



March 2011

FOUNDATION INVESTIGATION AND DESIGN REPORT

Existing CNR Overhead Retaining Wall D

Widening of Highway 7/8

**From 1.9 km West of Fischer-Hallman Road Interchange
Easterly to 0.8 km East of Courtland Avenue Interchange**

Kitchener

GWP 131-98-00

Ministry of Transportation, Ontario - West Region

Submitted to:

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REPORT



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Table of Contents

PART A - FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	2
2.1 General	2
2.2 Site Geology	2
3.0 INVESTIGATION PROCEDURES	4
4.0 SUBSURFACE CONDITIONS	6
4.1 Site Stratigraphy	6
4.1.1 Pavements	6
4.1.2 Fill	6
4.1.3 Topsoil	7
4.1.4 Silty Sand	7
4.1.5 Sand and Gravel	8
4.1.6 Clayey Silt	8
4.1.7 Sand	8
4.1.8 Silty Clay Till	9
4.1.9 Clayey Silt Till	9
4.1.10 Silt	9
4.1.11 Silty Clay	10
4.1.12 Sandy Silt	10
4.1.13 Sandy Silt Till	10
4.2 Groundwater Conditions	11
5.0 MISCELLANEOUS	13

PART B - FOUNDATION DESIGN REPORT

6.0 ENGINEERING RECOMMENDATIONS	14
6.1 General	14
6.2 Existing Retaining Wall D	14
6.2.1 Foundations	15
6.2.2 Lateral Resistances and Earth Pressures	15
6.3 Alternatives for Retaining Wall Modification	16



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

6.3.1	Additional Design Considerations	17
6.4	RSS Retaining Wall Foundations.....	18
6.4.1	Geotechnical Resistance – Shallow Foundations	18
6.4.2	Resistance to Lateral Forces.....	19
6.4.3	Stability.....	20
6.4.4	Settlement	20
6.5	Lateral Earth Pressures	20
6.5.1	Additional Considerations.....	21
6.6	Anchor Wall.....	22
6.6.1	Placement of Anchor Walls	22
6.6.2	Anchor Wall Capacity	22
6.7	Excavations and Temporary Cut Slopes.....	22
6.8	Construction Considerations	24
7.0	MISCELLANEOUS	26

TABLE I - Comparison of Alternatives for Replacement/Modification of CNR Overhead Retaining Wall D

LIST OF ABBREVIATIONS

LIST OF SYMBOLS

RECORD OF BOREHOLE SHEETS

FIGURE 1 - Key Plan

DRAWING 1 – Borehole Locations and Soil Strata

DRAWINGS 2 AND 3 - Soil Strata

APPENDICES

APPENDIX A

Laboratory Test Data

APPENDIX B

Records of Additional Boreholes

APPENDIX C

Site Photographs

APPENDIX D

Typical Cross-Sections for Modification of CNR Overhead Retaining Wall D



**FOUNDATION INVESTIGATION AND DESIGN REPORT
EXISTING CNR OVERHEAD RETAINING WALL D**

PART A

FOUNDATION INVESTIGATION REPORT

EXISTING CNR OVERHEAD RETAINING WALL D

WIDENING OF HIGHWAY 7/8

FROM 1.9 KM WEST OF FISCHER-HALLMAN ROAD INTERCHANGE

EASTERLY TO 0.8 KM EAST OF COURTLAND AVENUE INTERCHANGE

KITCHENER

GWP 131-98-00

MINISTRY OF TRANSPORTATION, ONTARIO - WEST REGION



1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) has been retained by Dillon Consulting Limited (Dillon) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out foundation investigations as part of the detail design work for GWP 131-98-00, the reconstruction and widening of Highway 7/8. This report presents the results of the foundation investigation conducted for the design of the modifications required for the existing Canadian National Rail (CNR) retaining wall D. The existing CNR overhead retaining wall D is located adjacent to the east bound lane of Highway 7/8, immediately west of the CNR crossing between Stations 16+475 and 16+645.

The purpose of the foundation investigation is to determine the subsurface conditions at the locations of the proposed works by drilling boreholes and carrying out in situ testing and laboratory testing on selected samples. The terms of reference for the scope of work are outlined in the MTO's Request for Proposal, Golder Associates' proposal P81-3002 dated April 8, 2008, our letters dated July 21 and 22, 2008 and our revised scope of work letter dated April 13, 2010. The work was carried out in accordance with our Quality Control Plan for Foundation Engineering dated July 4, 2008.

Dillon provided Golder Associates with preliminary drawings showing the plan and cross sections of the existing retaining wall for this project in digital format.



2.0 SITE DESCRIPTION

2.1 General

The project area of Highway 7/8 is located in the south-central area of Kitchener, Ontario. The site extends from 1.9 km west of Fischer-Hallman Road easterly to 0.8 km east of Courtland Avenue. The location of the project is shown on the Key Plan, Figure 1, and in Photograph 1 of Appendix C.

This section of Highway 7/8 is currently a four lane divided highway oriented generally east-west. Four overpass structures for Westmount Road, Homer Watson Boulevard, Ottawa Street South and Courtland Avenue East, one underpass structure for Fischer-Hallman Road, as well as an overhead structure for the CNR tracks are situated within the project limits.

Land use adjacent to this site is typically urban residential north of Highway 7/8 with predominantly industrial, commercial and institutional properties along the CNR right-of-way. The Rockway Municipal Golf Course is northeast of the proposed site.

The retaining wall was constructed between Stations 16+475 and 16+645 along the southern limit of the Highway 7/8 right-of-way and parallel to Ardelt Place. The east end of the approximately 179 metre long retaining wall is contiguous with the CNR Overhead west abutment wall. During a site visit on June 23, 2009, displacement of Panel 21, the easternmost retaining wall D panel, was noted (See Photographs 2 to 4 in Appendix C). The topography along the toe of the retaining wall slopes eastward towards Schneider Creek from approximately elevation 325 metres at the west end of the wall to elevation 318 metres at the CNR tracks.

2.2 Site Geology

This project lies within the physiographic region of southwestern Ontario known as the Waterloo Hills¹. The soils generally consist of sandy hills; some consist of sandy till while others are kames or kame moraines, with outwash sands deposited in the valleys. Adjoining the sandy hills is the Grand River spillway system comprised of alluvial terraces of sand and gravel.

Based on the Ministry of Northern Development and Mines, Mines and Mineral Division, Ontario Geological Survey Map 2508 entitled "Quaternary Geology, Cambridge Area, Southern Ontario", the site lies in an area of primarily ice contact sands, kames and eskers deposited in the Pleistocene era.

The Geologic Survey of Canada Map 1263A entitled "Geology, Toronto-Windsor Area, Ontario" indicates that the subcropping bedrock in the area of site is dolomite and mudstone of the Salina formation of Upper Silurian age.

¹ L.J. Chapman and D.F. Putnam: The Physiography of Southern Ontario, Third Edition. Ontario Geological Survey, Special Volume 2, 1984.



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

Based on the Ministry of Natural Resources Map P.1985 entitled “Bedrock Topography Series, Southern Ontario”, the bedrock surface at the site subcrops at about elevation 267 metres or some 51 to 58 metres below ground surface in the vicinity of the CNR Overhead and retaining wall D.



3.0 INVESTIGATION PROCEDURES

The field work for the investigation was carried out on November 20 and December 1, 2008 and on May 11 and June 4, 2010 at which time six boreholes (509 to 513) were drilled on Highway 7/8 adjacent to the existing CNR overhead retaining walls. The borehole locations are shown on the Borehole Location Plan, Drawing 1.

In total, six boreholes were advanced to depths of 5.0 to 11.1 metres at or within the immediate vicinity of the existing CNR overhead retaining wall D. It should be noted that borehole 510 was deepened (borehole 510A) approximately 1.0 metres east to obtain further subsurface information at depth. This information was supplemented with boreholes 504 through 506 that were advanced for the original design of the CNR Overhead structure (Geocres No. 40P08-175).

The table below summarizes the borehole locations, ground surface elevations at the borehole locations and the borehole depths:

Borehole	Location (m)		Ground Surface Elevation	Borehole Depth
	Northing	Easting	(m)	(m)
504 (40P08-175)	4 810 440	225 985	318.68	35.14
505 (40P08-175)	4 810 451	225 951	326.53	20.27
506 (40P08-175)	4 810 456	225 966	326.32	41.39
509	4 810 426	225 914	321.89	9.60
510	4 810 410	225 840	325.04	5.03
510A	4 810 410	225 839	325.04	9.60
511	4 810 419	225 835	327.62	9.60
512	4 810 442	225 916	326.92	11.13
513	4 810 406	225 793	328.00	9.60

The field work was carried out using truck mounted CME 45 and CME 75 power augers supplied and operated by specialist drilling contractors. In the boreholes, samples of the overburden were obtained at 0.75 and 1.5 metre intervals of depth using 50 millimetre outside diameter split spoon sampling equipment in accordance with the standard penetration test (SPT) procedures. The samplers used in the investigations limit the maximum particle size that can be sampled and tested to about 40 millimetres. Therefore, particles or objects that may exist within the soils that are larger than this dimension will not be sampled or represented in the grain size distributions. Larger particle sizes, including cobbles and boulders, are known to be present in the glacial till deposits as discussed in the text of this report.

Groundwater conditions were observed throughout the drilling operations and following completion of the field work. 12.5 millimetre diameter standpipes and 12.5 millimetre diameter piezometers were installed in boreholes 504 and 510A to monitor the groundwater conditions within the native soils. The boreholes were backfilled in accordance with current Ontario Ministry of Transportation (MTO) procedures and Ontario Regulation 372/07.



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

The field work was monitored on a full-time basis by experienced members of our engineering staff who located the boreholes in the field, monitored the drilling, sampling and in situ testing operations, logged the boreholes and surveyed the borehole locations and elevations. The samples were identified in the field, placed in labelled containers and transported to our London laboratory for further examination and testing. Index and classification tests, consisting of water content determinations, grain size distribution analyses and Atterberg limits determinations, were carried out on selected samples. The results of the testing are shown on the Record of Borehole sheets and in Appendix A.

The locations of the boreholes are shown on the Record of Borehole sheets and on Drawing 1, attached.

Existing information for the original design of the existing CNR Overhead retaining wall D was reviewed and the relevant Records of Boreholes are attached to this report in their original Imperial format in Appendix B. Data from boreholes 6, 6A, 6B, 7, 8 and 9 from Geocres Report No. 40P08-039 were used to review the initial ground conditions prior to the drilling of the current boreholes. It should be noted that following the construction of the CNR Overhead retaining wall D, the near surface ground conditions presented on the boreholes from Geocres Report No. 40P08-39 are no longer representative of the current ground conditions. The ground conditions at depth generally are in agreement with the soil information presented in the current boreholes.

The locations of the previous boreholes are shown in plan on Drawing 1 and on the Record of Borehole sheets. The location of the boreholes should be considered approximate since the location was referenced to Imperial chainage and offset rather than metric MTM coordinates. The table below summarizes the borehole locations, ground surface elevations at the borehole locations and the depths of the previous boreholes:

Borehole	Location (m)		Ground Surface Elevation	Borehole Depth
	Northing	Easting	(m)	(m)
6 & 6B	4 810 433	225 964	318.55	15.70
6A	4 810 425	225 932	319.40	6.55
7	4 810 418	225 903	320.07	6.55
8	4 810 403	225 843	323.51	6.55
9	4 810 389	225 786	325.28	8.08



4.0 SUBSURFACE CONDITIONS

4.1 Site Stratigraphy

The detailed subsurface soil and groundwater conditions encountered in the current boreholes, together with the results of the in situ and laboratory testing carried out on selected samples, are given on the attached Record of Borehole sheets following the text of this report and in Appendix A. A stratigraphic profile and sections are shown on Drawings 1, 2 and 3. The stratigraphic boundaries shown on the Record of Borehole sheets, profile and cross-sections are inferred from non-continuous sampling and observations of drilling resistance and represent transitions between soil types rather than exact planes of geological change. Subsurface conditions will vary between and beyond the borehole locations.

The boreholes drilled at the site generally encountered highly variable ground conditions, ranging from surficial topsoil and/or variable layers of fill underlain by clayey silt, clayey silt till, silty clay, silty clay till, silt, sandy silt, silty sand, sand and sand and gravel.

The borehole locations and soil stratigraphy are shown on Drawings 1, 2 and 3. The soil stratigraphy, as shown for borehole 504 below elevation 304 metres on Drawing 1 and for boreholes 504 and 506 below elevation 297 metres on Drawing 3, were excluded for clarity since the surficial soils are more critical for the stability of the existing CNR Overhead retaining wall D. A detailed description of the subsurface conditions encountered in the boreholes is provided on the Record of Borehole sheets and is summarized below.

4.1.1 Pavements

Asphaltic concrete was encountered from the ground surface in all boreholes with the exception of borehole 504 (40P8-175), where the asphalt layer was encountered near elevation 318.4 metres below topsoil and surficial granular fill. The thickness of the asphalt ranged from 60 to 150 millimetres.

With the exception of boreholes 510 and 510A, the asphalt is underlain by granular base and subbase materials that ranged in thickness from 230 to 550 millimetres.

4.1.2 Fill

Fill was encountered beneath the topsoil in borehole 504 (40P8-175) from elevation 318.7 metres and beneath the pavement structure from elevation 321.8 to 327.5 metres in the remaining boreholes. The fill was variable, predominantly granular and comprised of sand and gravel, sand, silty sand, and sandy silt with layers of clayey silt or silty sand. In boreholes 506 (40P8-175) and 512, the granular fill was found to be overlying cohesive fill.



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

The cohesive fill comprised clayey silt. The granular fill layers ranged between 0.2 and 8.8 metres in thickness and the cohesive fill layers, where found at depth, were generally 0.3 metres thick.

The very loose to very dense granular fill had N values ranging from 3 to over 100 blows per 0.3 metres. Water contents generally ranged between 2 and 17 per cent. A water content of 35 per cent was obtained from a sand and gravel fill sample that also contained fragments of wood.

The very stiff cohesive fill had an N value of 27 blows per 0.3 metres and water contents of 6 and 14 per cent. The cohesive fill layer is of low plasticity based on a single Atterberg limits determination carried out on a sample retrieved from the standard penetration test. The plastic limit, liquid limit and plasticity index were 17 per cent, 27 per cent and 10 per cent, respectively. The results of the Atterberg limits determination are presented on Figure A-10.

The results of the grain size testing conducted on fill samples are presented on Figure A-1 in Appendix A. The gradation of the cohesive fill, sample 9 of borehole 512, could not be determined due to an insufficient amount of sample.

4.1.3 Topsoil

A 20 millimetre thick layer of topsoil was found at elevation 318.7 at the ground surface of borehole 504 (40P08-175).

Topsoil, organics and wood fragments were encountered in the fill layers at elevation 318.5 and 316.8 metres in borehole 506, at elevation 320.5 metres in borehole 509 and elevation 323.3 metres and 319.9 metres in borehole 512. Materials designated as topsoil in this report were classified solely based on visual and textural evidence. Testing of organic content or for other nutrients was not carried out. Therefore, the use of materials classified as topsoil cannot be relied upon for support and growth of landscaping vegetation.

4.1.4 Silty Sand

Upper silty sand to silty fine sand layers were encountered in borehole 510A beneath the silty clay till from elevation 320.6 metres, beneath the clayey silt in borehole 511 from elevation 322.1 metres and below the sand and gravel in borehole 513 from elevation 324.5 metres. The compact to dense upper silty sand had N values of 10 to 41 blows per 0.3 metres and water contents of 8 to 20 per cent.

Lower silty sand was found at elevation 288.8 metres beneath the silty clay in borehole 504 and at elevation 299.5 metres below a silt layer in borehole 506 (40P08-175). The lower silty sand was dense with N values of 33 and 44 blows per 0.3 metres and water contents of 14 and 19 per cent.

The gradations of five samples of silty sand are shown on Figure A-2.



4.1.5 Sand and Gravel

Deposits of compact to very dense silty sand and gravel to sand and gravel were encountered in boreholes 505 (40P08-175), 506 (40P08-175), 509 and 513 from elevation 298.0 to 324.5 metres. The thicknesses of the sand and gravel layers varied from 0.7 to 1.5 metres. Borehole 505 (40P08-175) was terminated in sand and gravel after exploring for some 0.2 metres.

N values for the sand and gravel in boreholes 506 and 509 were 61 to 75 blows per 0.3 metres, respectively. The sand and gravel in boreholes 505 and 513 has been inferred as compact.

4.1.6 Clayey Silt

Layers of clayey silt were encountered in boreholes 504, 505, 506 (40P08-175) and 511 from elevation 317.3 and 322.4 metres. The clayey silt is interlayered with silt layers in boreholes 502, 504 and 506 (40P08-175). The clayey silt layers ranged between 0.4 and 8.2 metres thick.

The clayey silt had N values of 5 to 29 blows per 0.3 metres indicating a consistency of firm to very stiff. Water contents in the clayey silt ranged from 15 to 21 per cent. The clayey silt is of low plasticity based on plastic limits ranging from 11 to 18 percent, liquid limits ranging from 20 to 34 per cent and plasticity indices ranging from 7 to 17 per cent as determined during the Atterberg limits testing. The Atterberg limits results for six samples of clayey silt are shown on Figure A-10.

The results of the grain size testing conducted on selected clayey silt samples retrieved during standard penetration testing are presented on Figure A-3.

4.1.7 Sand

Compact to very dense sand layers were encountered in boreholes 504 (40P08-175), 505 (40P08-175), 511, 512 and 513 from elevations 294.9 to 321.3 metres. Where fully penetrated, the sand layers ranged from 1.0 to 1.5 metres thick. Boreholes 511, 512 and 513 were terminated in sand after exploring for 0.2 to 2.9 metres.

The sand had N values of 11 to 58 blows per 0.3 metres and water contents of 11 and 14 per cent.

Grain size distribution curves for samples of sand obtained during standard penetration testing are presented on Figure A-4.



4.1.8 Silty Clay Till

Layers of very stiff silty clay till were encountered beneath granular fill in boreholes 510 and 510A at elevations 321.1 and 321.4 metres, respectively. Borehole 510 was terminated in the silty clay till after exploring the layer for 1.1 metres. The silty clay till was found to be about 0.8 metres thick in borehole 510A.

The silty clay till had N values of 16 and 28 blows per 0.3 metres and a water content of 14 per cent. The silty clay till is of intermediate plasticity based on a single Atterberg limits determination that yielded a plastic limit of 17 per cent, a liquid limit of 38 per cent and a plasticity index of 21 per cent. The results of the Atterberg limits test are presented on Figure A-10.

The grain size distribution curve for a single sample of silty clay till is presented on Figure A-5. Although not specifically found in the boreholes, cobbles and boulders should be expected in silty clay till deposits due to the depositional history of the material.

4.1.9 Clayey Silt Till

Clayey silt till was encountered in boreholes 504 (40P08-175) and 512 from elevations 299.4 and 319.6 metres, respectively. The clayey silt till was found underlying layers of silt and clayey silt in borehole 504 (40P08-175) and underlying fill in borehole 512. The thicknesses of the clayey silt till layers were 4.6 and 1.1 metres, respectively.

The very stiff to hard clayey silt till had N values of 16 to 30 blows per 0.3 metres and a water content of 14 per cent. The clayey silt till is of low plasticity with a plastic limit, liquid limit and plasticity index of 15, 25 and 10 per cent, respectively. The Atterberg limits results for the test performed on the clayey silt till are shown on Figure A-10.

The results of the grain size testing conducted on a clayey silt till sample recovered during the standard penetration testing is presented on Figure A-6. Although not specifically encountered in the boreholes, cobbles and boulders should be anticipated in the clayey silt till due to the depositional history of this material.

4.1.10 Silt

Compact to very dense layers of silt were encountered in boreholes 504 (40P08-175), 505, 506 and 512 from elevation 310.1 and 317.8 metres. The silt was found to be interlayered with clayey silt and silt in boreholes 504 (40P08-175) through 506 and sands in borehole 512. The thicknesses of the silt layers ranged from 0.9 to 4.6 metres.

The silt had N values of 14 to 70 blows per 0.3 metres and water contents of 16 to 25 per cent.

Grain size distribution curves for the silts are shown on Figure A-7.



4.1.11 Silty Clay

Layers of silty clay were encountered from elevation 293.4 metres in borehole 504, elevation 296.5 metres in borehole 506 (40P08-175), elevation 316.4 metres in borehole 509 and elevation 318.0 metres in borehole 510A. The silty clay was encountered below sand and gravel in boreholes 506 (40P08-175) and 509, below sand in borehole 504 (40P08-175) and beneath sand in borehole 510A. Where fully penetrated, the thicknesses of the silty clay layers ranged from 3.0 to 7.6 metres. Borehole 510A was terminated in silty clay after exploring it for some 2.6 metres.

The N values in the silty clay ranged from 16 to over 100 blows per 0.3 metres indicating a very stiff to hard consistency. The water contents of the silty clay were 19 to 26 per cent. The silty clay is of intermediate plasticity based on a plastic limit range of 14 to 20 per cent, a liquid limit range of 29 to 45 per cent and a plasticity index range of 15 to 26 per cent as determined by the Atterberg limits tests. The results of the Atterberg limits tests are presented on Figure A-10. It should be noted that the silty clay sample retrieved from the standard penetration testing in borehole 510A contained an appreciable amount of sand.

Grain size distribution curves for samples of the silty clay are shown on Figure A-8.

4.1.12 Sandy Silt

Layers of sandy silt were found in boreholes 504 (40P08-175) from elevation 307.7 metres, borehole 506 from elevation 288.8 metres, borehole 509 from elevation 313.4 metres and borehole 510A from elevation 318.5 metres. The sandy silt was found below clayey silt in borehole 504, silty clay in boreholes 506 and 509 and silty sand in borehole 510A. Where fully penetrated, the sandy silt was found to be 0.5 to 2.1 metres thick. Borehole 509 was terminated in the sandy silt after exploring the layer for 1.1 metres.

N values for the sandy silt ranged from 28 to over 100 blows per 0.3 metres indicating a compact to very dense density. The density of the sandy silt in borehole 510A is inferred as compact. The sandy silt had a water content of 17 per cent.

The results of the grain size analysis conducted on a sample of the sandy silt are presented on Figure A-9.

4.1.13 Sandy Silt Till

Sandy silt till was encountered in boreholes 504 and 506 (40P08-175) from elevation 287.3 metres beneath silty sand and sandy silt layers, respectively. Boreholes 504 and 506 (40P08-175) were terminated in the sandy silt till after exploring it for 3.7 and 2.4 metres, respectively.



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

The sandy silt till was very dense with N values over 100 blows per 0.3 metres. Water contents were 11 and 12 per cent. Although not specifically encountered in the boreholes, cobbles and boulders should be anticipated in the sandy silt till due to the depositional history of this material.

4.2 Groundwater Conditions

The groundwater conditions in all of the current boreholes were monitored during and upon completion of drilling. The observed groundwater conditions are noted on the Record of Borehole sheets and are summarized in the following text and tables.

Summary of Encountered Groundwater Levels

Borehole	Ground Surface Elevation	Encountered Groundwater Level	
		Depth	Elevation
	(m)	(m)	(m)
504 (40P08-175)	318.68	2.1	316.6
505 (40P08-175)	326.53	9.7/16.4	316.8/310.1
506 (40P08-175)	326.32	8.2/17.7	318.1/308.6
509	321.89	3.4	318.5
510	325.04	3.0	322.0
510A	325.04	4.5/9.0	320.5/316.0
511	327.62	7.3	320.3
512	326.92	8.4	318.5
513	328.00	6.7	321.3

Summary of Measured Groundwater Levels

Borehole	Ground Surface Elevation (m)	Installation	Measured Groundwater Elevation (m)				
			Upon Installation	Jun 18/09	Aug 25/09	Jun 30/10	Oct 13/10
504 (40P08-175)	318.68	Shallow Standpipe Deep Piezometer	315.51 312.10	316.17 317.49	The Standpipes were found to be destroyed.	-	-
510A	325.04	Shallow Piezometer (2) Deep Piezometer (1)	321.10 319.69	-	-	320.09 319.86	319.96 319.81



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

Groundwater was encountered between elevations 308.6 and 322.0 metres in the boreholes. Standpipes and/or piezometers were installed in boreholes 504 (40P08-175) and 510A. Monitoring of the installations in borehole 504 (40P08-175) is no longer possible as they were found to be destroyed on August 25, 2009.

The encountered groundwater levels at elevation 318.1 metres in borehole 506 (40P08-175) and at elevation 322.0 metres in borehole 510 are considered to represent perched water in the fill. The encountered groundwater levels in the current boreholes are consistent with levels observed in the boreholes advanced for the 1964 investigation which ranged from elevation 316.0 to 321.5 metres (Geocres No. 40P08-36). The inferred groundwater level at the site varies as follows:

Station	Inferred Groundwater Elevation
(m)	(m)
16+450	321.0
16+500	320.0
16+575	318.5
16+625	317.5
16+640 (CNR tracks)	317.0

The inferred groundwater levels are based on encountered groundwater levels, measured groundwater levels and the colour change from brown to grey.

The above-noted water levels are considered to be representative of the long-term, stabilized groundwater conditions as readings were taken during the fall and late spring seasons. However, the groundwater levels are expected to fluctuate locally due to climatic and seasonal variations.



5.0 MISCELLANEOUS

This investigation was carried out using equipment supplied and operated by Aardvark Drilling Ltd. and All-Terrain Drilling Ltd., who are Ontario Ministry of Environment licensed well contractors. The field operations were supervised by Mr. Michael Arthur, Mr. Jordan Black and Mr. Matthew Rhody under the direction of Mr. David J. Mitchell.

The laboratory testing was carried out at Golder Associates' London laboratory under the direction of Mr. Chris M. Sewell. The laboratory is an accredited participant in the MTO Soil and Aggregate Proficiency Program and is certified by the Canadian Council of Independent Laboratories for testing Types C and D aggregates. This report was prepared by the Project Engineer, Ms. Dirka U. Prout, P.Eng., under the direction of the Team Leader, Mr. Philip R. Bedell, P.Eng. This report was reviewed by Mr. Fintan J. Heffernan, P.Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

GOLDER ASSOCIATES LTD.

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**FOUNDATION INVESTIGATION AND DESIGN REPORT
EXISTING CNR OVERHEAD RETAINING WALL D**

PART B

FOUNDATION DESIGN REPORT

EXISTING CNR OVERHEAD RETAINING WALL D

WIDENING OF HIGHWAY 7/8

FROM 1.9 KM WEST OF FISCHER-HALLMAN ROAD INTERCHANGE

EASTERLY TO 0.8 KM EAST OF COURTLAND AVENUE INTERCHANGE

KITCHENER

GWP 131-98-00

MINISTRY OF TRANSPORTATION, ONTARIO - WEST REGION



6.0 ENGINEERING RECOMMENDATIONS

6.1 General

This section of the report provides our recommendations on the foundation aspects of the design for modification of the existing retaining wall D of the Canadian National Railway (CNR) Overhead structure at Site No. 33-225. The recommendations are based on our interpretation of the factual information obtained during the investigation. It should be noted that the interpretation and recommendations are intended for use only by the design engineer. Where comments are made on construction they are provided only in order to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The width of the proposed embankment widening along existing CNR Overhead retaining wall D will vary from three (3) metres near the western end to four (4) metres at the eastern end where the wall returns to join with the west abutment face of the overhead structure. There will also be a 0.3 metre grade raise in the area of the existing retaining wall. The east end of CNR Overhead retaining wall D is exhibiting evidence of post construction rotation as demonstrated by the displacement of Panel 21. An assessment of the condition of the existing wall was conducted and preliminary foundation engineering comments provided in a Technical Memorandum issued to Dillon on November 8, 2010. The assessment indicated that the wall was subject to sliding east of approximately Station 16+575 Rt. West of Station 16+575 Rt, the analysis indicated that the existing wall is stable. It was determined that modification or replacement of the retaining wall D would be necessary in order to safely accommodate the proposed widening at this location.

6.2 Existing Retaining Wall D

As-built drawings for this structure are not available. Therefore, it has been assumed that retaining wall D was constructed in general conformance with the proposed design as shown on the following Department of Highways Ontario (DHO) drawings prepared in June 1967 for the Kitchener-Waterloo Expressway CNR Overhead structure under Contract No. 67-170:

- D-5637-1 – General Arrangement
- D-5637-12 – General Layout of Retaining Walls
- D-5637-13 – Detail of Panels – Retaining Wall “D”

The retaining wall was designed with 21 panels 8.53 metres in length for a total length of 179.22 metres. The design wall height, defined as the distance between the top of the wall and the top of the footing, varied between 4.12 metres at Panel 1 at the west end and 7.97 metres at Panel 20 at the east end.



A 1.8 metre wide zone of granular backfill was to have been placed between the rear of the wall and the general earth backfill for the Highway 7/8 platform. The ground surface in front of the retaining wall is generally horizontal. There was to be a 2 horizontal to 1 vertical backslope immediately behind the retaining wall forming of a swale with a 3 horizontal to 1 vertical slope behind the swale to the Highway 7/8 platform. The ground surface behind the swale in the curved portion of the wall (Panels 20 and 21) is sloped at between 2 and 3 horizontal to 1 vertical. The overall inclinations of the slope behind the wall is approximately 11 degrees to the horizontal.

Based on the results of the investigation and water level measurements, it appears that the existing retaining wall drainage system is functioning appropriately; however, the extent and nature of the granular drainage layer shown behind the wall on the design drawings has not been confirmed.

6.2.1 Foundations

The retaining wall is founded on a spread footing which ranges from 2.21 to 4.16 metres in width and is generally 0.6 metres in height except at Panels 20 and 21 where it is 0.7 metres high. The design founding elevation stepped from elevation 322.2 metres at the west end to 315.7 metres at the east end. The footing design incorporated a 0.4 metre wide shear key and there was to be cantilevered interlocking steel piling driven to elevation 314.6 metres at the wall toe. The existence of the 1.8 metre wide granular backfill zone could not be verified as there was no access behind the retaining wall for drilling equipment. Verification of the footing dimensions and elevations and presence of the cantilever interlocking sheet piling was not carried out as these structures are buried under the northern sidewalk of Ardelt Place.

Geotechnical Resistances

Based on the soils encountered in the current boreholes, the retaining wall footing is founded in primarily compact to dense sands between Stations 16+475 and 16+600. In localized areas, the footings may be founded in very stiff silty clay till or very dense sand and gravel. East of Station 16+600, the footing is likely founded in the stiff to very stiff clayey silt which is interlayered with compact to dense silt. Assuming a footing width of 2 to 4 metres, a factored geotechnical resistance of 300 kilopascals at Ultimate Limit States (ULS) and a geotechnical resistance of 200 kilopascals at Serviceability Limits States can be used for analysis of the existing wall and its foundations.

6.2.2 Lateral Resistances and Earth Pressures

The resistance to lateral forces/sliding resistance between the compacted granular fill and the subgrade soils should be calculated in accordance with Section 6.7.5 of the Canadian Highway Bridge Design Code (CHBDC). Also, the retaining wall shall be checked for overturning. The following angles of friction and corresponding



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

unfactored coefficient of friction, $\tan \delta$, may be used for the interaction between the concrete footings and the founding soil:

Footings on sands/sand and gravel	angle of friction $\tan \delta$	30° 0.58
Footings on clayey silt/silty clay till	angle of friction $\tan \delta$	28° 0.53
Footings on silt	angle of friction $\tan \delta$	29° 0.55

In accordance with the CHBDC, a factor of 0.8 is to be applied in calculating the horizontal resistance. The lateral earth pressures are based on the existing embankment fill materials and the following parameters (unfactored) may be assumed:

Soil unit weight:	20 kN/m ³
Coefficients of lateral earth pressure:	
Active, K_a (2 horizontal to 1 vertical slope)	0.53
Active, K_a (10 degree slope)	0.38
Passive, K_p (horizontal surface)	3.00

6.3 Alternatives for Retaining Wall Modification

Four alternatives are proposed for modification of the existing CNR Overhead retaining wall D and are briefly discussed below to accommodate the approximately 48 per cent increase in load resulting from the highway improvements. A comparative summary of the advantages, disadvantages, estimated costs and risk/consequences associated with these alternatives is presented in Table I. Typical cross-sections are shown in Appendix D on Figures D-1 to D-4 for the conditions at Station 16+575. It should be noted that these conditions do vary along the length of the wall.

- Remove the wall and replace with a new Reinforced Soil System (RSS) wall. This will require a new wall approximately 9 metres in height with an extensive excavation as shown on Figure D-1.
- Raise the wall to accommodate a 2 horizontal to 1 vertical slope and a drainage swale behind the wall. Reinforcement of the wall would also be required, typically using grouted earth anchors in the existing embankment fill as shown on Figure D-2. This option requires the services of a specialist subcontractor working from staging on the existing roadway and relies on developing adjacent anchorage in the existing embankment fill. A new concrete facing for the wall would be required.
- Construct an RSS wall behind and above the existing wall and reinforce the existing wall using tiebacks. This option allows the installation of an anchor block wall, or a steel sheet pile anchor wall in the open cut for the RSS wall as shown on Figure D-3. A new concrete facing for the wall would be required.



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

- iv) Construct a geo-reinforced slope with an inclination as steep as 1 horizontal to 1 vertical behind and above the existing wall and reinforce the existing wall using grouted earth anchors as shown on Figure D-4. This results in two specialist contractors being required and provision of a new wall facing.

Consideration may also be given to the use of light weight materials to replace a portion or all of the existing wall backfill. The use of expanded slag was ruled out due to the extent of the replacement required and problems associated with the in situ density increasing with time as the slag absorbs water. The use of expanded polystyrene foam blocks was dropped due to the very high cost. The use of shredded rubber tires was not considered feasible due to the extended period of time required to obtain a permit from the Ministry of the Environment for a landfill site.

Options ii), iii) and iv) result in additional loads being applied to the existing wall. Further, only options i) and iii) are compatible with a future widening to 8 lanes.

Option iii) is the least expensive option with Option iv) being the most expensive alternative. Cost analyses prepared by Dillon have indicated that where grouted earth anchors have been proposed, the substitution of a tie-rod and anchor wall system results in construction savings.

Overall, Option i) is the preferred option from foundation engineering, financial and long term performance perspectives.

6.3.1 Additional Design Considerations

RSS Walls/Slopes

Options i), iii) and iv) require construction of RSS walls and slopes. It is preferred that utilities with alignments parallel to the RSS wall/slope face not be placed within the reinforcement zone. The design of the RSS retaining walls must consider the proposed highway infrastructure such as culverts, overhead signs and noise barrier walls. This may require construction of a structural frame around the obstruction or splaying or full or partial omission of reinforcement in the area of the obstruction. The adjacent reinforcement must be designed to accommodate the additional loading resulting from removal of reinforcing elements in the area of the obstruction.

Grouted Earth Anchors, Tiebacks and Anchor Walls

The embankment fill at the CNR Overhead site is predominantly granular in nature and consists of very loose to very dense, variable layers of sand, sand and gravel and sandy silt with N values ranging from 3 to over 100 blows per 0.3 metres. N values in the fill were generally greater than 10 blows per 0.3 metres except for a loose zone between elevation 317.8 and 319.8 metres in borehole 509 and very loose to loose between elevation 321.1 and 323.7 metres in borehole 510 and 510A. In these areas, it may be necessary to modify the design or extend the earth anchors into the native materials. It is not anticipated that grouted earth anchors would be



placed in these zones. Grouted earth anchors, tiebacks and anchor walls are expected to be installed well above the groundwater level which is below the base of the fill. While the fill is considered to be capable of supporting the anchor walls, the design and installation of reliable grouted earth anchors or the like will be more difficult and appropriately cautious design assumptions and full scale load testing will be required for each grouted anchor.

Anchors should be designed and constructed in accordance with SP 999S26.

6.4 RSS Retaining Wall Foundations

The RSS wall is to be designed and constructed in accordance with Special Provision (SP) 599S22. If Option i) is selected, the replacement RSS wall can be founded at elevations similar to the footing for existing retaining wall D using the geotechnical resistances and parameters recommended for lateral resistances and earth pressure as noted in Sections 6.2.1 and 6.2.2.

The following recommendations pertain to Option iii) where the new RSS wall will be constructed within the existing fill.

6.4.1 Geotechnical Resistance – Shallow Foundations

An RSS wall constructed for Option iii) can be founded in the existing compact to very dense granular fill. A factored geotechnical resistance at ULS of 225 kilopascals and a geotechnical resistance of 150 kilopascals at SLS may be used for design purposes assuming a maximum footing width of 21 metres for the full face panel footing. The SLS value allows for 25 millimetres of settlement. Additional settlement will occur as a result of the embankment widening.

Alternatively, an RSS wall footing designed with the geotechnical resistances given above may be founded on a 0.3 metre thick compacted Granular A levelling pad constructed on the surface of the granular fill. It is anticipated that the reinforced width of the RSS wall would be approximately 75 per cent of the wall height.

A further alternative would consist of founding the RSS wall facing on the existing concrete walls after it has been lowered to 0.3 metres below ground level and capped with concrete.

Frost Protection and Embedment

All RSS retaining wall foundations consisting of strip footings should be provided with adequate embedment and frost protection comprised of 1.4 metres of soil cover or thermal equivalent. The RSS walls founded on levelling pads should also have sufficient embedment. The embedment depth, defined as the distance from the top of the



levelling pad to the top of the adjoining finished grade at the toe of the wall, should be no less than 0.6 metres or the maximum of:

- 0.5 metres;
- The minimum depth required for overall stability;
- $H/20$ – if the area in front of the wall is horizontal; or
- $H/7$ – if the area in front of the wall slopes at 2 horizontal to 1 vertical.

where H is the total wall height.²

In general, the embankment slope in front of the wall will be sloped at 2 horizontal to 1 vertical. To improve resistance to general bearing failure and to provide access for future maintenance and repairs, each RSS retaining wall should be provided with a bench in front of the wall with a minimum width of 1.0 metres measured from the face of the wall.

6.4.2 Resistance to Lateral Forces

The lateral pressures acting on the retaining wall will depend on the backfill soils, the type and method of placement of the backfill materials behind the wall, the subsequent lateral movement of the structure and the provision of reinforcement grids if an RSS wall is constructed.

The resistance to lateral forces/sliding resistance between the compacted granular fill (assumed to be Granular A) and the subgrade soils should be calculated in accordance with Section 6.7.5 of the Canadian Highway Bridge Design Code (CHBDC). Also, the retaining wall shall be checked for overturning. Assuming that the founding soils are not loosened/disturbed during excavation and footing construction, the following angles of friction and corresponding unfactored coefficient of friction, $\tan \delta$, may be used for the interaction between the concrete and the founding soil:

Spread footings on existing fill	angle of friction $\tan \delta$	30° 0.58
RSS wall levelling pad on existing fill	angle of friction $\tan \delta$	35° 0.70

In accordance with the CHBDC, a factor of 0.8 is to be applied in calculating the horizontal resistance.

² FHWA (2001). Mechanically Stabilized Earth Walls and Reinforced Soil Slopes: Design and Construction Guidelines. FHWA-NHI-00-043. Federal Highway Administration, Washington, D.C., USA.



6.4.3 Stability

The Factor of Safety related to the global stability under static loading for properly designed and constructed RSS walls at this site is greater than 1.3. The design and construction of the RSS wall should be carried out in accordance with the manufacturer's design recommendations. The internal stability of the mechanically-reinforced soil walls should be verified by the RSS supplier/designer.

Upon completion of the detail design, the RSS wall designer/supplier should provide analyses of the internal, external, global and compound stability confirming that the RSS retaining wall to be constructed at this site will be stable.

6.4.4 Settlement

The magnitude of the grade raise along CNR Overhead retaining wall D will be approximately 0.3 metres. The existing embankment fill in this area consists of granular material. The embankments were constructed on a competent foundation consisting of dense to very dense sand to sand and gravel and stiff to very stiff clayey silt to very hard clayey silt till interlayered with compact silt and silty sand to sandy silt. Based on these foundation conditions, and noting that the volume of fill to be placed above the wall for the proposed RSS wall will be relatively low, it is anticipated that the resulting total settlement will be less than 10 millimetres. Settlement of the existing embankment fill will be additional and is expected to be complete at the end of construction.

6.5 Lateral Earth Pressures

The lateral pressures acting on the existing CNR Overhead retaining wall D and on the new RSS walls will depend on the type and method of placement of the backfill materials, on the nature of the soils behind the backfill, on the freedom of lateral movement of the structure and on the drainage conditions behind the walls. The following recommendations are made concerning the design of the retaining walls in accordance with the CHBDC:

- Select, free-draining granular fill meeting the specifications of Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B but with less than 5 per cent passing the 0.075 micron sieve should be used as backfill behind the new retaining wall. This fill should be compacted in loose lifts not greater than 200 millimetres in thickness in accordance with SP105S10. Longitudinal drains and weep holes should be installed to provide positive drainage of the granular backfill.
- A compaction surcharge equal to 12 kilopascals should be included in the lateral earth pressures for the structural design of the new RSS wall in accordance with CHBDC, Figure 6.6. Compaction equipment should be used in accordance with SP105S10.



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

- In accordance with CHBDC Clause C6.9.1, the granular fill may be placed either in a zone with a width equal to at least 1.4 metres behind the back of the reinforced mass (Case a from Commentary on CHBDC, Figure C6.20) or within the wedge-shaped zone defined by a line drawn at 1.5 horizontal to 1 vertical extending up and back from the rear face of the reinforced mass (Case b from Commentary on CHBDC, Figure C6.20).
- For Case a, the pressures are based on the proposed embankment fill materials and the following parameters (unfactored) may be used assuming the use of Select Subgrade Material (SSM):

Soil unit weight:	20 kN/m ³
Coefficients of lateral earth pressure:	
Active, K_a	0.33
At rest, K_0	0.50
Passive, K_p	3.0

- For Case b, the pressures are based on the granular fill as placed and the following parameters (unfactored) may be assumed:

	<u>GRANULAR A</u>	<u>GRANULAR B</u> (Type III)
Soil unit weight:	22 kN/m ³	21 kN/m ³
Coefficients of lateral earth pressure:		
Active, K_a	0.27	0.31
At rest, K_0	0.43	0.47

- If the wall support and superstructure allow lateral yielding of the stem, active earth pressures may be used in the geotechnical design of the structure. If the wall support does not allow lateral yielding, at-rest earth pressures should be assumed for geotechnical design.

It should be noted that the above design parameters assume level backfill and ground surface behind the wall. For sloping backfill/ground surface, these parameters should be adjusted as indicated in Section C6.9.1 (e) of CHBDC.

6.5.1 Additional Considerations

Analysis of the lateral earth pressures on the existing CNR Overhead retaining wall D for Options ii) to iv) is to include surcharge loadings applicable to construction of the new RSS wall or slope, and if applicable, placement of additional fill including compaction activities and the like. The unbalanced earth pressures on the wall applicable for Option iii) including the effects of the RSS wall may be estimated using the attached Figures D-5a through D-5c for Stations 16+475, 16+575 and 16+625, respectively.

The design of an RSS wall for Option iii) must consider the presence of the anchor wall.



6.6 Anchor Wall

The anchor wall will be constructed in the existing fill which consists primarily of very loose to very dense but generally compact to dense sand and gravel, sand, silty sand and sandy silt. The inferred groundwater level along the length of the wall varies from elevation 317 to 321 metres with localized areas of perched groundwater in the fill near Stations 16+500 and 16+625.

6.6.1 Placement of Anchor Walls

Where feasible, the walls should be designed to ensure that there is no overlap between the passive and active zones, as shown on Figure D-3, and preferably within the shaded zone to develop full anchor capacity.

6.6.2 Anchor Wall Capacity

The deadman anchor wall capacity may be estimated using:

Coefficient of active earth pressure	0.33
Coefficient of passive earth pressure	3.0
Total unit weight of soil	20 kN/m ³

The earth pressure coefficients are based on a horizontal surface at the top of the existing wall and a surcharge equal to half the height of the RSS wall. The design of the anchor wall must consider the surcharge loadings for traffic, compaction and the like.

6.7 Excavations and Temporary Cut Slopes

All excavations should be carried out in accordance with the guidelines outlined in the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. Replacement of the existing CNR Overhead retaining wall D with a new RSS wall (Option i) will require excavation of the existing fills and penetration into the native surficial sands, silts, clayey silt, clayey silt till and silty clay till. Construction of footings for a replacement RSS wall will require dewatering of the granular fill where perched groundwater is present in the fill, and the saturated native sands and silts located below elevations 317 to 321 metres. Provision of temporary roadway protection will be necessary with this option.



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

Construction of a new RSS wall or slope for the widening (Options iii and iv, respectively) will require sub-excavation of the existing embankment fill only. Excavations for these options are expected to terminate above the groundwater level.

The groundwater level is expected to fluctuate and the depth of the groundwater table below the excavation base will depend on the time of year of construction. Sumps should be maintained outside of the actual footing limits. Surface water runoff should be directed away from the excavations at all times. The appropriate Non Standard Special Provision (NSSP) should be included in the contract documents to alert the contractor to the need for control of surface flows and the requirement for dewatering, if applicable.

The fill materials at this site would be classified as Type 3 soils as would any cohesionless materials below the groundwater level. The native clayey silt till, silty clay till, clayey silt, silty clay and properly dewatered cohesionless materials would be classified as Type 2 soils.

Temporary open cut slopes within the fill materials should be maintained no steeper than 1 horizontal to 1 vertical. Where space is restricted and will not permit open cuts, a temporary roadway protection support system should be installed to support the sides of the excavation and permit the use of vertical cuts. The temporary support system could consist of soldier piles and lagging where the H-piles would be driven to a suitable depth and horizontal lagging installed as the excavation proceeds or could consist of driven steel sheet piling. Support to the system could be in the form of struts and walers in the case of footing excavations or rakers and anchors in the case of roadway protection. The raker/anchor support must be designed to accommodate the loads applied from pressures and surcharge pressures from area, line or point loads as well as the impact of sloping ground behind the system. The temporary excavation support system should be designed and constructed in accordance with OPSS 539. The lateral movement of the temporary shoring system should meet Performance Level 2.

Passive toe restraint to the soldier piles may be determined using a triangular pressure distribution acting over an equivalent width equal to three times the pile socket diameter.

The unfactored triangular earth pressure distribution (p in kN/m^2 ; increasing with depth), can be calculated as follows:

$$\begin{aligned} p &= K_a (\gamma H + q) \\ \text{where } H &= \text{the height of the excavation at any point in metres} \\ K_a &= \text{active coefficient of earth pressure} \\ \gamma &= \text{soil unit weight} \\ q &= \text{surcharge for traffic and other loading} \end{aligned}$$

For the granular fill and native materials, the unfactored rectangular earth pressure distribution (p in kN/m^2 ; constant with depth), can be calculated as follows:

$$p = 0.65 K_a (\gamma H + q)$$



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

where H = the total height of the excavation
 K_a = active coefficient of earth pressure
 γ = soil unit weight
 q = surcharge for traffic and other loading

For the cohesive native materials, the unfactored trapezoidal earth pressure distribution (p in kN/m^2 ; varying with depth); can be calculated as follows:

p = $0.2\gamma H_T$ to $0.4\gamma H_T$
where H_T = the total height of the excavation
 γ = soil unit weight
 q = surcharge for traffic and other loading

The support systems may be designed using the following parameters:

Soil Type	Coefficient of Earth Pressure			Angle Of Internal Friction (degrees)	Unit Weight (kNm^{-3})
	Active, K_a	At Rest, K_o	Passive, K_p		
Granular Fill	0.33	0.50	3.0	30	19.0
Cohesive Fill	0.39	0.56	2.6	26	18.0
Clayey Silt and Silty Clay	0.38	0.55	2.7	27	19.0
Silt, Silty Sandy Silt and Sand	0.35	0.52	2.9	29	20.0
Glacial Till	0.33	0.50	3.0	30	21

The earth pressure coefficients noted above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are present, the coefficients should be adjusted accordingly.

6.8 Construction Considerations

Excavation, backfilling and inspection of the proposed RSS walls should be conducted in accordance with OPSS 902.

Should Option i) be pursued, care should be taken during construction to avoid disturbance of the clayey silt subgrade and silt subgrade prior to concrete placement. Placement of a working slab will be required at the base of the excavation for the concrete footing area. Exposure without the protection of a working slab may result in loosening of the founding soils. The cleaned excavation base should be inspected by the Quality Verification



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

Engineer (QVE) prior to placing the working slab. The footing excavation should be carried out such that the final 0.5 metres of excavation is completed with the QVE on site and that the working slab be placed immediately after footing inspection.

The appropriate NSSP should be included in the Contract Documents to highlight the potential for encountering cobbles and boulders during excavation and/or anchor installation in the glacial tills.



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

7.0 MISCELLANEOUS

This report was prepared by Ms. Dirka U. Prout, P.Eng. under the direction of the Team Leader, Mr. Philip R. Bedell, P.Eng. This report was reviewed by Mr. Fintan J. Heffernan, P.Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

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TABLE I

**COMPARISON OF ALTERNATIVES FOR REPLACEMENT/MODIFICATION OF
CNR OVERHEAD RETAINING WALL D**

Widening of Highway 7/8
GWP 131-98-00

REMEDIATION/ REPLACEMENT OPTION	ADVANTAGES	DISADVANTAGES	RELATIVE COSTS¹	RELATIVE RISKS/ CONSEQUENCES²
Replace existing retaining wall with new RSS wall (Option i)	<ul style="list-style-type: none"> • Can accommodate future widening to eight lanes. • Problems with displacement of existing wall eliminated. • Option with most straightforward construction. • May be completed with a single specialist contractor already on site. • Preferred technical option. 	<ul style="list-style-type: none"> • Less extensive excavation, than Option iii). • Option with the least traffic disruption to both Ardelt Place and Highway 7/8. • Restrictions on construction of future roadway/infrastructure must be enforced within reinforced zone. 	<ul style="list-style-type: none"> • Second least costly option. 	<ul style="list-style-type: none"> • Lowest overall risk of excessive wall deformation.
Reinforce with grouted earth anchor and extend existing retaining wall (Option ii)	<ul style="list-style-type: none"> • Maintains existing wall. • Minimal disruption to Highway 7/8 during construction. • Temporary roadway protection not required. • Restrictions on construction of future roadway/infrastructure limited to location of anchor wall and tiebacks. 	<ul style="list-style-type: none"> • Option with lowest surcharge load applied to existing wall. • New concrete facing required for existing wall. • Can only accommodate widening to six lanes. • Possibility that insufficient capacity available for anchors installed in the existing fill. 	<ul style="list-style-type: none"> • Third least costly option; however, anchor costing very uncertain. 	<ul style="list-style-type: none"> • Risk of excessive wall deformation expected to be intermediate between Options iii) and iv). • Costs related to installation of earth anchors may increase if extension into native soils required to achieve required capacity.

**COMPARISON OF ALTERNATIVES FOR REPLACEMENT/MODIFICATION OF
CNR OVERHEAD RETAINING WALL D**

REMEDICATION/ REPLACEMENT OPTION	ADVANTAGES	DISADVANTAGES	RELATIVE COSTS¹	RELATIVE RISKS/ CONSEQUENCES²
Construct new RSS wall behind existing wall with tieback reinforcement of existing retaining wall (Option iii)	<ul style="list-style-type: none"> • Can accommodate future widening to eight lanes. • Maintains existing wall. 	<ul style="list-style-type: none"> • Additional surcharge loading applied to existing wall expected to be intermediate between Options ii) and iv). • New concrete facing required for existing wall. • Lane restrictions likely required on Highway 7/8 for installations of anchor wall. • Two specialist contractors required. • Restrictions on construction of future roadway/infrastructure must be enforced within reinforced zone. • Greater impact on Highway 7/8 than Option i). • Uncertainty related to effective drainage of existing wall backfill remains. 	<ul style="list-style-type: none"> • Least costly option; however, actual cost of the tieback system uncertain. 	<ul style="list-style-type: none"> • Risk of excessive wall deformation expected to be intermediate between Options i) and iii).

**COMPARISON OF ALTERNATIVES FOR REPLACEMENT/MODIFICATION OF
CNR OVERHEAD RETAINING WALL D**

REMEDICATION/ REPLACEMENT OPTION	ADVANTAGES	DISADVANTAGES	RELATIVE COSTS¹	RELATIVE RISKS/ CONSEQUENCES²
Construct new RSS slope and reinforce existing retaining wall with grouted earth anchors or tie-rods and sheeting (Option iv)	<ul style="list-style-type: none"> • Maintains existing wall. • Minimal disruption to Highway 7/8 during construction. • Temporary roadway protection not required. 	<ul style="list-style-type: none"> • Potential for greatest surcharge loading applied to existing wall. • New concrete facing required for existing wall. • Can only accommodate widening to six lanes. • Possibility that insufficient capacity available for anchors installed in the existing fill. • Two specialist's contractors required. • Restrictions on construction of future roadway/infrastructure must be enforced within reinforced zone. 	<ul style="list-style-type: none"> • Next most expensive option compared to Option i). 	<ul style="list-style-type: none"> • Highest overall risk of excessive wall deformation. • Costs related to installation of earth anchors may increase if extension into native soils required to achieve required capacity. • Cost may increase if high appearance facing required.

- NOTES:
1. Cost estimates provided by Dillon.
 2. Risks/consequences and costs are relative to preferred alternative – Option i).
 3. Options listed in order of preference based on foundation engineering construction.
 4. Table to be read in conjunction with accompanying report.

Prepared By: DUP
Checked By: PRB

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split spoon sampler for a distance of 300 mm (12 in.)

(b) Cohesive Soils

Consistency	c_u, s_u	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

Dynamic Cone Penetration Resistance; N_d :

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. General

π	3.1416
$\ln x$,	natural logarithm of x
\log_{10}	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ϵ	linear strain
ϵ_v	volumetric strain
η	coefficient of viscosity
ν	poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l	liquid limit
w_p	plastic limit
I_p	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 + \sigma_3)/2$ or $(\sigma'_1 + \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 + \sigma_3)$
S_t	sensitivity

- Notes:** 1 $\tau = c' + \sigma' \tan \phi'$
 2 shear strength = (compressive strength)/2
 * density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

RECORD OF BOREHOLE No 509

1 OF 1

METRIC

PROJECT 08-1132-084-1

W.P. 131-98-00

LOCATION N 4810425.5 ; E 225913.5

ORIGINATED BY JB

DIST HWY 7/8

BOREHOLE TYPE POWER AUGER / HOLLOW STEM

COMPILED BY LMK



DATUM GEODETIC

DATE November 20, 2008

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
321.89	ROAD SURFACE																			
0.06	ASPHALT																			
321.28	FILL, sand and gravel Brown																			
0.61	FILL, sand, some gravel, with clayey silt layers Dense Brown		1	SS	33		321													
320.52																				
1.37	FILL, sandy silt, with black organics Compact Brown		2	SS	28		320													
319.76																				
2.13	FILL, silty sand, fine to medium, trace gravel, trace clay Loose Brown		3	SS	9		319									9 64 24 3				
			4	SS	8															
317.78							318													
4.11	SAND AND GRAVEL, some silt Very dense Brown		5	SS	61		317													
316.40																				
5.49	SILTY CLAY, trace sand Hard Grey		6	SS	34		316													
							315													
			7	SS	38		314									0 2 53 45				
313.36																				
8.53	SANDY SILT, some clay, trace gravel Dense Grey		8	SS	44		313													
312.29																				
9.60	END OF BOREHOLE																			
	Groundwater encountered at about elev. 318.5m during drilling on November 20, 2008.																			

PROJECT 08-1132-084-1		RECORD OF BOREHOLE No 510		1 OF 1		METRIC	
W.P. 131-98-00		LOCATION N 4810409.5 ; E 225840.0		ORIGINATED BY JB			
DIST _____ HWY 7/8		BOREHOLE TYPE POWER AUGER / HOLLOW STEM		COMPILED BY LMK			
DATUM GEODETIC		DATE November 20, 2008		CHECKED BY _____			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIQUID MOISTURE LIMIT CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L				
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						WATER CONTENT (%)					
						20 40 60 80 100						10 20 30							
325.04	ROAD SURFACE					▽	325												
0.06	ASPHALT FILL, sand, fine to medium, some gravel, trace to some silt, trace clay Very loose to dense Brown		1	SS	47		324								○				19 67 12 2
			2	SS	8		323							○					
							322								○				
			3	SS	3		321												
321.08	SILTY CLAY TILL, some sand, trace to some gravel Very stiff Brown																		
3.96																			
320.01			4	SS	28									○	—————			2 27 36 35	
5.03	END OF BOREHOLE																		
	Groundwater encountered at about elev. 322.0m during drilling on November 20, 2008.																		

LDN_MTO_06 08-1132-084-1.GPJ LDN_MTO.GDT 15/03/11

RECORD OF BOREHOLE No 510A

1 OF 1

METRIC

PROJECT 08-1132-084-1
W.P. 131-98-00 LOCATION N 4810409.5 ; E 225839.0 ORIGINATED BY MR
DIST HWY 7/8 BOREHOLE TYPE POWER AUGER / HOLLOW STEM COMPILED BY LMK
DATUM GEODETIC DATE June 4, 2010 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						
325.04	ROAD SURFACE															
0.06	ASPHALT FILL, sand						Asphalt Patch									
	STRATIGRAPHY TO ELEV. 322m HAS BEEN INFERRED FROM BOREHOLE 510.						Cuttings									
321.38			4	SS	6		Bentonite									
3.66	SILTY CLAY TILL, some sand, trace gravel Very stiff Brown		5	SS	16											
320.62							Cuttings									
4.42	SILTY SAND, trace gravel, trace clay Compact Brown		6	SS	10											
			7	SS	14											
							Piezometer 2									
			8	SS	11											
318.49														1 68 26 5		
6.55	SANDY SILT, Compact Brown															
318.03			9	SS	31		Bentonite									
7.01	SILTY CLAY, trace sand, with sand layers Very stiff to hard Grey		10	SS	32									0 15 42 43		
			11	SS	31		Piezometer 1									
			12	SS	21											
315.44	END OF BOREHOLE															
9.60	Groundwater encountered at about elev. 320.5m and 316.0m during drilling on June 4, 2010. Water level in Piezometer 1 at elev. 319.69m following installation on June 4, 2010. Water level in Piezometer 2 at elev. 321.10m following installation on June 4, 2010. Water level measured in Piezometer 1 at elev. 319.86m on June 30, 2010. Water level measured in Piezometer 2 at elev. 320.09m on June 30, 2010. Water level measured in Piezometer 1 at elev. 319.81m on October 13, 2010. Water level measured in Piezometer 2 at elev. 319.96m on October 13, 2010.															

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

PROJECT 08-1132-084-1		RECORD OF BOREHOLE No 511		1 OF 1		METRIC	
W.P. 131-98-00		LOCATION N 4810419.0 ; E 225835.3		ORIGINATED BY MA			
DIST _____ HWY 7/8		BOREHOLE TYPE POWER AUGER / HOLLOW STEM		COMPILED BY LMK			
DATUM GEODETIC		DATE December 1, 2008		CHECKED BY _____			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W _P	W	W _L		
327.62	ROAD SURFACE																
0.10	ASPHALT																
0.40	FILL, sand and gravel, trace silt, crushed Brown																
326.25	FILL, silty fine sand, trace gravel Compact Brown		1	SS	29								○				
1.37	FILL, sand, fine to medium, trace silt, with silty sand layers Very dense Brown		2	SS	67/ 150mm								○				
325.49																	
2.13	FILL, sandy silt, trace to some clay, trace gravel, with clayey silt layers Dense Brown		3	SS	37												
			4	SS	39								○				
			5	SS	36								○				
			6	SS	33									○			
322.44																	
5.18	CLAYEY SILT, trace sand, trace gravel Very stiff Brown		7	SS	22									○		2 45 36 17	
322.07																	
5.55	SILTY SAND, some clay, trace gravel, with clayey silt layers Compact Brown		8	SS	25									○		9 46 34 11	
320.61																	
7.01	SAND, some silt, trace gravel, trace clay Compact Brown		9	SS	12												

LDN_MTO_06 08-1132-084-1.GPJ LDN_MTO.GDT 15/03/11

RECORD OF BOREHOLE No 512

1 OF 1

METRIC

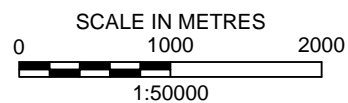
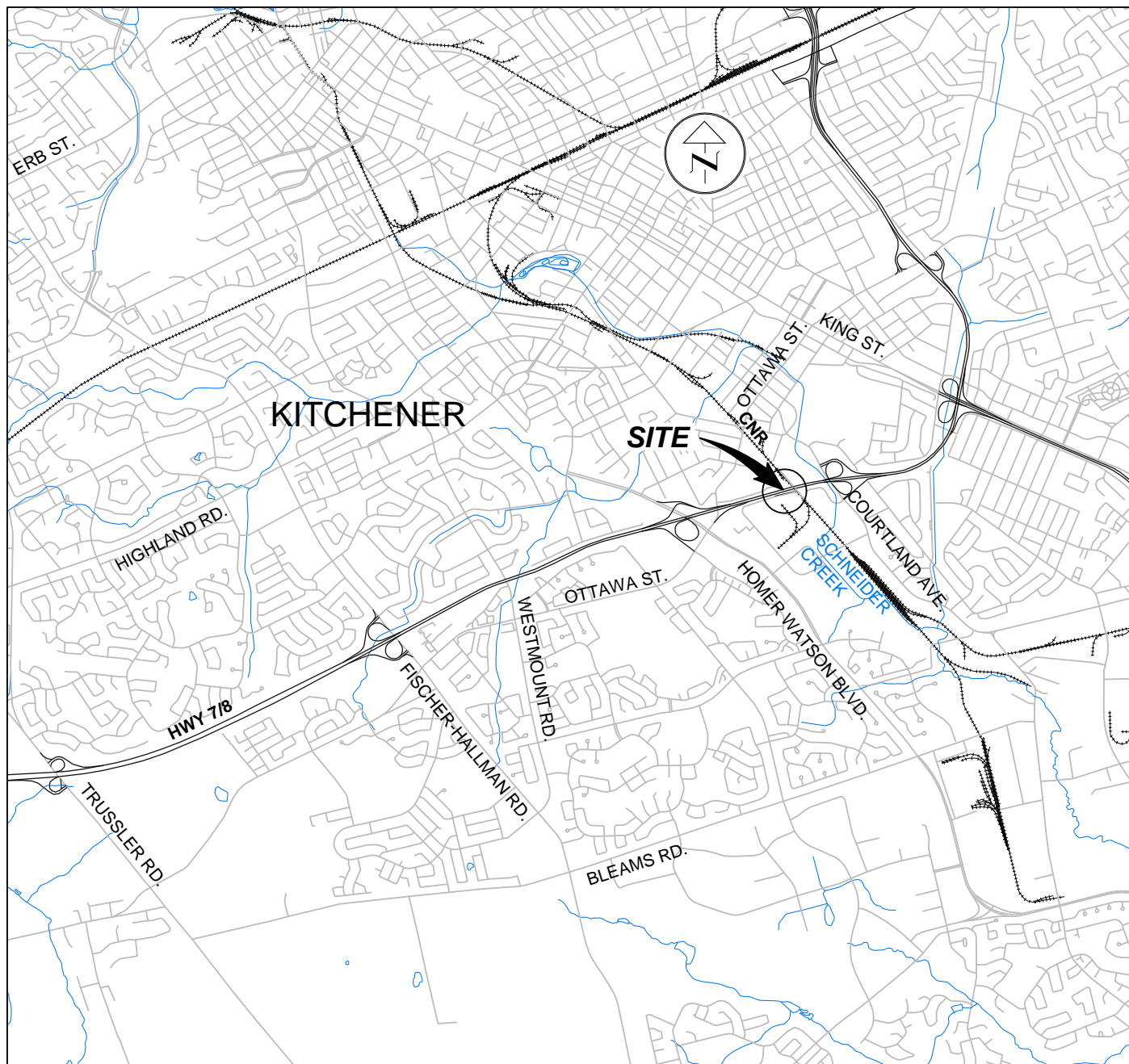
PROJECT 08-1132-084-1
W.P. 131-98-00 LOCATION N 4810442.0 ; E 225916.0 ORIGINATED BY MA
DIST HWY 7/8 BOREHOLE TYPE POWER AUGER / HOLLOW STEM COMPILED BY LMK
DATUM GEODETIC DATE December 1, 2008 CHECKED BY

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					
326.92	ROAD SURFACE						20	40	60	80	100	10	20	30		
0.10	ASPHALT															
0.33	FILL, sand and gravel, crushed, trace silt Brown															
	FILL, silty fine sand, trace gravel, with clayey silt pockets Compact Brown		1	SS	21							○				
			2	SS	19								○			
324.79																
2.13	FILL, sandy silt, trace gravel, with silty sand layers Compact to dense Brown		3	SS	23							○				
			4	SS	30							○				
323.26																
3.66	FILL, silty fine sand, trace topsoil, trace gravel, trace clay Compact to dense Brown		5	SS	27							○				2 62 28 8
			6	SS	31							○				
			7	SS	47							○				
			8	SS	34							○				
320.21																
6.71	FILL, sand and gravel, some silt, trace clay Compact Brown		9	SS	27							○				
7.01																
319.60	FILL, clayey silt, some sand, trace gravel, trace topsoil Very stiff Grey		10	SS	30							○				1 17 55 27
7.32																
318.54	CLAYEY SILT TILL, some sand, trace gravel Hard Grey															
8.38	SAND, fine, trace gravel, some silt Dense Brown		11	SS	38											
316.86																
10.06	SILT, trace sand, trace gravel Very dense Brown															
315.98			12	SS	63											
10.94	SAND, fine, some gravel, trace silt Very dense Brown															
11.13	END OF BOREHOLE															
	Groundwater encountered at about elev. 318.5m during drilling on December 1, 2008.															

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 513		1 OF 1		METRIC	
W.P. <u>131-98-00</u>		LOCATION <u>N 4810405.7 ; E 225793.2</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>		BOREHOLE TYPE <u>POWER AUGER / HOLLOW STEM</u>		COMPILED BY <u>WDF</u>			
DATUM <u>GEODETIC</u>		DATE <u>May 11, 2010</u>		CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
328.00	ROAD SURFACE																
0.10	ASPHALT																
327.51	FILL, sand and gravel, crushed Brown																
0.49	FILL, silty fine sand, trace to some clay, trace gravel Compact to dense Brown		1	SS	20												
			2	SS	16												
			3	SS	28												
			4	SS	41												
324.52	SAND AND GRAVEL, Compact Brown		5	SS	18												
323.82	SILTY FINE SAND, trace gravel, trace clay Compact Brown		6	SS	18												
4.18			7	SS	12												
			8	SS	10												
321.29	SAND, fine to medium, trace silt Compact to dense Brown		9	SS	11												
6.71			10	SS	33												
			11	SS	14												
318.40	END OF BOREHOLE		12	SS	11												
9.60	Groundwater encountered at about elev. 321.3m during drilling on May 11, 2010.																

LDN_MTO_06_08-1132-084-1.GPJ LDN_MTO.GDT 15/03/11



REFERENCE

DRAWING BASED ON CANMAP STREETFILES V2005.4.

NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

PROJECT

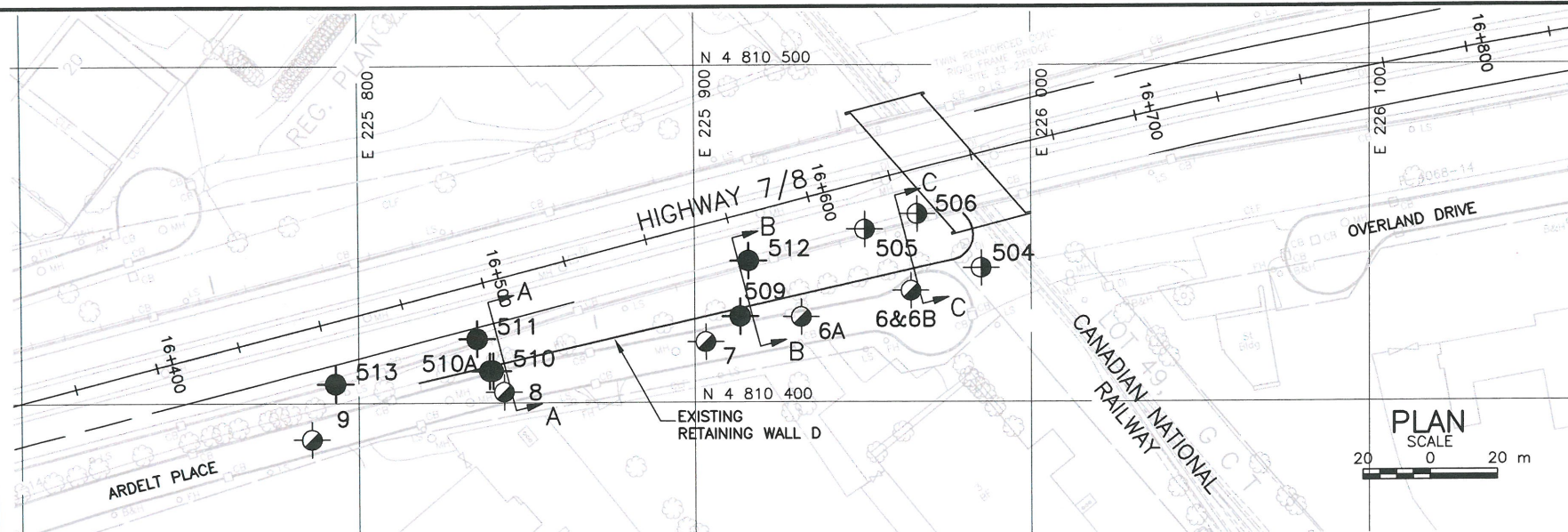
**EXISTING CNR OVERHEAD RETAINING WALL D
WIDENING OF HIGHWAY 7/8
GWP 131-98-00**

TITLE

KEY PLAN



PROJECT No. 08-1132-084-1		FILE No. 0811320841-F09001	
CADD	WDF	Nov. 04/10	SCALE AS SHOWN
CHECK			REV.
FIGURE 1			



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

NOTES

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

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

Stratigraphy has been simplified for clarity. Please refer to Record of Boreholes for further detail.

REFERENCE

Base plans provided in digital format by Dillon Consulting.

CONT No.
WP No. 131-98-00

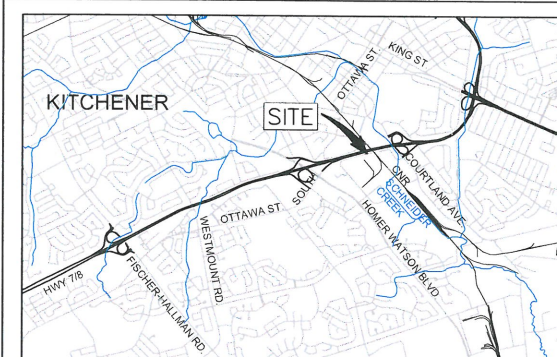


EXISTING CNR OVERHEAD
RETAINING WALL D
WIDENING OF HIGHWAY 7/8
BOREHOLE LOCATIONS & SOIL STRATA

SHEET



Golder Associates Ltd.
LONDON, ONTARIO, CANADA



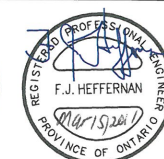
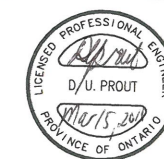
KEY PLAN

SCALE IN KILOMETRES
0 1 2

LEGEND

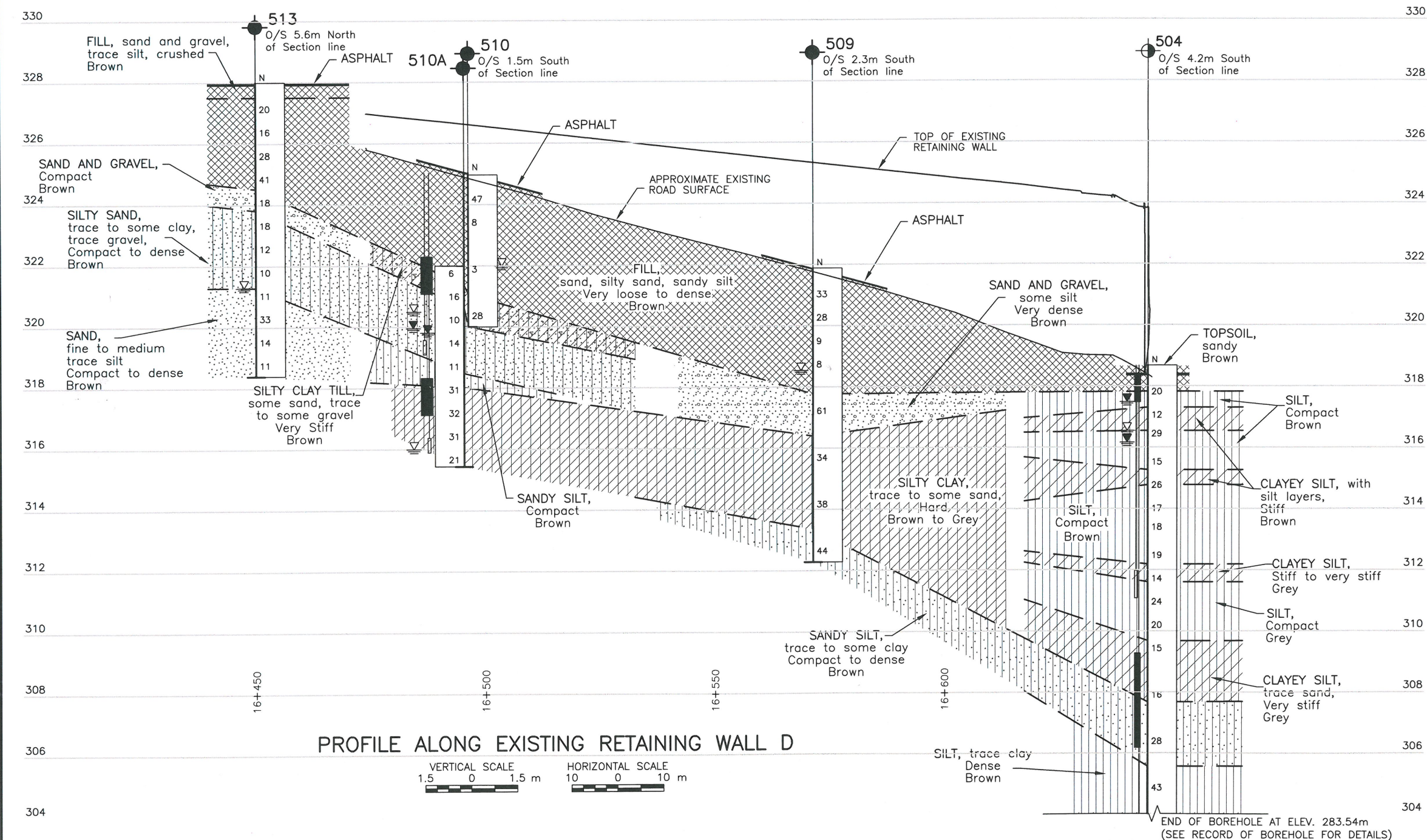
- Borehole - Current Investigation
- Borehole - (Geocres No. 40P8-175)
- Borehole (By Others) (Geocres 40P08-36)
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated
(Std. Pen. Test, 475 j/blow)
- DRY Borehole dry during drilling
- Seal
- Standpipe
- WL upon completion of drilling
- WL in piezometer

No.	ELEVATION	CO-ORDINATES (MTM ZONE 10)	
		NORTHING	EASTING
509	321.89	4 810 425.5	225 913.5
510	325.04	4 810 409.5	225 840.0
510A	325.04	4 810 409.5	225 839.0
511	327.62	4 810 419.0	225 835.3
512	326.92	4 810 442.0	225 916.0
513	328.00	4 810 405.7	225 793.2
(Geocres 40P08-175)			
504	318.68	4 810 439.8	225 985.2
505	326.53	4 810 451.2	225 950.6
506	326.32	4 810 455.9	225 966.2
By Others (Geocres 40P08-36)			
6&6B	318.55	4 810 433.1	225 964.3
6A	319.40	4 810 425.3	225 931.6
7	320.07	4 810 417.9	225 903.2
8	323.51	4 810 403.2	225 843.2
9	325.28	4 810 389.2	225 786.1



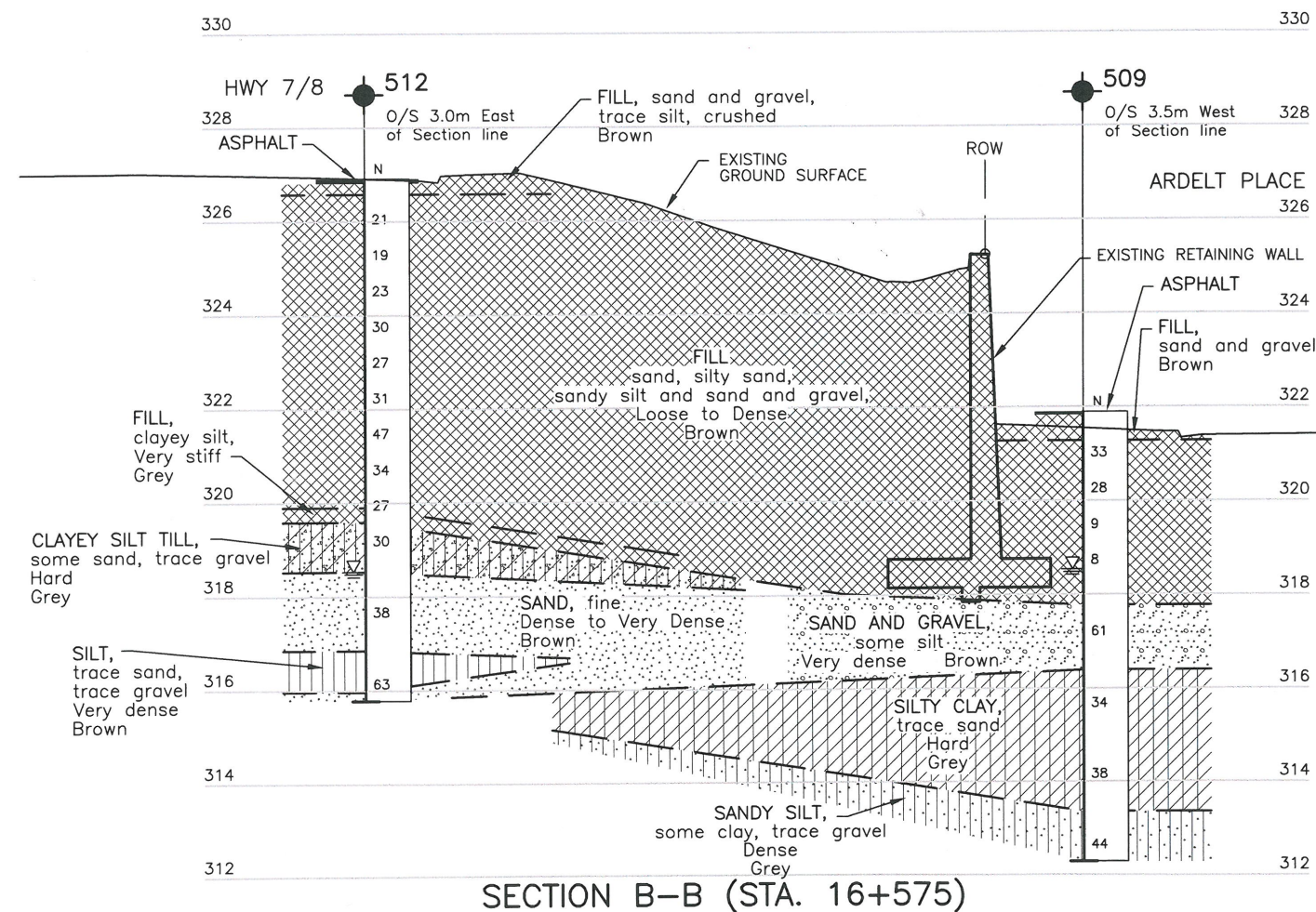
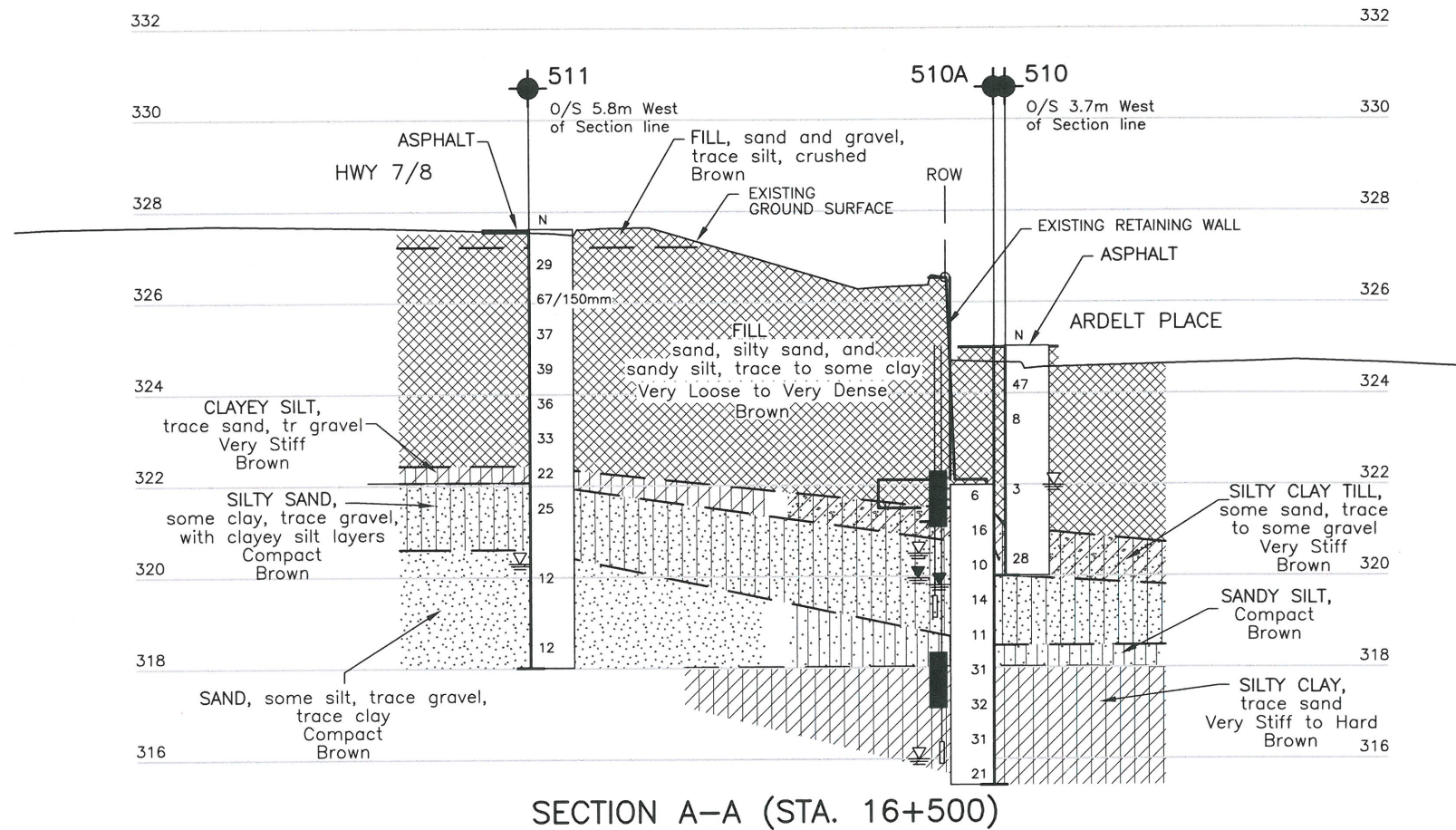
PROFILE ALONG EXISTING RETAINING WALL D

VERTICAL SCALE
1.5 0 1.5 m
HORIZONTAL SCALE
10 0 10 m



END OF BOREHOLE AT ELEV. 283.54m
(SEE RECORD OF BOREHOLE FOR DETAILS)

NO.	DATE	BY	REVISION
Geocres No. 40P8-193			
HWY.	7/8	PROJECT NO.	08-1132-084-1
SUBM'D.	DUP	CHKD.	DATE: Feb. 22/11
DRAWN:	WDF/LMK	CHKD.	APPD.
			DWG. 1



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

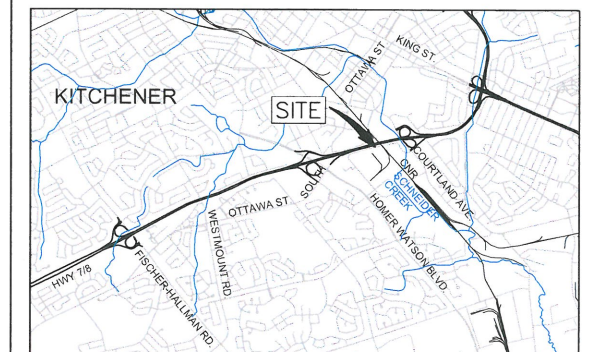
CONT No.
WP No. 131-98-00

EXISTING CNR OVERHEAD
RETAINING WALL D
WIDENING OF HIGHWAY 7/8
SOIL STRATA

SHEET



Golder Associates Ltd.
LONDON, ONTARIO, CANADA



KEY PLAN

SCALE IN KILOMETRES
0 1 2

LEGEND

- Borehole - Current Investigation
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- WL upon completion of drilling
- WL in piezometer (October 13, 2010)

No.	ELEVATION	CO-ORDINATES (MTM ZONE 10)	
		NORTHING	EASTING
509	321.89	4 810 425.5	225 913.5
510	325.04	4 810 409.5	225 840.0
510A	325.04	4 810 409.5	225 839.0
511	327.62	4 810 419.0	225 835.3
512	326.92	4 810 442.0	225 916.0

NOTES

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

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

Stratigraphy has been simplified for clarity. Please refer to Record of Boreholes for further detail.

REFERENCE

Base plans provided in digital format by Dillon Consulting.



NO.	DATE	BY	REVISION
Geocres No. 40P8-193			
HWY.	7/8	PROJECT NO.	08-1132-084-1
SUBM'D.	DUP	CHKD.	DATE: Feb. 22/11
DRAWN:	WDF/LMK	CHKD.	APPD.
			DWG. 2

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

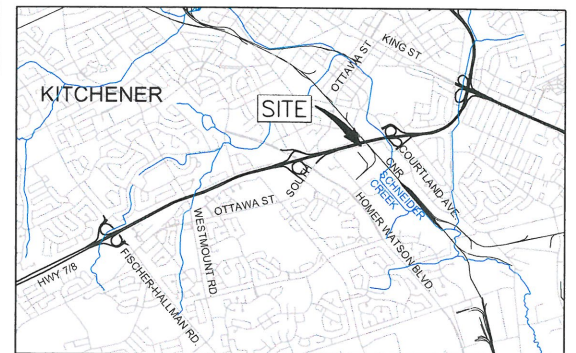
CONT No.
WP No. 131-98-00

EXISTING CNR OVERHEAD
RETAINING WALL D
WIDENING OF HIGHWAY 7/8
SOIL STRATA

SHEET



Golder Associates Ltd.
LONDON, ONTARIO, CANADA



KEY PLAN

SCALE IN KILOMETRES
0 1 2

LEGEND

- Borehole - (Geocres No. 40P8-175)
- Standard Penetration Test Value
- Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- Borehole dry during drilling
- Seal
- Standpipe
- WL upon completion of drilling
- WL in piezometer (June 18, 2009)

No.	ELEVATION	CO-ORDINATES (MTM ZONE 10)	
		NORTHING	EASTING
(Geocres 40P08-175)			
504	318.68	4 810 439.8	225 985.2
506	326.32	4 810 455.9	225 966.2

NOTES

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

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

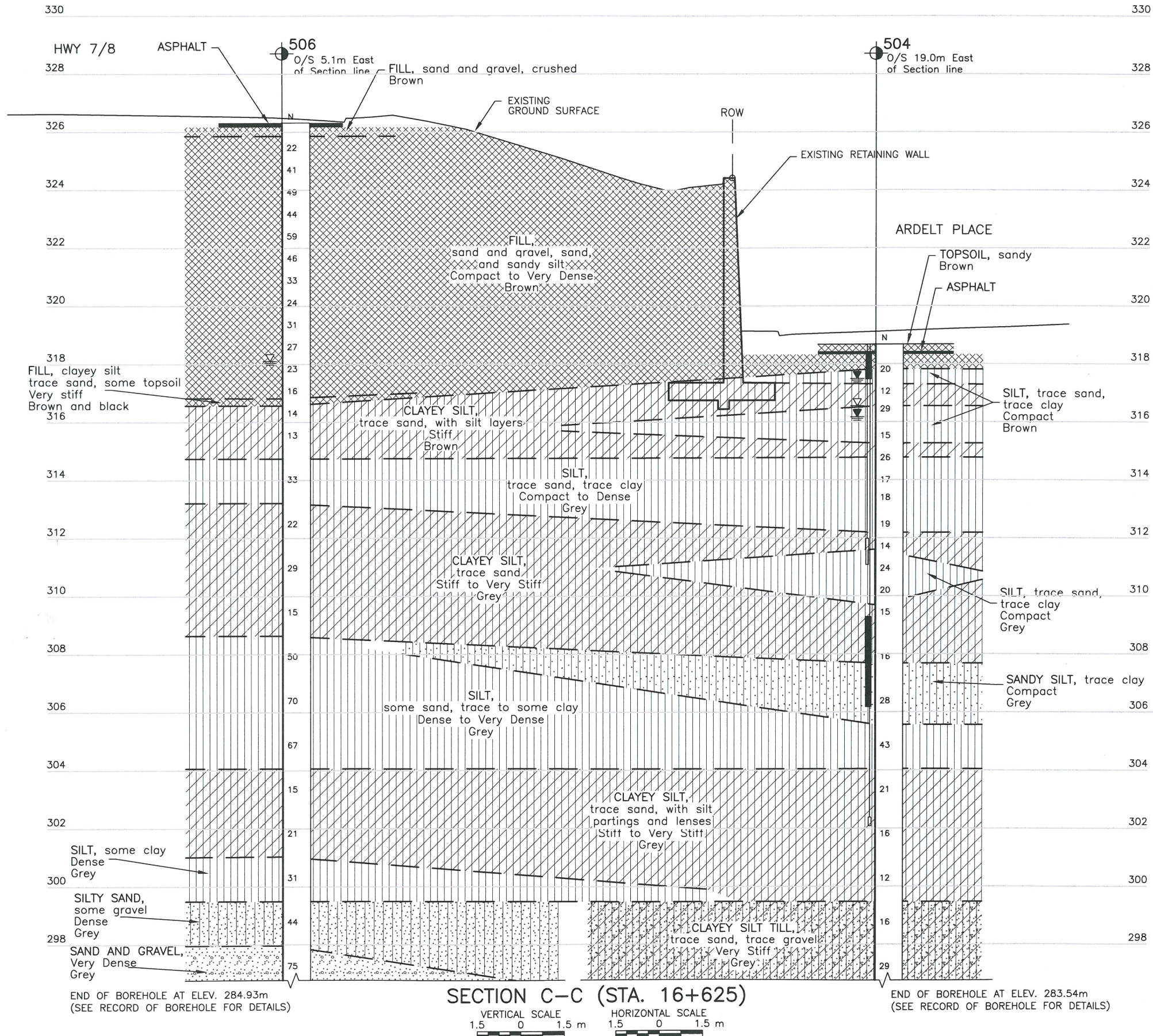
Stratigraphy has been simplified for clarity. Please refer to Record of Boreholes for further detail.

REFERENCE

Base plans provided in digital format by Dillon Consulting.



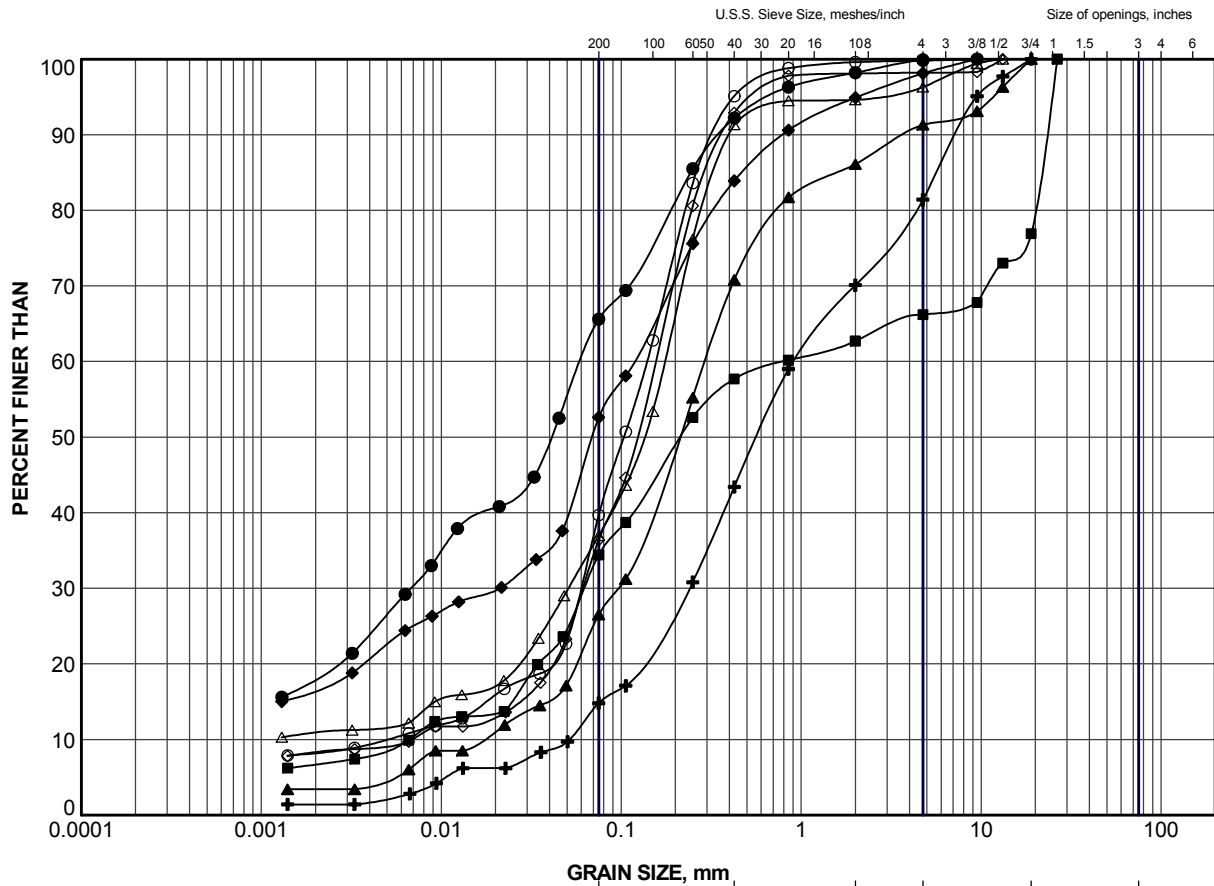
NO.	DATE	BY	REVISION
Geocres No. 40P8-193			
HWY.	7/8	PROJECT NO.	08-1132-084-1
SUBM'D.	DUP	CHKD.	DATE: Feb. 22/11
DRAWN:	WDF	CHKD.	APPD.
			DWG. 3





APPENDIX A

Laboratory Test Data



CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	505	2	324.8
■	505	7	321.0
▲	509	3	319.4
+	510	2	323.3
◆	511	6	322.8
◇	512	5	322.9
○	513	2	326.3
△	513	4	324.7

PROJECT
EXISTING CNR OVERHEAD RETAINING WALL D
WIDENING OF HIGHWAY 7/8
GWP 131-98-00

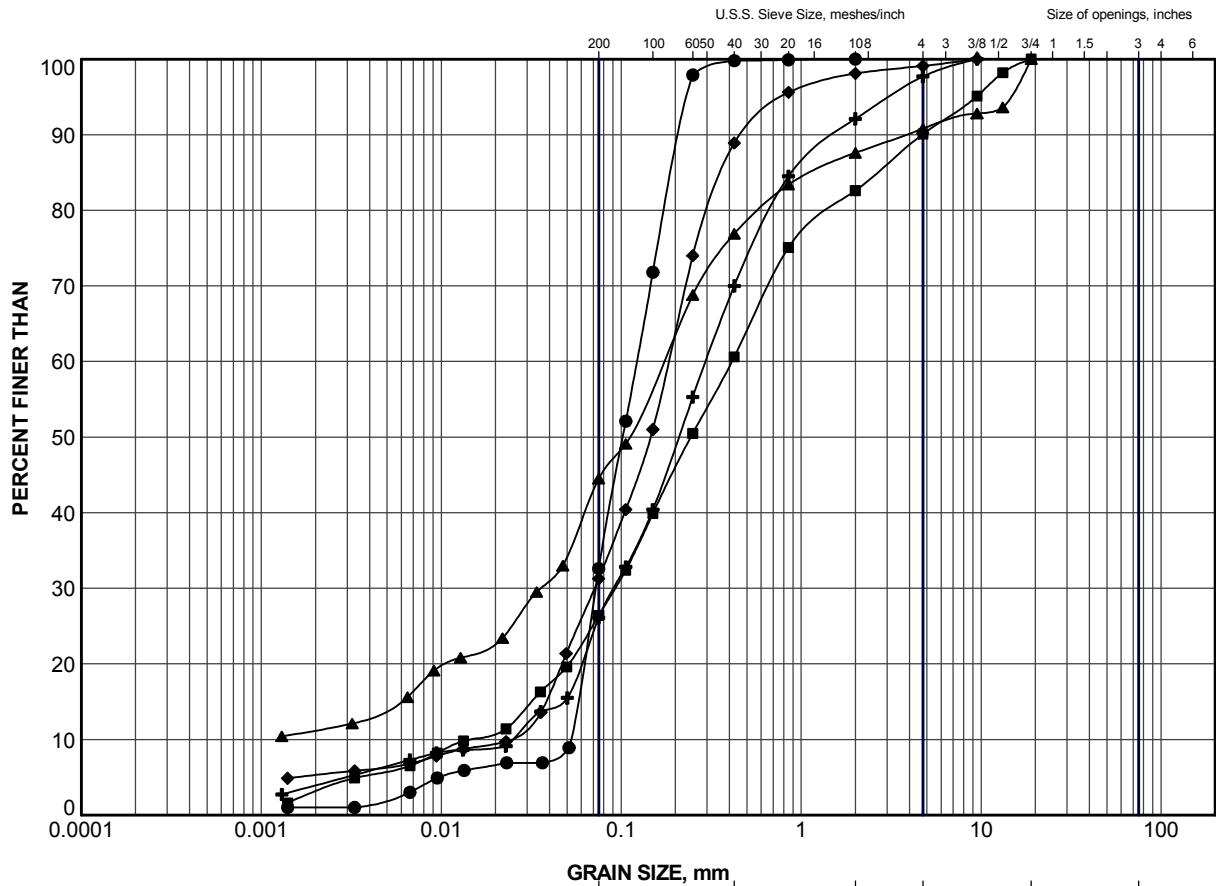
GRAIN SIZE DISTRIBUTION FILL



**Golder
Associates**
LONDON, ONTARIO

PROJECT No.	08-1132-084-1	FILE No.	0811320841-R090A1
DRAWN	WDF	Nov. 04/10	SCALE N/A REV.
CHECK			

FIGURE A-1



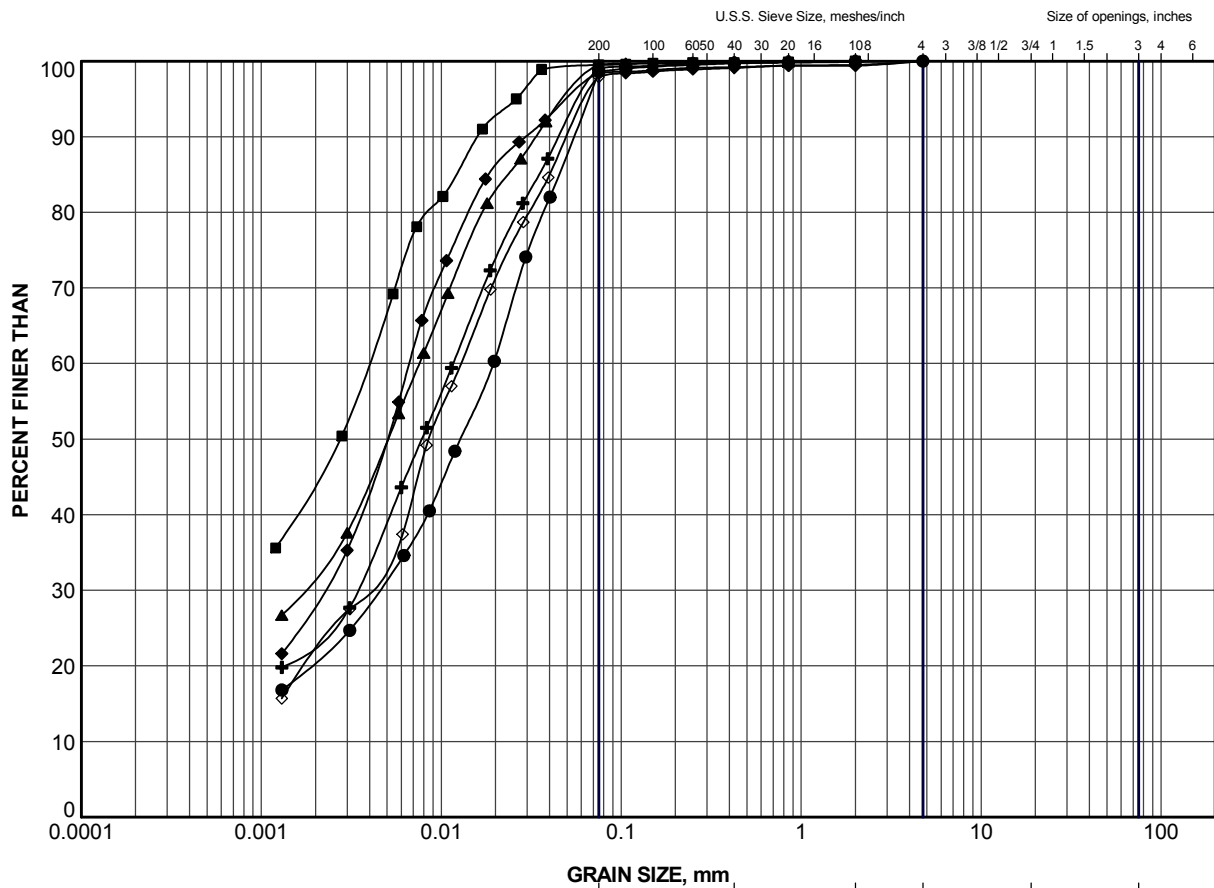
CLAY AND SILT		SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
		fine	medium	coarse	fine	coarse	
		SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	504	26	288.0
■	506	25	298.7
◆	510A	8	318.0
▲	511	8	321.3
+	513	8	321.7

PROJECT						EXISTING CNR OVERHEAD RETAINING WALL D WIDENING OF HIGHWAY 7/8 GWP 131-98-00					
TITLE						GRAIN SIZE DISTRIBUTION SILTY SAND					
PROJECT No.			08-1132-084-1			FILE No.			0811320841-R090A2		
DRAWN			WDF			Nov. 04/10			SCALE N/A REV.		
CHECK									FIGURE A-2		





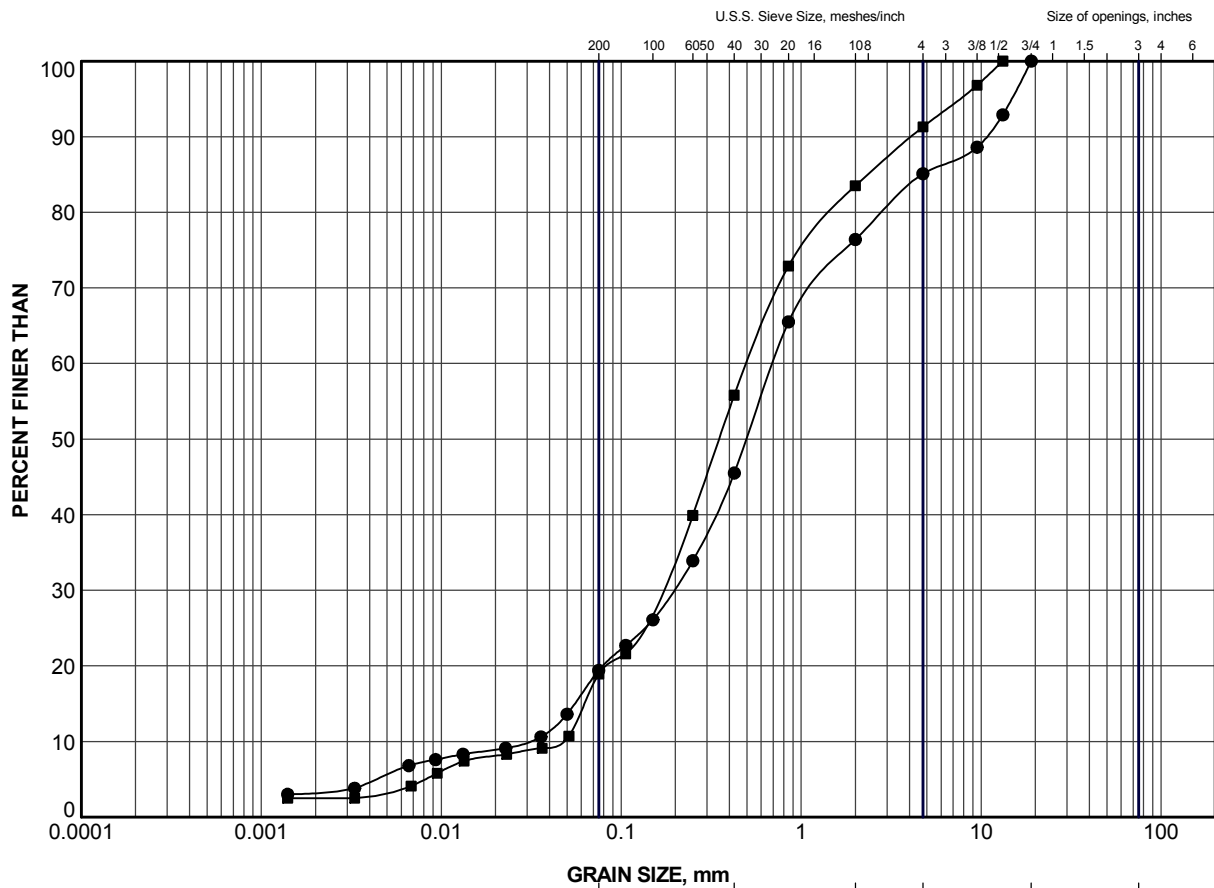
CLAY AND SILT	GRAVEL SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	504	12	309.3
■	504	18	300.2
▲	505	14	315.6
+	505	17	311.1
◆	506	13	316.2
◇	506	16	312.4

PROJECT				EXISTING CNR OVERHEAD RETAINING WALL D WIDENING OF HIGHWAY 7/8 GWP 131-98-00			
TITLE				GRAIN SIZE DISTRIBUTION CLAYEY SILT			
PROJECT No.		08-1132-084-1		FILE No.		0811320841-R090A3	
DRAWN		WDF		Nov. 04/10		SCALE N/A REV.	
CHECK						FIGURE A-3	




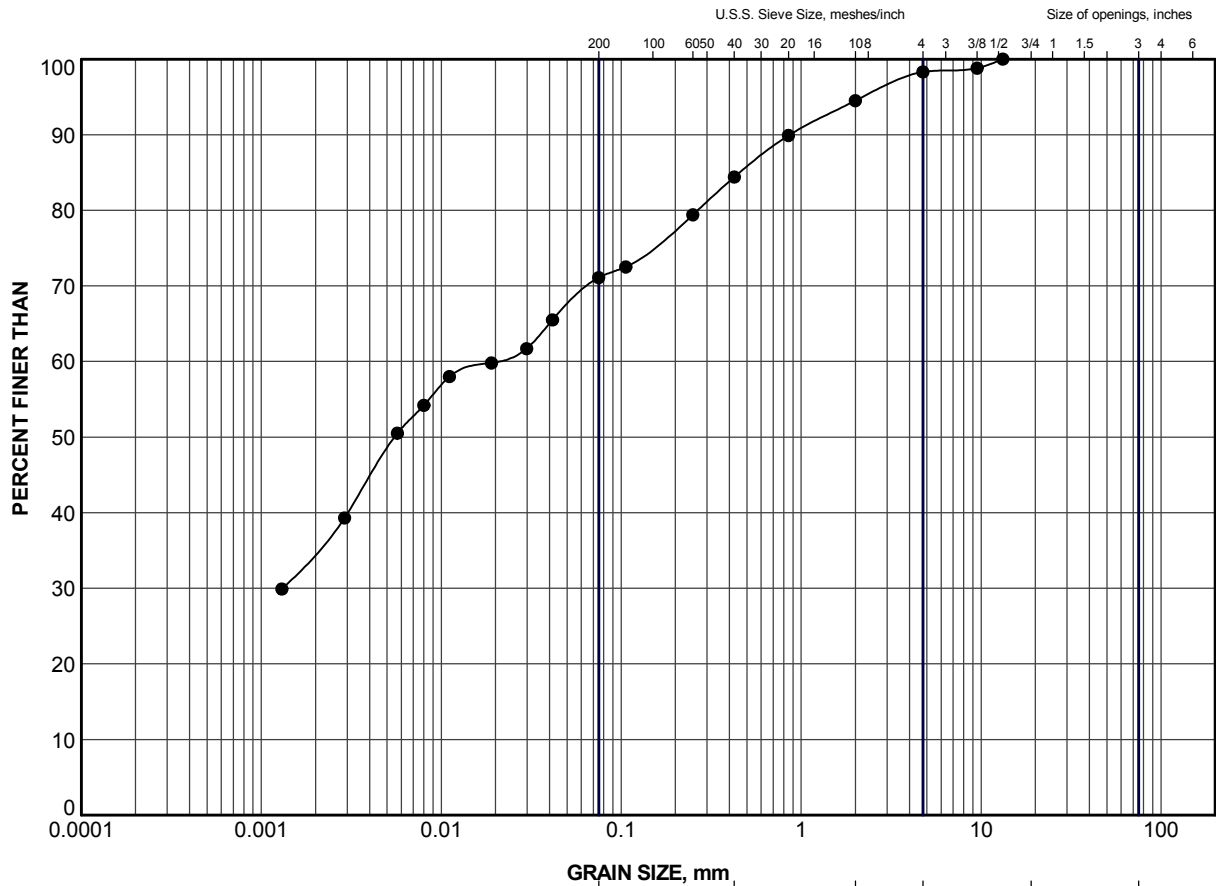


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	504	22	294.1
■	511	10	318.3

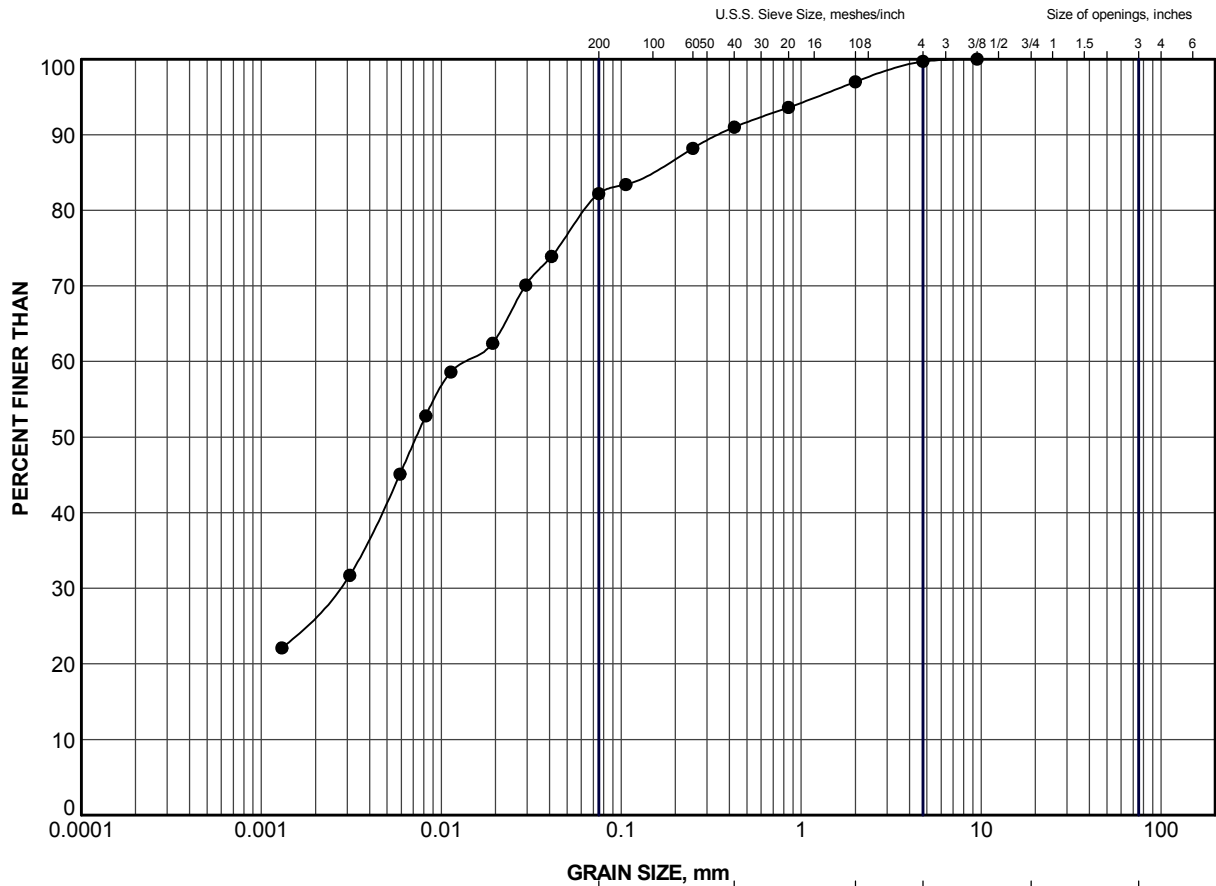
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TITLE					GRAIN SIZE DISTRIBUTION SAND				
PROJECT No.		08-1132-084-1		FILE No.		0811320841-R090A4			
DRAWN		WDF		Nov. 04/10		SCALE		N/A	
CHECK						REV.			
 Golder Associates LONDON, ONTARIO					FIGURE A-4				



CLAY AND SILT	GRAIN SIZE, mm					
	fine		medium	coarse		
	SAND SIZE			GRAVEL SIZE		Cobble Size


LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	510	4	320.2

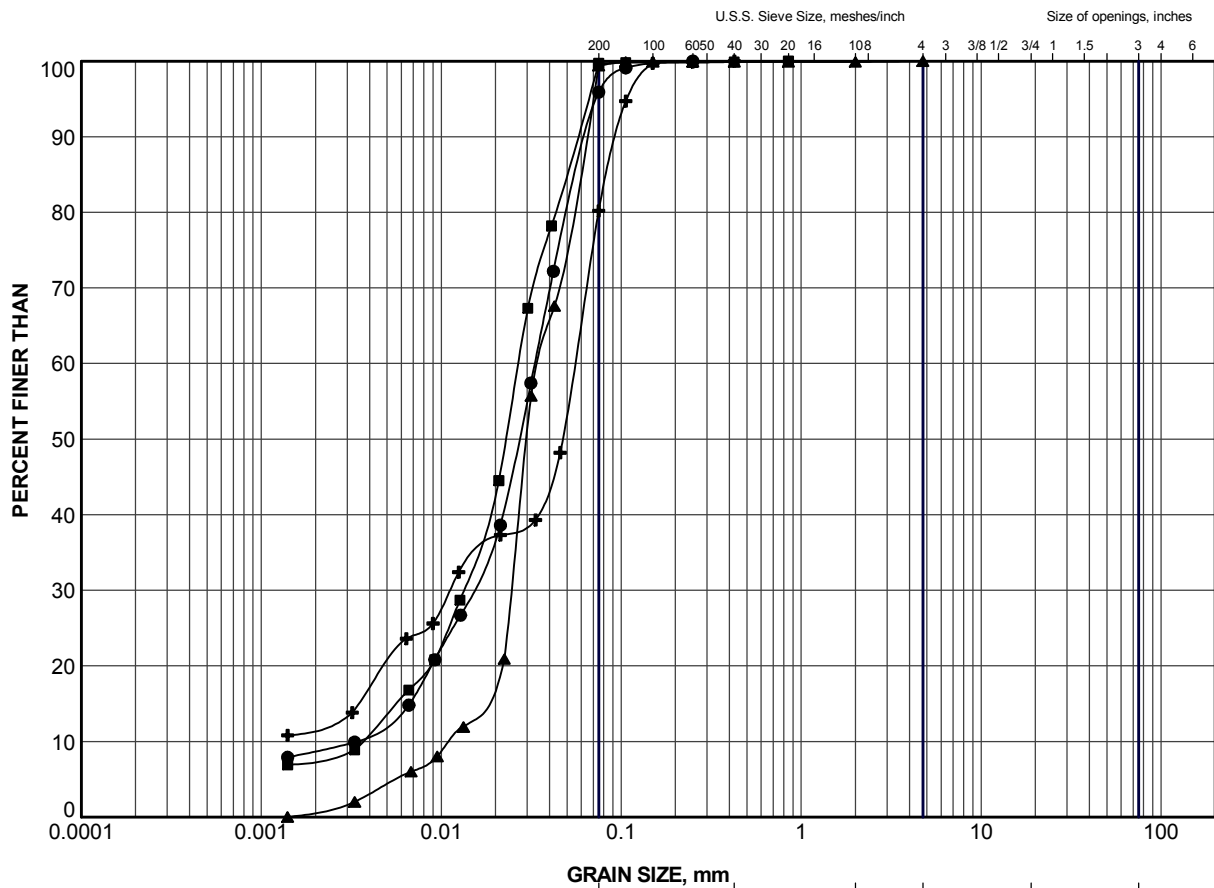
PROJECT					EXISTING CNR OVERHEAD RETAINING WALL D WIDENING OF HIGHWAY 7/8 GWP 131-98-00				
TITLE					GRAIN SIZE DISTRIBUTION SILTY CLAY TILL				
PROJECT No.		08-1132-084-1		FILE No.		0811320841-R090A5			
DRAWN		WDF		Nov. 04/10		SCALE		N/A	
CHECK						REV.			
 Golder Associates LONDON, ONTARIO					FIGURE A-5				



CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	512	10	319.1


PROJECT EXISTING CNR OVERHEAD RETAINING WALL D WIDENING OF HIGHWAY 7/8 GWP 131-98-00																			
TITLE GRAIN SIZE DISTRIBUTION CLAYEY SILT TILL																			
 Golder Associates LONDON, ONTARIO		<table border="1"> <tr> <td>PROJECT No.</td> <td>08-1132-084-1</td> <td>FILE No.</td> <td colspan="2">0811320841-R090A6</td> </tr> <tr> <td>DRAWN</td> <td>WDF</td> <td>Nov. 04/10</td> <td>SCALE</td> <td>N/A</td> </tr> <tr> <td>CHECK</td> <td></td> <td></td> <td>REV.</td> <td></td> </tr> </table>			PROJECT No.	08-1132-084-1	FILE No.	0811320841-R090A6		DRAWN	WDF	Nov. 04/10	SCALE	N/A	CHECK			REV.	
PROJECT No.	08-1132-084-1	FILE No.	0811320841-R090A6																
DRAWN	WDF	Nov. 04/10	SCALE	N/A															
CHECK			REV.																
			FIGURE A-6																

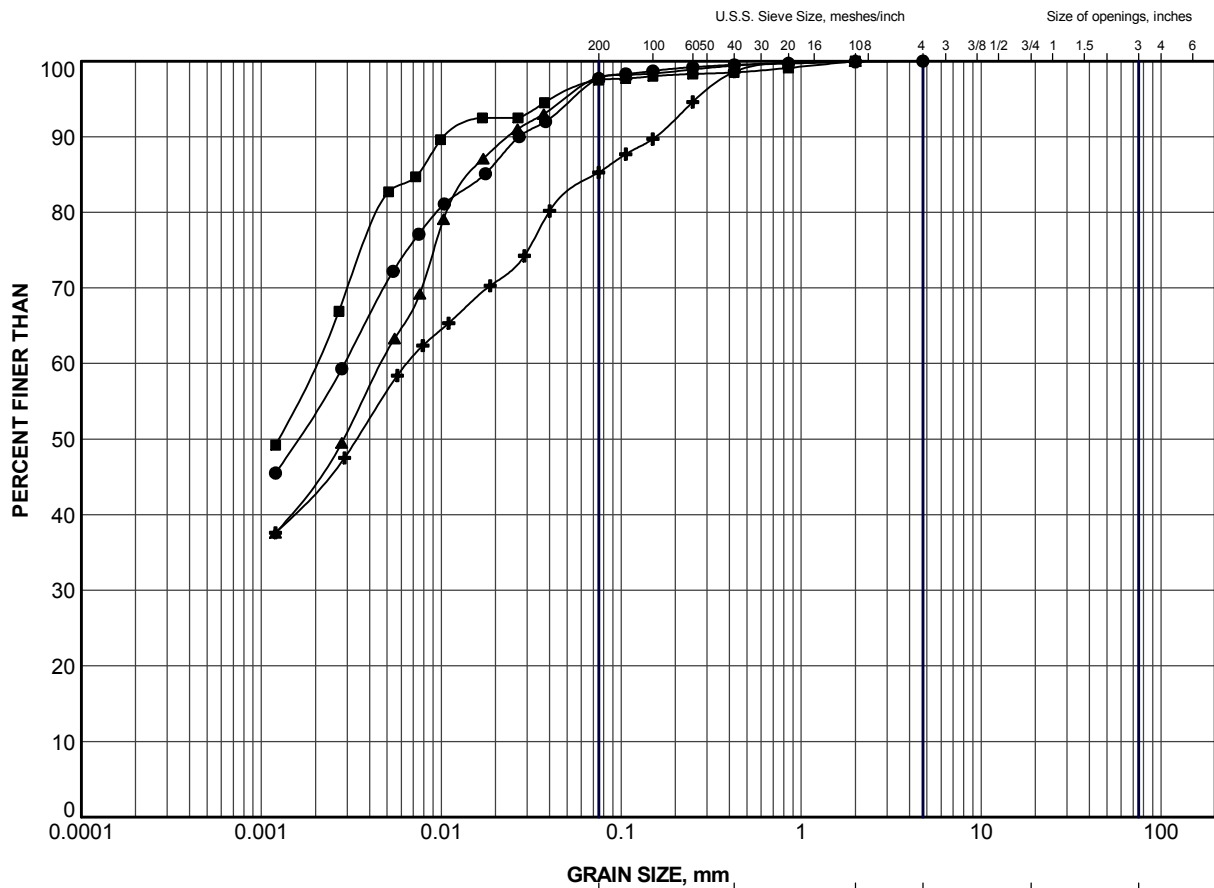


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	504	6	313.9
■	504	15	304.7
▲	506	15	313.9
+	506	19	307.8


PROJECT					EXISTING CNR OVERHEAD RETAINING WALL D WIDENING OF HIGHWAY 7/8 GWP 131-98-00				
TITLE					GRAIN SIZE DISTRIBUTION SILT				
PROJECT No.		08-1132-084-1		FILE No.		0811320841-R090A7			
DRAWN		WDF		Nov. 04/10		SCALE		N/A	
CHECK						REV.			
 Golder Associates LONDON, ONTARIO					FIGURE A-7				

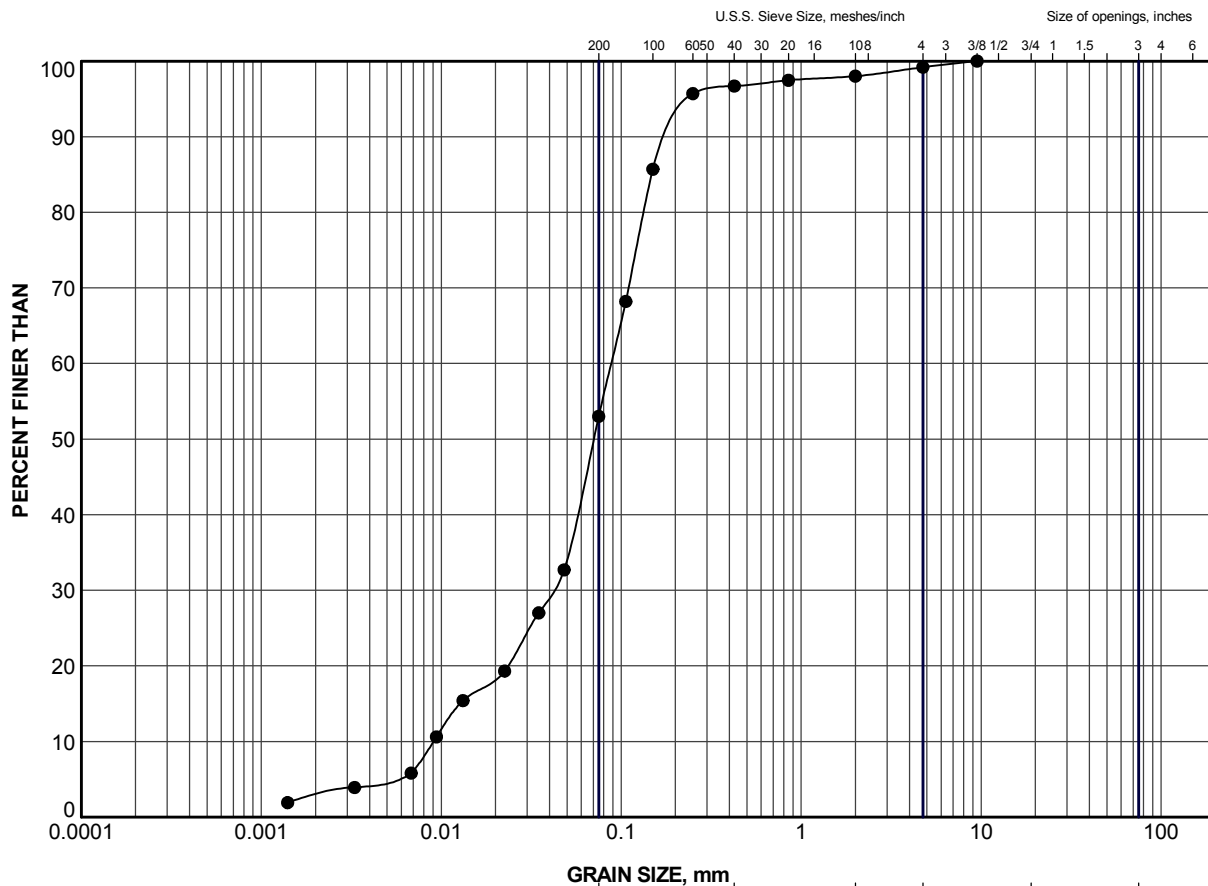


GRAIN SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	506	28	294.1
■	506	31	289.5
▲	509	7	314.0
+	510A	10	317.2


PROJECT					EXISTING CNR OVERHEAD RETAINING WALL D WIDENING OF HIGHWAY 7/8 GWP 131-98-00				
TITLE					GRAIN SIZE DISTRIBUTION SILTY CLAY				
PROJECT No.		08-1132-084-1		FILE No.		0811320841-R090A8			
DRAWN		WDF		Nov. 04/10		SCALE		N/A	
CHECK						REV.			
 Golder Associates LONDON, ONTARIO					FIGURE A-8				

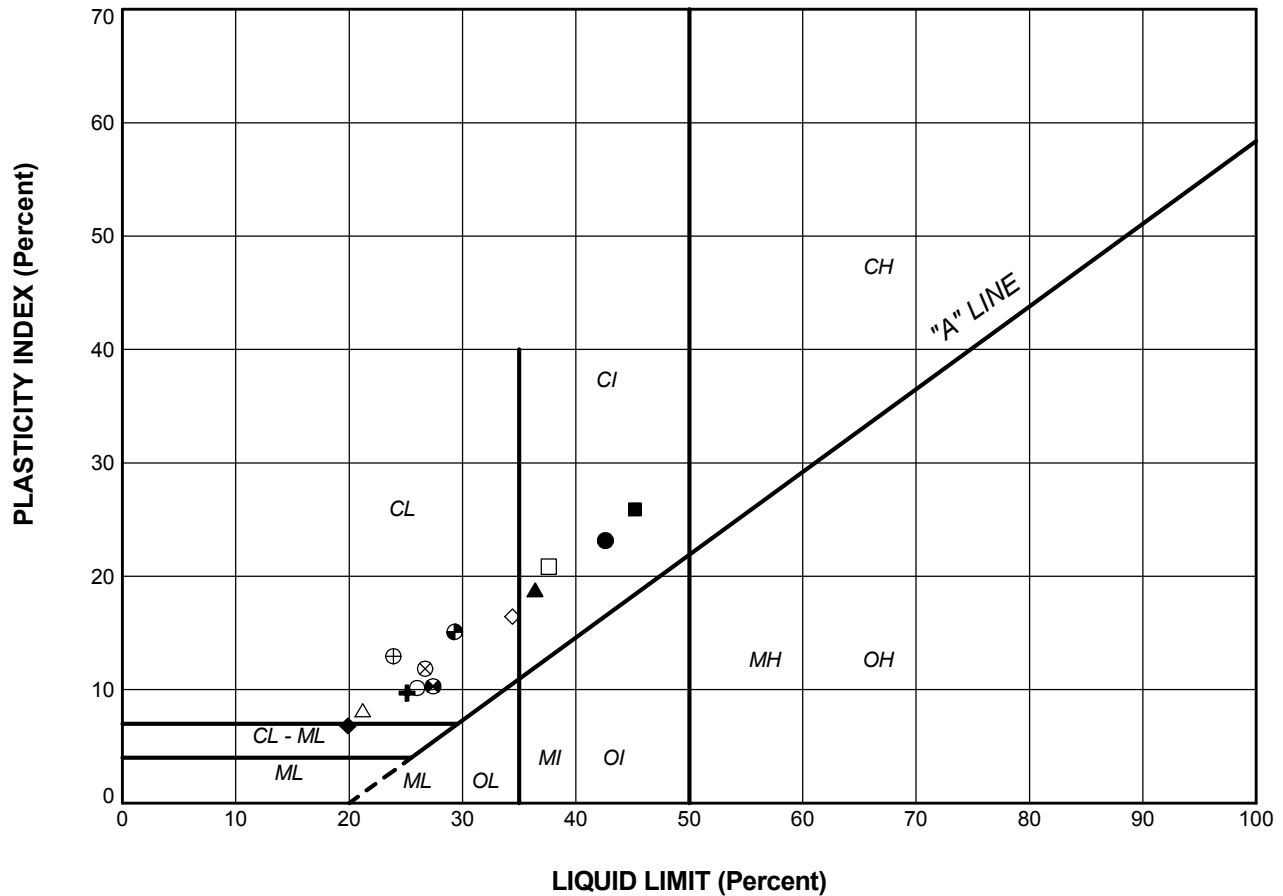


GRAVEL SIZE, mm						Cobble Size
CLAY AND SILT	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	506	32	288.0

PROJECT					EXISTING CNR OVERHEAD RETAINING WALL D WIDENING OF HIGHWAY 7/8 GWP 131-98-00				
TITLE					GRAIN SIZE DISTRIBUTION SANDY SILT				
PROJECT No.		08-1132-084-1		FILE No.		0811320841-R090A9			
DRAWN		WDF		Nov. 04/10		SCALE		N/A	
CHECK						REV.			
 Golder Associates LONDON, ONTARIO					FIGURE A-9				



LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
FILL (cohesive)					
●	512	9	27.4	17.1	10.3
SILTY CLAY					
●	506	28	42.6	19.5	23.2
■	506	31	45.2	19.3	25.9
▲	509	7	36.4	17.6	18.8
●	510A	10	29.3	14.2	15.1 (with sand layers)
CLAYEY SILT TILL					
+	512	10	25.1	15.4	9.7
CLAYEY SILT					
◆	504	12	19.9	13.1	6.8
◇	504	18	34.4	18.0	16.5
○	505	14	26.0	15.9	10.2
△	505	17	21.2	13.0	8.2
⊗	506	13	26.7	14.9	11.9
⊕	506	16	23.9	11.0	13.0
SILTY CLAY TILL					
□	510	4	37.6	16.8	20.9

PROJECT **EXISTING CNR OVERHEAD RETAINING WALL D
WIDENING OF HIGHWAY 7/8
GWP 131-98-00**

TITLE

PLASTICITY CHART



PROJECT No.	08-1132-084-1	FILE No.	0811320841-R09A010
DRAWN	WDF	Nov. 04/10	SCALE N/A REV.
CHECK			

FIGURE A-10



APPENDIX B

Records of Additional Boreholes



APPENDIX B-1

**Records of Previous Boreholes and Laboratory Data
(Geocres Report No. 40P08-36)**

e. m. peto associates ltd.
SOIL ENGINEERING SERVICE -- TORONTO, ONTARIO
BOREHOLE LOG

Job Name Kitchener-Waterloo Expressway Borehole No. 64225

Client Department of Highways, Ontario Casing 4 1/2" Auger





Elevation 1045.1 Compiled By A. A. M.

Borehole No. 6

Boring Date Sept. 19, 1964

Checked By rm

SAMPLE CONDITION

















-  **UNDISTURBED**
-  **FAIR**
-  **DISTURBED**
-  **LOST**

SAMPLE TYPE

- A.S. AUGER SAMPLE
- C.S. CASING SAMPLE
- S.S. 2" STANDARD SPLIT TUBE SAMPLE
- S.L. SPLIT BARREL WITH LINERS
- S.T. THIN-WALLED SHELBY TUBE SAMPLE
- W.S. WASH SAMPLE
- R.C. ROCK CORE

ABBREVIATIONS

- V.T. IN SITU VANE SHEAR TEST
- M. MOIST
- W.L. WATER LEVEL IN CASING
- W.T. GROUND WATER TABLE IN SOIL
- W.T.P.L. WETTER THAN PLASTIC LIMIT
- D.T.P.L. DRIER THAN PLASTIC LIMIT
- A.P.L. ABOUT PLASTIC LIMIT

SOIL DESCRIPTION	COLOUR	Density or Consistency	Depth Elevation	Legend	Sample No and Condition	Sample Type	No. of Blows per Ft.	Natural Moisture Content	WATER LEVELS & REMARKS
Ground Surface									Cone Probe
4" Sand, gravel fill									
Medium sand									
Clayey silt	Brown	Stiff	2'4"		1 	S.S.	13	18.9	
As above	Ditto	Very Stiff	6'8"		2 	S.S.	32	20.2	
Silty fine sand	Brown				3 	3" S.L.			
Some sandy silt layers	Brown				4 	S.S.	18	19.8	Saturated
Clayey silt with sand	Grey	Very stiff	10'8"		5 	S.S.	16	17.0	
Clayey silt	Grey				6 	S.S.	19	19.7	
Silty fine sand, odd	Grey	Compact	15'3"		7 	S.S.	16	17.0	
Clayey silt layer									
Ditto	Ditto	Compact	21'6"						





BOREHOLE LOG









6A
Borehole No.
Boring Date Sept. 25, 1964.
Checked By sb

ABBREVIATIONS

V.T.	IN SITU VANE SHEAR TEST
M.	MOIST
W.L.	WATER LEVEL IN CASING
W.T.	GROUND WATER TABLE IN SOIL
W.T.P.L.	WETTER THAN PLASTIC LIMIT
D.T.P.L.	DRIER THAN PLASTIC LIMIT
A.P.L.	ABOUT PLASTIC LIMIT

[illegible]

SAMPLE CONDITION		SAMPLE TYPE		ABBREVIATIONS	
	UNDISTURBED	A.S. AUGER SAMPLE	V.T. IN SITU VANE SHEAR TEST		
	FAIR	C.S. CASING SAMPLE	M. MOIST		
	DISTURBED	S.S. 2" STANDARD SPLIT TUBE SAMPLE	W.L. WATER LEVEL IN CASING		
	LOST	S.L. SPLIT BARREL WITH LINERS	W.T. GROUND WATER TABLE IN SOIL		
		S.T. THIN-WALLED SHELBY TUBE SAMPLE	W.T.P.L. WETTER THAN PLASTIC LIMIT		
		W.S. WASH SAMPLE	D.T.P.L. DRIER THAN PLASTIC LIMIT		
		R.C. ROCK CORE	A.P.L. ABOUT PLASTIC LIMIT		

SOIL DESCRIPTION	COLOUR	Density or Consistency	Depth Elevation	Legend	Sample No and Condition	Sample Type	No of Blows per Ft	Natural Moisture Content	WATER LEVELS & REMARKS
Ground surface			0'0"						Cone Probe
Sand and gravel	Brown		1'3"						Moist
Sandy, clayey silt with grits and pebbles	Brown	Very stiff	5'3"		1	SS	17	10.4	Wet 10 23 30
Coarse to medium sand, some gravel.	Brown	Dense	5'3"		2	SS	38	9.9	Wet 45 85
Silty fine to coarse sand and gravel	Brown	Dense			3	SS	35	11.4	Saturated from 8'
As above then clayey silt seams & silty sand	Brown	Hard	10'8" 11'8"		4	SS	63	17.2	Saturated Wet
Sand and gravel	Buff grey	Very dense	13'10"		5	SS	52	11.1	Saturated
Very clayey silt with silt pockets	Grey	Hard			6	SS	56	14.9	Quite moist.
Clayey silt	Ditto	Ditto	21'6"		7	SS	53	13.8	Quite moist.
Test Hole Terminated at 21'6".									

BOREHOLE LOG

[illegible]

BOREHOLE LOG

Borehole No. 9

Boring Date Sept. 21, 1964

Checked Byrm.....

ABBREVIATIONS

V.T.	IN SITU VANE SHEAR TEST
M.	MOIST
W.L.	WATER LEVEL IN CASING
W.T.	GROUND WATER TABLE IN SOIL
W.T.P.L.	WETTER THAN PLASTIC LIMIT
D.T.P.L.	DRIER THAN PLASTIC LIMIT
A.P.L.	ABOUT PLASTIC LIMIT

LOST

[illegible]



APPENDIX B-2

**Records of Boreholes from GWP 131-98-00 – Canadian National
Railway Overhead (Site No. 33-225)
(Geocres No. 40P08-175)**

RECORD OF BOREHOLE No 504

1 OF 3

METRIC

PROJECT 08-1132-084-1

W.P. 131-98-00

LOCATION N 4810439.8 ; E 225985.2

ORIGINATED BY MA

DIST HWY 7/8

BOREHOLE TYPE POWER AUGER / TRICONE

COMPILED BY LMK

DATUM GEODETIC

DATE November 13, 2008 and Borehole Deepened June 18 & 19, 2009

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE	W _P	W	W _L		
318.68	GROUND SURFACE						20 40 60 80 100							
0.02	TOPSOIL, sandy Brown						Concrete							
0.34	FILL, sand Brown													
317.83	ASPHALT													
0.85	FILL, sand and gravel Compact Brown		1	SS	20		Holeplug							
317.31	SILT, trace sand, trace clay Compact Brown		2	SS	12									
1.37	CLAYEY SILT, with silt layers Stiff Brown		3	SS	29									
316.55	SILT, some sand, trace clay Compact Brown		4	SS	15									
2.13	CLAYEY SILT, with silt layers Stiff Brown to grey at about elev. 315.0m		5	SS	26		Cuttings							
315.27	SILT, trace sand, trace clay Compact Grey		6	SS	17									0 4 87 9
3.90			7	SS	18									
			8	SS	19									
312.19	CLAYEY SILT, trace sand Stiff to very stiff Grey		9	SS	14		Standpipe							
6.49	SILT, trace sand, trace clay, with clayey silt layers Compact Grey		10	SS	24									
311.61			11	SS	20									
7.07	CLAYEY SILT, trace sand Very stiff Grey		12	SS	15									0 1 79 20
309.69														
8.99	SANDY SILT, trace clay Compact Grey		13	SS	16		Holeplug							
307.68			14	SS	28		Caved Material							
11.00														
305.57	SILT, trace clay, with clayey silt layers Dense Grey		15	SS	43		Filter sand							0 0 93 7
13.11														
304.05														
14.63														

Continued Next Page

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

LDN_MTO_06 08-1132-084-1 GPJ LDN_MTO_GDT 15/03/11

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 504		2 OF 3	METRIC
W.P. <u>131-98-00</u>	LOCATION <u>N 4810439.8 ; E 225985.2</u>	ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>	BOREHOLE TYPE <u>POWER AUGER / TRICONE</u>	COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>	DATE <u>November 13, 2008 and Borehole Deepened June 18 & 19, 2009</u>	CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p	W	W _L		GR	SA	SI	CL	
								20	40	60	80	100									
	CLAYEY SILT, with silt partings Very stiff Grey		16	SS	21																
			17	SS	16																
301.01																					
17.67	CLAYEY SILT, with silt lenses Stiff Grey		18	SS	12																
299.48																					
19.20	CLAYEY SILT TILL, trace sand and gravel Very stiff Grey		19	SS	16																
			20	SS	29																
			21	SS	26																
294.91																					
23.77	SAND, some gravel, some silt, trace clay Very dense Grey		22	SS	58																
293.38																					
25.30	SILTY CLAY, with silt layers Hard Grey		23	SS	63																
			24	SS	60																
			25	SS	33																
288.78																					

LDN_MTO_06_08-1132-084-1.GPJ LDN_MTO.GDT 15/03/11

Continued Next Page

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

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 504		3 OF 3	METRIC
W.P. <u>131-98-00</u>	LOCATION <u>N 4810439.8 ; E 225985.2</u>	ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>	BOREHOLE TYPE <u>POWER AUGER / TRICONE</u>	COMPILED BY <u>LMK</u>			
DATUM <u>GEODETIC</u>	DATE <u>November 13, 2008 and Borehole Deepened June 18 & 19, 2009</u>	CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	w _p		
29.90	SILTY SAND, fine, trace clay Dense Grey		26	SS	33									0 67 32 1
287.28														
31.40			SANDY SILT TILL, some clay, trace to some gravel Very dense Grey	27	SS	100/ 100mm								
		28		SS	100/ 100mm									
283.54	END OF BOREHOLE		29	SS	100/ 100mm									
35.14	Groundwater encountered at about elev. 316.6m during drilling on November 13, 2008. Water level measured in piezometer at elev. 312.10m on November 13, 2008. Water level measured in standpipe at elev. 315.51m on November 13, 2008. Water level measured in piezometer at elev. 317.49m on June 18, 2009. Water level measured in standpipe at elev. 316.17m on June 18, 2009. Standpipe and piezometer found to be destroyed on August 25, 2009.													

PROJECT 08-1132-084-1		RECORD OF BOREHOLE No 505		2 OF 2		METRIC	
W.P. 131-98-00		LOCATION N 4810451.2 ; E 225950.6		ORIGINATED BY MA			
DIST _____ HWY 7/8		BOREHOLE TYPE POWER AUGER / HOLLOW STEM		COMPILED BY LMK			
DATUM GEODETIC		DATE November 18, 23 and 24, 2008		CHECKED BY _____			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				GR	SA	SI	CL	
								20	40	60	80	100	W _p	W	W _L						
310.07																					
16.46																					
308.70																					
17.83																					
307.43																					
19.10																					
306.41																					
20.12																					
20.27																					
			</																		

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 506		1 OF 3	METRIC
W.P. <u>131-98-00</u>	LOCATION <u>N 4810455.9 ; E 225966.2</u>	ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>	BOREHOLE TYPE <u>POWER AUGER / TRICONE</u>	COMPILED BY <u>DMB</u>			
DATUM <u>GEODETIC</u>	DATE <u>November 24, 2008, May 31 and June 1, 2009.</u>	CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER TYPE "N" VALUES
326.32	GROUND SURFACE	[Pattern]	
0.00	ASPHALT	[Pattern]	
0.15	FILL, sand and gravel, crushed Brown	[Pattern]	
0.46	FILL, sand and gravel Brown	[Pattern]	
0.70	FILL, sand, fine to medium, trace to some gravel, sandy silt pockets Compact to very dense Brown	[Pattern]	1 SS 22
		[Pattern]	2 SS 41
		[Pattern]	3 SS 49
		[Pattern]	4 SS 44
		[Pattern]	5 SS 59
		[Pattern]	6 SS 46
		[Pattern]	7 SS 33
320.38	FILL, sandy silt, trace to some clay, trace gravel Compact to dense Brown	[Pattern]	8 SS 24
		[Pattern]	9 SS 31
318.49	FILL, sand and gravel, with wood Compact Brown	[Pattern]	10 SS 27
8.23	FILL, sand, fine to medium, trace silt, trace gravel Compact Brown	[Pattern]	11 SS 23
316.82	FILL, clayey silt, trace sand, some topsoil Very stiff Brown and black CLAYEY SILT, trace sand, with silt layers Stiff Brown	[Pattern]	12 SS 16
		[Pattern]	13 SS 14
		[Pattern]	14 SS 13
314.74	SILT, trace clay, trace sand Dense Grey	[Pattern]	15 SS 33
313.21	CLAYEY SILT, trace sand, with silt layers Very stiff Grey	[Pattern]	16 SS 22

Continued Next Page

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

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 506		2 OF 3		METRIC	
W.P. <u>131-98-00</u>		LOCATION <u>N 4810455.9 ; E 225966.2</u>		ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>		BOREHOLE TYPE <u>POWER AUGER / TRICONE</u>		COMPILED BY <u>DMB</u>			
DATUM <u>GEODETIC</u>		DATE <u>November 24, 2008, May 31 and June 1, 2009.</u>		CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL LIMIT MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)			GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
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LDN_MTO_06_08-1132-084-1.GPJ LDN_MTO.GDT 15/03/11

Continued Next Page

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

PROJECT <u>08-1132-084-1</u>		RECORD OF BOREHOLE No 506		3 OF 3	METRIC
W.P. <u>131-98-00</u>	LOCATION <u>N 4810455.9 ; E 225966.2</u>	ORIGINATED BY <u>MA</u>			
DIST <u> </u> HWY <u>7/8</u>	BOREHOLE TYPE <u>POWER AUGER / TRICONE</u>	COMPILED BY <u>DMB</u>			
DATUM <u>GEODETIC</u>	DATE <u>November 24, 2008, May 31 and June 1, 2009.</u>	CHECKED BY <u> </u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)		
29.87	SILTY CLAY, trace sand, with silt layers Very stiff to hard Grey																
			27	SS	81												
			28	SS	56/ 125mm												
			29	SS	48												
			30	SS	27												
			31	SS	36												
288.83	SANDY SILT, trace gravel, trace clay Very dense Grey		32	SS	111/ 250mm												
37.49																	
287.31	SANDY SILT TILL, trace clay, trace gravel Very dense Grey		33	SS	75/ 50mm												
39.01																	
284.93	END OF BOREHOLE		34	SS	102/ 250mm												
41.39																	
	Groundwater encountered at about elev. 318.1m and elev. 308.6m during drilling on November 24, 2008, and May 31, 2009, respectively.																

LDN_MTO_06_08-1132-084-1.GPJ LDN_MTO.GDT 15/03/11



FOUNDATION INVESTIGATION AND DESIGN REPORT EXISTING CNR OVERHEAD RETAINING WALL D

APPENDIX C

Site Photographs



APPENDIX C SITE PHOTOGRAPHS



Photograph 1: View of CNR Overhead Retaining Wall D, looking west from cul-de-sac of Overland Drive.



Photograph 2: View of construction joint between panels 20 (left side of photograph) and 21 (right side of photograph).



APPENDIX C SITE PHOTOGRAPHS



Photograph 3: Joint between Panels 20 and 21 at east end of retaining Wall D. Construction joint appears to be opening up.

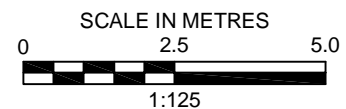
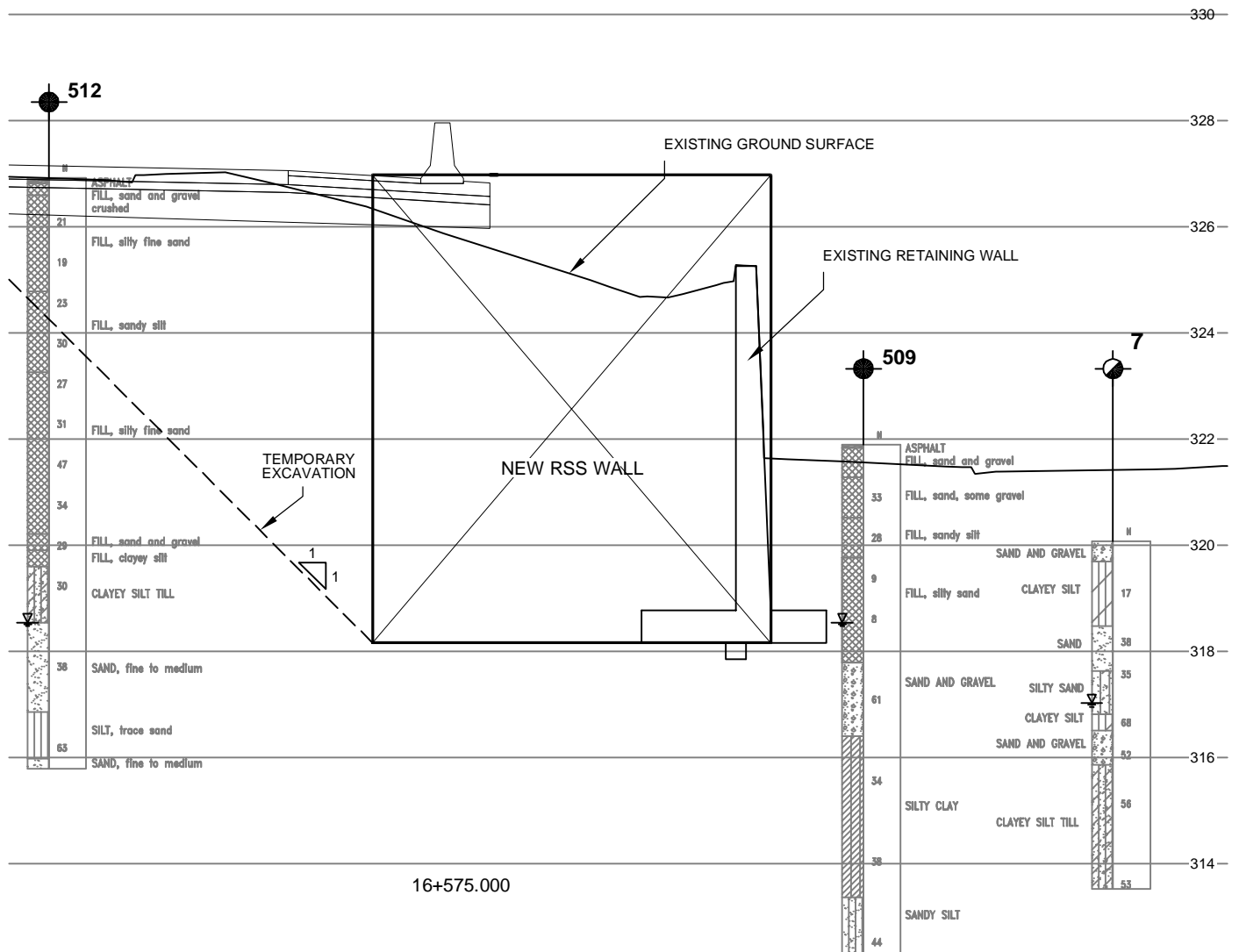


Photograph 4: Expansion joint between Panel 21 and south end of west abutment wall. Displacement of retaining wall relative to west abutment is evident in top part of photograph.



APPENDIX D

Typical Cross-Sections for Modification of CNR Overhead Retaining Wall D



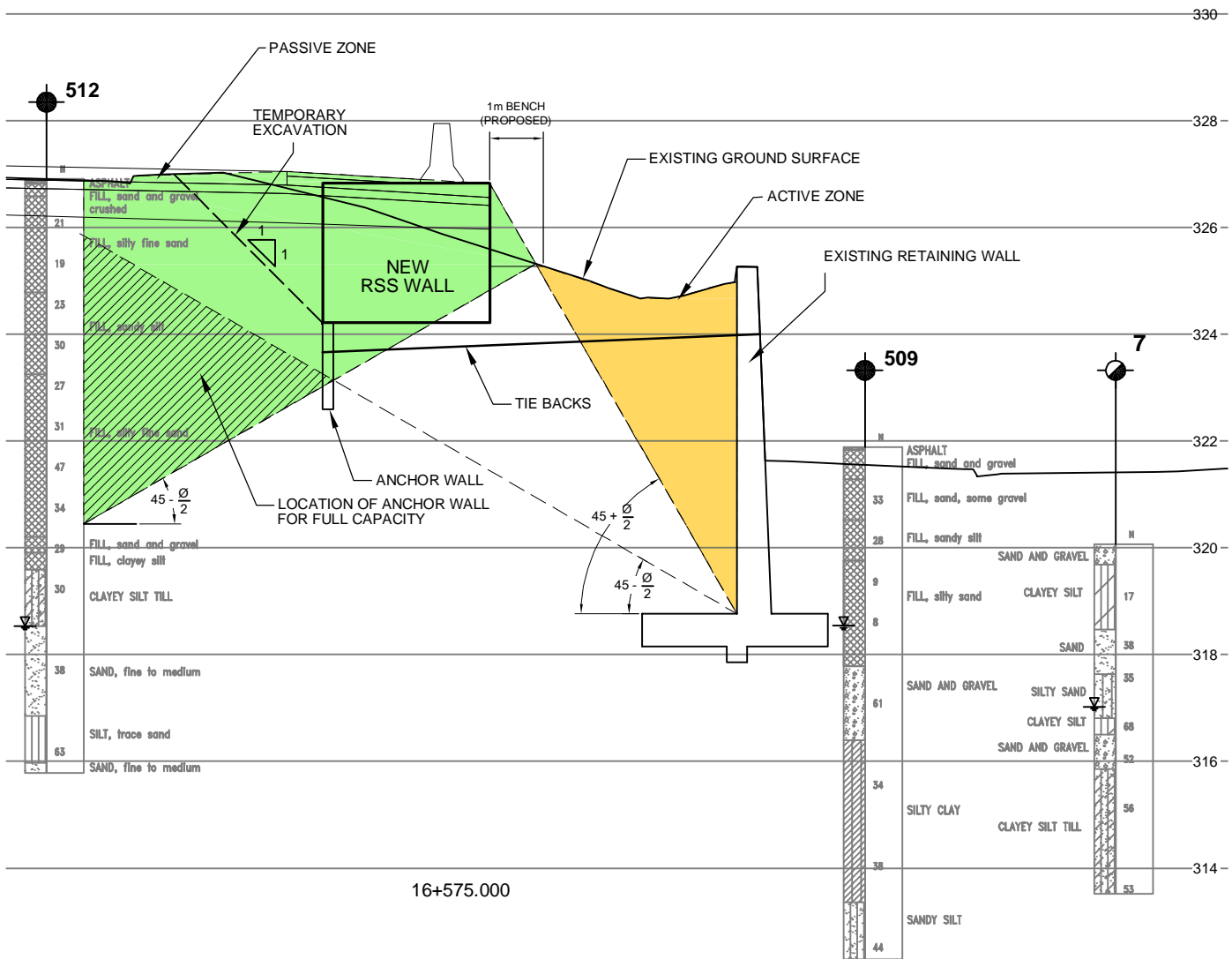
LEGEND

- BOREHOLE
CURRENT INVESTIGATION
- BOREHOLE
PREVIOUS INVESTIGATION, GEOCREs No. 40P08-36
E.M.PETO ASSOCIATES LTD.
PROJECT No. 64225 JANUARY 1965

NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH
ACCOMPANYING TEXT.

PROJECT EXISTING CNR OVERHEAD RETAINING WALL D WIDENING OF HIGHWAY 7/8 GWP 131-98-00			
TITLE			
OPTION i NEW RSS WALL			
PROJECT No. 08-1132-084-1		FILE No. 0811320841-F090D1	
CADD	WDF/AMG	DEC. 17/10	SCALE AS SHOWN
CHECK			REV. 0
Golder Associates LONDON, ONTARIO			FIGURE D-1



LEGEND



BOREHOLE
CURRENT INVESTIGATION



BOREHOLE
PREVIOUS INVESTIGATION, GEOCREs No. 40P08-36
E.M.PETO ASSOCIATES LTD.
PROJECT No. 64225 JANUARY 1965



PASSIVE ZONE



ACTIVE ZONE

NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH
ACCOMPANYING TEXT.

PROJECT EXISTING CNR OVERHEAD RETAINING WALL D
WIDENING OF HIGHWAY 7/8
GWP 131-98-00

TITLE

**OPTION iii
RSS WALL**



PROJECT No. 08-1132-084-1

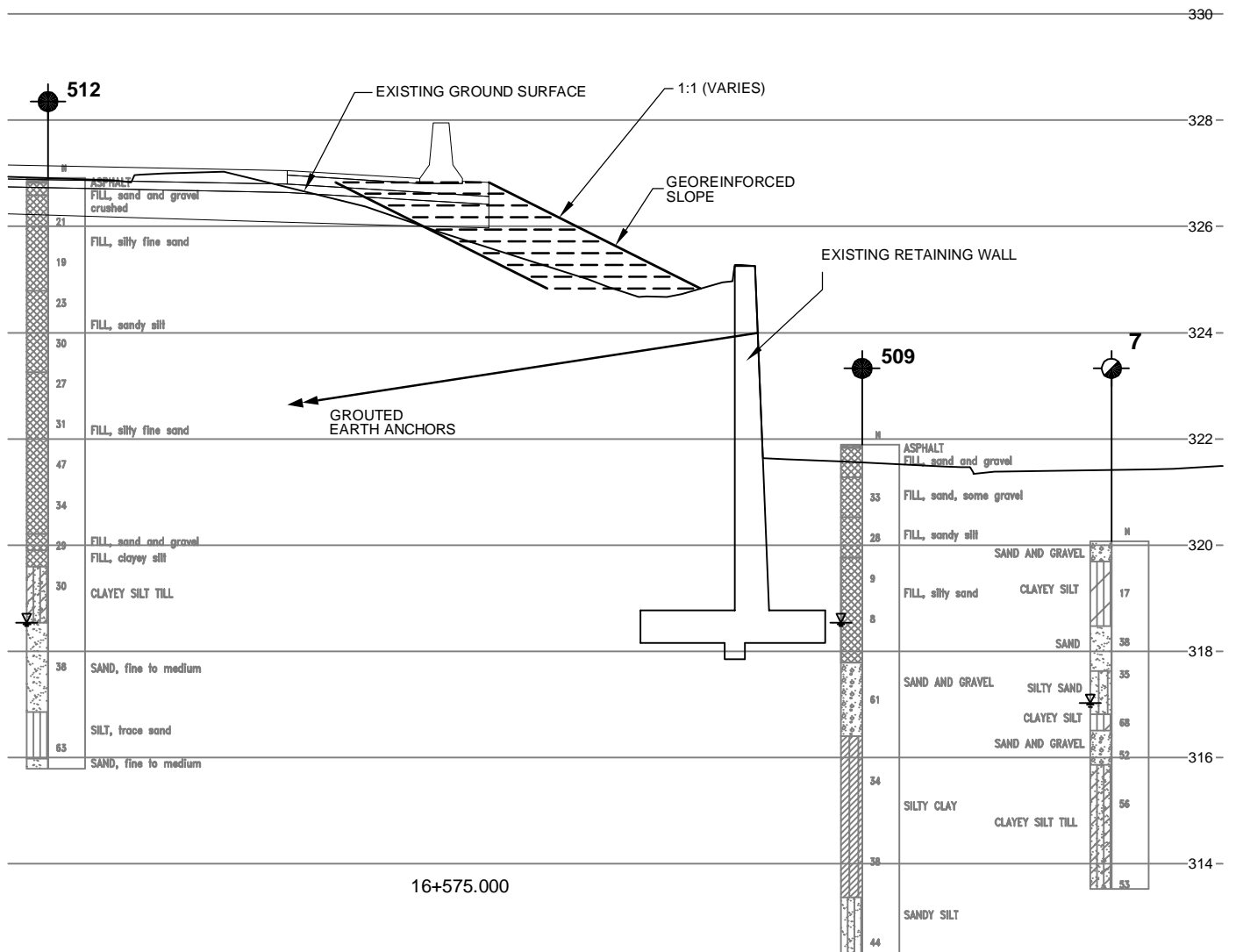
FILE No. 0811320841-F090D1

CADD WDF/AMG DEC. 17/10

SCALE AS SHOWN REV. 0

CHECK

FIGURE D-3



LEGEND

- BOREHOLE CURRENT INVESTIGATION
- BOREHOLE PREVIOUS INVESTIGATION, GEOCREs No. 40P08-36 E.M.PETO ASSOCIATES LTD. PROJECT No. 64225 JANUARY 1965

NOTE

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

PROJECT		EXISTING CNR OVERHEAD RETAINING WALL D	
		WIDENING OF HIGHWAY 7/8	
		GWP 131-98-00	
TITLE		OPTION iv	
		GEOREINFORCED SLOPE	
PROJECT No.		08-1132-084-1	FILE No. 0811320841-F090D1
CADD		WDF/AMG	DEC. 17/10
CHECK			
SCALE		AS SHOWN	REV. 0
		FIGURE D-4	



Drawing file: 0811320841-F090D1.DWG Mar 15, 2011 - 1:14pm

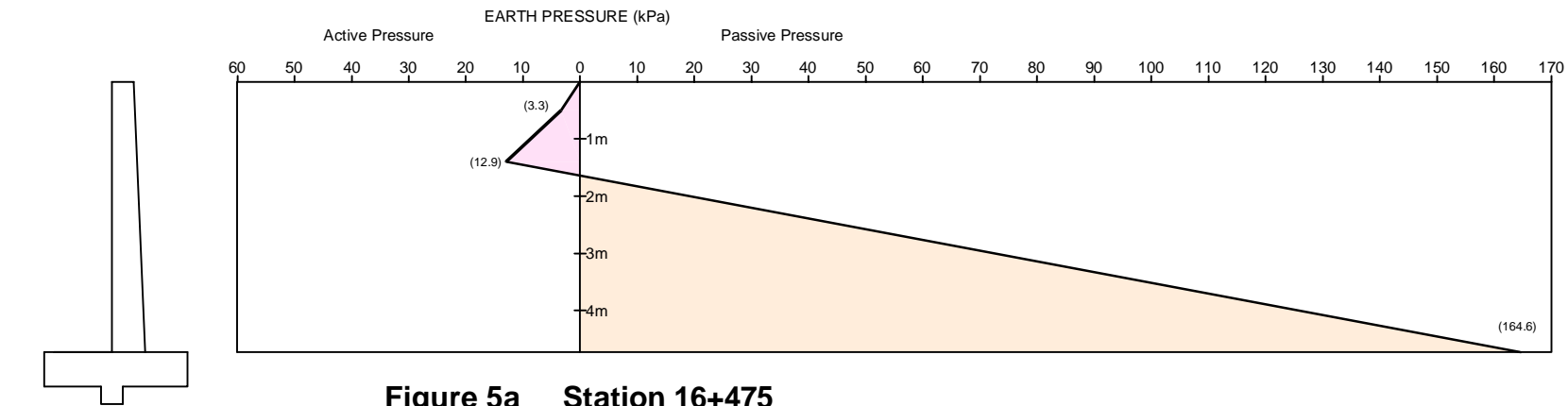


Figure 5a Station 16+475

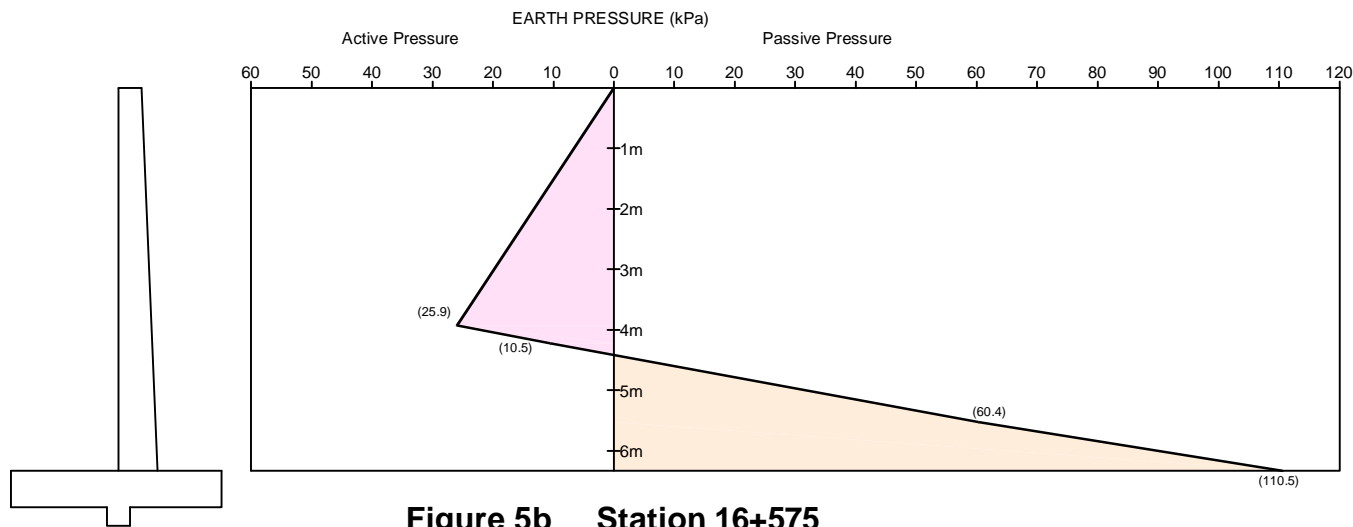


Figure 5b Station 16+575

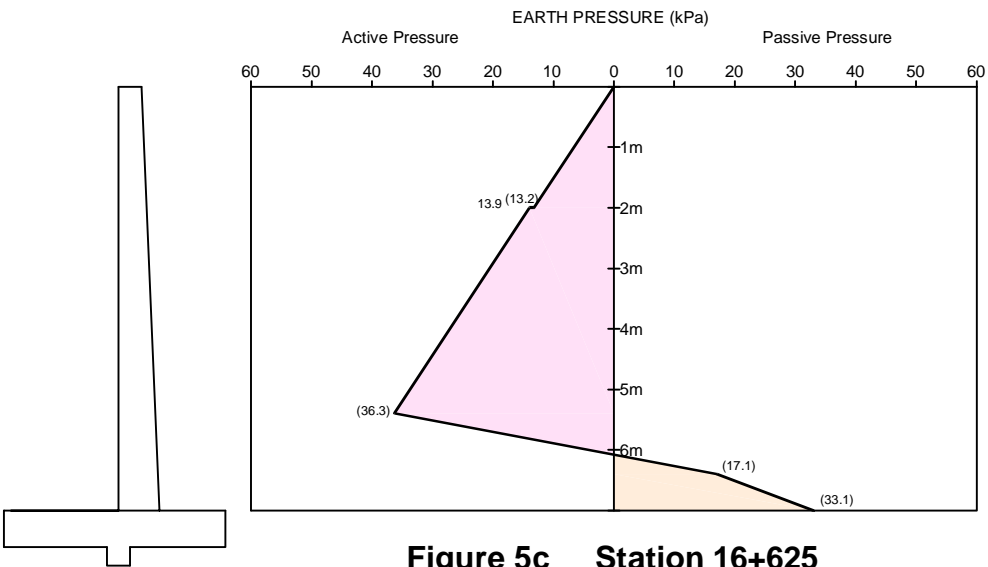



Figure 5c Station 16+625

NOTE
THIS DRAWING IS TO BE READ IN CONJUNCTION WITH
ACCOMPANYING TEXT.

PROJECT	EXISTING CNR OVERHEAD RETAINING WALL D WIDENING OF HIGHWAY 7/8 GWP 131-98-00							
	TITLE							
EARTH PRESSURE DIAGRAMS								
 Golder Associates LONDON, ONTARIO	PROJECT No.		08-1132-084-1		FILE No.	0811320841-F090D1		
	CADD	WDF	Nov. 04/10		SCALE	AS SHOWN	REV.	0
	CHECK				FIGURE D-5			

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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