



February 2011

## FOUNDATION INVESTIGATION AND DESIGN REPORT

**Proposed Noise Barrier Wall 4**

**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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**FOUNDATION INVESTIGATION AND DESIGN REPORT  
PROPOSED NOISE BARRIER WALL 4**

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**PART A**

**FOUNDATION INVESTIGATION REPORT**

**PROPOSED NOISE BARRIER WALL 4**

**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 the foundation investigations as part of the detail design work for GWP 131-98-00, the reconstruction and widening of Highway 7/8 within the project limits. This report presents the results of the foundation investigation conducted for the proposed Noise Barrier Wall 4 located west of the Fischer-Hallman Road Interchange from Station 11+475 to 12+125 Lt along Highway 7/8.

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 locations and extent of the noise barrier walls in plan 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 project extends from 1.9 km west of Fischer-Hallman Road easterly to 0.8 km east of Courtland Avenue. The location of the proposed noise barrier wall 4 is shown on the Key Plan, Figure 1 and the Noise Barrier Wall Location Plan, Figure 2.

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 CNR tracks are situated within the project limits.

Land use adjacent to this site is typically urban residential with some industrial and commercial areas to the south. Forest Heights Trail Corridor runs alongside the westbound lanes of Highway 7/8 in this area.

The proposed shoulder mounted Noise Barrier Wall 4 is to be located west of the Fischer-Hallman Road Interchange from Station 11+475 to 12+125 Lt along Highway 7/8. The topography adjacent to the highway in this area is hummocky to gently undulating with ground surface elevations ranging from about 370 metres at the west end to 350 metres at the east end of the proposed wall.

### 2.2 Site Geology

This project lies within the physiographic region of southwestern Ontario known as the Waterloo Hills<sup>1</sup>. The soils generally consist of sandy hills; some are ridges 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 Map 2559 entitled "Quaternary Geology, Stratford Area", the site lies primarily in an area of ice contact gravel deposited in the Pleistocene era. The ice-contact gravel deposits are described as "poorly to well sorted, fine gravel and/or sand to coarse gravel and/or sand textured". The eastern corner of the site is situated on the boundary of a Maryhill Till (clay till) area that generally surrounds the site.

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



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The Geologic Survey of Canada Map 1263A entitled “Geology, Toronto-Windsor Area, Ontario” indicates that the subcropping bedrock in the area of the site is dolomite and mudstone of the Salina formation of Upper Silurian age. Based on the Ministry of Natural Resources Map P.168 entitled “Bedrock Topography Series, Stratford Area, Southern Ontario”, the bedrock surface at the site is at an elevation of just under 275 metres.



### 3.0 INVESTIGATION PROCEDURES

The foundation investigation fieldwork for the design of the proposed noise wall barrier 4 was carried out on May 18 to 20 and June 10, 2010 during which time ten boreholes were drilled along Highway 7/8 in the areas of proposed Noise Barrier Wall 4. The borehole locations are shown on the Borehole Location Plan, Drawing 1. Boreholes 82 and 83 were added during the drilling program after the originally proposed Noise Barrier Wall was re-designed and extended. Based on the current barrier wall design, borehole 83 is approximately 50 metres to the east of the east end of the wall.

The boreholes (1 to 8, 82 and 83) were advanced to a depth of 5.0 to 6.6 metres. The table below summarises 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)
1	4 808 600	221 189	369.79	5.18
2	4 808 629	221 252	369.79	6.55
3	4 808 662	221 320	365.41	5.18
4	4 808 690	221 380	363.18	5.03
5	4 808 726	221 455	361.47	5.18
6	4 808 757	221 519	360.23	5.18
7	4 808 790	221 589	359.48	5.79
8	4 808 824	221 660	358.50	5.18
82	4 808 865	221 746	357.32	5.03
83	4 808 895	221 810	356.49	5.03

The drilling was carried out using truck mounted CME 45 power augers supplied and operated by a specialist drilling contractor. In the boreholes, samples of the overburden were obtained at 0.75 metre intervals of depth using 50 millimetres outside diameter split spoon sampling equipment in accordance with the standard penetration test 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. In addition, dynamic cone penetration testing was carried out in boreholes 2 and 7 in order to further characterize the condition of the soils at these locations.

The groundwater conditions were observed throughout the drilling operations and upon completion of drilling. A summary of the groundwater level observations are presented in Table 1. The boreholes were backfilled in accordance with current Ontario Ministry of Transportation (MTO) procedures and Ontario Regulation 372/07.





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## FOUNDATION INVESTIGATION AND DESIGN REPORT PROPOSED NOISE BARRIER WALL 4

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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.



## **4.0 SUBSURFACE CONDITIONS**

### **4.1 Site Stratigraphy**

The detailed subsurface soil and groundwater conditions encountered in the 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. The stratigraphic boundaries shown on the Record of Borehole sheets and stratigraphic profiles 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, consisting of fill materials underlain by layers of clayey silt, sand, sandy silt, sandy silt till, silt, silty sand and sand and gravel.

The borehole locations are shown on Drawing 1. 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 Fill**

The boreholes were advanced in the northern shoulder of the westbound lanes of Highway 7/8. Granular roadbase materials were encountered at the ground surface in all boreholes. The granular roadbase was found to be 150 to 520 millimetres thick.

In boreholes 1 to 8, the granular roadbase was underlain by fill materials, which were granular in nature. Where fully penetrated, the thickness of the granular fill layers ranged from 0.4 to 4.9 metres. Borehole 5 was terminated in the fill after exploring it for about 5.2 metres. The presence of cobbles was noted within the upper granular fill layers at elevations 369.6, 359.2 and 358.3 metres in boreholes 2, 7 and 8, respectively. Trace amounts of topsoil were also observed within the granular fill in borehole 2 at elevation 369.0 metres. A layer of cohesive fill, about 3.9 metres thick, was encountered at elevation 362.6 metres underneath the granular fill in borehole 4. Layers of cohesive fill, about 0.3 and 0.7 metres thick, were found interlayered with granular fill at elevations 357.1 and 357.9 metres in boreholes 5 and 8, respectively.

The granular fill comprised sand and gravel, sand, sandy silt and silty sand. The granular fill was loose to dense with standard penetration test N values ranging from 2 to 34 blows per 0.3 metres with water contents ranging from 6 to 23 per cent. An Atterberg limits determination was carried out on a sample of sandy silt fill with some clay and confirmed the fill in borehole 8 at elevation 355.2 metres to be non-plastic.

The stiff to hard cohesive fill consisted of clayey silt and had N values ranging from 10 to 48 blows per 0.3 metres and water contents of 5 to 12 per cent. The cohesive fill is of low plasticity based on a single Atterberg limits determination carried out on a sample obtained during standard penetration testing. The plastic limit, liquid



limit and plasticity index were 12, 19 and 7 per cent, respectively. The Atterberg limits data for the cohesive fill sample are presented on Figure A-5 in Appendix A.

The results of the grain size testing conducted on granular and cohesive fill layers are presented on Figure A-1.

### 4.1.2 Sand

Loose to very dense sand layers were encountered underlying the granular fill in boreholes 1 and 83 at elevation 369.3 and 356.1 metres, respectively. The sand layer was 4.0 metres thick in borehole 83. Borehole 1 was terminated in the sand after exploring the stratum for about 4.7 metres.

N values in the sand layers varied from 7 to 62 blows per 0.3 metres. Water contents of 2 to 4 per cent were measured on sand samples.

The grain size distribution curves for three samples of sand obtained during standard penetration testing are presented on Figure A-2.

### 4.1.3 Sandy Silt

Layers of sandy silt were found underneath the fill materials in borehole 2 at elevation 364.9 metres and in borehole 7 at elevation 357.2 metres. A layer of silty sand was found within the sandy silt deposit at elevation 364.3 metres in borehole 2. The thicknesses of the sandy silt layers in borehole 2 (upper layer) and borehole 7 were 0.6 metres. The lower sandy silt layer was explored for 0.6 metres before termination of borehole 2.

N values in the sandy silt ranged between 2 and 23 blows per 0.3 metres indicating a very loose to compact density. A water content of 15 per cent was measured in a sandy silt sample obtained during standard penetration testing.

### 4.1.4 Silty Sand

Deposits of compact to very dense silty sand and silty fine sand were encountered in boreholes 2, 4, 6, 8 and 83 from elevation 352.1 to 364.3 metres. The silty sand was found underlying the granular fill, clayey silt, sandy silt and sand in these borehole locations. The silty sand layer in borehole 6 was noted to contain clayey silt pockets. The silty sand layers were 0.4 and 0.6 metres thick in boreholes 2 and 6, respectively. Boreholes 4, 8 and 83 were terminated in the silty sand after exploring the strata for 0.1, 0.8 and 0.6 metres, respectively.

The silty sand had N values ranging from 23 to 91 blows per 0.3 metres and a water content of 11 per cent.



### 4.1.5 Silt

Compact to dense layers of silt were encountered in boreholes 3, 6 and 7 at elevations 361.8, 355.2 and 354.2 metres, respectively. The silt was encountered underlying layers of fill in borehole 3 and at depth underlying silty sand and clayey silt in boreholes 6 and 7, respectively. The thickness of the silt layer was 0.4 metres in borehole 3. Boreholes 6 and 7 were terminated in the silt after exploring it for 0.2 and 0.6 metres, respectively.

The silt had an N value of 30 blows per 0.3 metres and water contents of 8 and 12 per cent.

### 4.1.6 Clayey Silt

Layers of clayey silt were encountered in boreholes 3, 4, and 6 through 8 from elevation 354.8 to 361.4 metres. The clayey silt was generally found underlying layers of fill with the exception of boreholes 3 and 7, which were found underlying silt and sandy silt layers, respectively. Where fully penetrated, the clayey silt layers ranged from 0.2 to 2.3 metres thick. Borehole 3 was terminated in the clayey silt after exploring the stratum for about 1.2 metres.

The clayey silt deposits had N values of 4 to 91 blows per 0.3 metres indicating a firm to hard consistency. The water contents in the clayey silt ranged from 12 to 19 per cent. The clayey silt is of low plasticity based on a single Atterberg limits determination carried out on a sample obtained during standard penetration testing. The plastic limit, liquid limit and plasticity index were 14, 23 and 9 per cent, respectively. The Atterberg limits data for the clayey silt are presented on Figure A-5.

The results of the grain size testing conducted on a clayey silt sample are presented on Figure A-3.

### 4.1.7 Sandy Silt Till

Sandy silt till was encountered in borehole 82 at elevation 356.8 metres underneath the granular roadbase. The thickness of the sandy silt till deposit was about 3.9 metres.

The loose to compact sandy silt till had N values of 9 to 22 blows per 0.3 metres with water contents of 8 and 12 per cent.

The results of the grain size testing conducted on two sandy silt till samples are presented on Figure A-4.



### 4.1.8 Sand and Gravel

Silty sand and gravel was encountered in borehole 82 at elevation 352.9 metres underneath the sandy silt till. The borehole was terminated in the sand and gravel after exploring it for 0.6 metres.

The compact sand and gravel had an N value of 12 blows per 0.3 metres.

## 4.2 Groundwater Conditions

The groundwater conditions in all 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 Table 1.

**Table 1: Summary of Encountered Groundwater Levels**

Borehole	Ground Surface Elevation (m)	Encountered Groundwater Level	
		Depth (m)	Elevation (m)
1	369.79	Dry	Below 364.6
2	369.79	Dry	Below 363.2
3	365.41	Dry	Below 360.2
4	363.18	Dry	Below 358.2
5	361.47	Dry	Below 356.3
6	360.23	Dry	Below 355.1
7	359.48	Dry	Below 353.7
8	358.50	4.6	353.9
82	357.32	4.6	352.7
83	356.49	Dry	Below 351.5

Groundwater was encountered at elevation 353.9 and 352.7 metres in boreholes 8 and 82 only. The remaining boreholes were dry and did not intercept grey soils.

The above noted water levels are not considered to be representative of the long-term, stabilized groundwater conditions as the readings were taken for a short duration only. West of approximate Station 11+965 LT, the groundwater level is anticipated to be below the depth of exploration (5 metres) or below elevation 355 to 365 metres. East of Station 11+965 LT, the inferred groundwater level is expected to vary between elevation 354



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## FOUNDATION INVESTIGATION AND DESIGN REPORT PROPOSED NOISE BARRIER WALL 4

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metres near Station 11+965 LT and 353 metres near the east end of the wall at Station 12+125. The groundwater levels are expected to fluctuate due to climatic and seasonal variations.



## **5.0 MISCELLANEOUS**

This investigation was carried out using equipment supplied and operated by Aardvark Drilling Ltd., who is an Ontario Ministry of Environment licensed well contractor. The field operations were supervised by Mr. Michael Arthur 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.

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**FOUNDATION INVESTIGATION AND DESIGN REPORT  
PROPOSED NOISE BARRIER WALL 4**

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**PART B**

**FOUNDATION DESIGN REPORT**

**PROPOSED NOISE BARRIER WALL 4**

**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 foundation engineering parameters and recommendations for the geotechnical aspects of the design for proposed Noise Barrier Wall 4 along the north side of Highway 7/8 between Stations 11+475 and 12+125 LT. Noise Barrier Wall 4 is to be shoulder mounted.

The design parameters and recommendations have been developed based on interpretation of the factual data obtained from the boreholes advanced at the site. The interpretation and recommendations are intended to provide the designer with sufficient information to design the proposed noise barrier wall foundations. Where comments are made on construction, they are provided in order to highlight those aspects that could affect the design or for which special provisions or operational constraints may be required in the Contract Documents. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect the equipment selection, proposed construction methods, scheduling and the like.

### **6.2 Noise Barrier Wall Foundation Design**

The noise barrier wall foundations should be designed and constructed in accordance with MTO SP599F01. The noise barrier wall will be supported using conventional augered caissons with a diameter of 0.6 to 0.9 metres. Foundation design parameters for design of the caisson foundations are provided in Table I following the text of this report based on the soil conditions encountered along the proposed noise barrier wall alignments. The stratigraphy presented in Table I has been simplified for the purposes of the noise barrier wall foundation design.

Where both an undrained shear strength,  $c_u$ , and an effective friction angle,  $\phi'$ , have been given for a specific stratum, the caisson design should be checked for both the drained and the undrained condition and the larger of the two calculated caisson depths shall govern.

The passive resistance in the upper 1.4 metres below ground should be neglected to account for frost action. In addition, for foundation design, full passive resistance will be mobilized only where the ground surface in front of and behind the caisson is level. Where sloping ground is present adjacent to the noise barrier wall, the  $K_p$  values used in the calculation should be adjusted to account for the presence of the sloping ground. The ground surface behind the proposed noise barrier wall between approximate stations 11+650 and 11+890 LT will slope downwards at 3 horizontal to 1 vertical. Adjusted  $K_p$  values are provided in Table I for these areas. The adjusted  $K_p$  value is to be applied to that portion of the caisson that is above the elevation of the ground surface at the toe of the embankment or slope; below this elevation, the full  $K_p$  is to be applied.



The noise barrier wall will cross an existing corrugated steel pipe (CSP) culvert, 1050 millimetres in diameter, near approximate Station 11+535 LT. According to the ETR plates, the obvert is near elevation 365 metres. The design of the foundations for the noise barrier wall should consider the location of this culvert.

### 6.3 Construction Considerations

Excavations for construction of the caissons for the noise barrier wall foundations will penetrate the surficial fill and will extend through deposits of sand, sandy silt, silty sand, silt, sandy silt till and clayey silt. The sands are predominantly fine grained and uniform in composition. The sands, silts and clayey silt at this site are susceptible to disturbance during caisson excavation and construction.

Excavation of granular materials below the groundwater level will be required east of approximate Station 11+965 LT. With proactive dewatering, a temporary liner will be required to support the sides of the excavation and permit cleaning and inspection of the base. Careful cleaning of the base of the caisson should be carried out prior to placement of concrete to remove all loosened or disturbed materials. Alternatively, the foundations could be installed using mud drilling techniques (augering with the hole filled with bentonite slurry) and placement of concrete by tremie. Surface water run off should be directed away from the excavation. It is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract Documents to alert the Contractor about the requirements for support of the augered excavation and measures to deal with excavation of saturated granular soils below the groundwater level. The NSSP should also state that measures and equipment are required to deal with cobbles and boulders which can be expected in the sandy silt till found in borehole 82.

The caissons should be constructed and inspected in accordance with Ontario Provincial Standard Specifications 903 and SP599F01. Following construction, the Quality Verification Engineer shall submit a Certificate of Conformance confirming that the noise barrier wall foundations have been constructed in general conformance with the contract documents.



## **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

**FOUNDATION DESIGN PARAMETERS  
PROPOSED NOISE BARRIER WALL 4**

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

Station and Borehole	Soil Type	Elevation Interval (m)	Design Groundwater Elevation (m)	Undrained Shear Strength, $c_u^1$ (kPa)	Effective Angle of Friction, $\phi^1$ (°)	Coefficient of Passive Pressure, $K_p^2$ Level Ground/ 3H:1V	Coefficient of Active Pressure, $K_a$ Level Ground	Unit Weight <sup>3</sup> (kNm <sup>-3</sup> )	
								Bulk, $\gamma$	Effective, $\gamma'$
11+475 to 11+515 Borehole 1	Compact to very dense sand	Below 368	Below 365	-	32	3.3/N/A	0.31	19.5	9.5
11+515 to 11+590 Borehole 2	Very loose to compact granular fill	Above 365	Below 363	-	28	2.8/N/A	0.36	18.0	8.0
	Compact sandy silt and silty sand	Below 365		-	30	3.0/N/A	0.33	18.5	8.5
11+590 to 11+660 Borehole 3	Very loose to compact granular fill	364 to 362	Below 360	-	28	2.8/N/A	0.36	18.0	8.0
	Hard clayey silt	Below 362		200	30	3.0/1.6	0.33	19.0	9.0
11+660 to 11+735 Borehole 4	Stiff to hard cohesive fill	Above 359	Below 358	180	29	2.9/1.6	0.35	19.0	9.0
	Hard clayey silt	Below 359		300	30	3.0/1.6	0.33	19.0	9.0
11+735 to 11+810 Borehole 5	Compact to dense granular fill	Below 360	Below 356	- -	30	3.0/1.6	0.33	19.0	9.0
11+810 to 11+890 Borehole 6	Compact to dense granular fill	359 to 356	Below 355	-	30	3.0/1.6	0.33	19.0	9.0
	Dense silty sand to silt	Below 356		-	32	3.3/1.8	0.31	19.0	9.0

**FOUNDATION DESIGN PARAMETERS  
PROPOSED NOISE BARRIER WALL 4**

Station and Borehole	Soil Type	Elevation Interval  (m)	Design Groundwater Elevation  (m)	Undrained Shear Strength, $c_u^1$ (kPa)	Effective Angle of Friction, $\phi'^1$ (°)	Coefficient of Passive Pressure, $K_p^2$ Level Ground/ 3H:1V	Coefficient of Active Pressure, $K_a$ Level Ground	Unit Weight <sup>3</sup> (kNm <sup>-3</sup> )	
								Bulk, $\gamma$	Effective, $\gamma'$
11+890 to 11+965 Borehole 7	Loose to compact granular fill	358 to 357	Below 354	-	29	2.9/N/A	0.35	18.5	8.5
	Firm to very stiff clayey silt	357 to 354		60	28	2.8/N/A	0.36	19.0	9.0
	Dense silt	Below 354		-	30	3.0/N/A	0.33	19.0	9.0
11+965 to 12+050 Borehole 8	Loose to compact granular fill	357 to 355	354	-	29	2.9/N/A	0.35	18.0	8.0
	Stiff clayey silt	355 to 354		100	29	2.9/N/A	0.35	19.0	9.0
	Compact silty fine sand	Below 354		-	31	3.1/N/A	0.32	19.0	9.0
12+050 to 12+125 Borehole 82	Loose to compact sandy silt till	Above 353	353	-	31	3.1/N/A	0.32	20.5	10.5
	Compact silty sand and gravel	Below 353		-	32	3.3/N/A	0.31	20.5	10.5

**NOTES:**

1. Where both  $c_u$  and  $\phi'$  have been given for a specific stratum, the foundation design should be checked for both the drained and undrained conditions, and the larger of the two calculated foundation depths shall govern.
2. Passive earth pressure coefficient ( $K_p$ ) values are provided for level ground. Where sloping ground is present adjacent to the noise barrier wall, adjusted  $K_p$  values must be used in the foundations design. Between approximate Stations 11+650 and 11+890, the ground behind the relocated noise barrier wall will slope downwards at 3 horizontal to 1 vertical.
3. Below the groundwater level, the effective unit weight of the soil ( $\gamma'$ ) should be used.
4. This table is to be read in conjunction with the accompanying report.

Prepared By: DB  
Checked By: DUP

## 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

	$c_u, s_u$	
	<u>kPa</u>	<u>psf</u>
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 cm<sup>2</sup> 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 <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	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)
$\gamma$	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

$\pi$	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

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\epsilon$	linear strain
$\epsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	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
$\gamma'$	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
$\sigma'_p$	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	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  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density x acceleration due to gravity)

PROJECT <u>08-1132-084-1</u>		<b>RECORD OF BOREHOLE No 1</b>		1 OF 1		<b>METRIC</b>	
W.P. <u>131-98-00</u>		LOCATION <u>N 4808599.9 ; E 221188.5</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/LMK</u>			
DATUM <u>GEODETIC</u>		DATE <u>May 19, 2010</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					w <sub>p</sub>	w	w <sub>L</sub>					
								○ UNCONFINED                      + FIELD VANE ● QUICK TRIAXIAL                  × LAB VANE												
369.79	GROUND SURFACE						20	40	60	80	100									
0.00	FILL, sand and gravel, crushed Brown																			
0.24	FILL, sand, trace gravel Brown																			
0.52	SAND, fine to coarse, layered, trace to some clay, trace silt Loose to very dense Brown		1	SS	7															
			2	SS	14															
			3	SS	19															
			4	SS	26															
			5	SS	30															
			6	SS	62															
364.61	END OF BOREHOLE																			
5.18	Borehole dry during drilling on May 19, 2010.																			



**RECORD OF BOREHOLE No 2**

1 OF 1

**METRIC**

PROJECT 08-1132-084-1

W.P. 131-98-00

LOCATION N 4808629.0 ; E 221252.2

ORIGINATED BY MA

DIST HWY 7/8

BOREHOLE TYPE POWER AUGER / HOLLOW STEM

COMPILED BY WDF/LMK

DATUM GEODETIC

DATE May 19, 2010 - May 20, 2010

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT  w <sub>p</sub>	NATURAL MOISTURE CONTENT  w	LIQUID LIMIT  w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	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						× LAB VANE		
369.79	GROUND SURFACE																	
0.00	FILL, sand and gravel, crushed Brown																	
0.15	FILL, sand and gravel, trace silt, with cobbles Brown																	
369.03	FILL, sandy silt, some clay, trace gravel, trace topsoil Loose to compact Brown		1	SS	11													
0.76			2	SS	26													
			3	SS	12													
366.38			4	SS	8													
3.41	FILL, sand, fine, some silt Loose Brown																	
3.66	FILL, sand, fine to medium Very loose Brown		5	SS	3													
3.96	FILL, sandy silt, trace to some clay, trace gravel Very loose Brown		6	SS	2													
364.91	SANDY SILT, some clay, trace gravel Very loose to compact Brown		7	SS	23													
4.88	SILTY FINE SAND, trace gravel Compact Brown		8	SS	22													
364.27																		
5.52																		
363.85																		
5.94																		
363.24																		
6.55	END OF BOREHOLE																	
	Borehole dry during drilling on May 19, 2010.																	

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

**RECORD OF BOREHOLE No 3**

1 OF 1

**METRIC**

PROJECT 08-1132-084-1  
W.P. 131-98-00 LOCATION N 4808661.6 ; E 221319.6 ORIGINATED BY MA  
DIST HWY 7/8 BOREHOLE TYPE POWER AUGER / HOLLOW STEM COMPILED BY WDF/LMK  
DATUM GEODETIC DATE May 19, 2010 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT  w <sub>p</sub>	NATURAL MOISTURE CONTENT  w	LIQUID LIMIT  w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	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									
365.41	GROUND SURFACE						20	40	60	80	100						
0.00	FILL, sand and gravel, crushed Brown																
0.18																	
364.86	FILL, sand, some gravel Brown																
0.55	FILL, sandy silt, some clay, trace gravel Very loose to compact Brown		1	SS	20								○				
			2	SS	20									○		0 31 51 18	
			3	SS	3									○		0 27 51 22	
			4	SS	2									○			
361.75																	
3.66	SILT, some clay, trace sand Compact Brown		5	SS	26												
361.39																	
4.02	CLAYEY SILT, trace sand, trace gravel Hard Brown		6	SS	31												
360.23																	
5.18	END OF BOREHOLE  Borehole dry during drilling on May 19, 2010.																

**RECORD OF BOREHOLE No 4**

1 OF 1

**METRIC**

PROJECT 08-1132-084-1  
W.P. 131-98-00 LOCATION N 4808690.3 ; E 221379.5 ORIGINATED BY MA  
DIST HWY 7/8 BOREHOLE TYPE POWER AUGER / HOLLOW STEM COMPILED BY WDF/LMK  
DATUM GEODETIC DATE May 19, 2010 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
363.18	GROUND SURFACE							20	40	60	80	100						
0.00	FILL, sand and gravel, crushed Brown						363											
0.15																		
362.63	FILL, sand, some gravel Brown																	
0.55	FILL, clayey silt, some sand, trace gravel Stiff to hard Brown and grey		1	SS	31		362											
			2	SS	16													
			3	SS	10		361											
			4	SS	48		360											
			5	SS	29		359											
358.76																		
4.42	CLAYEY SILT, trace sand, trace gravel Hard Brown and grey		6	SS	91													
358.24																		
5.03	SILTY FINE SAND, trace gravel Very dense Brown END OF BOREHOLE																	
	Borehole dry during drilling on May 19, 2010.																	

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

**RECORD OF BOREHOLE No 5**

1 OF 1

**METRIC**

PROJECT 08-1132-084-1

W.P. 131-98-00

LOCATION N 4808725.9 ; E 221454.5

ORIGINATED BY MA

DIST HWY 7/8

BOREHOLE TYPE POWER AUGER / HOLLOW STEM

COMPILED BY WDF/LMK

DATUM GEODETIC

DATE May 19, 2010

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	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	×	LAB VANE									
361.47	GROUND SURFACE						20	40	60	80	100	10	20	30				
0.00	FILL, sand and gravel, crushed Brown																	
0.15																		
360.92	FILL, sand, some gravel Brown																	
0.55	FILL, silty sand, trace gravel, trace clay Compact to dense Brown		1	SS	34							○						
			2	SS	33							○			4 47 41 8			
			3	SS	18							○						
			4	SS	25							○						
			5	SS	27							○	○					
357.05																		
4.42	FILL, clayey silt, trace sand Very stiff Grey											○						
4.66			6	SS	15							○						
356.29	FILL, sandy silt, trace clay, trace gravel Compact Brown																	
5.18	END OF BOREHOLE																	
	Borehole dry during drilling on May 19, 2010.																	

**RECORD OF BOREHOLE No 6**

1 OF 1

**METRIC**

PROJECT 08-1132-084-1  
W.P. 131-98-00 LOCATION N 4808756.7 ; E 221519.4 ORIGINATED BY MA  
DIST HWY 7/8 BOREHOLE TYPE POWER AUGER / HOLLOW STEM COMPILED BY WDF/LMK  
DATUM GEODETIC DATE May 18, 2010 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20 40 60 80 100		W <sub>P</sub>	W	W <sub>L</sub>		
								○ UNCONFINED + FIELD VANE		WATER CONTENT (%)				
								● QUICK TRIAXIAL × LAB VANE						
								20 40 60 80 100		10	20	30		
360.23	GROUND SURFACE													
0.00	FILL, sand and gravel, crushed Brown						360							
0.30	FILL, sand, some gravel Brown													
359.62	FILL, sand, some gravel Brown													
0.61	FILL, sandy silt, some clay, trace gravel, with sand layers Compact Brown		1	SS	14		359							
			2	SS	15									
358.10	FILL, silty sand and gravel Compact Brown						358							
2.13	FILL, silty sand and gravel Compact Brown													
357.76	FILL, silty sand and gravel Compact Brown		3	SS	24									
2.47	FILL, silty fine sand, trace gravel, with clayey silt pockets Compact to dense													
							357							
			4	SS	34									
356.02	CLAYEY SILT, trace sand Very stiff Brown		5	SS	17		356							
4.21	CLAYEY SILT, trace sand Very stiff Brown													
4.42	CLAYEY SILT, trace sand Very stiff Brown													
355.20	SILTY FINE SAND, with clayey silt pockets Dense Brown		6	SS	37									
5.03	SILTY FINE SAND, with clayey silt pockets Dense Brown													
5.18	SILT, some clay, trace sand, gravel Dense Brown													
	END OF BOREHOLE													
	Borehole dry during drilling on May 18, 2010.													

## METRIC

PROJECT 08-1132-084-1

W.P. 131-98-00

LOCATION N 4808789.8 ;E 221588.9

ORIGINATED BY MA

DIST \_\_\_\_\_ HWY 7/8

BOREHOLE TYPE POWER AUGER / HOLLOW STEM

COMPILED BY WDF/LMK

DATUM GEODETIC

DATE May 18, 2010

\_\_\_\_ CHECKED BY \_\_\_\_

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

**RECORD OF BOREHOLE No 8**

1 OF 1

**METRIC**

PROJECT 08-1132-084-1  
W.P. 131-98-00 LOCATION N 4808824.2 ; E 221660.0 ORIGINATED BY MA  
DIST HWY 7/8 BOREHOLE TYPE POWER AUGER / HOLLOW STEM COMPILED BY WDF/LMK  
DATUM GEODETIC DATE May 18, 2010 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
358.50	GROUND SURFACE							20	40	60	80	100								
0.00	FILL, sand and gravel, crushed Brown																			
0.21																				
357.92	FILL, sand, trace gravel, with cobbles Brown																			
0.58																				
	FILL, clayey silt, trace sand, trace gravel Very stiff Brown		1	SS	18										○					
357.13																				
1.37																				
	FILL, silty sand and gravel Compact Brown		2	SS	25										○					
356.37																				
	FILL, sandy silt, some clay, trace gravel Loose Brown		3	SS	9										○					
2.13																				
			4	SS	8											○				
354.84																				
3.66	CLAYEY SILT, trace sand, trace gravel Stiff Brown		5	SS	14															
354.08																				
4.42	SILTY FINE SAND Compact Brown		6	SS	23															
353.32																				
5.18	END OF BOREHOLE																			
	Groundwater encountered at about elev. 353.9m during drilling on May 18, 2010.																			

**RECORD OF BOREHOLE No 82**

1 OF 1

**METRIC**

PROJECT 08-1132-084-1  
W.P. 131-98-00 LOCATION N 4808865.3 ; E 221746.2 ORIGINATED BY MR  
DIST HWY 7/8 BOREHOLE TYPE POWER AUGER / HOLLOW STEM COMPILED BY WDF  
DATUM GEODETIC DATE June 10, 2010 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT  w <sub>p</sub>	NATURAL MOISTURE CONTENT  w	LIQUID LIMIT  w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	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    × LAB VANE												
357.32	GROUND SURFACE					▽														
0.00	FILL, sand and gravel, crushed Brown						357													
356.80							356							○				10 36 40 14		
0.52	SANDY SILT TILL, trace to some clay, trace to some gravel Loose to compact Grey		1	SS	22		355													
			2	SS	13		354													
			3	SS	9															
			4	SS	13															
			5	SS	11									○				0 24 61 15		
352.90							353													
4.42	SILTY SAND AND GRAVEL Compact Brown		6	SS	12															
352.29																				
5.03	END OF BOREHOLE																			
	Groundwater encountered at about elev. 352.7m during drilling on June 10, 2010.																			



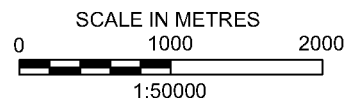
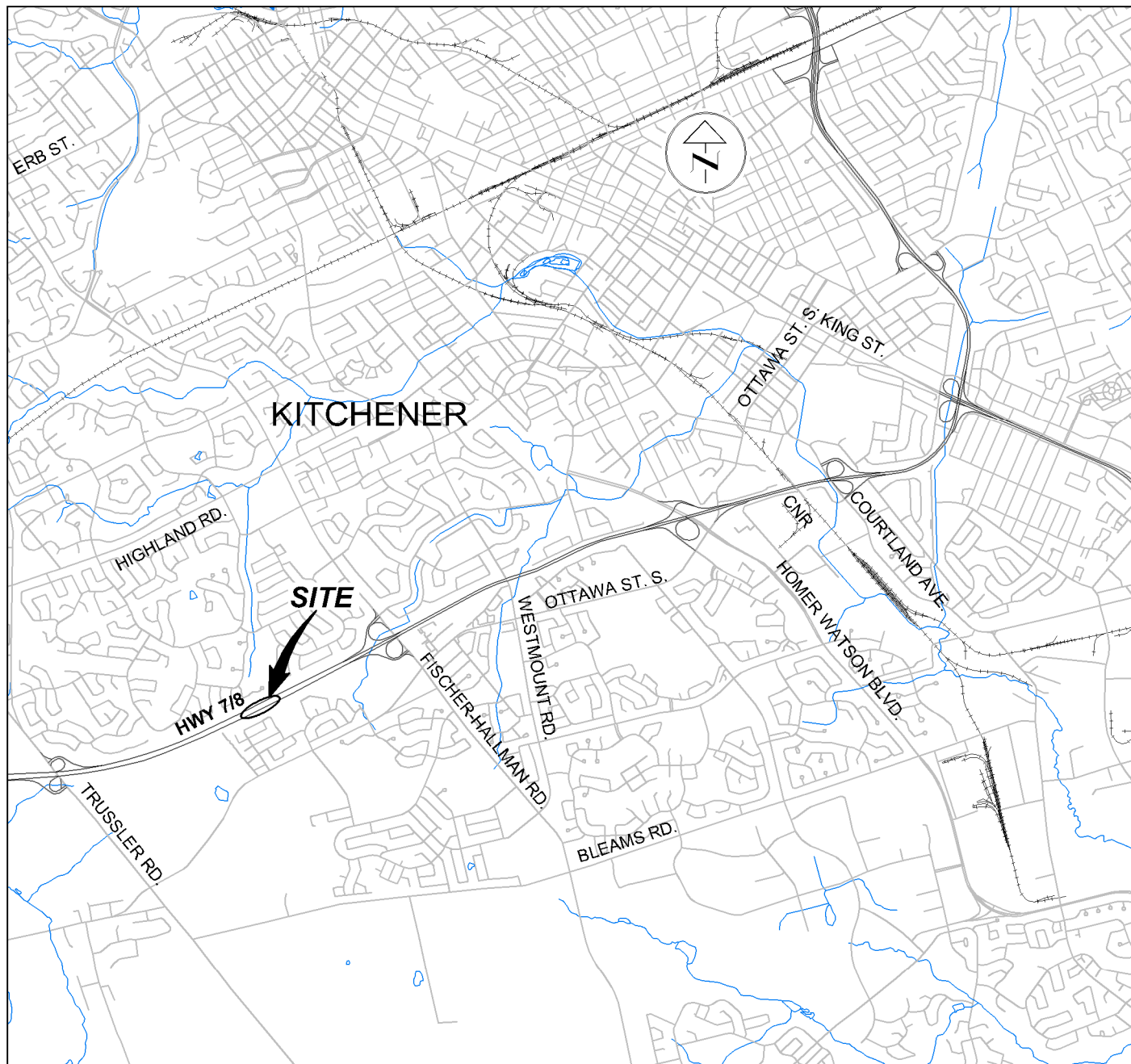
**RECORD OF BOREHOLE No 83**

1 OF 1

**METRIC**

PROJECT 08-1132-084-1  
W.P. 131-98-00 LOCATION N 4808895.2 ; E 221809.5 ORIGINATED BY MR  
DIST HWY 7/8 BOREHOLE TYPE POWER AUGER / HOLLOW STEM COMPILED BY WDF  
DATUM GEODETIC DATE June 10, 2010 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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				W <sub>p</sub> W                      W <sub>L</sub>						
								○ UNCONFINED                      + FIELD VANE ● QUICK TRIAXIAL                      × LAB VANE				WATER CONTENT (%)						
356.49	GROUND SURFACE							20	40	60	80	100						
0.00	FILL, sand and gravel, crushed Brown																	
356.09																		
0.40	SAND, fine, trace silt, trace clay Compact Brown						356											
			1	SS	14													
							355											
			2	SS	18													
			3	SS	24		354							○				0   90   8   2
			4	SS	27		353											
			5	SS	26													
352.07																		
4.42	SILTY FINE SAND Dense Brown						352											
351.46			6	SS	33													
5.03	END OF BOREHOLE																	
	Borehole dry during drilling on June 10, 2010.																	



## REFERENCE

DRAWING BASED ON CANMAP STREETFILES V2005.4.

## NOTE

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

PROJECT

PROPOSED NOISE BARRIER WALL 4  
WIDENING OF HIGHWAY 7/8  
GWP 131-98-00

TITLE

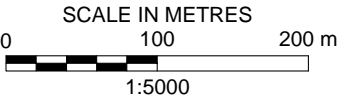
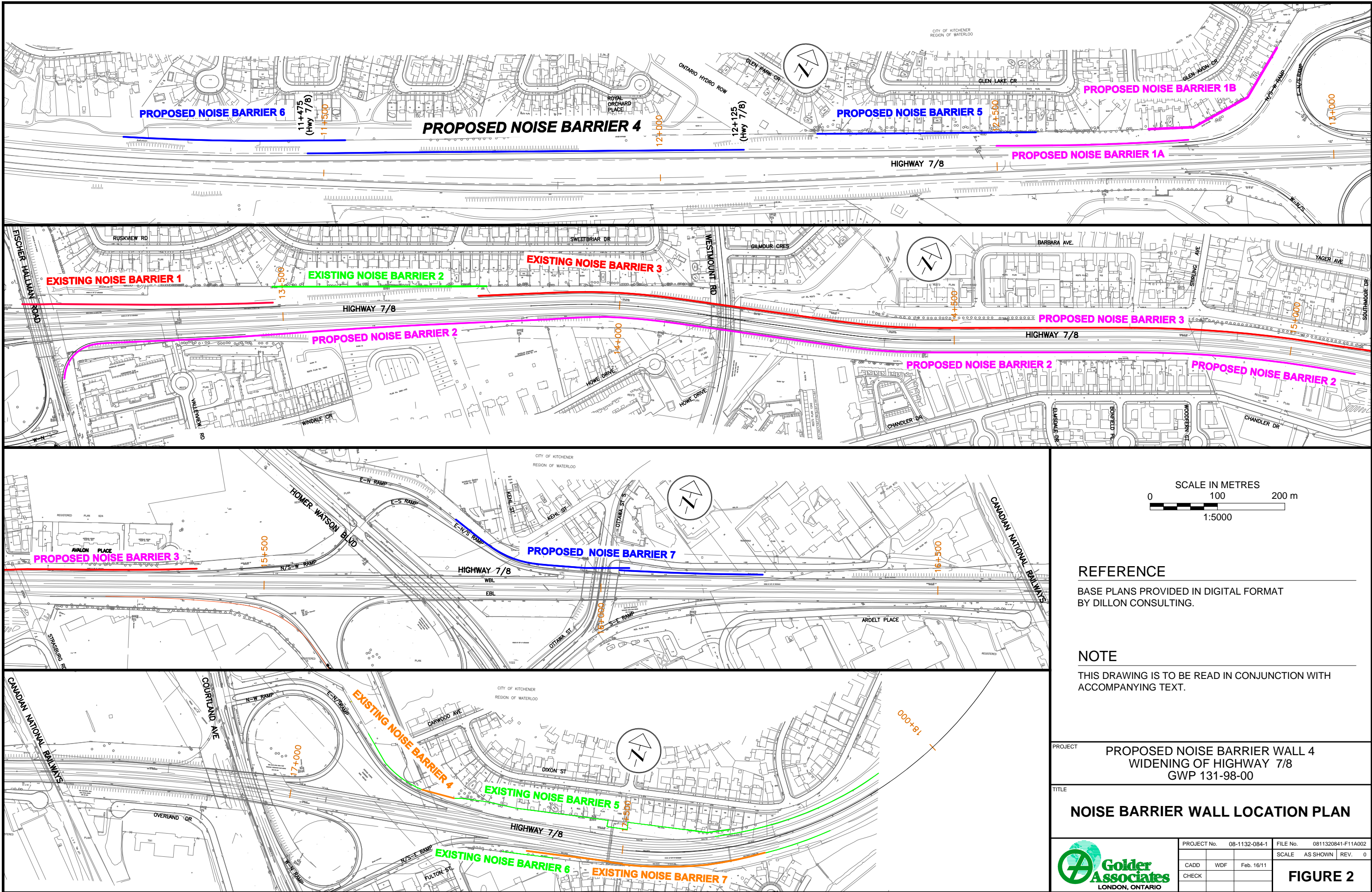
## KEY PLAN



PROJECT No. 08-1132-084-1			FILE No. 0811320841-F11A001	
CADD	WDF	July 21/10	SCALE	AS SHOWN
CHECK			REV.	
FIGURE 1				



Drawing file: 0811320841-F11A002.dwg Feb 23, 2011 - 9:25pm




### REFERENCE

BASE PLANS PROVIDED IN DIGITAL FORMAT  
BY DILLON CONSULTING.

### NOTE

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

PROJECT	PROPOSED NOISE BARRIER WALL 4 WIDENING OF HIGHWAY 7/8 GWP 131-98-00		
TITLE	NOISE BARRIER WALL LOCATION PLAN		
 <b>Golder Associates</b> LONDON, ONTARIO	PROJECT No.	08-1132-084-1	FILE No. 0811320841-F11A002
	CADD	WDF	Feb. 16/11
	CHECK		
		SCALE	AS SHOWN
		REV.	0
FIGURE 2			



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

CONT No.  
WP No. 131-98-00



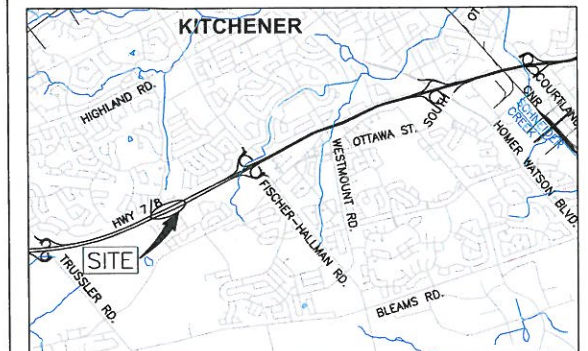
PROPOSED NOISE BARRIER WALL 4

SHEET

WIDENING OF HIGHWAY 7/8  
BOREHOLE LOCATIONS



**Golder Associates Ltd.**  
LONDON, ONTARIO, CANADA



KEY PLAN

SCALE IN KILOMETRES  
0 1 2

LEGEND

● Borehole - Current Investigation

No.	ELEVATION	CO-ORDINATES (MTM ZONE 10)	
		NORTHING	EASTING
1	369.79	4 808 599.9	221 188.5
2	369.79	4 808 629.0	221 252.2
3	365.41	4 808 661.6	221 319.6
4	363.18	4 808 690.3	221 379.5
5	361.47	4 808 725.9	221 454.5
6	360.23	4 808 756.7	221 519.4
7	359.48	4 808 789.8	221 588.9
8	358.50	4 808 824.2	221 660.0
82	357.32	4 808 865.3	221 746.2
83	356.49	4 808 895.2	221 809.5



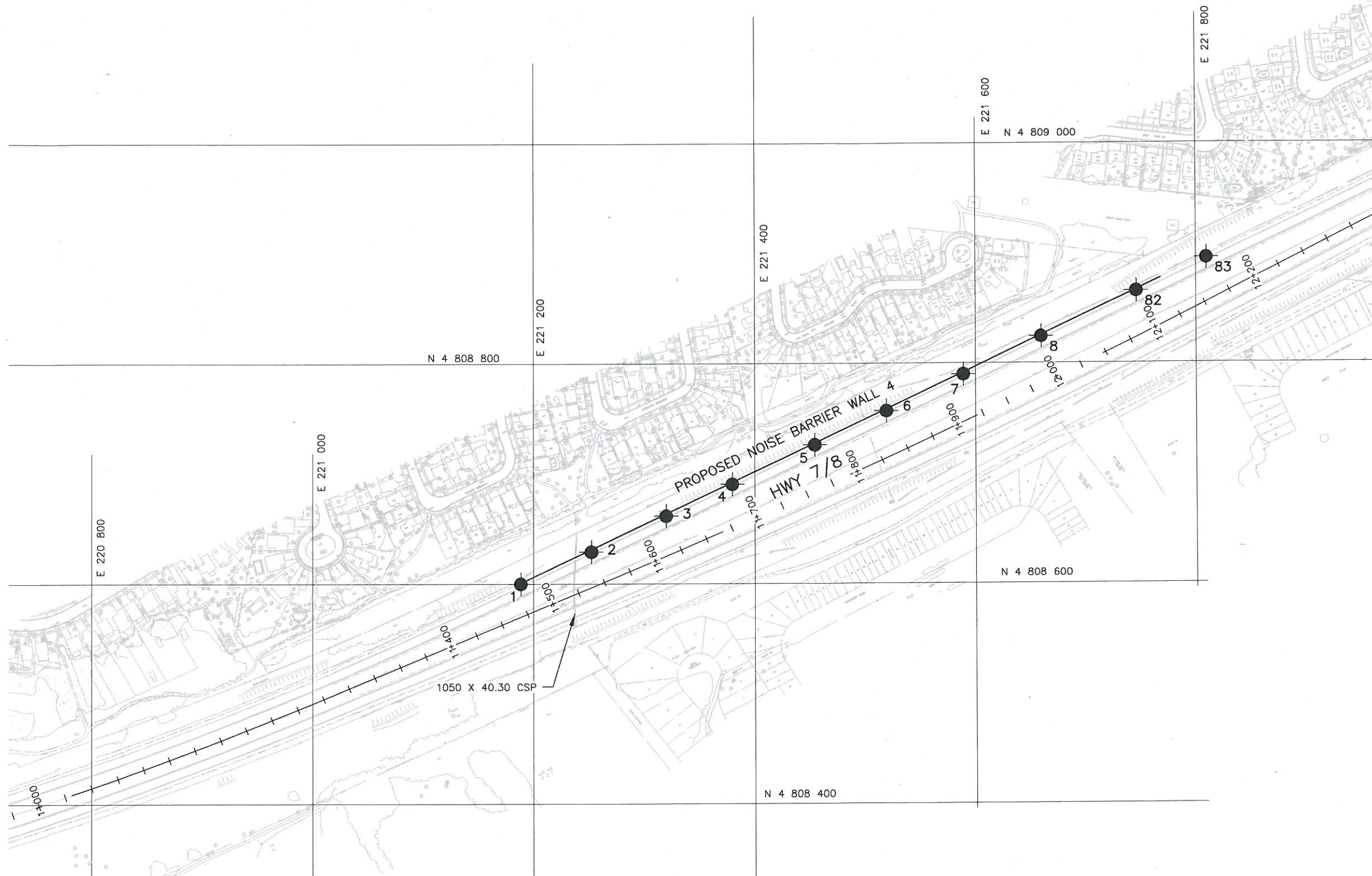
NOTES

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

REFERENCE

Base plans provided in digital format by Dillon Consulting.

NO.	DATE	BY	REVISION
Geocres No. 40P7-58			
HWY.	7/8	PROJECT NO.	08-1132-084-1
SUBM'D.	ML	CHKD.	DATE: Oct. 22/10
DRAWN:	WDF	CHKD.	APPD.
			SITE:
			DWG. 1



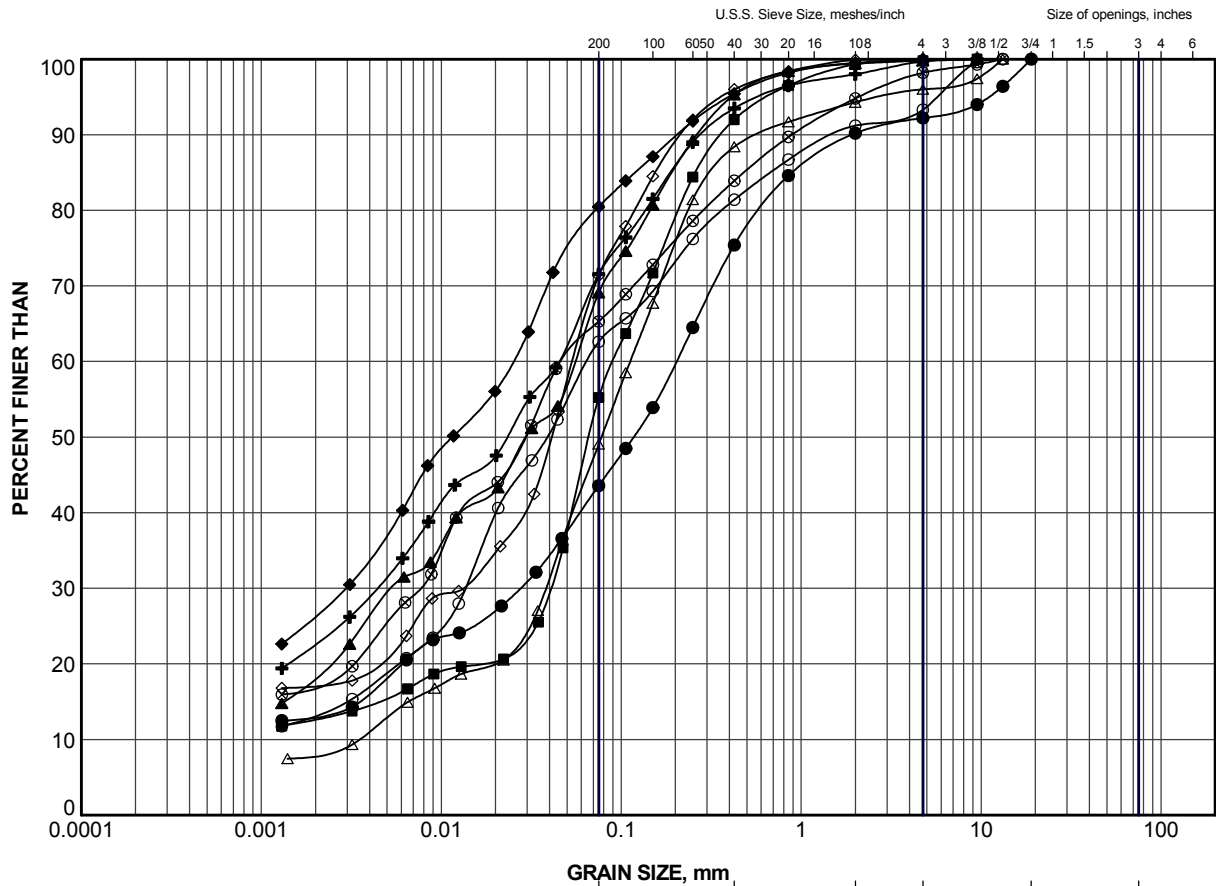
PLAN

SCALE  
40 0 40 m



# **APPENDIX A**

## **Laboratory Test Data**



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

### LEGEND

SYMBOL BOREHOLE SAMPLE ELEV (m)

#### NON COHESIVE

● 2 3 367.3  
 ■ 2 6 365.1  
 ▲ 3 2 363.7  
 + 3 3 362.9  
 △ 5 2 359.7  
 ⊗ 6 2 358.5  
 ◇ 7 2 357.7  
 ○ 8 4 355.2

#### COHESIVE

◆ 4 3 360.7

PROJECT

PROPOSED NOISE BARRIER WALL 4  
WIDENING OF HIGHWAY 7/8  
GWP 131-98-00

TITLE

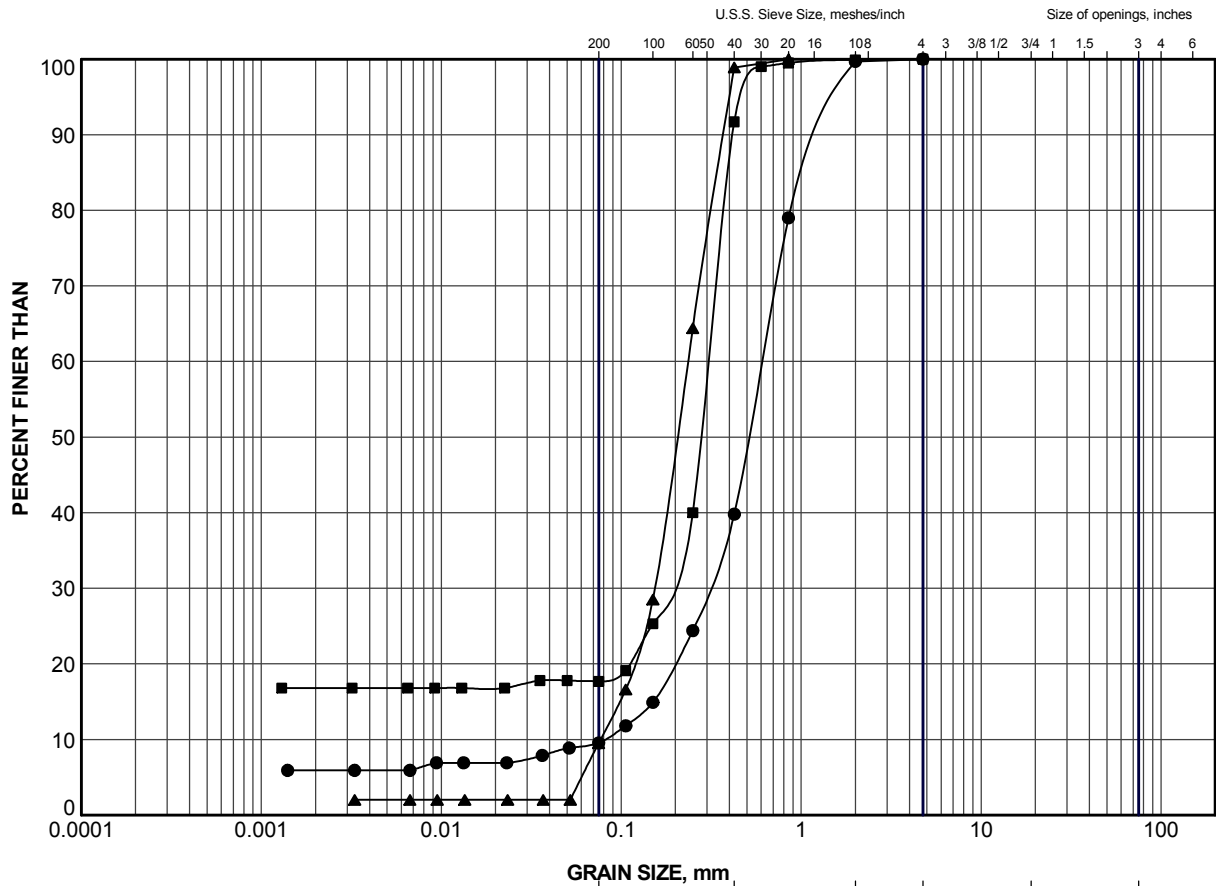
## GRAIN SIZE DISTRIBUTION FILL



**Golder Associates**  
LONDON, ONTARIO

PROJECT No.	08-1132-084-1	FILE No.	0811320841-R11A0A1
DRAWN	LMK	Jul 21/10	SCALE N/A REV.
CHECK			


**FIGURE A-1**

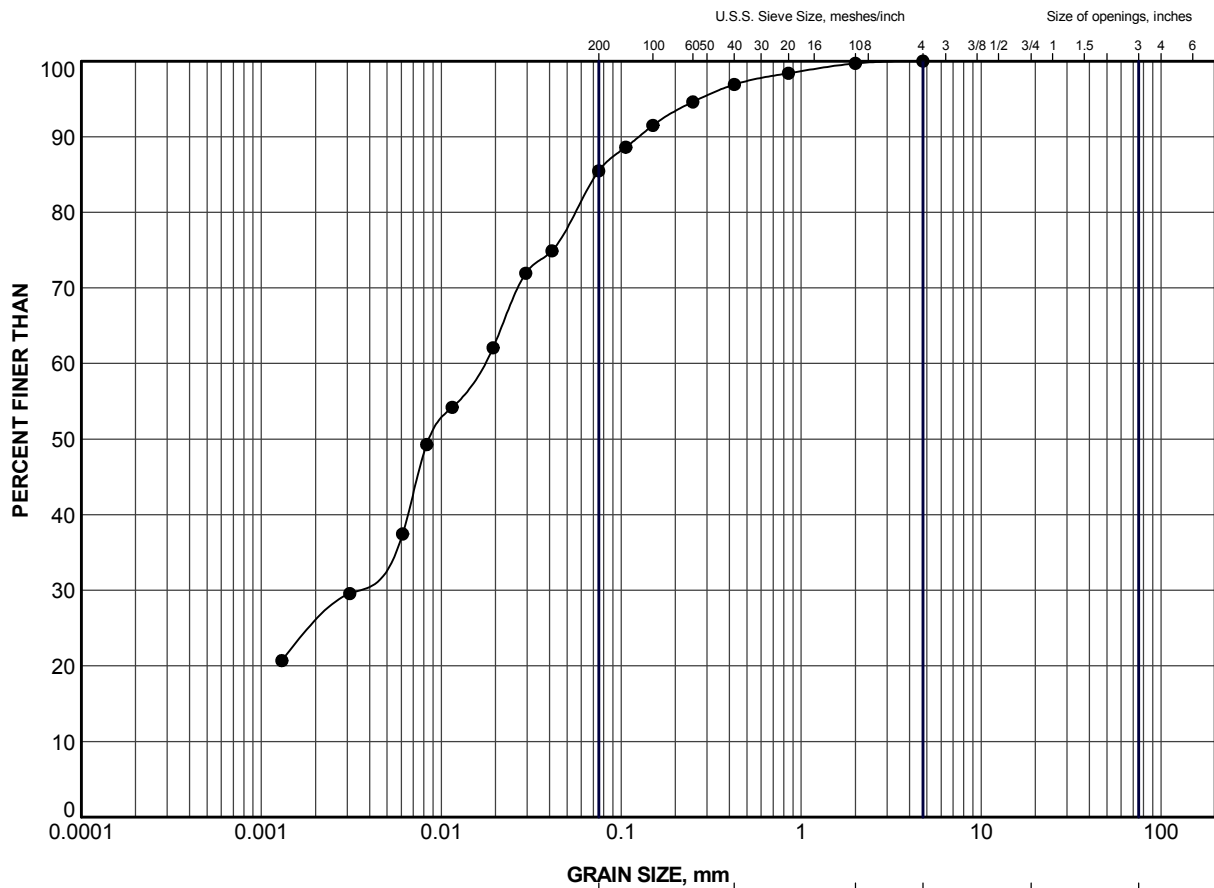


CLAY AND SILT	SAND SIZE, mm					Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

#### LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	2	368.0
■	1	5	365.8
▲	83	3	354.0

PROJECT		PROPOSED NOISE BARRIER WALL 4 WIDENING OF HIGHWAY 7/8 GWP 131-98-00			
TITLE		GRAIN SIZE DISTRIBUTION SAND			
 <b>Golder Associates</b> LONDON, ONTARIO		PROJECT No. 08-1132-084-1		FILE No. 0811320841-R11A0A2	
		DRAWN LMK Jun 29/10		SCALE N/A REV.	
		CHECK			
		<b>FIGURE A-2</b>			

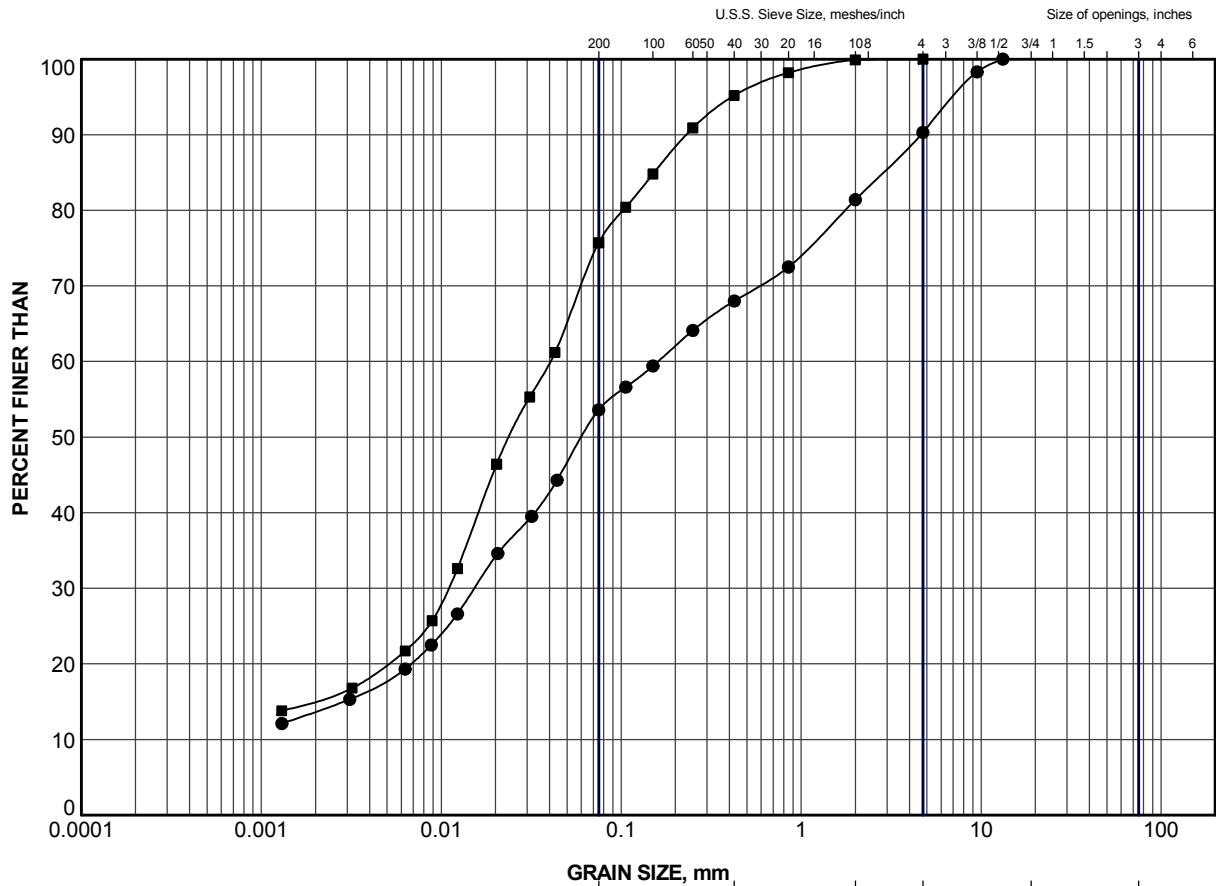


### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	7	4	356.2


PROJECT				PROPOSED NOISE BARRIER WALL 4 WIDENING OF HIGHWAY 7/8 GWP 131-98-00			
TITLE				GRAIN SIZE DISTRIBUTION CLAYEY SILT			
PROJECT No.		08-1132-084-1		FILE No.		0811320841-R11A0A3	
DRAWN		LMK		SCALE		N/A	
CHECK				REV.			
		Jun 23/10					
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-3</b>			



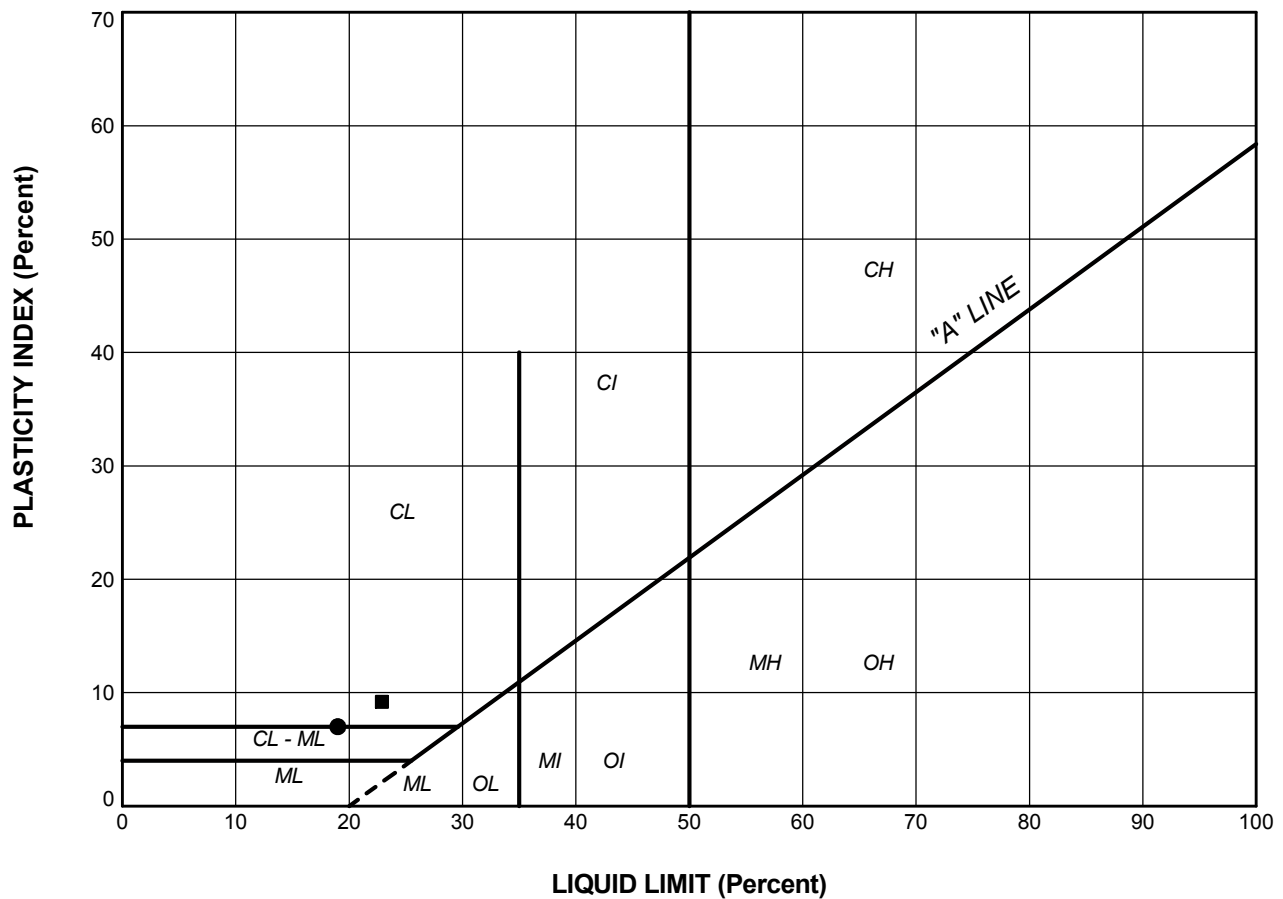


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	82	2	355.6
■	82	5	353.3

PROJECT				PROPOSED NOISE BARRIER WALL 4 WIDENING OF HIGHWAY 7/8 GWP 131-98-00			
TITLE				GRAIN SIZE DISTRIBUTION SANDY SILT TILL			
PROJECT No.		08-1132-084-1		FILE No.		0811320841-R11A0A4	
DRAWN		LMK		SCALE		N/A	
CHECK				REV.			
		Jun 29/10					
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-4</b>			

LDN\_MTO\_NEW\_GLDR\_LDN.GDT



### LEGEND

SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
FILL (cohesive)					
●	4	3	19.0	12.0	7.0
CLAYEY SILT					
■	7	4	22.9	13.7	9.2

PROJECT				PROPOSED NOISE BARRIER WALL 4 WIDENING OF HIGHWAY 7/8 GWP 131-98-00			
TITLE				PLASTICITY CHART			
PROJECT No.		08-1132-084-1		FILE No.		0811320841-R11A0A5	
DRAWN	LMK	Jun 23/10		SCALE	N/A	REV.	
CHECK				FIGURE A-5			



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