



May 31, 2013

## FOUNDATION INVESTIGATION AND DESIGN REPORT

### Noise Barrier Walls Highway 401 Eastbound Collector Rehabilitation from Jane Street to Avenue Road Toronto, Ontario G.W.P. 2131-01-00

**Submitted to:**  
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REPORT





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# **PART A**

**FOUNDATION INVESTIGATION REPORT  
NOISE BARRIER WALLS  
HIGHWAY 401 EBC REHABILITATION FROM  
JANE STREET TO AVENUE ROAD  
TORONTO, ONTARIO  
G.W.P. 2131-01-00**



## FOUNDATION REPORT - NOISE BARRIER WALLS

### 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by URS Canada Inc. on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services in support of the rehabilitation of the Highway 401 eastbound collector (EBC) between Jane Street and Avenue Road in Toronto, Ontario.

This report addresses the Foundation Investigation for four proposed Noise Barrier Walls to be replaced along Highway 401 extending for lengths between about 270 m and 1,280 m, approximately at the locations shown on Drawings 1 to 4.

The Terms of Reference for the foundation investigation are outlined in MTO's Request for Proposal (RFP) for Agreement No. 2009-E-0011, issued on December 16, 2009 and MTO's revised Terms of Reference in the Addendum for Noise Barrier Walls sent electronically to URS on May 23, 2012. The Scope of Work for the foundation engineering services is presented in Golder's revised scope change letter, dated June 20, 2012.

This Foundation Investigation report is based on a desktop study of existing geotechnical information supplemented with a total of six (6) new boreholes in accordance with the revised Scope of Work.

### 2.0 SITE DESCRIPTION

Based on information provided by URS, a description of each site of proposed Noise Barrier Wall replacement is summarized below and shown on Drawings 1 to 4.

Noise Barrier Wall Number	Noise Barrier Wall Location		Site Description
	Original Highway 401 EBC Stationing	New Highway 401 EBC Stationing	
NBW1	Jane Street to Keele Street		The existing noise barrier wall extends along Highway 401 EBC behind an existing guide rail and will be replaced for a length of about 1,280 m. The right paved shoulder separates active lanes from the noise barrier wall.
	STA 27+830 to STA 29+110	STA 12+734 to STA 14+010	
NBW2	Keele Street to CNR Overhead		The existing noise barrier wall starts at the top of the on-ramp from Keele Street northbound and extends along Highway 401 EBC behind an existing guide rail and will be replaced for a length of about 500 m. The right paved shoulder separates active lanes from the noise barrier wall.
	STA 29+800 to STA 30+300	STA 14+717 to STA 15+219	
NBW3	Allen Road to Bathurst Street		The existing noise barrier wall starts at the on-ramps from Allen Road North and South and extends along Highway 401 EBC behind an existing rail and will be replaced for a length of about 780 m. The right paved shoulder separates active lanes from the noise barrier wall.
	STA 32+970 to STA 33+750	STA 17+874 to STA 18+650	
NBW4	Avenue Road Area		The existing noise barrier wall starts at the off-ramp from Highway 401 West to Avenue Road North/South and extends along the South side of the ramp behind an existing concrete guide rail and will be replaced for a length of about 270 m.
	STA 34+730 to STA 35+000	STA 19+624 to STA 19+897	



### 3.0 INVESTIGATION PROCEDURES

#### 3.1 Previous Investigations

As part of the Highway 401 construction and widening from Jane Street to Avenue Road in the early 1960's, and subsequent rehabilitation/widening works, various subsurface investigations were carried out by or on behalf of MTO in these areas. The majority of subsurface information used in this report was obtained from the existing Foundation Investigation pertinent to this section of Highway 401 corridor, available from MTO Pavement and Foundations Section's GEOCRES database, as follows:

- **MTO GEOCRES No. 30M11-076:** Report titled "Avenue Road – Highway No. 401, Interchange – Leg "A", Retaining Wall (W.P. 85-59-2)", by Dominion Soil Investigation Limited, dated December 1962.
- **MTO GEOCRES No. 30M11-084:** Report titled "Foundation Investigation Report for Proposed New Structure at Keele Street and Hwy. 401, Toronto, W.J. 63-F-87, W.P. 231-60, District 6", by Department of Highways – Ontario, Materials and Research Section, dated August 1963.
- **MTO GEOCRES No. 30M11-134:** Report titled "Proposed Extension of Bridge at Black Creek and Hwy. No. 401, North York, County of York, District No.6, W.J. 61-F-113 - - W.P. 85-59-3," by Department of Highways – Ontario, Materials and Research Section, dated January 19, 1962.
- **MTO GEOCRES No. 30M11-136:** Report titled "Proposed Basket Weave Structure at Springview Ave. South & Hwy. # 401, Toronto, Ontario. District #6, W.J. 62-F-86 - - W.P. 104-62," by Department of Highways – Ontario, Materials and Research Section, dated August 10, 1962.

The available existing information at the noise barrier wall locations is as follows:

Noise Barrier Wall Number	Existing Information
NBW1	A total of ten (10) boreholes (designated as 134-1, 134-7, and 136-1 to 136-8) were drilled in the vicinity of the proposed noise barrier wall replacement in 1962 and 1963 by the Department of Highways, Ontario (GEOCRES No. 30M11-134 and 30M11-136).
NBW2	One (1) borehole (designated as 84-2) was drilled in the vicinity of the proposed noise barrier wall replacement in 1963 by the Department of Highways, Ontario (GEOCRES No. 30M11-084).
NBW3	No existing subsurface information was found of GEOCRES for this extent of wall.
NBW4	A total of two (2) boreholes (designated as 76-1 and 76-2) were drilled in the vicinity of the proposed noise barrier wall replacement in 1962 by Dominion Soil Investigation Limited (GEOCRES No. 30M11-076).

The majority of subsurface information pertinent to the investigation of the subsurface conditions along the proposed noise barrier walls was collected from previous investigations performed at the site(s) in 1962 and 1963. A total of 13 boreholes were drilled near the proposed noise barrier wall replacement locations (GEOCRES No. 30M11-076, 30M11-084, 30M11-134 and 30M11-136). The available information in GEOCRES indicated that the previous boreholes were advanced through the overburden using either augering or wash boring methods/techniques. Soil samples were generally obtained at 0.75 m to 1.5 m intervals of depth, using 50 mm outer diameter split-spoon samplers. It is assumed that sampling was carried out by driving a manual



hammer as part of the Standard Penetration Test (SPT) procedure. Wash boring method was implemented to recover samples of the bedrock with an 'NX' size casing.

Groundwater levels recorded in the open boreholes are shown on the Record of Borehole sheets. All previous investigations were carried out by the Department of Highways Ontario and Dominion Soil Investigation Limited.

The GEOCREs sourced borehole (76-1, 76-2, 84-2, 134-1, 134-7, and 136-1 to 136-8) locations, as shown on Drawings 1 to 4, were identified on the drawings provided in the GEOCREs reports and cross-referenced with the base drawings provided by URS using the Highway 401 centreline and predominant surface features. Thus, borehole locations are considered approximate and have been converted to MTM NAD83 northing and easting coordinates, the ground surface elevations are referenced to Geodetic datum as taken from the Record of Borehole sheets.

The GEOCREs sourced boreholes used in this report have been re-numbered to show the MTO GEOCREs No. followed by the original borehole designation; for example, the boreholes from MTO GEOCREs 30M11-076 have been re-numbered to 76-X, where X is the original borehole number.

### 3.2 Current Investigation

The field work for the supplementary subsurface investigation was carried out by Golder between March 13 and 15, 2013, during which time six boreholes (designated as Boreholes 13-1 to 13-6) were advanced using a CME-55 truck mounted drill rig, supplied and operated by DBW Drilling of North York, Ontario. The boreholes were advanced using 101 mm diameter solid stem augers. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth using a 50 mm outside diameter split-spoon sampler driven by an automatic hammer in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586).

The groundwater conditions were observed in the open boreholes during and immediately following the drilling operations. The boreholes were backfilled to immediately below ground surface with bentonite pellets upon completion, in accordance with Ontario Regulation 903 (as amended). The upper 1.3 m portion of each borehole above the bentonite backfill was capped using soil cuttings from the borehole and asphalt patch where appropriate.

The field work was observed on a full-time basis by a member of Golder's technical staff who located the boreholes in the field, arranged for the clearance of underground utilities, directed the drilling, sampling and in situ testing operations, and logged the boreholes. The soil samples were identified in the field, placed in labelled containers and transported to Golder's laboratory in Mississauga for further examination and laboratory testing. Index and classification tests (water contents, Atterberg limits and grain size distributions) were carried out on selected soil samples. All geotechnical laboratory testing was completed to ASTM and/or MTO LS standards, as applicable.

The borehole locations were measured on-site relative to the existing site features and the ground surface elevations were obtained from the Digital Terrain Model for the site, provided by URS. The borehole locations in MTM NAD83 northing and easting coordinates and ground surface elevations referenced to Geodetic datum, are summarized below and are shown on Drawings 1 to 4.





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Borehole No.	MTM NAD83 Northing	MTM NAD83 Easting	Ground Surface Elevation (m)	Borehole Depth (m)
13-1	4843397.0	309473.8	189.9	6.7 m
13-2	4843908.4	310067.4	187.5	6.7 m
13-3	4844530.7	310850.8	180.5	6.7 m
13-4	4841993.9	304833.0	142.1	6.7 m
13-5	4842257.2	305656.0	158.5	6.7 m
13-6	4842643.8	306802.2	184.5	6.7 m

## 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

### 4.1 Regional Geology

The section of Highway 401 from Jane Street to Avenue Road is located within the physiographic region known as the Peel Plain, according to *The Physiography of Southern Ontario* (Chapman and Putnam, 1984)<sup>1</sup>.

A surficial till sheet, which generally follows the surface topography, is generally present throughout much of this area. The till is typically comprised of clayey silt to silty clay, with occasional silt to sand zones and is mapped in this area as the Halton Till. Shallow, localized deposits of loose silt and sand and/or soft clay can overlie this uppermost till sheet, and these represent relatively recent deposits, formed in small glacial melt water ponds scattered throughout the Peel Plain and concentrated near river valleys, such as the West Don River valley. The recent sand, silt and clay and uppermost till deposits in this area overlie and are interbedded with stratified deposits of sand, silt and clay.

### 4.2 Subsurface Conditions

As part of the current subsurface investigation, six boreholes (Boreholes 13-1 to 13-6) were advanced along the extent of proposed noise barrier wall replacement sections. The borehole locations and ground surface elevations are shown on Drawings 1 to 4.

The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced as part of the current investigation and the results of in situ and laboratory testing are given on the Record of Borehole sheets contained in Appendix A; the results of geotechnical laboratory testing are contained in Appendix B. Copies of the relevant Record of Borehole sheets (and laboratory testing results) from previous investigations are presented in Appendix C.

The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from observations of drilling progress and from non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil conditions will vary between and beyond the borehole locations.

<sup>1</sup> Chapman, L.J. and Putman, D.F., 1984. *The Physiography of Southern Ontario*, Ontario Geological Society, Special Volume 2, Third Edition. Accompanied by Map p. 2715, Scale 1:600,000.





A detailed description of the subsurface conditions encountered at the noise barrier wall locations is provided in the following sections.

### 4.2.1 Noise Barrier Wall 1 - Station 27+830 to Station 29+110

The boreholes pertinent to this section of noise barrier wall are Boreholes 13-4, 13-5, 134-1, 134-7, and 136-1 to 136-8. The existing ground surface at Highway 401 EBC along the proposed NBW1 location ranges from about Elevation 132 m at the west limit to Elevation 159 m at the east limit.

#### 4.2.1.1 Asphalt/Granular Fill

An approximately 100 mm thick layer of asphalt underlain by a 0.7 m thick layer of granular fill comprised of sand and gravel, trace silt was encountered in Boreholes 13-4 and 13-5. A layer of fill comprised of sand, trace gravel, trace clay was encountered in Boreholes 136-8 and 134-1 below the then existing ground surface (Elevations 134.1 m and 124.5 m). The thickness of the deposit is about 0.9 m and 3.2 m in the respective boreholes.

The SPT 'N'-values within the sand and gravel fill are 16 blows and 34 blows per 0.3 m of penetration, indicating a compact to dense relative density. An SPT 'N'-value of 12 blows per 0.3 m of penetration was measured within the sand fill layer in Borehole 134-1, indicating a compact relative density.

The natural water content measured on a sample of the fill is about 5 per cent.

#### 4.2.1.2 Clayey Silt Fill

A deposit of fill comprised of clayey silt some to with sand, trace gravel was encountered below the granular fill in Boreholes 13-4 and 13-5. The top of the fill deposit is at about Elevations 141.3 m and 157.7 m and the thickness of the deposit is about 1.4 m and 3.8 m in the respective boreholes. An approximately 3.5 m deposit of fill comprised of clayey silt, trace sand and gravel was also encountered in Borehole 134-7 located at the west limit of the proposed wall replacement. The top of the cohesive fill deposit in Borehole 134-7 is at about Elevation 125.3 m.

The measured SPT 'N'-values within the clayey silt fill deposit range from 6 blows to 16 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency.

The natural water content measured on six samples of the cohesive fill from the current investigation ranges from about 12 per cent to 19 per cent. The natural water content measured on one sample from the previous investigation is about 25 per cent.

The Result of a grain size distribution test completed on one selected sample of the cohesive fill deposit from the current investigation is shown on Figure B1 in Appendix B.

Atterberg limits tests were carried out on three samples of the cohesive fill and measured liquid limits between about 27 per cent and 30 per cent, plastic limits of about 14 per cent to 15 per cent, and plasticity indices between about 13 per cent and 15 per cent. The result of the Atterberg limits test carried out on a sample of the



clayey silt fill in the previous investigation measured a liquid limit of about 30 per cent, a plastic limit of about 20 per cent, and a plasticity index of about 10 per cent. The results of Atterberg limits test for the current investigation are shown on plasticity chart on Figure B2 and together with the results from the previous investigations indicate that the cohesive fill material is classified as clayey silt of low plasticity.

### **4.2.1.3 Upper Clayey Silt to Silty Clay Till**

A till deposit comprised of clayey silt to silty clay some to with sand and trace gravel was encountered below the clayey silt fill in Boreholes 13-4 and 13-5 at depths of 2.2 m and 4.6 m below ground surface during the current investigation corresponding to Elevations 139.9 m and 153.9 m. Both boreholes terminated within this deposit penetrating it to a depth of about 6.7 m below ground surface (corresponding to Elevations 135.4 m and 151.8 m in respective boreholes). In the previous investigations the clayey silt to silty clay deposit was encountered below the fill in Boreholes 134-1, 134-7 and 136-8 and at the ground surface in Boreholes 136-1 to 136-4. Although the borehole records of the previous investigations do not designate this deposit as a glacial till (with the exception of 136-1) it is anticipated that the clayey silt to silty clay deposit is glacially derived. Boreholes 134-7, and 136-1 to 136-4 were terminated within this deposit at depths ranging from 6.0 m to 15.7 m below ground surface (Elevations 129.2 m to 115.4 m).

The measured SPT 'N'-values within this glacial deposit range from 4 blows to 62 blows per 0.3 m of penetration, suggesting a firm to hard consistency. Typically, the SPT 'N'-values range from 12 blows to 38 blows (average of 22 blows) per 0.3 m of penetration above Elevation 126 m and from 4 blows to 19 blows (average of 11 blows) per 0.3 m of penetration below Elevation 126 m, suggesting the deposit transitions from predominantly very stiff to stiff at depth.

The natural water content measured on selected samples of the till from the current investigation ranges from about 14 per cent to 18 per cent, which is consistent with the natural water contents shown on the previous borehole records in this deposit ranging from about 12 per cent to 37 per cent.

The grain size distribution test of one selected sample of the till deposit from the current investigation is shown on Figure B3 in Appendix B. The Results of grain size distribution tests in the clayey silt deposit from the previous investigation are shown on the copies of the borehole records in Appendix C.

Atterberg limits tests were carried out on three selected samples of the till from the current investigation and measured liquid limits between about 27 per cent and 31 per cent, plastic limits between about 12 per cent and 15 per cent and plasticity indices between about 14 per cent and 16 per cent. These test results, which are plotted on Figure B4 in Appendix B, indicate that the till consists of clayey silt of low plasticity. Atterberg limits tests performed on thirty samples of the till as shown on the borehole records of the previous investigations measured liquid limits between about 19 per cent and 45 per cent, plastic limits between about 10 per cent and 24 per cent and plasticity indices between about 6 per cent and 24 per cent, indicating that the till material is classified as clayey silt of low plasticity to silty clay of intermediate plasticity.

The results of fifteen field vane tests performed in the upper clayey silt till (below Elevation 126 m) during the previous investigation measured undrained shear strength ranging from about 26 kPa to 58 kPa as shown on the Record of Borehole sheets.



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The results of nine unconfined compression tests performed on the selected samples of the upper clayey silt till deposit are shown on the borehole records of the previous investigations and are summarized below.

Borehole	Depth (m)	Elevation (m)	Soil Type	*Shear Strength (KPa)	*Bulk Density (KN/m <sup>3</sup> )
134-1	5.2	119	Silty Clay, trace sand & gravel	35	19.1
	7.9	115		25	18.0
	9.4	117		36	19.7
136-5	10.6	124	Clayey Silt with gravel	17	19.4
	12.6	122		16	19.2
	14.6	120		17	20
	17.6	117		23	20
134-7	6.3	119	Clayey Silt with sand	34	19.1
	9.3	116		17	19.5

\*Measured from Unconfined Compression Test as indicated on Record of Borehole sheets.

Based on the results of the in situ and field vane tests and laboratory testing, the upper clayey silt till deposit below Elevation 126 m ranges in consistency from a soft to stiff, but is generally firm.

### 4.2.1.4 Sandy Silt to Silty Sand

A deposit of sandy silt to silty sand some gravel, was encountered underlying the clayey silt to silty clay (inferred "till") deposit in Boreholes 136-5 to 136-8. The top of the deposit was encountered at depths ranging from about 16.2 m to 19.8 m below the previous ground surface, corresponding to between Elevations 118.8 m and 114.3 m, and the thickness of the deposit ranges from about 4.6 m to 9.8 m.

The measured SPT 'N'-values within this deposit range from 11 blows per 0.3 of penetration to greater than 100 blows per 0.3 m of penetration, indicating a compact to very dense relative density.

The natural water content measured on selected samples of the sandy silt to silty sand from the previous investigation range from about 8 per cent to 19 per cent.

The results of grain size distribution tests completed on three samples of the sandy silt to silty sand are shown on the borehole records of the previous investigations and indicate the samples contain 7 per cent to 8 per cent clay, 25 per cent to 56 per cent silt, 30 per cent to 65 per cent sand, and 0 per cent to 7 per cent gravel.

### 4.2.1.5 Lower Clayey Silt Till

A till deposit comprised of clayey silt with sand and gravel was encountered underlying the sandy silt to silty sand deposit in Boreholes 136-5 to 136-8 and directly below the upper till in Borehole 134-1. The borehole records of the previous investigations indicate the presence of boulders within the till deposit. The lower till deposit in Borehole 134-1 is also interlayered with sandy silt lenses about 75 mm thick as indicated in Record of



Borehole sheet. The lower deposit was encountered at depths ranging from about 18.4 m to 27.4 m below the then existing ground surface, corresponding to between Elevations 112.1 m and 107.2 m.

The measured SPT 'N'-values within this deposit are generally greater than 100 blows per 0.3 m of penetration, suggesting a hard consistency. Although the 'N'-values in Borehole 134-1 range from about 15 blows to 52 blows per 0.3 m of penetration, suggesting a stiff to hard consistency.

The natural water content measured on selected samples of the lower clayey silt till deposit range from about 3 per cent to 16 per cent.

The results of a grain size distribution test completed on a sample of the transition between the sandy silt and the clayey silt till from the previous investigation indicates 10 per cent clay, 59 per cent silt, 21 per cent sand, and 10 per cent gravel.

### **4.2.1.6      *Bedrock***

Weathered to sound shale bedrock is reported to have been encountered below the clayey silt till deposit in Boreholes 136-5 to 136-8 during the previous investigation. The surface of the bedrock was encountered at depths ranging from about 29 m to 30.8 m below ground surface (between Elevation 105.9 m and 104.1 m) and the borehole records indicate the rock was cored to depths of up to 5 m.

## **4.2.2      Noise Barrier Wall 2 - Station 29+800 to Station 30+300**

The boreholes pertinent to this section of noise barrier wall are Boreholes 13-6 and 84-2. The existing Highway 401 EBC road surface along the proposed NBW2 replacement location ranges from about Elevation 178 m at the west limit to about Elevation 185 m at the east limit the wall.

### **4.2.2.1      *Asphalt/Fill***

An approximately 150 mm thick layer of asphalt was encountered at the ground surface in Borehole 13-6 advanced on the right shoulder of the Highway 401 EBC lanes.

A 0.8 m thick deposit of granular fill consisting of sand and gravel, trace silt, was encountered below the asphalt in Borehole 13-6. A 0.9 m thick surficial deposit of topsoil and "road fill" was encountered in Borehole 84-2 located at the west limit of the site.

A measured SPT 'N'-value within the sand and gravel fill is 27 blows per 0.3 m of penetration, indicating a compact relative density.

### **4.2.2.2      *Clayey Silt to Silty Clay Fill***

A 4.7 m thick deposit of fill comprised of clayey silt to silty clay with sand, trace gravel was encountered below the granular fill in Borehole 13-6 at a depth of 0.8 m below ground surface (Elevation 183.7 m). The fill contains sand seams and trace organics (i.e. rootlets and wood fragments) in the upper 2.9 m portion of the deposit.



The measured SPT 'N'-values within the clayey silt to silty clay fill range from 8 blows to 22 blows per 0.3 m of penetration, suggesting a stiff to very stiff consistency.

The natural water content measured on selected samples of the cohesive fill ranged from 10 per cent to 22 per cent.

Atterberg limits tests were carried out on two samples of the cohesive fill and measured liquid limits of about 25 per cent and 37 per cent, plastic limits of about 14 per cent and 19 per cent, corresponding to plasticity indices of about 11 per cent and 18 per cent. These test results, which are plotted on Figure B5 in Appendix B, indicate that the cohesive fill material is classified as clayey silt of low plasticity to silty clay of intermediate plasticity.

### 4.2.2.3 *Clayey Silt Till*

A till deposit consisting of clayey silt, some to with sand, some gravel was encountered below the clayey silt to silty clay fill in Borehole 13-6 and below the topsoil and "road fill" in Borehole 84-2. The top of the clayey silt till was encountered at depths of about 5.5 m and 1.0 m below ground surface at Elevations 179 m and 176.9m in Borehole 13-6 and 84-2 respectively. Boreholes 13-6 and 84-2 were terminated within this deposit, at depths of 6.7 m and 15.7 m below ground surface (Elevation 177.8 m and 162.1 m) respectively.

The measured SPT 'N'-values within the clayey silt till deposit range from 24 blows to 52 blows per 0.3 m of penetration, suggesting a very stiff to hard consistency.

The natural water content measured on selected samples of the clayey silt till range from about 12 per cent to 15 per cent.

The result of a grain size distribution test completed on one selected sample of the cohesive till deposit from the current investigation is shown on Figure B6 in Appendix B.

Atterberg limits tests carried out on samples of the till deposit obtained during current and previous investigations measured liquid limits between about 19 per cent and 27 per cent, plastic limits between about 11 per cent and 15 per cent, and plasticity indices between about 9 per cent and 12 per cent. The test result for one sample from the current investigation is shown on plasticity chart on Figure B7 in Appendix B and together with the results from the previous investigations indicate that the till material is classified as clayey silt of low plasticity.

### 4.2.3 **Noise Barrier Wall 3 – Station 32+970 to Station 33+750**

The boreholes pertinent to this section of noise barrier wall are Boreholes 13-1 and 13-2. The existing Highway 401 EBC road and associated ramp road surface at the proposed wall replacement ranges from about Elevation 191 m at the west limit and to about Elevation 187 m at the east limit of the wall.



### 4.2.3.1 *Asphalt/Granular Fill*

An approximately 100 mm and 125 mm thick layer of asphalt was encountered immediately below the ground surface in Boreholes 13-1 and 13-2, which were drilled on the right shoulder of the Highway 401 EBC lane road surface. A layer of concrete about 180 mm thick was encountered below the asphalt in Borehole 13-2.

A 0.5 m to 0.7 m thick deposit of granular fill was encountered below the asphalt and the concrete in Boreholes 13-1 and 13-2, respectively. The fill consists of sand and gravel and silty sand and gravel, trace silt in Boreholes 13-1 and 13-2, respectively.

The measured SPT 'N'-values within the granular fill deposit are 11 blows and 16 blows per 0.3 m of penetration, indicating a compact relative density.

The natural water content measured on one selected sample of the granular fill is about 7 per cent.

### 4.2.3.2 *Clayey Silt Fill*

A fill deposit comprised of predominantly clayey silt trace to with sand, trace gravel was encountered below the granular fill at a depth of 0.8 m (Elevations 189.1 m and 186.7 m) and the overall thickness of the fill deposit is 3.1 m and 4.8 m thick in Boreholes 13-1 and 13-2, respectively. In Borehole 13-2, a 0.8 m thick pocket of sand fill as encountered within the clayey silt fill at a depth of 2.2 m (Elevation 185.3 m).

The measured SPT 'N'-values within the clayey silt fill deposit range from 5 blows to 22 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency. An SPT 'N'-value of 31 blows per 0.3 m of penetration was measured within the sand pocket, indicating a dense relative density.

The natural water content measured on selected samples of the cohesive fill ranged from 12 per cent to 15 per cent. The laboratory water content measured on one selected sample of the sand fill interlayer was 6 per cent.

The results of a grain size distribution test completed on one selected sample of the cohesive fill deposit from the current investigation are shown on Figure B8 in Appendix B.

Atterberg limits tests were carried out on three selected samples of the cohesive fill and measured liquid limits between about 22 per cent and 25 per cent, plastic limits between about 11 per cent and 13 per cent and plasticity indices between about 10 per cent and 12 per cent. These test results, which are plotted on Figure B9 in Appendix B, indicate that the fill material is classified as clayey silt of low plasticity.

### 4.2.3.3 *Clayey Silt*

A deposit of clayey silt, some sand and trace gravel was encountered underlying the clayey silt fill in Boreholes 13-1 and 13-2. Rootlets and wood fragments were also encountered in the upper zone of the clayey silt deposit in both boreholes. The clayey silt deposit was 1.1 m thick in both boreholes and Borehole 13-2 was terminated within this deposit at a depth of about 6.7 m below ground surface (Elevation 180.8 m).

The measured SPT "N"-values within the clayey silt deposit is 13 blows per 0.3 m of penetration, suggesting a stiff consistency.



The natural water content measured on two selected samples of the clayey silt is about 18 per cent and 20 per cent.

Atterberg limits tests were carried out on two samples of the cohesive deposit and measured liquid limits of about 28 per cent and 30 per cent, plastic limits of about 14 per cent, and corresponding plasticity indices of 14 and 16 per cent. These test results, which are plotted on Figure B10 in Appendix B, indicate that the material is classified as clayey silt of low plasticity.

### **4.2.3.4 Clayey Silt with Sand Till**

A till deposit consisting of clayey silt with sand was encountered underlying the clayey silt deposit in Borehole 13-1. The borehole terminated within this deposit at a depth of 6.7 m (Elevation 183.2 m) penetrating it for a thickness of 1.1 m.

An SPT 'N'-value of 28 blows per 0.3 m of penetration was measured within the till deposit, suggesting a very stiff consistency.

The natural water content measured on one selected sample of the till is 12 per cent.

The results of a grain size distribution test completed on a sample of the clayey silt till deposit from the current investigation are shown on Figure B11 in Appendix B.

An Atterberg limits test was carried out on one selected sample of the till and measured a liquid limit of about 23 per cent, a plastic limit of about 13 per cent, and a corresponding plasticity index of about 10 per cent. The test results are shown on plasticity chart on Figure B12 in Appendix B and indicate that the material is classified as clayey silt of low plasticity.

### **4.2.4 Noise Barrier Wall 4 - Station 34+730 to Station 35+000**

The boreholes pertinent to this section of noise barrier wall are Boreholes 13-3, 76-1 and 76-2. The existing Highway 401 EBC and Highway 401 West-Avenue Road N/S Ramp Road surface along the proposed noise barrier wall replacement ranges from about Elevation 182 m at the west limit to about 180 m near the middle of the wall replacement and then rises again to about Elevation 181 m at the east limit of the wall.

#### **4.2.4.1 Granular Fill/Topsoil**

A 0.8 m thick deposit of granular fill consisting of sand and gravel was encountered immediately below the existing ground surface in Borehole 13-3, which was advanced on the shoulder of the Highway 401W-Avenue Road N/S Ramp. A thin layer of topsoil was encountered at the ground surface in Boreholes 76-1 and 76-2 during the 1962 investigation.

An SPT 'N'-value of 15 blows per 0.3 m of penetration was measured within the sand and gravel deposit, indicating a compact relative density.





### 4.2.4.2 Clayey Silt Fill

A 0.6 m thick fill deposit comprised of clayey silt, trace sand and trace gravel, was encountered below the granular fill in Borehole 13-3.

An SPT 'N'-value of 8 blows per 0.3 m of penetration was measured within the clayey silt fill deposit, suggesting a firm consistency.

The natural water content measured on a selected sample of the cohesive fill is about 11 per cent.

### 4.2.4.3 Clayey Silt to Silty Clay Till

A till deposit of clayey silt to silty clay containing sand and trace gravel was encountered below the clayey silt fill in Borehole 13-3 and below the topsoil in Boreholes 76-1 and 76-2. The upper portion of the till deposit in Boreholes 76-1 and 76-2 is classified as a sandy clayey silt. Sandy silt and silt interlayers were encountered within this deposit and the presence of cobbles and boulders is inferred from auger advancement in Borehole 13-3. In Boreholes 76-1 and 76-2, the till deposit is interlayered by an approximately 1.5 m and 3.0 m thick deposits of brown to grey silt to sandy silt, with the surface of the deposit at about 3.8 m and 2.4 m below the then existing ground surface, respectively, corresponding to about Elevations 176.7 m and 177.8 m. Boreholes 13-3, 76-1, and 76-2 terminated within this deposit at depths ranging from about 6 m to 6.7 m below the ground surface (Elevation 173.8 m to 174.5 m), penetrating it for a thickness of between about 5.3 m and 5.7 m.

In Borehole 13-3, the measured SPT 'N'-values within the till deposit range from 16 blows to 58 blows per 0.3 m of penetration, suggesting a very stiff to hard consistency. The measured SPT 'N'-values in Boreholes 76-1 and 76-2 range from about 40 blows per 0.3 m of penetration to greater than 100 blows per 0.3 m of penetration which is consistent with the hard consistency of the deposit as measured during the current investigation. The SPT 'N'-values measured within the silt to sandy silt interlayer are greater than 146 blows per 0.3 m of penetration indicating a very dense relative density.

The natural water content measured on selected samples of the till range from about 11 per cent to 18 per cent.

The results of a grain size distribution test completed on a sample of the till deposit from the current investigation are shown on Figure B13 in Appendix B.

Atterberg limits tests were carried out on three selected samples of the till deposit and measured liquid limits between about 16 per cent and 39 per cent, plastic limits between about 10 per cent and 17 per cent and plasticity indices between about 5 per cent and 22 per cent. These test results, which are plotted on Figure B14 in Appendix B, confirm that the material may be classified as clayey silt of low plasticity to silty clay of intermediate plasticity.

### 4.2.5 Groundwater Conditions

The observed/recorded water levels in the open boreholes following completion of drilling are shown on the Record of Borehole sheets and are summarized below.



## FOUNDATION REPORT - NOISE BARRIER WALLS

Noise Barrier Wall No.	Borehole Number	Ground Surface Elevation (m)	Depth to Water Level below Ground Surface (m)	Groundwater Elevation (m)	Date
NBW1	13-4	142.1	Dry	-	March 14, 2013
	13-5	158.5	Dry	-	March 14, 2013
	134-1	124.5	2.6	121.9	November 14, 1961
	136-1	134.4	9.8	124.6	July 10, 1962
	136-6	134.9	4.9	130.0	September 21, 1962
	136-7	134.9	2.2	132.2	September 27, 1962
	136-8	134.1	6.4	127.7	October 4, 1962
NBW2	13-6	184.5	Dry	-	March 15, 2013
	84-2	177.8	9.5	168.3	August 14, 1963
NBW3	13-1	189.9	Dry	-	March 14, 2013
	13-2	187.5	Dry	-	March 13, 2013
NBW4	13-3	180.5	6.1	174.4	March 14, 2013
	76-1	180.5	~ 1.7	~ 178.8	November 19, 1962
	76-2	180.2	~ 0.6	~ 179.6	November 19, 1962

- Water levels not recorded in Boreholes 134-7, 136-2 to 136-5.

The water levels presented above and on the Record of Borehole sheets may not represent stabilized groundwater conditions at the time of the investigation. It is also noted that the groundwater measured during the 1962 and 1963 investigations have likely changed over the past 50 years.

The water level at each site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the Spring and periods of precipitation.



## FOUNDATION REPORT - NOISE BARRIER WALLS

### 5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Nikol Kochmanová, P.Eng., and reviewed by Mr. Kevin Bentley, P.Eng., an Associate and Senior Geotechnical Engineer at Golder. Mr. Jorge Costa, P.Eng., a Designated MTO Contact and Principal with Golder, conducted an independent review and quality control audit of this report.

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# **PART B**

**FOUNDATION DESIGN REPORT  
NOISE BARRIER WALLS  
HIGHWAY 401 EBC REHABILITATION FROM  
JANE STREET TO AVENUE ROAD  
TORONTO, ONTARIO  
G.W.P. 2131-01-00**



## 6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

### 6.1 General

This section of the report provides geotechnical parameters and recommendations for the geotechnical aspects of design of the proposed noise barrier walls associated with the rehabilitation of the Highway 401 Eastbound Collector lanes. The design parameters and recommendations have been developed based on interpretation of the factual data obtained from the boreholes advanced during the current and previous subsurface investigations in the vicinity of the proposed noise barrier walls. The interpretation and recommendations contained in this report are intended to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the design of the structure foundations.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions or operational constraints may be required in the Contract Documents. Those requiring information on the aspects of construction should make their own interpretation of the factual information provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

### 6.2 Noise Barrier Wall Foundation Design

It is assumed that the noise barrier walls will be supported using conventional augered caissons, with a diameter of 0.6 m to 0.9 m. Geotechnical design parameters for design of the caisson foundations for the proposed Noise Barrier Walls 1 to 4 are provided in Table 1 following the text of this report, based on the subsurface conditions encountered in the current and previous investigations boreholes in the vicinity of the proposed noise barrier walls. The stratigraphy presented in Table 1 has been simplified for the purposes of the noise barrier wall foundation design.

Where both an undrained shear strength,  $s_u$ , 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 within the upper 1.2 m below ground surface 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 caissons is level (i.e. the width of soil in front and behind the caissons is equal to or greater than eight caisson diameters). If there is a lesser width of a zone of soil for development of passive resistance (i.e. if there is sloping ground adjacent to the noise barrier wall), the magnitude of the passive resistance may be determined by interpolating between zero passive resistance at ground surface and full passive resistance at the depth where the slope face is at a distance greater than eight caisson diameters away from the face of the caisson.

### 6.3 Construction Considerations

Caisson construction is anticipated to require augering/excavation through the existing fill and into the clayey silt to silty clay till deposit at the noise barrier wall locations. The existing fills and tills contain granular layers (potentially saturated) which may be susceptible to disturbance during caisson excavation and construction. The



## FOUNDATION REPORT - NOISE BARRIER WALLS

use of a temporary liner to advance the auger holes for caissons at the noise barrier walls is recommended, in order to reduce disturbance and ground loss during drilling and concrete placement. Further, cobbles and boulders were encountered or are inferred to be present within the till deposit and appropriate equipment and methods will need to be employed to penetrate through such obstruction, if encountered. It is recommended that a Non-Standard Special Provision (NSSP) be included in the Contract Documents to warn the Contractor of these conditions since they may affect the installation of the noise barrier wall foundations. A sample NSSP for each condition is provided in Appendix D.

The noise barrier walls should be constructed in accordance with MTO's Special Provision (SP) 799F01.

### 7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Nikol Kochmanová, P.Eng., and reviewed by Mr. Kevin Bentley, P.Eng., an Associate and Senior Geotechnical Engineer at Golder. Mr. Jorge Costa, P.Eng., a Designated MTO Contact and Principal with Golder, conducted an independent review and quality control audit of this report.

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FOUNDATION REPORT - NOISE BARRIER WALLS

TABLE 1 - GEOTECHNICAL DESIGN PARAMETERS FOR NOISE BARRIER WALLS  
HIGHWAY 401 EBC REHABILITATION – JANE STREET TO AVENUE ROAD

Noise Barrier Wall No.	Noise Barrier Wall Location (Original Highway 401 EBC Stationing)	Approximate Existing Ground Surface Elevation (m)	Relevant Boreholes	Stratum	Depth <sup>1</sup> (m)	Elevation <sup>1</sup> (m)	Design Parameters <sup>2,3</sup>					Design Groundwater Elevation (m)
							s <sub>u</sub>	φ'	γ	γ'	K <sub>p</sub>	
NBW1	STA 27+830 to STA 27+900	132 to 133	134-1 and 134-7	*Fill (Existing and assumed firm to stiff clayey silt)	0 – 3	Above 121	50	28	19	9	2.8	122
				Soft to very stiff clayey silt to silty clay (inferred till)	3 – 18	121 - 106	25	28	19	9	2.8	
				Very stiff to hard clayey silt with sand (inferred till)	18 – 24	106 - 100	-	34	21	11	3.7	
	STA 27+900 to STA 28+100	133 to 136	136-1 to 136-6 and 136-8	*Fill (Assumed – clayey silt)	0 – 1	Above 135	50	28	19	9	2.8	128
				Very stiff clayey silt till	1 – 9	135 - 126	-	32	21	11	3.3	
				Soft to stiff clayey silt (inferred till)	8 - 18	126 - 117	25	28	19	9	2.8	
	STA 28+100 to STA 28+200	136 to 140	136-7	*Fill (Assumed – clayey silt)	0 - 2	Above 133	50	28	19	9	2.8	135.5
				Very stiff to hard silty clay (inferred till)	2 – 9	133 - 126	-	34	21	11	3.0	
				Soft to stiff silty clay (inferred till)	9 – 17	126 - 118	50	28	19	9	2.8	
				Compact to very dense sandy silt	17 – 25	118 - 110	-	34	20	10	3.5	
				Hard clayey silt till	25 – 29	110 – 106	-	34	21	11	3.5	
				Weathered shale bedrock	Below 29	Below 106	-	34	21	11	3.5	
	STA 28+200 to STA 28+500	140 to 147	13-4	*Fill (Existing firm to stiff clayey silt)	0 - 2	Above 140	50	28	19	9	2.8	Dry to 135
				Stiff to very stiff clayey silt till	2 – 6.5	140 – 135.5	-	32	21	11	3.3	
	STA 28+500 to STA 29+110	147 to 158.5	13-5	*Fill (Existing firm to stiff clayey silt)	0 - 4.5	Above 154	50	28	19	9	2.8	Dry to 152
				Stiff to very stiff clayey silt till	4.5 – 6.5	154 – 151.5	-	32	21	11	3.3	
NBW2	STA 29+800 to STA 30+050	178	84-2	*Fill (Existing and assumed embankment)	0 – 1.5	Above 176	50	28	19	9	2.8	169
				Very stiff to hard clayey silt till	1.5 – 15.5	176 - 162	-	34	21	11	3.5	
	STA 30+050 to STA 30+300	178 to 185	13-6	Fill (Existing stiff to very stiff clayey silt)	0 – 5.5	Above 179	50	28	19	9	2.8	Dry to 178
				Very stiff clayey silt till	5.5 – 7	179 – 177.5	-	34	21	11	3.7	
NBW3	STA 32+970 to STA 33+400	186.5 to 191	13-1	*Fill (Existing firm to very stiff clayey silt)	0 – 4.5	Above 185.5	50	28	19	9	2.8	Dry to 183
				Stiff clayey silt	4.5 – 5.5	185.5 – 184.5	50	28	19	9	2.8	
				Very stiff clayey silt till	5.5 - 7	184.5 - 183	-	34	21	11	3.5	
	STA 33+400 to STA 33+750	186 to 188	13-2	*Fill (Existing firm to very stiff clayey silt)	0 – 5.5	Above 181.5	50	28	19	9	2.8	Dry to 181
				Stiff clayey silt	5.5 - 7	181.5 – 180.5	50	28	19	9	2.8	
NBW4	STA 34+730 to STA 34+900	180 to 181	13-3	*Fill (Existing firm to stiff clayey silt)	0 - 1.5	Above 179	50	28	19	9	2.8	175
				Very stiff to hard clayey silt to silty clay till	1.5 – 6.5	179 – 173.5	-	34	21	11	3.5	
	STA 34+900 to STA 35+000	180 to 181	76-1 and 76-2	*Fill (Assumed clayey silt)	0 – 1	Above 180	50	28	19	9	2.8	179
				Hard sandy/clayey silt till	1 - 4	180 – 177	-	34	21	11	3.5	
				Very dense silt/sandy silt	4 – 5.5	177 – 175.5	-	34	21	11	3.5	
				Very stiff to hard clayey silt till	5.5 – 8	175.5 – 173	-	34	21	11	3.5	

Reviewed By: KJB



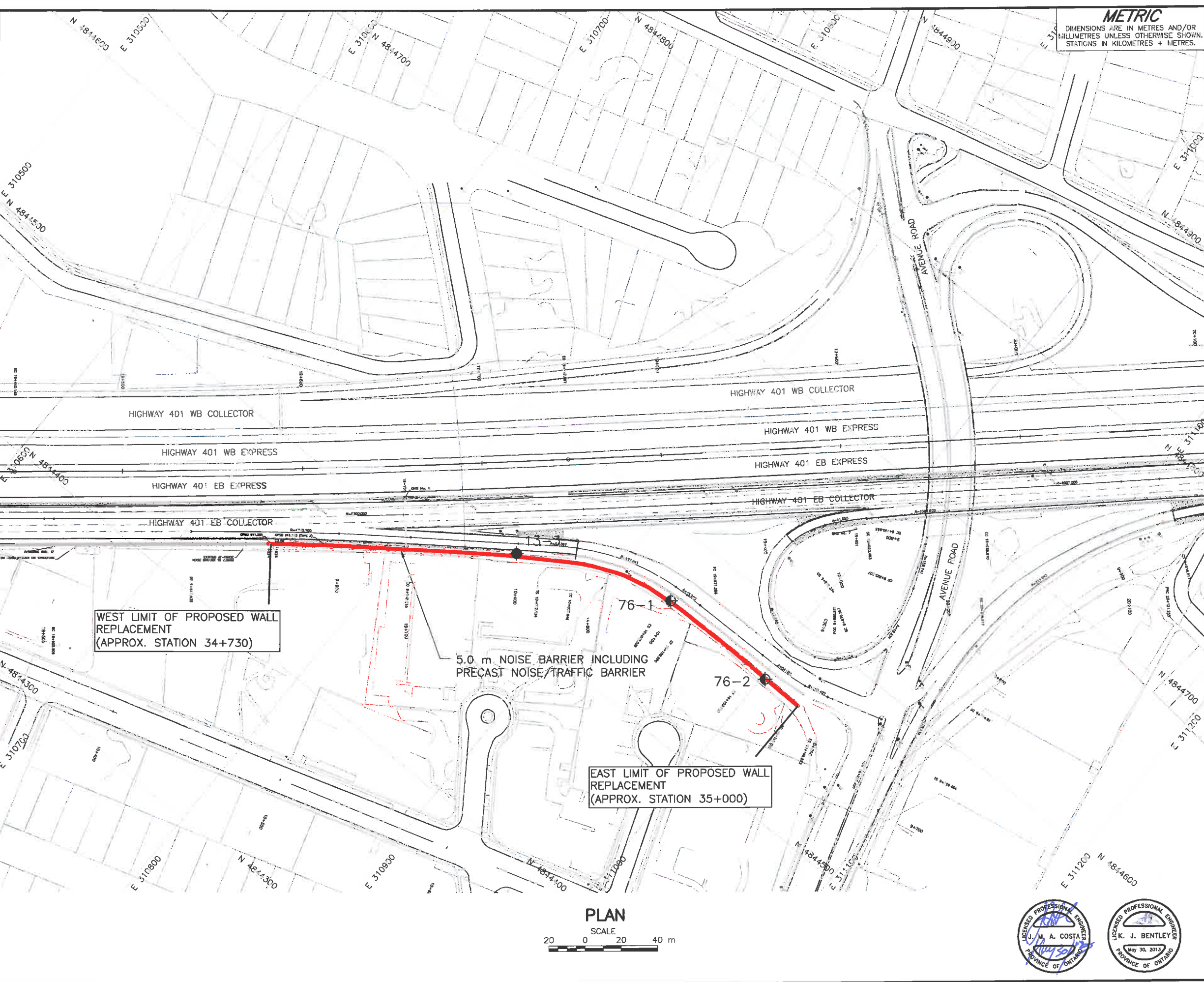


NOTES:

\*Deposit thickness for design to be considered ½ of the fill thickness presented

1. Depths are given at closest borehole location(s) relative to present (2011) estimated ground surface according to topographic plan provided by URS; the ground surface elevation at the borehole location(s) should be compared to the ground surface elevation at the actual noise barrier wall location, and the depths to various soil stratum adjusted accordingly.
2. Design parameters:
  - $s_u$  = undrained shear strength (kPa);
  - $\phi'$  = effective friction angle (degrees);
  - $\gamma$  = bulk unit weight (kN/m<sup>3</sup>);
  - $\gamma'$  = effective unit weight below the groundwater level (kN/m<sup>3</sup>); and
  - $K_p$  = passive earth pressure coefficient (assuming level ground).
3. Although the passive resistance in the upper 1.2 m is neglected to account for frost action,  $s_u$ ,  $\phi'$  and  $K_p$  parameters are given for the soil, in the event that the ground surface elevation varies significantly between that at the borehole location and the noise barrier wall locations.

MINISTRY OF TRANSPORTATION, ONTARIO  
PROJECT DATE: May 20, 2013  
FILE NAME: N:\Projects\2009\09-1111-6007\Bentley\Drawings\Drawings\09-1111-6007\Hwy401\_30M11-248.dwg

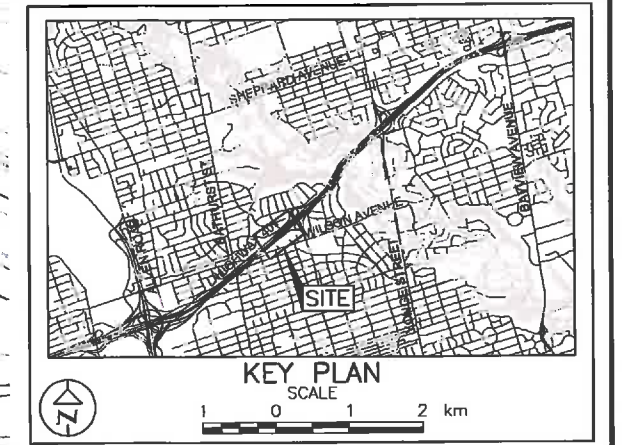


**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 2131-01-00

HIGHWAY 401 EBC REHABILITATION  
NOISE BARRIER WALL 4  
BOREHOLE LOCATIONS

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



**LEGEND**

Borehole - Current Investigation  
 Approximate Borehole Location - Previous Investigation (Geocres No. 30M11-76)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
13-3	180.5	4844530.7	310850.8
76-1	180.5	4844564.3	310934.0
76-2	180.2	4844563.3	311002.2

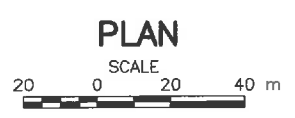
**NOTES**

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

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

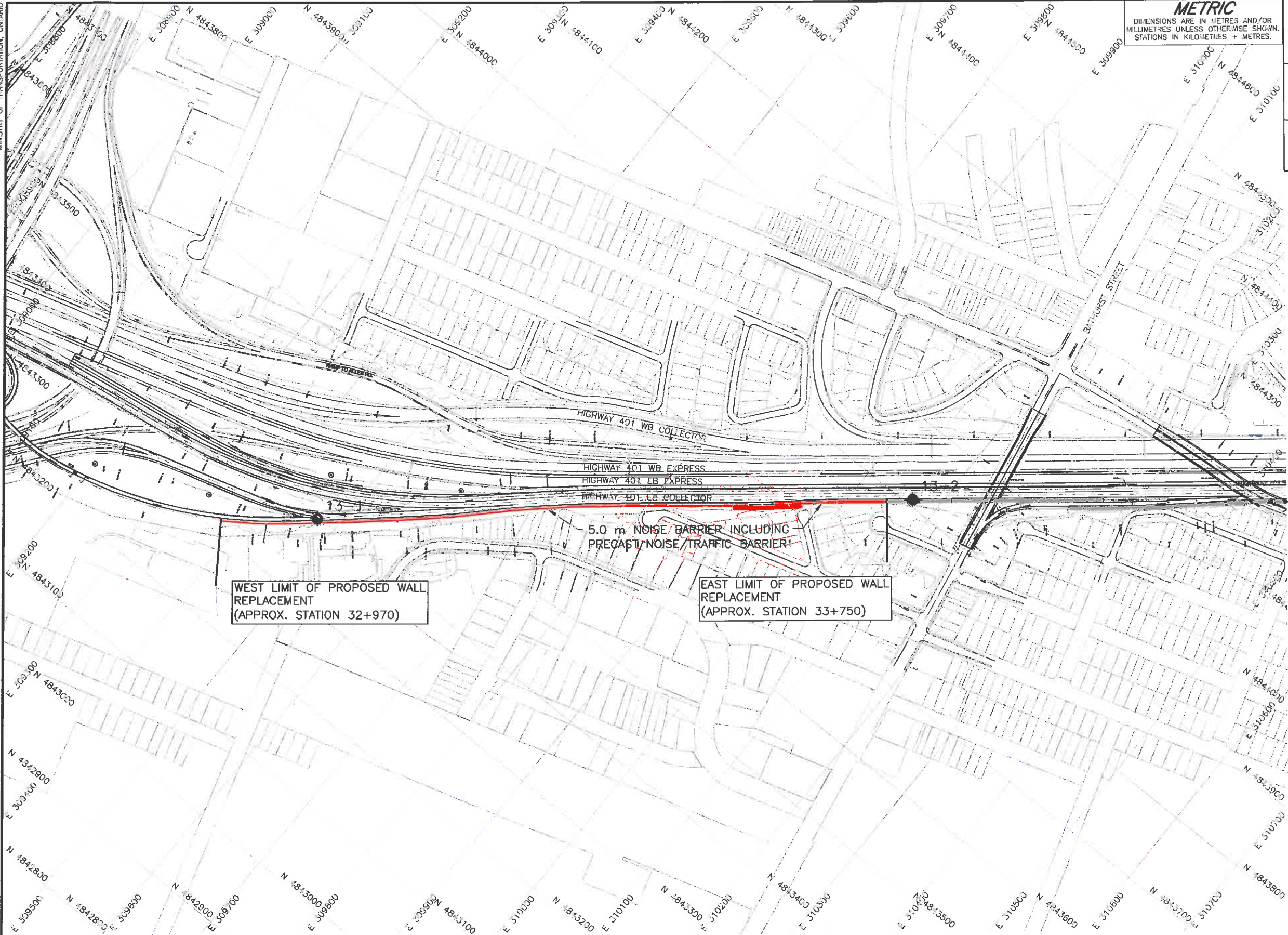
**REFERENCE**

Base plans provided in digital format by URS, drawing file names: Hwy401\_b3d.dwg, received August 3, 2011 and Hwy401\_alignment.dwg, Hwy401\_plan\_cont\_2\_Noise Barrier.dwg, received February 12, 2013.



NO.	DATE	BY	REVISION
Geocres No. 30M11-248			
Hwy. 401	PROJECT NO. 09-1111-6007		DIST. Central
SUBM'D. AV	CHKD. NK	DATE: 4/12/2013	SITE:
DRAWN: JFC	CHKD. KJB	APPD. JMAC	DWG. 4





WEST LIMIT OF PROPOSED WALL  
 REPLACEMENT  
 (APPROX. STATION 32+970)

EAST LIMIT OF PROPOSED WALL  
 REPLACEMENT  
 (APPROX. STATION 33+750)

**PLAN**  
 SCALE  
 50 0 50 100 m

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

**CONT No.**  
**GWP No. 2131-01-00**

**HIGHWAY 401 EBC REHABILITATION**  
 NOISE BARRIER WALL 3  
**BOREHOLE LOCATIONS**



**SHEET**



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



**KEY PLAN**  
 SCALE  
 1 0 1 2 km

**LEGEND**

● Borehole - Current Investigation

**BOREHOLE CO-ORDINATES**

No.	ELEVATION	NORTHING	EASTING
13-1	169.9	4843397.0	309473.3
13-2	187.5	4843908.4	310057.5

**NOTES**

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**REFERENCE**

Base plans provided in digital format by URS, drawing file names:  
 Hwy401\_bgd.dwg, received August 3, 2011 and Hwy401\_alignment.dwg,  
 Hwy401\_plan\_cont 2\_Noise Barrier.dwg, received February 12, 2013.



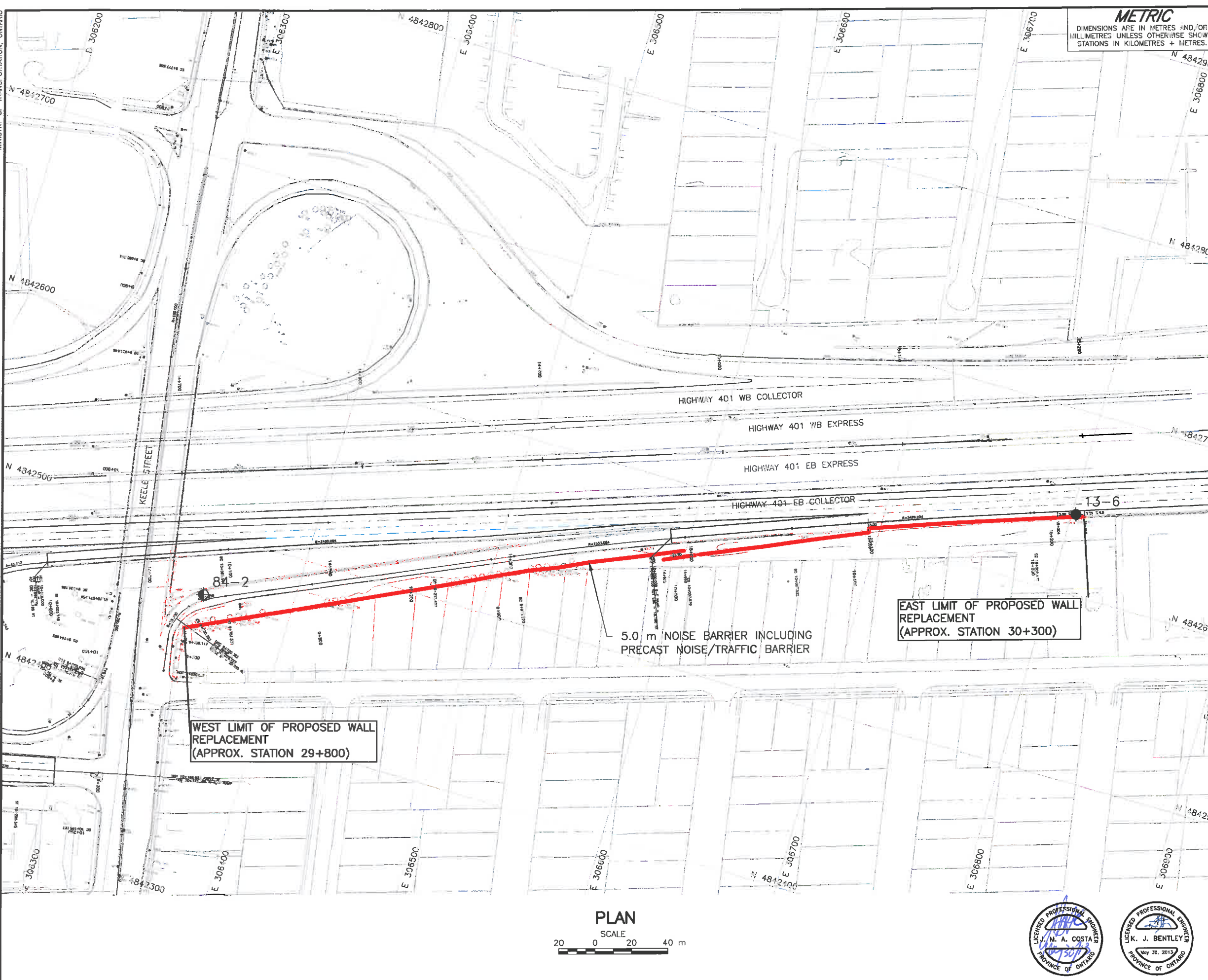
NO.	DATE	BY	REVISION

Geocres No. 30M11-248

HWY. 401	PROJECT NO. 09-1111-6007	DIST. Central
SUBM'D. AV	CHKD. NK	DATE: 4/12/2013
DRWN: JFC	CHKD. KJB	APPD. JMAC
		DWG. 3



MINISTRY OF TRANSPORTATION, ONTARIO

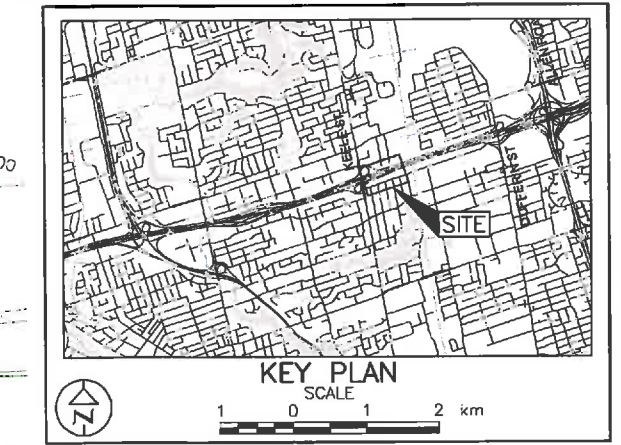


**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 2131-01-00

HIGHWAY 401 EBC REHABILITATION  
NOISE BARRIER WALL 2  
BOREHOLE LOCATIONS

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



**LEGEND**

Borehole - Current Investigation

Approximate Borehole Location - Previous Investigation (Geocres No. 30M11-84)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
13-6	164.5	4842643.8	306802.2
84-2	177.8	4842465.9	306350.6

**NOTES**

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

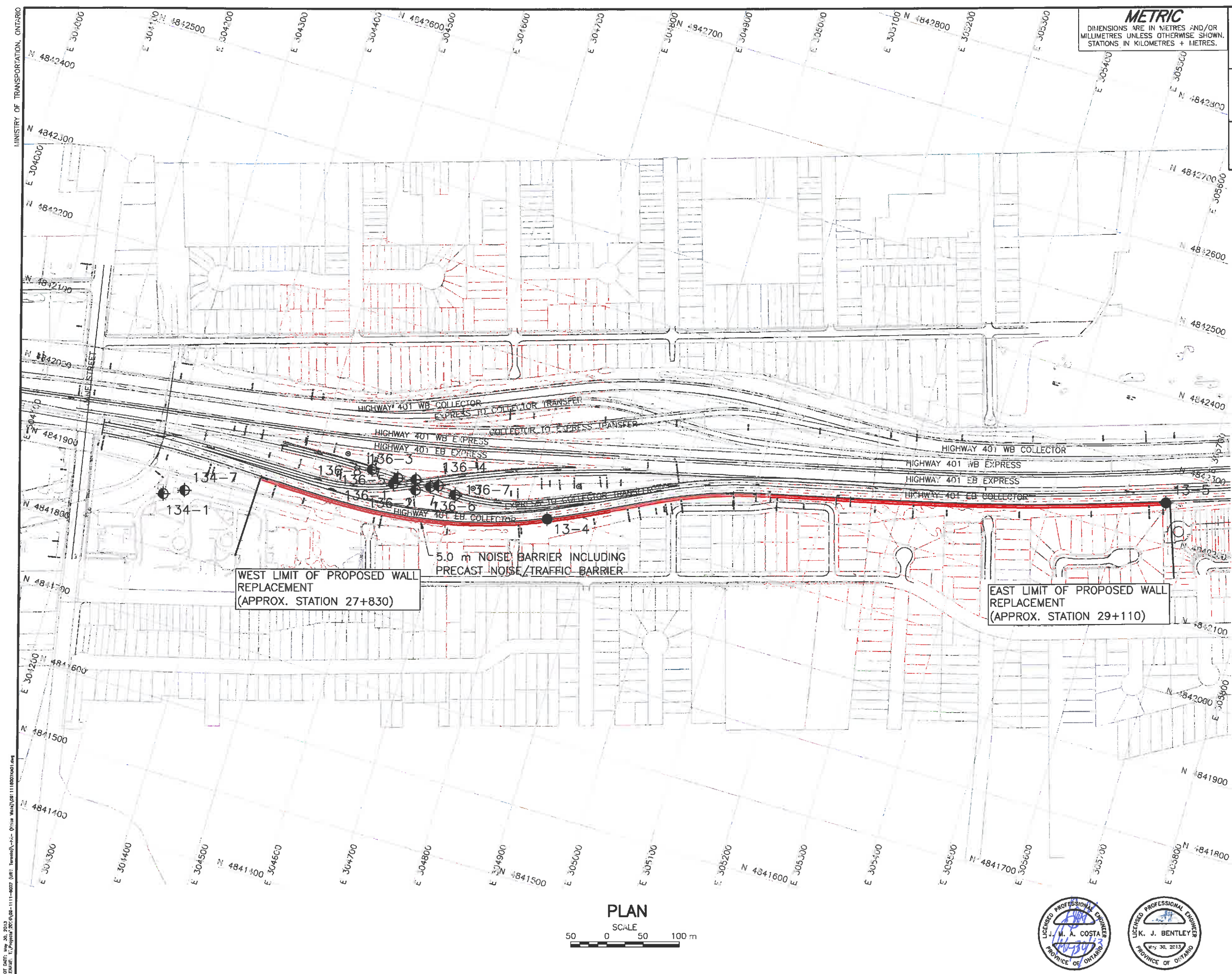
The complete Foundation Investigation and Design Report for this project and other related documents may be examined at the Materials Engineering and Research Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with Section 2.01 of OPS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

**REFERENCE**

Base plans provided in digital format by URS, drawing file names: Hwy401\_bgd.dwg, received August 3, 2011 and Hwy401\_alignment.dwg, Hwy401\_plan\_cont 2\_Noise Barrier.dwg, received February 12, 2013.

NO.	DATE	BY	REVISION
1			
Geocres No. 30M11-248			
HWY. 401	PROJECT NO. 09-1111-6007		DIST. Central
SUBM'D. AV	CHKD. NK	DATE: 4/12/2013	SITE:
DRAWN: JFC	CHKD. KJB	APPD. JMAC	DWG. 2





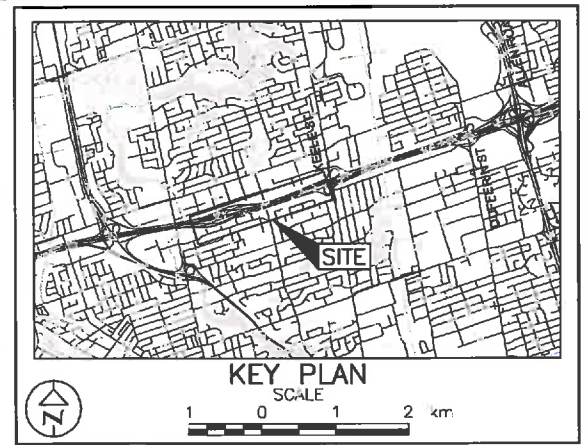
**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 2131-01-00

HIGHWAY 401 EBC REHABILITATION  
NOISE BARRIER WALL 1  
BOREHOLE LOCATIONS

SHEET

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



LEGEND

Borehole - Current Investigation  
 Approximate Borehole Location - Previous Investigation (Geocres No. 30M11-134 and 30M11-136)

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
13-4	142.1	4841993.9	304833.0
13-5	158.5	4842257.2	305656.0
134-1	124.5	4841874.4	304310.4
134-7	125.5	4841887.7	304337.4
136-1	134.4	4841979.9	304613.5
136-2	135.3	4841980.3	304645.9
136-3	135.0	4841994.3	304642.0
136-4	135.0	4841995.2	304674.7
136-5	134.6	4841985.1	304617.2
136-6	134.9	4841990.6	304664.4
136-7	134.9	4841989.7	304700.7
136-8	134.1	4841990.3	304579.4

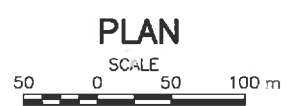
**NOTES**

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

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

**REFERENCE**

Base plans provided in digital format by URS, drawing file names: Hwy401\_bgd.dwg, received August 3, 2011 and Hwy401\_alignment.dwg, Hwy401\_plan\_cont 2\_Noise Barrier.dwg, received February 12, 2013.



NO.	DATE	BY	REVISION
1	4/12/2013	JFC	1
Geocres No. 30M11-248			
HWY. 401		PROJECT NO. 09-1111-6007	
SUBM'D. AV	CHKD. NK	DATE: 4/12/2013	SITE:
DRAWN: JFC	CHKD. KJB	APPD. JMAC	DWG. 1

PLOT DATE: May 30, 2013  
FILENAME: I:\Project\2013\09-1111-6007\09-1111-6007.dwg  
PLOTTER: HP DesignJet 2450-600



# APPENDIX A

## Record of Borehole Sheets from Current Investigation



## 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

### 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.) drive open sampler for a distance of 300 mm (12 in.)

#### 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.).

<b>PH:</b>	Sampler advanced by hydraulic pressure
<b>PM:</b>	Sampler advanced by manual pressure
<b>WH:</b>	Sampler advanced by static weight of hammer
<b>WR:</b>	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.

### III. SOIL DESCRIPTION

#### (a) Cohesionless Soils

Density Index	N
Relative Density	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

#### (b) Cohesive Soils Consistency

	kPa	$C_u, S_u$	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

### 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 <sub>4</sub>	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.

### V. MINOR SOIL CONSTITUENTS

Percent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (cohesionless) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand





## 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: $\Delta \sigma$
$\varepsilon$	linear strain
$\varepsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - \mu$ )
$\sigma'_{vo}$	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
$\mu$	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

$T_p, T_r$	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

\* Density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density multiplied by acceleration due to gravity)

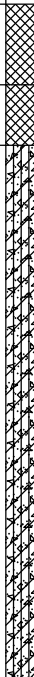
Notes: 1  $\tau = c' + \sigma' \tan \phi'$   
2 shear strength = (compressive strength)/2

PROJECT <u>09-1111-6007 (10000)</u>		<b>RECORD OF BOREHOLE No 13-1</b>		SHEET 1 OF 1		<b>METRIC</b>	
G.W.P. <u>2131-01-00</u>		LOCATION <u>N 4843397.0 ; E 309473.8</u>		ORIGINATED BY <u>SB</u>			
DIST <u>Central</u> HWY <u>401</u>		BOREHOLE TYPE <u>CME-55 Truck Mounted, 101 mm Diameter Solid Stem Augers</u>		COMPILED BY <u>NK</u>			
DATUM <u>Geodetic</u>		DATE <u>March 13, 2013</u>		CHECKED BY <u>KJB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT			UNIT WEIGHT  $\gamma$  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					w <sub>p</sub>	w	w <sub>L</sub>					
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    x REMOULDED												
189.9	GROUND SURFACE																			
0.0	ASPHALT																			
189.1	Sand and gravel, trace silt (FILL) Compact Brown Moist		1	SS	11								○							
0.8	Clayey silt, trace to with sand, trace gravel (FILL) Firm to very stiff Brown Moist		2	SS	15															
			3	SS	14								○							
			4	SS	7															
			5	SS	22															
			6	SS	14															
185.4																				
4.5	CLAYEY SILT, some sand, trace gravel, trace rootlets and wood fragments Stiff Brown Moist		7	SS	13															
184.3																				
5.6	CLAYEY SILT with SAND, trace gravel (TILL) Very stiff Brown Moist																			
183.2			8	SS	28															
6.7	END OF BOREHOLE																			
	NOTE:  1. Open borehole dry on completion of drilling.																			

PROJECT		RECORD OF BOREHOLE No 13-2		SHEET 1 OF 1		METRIC											
G.W.P. 09-1111-6007 (10000)		LOCATION N 4843908.4 ; E 310067.5		ORIGINATED BY SB													
DIST Central HWY 401		BOREHOLE TYPE CME-55 Truck Mounted, 101 mm Diameter Solid Stem Augers		COMPILED BY NK													
DATUM Geodetic		DATE March 15, 2013		CHECKED BY KJB													
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)			γ kN/m³	GR SA SI CL
							20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	10 20 30					
187.5	GROUND SURFACE																
0.0	ASPHALT																
0.3	CONCRETE																
186.7	Silty sand and gravel (FILL) Compact		1	SS	16		187										
0.8	Brown and black Moist		2	SS	12												
	Clayey silt, some sand, trace gravel, contains sand interlayers (FILL)		3	SS	15		186										
185.3	Stiff to very stiff Brown and grey Moist																
2.2	Sand, some silt, trace gravel (FILL)		4	SS	31		185										
184.5	Dense Brown Moist																
3.0	Clayey silt with sand, trace gravel, contains sand pockets and interlayers (FILL)		5	SS	5		184										
	Firm to very stiff Brown Moist		6	SS	11												
			7	SS	16		183										
181.9							182										
5.6	CLAYEY SILT with SAND, trace rootlets																
	Stiff Grey Moist		8	SS	13		181										
180.8																	
6.7	END OF BOREHOLE																
	NOTE:  1. Open borehole dry upon completion of drilling.																

PROJECT <u>09-1111-6007 (10000)</u>		<b>RECORD OF BOREHOLE No 13-3</b>		SHEET 1 OF 1		<b>METRIC</b>	
G.W.P. <u>2131-01-00</u>		LOCATION <u>N 4844530.7 ; E 310850.8</u>		ORIGINATED BY <u>SB</u>			
DIST <u>Central</u> HWY <u>401</u>		BOREHOLE TYPE <u>CME-55 Truck Mounted, 101 mm Diameter Solid Stem Augers</u>		COMPILED BY <u>NK</u>			
DATUM <u>Geodetic</u>		DATE <u>March 14, 2013</u>		CHECKED BY <u>KJB</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL LIMIT   MOISTURE   LIQUID CONTENT   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 <sub>p</sub>	W	W <sub>L</sub>						
180.5	GROUND SURFACE																				
0.0	Sand and gravel, some silt (FILL) Compact Brown Moist		1	SS	15																
179.7																					
0.8	Clayey silt, trace sand, trace gravel (FILL) Firm Brown Moist		2	SS	8																
179.1																					
1.4	CLAYEY SILT to SILTY CLAY, trace sand, trace gravel, contains oxidation staining to 2.1 m, contains sand pockets between depths 3.6 m - 5.6 m (TILL) Very stiff to hard Brown becoming grey at a depth of 2.4 m Moist		3	SS	29																
	Inferred cobbles and boulders at a depth of 3.8 m		4	SS	21																
			5	SS	16																
			6	SS	58																
			7	SS	20																
			8	SS	25																
173.8	END OF BOREHOLE																				
6.7	NOTE:  1. Water level in open borehole at a depth of 6.1 m below ground surface ( Elev. 174.4 m) on completion of drilling.																				

PROJECT 09-1111-6007 (10000)			RECORD OF BOREHOLE No 13-4			SHEET 1 OF 1			METRIC								
G.W.P. 2131-01-00			LOCATION N 4841993.9 ; E 304833.0			ORIGINATED BY SB											
DIST Central HWY 401			BOREHOLE TYPE CME-55 Truck Mounted, 101 mm Diameter Solid Stem Augers			COMPILED BY NK											
DATUM Geodetic			DATE March 14, 2013			CHECKED BY KJB											
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									
142.1	GROUND SURFACE																
0.0	ASPHALT																
141.3	Sand and gravel, trace silt (FILL) Compact Brown Moist		1	SS	16												
0.8	Clayey silt, some sand, trace gravel, contains sand pockets (FILL) Firm to Stiff Brown Moist		2	SS	8												
			3	SS	13												
139.9	Sandy CLAYEY SILT, trace gravel (TILL) Stiff to very stiff Brown becoming grey at a depth of 5.5 m Moist		4	SS	15												
2.2			5	SS	13												
			6	SS	15												
			7	SS	18												
			8	SS	15												
135.4	END OF BOREHOLE																
6.7	NOTE: 1. Open borehole dry on completion of drilling.																

PROJECT		RECORD OF BOREHOLE No 13-5		SHEET 1 OF 1		METRIC												
G.W.P. 09-1111-6007 (10000)		LOCATION N 4842257.2 ; E 305656.0		ORIGINATED BY SB														
DIST Central HWY 401		BOREHOLE TYPE CME-55 Truck Mounted, 101 mm Diameter Solid Stem Augers		COMPILED BY NK														
DATUM Geodetic		DATE March 14, 2013		CHECKED BY KJB														
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)					
158.5	GROUND SURFACE							20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED					W <sub>p</sub> — W — W <sub>L</sub> 10 20 30					
0.0	ASPHALT																	
157.7	Sand and gravel, trace silt (FILL) Dense Brown Moist		1	SS	34		158											
0.8	Clayey silt with sand, trace gravel (FILL) Stiff to firm Brown becoming grey at a depth of 3.0 m Moist		2	SS	14		157						○ —					
			3	SS	10		156						○					
			4	SS	9		155											
			5	SS	8		154						—					
			6	SS	6		153						—					
153.9	CLAYEY SILT, some sand, trace gravel, contains oxidation staining between depths of 4.6 m and 5.2 m (TILL) Stiff to very stiff Brown Moist		7	SS	13		152											
4.6			8	SS	17													
151.8	END OF BOREHOLE																	
6.7	NOTE: 1. Open borehole dry on completion of drilling.																	

PROJECT		RECORD OF BOREHOLE No 13-6		SHEET 1 OF 1		METRIC												
G.W.P. 09-1111-6007 (10000)		LOCATION N 4842643.8 ; E 306802.2		ORIGINATED BY SB														
DIST Central HWY 401		BOREHOLE TYPE CME-55 Truck Mounted, 101 mm Diameter Solid Stem Augers		COMPILED BY NK														
DATUM Geodetic		DATE March 15, 2013		CHECKED BY KJB														
SOIL PROFILE			SAMPLES			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	SHEAR STRENGTH kPa					WATER CONTENT (%)					
								20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>	10 20 30	γ	GR	SA	SI	CL
184.5	GROUND SURFACE																	
0.0	ASPHALT																	
183.7	Sand and gravel, trace silt (FILL) Compact Brown Moist		1	SS	27		184											
0.8	Clayey silt to silty clay with sand, trace gravel, contains sand pockets, contains rootlets and wood fragments below a depth of 3.7 m (FILL) Stiff to very stiff Brown becoming grey below a depth of 3.0 m Moist		2	SS	12		183											
			3	SS	8		182											
			4	SS	11		181											
			5	SS	11		180											
			6	SS	22		179											
			7	SS	14		178											
179.0	CLAYEY SILT with SAND, trace gravel (TILL) Very stiff Brown Moist		8	SS	24		177											
177.8	END OF BOREHOLE																	
6.7	NOTE: 1. Open borehole dry on completion of drilling.																	





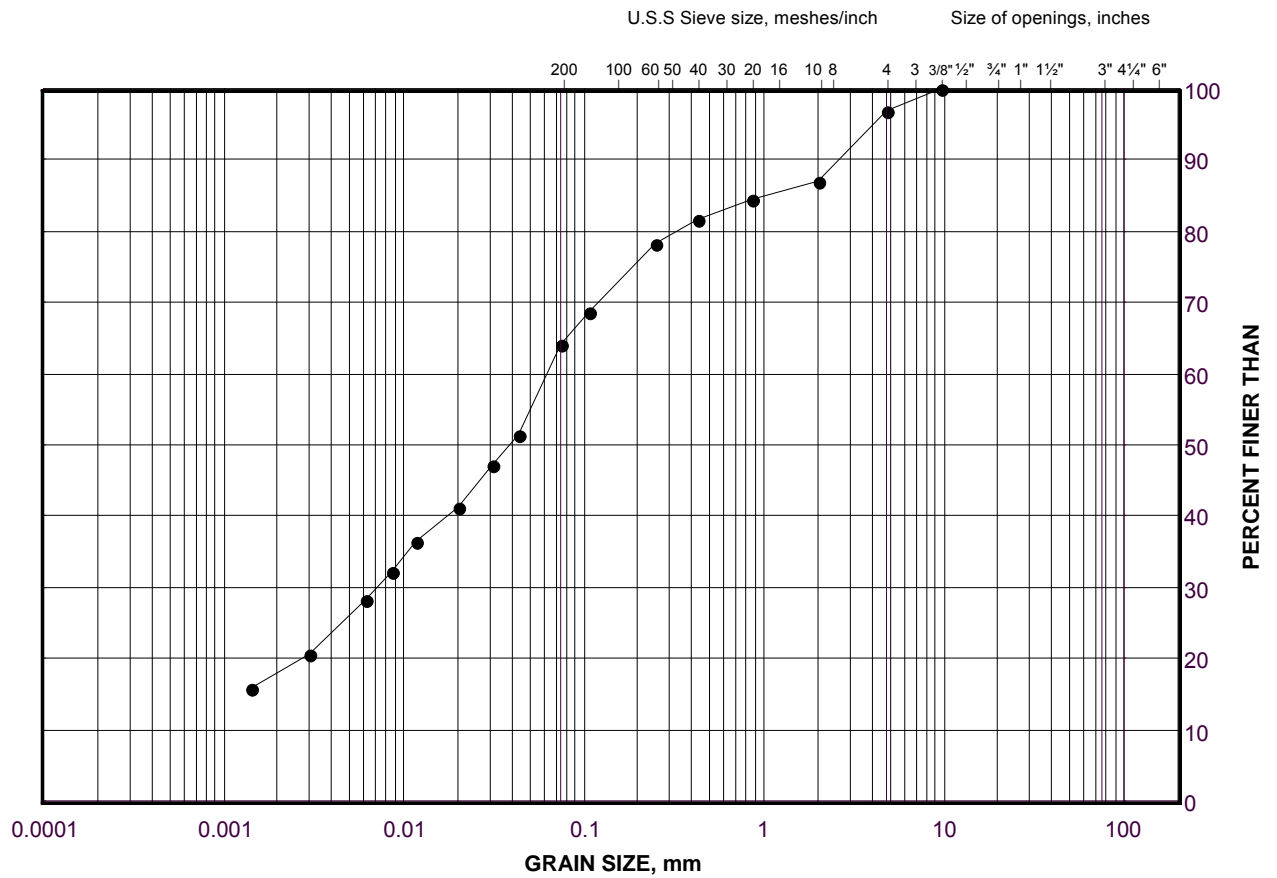
# APPENDIX B

## Laboratory Test Results

# GRAIN SIZE DISTRIBUTION

Clayey Silt (Fill)  
Noise Barrier Wall 1

FIGURE B1



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

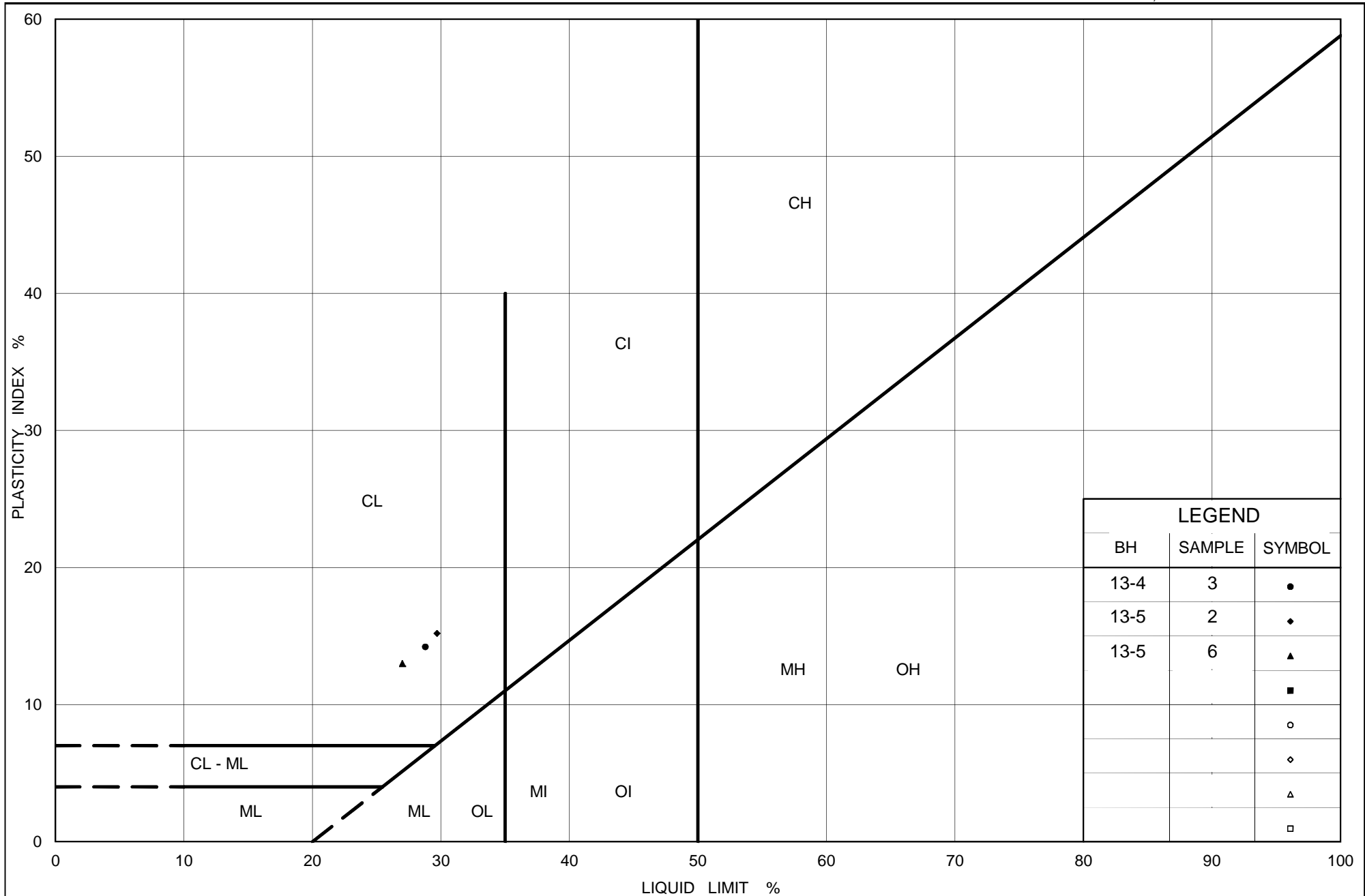
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	13-5	6	154.4

Project Number: 09-1111-6007

Checked By: KJB

**Golder Associates**

Date: 24-May-13



Ministry of Transportation

Ontario

# PLASTICITY CHART Clayey Silt (Fill) Noise Barrier Wall 1

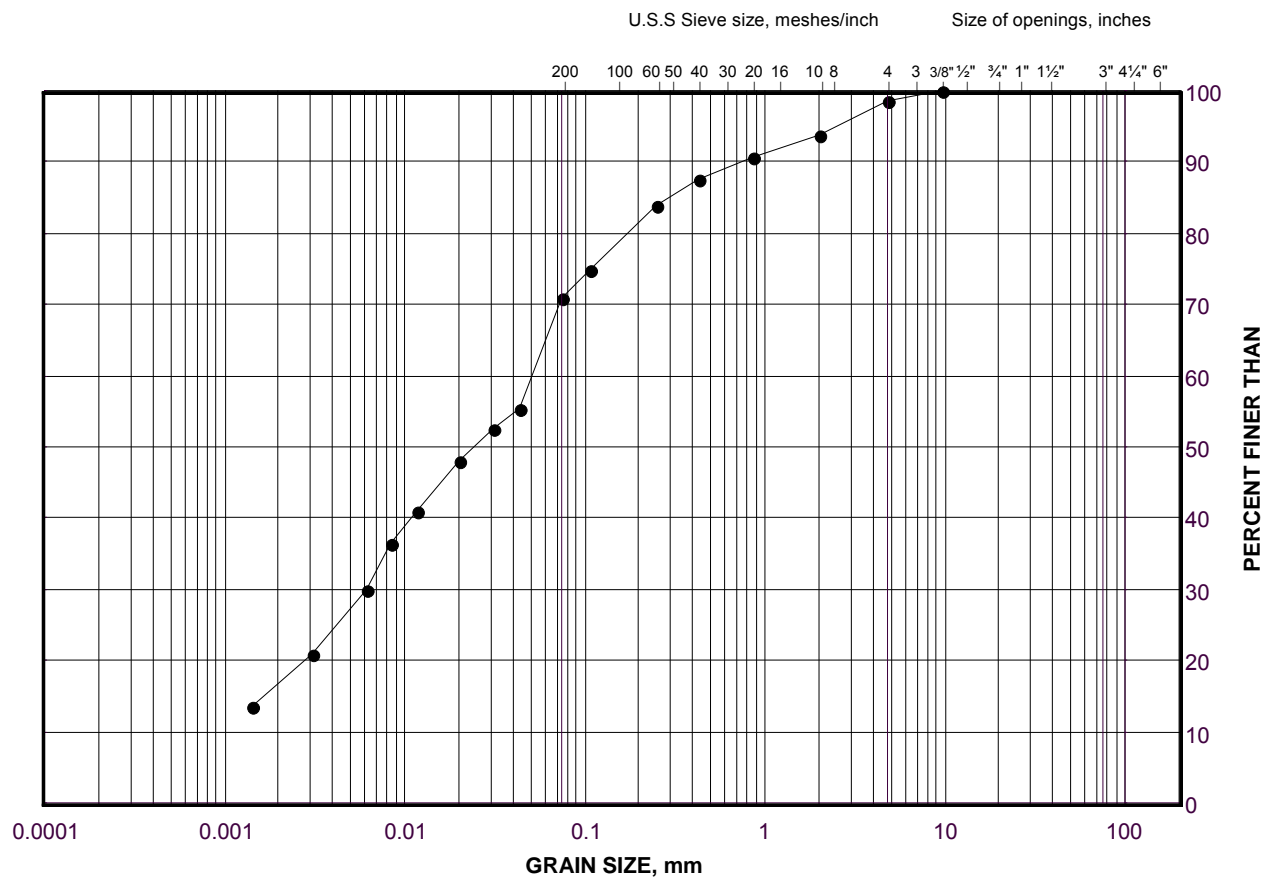
Figure No. B2

Project No. 09-1111-6007

Checked By: KJB

Clayey Silt (Till)  
Noise Barrier Wall 1

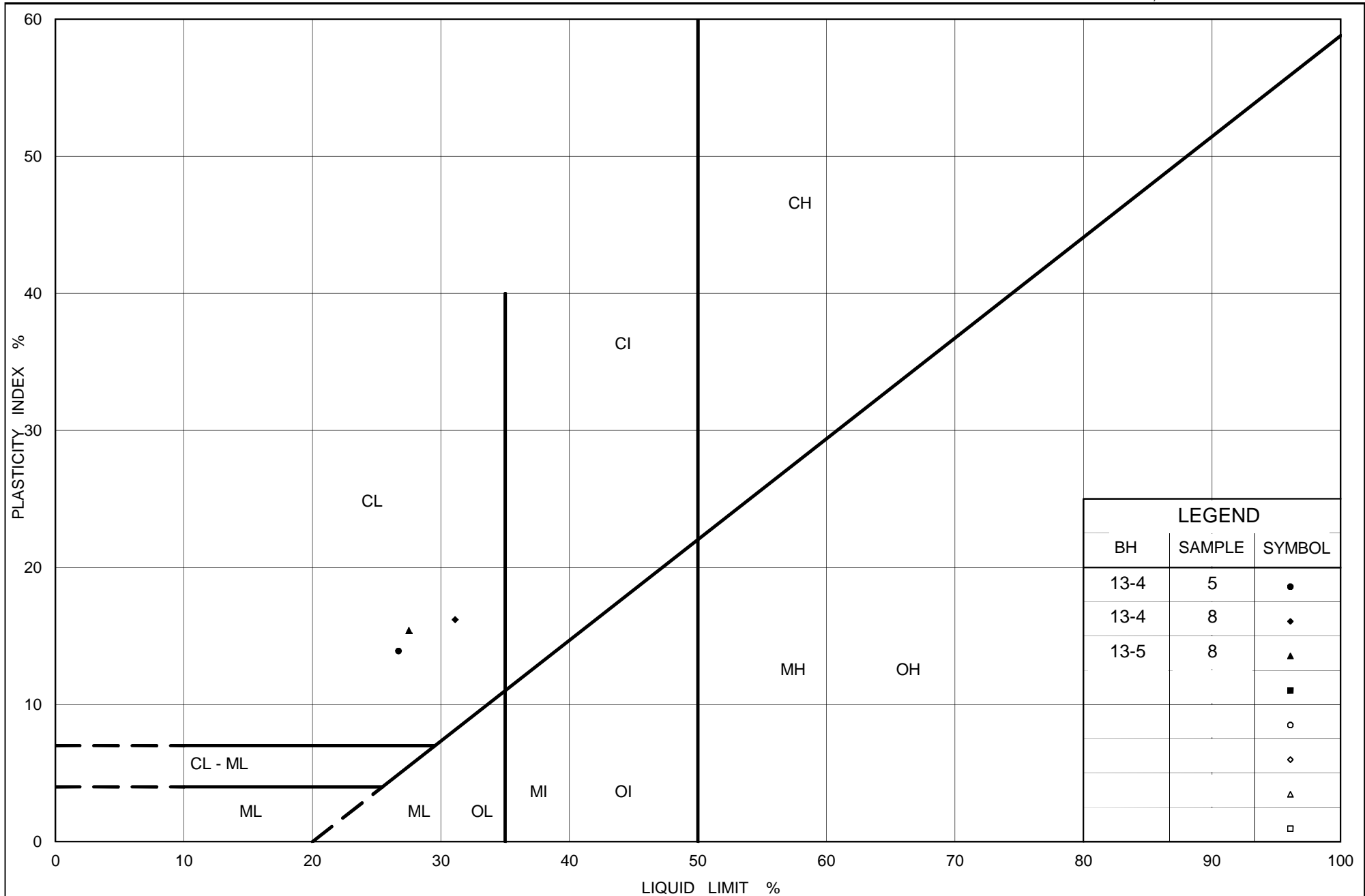
FIGURE B3



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		

## LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
●	13-4	5	138.8



Ministry of Transportation

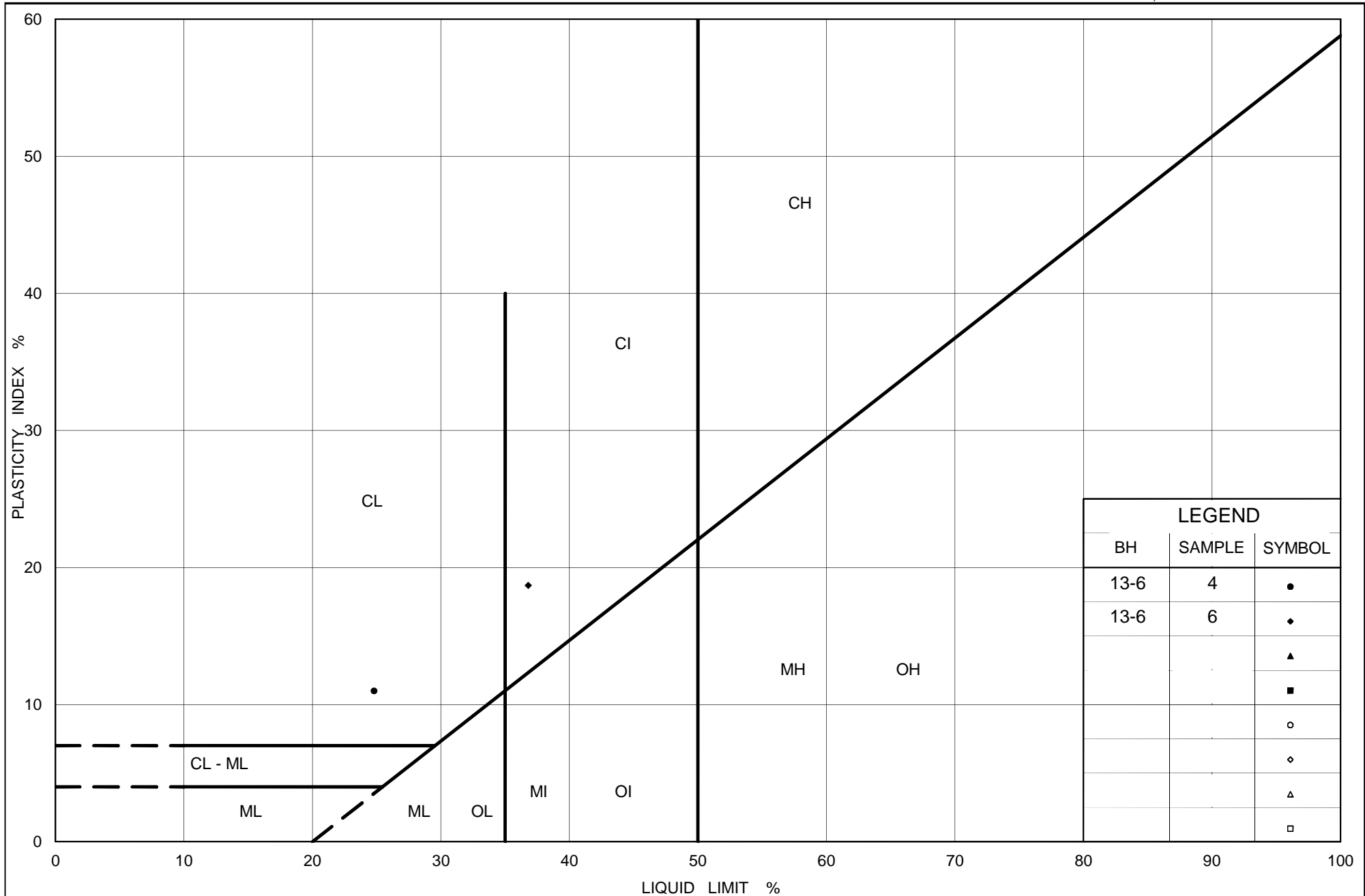
Ontario

# PLASTICITY CHART Clayey Silt (Till) Noise Barrier Wall 1

Figure No. B4

Project No. 09-1111-6007

Checked By: KJB



Ministry of Transportation

Ontario

**PLASTICITY CHART**  
 Clayey Silt to Silty Clay (Fill)  
 Noise Barrier Wall 2

Figure No. B5

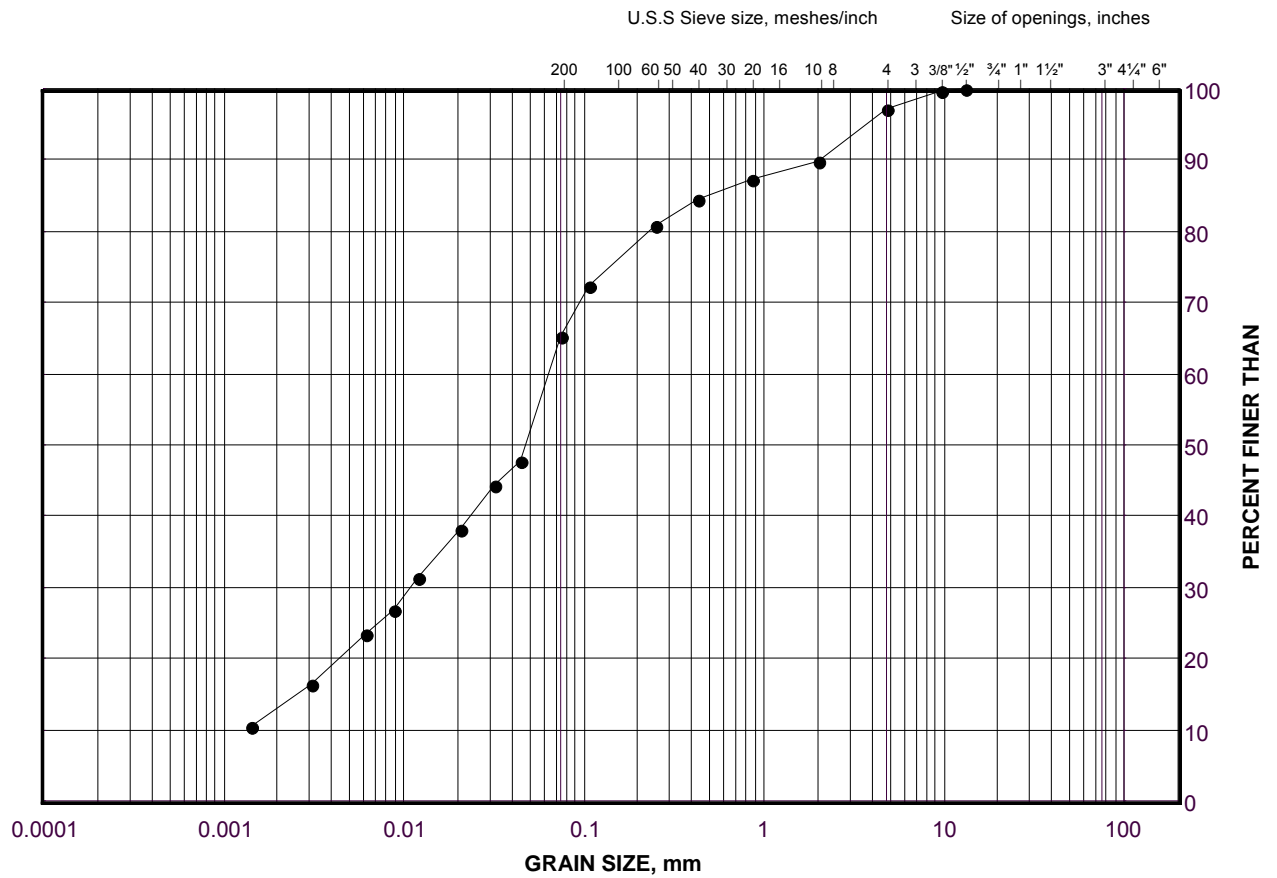
Project No. 09-1111-6007

Checked By: KJB

# GRAIN SIZE DISTRIBUTION

Clayey Silt (Till)  
Noise Barrier Wall 2

FIGURE B6



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

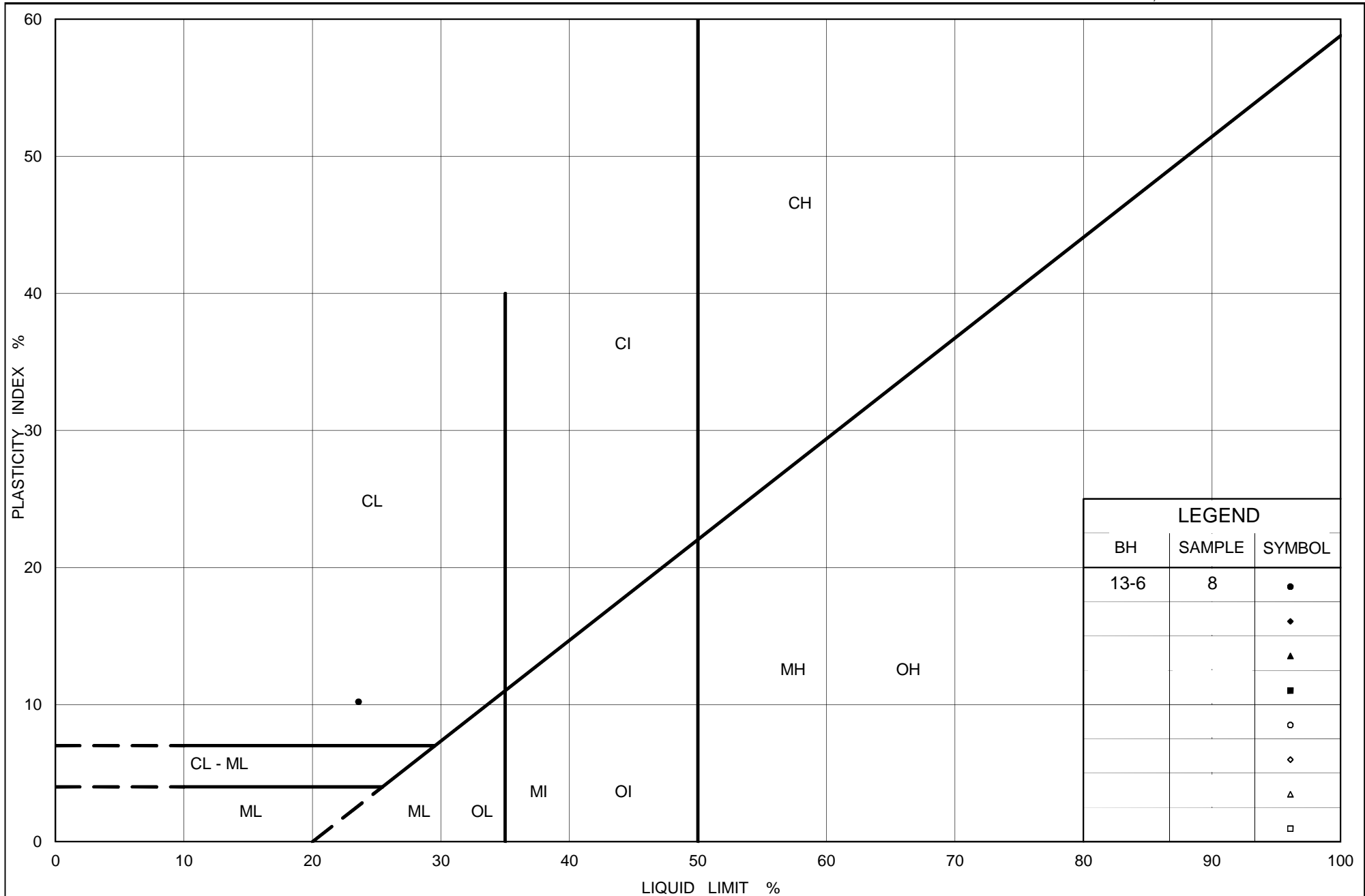
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	13-6	8	178.1

Project Number: 09-1111-6007

Checked By: KJB

**Golder Associates**

Date: 24-May-13



Ministry of Transportation

Ontario

# PLASTICITY CHART Clayey Silt (Till) Noise Barrier Wall 2

Figure No. B7

Project No. 09-1111-6007

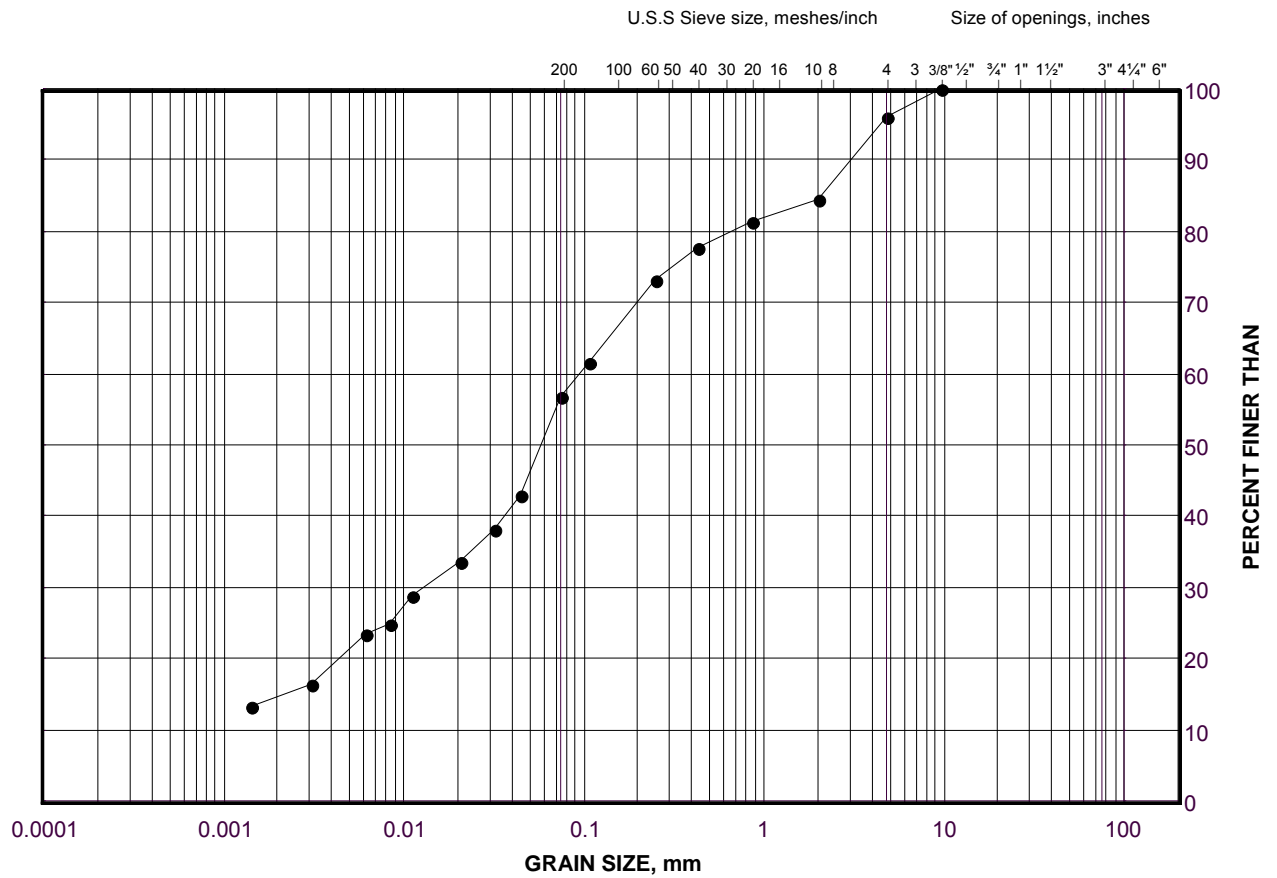
Checked By: KJB



# GRAIN SIZE DISTRIBUTION

Clayey Silt (Fill)  
Noise Barrier Wall 3

FIGURE B8



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

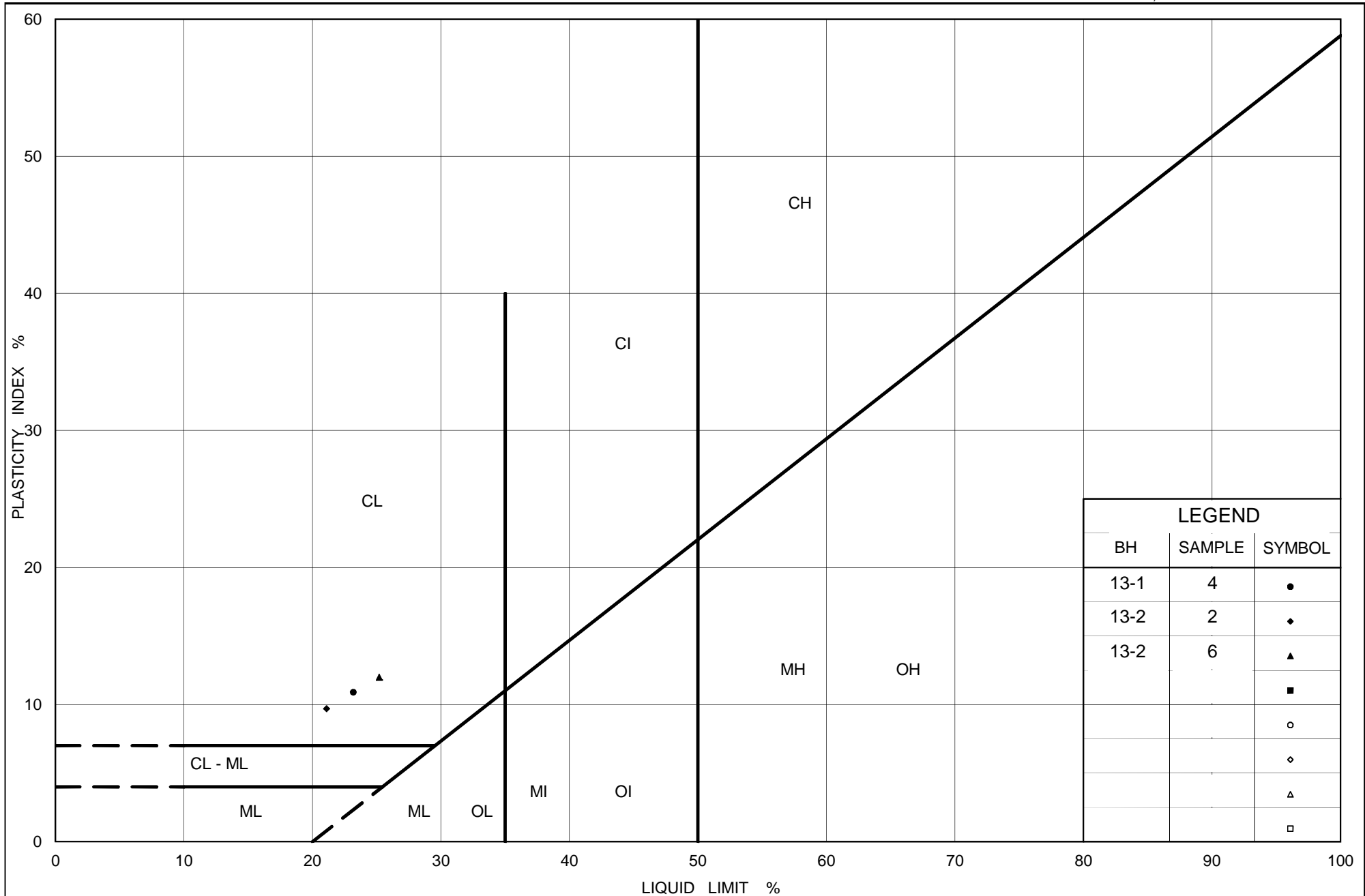
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	13-2	6	183.4

Project Number: 09-1111-6007

Checked By: KJB

**Golder Associates**

Date: 24-May-13



Ministry of Transportation

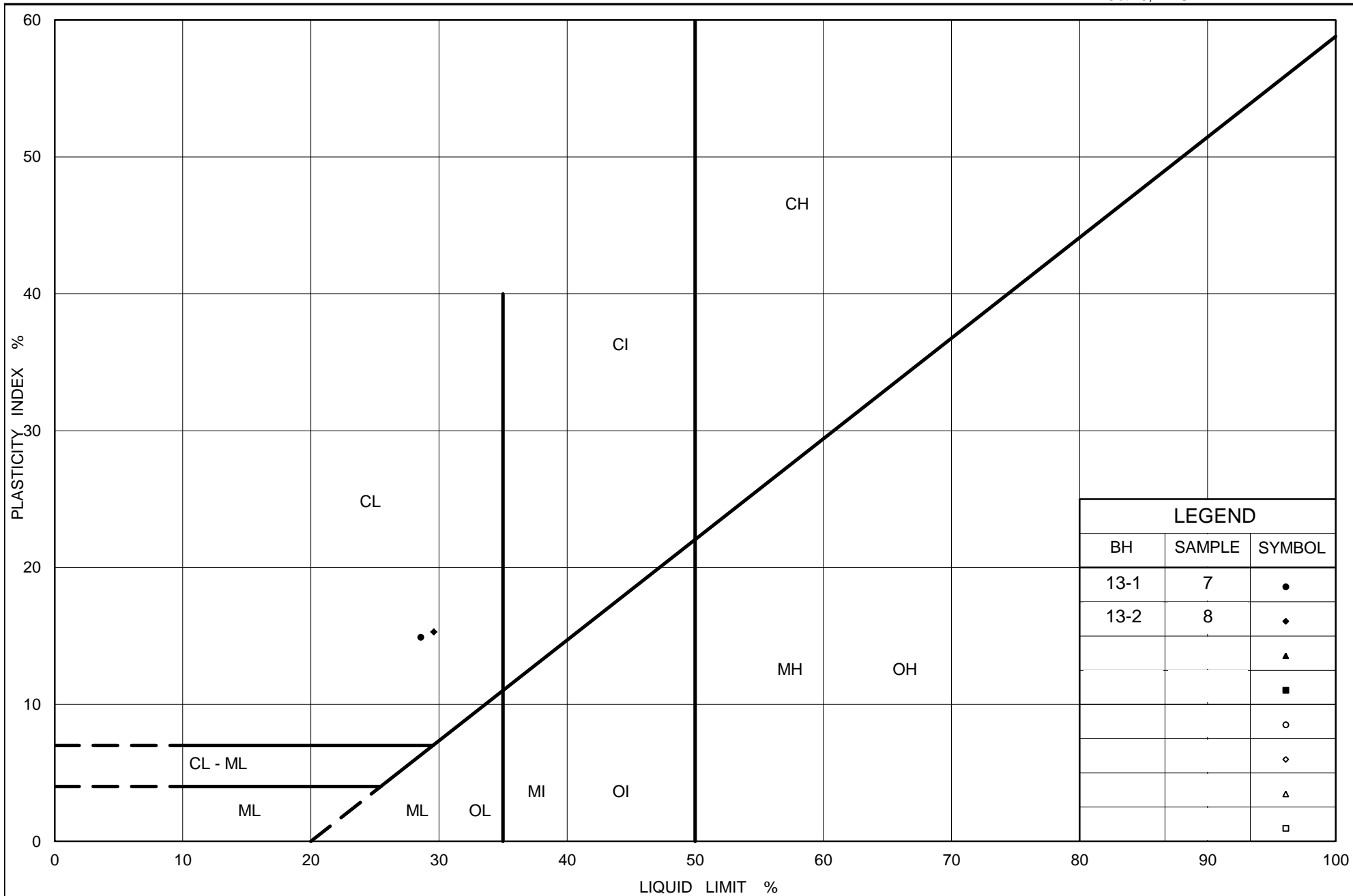
Ontario

# PLASTICITY CHART Clayey Silt (Fill) Noise Barrier Wall 3

Figure No. B9

Project No. 09-1111-6007

Checked By: KJB



Ministry of Transportation

Ontario

PLASTICITY CHART  
Clayey Silt  
Noise Barrier Wall 3

Figure No. B10

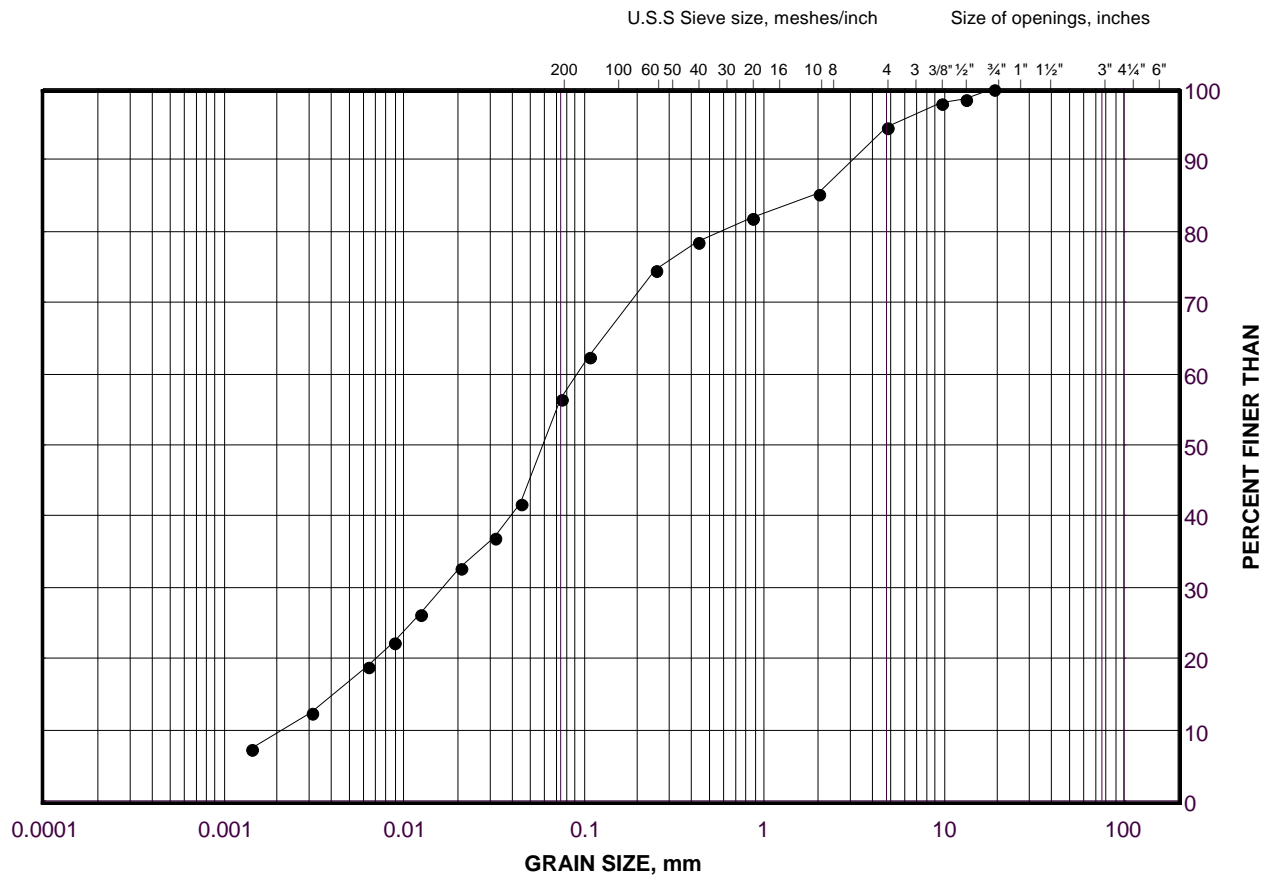
Project No. 09-1111-6007

Checked By: KJB

# GRAIN SIZE DISTRIBUTION

Clayey Silt (Till)  
Noise Barrier Wall 3

FIGURE B11



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

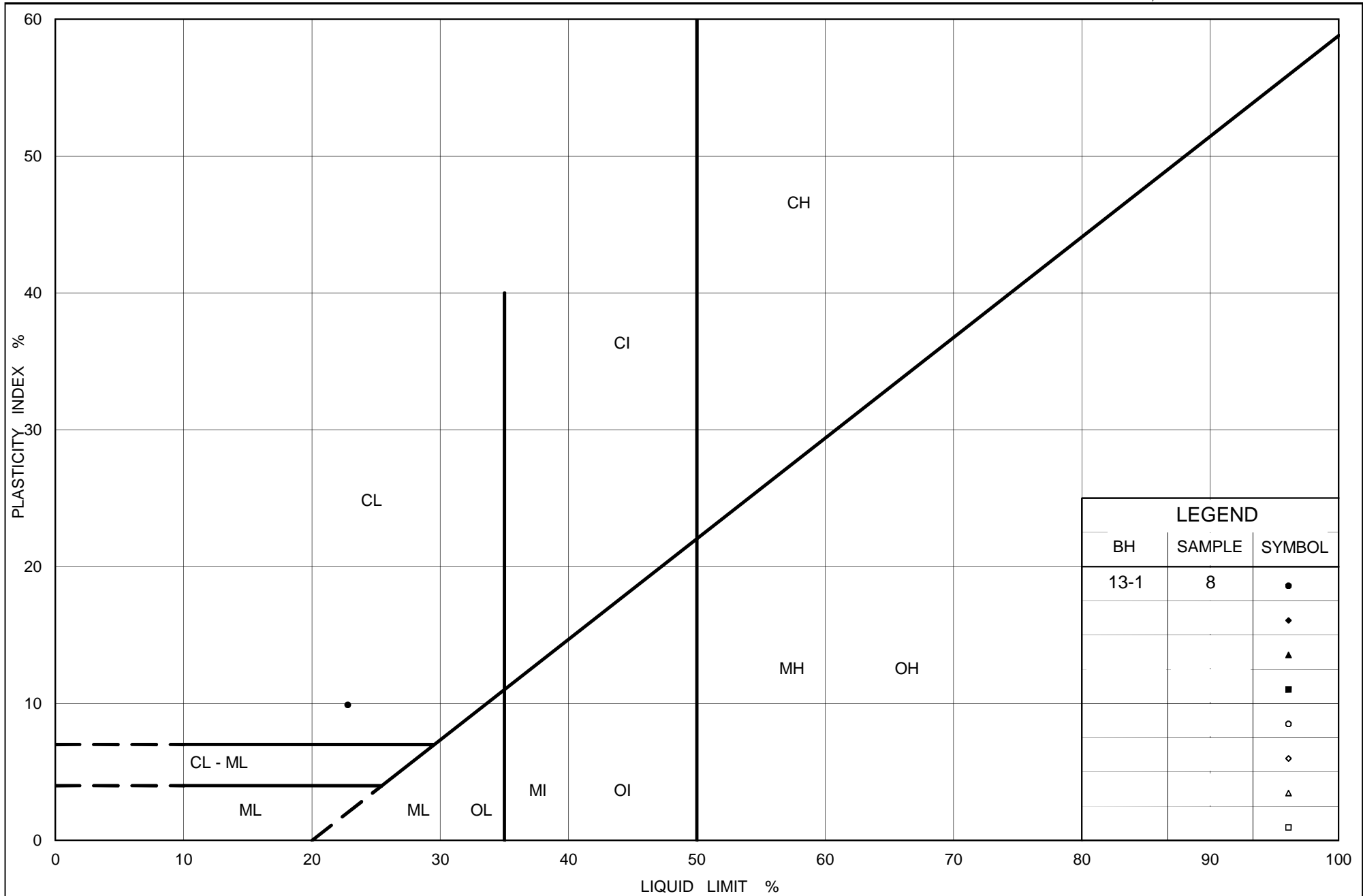
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	13-1	8	183.5

Project Number: 09-1111-6007

Checked By: \_\_\_\_\_

**Golder Associates**

Date: 24-May-13



Ministry of Transportation

Ontario

# PLASTICITY CHART Clayey Silt (Till) Noise Barrier Wall 3

Figure No. B12

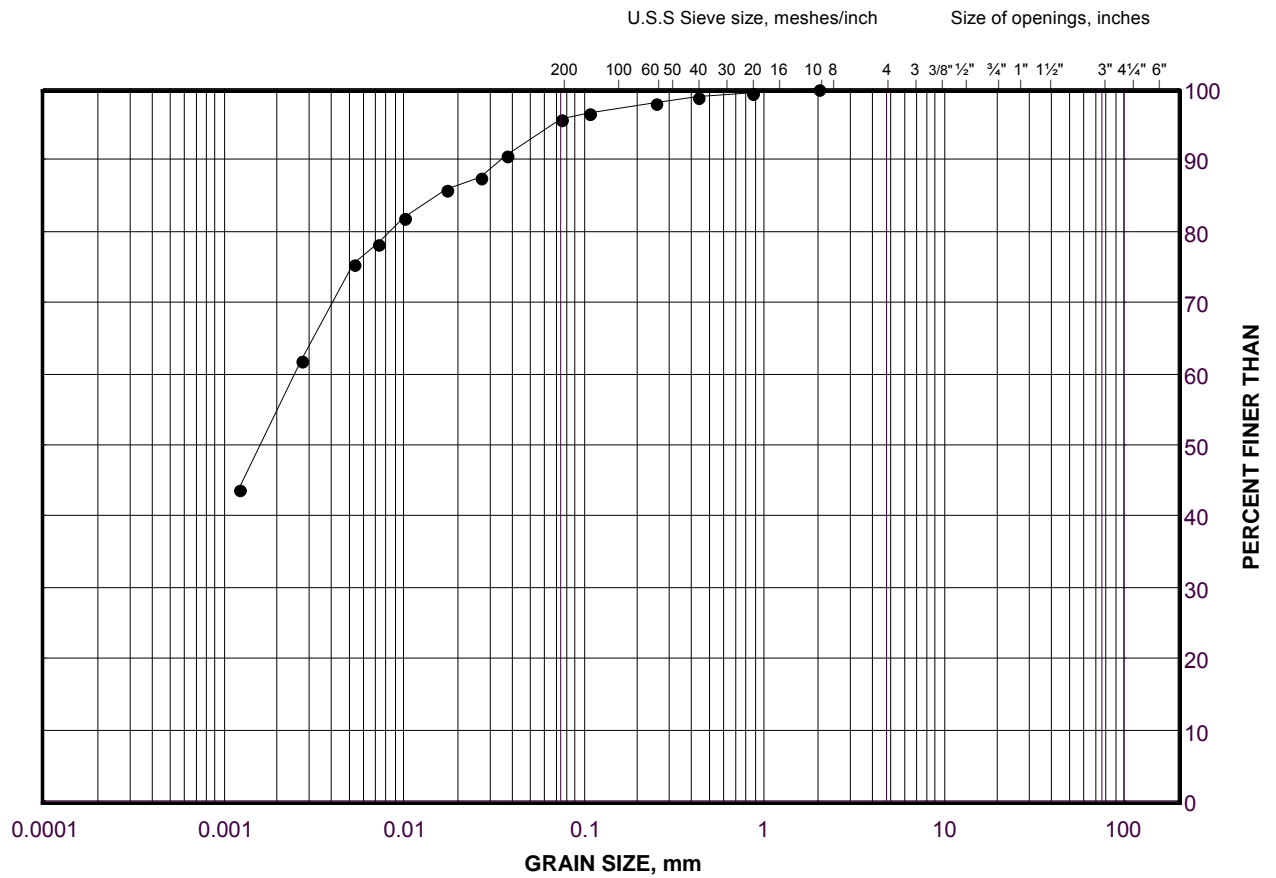
Project No. 09-1111-6007

Checked By: KJB

# GRAIN SIZE DISTRIBUTION

Silty Clay (Till)  
Noise Barrier Wall 4

FIGURE B13



SILT AND CLAY SIZES		FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE
FINE GRAINED		SAND SIZE			GRAVEL SIZE		SIZE

## LEGEND

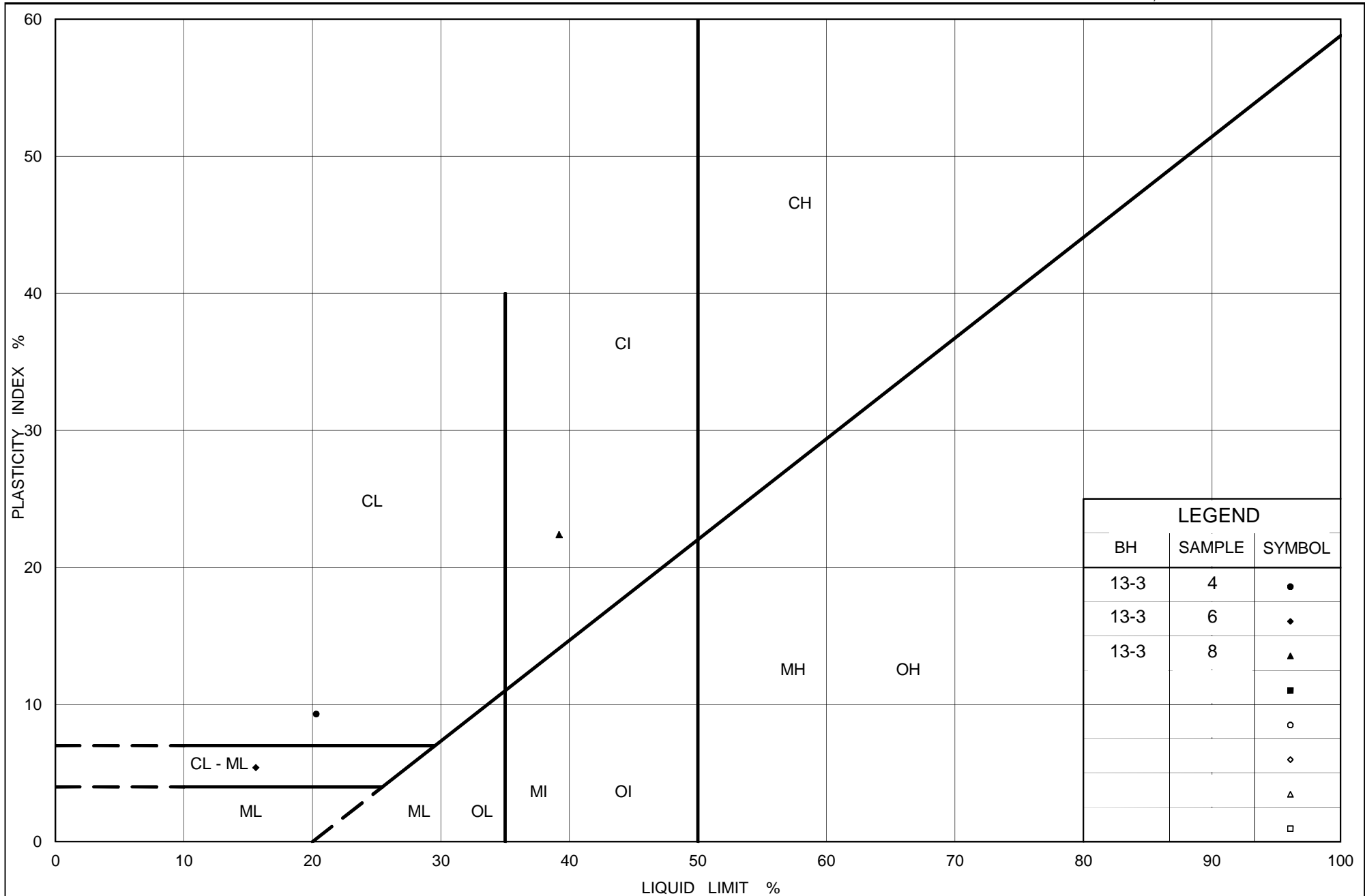
SYMBOL	BOREHOLE	SAMPLE	ELEVATION(m)
•	13-3	8	174.1

Project Number: 09-1111-6007

Checked By: KJB

**Golder Associates**

Date: 24-May-13



Ministry of Transportation

Ontario

# PLASTICITY CHART Clayey Silt to Silty Clay Noise Barrier Wall 4

Figure No. B14

Project No. 09-1111-6007

Checked By: KJB



# APPENDIX C

## Records of Borehole Sheets from Previous Investigation



# GEOTECHNICAL DATA SHEET FOR BOREHOLE 1. BH76-1

OUR REFERENCE NO 2-II-2

CITY OF ONTARIO DEPARTMENT OF HIGHWAYS

METHOD OF BORING AUGERING

ENCLOSURE NO 3

PROJECT AVENUE ROAD - HWY 401 RETAINING WALL

DIAMETER OF BOREHOLE 6"

LOCATION SEE ENCL. 2.

DATE NOVEMBER 19, 1962.

DATUM ELEVATION 592.2

ELEVATION (m)

180.5

179.8

178.3

176.8

175.3

173.7

172.2

ELEVATION ft	DEPTH ft	STRATIFICATION SYMBOL	STRATIFICATION DESCRIPTION	SAMPLES			PENETRATION RESISTANCE			CONSISTENCY	REMARKS
				NO.	TYPE	BLOWS	0	120	140		
592.2	0		TOPSOIL								
590	2			1	SS	40					
585	5		DAMP HARD SANDY CLAYEY SILT TILL								HAMMER BOUNCING
580	10		brown grey	2	SS	75					
575	15		GREY DAMP VERY DENSE SILT slightly cemented	3	SS	450					
570	20		GREY HARD CLAYEY SILT TILL	4	SS	150					
	25			5	SS	110					
565	30										

DETAILS OF  
EXTRAPOLATED  
PENETRATION  
RESISTANCES:

SA": BLOWS:

1	15/6"	25/6"
2	20/6"	30/6"
	15/2"	
3	75/2"	
4	38/6"	65/8"
5	36/6"	50/6"
	20/2"	

VERTICAL SCALE: 1 IN TO 5 FT

DOMINION SOIL INVESTIGATION LIMITED

MADE: MB

CH'D: R. R.

# GEOTECHNICAL DATA SHEET FOR BOREHOLE **2 BH76-2**

DATE REFERENCE NO. 2-11-2

CLIENT: ONTARIO DEPARTMENT OF HIGHWAYS  
 PROJECT: AVENUE RD - HWY 401 RETAINING WALL  
 LOCATION: SEE ENCL. 2.  
 DATUM ELEVATION: 591.2

METHOD OF BORING: AUGERING  
 DIAMETER OF BOREHOLE: 6"  
 DATE: NOVEMBER 19, 1962.

ENCLOSURE NO. 4

ELEVATION ft.	DEPTH ft.	STRATIFICATION DESCRIPTION	STRATIFICATION SYMBOL	SAMPLES			PENETRATION RESISTANCE Blows per ft.			CONSISTENCY water content %			REMARKS
				NO.	TYPE	TEST	0	20	40	60	80	100	
180.2	591.2	TOPSOIL	(Symbol)										
179.8	590	BROWN DAMP HARD SANDY CLAYEY SILT TILL	(Symbol)	1	SS	61							
178.3	585	BROWN DAMP VERY DENSE SANDY SILT slightly cemented	(Symbol)	2	SS	146							
176.8	580	GREY DAMP VERY DENSE SANDY SILT	(Symbol)	3	SS	150							
175.3	575	GREY HARD CLAYEY SILT	(Symbol)	4	SS	130							
173.7	570												
172.2	565												

DETAILS OF  
 EXTRAPOLATED  
 PENETRATION  
 RESISTANCES:

SA<sup>2</sup>: BLOWS:  
 2 27/6"  
 73/6"  
 3 75/6"  
 4 35/6"  
 65/6"

VERTICAL SCALE: 1 IN. TO 5 FT.

DOMINION SOIL INVESTIGATION LIMITED

MADE: MB

CHD: *Recher*

RECORD OF BOREHOLE NO. 2 **BH84-2**

FOUNDATION SECTION

JOB 64-P-87 LOCATION Stn. 22R/40 and 219' to left of E Hwy. 401 ORIGINATED BY B.M.G.  
W P 231-60 BORING DATE Aug. 14, 1963. COMPILED BY B.M.G.  
DATUM G.S.C. BOREHOLE TYPE Pennsylvania Auger - 3 1/2" Ø CHECKED BY A.G.S.

SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION (meters)	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	PLASTIC LIMIT — WP	WATER CONTENT — W		
583.3	177.8 Groundlevel								
	Topsoil & road fill.								
3.0		1	SS	35					
	Clayey silt - some sand and gravel (Glacial till)	2	SS	45					
	V. stiff to hard.	3	SS	32					
	Brown changing to grey at Elev. 570	4	SS	29					
	(173.7m)	5	SS	41					
		6	SS	38					
		7	SS	32					
		8	SS	52					
		9	SS	37					
531.8	162.1	10	SS	34					
51.6	End of borehole.								

WL  
Elev. 552.3  
(168.3m)

# DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS AND RESEARCH SECTION

W.R. 85-59-3 BORE HOLE NO. 1 **BH134-1**

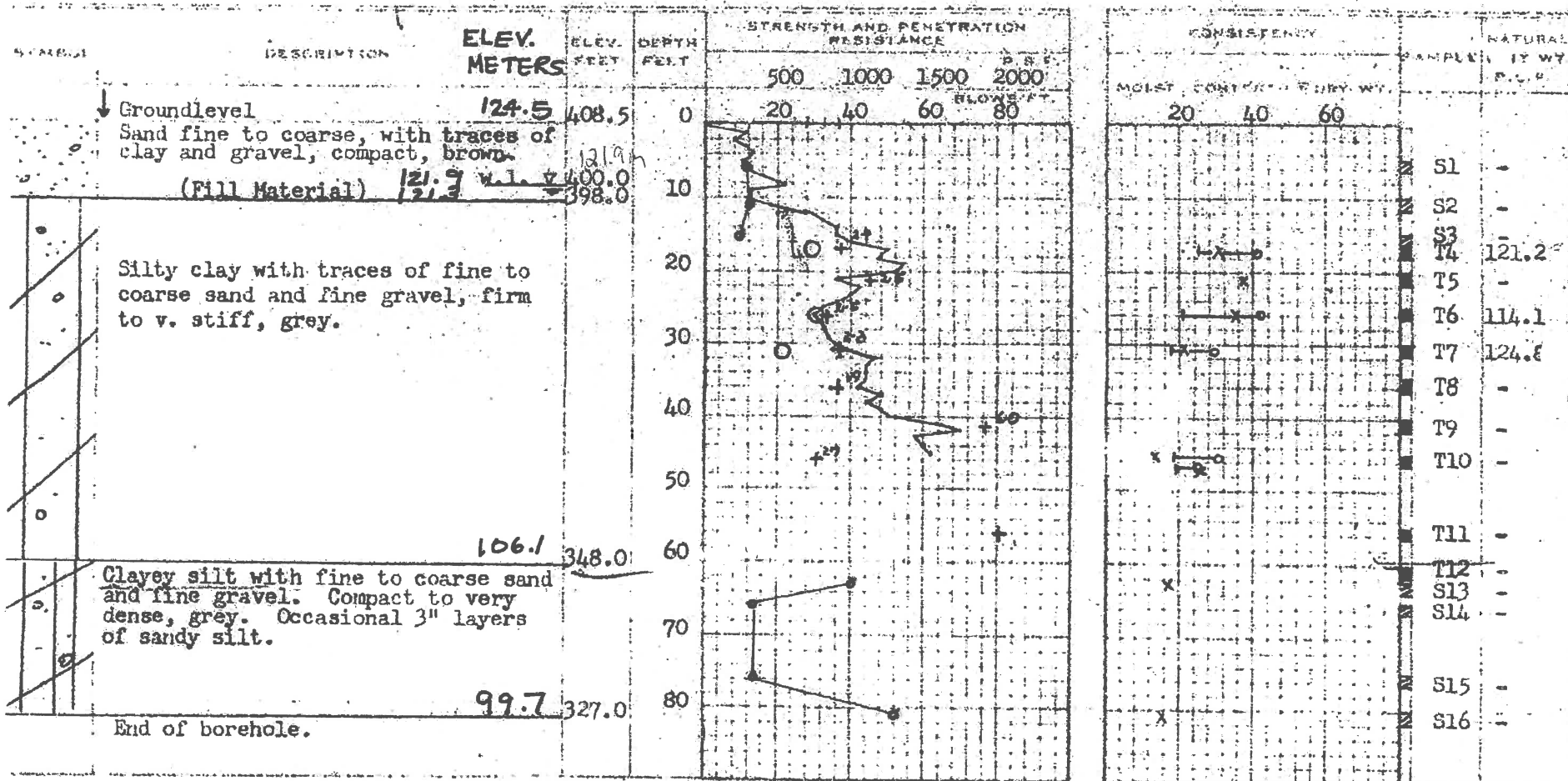
JOB 61-F-113 STATION 84+80 (121' Lt.)

DATUM 408.5 COMPILED BY I.H.

BORING DATE Nov. 14/61. CHECKED BY K.S.

2" DIA. SPLIT TUBE  
2" SHELBY TUBE  
2" SPLIT TUBE  
2" DIA. CONE  
2" SHELBY  
CASING

## LEGEND

1/2 UNCONFINED COMPRESSION (QU) O  
VANE TEST (C) AND SENSITIVITY (S) +  
NATURAL MOISTURE AND LIQUIDITY INDEX LI  
LIQUID LIMIT X  
PLASTIC LIMIT




DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH DIVISION

## RECORD OF BOREHOLE NO. 1 BH136-1

FOUNDATION SECTION

JOA 62-F-86

LOCATION Hwy. #401, Sta. 95445, 173' Rt. of C

RECEIVED BY I.H.

W.P. 104-62

FORING DATE July 10, 1962.

COMPILED BY                      H.S.

DATUM 441.0

SOREHOLE TYPE 4 1/2" Auger Borehole.

RECEIVED BY I.H.

SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — %L PLASTIC LIMIT — %P WATER CONTENT — %W		BULK DENSITY P C F	REMARKS
ELEV DEPTH (m)	DESCRIPTION	STRAT. PLCT	NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	500 1000 1500 2000 2500	WATER CONTENT % 10 20 30		
134.4 41.0 0.0	Groundlevel					440				
	Clayey silt with some fine to coarse sand and traces of fine gravel. <i>VERY STIFF.</i> Compact to dense. (Glacial Till)		1	SS	19					
			2	SS	26					133
			3	SS	38	430				
			4	SS	24					146
			5	SS	22					
			6	SS	22	420				
			7	SS	22	410				140
124.4 406.0 33.0	Clayey silt to silty clay stiff.		8	SS	19	410				
			9	SS	11	400				
121.3 398.0 43.0 (13.1m)	End of borehole.					390				
Notes: $+2.8$ Sensitivity										

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH DIVISIONRECORD OF BOREHOLE NO. 2 **BH136-2**

FOUNDATION SECTION

JOB 62-F-86LOCATION Hwy. #401, Sta. 96+48, 197' Rt. of CORIGINATED BY I.H.W.P. 104-62BORING DATE July 11, 1962.COMPILED BY I.H.DATUM 444.0BOREHOLE TYPE 4" Auger borehole.CHECKED BY I.H.

SOIL PROFILE			SAMPLES		DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT _____ w <sub>L</sub>		BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	PLASTIC LIMIT _____ w <sub>P</sub>			
							WATER CONTENT _____ w <td></td> <td></td> <td></td>			
							_____ w <sub>P</sub>			
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DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 3 **BH136-3**

FOUNDATION SECTION

JOB 62-F-86 LOCATION Hwy. #401, Sta. 96+48, 150' Rt. of E ORIGINATED BY I.H.  
W P 104-62 BORING DATE July 11, 1962. COMPILED BY H.S.  
DATUM 443.0 BOREHOLE TYPE 4 1/2" Auger Borehole. CHECKED BY I.H.

SOIL PROFILE		SAMPLES		DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL		BULK DENSITY P.C.F.	REMARKS			
ELEV. DEPTH	DESCRIPTION	STRAT. PLT	NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	BLOWS / FOOT					
							SHEAR STRENGTH P.S.F.			PLASTIC LIMIT — WP		
										WATER CONTENT — W		
						WATER CONTENT %						
443.0	135.0 Groundlevel											
0.0	Clayey silt with some fine to coarse sand and traces of fine gravel.					440						
						430						
423.0	128.9											
20.0	End of borehole.					420						



DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 4 BH136-4

FOUNDATION SECTION

LOCATION Hwy. #401, Sta. 97+50, 174' Rt. of C

ORIGINATED BY I.H.

W.P. 104-62

SORING DATE July 10, 1962.

COMPILED BY \_\_\_\_\_ H.S.

DATUM 443.0

BOREHOLE TYPE. 4 1/2" AUGER

CHECKED BY \_\_\_\_\_ I.H.

SOIL PROFILE		SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE	Liquid Limit	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER		TYPE	BLOWS / FOOT	
					SHEAR STRENGTH P.S.F.	WATER CONTENT %	
					Field Vane	W L	
					Unconfined compr. strength	10 20 30	
					500 1000 1500 2000 2500		
135.0 0.0	Groundlevel						
	Clayey silt to silty clay with some fine to coarse sand and traces of fine gravel.	1	SS	62	440		
		2	SS	35			
		3	SS	37			
	Very dense to compact.	4	SS	21	430		
		5	SS	24			
		6	SS	19	420		
		7	SS	15			
125.6 412.0 31.0	Clayey silt to silty clay.	8	SS	8	410		
	Firm.	9	TW	PH	400		
120.4 395.0							
117.4 48.0 391.5	Clayey silt with some sand, Dense.	10	TW	37	390		
51.5 (5.7m)	End of borehole.						
Note:					Strain Sensitivity		





DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH DIVISION

## RECORD OF BOREHOLE NO. 6

FOUNDATION SECTION

JOB 62-F-86

LOCATION Sta. 285+83 192' Lt. New G Hwy. #401

ORIGINATED BY H.S.

W.P. 104-62

BORING DATE Sept. 21, 1962.

COMPILED BY H.S.

DATUM 442.7

BOREHOLE TYPE Washboring.

CHECKED BY B.K.

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL			BULK DENSITY	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLAT	NUMBER	TYPE		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	PLASTIC LIMIT — WP	WATER CONTENT — W	WATER CONTENT %		
442.7	124.9 Groundlevel				450							
0.0	Desiccated zone -											
	Very stiff.											
430.7	131.3 m		1	SS	12							
12.0	Clayey silt with											
	fine gravel.		2	SS	11							
	Soft to firm.				420							
			3	SS	4							
389.7	118.8		4	SS	6							
53.0	Sandy silt with some				390							
	gravel.		5	SS	13							
	Dense to very dense.											
			6	SS	55							
367.7	112.1											
75.0	Clayey silt with sand		7	SS	>100							
	gravel and boulders.				360							
	(Glacial Till)											
	Very dense.		8	RC	-							
341.7	104.2											
101.0	Weathered Bedrock.	NEW										
336.7	102.6	NEW	9	RC	-							
106.0	Sound Bedrock.											
331.5	(Grey Shale) 101.0											
111.2	End of borehole.				330							

WL in casing  
on 26/9/62426.7  
16.0Gr. 7%  
Sa. 30%  
Si. 51%  
Cl. 12%Sa. 37%  
Si. 56%  
Cl. 7%

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 7 BH136-7 FOUNDATION SECTION

JOB 62-F-86 LOCATION Sta. 284+69 218.5' Lt. of E. Hwy. #401 ORIGINATED BY H.S.  
W.P. 104-62 BORING DATE Sept. 27, 1962. COMPILED BY H.S.  
DATUM 442.6 BOREHOLE TYPE Washboring CHECKED BY B.K.

SOIL PROFILE		SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE		LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W		BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	(M) DESCRIPTION	STRAT. PLOT	NUMBER	TYPE		BLOWS / FOOT	SHEAR STRENGTH P.S.F.	WP	WL		
442.6 0.0	134.9 Ground level				450						
420.6 12.0	131.2 Desiccated zone - Hard to very stiff.										WL in bore- hole on 9/10/62 - 134.2
	Clayey silt with fine gravel.		1	SS	420						
	Firm to stiff.		2	SS	6						Sa. 1% Sl. 48% Cl. 51%
387.6 55.0	118.1		3	SS	24						
347.6 95.0	Sandy silt to silty sand with some gravel.		4	SS	11						Gr. 2% Sa. 65% Sl. 25% Cl. 8%
361.6 81.0	110.2 Clayey silt with sand, gravel and boulders. (Glacial Till)		6	SS	2100						Gr. 10% Sa. 21% Sl. 59% Cl. 10%
347.6 95.0	105.9 Weathered Bedrock		7	RC							
343.9 98.7	104.8 Sound Bedrock (Grey Shale)		8	RC							
330.9 111.7	100.9 End of borehole.		9	RC							
34.0					330						



DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & RESEARCH DIVISION

## RECORD OF BOREHOLE NO. 8

FOUNDATION SECTION

JOB 62-F-86

LOCATION Sta. 288+57 (139' Lt. of E. Hwy. #401)

BH 136-8

ORIGINATED BY H.S.

W.P. 104-62

BORING DATE Oct. 4, 1962.

COMPILED BY H.S.

DATUM 440.1

BOREHOLE TYPE Washboring

CHECKED BY B.K.

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE			LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W			BULK DENSITY P.C.F.	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT		BLOWS / FOOT			WATER CONTENT % 20 40 60				
134.1														
440.1	Groundlevel					440								
437.1	Sand (Fill Material)													
3.0	133.2													
	Desiccated zone - Hard to very stiff.													
426.1														
14.0	129.9													
			1	SS	29									
	Clayey silt with occasional gravel.  Firm to stiff.		2	SS	8	410								
			3	SS	9	380								
375.1	114.3													
65.0	Sandy silt with some gravel. Very dense.													
360.1	109.7													
80.0	Clayey silt with sand gravel and boulders. (Glacial Till)  Very dense.		4	SS	>100	350								
			5	RC	-									
342.1	104.3													
98.0	Weathered Bedrock.		6	RC	-									
233.6	101.7													
106.5	Sound Bedrock		7	RC	-									
329.9	(Grey Shale)													
110.2	End of borehole.					320								

WL in bore-  
hole on 11/10/62  
= 419.1  
= 21.0Sa. 14  
Sl. 83%  
Cl. 16%Sa. 4%  
Sl. 73%  
Cl. 23%



# APPENDIX D

## Non-Standard Special Provisions



## FOUNDATION REPORT - NOISE BARRIER WALLS

### **CONTROL OF OVERBURDEN SOILS DURING NOISE BARRIER WALL FOUNDATION INSTALLATION - Item No.**

#### Special Provision

Excavations for the noise barrier wall foundations will be advanced through cohesionless fill materials (where present), into clayey silt till containing lenses or layers of potentially saturated cohesionless soils. These cohesionless soils could slough (if dry) or flow (if water-bearing) into unsupported auger holes during caissons installation. Appropriate construction procedures and equipment will be required to minimize ground loss during drilling, caisson installation and concrete placement.

#### **Basis of Payment**

Payment at the lump sum contract price for this tender item shall be full compensation for all labour, equipment and materials for completion of the work.

#### **END OF SECTION**



### **BOULDERS/OBSTRUCTIONS DURING EXCAVATION FOR NOISE BARRIER WALL FOUNDATIONS – Item No. 799F01**

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#### Special Provision

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The soils at the site are glacially-derived and should be expected to contain cobbles and boulders. Appropriate equipment and procedures will be required to penetrate obstructions (cobbles and boulders) that are encountered during excavation for noise barrier wall foundations.

#### **Basis of Payment**

Payment at the contract price for the above tender item shall include full compensation for all labour and materials to complete the work.

**END OF SECTION**



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