1	SS	6												
96.9	Sand, trace to some silt Loose Brown																
1.1	Het. Mixture of Sandy Silt, some clay and gravel, Brown & Grey occ. boulders Grey (Glacial Till) Dense to Very Dense		2	SS	61												
			3	SS	43												
			4	SS	124												22 27 (51)
			5	SS	85/ 12cm												
			6	SS	140/ 12 cm												
			7	SS	200/ 12 cm												
89.4			8	SS	150/ 10 cm												
8.6	End of borehole																



RECORD OF BOREHOLE No 91-6

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 297.7 E: 384 348.1 ORIGINATED BY Y.L.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger, N-Casing COMPILED BY C.K.K.
DATUM Geodetic DATE April 25 to 26, 1991 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
98.3	Ground Surface																
	Topsoil						98										
0.3	Sand, trace to some silt						May 10, 1991, March 30, 1992										
97.3	Loose Brown		1	SS	6		97										
1.0	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till)						Native Backfill										
	Loose to Very Dense Brown Grey		2	SS	50/8		96										
							Seal										
			3	SS	64		95										
							94						o				
			4	SS	45		Sand Backfill										
							93						o				
							92										
			5	SS	88		91						o				
			6	SS	132		90										
			7	SS	99		Piezometer										
							89										
			8	SS	130/15cm		88						o				
							87										
86.3			9	SS	68								o				
12.0	End of borehole																



RECORD OF BOREHOLE No 91-7

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 284.8 E: 384 385.8 ORIGINATED BY Y.L.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
DATUM Geodetic DATE April 29, 1991 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	SHEAR STRENGTH kPa		WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE								
								● QUICK TRIAXIAL x LAB VANE								
97.7	Ground Surface															
0.1	Topsoil															
0.3	Sand trace to some silt, Brown		1	SS	10											
	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till) Compact to Very Dense		2	SS	37											
			3	SS	15											
			4	SS	35											
			5	SS	65											
			6	SS	57											
			7	SS	44											
92.5																
5.2	End of borehole															



RECORD OF BOREHOLE No 91-8

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 277.5 E: 384 414.4 ORIGINATED BY Y.L.
DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
DATUM Geodetic DATE April 29, 1991 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
97.5	Ground Surface															
0.1	Topsoil															
0.2	Sand trace to some silt, Loose, Brown		1	SS	4		Seal									
	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial till) Brown		2	SS	9		Native Backfill									
			3	SS	39		Seal									
			4	SS	92		Sand Backfill									
94.2			5	SS	50/		Piezometer									
3.3	End of Borehole				15 cm											

RECORD OF BOREHOLE No 92-1

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 282.1 E: 384 396.5 ORIGINATED BY Y.L.
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE March 30, 1992 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100					
98.0	Ground Surface																
	Topsoil																
0.2	Sand, trace to some silt																
97.1																	
0.9	Compact Brown		1	SS	16		97										
	Het. Mixture of Sandy Silt, some clay and gravel, occ. boulders (Glacial Till)		2	SS	16		96										
	Compact to Very Dense		3	SS	77		95										
	Brown Grey		4	SS	46		94										
			5	SS	84		93										
			6	SS	100/13 cm		92										
			7	SS	59		91										
			8	SS	58		90										
			9	SS	48		89										
87.7			10	SS	187/23 cm		88										
10.3	End of Borehole																

RECORD OF BOREHOLE No 92-2

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 376.0 E: 384 223.6
 DIST 9 HWY 416 BOREHOLE TYPE Hollow Stem Auger
 DATUM Geodetic DATE March 30, 1992
 ORIGINATED BY Y.L.
 COMPILED BY C.K.K.
 CHECKED BY G.J.K.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					NATURAL MOISTURE CONTENT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100	W _p	W	W _L		
96.7	Ground Surface															GR SA SI CL	
0.1	Topsoil		1	SS	3												
	Clayey Silt Soft to Firm Brown		2	SS	36												
95.0			3	SS	55												
1.7	Het. Mixture of Sandy																
94.4	Silt, tract to some gravel, occ. boulders (Glacial Till) Dense to Very Dense																
2.3	End of Borehole																

RECORD OF BOREHOLE No 92-3

METRIC

W P 177-89-02 LOCATION Co-ords: N: 4 958 387.2 E: 384 213.9 ORIGINATED BY Y.L.
 DIST HWY 416 BOREHOLE TYPE Hollow Stem Auger COMPILED BY C.K.K.
 DATUM Geodetic DATE March 30, 1992 CHECKED BY G.J.K.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80					
96.2																
0.1	Topsoil															
	Sand, some silt, trace gravel Compact Brown		1	SS	20											
94.5																
			2	SS	64											
1.7	Het. Mixture of Sandy Silt to Silty Sand, some gravel, occ. boulders (Glacial Till) Very Dense Brown															
92.7																
			3	SS	183											
3.5	End of Borehole No groundwater seepage during drilling															



Appendix C.

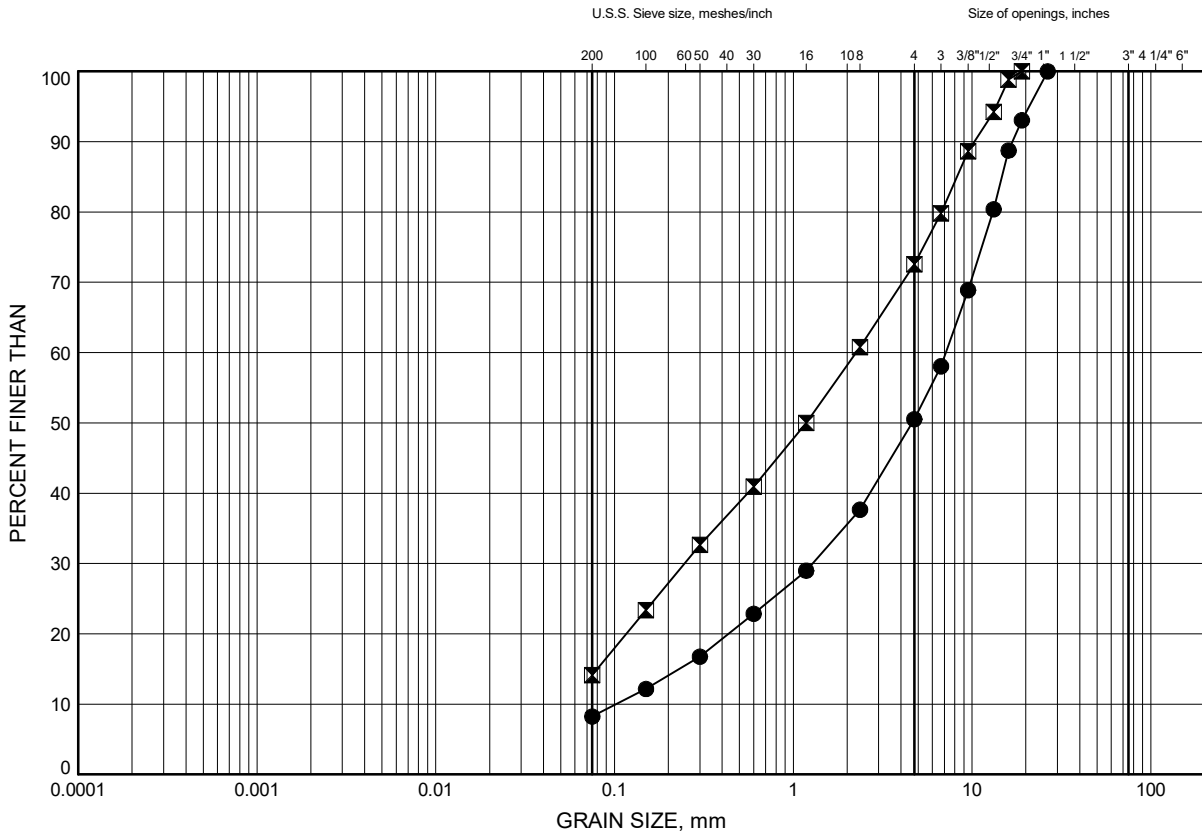
Laboratory Testing



Appendix C.1
Particle Size Analysis Figures (2021)
Atterberg Limit Test Results (2021)

GRAIN SIZE DISTRIBUTION

UPPER EMBANKMENT FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	308-21-1	0.5	103.5
⊠	308-21-1	1.1	102.9

Date November 2021

WP# 4024-20-00



Prep'd SH

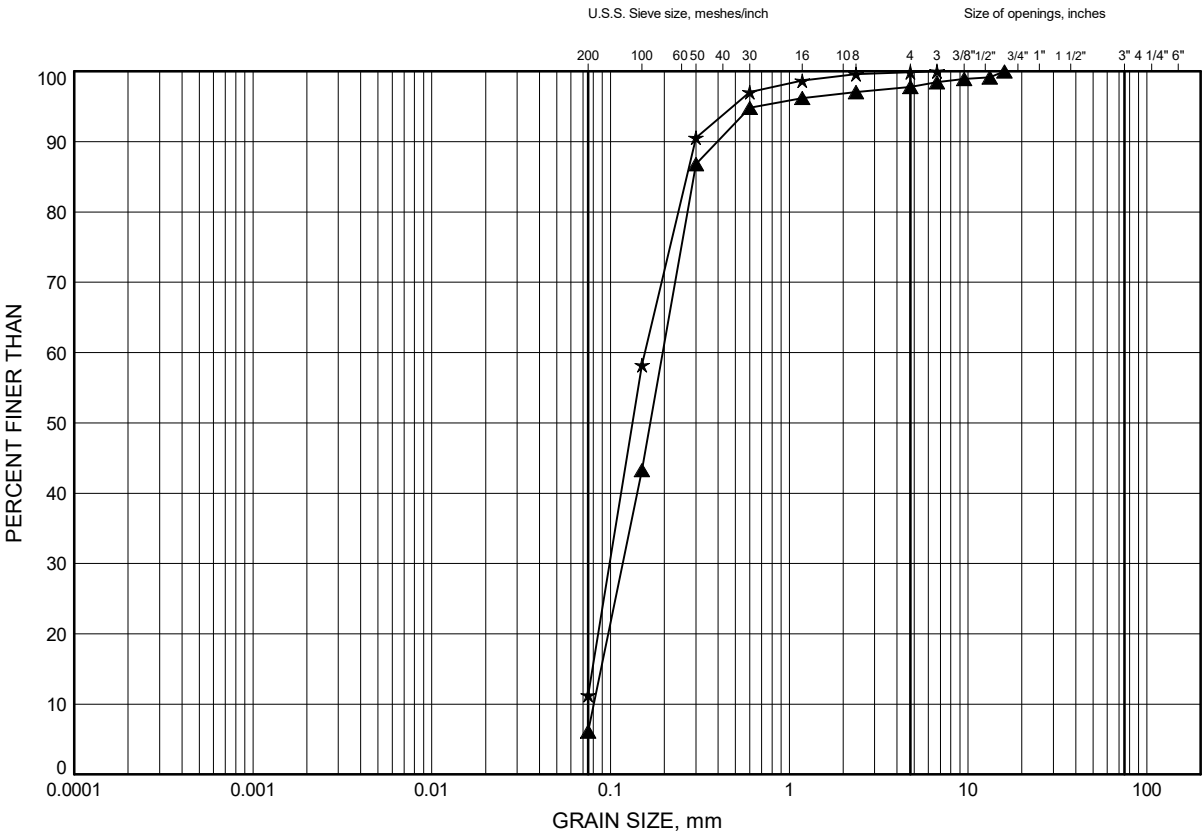
Chkd. MJK

Hwy 416 SB Connector N-E (Site No. 16X-0308)

GRAIN SIZE DISTRIBUTION

FIGURE C2

LOWER EMBANKMENT FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
▲	308-21-1	4.9	99.1
★	308-21-2	3.4	101.7

GRAIN SIZE DISTRIBUTION - THURBER 29381 BOREHOLE LOGS.GPJ 24/6/21

Date November 2021

WP# 4024-20-00



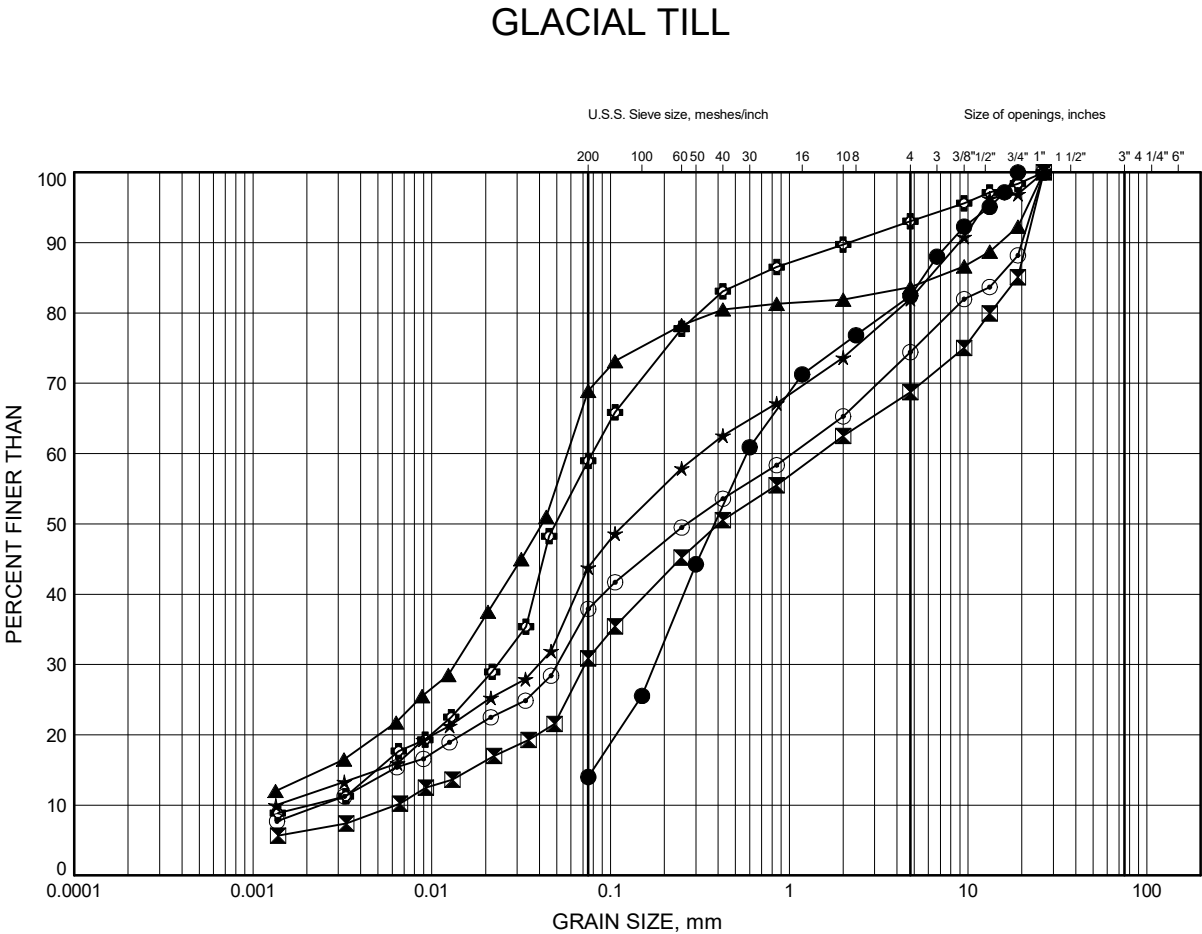
Prep'd SH

Chkd. MJK

Hwy 416 SB Connector N-E (Site No. 16X-0308)

GRAIN SIZE DISTRIBUTION

FIGURE C3



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	308-21-1	9.2	94.8
⊠	308-21-1	14.0	90.0
▲	308-21-1	19.9	84.1
★	308-21-2	10.9	94.2
⊙	308-21-2	14.0	91.1
⊕	308-21-2	21.0	84.1

GRAIN SIZE DISTRIBUTION - THURBER 29381 BOREHOLE LOGS.GPJ 24/6/21

Date November 2021

WP# 4024-20-00



Prep'd SH

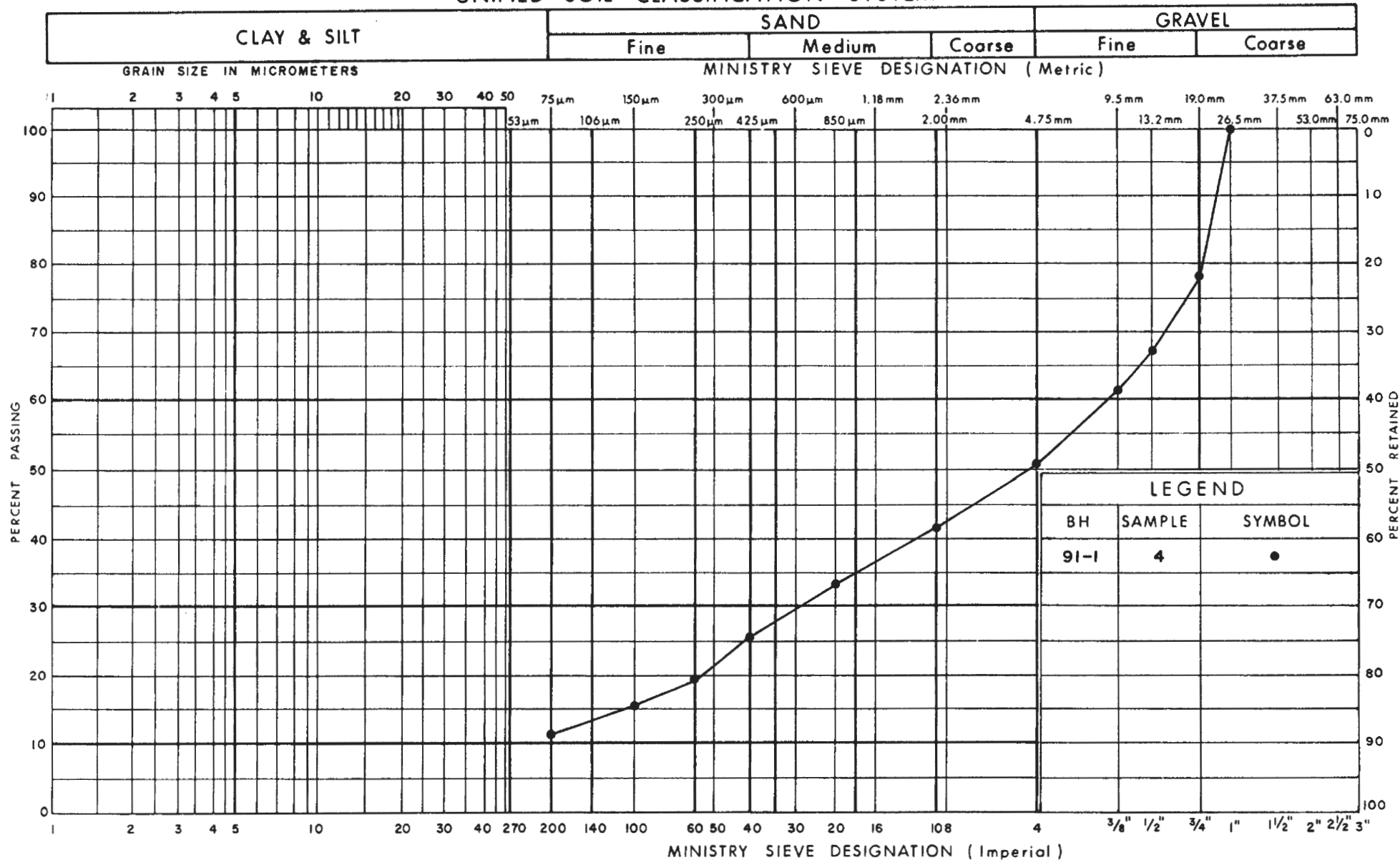
Chkd. MJK



Appendix C.2

Particle Size Analysis Figures (1991)

UNIFIED SOIL CLASSIFICATION SYSTEM

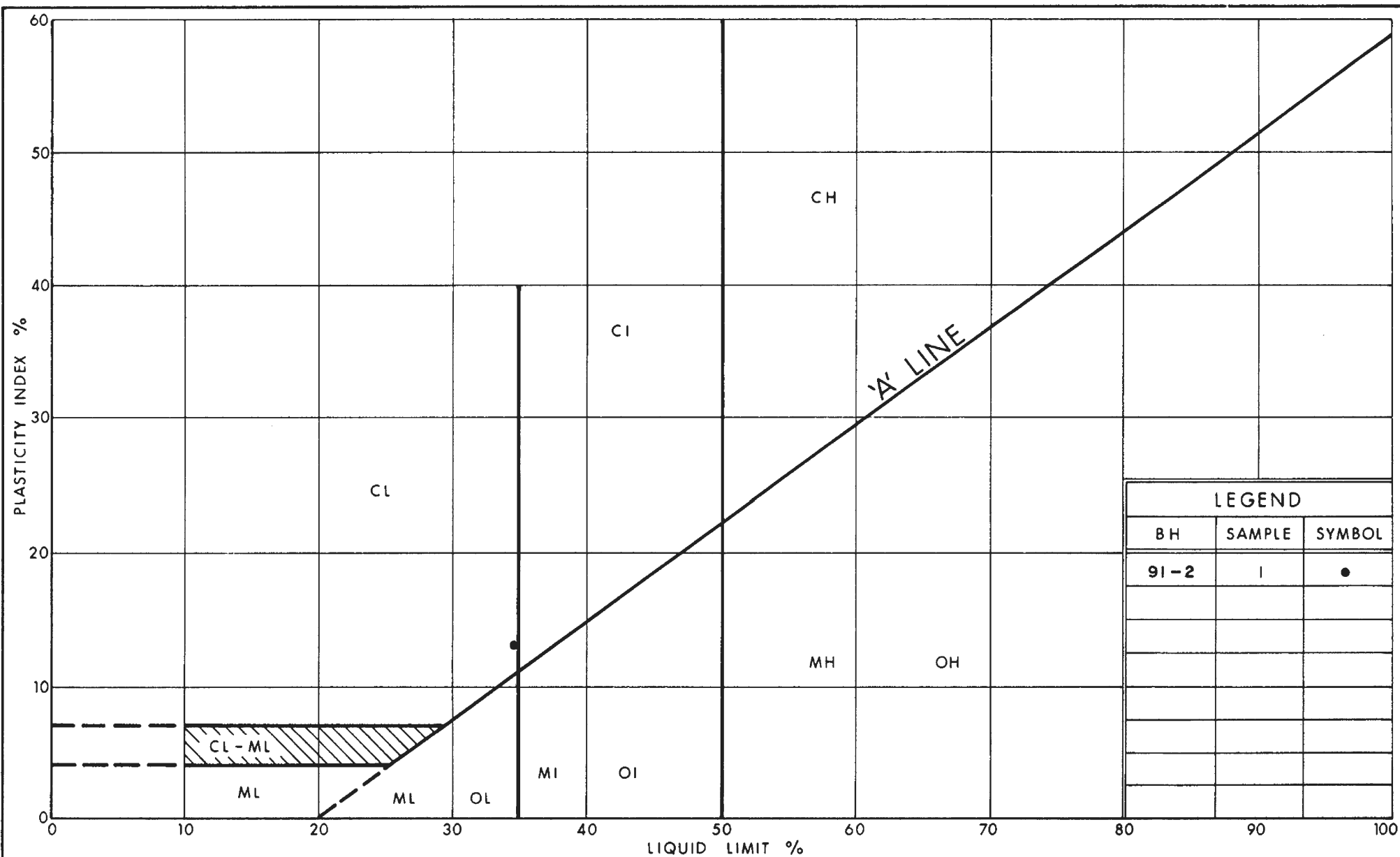


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION SAND & GRAVEL

FIG No C4

W P 177 - 89 - 02



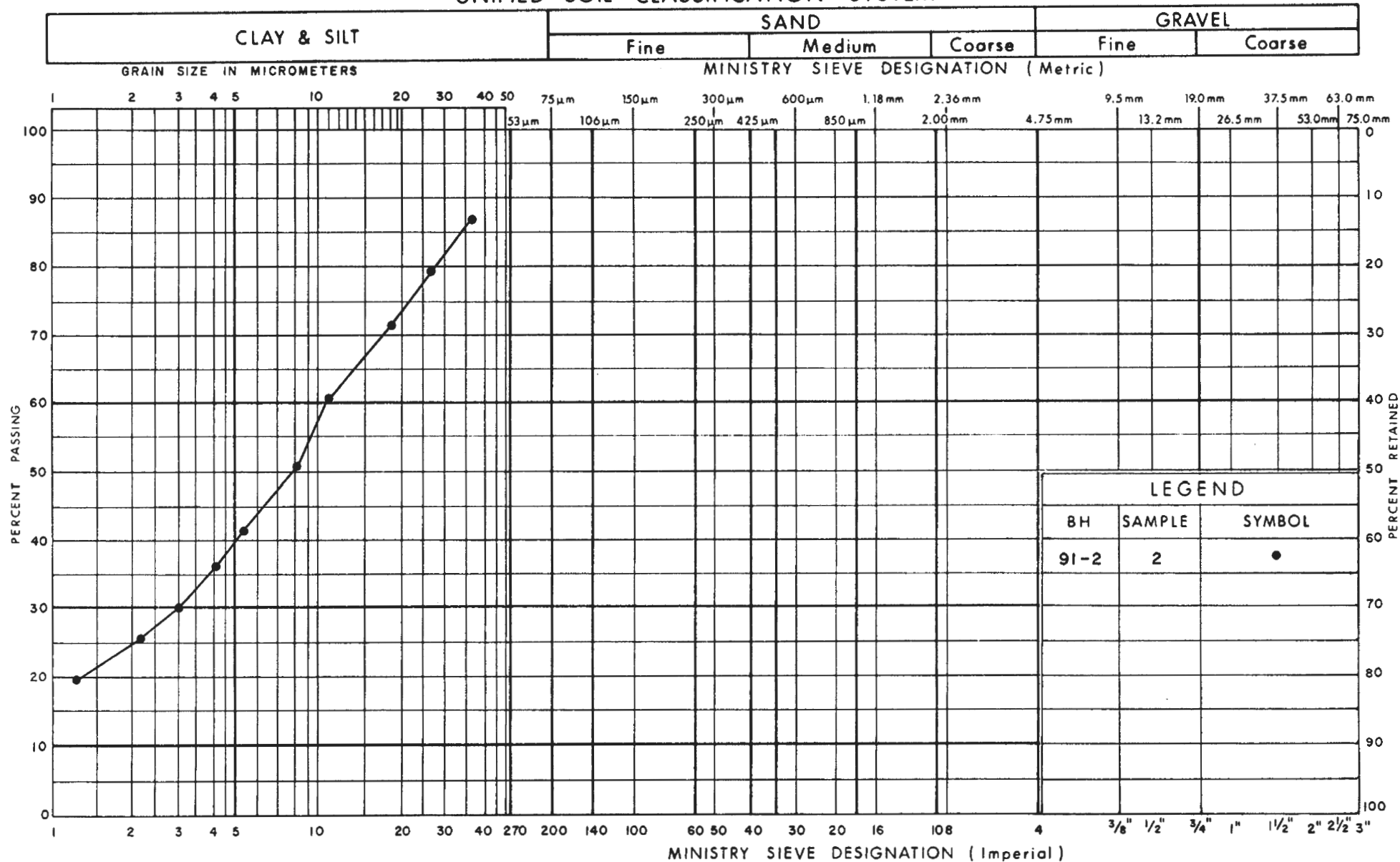
Ministry of
Transportation

PLASTICITY CHART CLAYEY SILT

FIG No C5

W P 177 - 89 - 02

UNIFIED SOIL CLASSIFICATION SYSTEM



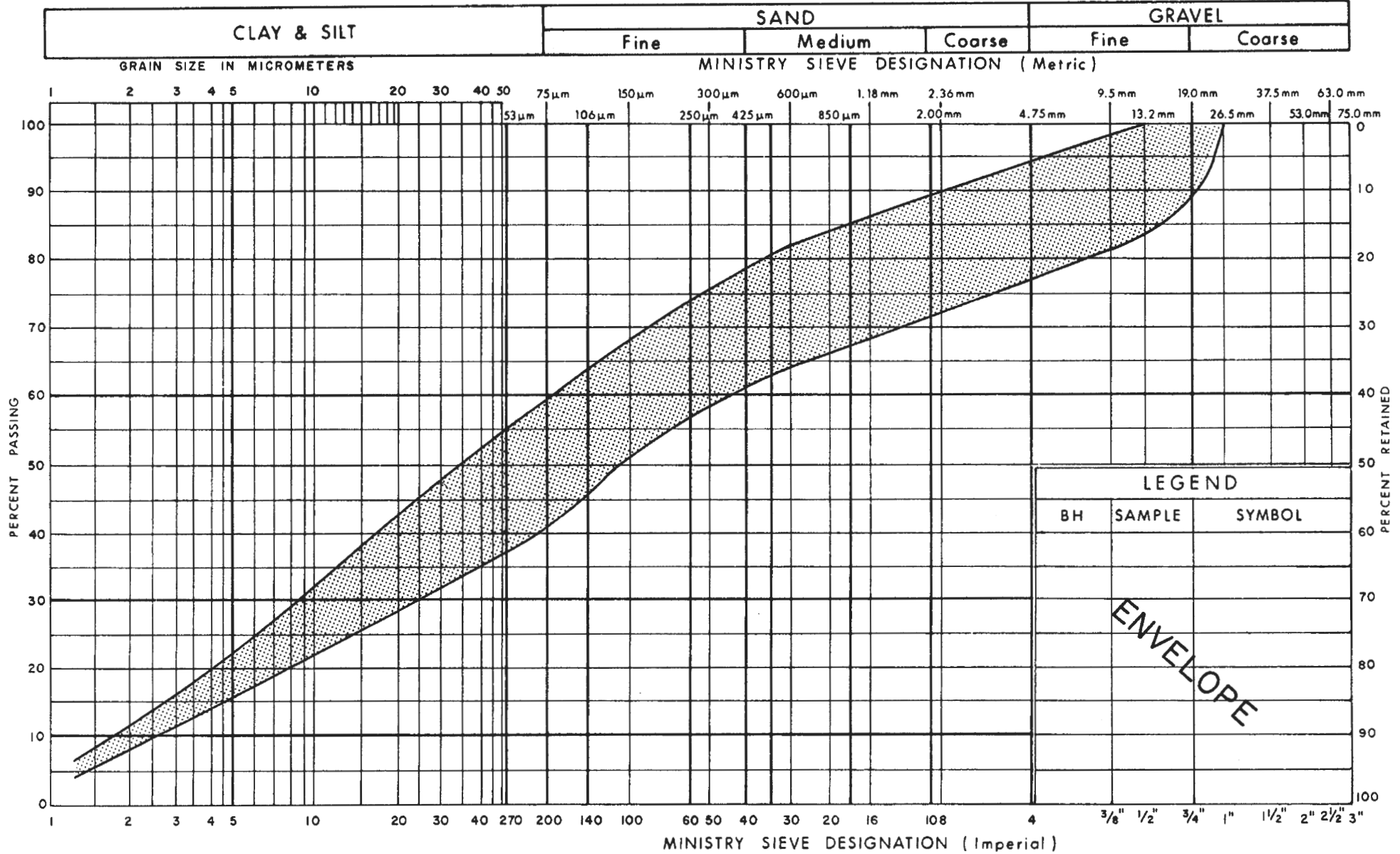
Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
CLAYEY SILT

FIG No C6

W P 177 - 89 - 02

UNIFIED SOIL CLASSIFICATION SYSTEM

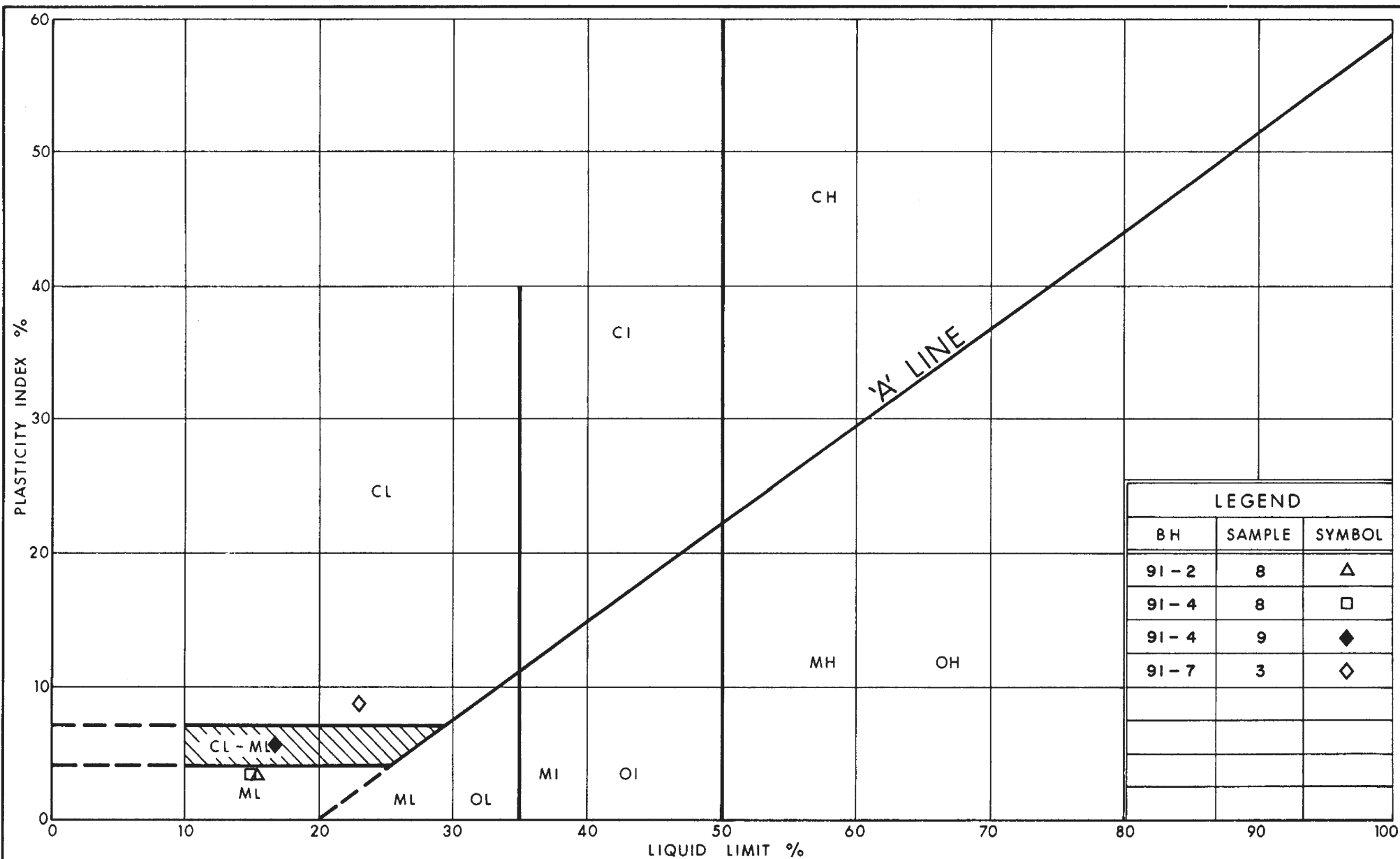


Ministry of
Transportation

GRAIN SIZE DISTRIBUTION
HET MIXTURE OF SANDY SILT,
SOME CLAY & GRAVEL, OCCASIONAL BOULDERS (Glacial Till)

FIG No C7

W P 177-89-02



Ministry of
Transportation

Ontario

PLASTICITY CHART
HET MIXTURE OF SANDY SILT,
SOME CLAY & GRAVEL, OCCASIONAL BOULDERS (Glacial Till)

FIG No C8

W P 177-89-02



Appendix C.3

UCS Test Results



Stantec

Stantec Consulting Ltd
2781 Lancaster Rd, Suite 100 A&B
Ottawa, ON K1B 1A7
Tel: (613) 738-6075
Fax: (613) 722-2799

May 25, 2021
File: 122410864

Attention: Thurber Engineering, File #29381

Reference: ASTM D7012, Method C, Unconfined Compressive Strength of Intact Rock Core
Highway 401/416 Interchange

The following table summarizes unconfined compressive strength results for five intact rock cores.

Location	Sample Depth	Compressive Strength (MPa)	Description of Break
259-21-1 Run-2	8'6"-9'1"	205.3	Well-formed cone at both ends
306-21-2 Run-1	77'2"-77'9"	219.8	Well-formed cone at both ends
307-21-1 Run-1	55'-55'7"	162.4	Well-formed cone at both ends
308-21-1 Run-2	72'6"-73'3"	216.9	Vertical cracking throughout, no well-formed cones.
250-21-21 Run-2	24'8"-25'3"	181.6	Well-formed cone at both ends

Sincerely,

Stantec Consulting Ltd

Brian Prevost

Brian Prevost
Laboratory Supervisor
Tel: 613-738-6075
brian.prevost@stantec.com



Appendix C.4

Bedrock Core Photographs

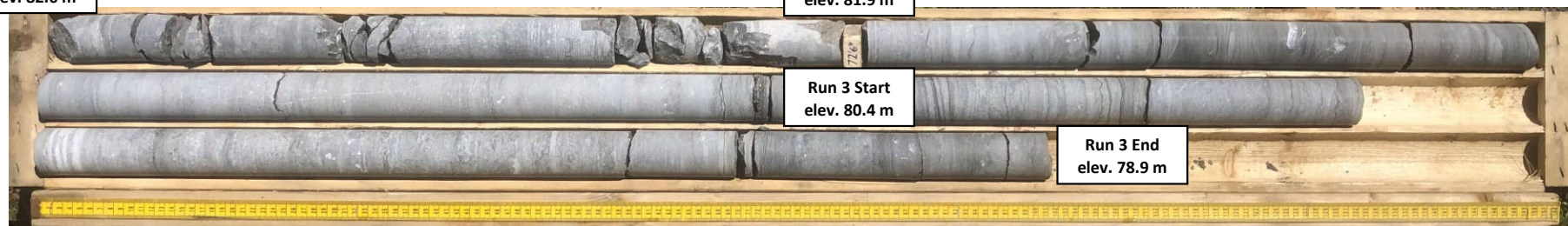
Borehole 308-21-1
Run 1 to 3 (of 3)
Elevation 82.6 m to 78.9 m
Dry

Run 1 Start
elev. 82.6 m

Run 2 Start
elev. 81.9 m

Run 3 Start
elev. 80.4 m

Run 3 End
elev. 78.9 m



Borehole 308-21-1
Run 1 to 3 (of 3)
Elevation 82.6 m to 78.9 m
Wet

Run 1 Start
elev. 82.6 m

Run 2 Start
elev. 81.9 m

Run 3 Start
elev. 80.4 m

Run 3 End
elev. 78.9 m



THURBER ENGINEERING LTD.

Highway 401/416 Interchange
Hwy 416 SB Connector N-E (Site No. 16X-0308)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 308-21-1
Project No.: 29381

Borehole 308-21-2
Run 1 to 3 (of 3)
Elevation 83.6 m to 79.9 m
Dry

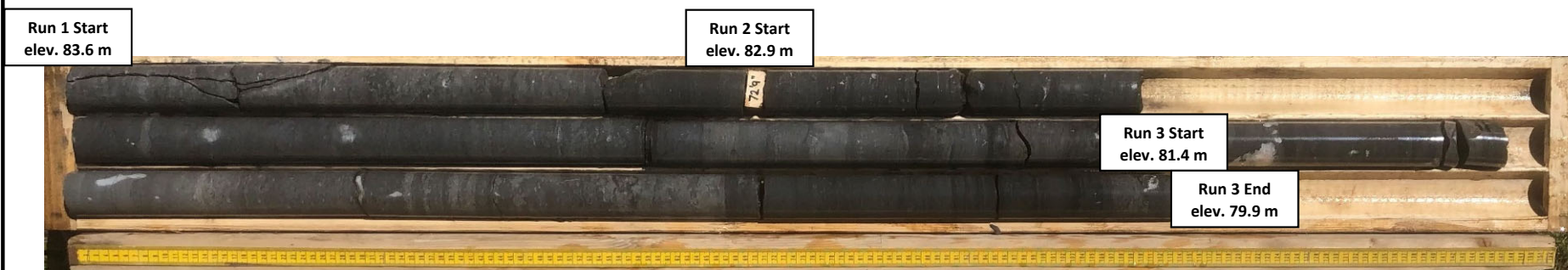


THURBER ENGINEERING LTD.

Highway 401/416 Interchange
Hwy 416 SB Connector N-E (Site No. 16X-0308)
Assignment No. 4019-E-0010.2, GWP 4024-20-00

BH 308-21-2
Project No.: 29381

Borehole 308-21-2
Run 1 to 3 (of 3)
Elevation 83.6 m to 79.9 m
Wet





Appendix D.

Site Photographs



Photo 1. Looking west from east abutment (2021/05/03)



Photo 2. Looking east from west abutment (2021/04/29)



Photo 3. Looking west from west abutment. (2021/04/29)



Photo 4. Looking north from west abutment. (2021/04/28)



Appendix E.

GSC Seismic Hazard Calculation

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 44.761N 75.496W

User File Reference: Bridge Site 16-308

2021-04-26 21:06 UT

Requested by: Matt Kennedy, P.Eng., Thurber Engineering Ltd.

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.386	0.217	0.130	0.037
Sa (0.1)	0.456	0.266	0.166	0.052
Sa (0.2)	0.384	0.228	0.145	0.048
Sa (0.3)	0.293	0.176	0.113	0.039
Sa (0.5)	0.209	0.126	0.081	0.028
Sa (1.0)	0.106	0.064	0.042	0.014
Sa (2.0)	0.051	0.030	0.019	0.006
Sa (5.0)	0.013	0.007	0.004	0.001
Sa (10.0)	0.005	0.003	0.002	0.001
PGA (g)	0.247	0.145	0.090	0.028
PGV (m/s)	0.174	0.101	0.062	0.019

Notes: Spectral ($S_a(T)$, where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information



Natural Resources
Canada

Ressources naturelles
Canada

Canada



Appendix F.

General Arrangement Drawing (1997)

Foundation Layout Drawing (1997)

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

DISTRICT NO. 42
CONT No 97-68
WP No 177-89-02



HWY. 401/416 INTERCHANGE
RAMP 416 S.B. CONNECTION
GENERAL ARRANGEMENT

SHEET
180

DELCAN ENGINEERS
PLANNERS

LEGEND

T/P DENOTES TOP OF PAVEMENT
WP DENOTES WORKING POINT

GENERAL NOTES:

CLASS OF CONCRETE

DECK 35 MPa
REMAINDER 30 MPa

CLEAR COVER TO REINFORCING STEEL

FOOTINGS 100 ± 25mm
DECK TOP SLAB, TOP 70 ± 20mm
DECK TOP SLAB, BOTTOM 40 ± 10mm
BOT SLAB, TOP 40 ± 10mm
BOT SLAB, BOTTOM 50 ± 10mm
WEBS 60 ± 10mm
REMAINDER 70 ± 20mm
UNLESS OTHERWISE SPECIFIED

REINFORCING STEEL

1. REINFORCING STEEL SHALL BE GRADE 400 UNLESS OTHERWISE SPECIFIED. BAR SIZES WITH PREFIX "C" DENOTE COATED BARS.
2. UNLESS SHOWN OTHERWISE, TENSION LAP LENGTHS NOT INDICATED ON THE CONTRACT DRAWINGS SHALL BE CLASS B.
3. BAR HOOKS SHALL BE MINIMUM LENGTH AND STIRRUPS SHALL HAVE MINIMUM HOOKS, UNLESS INDICATED OTHERWISE.

CONSTRUCTION NOTES

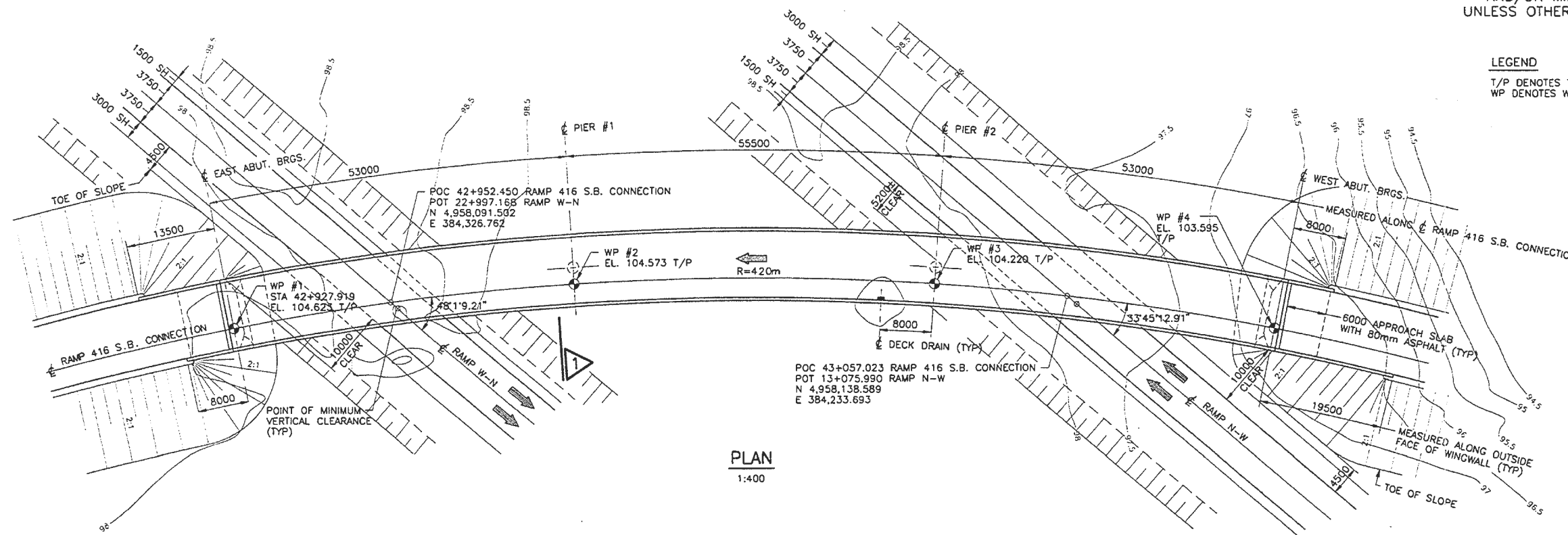
1. THE CONTRACTOR SHALL ESTABLISH THE BEARING SEAT ELEVATIONS BY DEDUCTING THE ACTUAL BEARING THICKNESSES FROM THE TOP OF BEARING ELEVATIONS. IF THE ACTUAL BEARING THICKNESSES ARE DIFFERENT FROM THOSE GIVEN WITH THE BEARING DESIGN DATA, THE CONTRACTOR SHALL ADJUST THE REINFORCING STEEL TO SUIT.
2. IF THE DEPTH OF BLOCKOUT FOR THE SELECTED MODULAR JOINT IS DIFFERENT FROM THAT GIVEN ON THE MODULAR EXPANSION JOINT ASSEMBLY DRAWINGS, THE CONTRACTOR SHALL ADJUST THE DEPTH OF BLOCKOUT AND THE REINFORCING STEEL TO SUIT THE SELECTED MODULAR JOINT.

LIST OF DRAWINGS

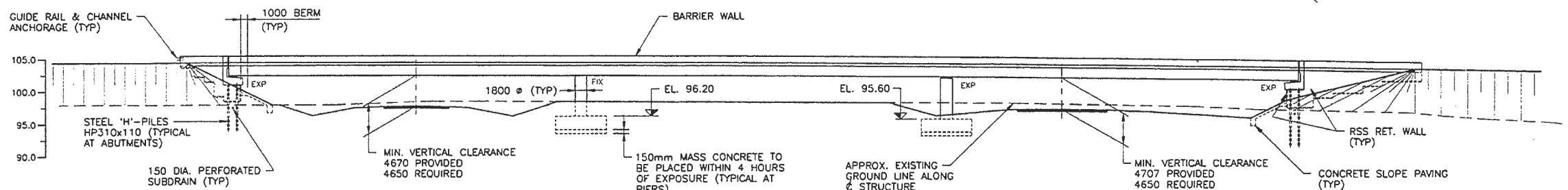
1. GENERAL ARRANGEMENT
2. BOREHOLE LOCATIONS & SOIL STRATA
3. FOUNDATION LAYOUT
4. PIER FOOTING REINFORCEMENT
5. EAST ABUTMENT
6. WEST ABUTMENT
7. RETAINED SOIL SYSTEM (OPTION 1) - PLAN & DETAILS
8. RETAINED SOIL SYSTEM (OPTION 1) - FRONT FACE ELEVATIONS
9. RETAINED SOIL SYSTEM (OPTION 1) - TYPICAL DETAILS
10. RETAINED SOIL SYSTEM (OPTION 2) - WALL ELEVATIONS
11. RETAINED SOIL SYSTEM (OPTION 2) - TYPICAL DETAILS
12. RETAINED SOIL SYSTEM (OPTION 2) - STANDARD DETAIL SHEET
13. RETAINED SOIL SYSTEM (OPTION 2) - WIRE WALL DETAILS
14. PIERS
15. BEARINGS
16. DECK DETAILS
17. LONGITUDINAL TENDONS I
18. LONGITUDINAL TENDONS II
19. TRANSVERSE TENDONS
20. DECK REINFORCEMENT I
21. DECK REINFORCEMENT II
22. DECK REINFORCEMENT III
23. DECK REINFORCEMENT IV
24. EXPANSION JOINT ASSEMBLY - EAST ABUTMENT
25. EXPANSION JOINT DETAILS - EAST ABUTMENT
26. EXPANSION JOINT ASSEMBLY - WEST ABUTMENT
27. EXPANSION JOINT DETAILS I - WEST ABUTMENT
28. EXPANSION JOINT DETAILS II - WEST ABUTMENT
29. BARRIER WALL w/o RAILING
30. BARRIER WALL w/o RAILING ON RSS WALL I
31. BARRIER WALL w/o RAILING ON RSS WALL II
32. 6000mm APPROACH SLAB
33. DETAILS OF CONCRETE SLOPE PAVING
34. AS CONSTRUCTED ELEVATIONS AND DIMENSIONS
35. PILE DRIVING - STEAM & DIESEL HAMMERS
36. ELECTRICAL EMBEDDED WORK
37. STANDARD DETAILS
38. QUANTITIES - STRUCTURES I
39. QUANTITIES - STRUCTURES II

APPLICABLE STANDARD DRAWINGS:

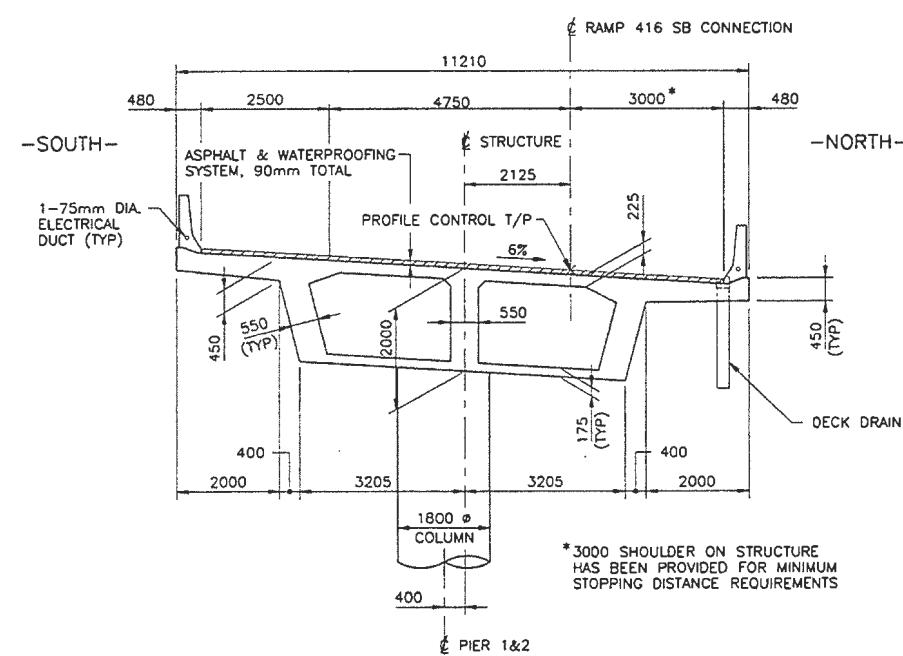
- OPSD-4010.00 GUIDE RAIL AND CHANNEL ANCHORAGE
OPSD-3906.02 BRIDGE DECK WATERPROOFING - HOT APPLIED ASPHALT MEMBRANE WITH ASPHALT IMPREGNATED PROTECTION BOARD
OPSD-3906.03 BRIDGE DECK WATERPROOFING DETAILS AT ACTIVE WIDE CRACKS (GREATER THAN 2mm) AND CONSTRUCTION JOINTS



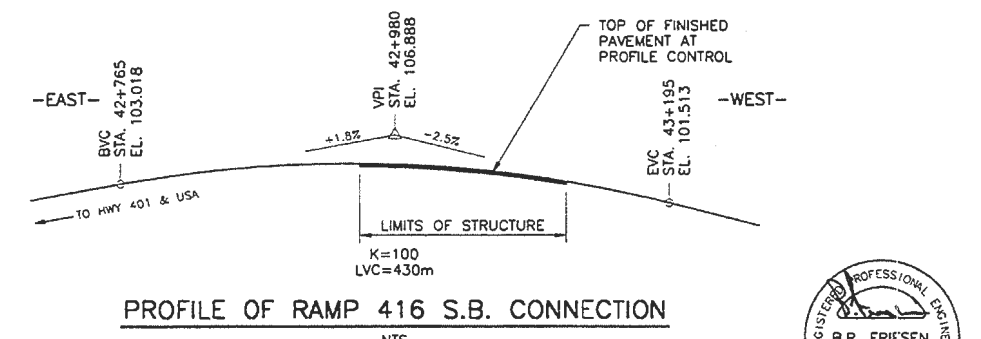
PLAN
1:400



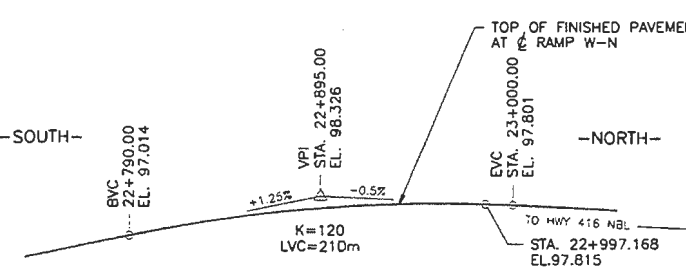
ELEVATION
1:400



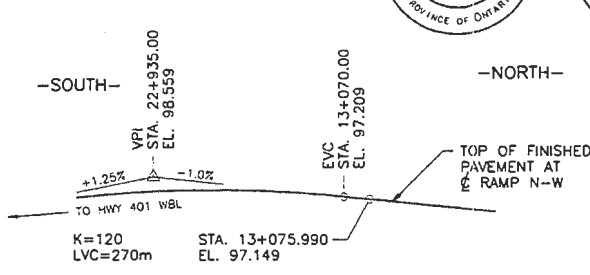
*3000 SHOULDER ON STRUCTURE HAS BEEN PROVIDED FOR MINIMUM STOPPING DISTANCE REQUIREMENTS



PROFILE OF RAMP 416 S.B. CONNECTION
NTS



PROFILE OF RAMP W-N
NTS



PROFILE OF RAMP N-W
NTS



DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

B.M.
EL. 86.347
N.&W. IN N.E. CORNER OF
CONCRETE CULVERT, 21.6m LT.
OF STA. 13+260 HWY. 401

DATE	BY	DESCRIPTION
DESIGN	BRF	CHK DBM CODE OHBC-91 LOAD OHBD DATE NOV 1997
DRAWN	GG	CHK BRF SITE 16-308 DWG. 1

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

CONT No 97-68
WP No 177-89-02



HWY. 401/416 INTERCHANGE
RAMP 416 S.B. CONNECTION

SHEET
182

DELCAN ENGINEERS
PLANNERS

NOTES:

- PILE SPACING IS MEASURED AT THE UNDERSIDE OF FOOTING.
- PILE LENGTHS SHOWN ARE THE THEORETICAL LENGTH BELOW CUT-OFF.
- PILES TO BE DRIVEN IN ACCORDANCE WITH M.T.O. STANDARD SS 103-10 OR SS103-11 USING AN ULTIMATE CAPACITY OF 3450 kN PER PILE.

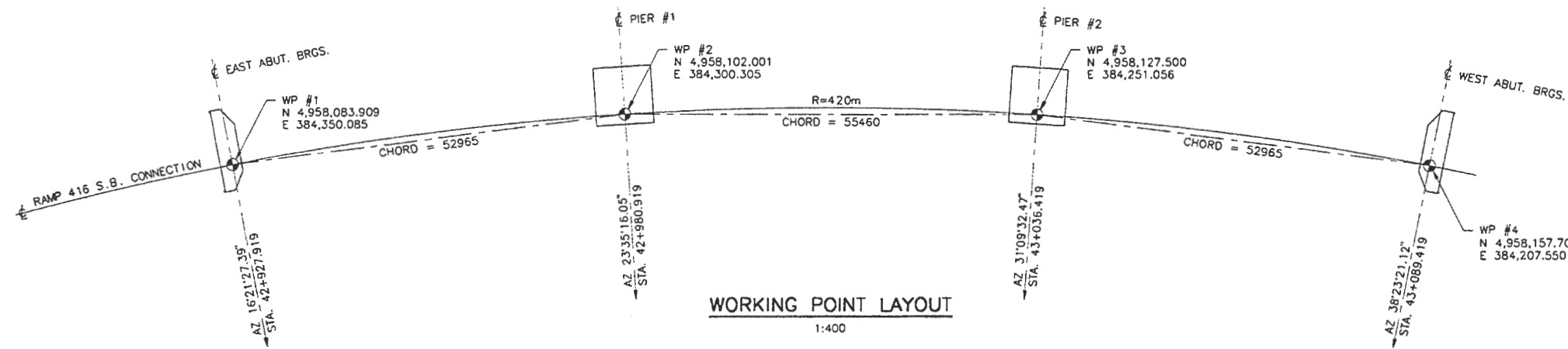
PILE DESIGN DATA

STEEL 'H' PILES:

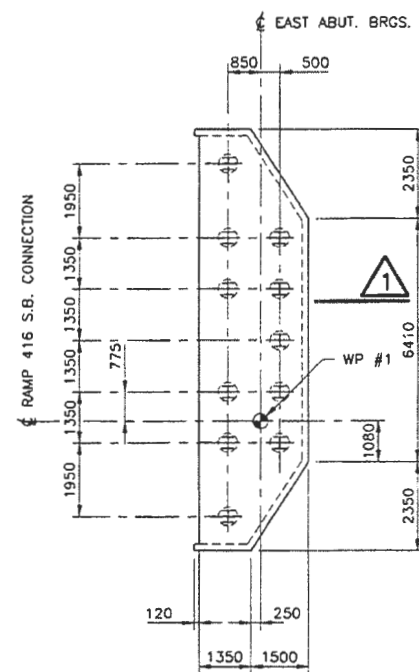
CAPACITY AT SLS = 1150 kN
FACTORED CAPACITY AT ULS = 1600 kN

ABUTMENT CONSTRUCTION SEQUENCE

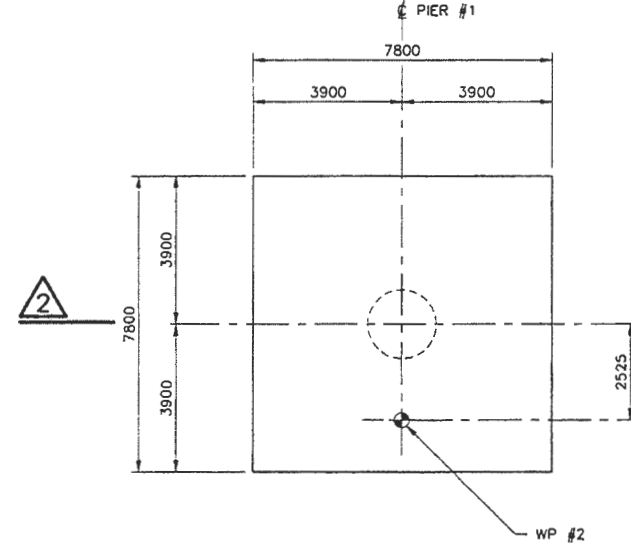
- DRIVE PILES TO REFUSAL; CUT-OFF AT ELEVATIONS INDICATED.
- INSTALL 500mm ϕ GALVANIZED CSP'S AND FILL WITH CONCRETE.
- CONSTRUCT FIRST STAGE OF RSS WALL TO BOTTOM OF PILE CAP/ABUTMENT BEARING SEAT.
- CONSTRUCT WIRE MESH FACING INCLUDING REINFORCING STRIPS/MESH AND EARTH VOLUME TO "FILL LINE AT TIME OF POST TENSIONING". SEE RSS WALL DRAWINGS.
- EXTEND RSS WALLS TO THIS ELEVATION.
- CONSTRUCT PILE CAP/ABUTMENT BEARING SEAT.
- CONSTRUCT CONCRETE DECK, INCLUDING LONGITUDINAL POST-TENSIONING.
- CONSTRUCT REMAINING WIRE MESH FACING FOR BALLAST WALLS INCLUDING REINFORCING STRIPS/MESH AND EARTH VOLUME, AND THE REMAINING RSS WALLS TO THE TOP OF THE WIRE MESH FACING.
- CONSTRUCT BALLAST WALLS.
- CONSTRUCT REMAINING RSS WALLS TO THEIR FINAL ELEVATIONS.



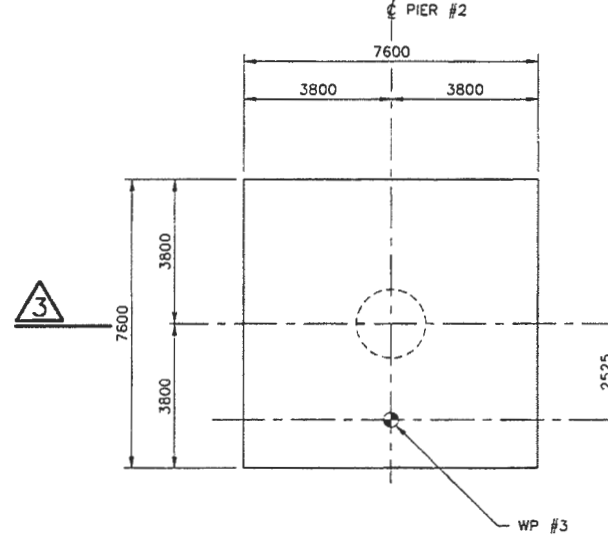
WORKING POINT LAYOUT
1:400



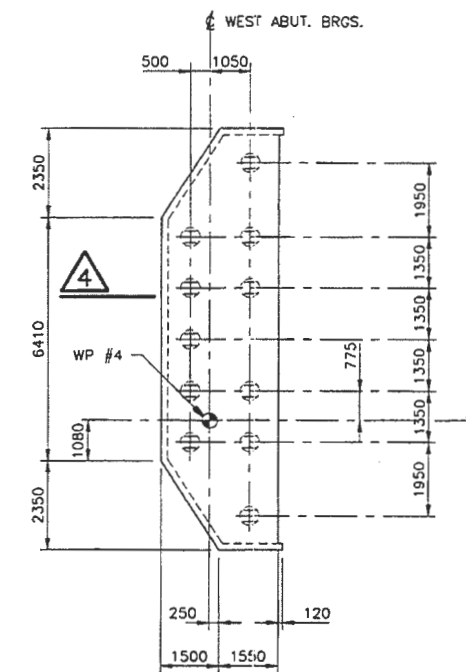
PLAN - EAST ABUTMENT
1:100



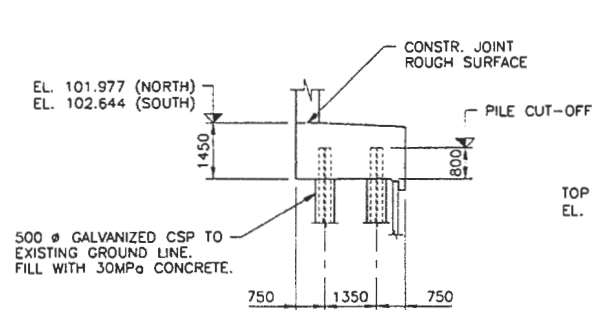
PLAN - PIER #1
1:100



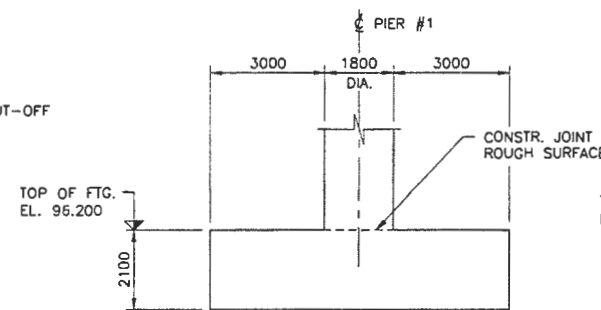
PLAN - PIER #2
1:100



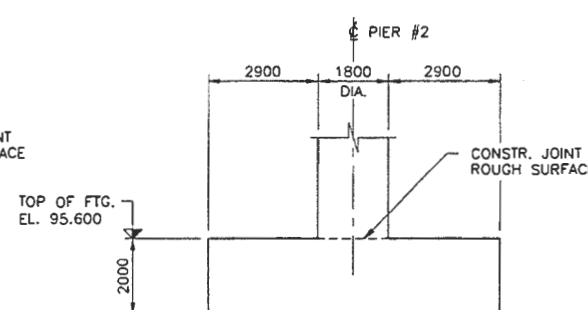
PLAN - WEST ABUTMENT
1:100



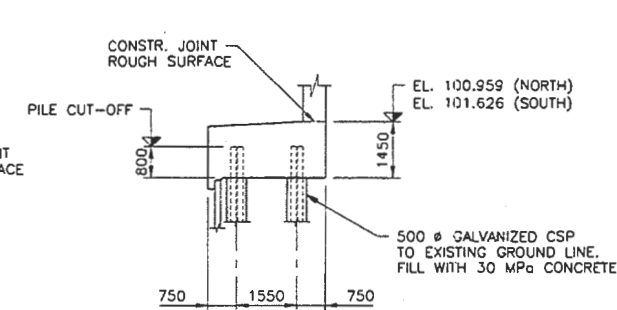
1
1:100



2
1:100



3
1:100



4
1:100

STEEL H-PILE DATA				
LOCATION	BATTER	NO. REQ'D	*LENGTH (m)	TYPE
EAST ABUT	VERTICAL	11	11.7	HP 310 x 110 WITH DRIVING SHOES
WEST ABUT	VERTICAL	11	10.7	

*DUE TO THE NATURE OF THE BOULDERLY MATERIAL USED TO FOUND THE PILES, THE DEPTH TO PILE REFUSAL CANNOT BE ACCURATELY PREDICTED PRIOR TO INSTALLATION.

APPLICABLE STANDARD DRAWINGS:

OPSD-3301.00 (MOD.) SPLICE AND DRIVING SHOE DETAILS FOR STEEL 'H'-PILES.



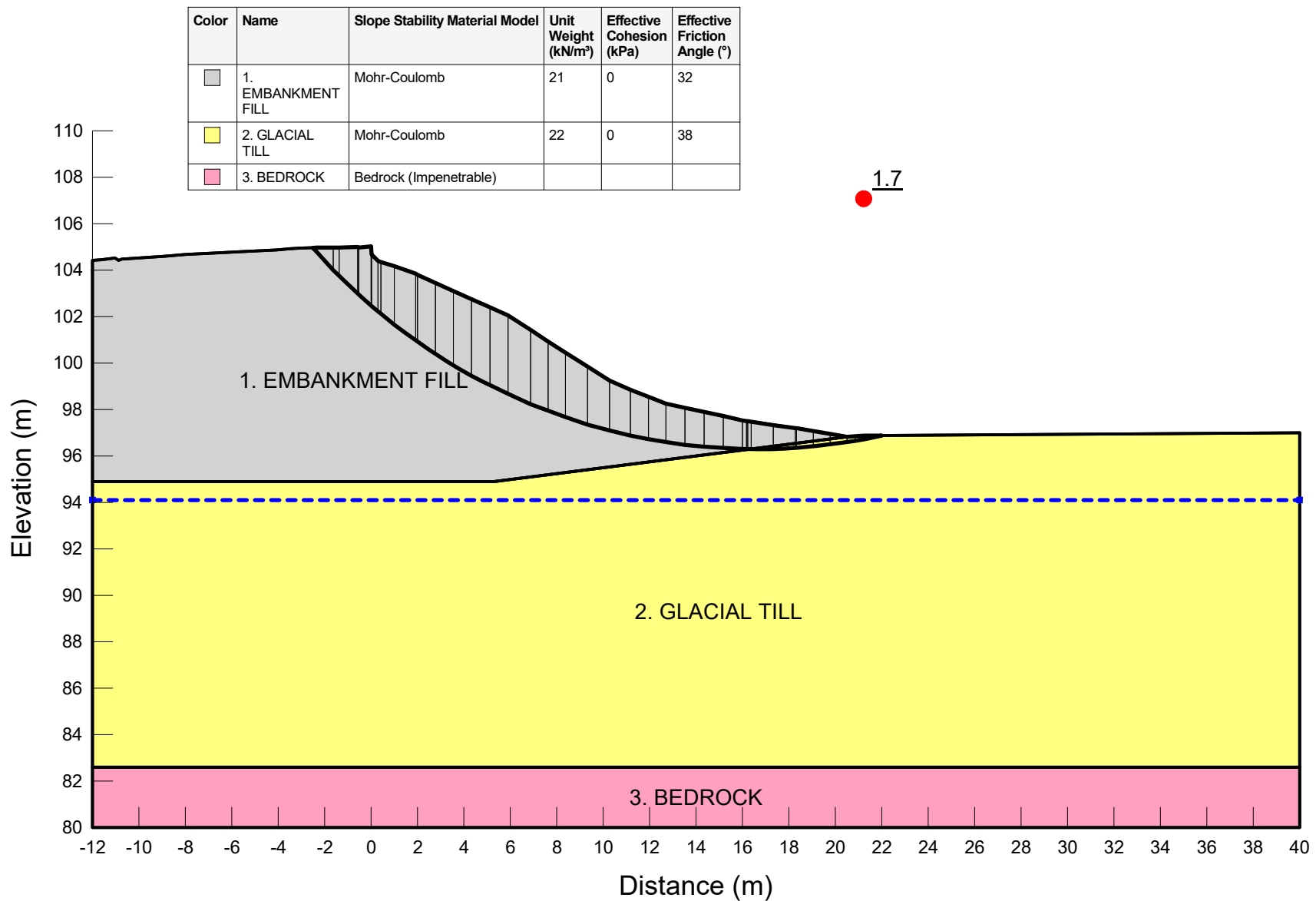
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

DATE	BY	DESCRIPTION
DESIGN	FL/BRF	CHK DBM
DRAWN	GG	CHK BRF
CODE	OHBC-91	LOAD OHBD
SITE	16-308	
DATE	NOV 1997	
DWG.	3	



Appendix G.

Slope Stability Analysis Figures



Project
Hwy 416 SB Connector (Site 16-308) SE Embankment

Analysis
Permanent

Seismic Coefficient
H: g, V: g

Last Run
11/16/2021, 09:39:00 AM

Scale
1:250

Additional Details

Name: 1 16-308: 2H:1V Earth Embankment

Comments:

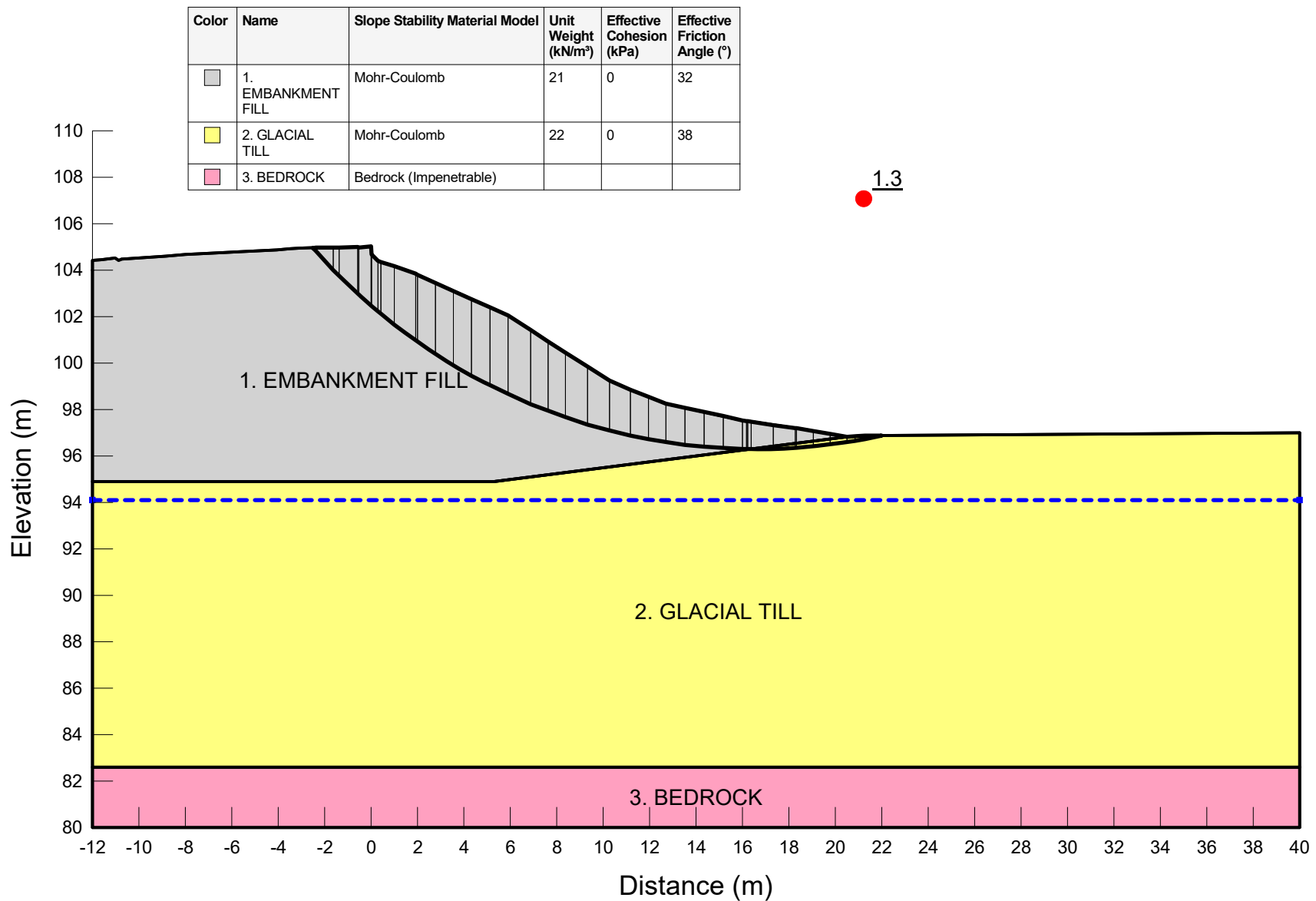
Method: Morgenstern-Price, Half-Sine

Minimum Slip Surface Depth: 2 m

Entry: (-2.4999999, 104.96034) m, Exit: (22, 96.881857) m

Center: (16.5962, 121.6839) m, Radius: 25.3839 m

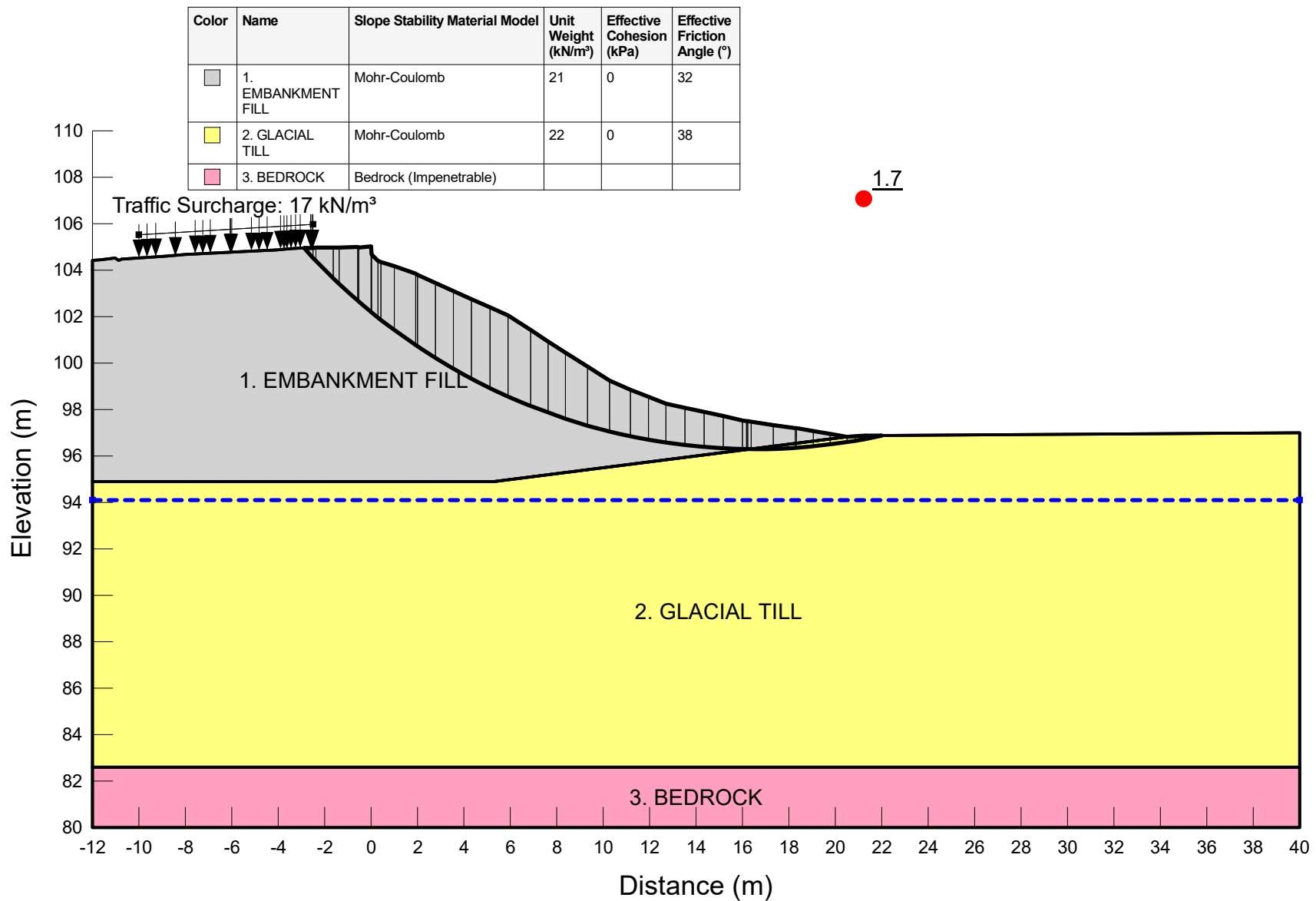
Figure G1



Project		
Hwy 416 SB Connector (Site 16-308) SE Embankment		
Analysis		
Temporary - Pseudo-Static Seismic (2,475-year EQ)		
Seismic Coefficient	Last Run	Scale
H: 0.12g, V: 0g	11/16/2021, 09:39:20 AM	1:250

Additional Details	
Name: 1 16-308: 2H:1V Earth Embankment	
Comments:	
Method: Morgenstern-Price, Half-Sine	
Minimum Slip Surface Depth: 2 m	
Entry: (-2.4999999, 104.96034) m, Exit: (22, 96.881857) m	
Center: (16.5962, 121.6839) m, Radius: 25.3839 m	

Figure G2



Project
Hwy 416 SB Connector (Site 16-308) SE Embankment

Analysis
Temporary - Traffic

Seismic Coefficient
H: 0g, V: 0g

Last Run
11/16/2021, 09:39:41 AM

Scale
1:250

Additional Details

Name: 1 16-308: 2H:1V Earth Embankment

Comments:

Method: Morgenstern-Price, Half-Sine

Minimum Slip Surface Depth: 2 m

Entry: (-2.8772397, 104.94524) m, Exit: (22, 96.881857) m

Center: (16.521137, 122.38586) m, Radius: 26.085861 m

Figure G3