

Foundation Investigation and Design Report

Storm Sewer Replacement

Lviv Boulevard, City of Oshawa, Durham Region, Ontario

G.W.P. 2298-13-00 / 2164-19-00, Assignment #: 2016-E-0022

Submitted to:

WSP

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Table of Contents

PART A – FOUNDATION INVESTIGATION REPORT

1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION	1
3.0 INVESTIGATION PROCEDURES	1
3.1 Previous Investigations	1
3.2 Current Investigation	2
4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS	3
4.1 Regional Geology	3
4.2 Subsurface Conditions	3
4.2.1 Topsoil	4
4.2.2 Pavement Structure	4
4.2.3 Sandy Silt to Gravelly Sand Fill	4
4.2.4 Clayey Silt to Silty Clay Fill	4
4.2.5 Silt and Sand to Silty Sand Till – Upper Deposit	5
4.2.6 Gravelly Silty Sand to Sand and Gravel – Upper Deposit	5
4.2.7 Silt and Sand Till – Lower Deposit	6
4.2.8 Clayey Silt to Silty Clay	6
4.2.9 Gravelly Silty Sand to Silty Sand and Gravel – Lower Deposit	6
4.2.10 Groundwater Conditions	6
4.3 Analytical Testing	7
5.0 CLOSURE	7

PART B - FOUNDATION DESIGN REPORT

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS	9
6.1 General	9
6.2 Cut-and-Cover Construction	9
6.2.1 Founding Depth and Subgrade Conditions	9
6.2.2 Pipe Bedding, Cover, and Trench Backfill	10
6.2.2.1 Bedding and Cover	10

6.2.2.2	Trench Backfill.....	10
6.3	Construction Considerations.....	10
6.3.1	Excavations.....	10
6.3.2	Temporary Excavation Support Systems.....	11
6.3.2.1	Trench Boxes.....	12
6.3.2.2	Engineered Support Systems.....	12
6.3.3	Groundwater Control.....	13
6.3.4	Corrosion Assessment and Protection.....	13
7.0	CLOSURE.....	14

REFERENCES

DRAWING

Drawing 1 Borehole Locations and Soil Strata

APPENDICES

APPENDIX A - Borehole Records

Lists of Symbols and Abbreviations

Record of Boreholes AS-8, NRW-1, SS-10, and STM-1 to STM-4

APPENDIX B – Geotechnical Laboratory Test Results

Figure B-1	Grain Size Distribution – GRANULAR BASE AND GRANULAR SUBBASE
Figure B-2	Grain Size Distribution – SILTY CLAY (CI) to Sandy CLAYEY SILT (CL) (FILL)
Figure B-3	Plasticity Chart – SILTY CLAY (CI) to Sandy CLAYEY SILT (CL) (FILL)
Figure B-4	Grain Size Distribution – Sandy CLAYEY SILT (CL) to SILT and sand (ML) to SILTY SAND (SM) (TILL)
Figure B-5	Plasticity Chart – Sandy CLAYEY SILT (CL) (TILL)
Figure B-6	Grain Size Distribution – Gravelly SILTY SAND (SM) to SAND and gravel (SW-SM)
Figure B-7	Grain Size Distribution – SILT and SAND (ML) (TILL)
Figure B-8	Grain Size Distribution – SILTY CLAY (CI)
Figure B-9	Plasticity Chart – CLAYEY SILT (CL) to SILTY CLAY (CI)
Figure B-10	Grain Size Distribution – Gravelly SAND (SW-SM) to SILTY SAND and gravel (SM/GM)

APPENDIX C – Analytical Laboratory Test Results

Certificate of Analysis Report No. R6860459

Certificate of Analysis Report No. R6902994

APPENDIX D – Non-Standard Special Provisions

Vibration Monitoring

Pre-Condition and Post-Condition Surveys

PART A

FOUNDATION INVESTIGATION REPORT STORM SEWER REPLACEMENT

LVIV BOULEVARD, CITY OF OSHAWA, DURHAM REGION, ONTARIO
G.W.P. 2298-13-00 / 2164-19-00, ASSIGNMENT #: 2016-E-0022

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by WSP on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the storm sewer replacement along Lviv Boulevard, replacement of underpasses structures and culverts, and rehabilitation of a creek crossing structure, associated with the improvements and future widening of the Highway 401 in the Oshawa area, in the Region of Durham, Ontario.

This report presents the results of the foundation investigation for the proposed storm sewer replacement along Lviv Boulevard. The purpose of this investigation is to establish the subsurface soil conditions at the location of the proposed storm sewer, through borehole drilling and laboratory testing of selected soil samples. The results of foundation investigations at other structures associated with the widening and structure replacement are presented under separate covers.

This report was developed based on information from the current pavement and foundation investigation, supplemented with relevant information from Golder's previous foundation investigations carried out within the project limits. The results of the previous foundation investigations are presented in the following reports:

- "Foundation Investigation and Design Report, Retaining Walls, Simcoe Street to Albert Street, Highway 401 Replacement of Three Underpasses and Rehabilitation of Oshawa Creek Bridge, Ministry of Transportation, Ontario, G.W.P. 2298-13-00", GEOCRE Report No. 30M14-506, dated October 21, 2019.
- "Foundation Investigation and Design Report, Replacement of Simcoe Street Underpass, Highway 401, Replacement of Three Underpasses and Rehabilitation of Oshawa Creek Bridge, Region on Durham, Ontario, Ministry of Transportation, Ontario, G.W.P. 2298-13-00", GEOCRE Report No. 30M15-324, dated November 14, 2018.
- "Foundation Investigation and Design Report, Replacement of Albert Street Underpass, Highway 401, Rehabilitation and Widening, Oshawa, Ontario, MTO, G.W.P. 2298-13-00", GEOCRE Report No. 30M15-330, dated January 30, 2020.

2.0 SITE DESCRIPTION

The proposed storm sewer is approximately 250 m long and generally runs along the north side of Lviv Boulevard, from about 30 m east of Albert Street to about 80 m west of Simcoe Street. The proposed storm sewer will cross under Albert Street, Simcoe Street, and the N/S-W Ramp to Highway 401. The proposed storm sewer will connect to the existing storm sewer west of the N/S-W Ramp.

The existing ground surface along the proposed storm sewer ranges from about Elevations 96 m to 102.5 m. The ground surface/road grade is relatively flat along Lviv Boulevard, but from the west of Simcoe Street, the ground surface generally slopes down towards the Oshawa Creek, as shown on Drawing 1.

Land use along Lviv Boulevard consists of both commercial and residential developments as well as a church. In addition, Oshawa Creek is located about 50 m west of the west limit of the proposed storm sewer.

3.0 INVESTIGATION PROCEDURES

3.1 Previous Investigations

As part of the previous foundation investigations, Boreholes SS-10, AS-8, and NRW-1 were advanced along the general alignment of the proposed storm sewer replacement on November 1 and 20, 2017, and March 5, 2018,

respectively. The locations of the boreholes are shown on Drawing 1. A copy of the borehole records is provided in Appendix A. The borehole locations (including geographic coordinates), ground surface elevations, and borehole depths are summarized below.

Borehole No.	MTM NAD83 Northing (Latitude, °)	MTM NAD83 Easting (Longitude, °)	Ground Surface Elevation (m)	Borehole Depth (m)
AS-8	4,860,464.3 (43.882338)	356,666.4 (-78.854550)	102.6	10.8
SS-10	4,860,412.3 (43.881880)	356,506.7 (-78.856540)	101.3	11.2
NRW-1	4,860,427.8 (43.882015)	356,592.0 (-79.855479)	102.2	10.8

3.2 Current Investigation

The current investigation was carried out on October 1 and November 7, 2021, during which time, four boreholes (designated as Boreholes STM-1 to STM-4) were advanced in the vicinity of the proposed storm sewer, at the locations shown on Drawing 1.

Boreholes STM-1 and STM-2 were advanced using a track-mounted MST Marl drill rig, supplied and operated by Drilltech Drilling of Newmarket, Ontario. Boreholes STM-3 and STM-4 were advanced using a track-mounted AMS 9570-VTR PowerProbe drill rig, supplied and operated by Golder. The boreholes were advanced through the overburden using 150 mm solid stem augers and 200 mm hollow-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. The split-spoon samplers used in the investigation limit the maximum particle size that can be sampled and tested to about 35 mm. Therefore, particles or objects that may exist within the soils that are larger than this dimension would not be sampled or represented in the grain size distributions.

The groundwater conditions were noted in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in Boreholes STM-1 and STM-4 to allow for monitoring of the groundwater level. The remaining boreholes were backfilled with bentonite and the ground surface was restored to near original condition as practical.

The field work was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, and logged the boreholes. The samples were identified in the field, placed in appropriate containers, labelled, and transported to Golder's Whitby laboratory where the samples underwent further visual examination. Geotechnical laboratory testing (water content, grain size distribution, and Atterberg limits) was carried out on select soil samples, in general accordance with MTO and / or ASTM Standards, as appropriate. In addition, select soil samples were submitted to Bureau Veritas Laboratories of Mississauga, Ontario for analysis of select parameters to assess for the potential corrosion and to buried steel and deterioration of concrete.

The borehole locations are provided on Drawing 1 and on the borehole records in Appendix A. Boreholes from the current investigation were surveyed by Golder using a Trimble Geo 7x GPS unit. The locations are positioned relative to MTM NAD 83 northing and easting (Zone 10 CSRS CBNv6-2010.0) coordinates and the ground surface elevations are referenced to CGVD28 Geodetic datum benchmark. The borehole locations (including geographic coordinates), ground surface elevations, and borehole depths are summarized below.

Borehole No.	MTM NAD83 Northing (Latitude, °)	MTM NAD83 Easting (Longitude, °)	Ground Surface Elevation (m)	Borehole Depth (m)
STM-1	4,860,386.4 (43.881655)	356,406.8 (-78.857788)	92.1	5.2
STM-2	4,860,398.9 (43.881763)	356,461.2 (-78.857110)	96.0	5.2
STM-3	4,860,414.5 (43.881898)	356,547.0 (-78.856041)	102.0	5.0
STM-4	4,860,467.0 (43.882360)	356,700.8 (-78.854121)	101.9	5.0

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The project area is located within the Iroquois Plain physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putman, 1984)¹ and *Urban Geology of Canadian Cities* (Brennand, 1998)². The Iroquois Plain extends around the western shores of Lake Ontario and is comprised of the flat to undulating lakebed and beaches of the former glacial Lake Iroquois, which occupied this area during the last glacial recession.

The surficial soils in this area of the Iroquois Plain are typically comprised of glaciolacustrine clays, silts, and sands to gravelly sands, which are underlain by an extensive till deposit that is mapped in this area as the Bowmanville Till. More recent alluvial deposits of gravel, sand, silt, and/or clay are present in the creek valleys.

Bedrock at the site location is described as Shale of the Whitby Formation.

4.2 Subsurface Conditions

The subsurface soil and groundwater conditions as encountered in the boreholes are presented on the borehole records in Appendix A. *Method of Soil Classification, Abbreviations and Terms Used on Records of Boreholes and Test Pits* and *List of Symbols* sheets are provided in Appendix A to assist in the interpretation of the borehole records. The geotechnical and analytical laboratory test results are presented in Appendix B and Appendix C, respectively.

The results of the in-situ field tests (i.e., SPT “N”-values) as presented on the borehole records and in Section 4.2 are uncorrected. The boundaries between deposits on the borehole records have been inferred from drilling observations and non-continuous sampling and, therefore, these boundaries represent transitions between soil types rather than exact planes of geological change. The interpreted stratigraphic profiles along the proposed sewer alignments, as shown on Drawing 1, are a simplification of the subsurface conditions. Variation in the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In general, the subsurface conditions generally consist of very loose to dense gravel and sand to firm to very stiff silty clay fill, underlain by a compact to dense silt and sand to silty sand till or a very dense sand to gravel to gravelly silty sand deposit. The sand to gravel to gravelly silty sand deposit is in turn underlain by a dense to very dense

¹ 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.)

² Brennand, T.A., 1998. *Urban Geology Note: Oshawa Ontario*. In P.F. Karrow, and O.L. White (Eds.), *Geological Association of Canada, Special Papers 42: Urban Geology of Canadian Cities*, p. 353-364.

silty sand to silt and sand till. Deposits of stiff clayey silt to silty clay and very loose to dense gravelly silty sand to silty sand and gravel were encountered west of Simcoe Street, towards Oshawa Creek.

Detailed descriptions of the subsurface conditions encountered in the boreholes are provided in the following sections.

4.2.1 Topsoil

An approximately 150 mm and 100 mm thick layer of topsoil was encountered at ground surface in Boreholes STM-1 and STM-2, respectively.

4.2.2 Pavement Structure

An approximately 35 mm to 150 mm thick layer of asphalt pavement was encountered at ground surface in all boreholes, excluding Boreholes STM-1 and STM-2.

A granular base layer and a granular subbase layer were encountered underlying the asphalt, extending to up to depths of 0.8 m below the ground surface. In Boreholes STM-3 and STM-4, the granular base consists of gravel and sand, trace fines and the granular subbase consists of sand and gravel, trace fines. In Borehole NRW-1, AS-8, and SS-10, the granular base and subbase are collectively identified as sand fill, some gravel to gravelly, some silt.

SPT “N”-values measured within the granular base / granular subbase range from 3 blows to 36 blows per 0.3 m of penetration, indicating a very loose to dense state of compactness.

The water content measured on two samples of the granular base/subbase layers are about 2%.

Grain size distribution testing was carried out on two samples of the granular base / subbase and the results are presented on Figure B-1 in Appendix B.

4.2.3 Sandy Silt to Gravelly Sand Fill

A 1.3 m and 1.5 m thick layer of non-cohesive fill was encountered underlying the topsoil in Borehole STM-1 and underlying the pavement structure in Borehole STM-3. The non-cohesive fill was encountered at depths ranging from 0.2 m and 0.6 m below ground surface (Elevations 101.4 m to 91.9 m) and extends to depths of 1.5 m to 2.1 m below ground surface (Elevations 99.9 m to 90.7 m). The non-cohesive fill ranges from sandy silt to silty sand to gravelly sand. The non-cohesive fill encountered in Borehole STM-1 also contains organics and rootlets.

The SPT “N”-values measured within the non-cohesive fill range from 3 blows to 11 blows per 0.3 m of penetration, indicating a very loose to compact state of compactness.

4.2.4 Clayey Silt to Silty Clay Fill

A 0.9 m to 3.0 m thick layer of cohesive fill was encountered underlying the topsoil in Borehole STM-2 and underlying the pavement structure in Boreholes AS-8, NRW-1, SS-10, and STM-4. The cohesive fill was encountered at depths ranging from 0.1 m to 0.7 m (Elevations 102.0 m to 95.9 m) and extends to depths ranging from 1.5 m to 3.7 m below ground surface (Elevation 100.5 m to 93.8 m). The cohesive fill generally consists of sandy clayey silt, trace to some gravel to silty clay, some sand. At Borehole NRW-2, the cohesive consists of sandy clayey silt to sand with clayey silt with sand. The cohesive fill encountered in Borehole STM-2 contains organics and rootlets. Trace organics and trace asphalt fragments were noted within the cohesive fill in Borehole NRW-1.

The SPT “N”-values measured within the cohesive fill range from 4 blows to 19 blows per 0.3 m of penetration, suggesting a firm to very stiff consistency.

The water content measured on three samples of the deposit ranges from about 10% to 25%.

Grain size distribution testing was carried out on three samples of the cohesive fill and the results are presented on Figure B-2 in Appendix B. Atterberg limit testing was carried out on four samples of the cohesive fill and the results are presented on Figure B-3 in Appendix B. The Atterberg limits test measured a liquid limit ranging from 19% to 42%, a plastic limit ranging from 12% to 18%, and a plasticity index ranging from 7% to 24%, indicating the cohesive fill is of low to intermediate plasticity.

4.2.5 Silt and Sand to Silty Sand Till – Upper Deposit

An upper 1.9 m to 3.5 m thick glacial till deposit was encountered in Boreholes AS-8, SS-10, and STM-4 at depths from 1.5 m to 2.1 m below ground surface (Elevations 100.5 m to 99.2 m), which extends to depths from 4.0 m to 5.6 m below ground surface (Elevations 98.6 m to 95.7m). In general, the till deposit consists of silt and sand to silty sand till, trace to some gravel but in Borehole STM-4, the upper 0.6 m of the till is classified as a sandy clayey silt.

The SPT “N”-values measured within the non-cohesive portion of the upper till deposit range from 21 blows to 83 blows per 0.3 m of penetration, indicating a compact to very dense state of compactness, while a SPT “N”-value of 21 was measured within the cohesive portion of the upper till deposit, suggesting a very stiff consistency.

The water content measured on samples of the non-cohesive portions of the upper till deposit range from 7% to 9% and a water content of 11% was measured on a sample of the cohesive portion of the till deposit.

Grain size distribution testing was carried out on four samples of the upper till deposit and the results are presented on Figure B-4 in Appendix B. Atterberg limit testing was carried out on two samples of the till deposit. One Atterberg limit test determined that the upper till was non-plastic while the one Atterberg test measured a liquid limit of 22%, a plastic limit of 12%, corresponding to a plasticity index 10%. The Atterberg test results are presented on Figure B-5 in Appendix B and indicate the cohesive portion of the till deposit is a clayey silt of low plasticity.

4.2.6 Gravelly Silty Sand to Sand and Gravel – Upper Deposit

A 2.9 m to 5.5 m thick deposit of gravelly silty sand to sand and gravel was encountered underlying non-cohesive fill in Borehole STM-3, underlying the cohesive fill in Borehole NRW-1, underlying the non-cohesive till deposit in Borehole AS-8, and underlying the non-cohesive till in Borehole SS-10 at depths ranging from 2.1 m to 5.6 m below ground surface (Elevations 99.9 m to 95.7 m). The sand to sand and gravel deposit extends to depths ranging from 5.0 m to 11.1 m below ground surface (Elevations 97.0 m to 90.2 m). The deposit ranges from sand, some gravel, some fines to gravelly silty sand to silty sand and gravel, to sand and gravel, trace to some fines. Rock fragments and auger grinding was encountered within the deposit in Boreholes STM-3 and SS-10. In Borehole AS-8, a 50 mm thick silty clay layer was noted at a depth of 8.0 m below ground surface (Elevation 94.6 m).

The SPT “N”-values measured within the upper sand to sand and gravel deposit range from 38 blows per 0.3 m of penetration to 100 blows per 0.13 m of penetration, indicating a dense to very dense state of compactness.

The water content measured on samples of the deposit range from 2% to 22%.

Grain size distribution testing was carried out on three samples of the upper gravelly silty sand to sand and gravel deposit and the results are presented on Figure B-6 in Appendix B.

4.2.7 Silt and Sand Till – Lower Deposit

A 2.7 m to 4.0 m thick glacial till deposit consisting of silt and sand trace to some gravel was encountered underlying the sand to sand and gravel deposit in Boreholes AS-8 and NRW-1 at depths from 6.8 m to 8.1 m below ground surface (Elevation 95.4 m to 94.5 m). The lower till deposit extends to the borehole termination depths 10.8 m below ground surface (Elevations 91.8 m and 91.4 m).

The SPT “N”-values measured within the lower till deposit range from 118 blows per 0.3 m penetration to 100 blows per 0.1 m of penetration, indicating a very dense state of compactness.

The water content measured on samples of the non cohesive deposit range from about 7% to 8%.

Grain size distribution testing was carried out on two samples of the lower till deposit and the results are presented on Figure B-7 in Appendix B.

4.2.8 Clayey Silt to Silty Clay

A 3.0 m thick deposit of clayey silt to silty clay, trace sand was encountered underlying the cohesive fill in Borehole STM-2, at a depth of 2.2 m below ground surface (Elevation 93.8 m), which extends to a depth of 5.2 m below ground surface (Elevation 90.8 m) prior to borehole termination.

The SPT “N”-values measured within the clayey silt to silty clay deposit range from 9 blows to 12 blows per 0.3 m of penetration, suggesting a stiff consistency.

The water content measured on two samples of the clayey silt to silty clay deposit are 22% to 31%.

Grain size distribution testing was carried out on one sample of the cohesive fill deposit and the results are presented on Figure B-8 in Appendix B. Atterberg limit testing was carried out on two samples of the clayey silt to silty clay deposit and the results are presented on Figure B-9 in Appendix B. The Atterberg limits tests measured liquid limits of 29% and 31%, plastic limits of 16% and 17%, corresponding to plasticity indices of 13% and 14%, indicating the deposit ranges from a clayey silt of low plasticity to a silty clay of intermediate plasticity.

4.2.9 Gravelly Silty Sand to Silty Sand and Gravel – Lower Deposit

A 3.7 m thick gravelly silty sand to silty sand and gravel deposit was encountered underlying the non-cohesive fill in Borehole STM-1. The non-cohesive deposit was encountered at a depth of 1.5 m (Elevation 90.7 m) below ground surface and extends to a depth of 5.2 m below ground surface (Elevation 86.9 m) prior to borehole termination.

The SPT “N”-values measured within the lower gravelly silty sand to silty sand and gravel deposit range from 12 blows to 37 blows per 0.3 m penetration, indicating a compact to dense state of compactness.

The water content measured on samples of the non cohesive deposit range from about 6% to 22%.

Grain size distribution testing was carried out on two samples of the lower gravelly silty sand to silty sand and gravel deposit and the results are presented on Figure B-10 in Appendix B.

4.2.10 Groundwater Conditions

Details of the water levels observed in the boreholes upon completion of drilling and standpipe piezometers installations are presented on the Record of Boreholes in Appendix A. The recorded depths to groundwater and corresponding elevations, measured within the piezometers are summarized in the table below. It should be noted

that the groundwater level is subject to seasonal fluctuations and precipitation events and should be expected to be higher during wet periods of the year.

Borehole	Screened Stratigraphy	Depth(m)	Elevation (m)	Date of Measurement
NRW-1	Silt and sand till	6.8	95.4	August 13, 2018
		6.3	95.9	February 8, 2019
STM-1	Gravelly silty sand to silty sand and gravel	1.2 ¹	90.9 ¹	November 7, 2021 ¹
		1.5	90.6	November 23, 2021
STM-4	Sandy silty clay to silty sand till	4.4	97.5	November 7, 2021

Note: 1. Water measurement obtained upon completion of piezometer installation and therefore may not be representative of the stabilized groundwater condition.

4.3 Analytical Testing

Two soil samples were collected as part of the current investigation and submitted for analyses of parameters used to assess corrosion potential and sulphate attack. A summary of the results of the analysis is presented below and the detailed test results and Certificates of Analysis are presented in Appendix C.

Borehole	Sample	Sample Depth / Elevation (m)	Soil Type	Parameters				
				Chloride (µg/g)	Sulphate (µg/g)	pH	Conductivity (umho/cm)	Resistivity (ohm-cm)
STM-2	6	4.1 / 91.9	Clayey silt to silty clay	38	79	7.62	243	4,100
STM-3	5	3.3 / 98.7	Gravelly silty sand fill	610	34	7.98	1,080	930

5.0 CLOSURE

This Foundation Investigation Report was prepared by Mr. Jordan Schaaf, a geotechnical analyst with Golder, and reviewed by Ms. Anastasia Poliacik, P.Eng., a geotechnical engineer with Golder. Mr. Christopher Ng, P.Eng., an Associate and an MTO Foundations Designated Contact for Golder, conducted an independent technical and quality control review of this report.

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PART B

FOUNDATION DESIGN REPORT
STORM SEWER REPLACEMENT

LVIV BOULEVARD, CITY OF OSHAWA, DURHAM REGION, ONTARIO
G.W.P. 2298-13-00 / 2164-19-00, ASSIGNMENT #: 2016-E-0022

6.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

This section of the report provides foundation design recommendations for the detail design of the proposed storm sewer replacement along Lviv Boulevard, which forms a part of the overall improvements and future widening of the Highway 401 in the City of Oshawa, Ontario.

These recommendations are based on interpretation of the data obtained from the boreholes advanced during the previous and current field investigations. The discussion and recommendations presented are intended to provide the designers with information to carry out the design of the proposed storm sewer replacement. The Foundation Design Report, discussion and recommendations are intended for the use of MTO and its designers and shall not be used or relied upon for any other purpose or by any other parties, including the construction contractor. Contractors must make their own interpretation based on the factual data presented in the Foundation Investigation Report (Part A of this report). 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 may be required in the Contract Documents. Those requiring information on aspects of construction must make their own interpretation of the data provided as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

6.1 General

It is understood that the proposed storm sewer is approximately 250 m and will be installed by cut-and-cover construction methods. Based on the proposed storm sewer profile provided by WSP on January 14, 2022, the proposed sewer diameter ranges from 375 mm to 900 mm. The proposed sewer invert depths generally range from about 2 m to 4.5 m below existing ground surface, with one location below Simcoe Street with invert depths extending to about 7.5 m below existing ground surface. The invert elevations range from about Elevation 99.8 m at the east limit to about Elevation 93.0 m at the west limit.

Considering the depth of the proposed sewer is generally less than 4.5 m below existing ground surface, open cut installation is considered the more practical, and cost effective and therefore trenchless installation methods have not been considered further.

6.2 Cut-and-Cover Construction

6.2.1 Founding Depth and Subgrade Conditions

The anticipated founding conditions along the proposed storm sewer alignment varies from stiff clayey silt/silty clay to very dense sand and gravel/gravelly sand to very stiff/compact to very dense glacial till, and firm to very stiff cohesive fill, as shown on the stratigraphic profile on Drawing 1. The existing soils at the anticipated founding depths are considered suitable for supporting the pipes, provided the integrity of the base of the excavation can be maintained during construction.

The subgrade should be inspected by geotechnical personnel to ensure that all softened or loosened soils and other unsuitable materials have been removed. Where softened/loosened zones are present, these zones should be sub-excavated and replaced with granular backfill meeting OPSS.PROV 1010 (*Aggregates*) Granular 'A' or Granular 'B' Type II. The granular backfill should be placed and compacted in accordance with OPSS.PROV 501 (*Compacting*) as amended by Special Provision 105S22. Further, care will be required to avoid disturbing the base of the excavation during construction which could lead to loss of support of the storm sewer pipes. Any materials that are disturbed by construction at the base of the excavation should be removed and replaced with granular backfill or additional bedding materials.

6.2.2 Pipe Bedding, Cover, and Trench Backfill

The bedding, cover, and backfill for the concrete storm sewer pipe should be compatible with the type and class of pipe, the surrounding subsoil conditions and anticipated loading conditions and should be designed using Class B Bedding as presented in OPSD 802.030, 802.031 and 802.032 (*Rigid Pipe Bedding, Cover, and Backfill*), for earth excavation in Type 2, Type 3, and Type 4 soil, as applicable. The soil types as defined by Occupational Health and Safety Act and Regulations for Construction Projects that is along the proposed storm sewer alignment is discussed in Section 6.3.1.

6.2.2.1 Bedding and Cover

The bedding and cover material should consist of the material as specified in OPSS.PROV 401 (*Trenching, Backfilling, and Compacting*). Clear stone should not be used as bedding or cover material. Bedding shall consist of OPSS.PROV 1010 (*Aggregates*) Granular 'A' or OPSS.PROV 578 (*Unshrinkable Fill*) unshrinkable fill. All bedding and cover material should be placed in loose lifts and uniformly compacted to at least 98% of the material's Standard Proctor Maximum Dry Density (SPMDD), in accordance with OPSS.PROV 501 (*Compacting*), as amended by Special Provision 105S22.

6.2.2.2 Trench Backfill

The existing fill and native site soils may be used for trench backfill, provided they are free of organic material or other deleterious materials. If water contents of the site soils at the time of construction are too high, or if there is a shortage of suitable in-situ material, then an approved imported material which meets the requirements for OPSS.PROV 1010 (*Aggregates*) Select Subgrade Material (SSM) or Granular 'B' Type I could be used. Backfill should be placed and compacted as indicated above for granular materials and to 95% of the materials Standard Proctor Modified Dry Density (SPMDD) for native soils/excavated fills. All work should be protected from freezing and that bedding material should not be placed on frozen ground. Backfilling operations during cold weather should avoid inclusions of frozen lumps of material, snow and ice, and backfilling with fine grained (i.e., silts and/or clays) materials should not be undertaken.

Some settlement of the compacted trench backfill should be anticipated, which the majority of which should take place within 6 months following the completion of trench backfilling operations. This settlement will be reflected at the ground surface and may be compensated by placing additional granular material as required. Alternatively, if the asphalt binder course is placed shortly following the completion of trench backfilling operations in these areas, any settlement that may be reflected by subsidence of the surface of the binder asphalt should be compensated for by placing an additional thickness of binder asphalt or by padding.

The design frost depth in the area is estimated to be 1.3 m below ground surface, as interpreted from OPSD 3090.101 (*Frost Penetration Depths for Southern Ontario*). To avoid undue differential movements of ground surface adjacent to and over the trench, the backfill materials should match, as practically as possible, the native or fill material exposed in the trench walls, or granular materials should be used as backfill as it will undergo most of the settlement during construction.

6.3 Construction Considerations

6.3.1 Excavations

All excavations should be carried out in accordance with the guidelines outlined in the Occupational Health and Safety Act and its Regulations (OHSA), and as outlined in OPSS.PROV 401 (*Trenching, Backfilling and Compacting*). According to OHSA, the soil classification and corresponding excavation side slopes of the soils anticipated to be excavated are provided below. However, depending upon the construction procedures adopted by the contractor, actual groundwater seepage conditions, the success of the contractor's groundwater control

methods and weather conditions at the time of construction, some flattening and/or blanketing of the slopes may be required.

Soil Description	Above/Below Groundwater	OHSA Soil Type	Maximum Foundation Excavation Side Slopes
Very loose to compact non-cohesive fill, Stiff to very stiff cohesive fill, and Very loose to loose sand	Above	Type 3	1 Horizontal :1 Vertical
	Below	Type 4	3 Horizontal :1 Vertical
Stiff clayey silt to silty clay, Compact to dense silty sand to sand and gravel, Very stiff cohesive glacial till, and Dense to very dense non-cohesive glacial till	Above	Type 2	1 Horizontal :1 Vertical to within 1.2 m of the bottom of the excavation
	Below	Type 3	1 Horizontal :1 Vertical

Excavated material must be stockpiled at a distance away from the excavation equal to or greater than the depth of the open cut excavation through the overburden. Where sufficient space is not available for stockpiling excavated material, off-site storage of the excavated material intended for reuse is required. Care must also be taken during excavation to ensure that during excavation operations, adequate support should be provided for any existing structures, roadways and underground services located adjacent to the excavations. In addition, in accordance with OPPS.PROV 401 (*Trenching, Backfilling, and Compacting*) trenches shall be stable and dry and therefore, surface water runoff should be directed away from the open excavations.

6.3.2 Temporary Excavation Support Systems

Temporary excavation support systems will be required to facilitate trench excavations where space and/or property restrictions limit open-cut excavation. Temporary excavation support systems may consist of (but are not limited to) the following:

- § Prefabricated or Hydraulic Support Systems (i.e., trench boxes): to protect workers and can be used in areas which can tolerate lateral movement of the soil deposits adjacent to the support system; and,
- § Engineered Support Systems (i.e., soldier pile and lagging, sheetpiles, etc.): to protect workers, and can be used in areas where sensitive underground services / structures require restricted lateral movements.

The design and construction of all temporary excavation support systems is the responsibility of the Contractor and must be in accordance with the latest version of the *Ontario Occupational Health and Safety Act for Construction Projects (OHSA)*, as amended. Recommended values of the geotechnical parameters for use in design of temporary protection systems are provided below. Where both total stress and effective stress parameters are provided, the temporary excavation support system design should be verified using each independent analytical method (i.e., total stress versus effective stress).

Stratigraphic Unit	Unit Weight of Material, γ (kN/m ³)	Angle of Internal Friction, ϕ (°)	Coefficients of Static Lateral Earth Pressure		
			Active, K_a	At Rest, K_a	Passive, K_p
Very loose to compact sandy silt to gravelly sand fill	20	30	0.33	0.50	3.00
Firm to very stiff clayey silt to silty clay fill	19	30	0.33	0.50	3.00
Stiff clayey silt to silty clay	19	32	0.31	0.47	3.25
Very loose to loose sand	20	30	0.33	0.50	3.00
Compact to dense silty sand to sand and gravel	20	33	0.29	0.46	3.39
very stiff cohesive glacial till / dense to very dense non-cohesive glacial till	19	35	0.31	0.47	3.25

Notes:

1. The lateral earth pressure coefficients presented above are based on a horizontal surface adjacent to the excavation. If sloped surfaces are expected, the coefficients showed need to be corrected accordingly.
2. The total passive resistance below the base of the excavation (i.e., within the shored excavation and / or adjacent to the temporary protection system, may be calculated based on the value of K_p indicated above but reduced by an appropriate factor that considers the allowable wall movement in accordance with Figure C6.27 of the CHBDC (2019) to account for the fact that a large strain would be required for mobilization of the full passive resistance.

The measured groundwater level along the proposed sewer alignment (as measured in the piezometers) ranges from about Elevation 97.5 m to 90.6 m west of the proposed sewer alignment. The design groundwater elevation is generally expected to range between these elevations, dependant on the location along the proposed alignment.

6.3.2.1 Trench Boxes

Prefabricated support systems (e.g. trench box) provide protection for construction personnel but do not provide a close-fit for lateral support against the adjacent excavation walls. As a result, any underground services or existing structures (including pavement structure) located within the zone of influence should be assessed by the Contractor for potential ground movements based on the chosen support system. Any services / structures that cannot tolerate the estimated ground movements should be accurately located prior to construction such that adequate additional support can be provided, or other mitigation measures adopted, as required.

The trench boxes should be designed and constructed in accordance with OPSS.PROV 404 (*Support Systems*). It is understood that the proposed sewer will be installed sequentially within each trench box section and therefore, it is anticipated that a short section of the trench excavation will be open at any one time. The trench excavations should be backfilled as soon as practical and must be completely backfilled at the end of each working day/shift.

To limit ground movements / disturbance during and after construction, OPSS.PROV 1010 (*Aggregates*) Granular 'A' or 'B' (Type I or II) should be placed and compacted between the excavated face/side-slope and the exterior of trench box. Depending on the workmanship and care exercised in the excavation and trench box installation / removal sequencing and backfill operations, disturbance to the pavement structure and underlying soils within the zone of influence may occur and future rehabilitation / repairs to the roadway may be required.

6.3.2.2 Engineered Support Systems

Where feasible and applicable to limit ground movements, temporary protection systems could consist of sheet piles, soldier pile and lagging, and/or slide-rail system. The presence of cobbles / boulders / gravelly soils within the till deposit and the presence of bedrock could impede installation of the temporary protection systems and

therefore, pre-drilling and/or removal of obstructions to facilitate construction of the temporary protection systems may be required.

The temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems*), as amended by Special Provision 105S09. The lateral movement of the protection systems should meet Performance Level 2 as specified in OPSS.PROV 539 within the roadway, provided that adjacent utilities and structures can tolerate this magnitude of deformation. Depending on the Contractors sequence of operations / excavation, the temporary global stability of the bridge embankments / abutment walls should be checked as per OPSS.PROV 539 and the applicable loads / pressures must be incorporated into the design of the temporary protection system. The owners of utilities located adjacent to or that cross the proposed excavation should be contacted to understand their owner's requirements and tolerances for movement.

It is recommended that the temporary protection system be fully removed upon completion of construction or each stage of the construction to mitigate potential impediments to future rehabilitation/reconstruction work. If the temporary protection system is left in place, it should be cut off at or below the depth of frost penetration, or a depth of 1.3 m or greater below the pavement surface.

6.3.3 Groundwater Control

The measured groundwater level along the proposed sewer alignment (as measured in the piezometers) ranges from about Elevation 97.5 m at the east end of the alignment to Elevation 90.6 m west of the proposed sewer alignment, as presented in Section 4.2.8. Depending on the time of year of construction, perched groundwater conditions may be present within the fill layers.

Based on the observed groundwater conditions, groundwater / perched water inflow into excavations for the sewers can likely be controlled by pumping from sumps at the base of the excavations. It is recommended that additional water levels be obtained from the piezometers installed on site at the time of construction to confirm the dewatering requirements at the time of construction.

Surface water should be directed away from open excavation areas to prevent ponding of water that could result in disturbance and weakening of the founding soils and/or affect construction, as applicable.

6.3.4 Corrosion Assessment and Protection

The results of analytical testing on two soil samples are summarized in Section 4.3 and the analytical laboratory test reports are included in Appendix C. The potential for sulphate attack and corrosion are discussed below, however it is ultimately up to the designer to determine the appropriate construction materials, including exposure class and ensuring that all aspects of CSA A23.1 Section 4.1.1 "Durability Requirements" are followed when designing concrete elements.

The analytical test results for sulphate were compared to CSA A23.1 Table 3 (*"Additional requirements for concrete subjected to sulphate attack"*) to assess the potential severity of sulphate attack on concrete during its service life. The sulphate concentration measured on the submitted soil samples are less than 0.1%, which is below the Moderate degree of exposure (i.e. below the Class S-3 exposure limits) and the degree of sulphate attack is considered 'Negligible' according to Table 7.2 in MTO's *Gravity Pipe Design Guidelines* (2014). Therefore, based on the soil samples tested, when the designer is selecting the exposure class for concrete structures, the effects of sulphates from within the site soils in contact with any portion of the proposed structures constructed below the ground surface may not need to be considered. However, given the proximity of the sewers to de-icing salt, consideration should be given by the designer to designing for a "C" type exposure class as defined by CSA A23.1 Table 1.

According to MTO's *Gravity Pipe Design Guidelines* (2014), the pH is not considered detrimental to steel durability as it is less than a pH of 8.5.

The resistivity measured in the tested soil samples (930 ohm-cm to 4,100 ohm-cm) indicates that the soil corrosiveness ranges from "severe" ($R < 2,000$ ohm-cm) to "moderate" ($4,500$ ohm-cm $< R < 2,000$ ohm-cm) as per Table 3.2 of MTO's *Gravity Pipe Design Guidelines* (2016), and some level of corrosion protection should be applied to the storm sewer.

7.0 CLOSURE

This Foundation Design Report was prepared by Ms. Anastasia Poliacik, P.Eng., a geotechnical engineer with Golder. Mr. Christopher Ng, P.Eng., an Associate with Golder and an MTO Foundations Designated Contact conducted an independent technical and quality control review of this report.

Signature Page

Golder Associates Ltd.



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Associate, MTO Foundations Designated Contact

AMP/CN/ljv

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[https://golderassociates.sharepoint.com/sites/146559/project files/4 deliverables/1- lviv stm fidr/3.final/21466052-fidr rev0-2022'03'31-storm sewers.docx](https://golderassociates.sharepoint.com/sites/146559/project%20files/4%20deliverables/1-iviv%20stm%20fidr/3.final/21466052-fidr%20rev0-2022%2003%2731-storm%20sewers.docx)

REFERENCES

Canadian Standard Association (CSA) Group. *Canadian Highway Bridge Design Code* (CHBDC (2019)) and *Commentary on CAN/CSA-S6-14*.

Chapman, L.J. and Putnam, D.F. 1984. *The Physiography of Southern Ontario*, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.

Ministry of Transportation, Ontario. 2014. *Gravity Pipe Design Guidelines*.

Ontario Occupational Health and Safety Act:

Ontario Reg. 213 Construction Projects (as amended)

Ontario Provincial Standard Specifications (OPSS)

OPSS.PROV 401	Construction Specification for Trenching, Backfilling, and Compacting
OPSS.PROV 404	Construction Specification for Support Systems
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 517	Construction Specification for Dewatering
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 578	Construction Specification for The Placement of Unshrinkable Fill
OPSS.PROV 1010	Construction Specification for Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material

Ontario Provincial Standard Drawings (OPSD)

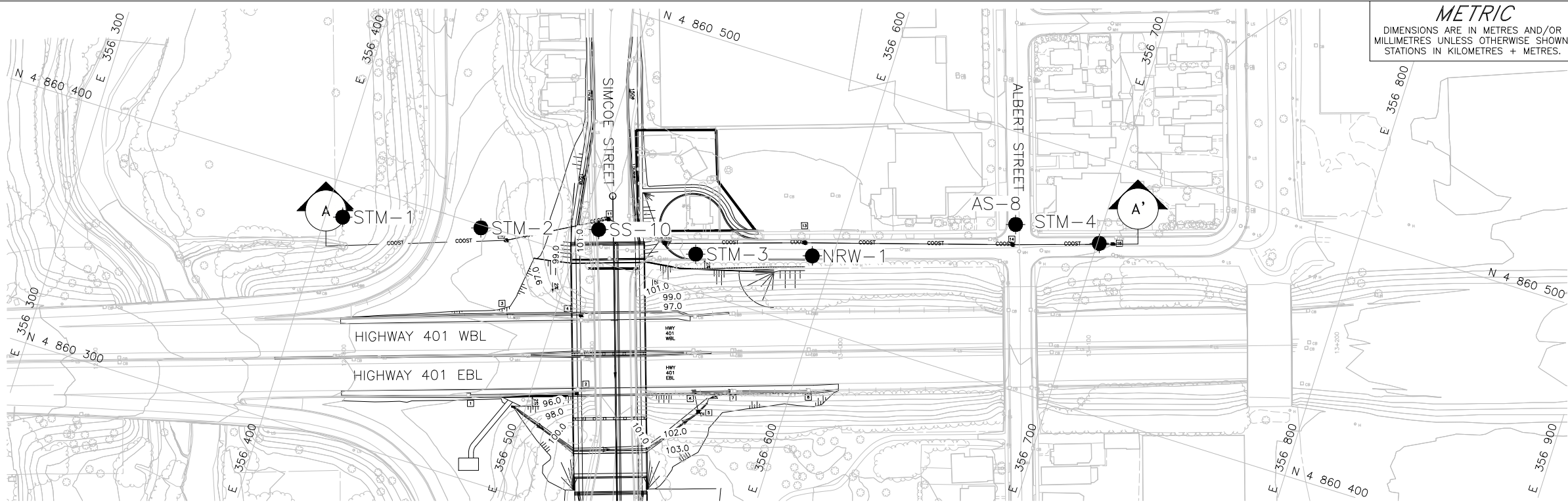
OPSD 802.030	Rigid Pipe Bedding, Cover and Backfill – Type 1 or 2 Soil – Earth Excavation
OPSD 802.031	Rigid Pipe Bedding, Cover and Backfill – Type 3 Soil – Earth Excavation
OPSD 802.032	Rigid Pipe Bedding, Cover and Backfill – Type 4 Soil – Earth Excavation
OPSD 3090.101	Foundation, Frost Penetration Depths for Southern Ontario

MTO Special Provisions (SSP)

105S09	Amendment to OPSS 539, November 2014
105S22	Amendment to OPSS 501, November 2014

Ontario Water Resources Act

Ontario Regulation 903 Wells (as amended)



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

CONT No.
WP No.

HWY 401
LVIV STM SEWER
BOREHOLE LOCATION PLAN AND
SOIL STRATA



SHEET



KEY PLAN



LEGEND

- Borehole – Current Investigation
- ⊢ Seal
- ⊢ Piezometer
- N Standard Penetration Test Value
- 16 Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- ≡ WL in piezometer, measured on MMM DD, YYYY

BOREHOLE CO-ORDINATES			
No.	ELEVATION	NORTHING	EASTING
AS-8	102.6	4860464.3	356666.4
NRW-1	102.2	4860427.8	356592.0
SS-10	101.3	4860412.3	356506.7
STM-1	92.1	4860386.4	356406.8
STM-2	96.0	4860398.9	356461.2
STM-3	102.0	4860414.5	356547.0
STM-4	101.9	4860467.0	356700.8

Site Coordinates: Long. -78.85604113, Lat.43.88189846

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.

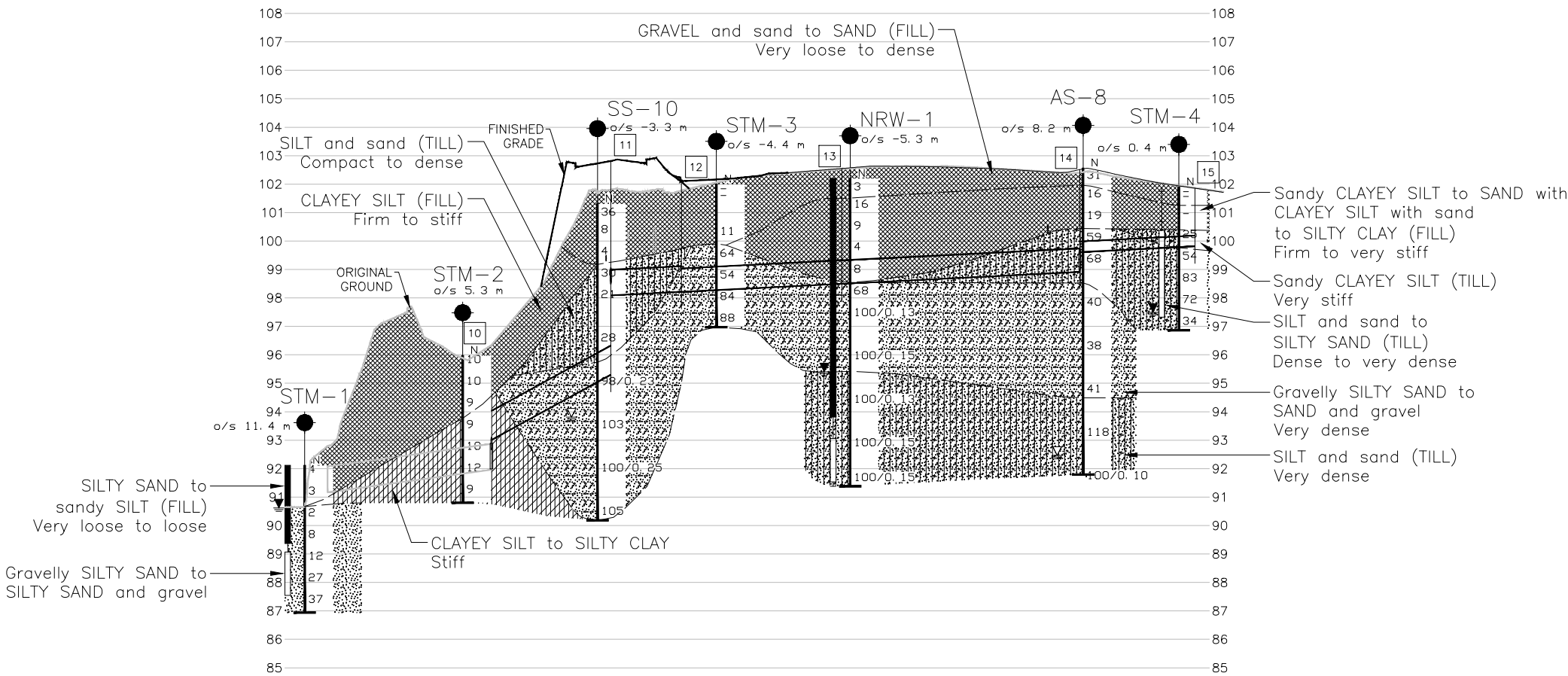
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

REFERENCE

Base plans provided in digital format by client, dated June 6, 2015.

Storm Sewer plan provided in digital format by WSP, file nos. 171-04557-00_XR_Lviv Blvd Storm Sewer.dwg, received January 14, 2022.

Design plan provided in digital format by WSP, file nos. 171-04557-00_XR_New Construction.dwg, received January 14, 2022.



PLAN

VERTICAL SCALE



HORIZONTAL SCALE



NO.	DATE	BY	REVISION
Geocres No. 30M14-544			
HWY. 401	PROJECT NO. 21466052	DIST. .	
SUBM'D. AK	CHKD. AK	DATE: 03/31/2022	SITE: .
DRAWN: SMD/DD	CHKD. AMP	APPD. CN	DWG. 1

APPENDIX A

Borehole Records

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

MINISTRY OF TRANSPORTATION, ONTARIO

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>200	>8
COBBLES	Not Applicable	75 to 200	3 to 8
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
FINES	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY COMPONENTS^{1,2}

Percentage by Mass	Modifier
> 35	Use 'and' to combine primary and secondary component (<i>i.e.</i> , SAND and gravel)
> 20 to 35	Primary soil name prefixed with "gravelly, sandy" as applicable
> 10 to 20	some (<i>i.e.</i> , some sand)
≤ 10	trace (<i>i.e.</i> , trace fines)

1. Only applicable to components not described by Primary Group Name.

2. Classification of Primary Group Name based on Unified Soil Classification System (ASTM D2487) for coarse-grained soils; fine-grained soils described per current MTO Soil Classification System.

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.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

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

Dynamic Cone Penetration Resistance (DCPT); 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

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC / SC	Rock core / Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample
OD / ID	Outer Diameter / Inner Diameter
HSA / SSA	Hollow-Stem Augers / Solid-Stem Augers

SOIL TESTS

w	water content
PL, w _p	plastic limit
LL, w _L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D _R	relative density (specific gravity, G _s)
DS	direct shear test
GS	specific gravity
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 (FV)	field vane (LV-laboratory vane test)
Y	unit weight

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

COARSE-GRAINED SOILS

Compactness¹

Term	SPT 'N' (blows/0.3m) ²
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

- Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grain size. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.
- SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.

FINE-GRAINED SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N' ^{1,2} (blows/0.3m)
Very Soft	< 12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	> 200	> 30

- SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
- SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

LIST OF SYMBOLS

MINISTRY OF TRANSPORTATION, ONTARIO

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

I. GENERAL

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

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)

σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

w	water content
w_L or LL	liquid limit
w_P or PL	plastic limit
I_P or PI	plasticity index $= (w_L - w_P)$
NP	non-plastic
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
$C_{a(e)}$	secondary compression index
C_a	rate of secondary compression
$C_{a(e)}$	modified secondary compression index
m_v	coefficient of volume change
C_v	coefficient of consolidation (vertical direction)
C_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

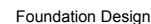
(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
c'	effective cohesion
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
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 or 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 ρ . Unit weight symbol is γ .
where $\gamma = \rho \cdot g$ (i.e., mass density multiplied by
acceleration due to gravity)

Notes: 1
2

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



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

PROJECT 1662582		RECORD OF BOREHOLE No NRW-1		SHEET 1 OF 1		METRIC							
G.W.P. 2298-13-00		LOCATION N 4860427.8; E 356592.0 MTM NAD 83 ZONE 10 (LAT. 43.882015; LONG. -78.855480)		ORIGINATED BY LP									
DIST Central HWY 401		BOREHOLE TYPE 216 mm O.D Hollow Stem Augers		COMPILED BY AK									
DATUM HT2_0 (Geodetic)		DATE March 5, 2018		CHECKED BY CN									
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					
102.2	GROUND SURFACE												
0.0	ASPHALT (150 mm)												
0.2	Sand, some silt, some gravel (FILL)		1	SS	3								
101.5	Very loose Brown Moist		2	SS	16								
0.7	Sandy clayey silt to sand with clayey silt with sand, trace to some gravel, trace asphalt pieces (FILL)		3	SS	9								
	Firm to very stiff Brown Moist		4	SS	4								
	- Trace organics between depths of 0.7 m and 2.1 m (Elev. 101.5 m and 100.1 m)		5	SS	8								
98.5			6	SS	68								18 49 22 11
3.7	SAND and GRAVEL, trace to some silt, trace clay Very dense Brown to grey Moist		7	SS	100/0.15								47 43 7 3
			8	SS	100/0.15								
95.4			9	SS	100/0.15								
6.8	SILT and SAND, trace to some clay, trace gravel (TILL) Very dense Grey Moist		10	SS	100/0.15								2 43 44 11
			11	SS	100/0.15								
91.4													
10.8	END OF BOREHOLE												
NOTES: 1. Borehole dry upon completion of drilling. 2. Water level in piezometer measured as follows: Date Depth (m) Elev. (m) Aug. 13/18 6.8 95.4 Feb. 8/19 6.3 95.9													

PROJECT		1662582 (2000)		RECORD OF BOREHOLE No SS-10				SHEET 1 OF 1		METRIC							
G.W.P.		2298-13-00		LOCATION		N 4860412.3; E 356506.7 MTM NAD ZONE 10 (LAT. 43.881880; LONG. -78.856540)				ORIGINATED BY LP							
DIST		Central HWY 401		BOREHOLE TYPE		216 mm O.D Hollow Stem Augers				COMPILED BY AK							
DATUM		Geodetic		DATE		November 01, 2017				CHECKED BY							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
101.3	GROUND SURFACE																
0.0	ASPHALT (135 mm)																
0.1	Sand, some gravel, some silt (FILL)		1	SS	36												
100.5	Dense Brown Moist		2	SS	8												
0.8	Clayey silt, some sand (FILL)																
	Firm Dark brown Moist		3	SS	4												
99.2																	
2.1	SILT and SAND, trace to some clay, trace to some gravel (TILL)		4	SS	30												
	Compact to dense Brown, becoming grey below a depth of 4.6 m (Elev. 96.7 m)		5	SS	21												
	- Oxidation staining from a depth of 2.1 m to 4.6 m (Elev. 96.7 m to 99.2 m)		6	SS	28												
95.7																	
5.6	SAND and GRAVEL, trace to some silt, trace clay		7	SS	98/0.23												
	Very dense Grey Moist to wet																
	- Crushed rock fragments recovered at a depth of 6.1 m (Elev. 95.2 m)																
			8	SS	103												
			9	SS	100/0.25												
			10	SS	105												
90.2																	
11.1	END OF BOREHOLE																
	NOTES:																
	1. Groundwater level in borehole measured at a depth of 7.5 m below ground surface (Elev. 93.8 m) upon completion of drilling.																
	2. Borehole caved to a depth of 7.6 m (Elev. 93.7 m) below ground surface upon completion of drilling and auger removal.																

PROJECT		21466052		RECORD OF BOREHOLE No STM-1		SHEET 1 OF 1		METRIC										
G.W.P.		2298-13-00		LOCATION		N 4860386.4; E 356406.8 MTM NAD 83 ZONE 10 (LAT. 43.881655; LONG. -78.857788)		ORIGINATED BY										
DIST		Central HWY 401		BOREHOLE TYPE		Power Auger; 150 mm O.D. Solid Stem Augers		COMPILED BY										
DATUM		HT2 0 (Geodetic)		DATE		November 07, 2021		CHECKED BY										
AMP																		
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	20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	γ	GR	SA	SI	CL
92.1		GROUND SURFACE																
0.0		TOPSOIL (150 mm)																
0.2		SILTY SAND (SM), trace organics, containing rootlets (FILL)		1	SS	4												
91.4		Loose Dark brown Moist		2	SS	3												
0.7																		
90.7		Sandy SILT (ML), containing organics and rootlets (FILL)																
1.5		Very loose Black Moist		3	SS	2												
		Gravelly SAND (SW-SM), some fines																
89.1		Very loose to loose Grey Wet		4	SS	8												
3.0		Gravelly SILTY SAND (SM) to SILTY SAND (SM/GM) and gravel																
		Compact to dense Grey Wet		5	SS	12												
				6	SS	27												
				7	SS	37												
86.9		END OF BOREHOLE																
5.2		NOTES:																
		1. Water measured in open borehole at a depth of 1.5 m below ground surface (Elev. 90.6 m) upon completion of drilling.																
		2. Borehole caved to a depth of 3.7 m below ground surface (Elev. 88.4 m) upon completion of drilling.																
		3. Water measured in piezometer as follows:																
		Date Depth (m) Elev. (m)																
		07-Nov-21 1.2 90.9																
		23-Nov-21 1.5 90.6																

GTA-MTO 001 S:\CLIENTS\MTOWHY_401_OSHAWA\02_DATA\GINT\HWY_401_OSHAWA.GPJ GAL-GTA.GDT 3/1/22

GTA-MTO 001 S:\CLIENTS\MTO\HWY 401 OSHAWA\02 DATA\GINT\HWY 401 OSHAWA.GPJ GAL-GTA.GDT 3/1/22

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

GTA-MTO 001 S:\CLIENTS\MTO\HWY 401 OSHAWA\02 DATA\GINT\HWY 401 OSHAWA.GPJ GAL-GTA.GDT 3/1/22

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

PROJECT <u>21466052</u>			RECORD OF BOREHOLE No STM-4			SHEET 1 OF 1			METRIC																					
G.W.P. <u>2298-13-00</u>			LOCATION <u>N 4860467.0; E 356700.8 MTM NAD 83 ZONE 10 (LAT. 43.882360; LONG. -78.854121)</u>			ORIGINATED BY <u>JU</u>																								
DIST <u>Central</u> HWY <u>401</u>			BOREHOLE TYPE <u>Power Auger; 200 mm O.D. Solid Stem Augers</u>			COMPILED BY <u>MJB</u>																								
DATUM <u>HT2 0 (Geodetic)</u>			DATE <u>October 01, 2021</u>			CHECKED BY <u>AMP</u>																								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS			ELEVATION SCALE			DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SHEAR STRENGTH kPa			WATER CONTENT (%)			UNIT WEIGHT			REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES																									
101.9	GROUND SURFACE																													
0.0	ASPHALT (35 mm)		1	GS	-																									
0.2	GRANULAR BASE (165 mm)		2	GS	-																									
101.3	GRANULAR SUBBASE (440 mm)																													
0.6	SILTY CLAY (CI), some sand (FILL) Brown Moist		3	GS	-																									
100.4	Sandy CLAYEY SILT (CL), trace gravel (TILL) Very stiff Brown Moist		4	SS	25																									
99.8																														
2.1	SILTY SAND (SM), some gravel (TILL) Dense to very dense Grey Moist		5	SS	54																									
			6	SS	83																									
			7	SS	72																									
			8	SS	34																									
96.9	END OF BOREHOLE																													
5.0	NOTES: 1. Borehole open and dry upon completion of drilling. 2. Water measured in piezometer as follows: Date <u>07-Nov-21</u> Depth (m) <u>4.4</u> Elev. (m) <u>97.5</u>																													

GTA-MTO 001 S:\CLIENTS\MTOWHY_401_OSHAWA02_DATA\GINT\HWY_401_OSHAWA.GPJ GAL-GTA.GDT 3/1/22

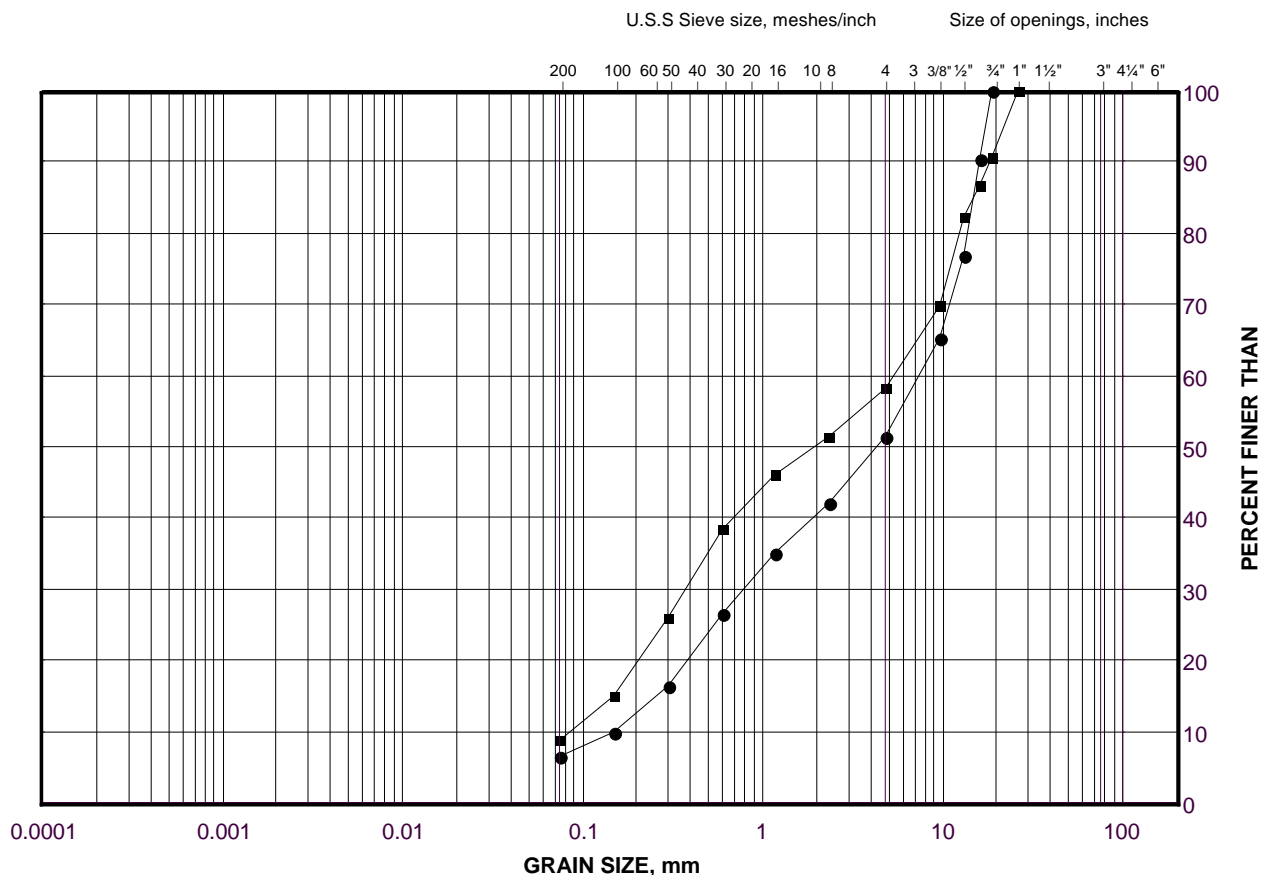
APPENDIX B

Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

GRANULAR BASE and GRANULAR SUBBASE

FIGURE B-1



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	STM-4	1	35 - 200
■	STM-3	2	230 - 580

Project Number: 21466052

Checked By: _AMP_____

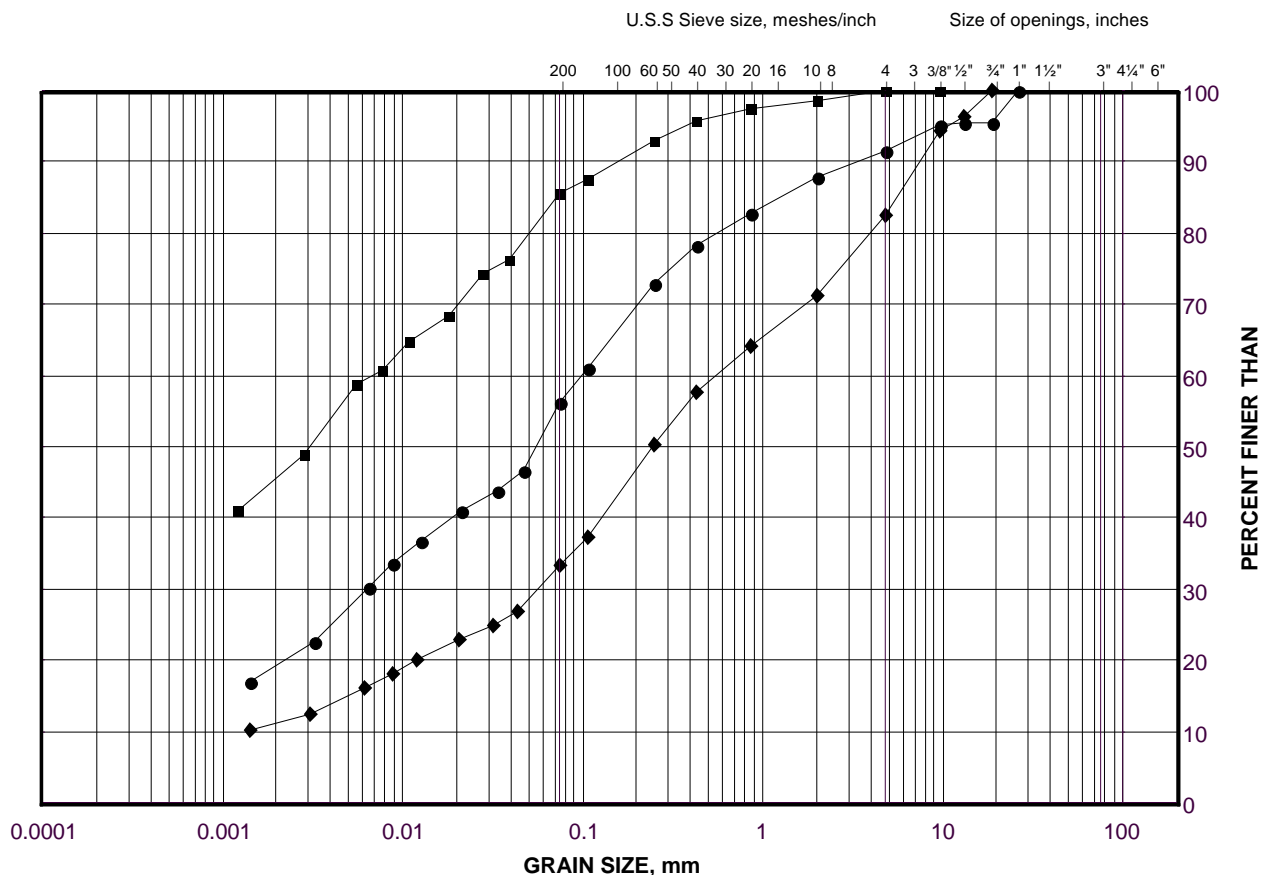
Golder Associates

Date: 21-Mar-22

GRAIN SIZE DISTRIBUTION

SILTY CLAY (CI) to Sandy CLAYEY SILT (CL) (FILL)

FIGURE B-2



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

LEGEND

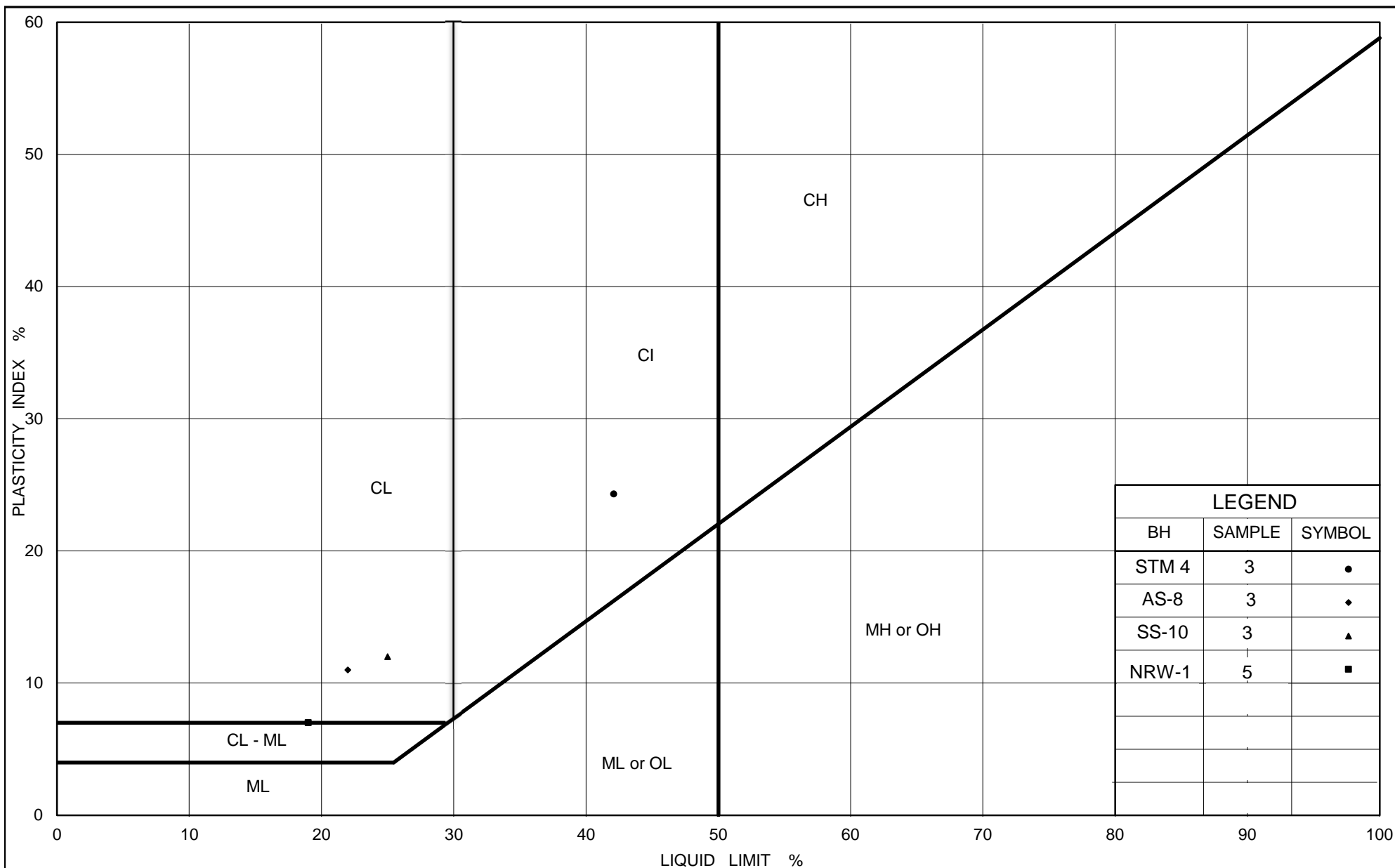
SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	AS-8	3	100.8
■	STM-4	3	101.0
◆	NRW-1	5	98.8

Project Number: 21466052

Checked By: _AMP_____

Golder Associates

Date: 21-Mar-22



PLASTICITY CHART

SILTY CLAY (CI) to Sandy CLAYEY SILT (CL) (FILL)

Figure No. B-3

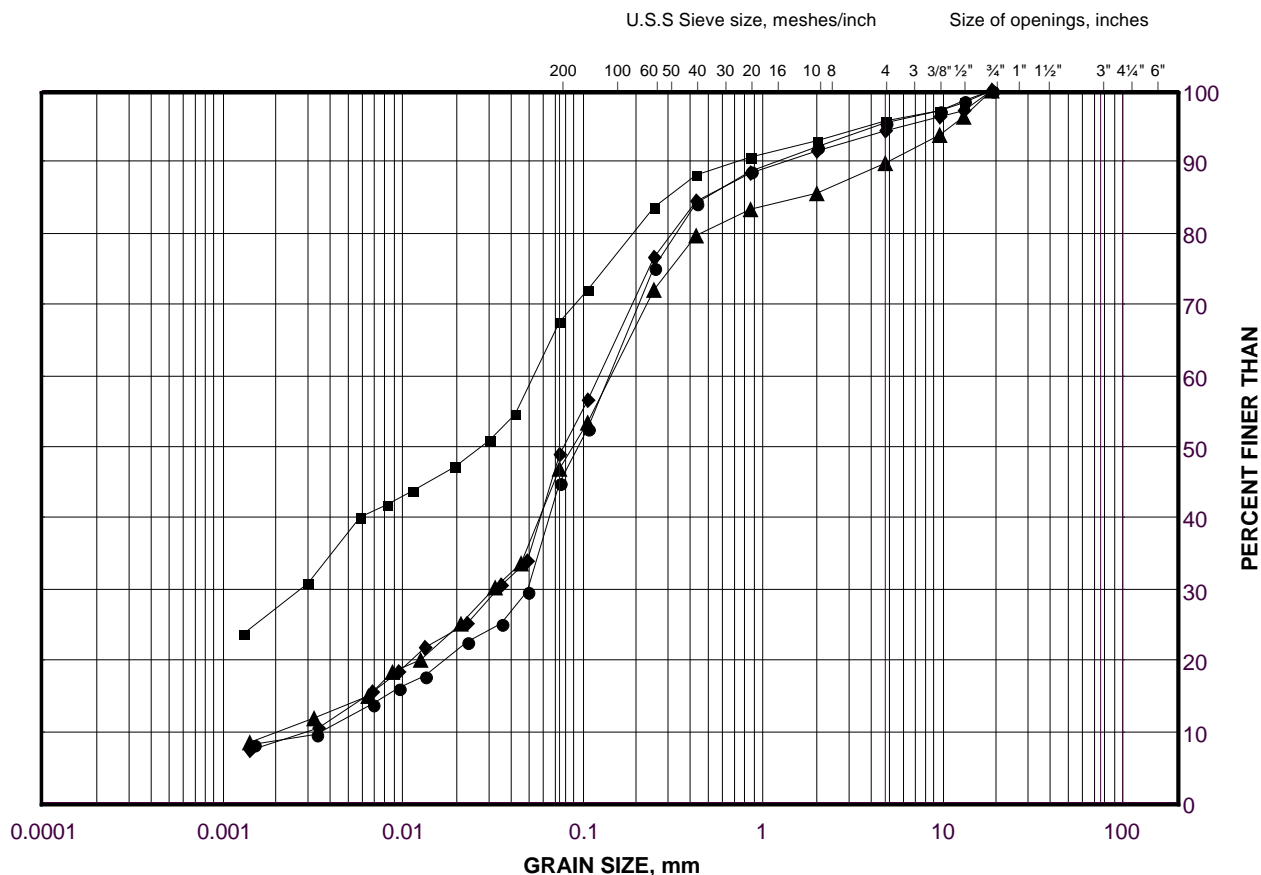
Project No. 21466052

Checked By: AMP

GRAIN SIZE DISTRIBUTION

Sandy CLAYEY SILT (CL) to
SILT and sand (ML) to SILTY SAND (SM) (TILL)

FIGURE B-4



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	AS-8	4	100.1
■	STM-4	4	100.2
◆	SS-10	5	98.1
▲	STM-4	7	97.1

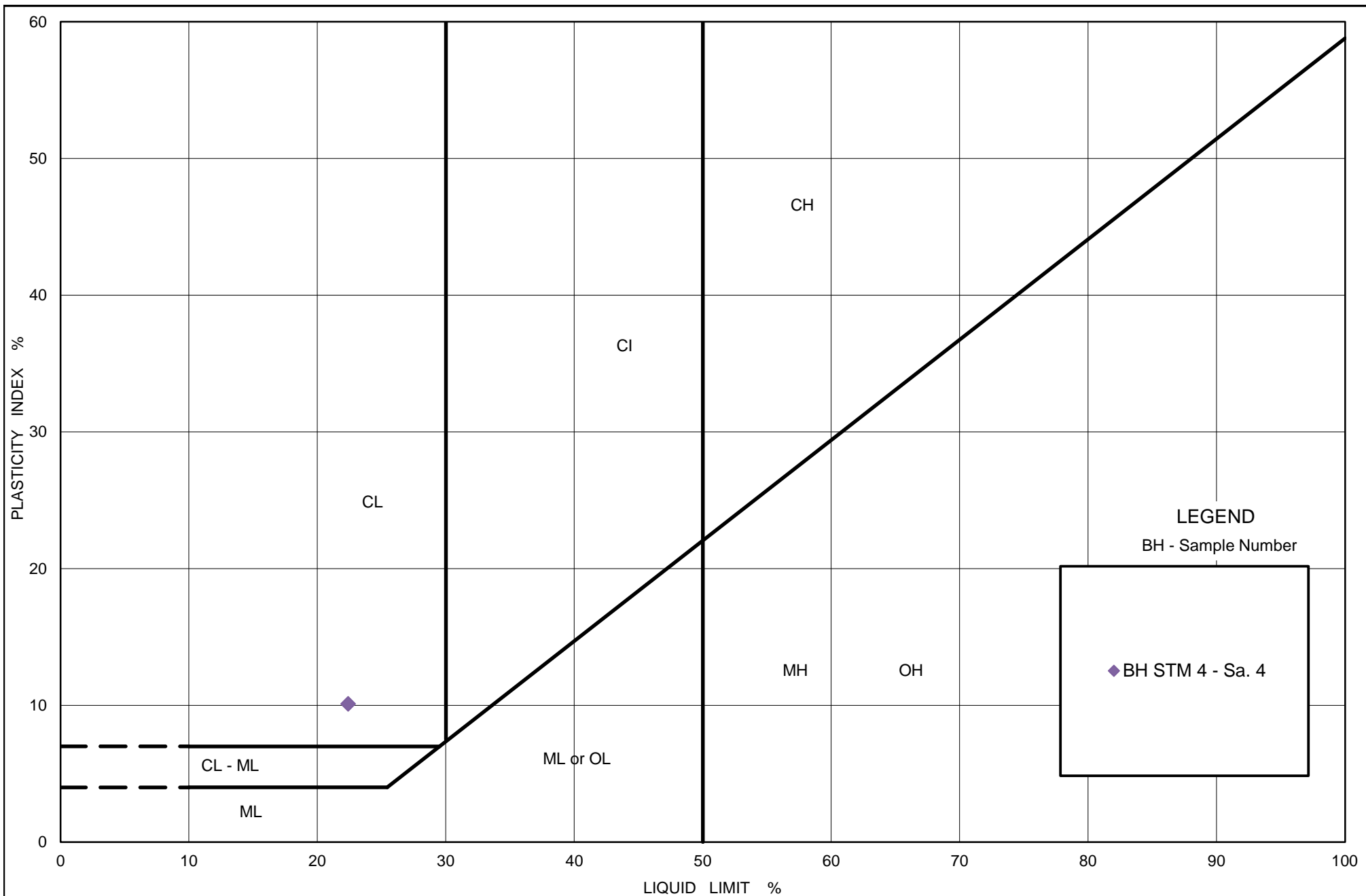
Project Number: 21466052

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Golder Associates

Date: 21-Mar-22

LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ASTM D4318)



PLASTICITY CHART

Sandy CLAYEY SILT (CL) (TILL)

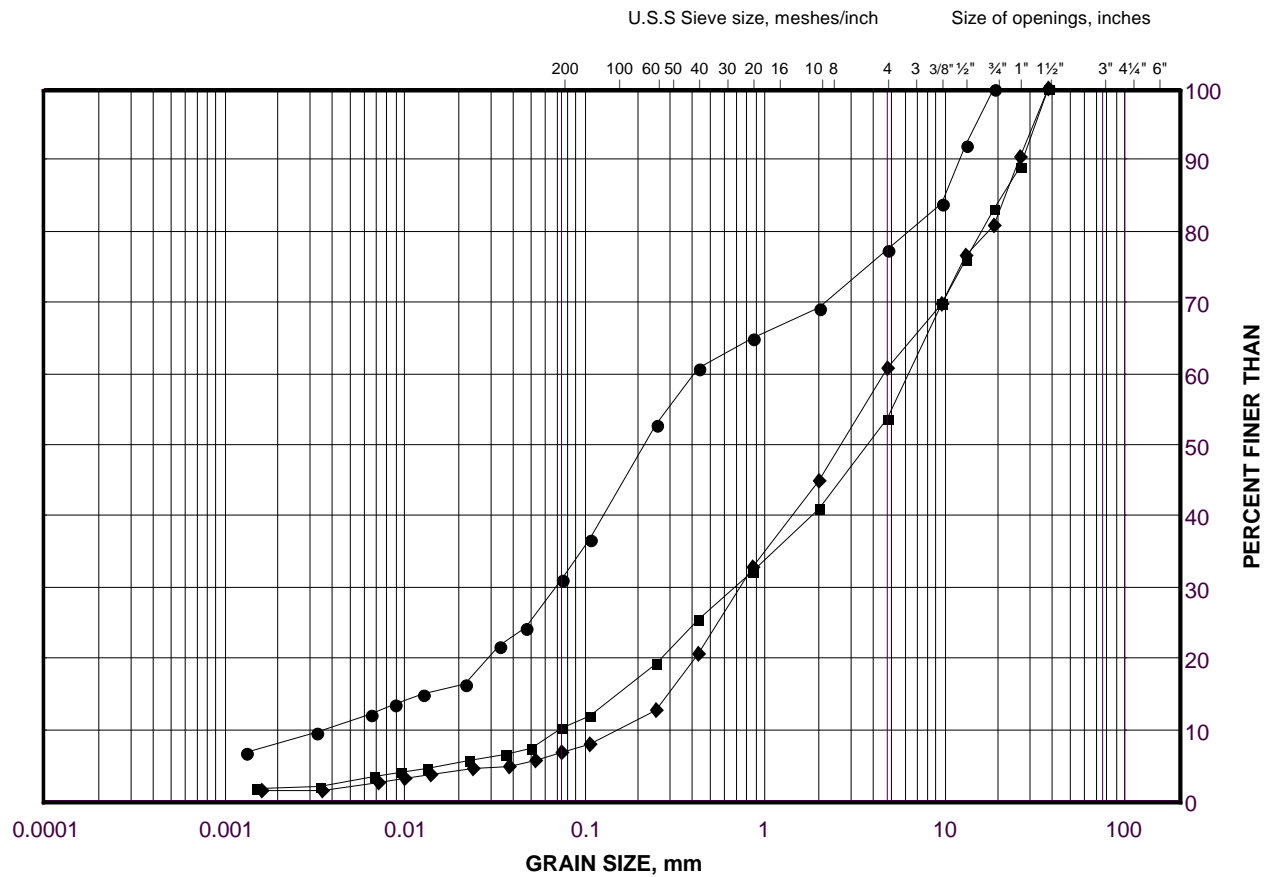
Figure No.: B-5

Project No.: 21466052

Checked By: AMP

Gravelly SILTY SAND (SM) to SAND and gravel (SW-SM)

FIGURE B-6



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	STM-3	5	98.5
■	NRW-1	6	98.1
◆	SS-10	8	93.4

Project Number: 21466052

Checked By: AMP

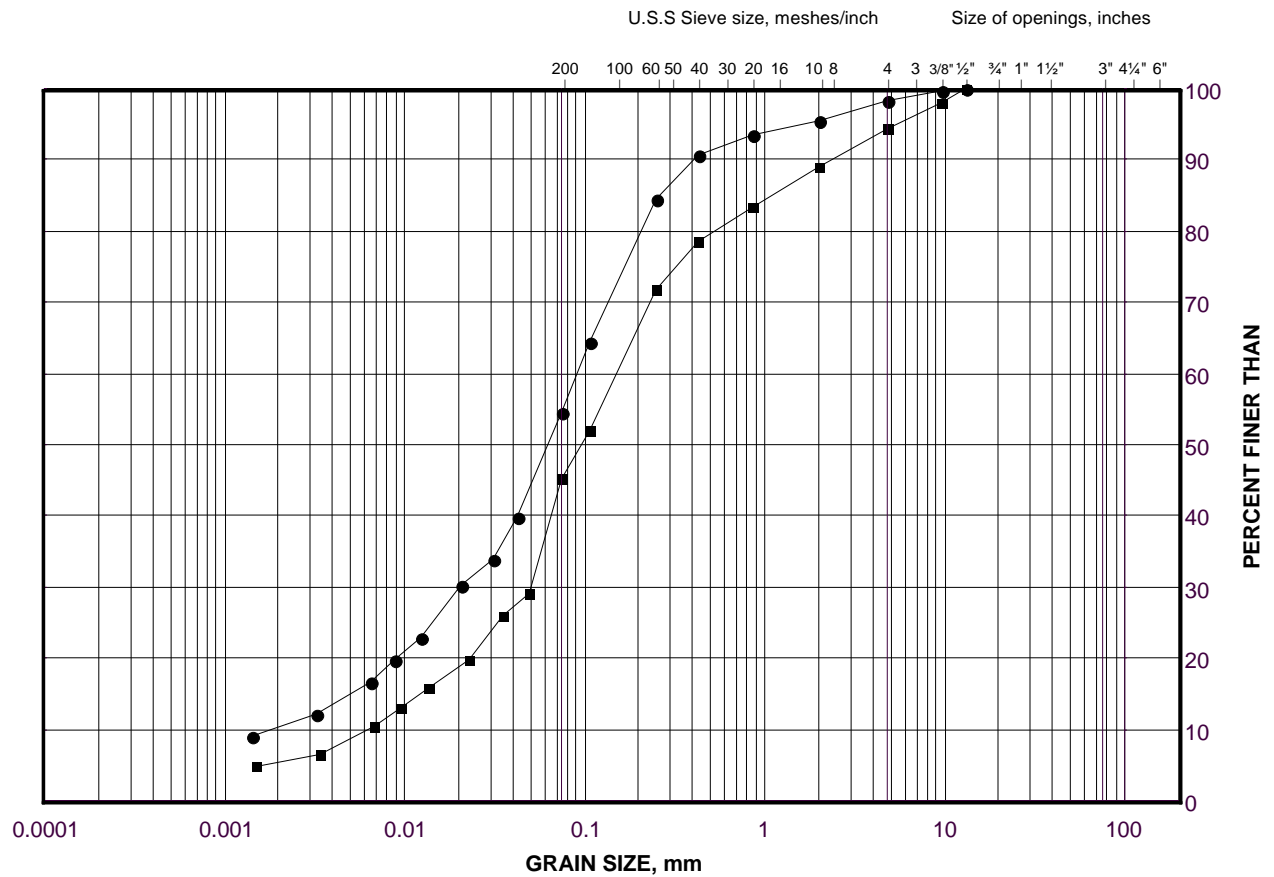
Golder Associates

Date: 21-Mar-22

GRAIN SIZE DISTRIBUTION

SILT and SAND (ML) (TILL)

FIGURE B-7



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	NRW-1	10	92.8
■	AS-8	9	93.2

Project Number: 21466052

Checked By: AMP

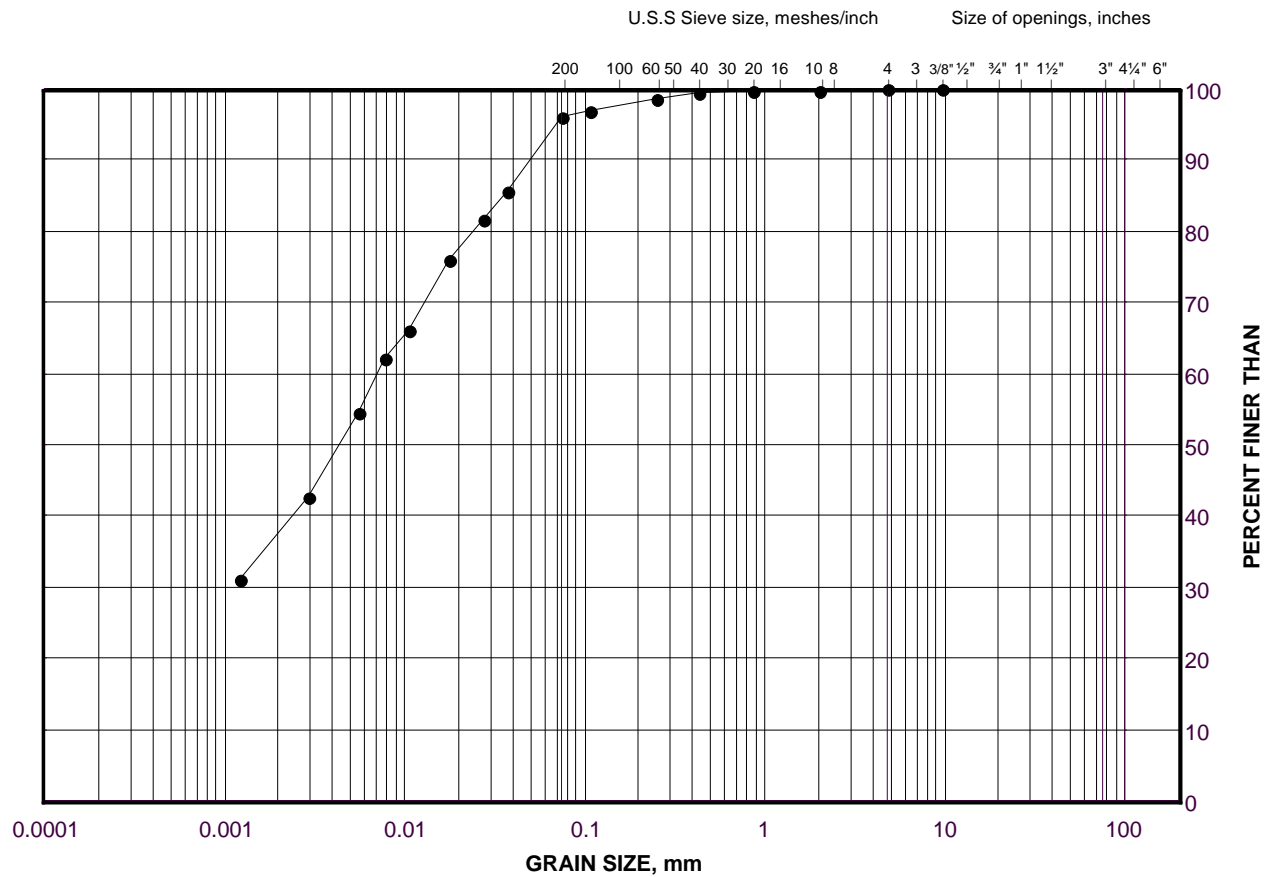
Golder Associates

Date: 21-Mar-22

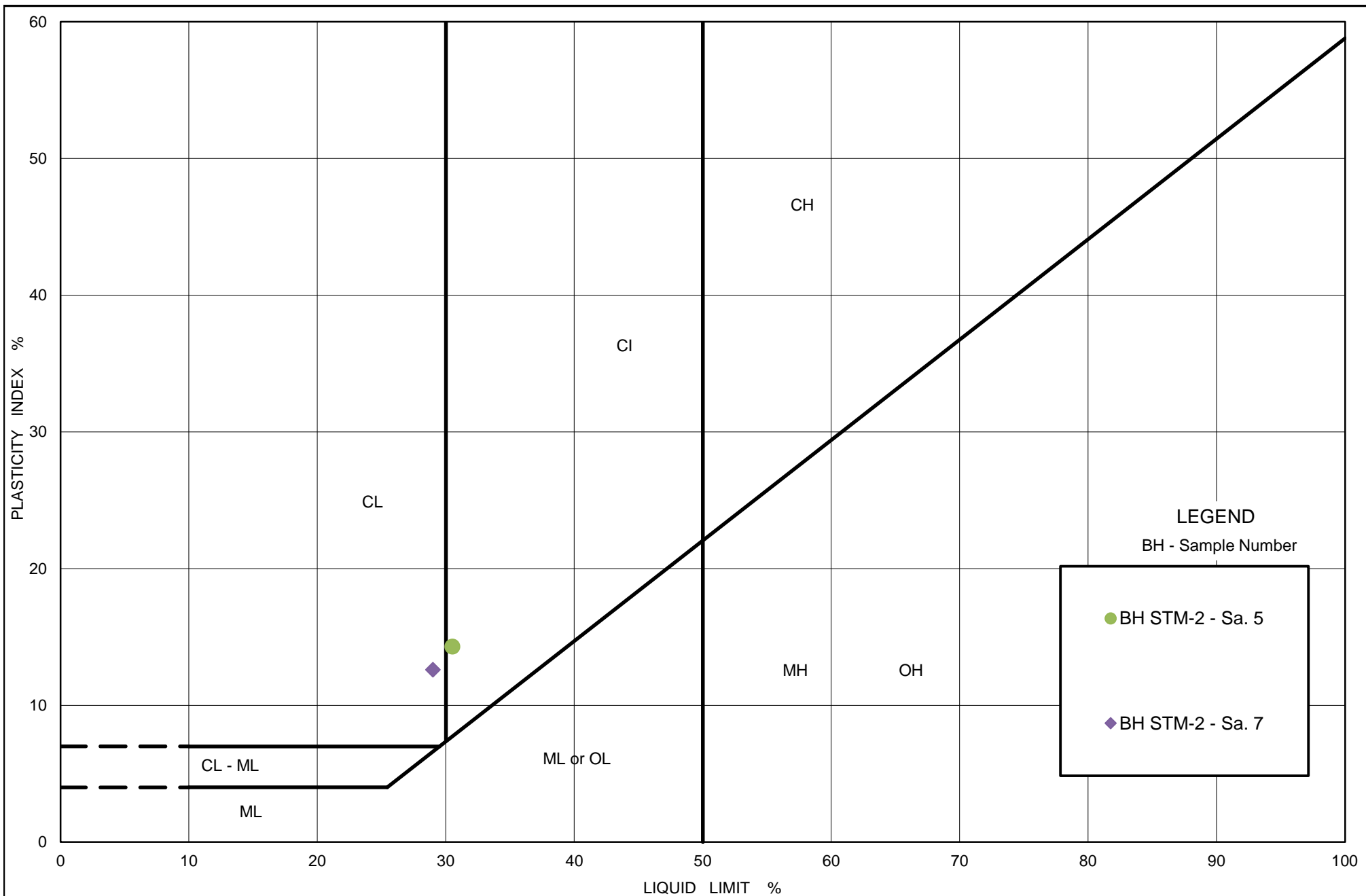
GRAIN SIZE DISTRIBUTION

SILTY CLAY (CI)

FIGURE B-8



LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS (ASTM D4318)



PLASTICITY CHART

CLAYEY SILT (CL) to SILTY CLAY (CI)

Figure No.: B-9

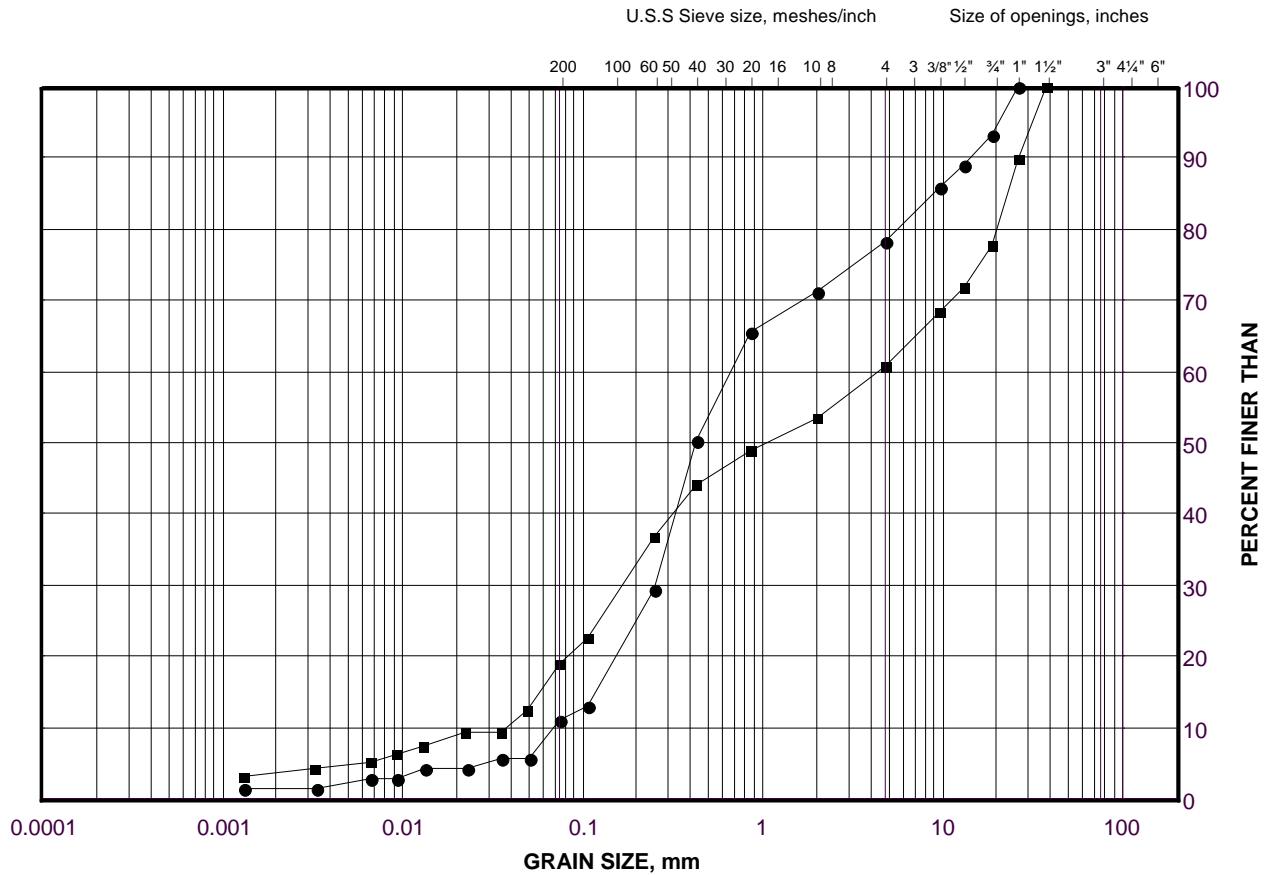
Project No.: 21466052

Checked By: AMP

GRAIN SIZE DISTRIBUTION

Gravelly SAND (SW-SM) to SILTY SAND and gravel (SM/GM)

FIGURE B-10



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	STM-1	4	89.5
■	STM-1	6	88.0

Project Number: 21466052

Checked By: _AMP_____

Golder Associates

Date: 21-Mar-22

APPENDIX C

Analytical Test Results



Your Project #: 21466052
 Site Location: LVIV BLVD
 Your C.O.C. #: 847598-101-01

Attention: Anastasia Poliacik

Golder Associates Ltd
 100 Scotia Crt
 Whitby, ON
 CANADA L1N 8Y6

Report Date: 2021/10/20
 Report #: R6860459
 Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1T4258

Received: 2021/10/08, 16:16

Sample Matrix: Soil
 # Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Chloride (20:1 extract)	1	2021/10/15	2021/10/15	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	1	2021/10/15	2021/10/15	CAM SOP-00414	OMOE E3530 v1 m
Moisture (Subcontracted) (1, 3)	1	N/A	2021/10/15	AB SOP-00002	CCME PHC-CWS m
Sulphide in Soil (1)	1	N/A	2021/10/15	AB SOP-00080	EPA9030B/SM4500S2-DF
pH CaCl2 EXTRACT	1	2021/10/15	2021/10/15	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	1	2021/10/09	2021/10/15	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	1	2021/10/15	2021/10/15	CAM SOP-00464	EPA 375.4 m
Redox Potential (2, 4)	1	N/A	N/A		

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.

Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.

This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Bureau Veritas Calgary (19th), 4000 19th Street NE, Calgary, AB, T2E 6P8

(2) This test was performed by Eurofins Environment Testing Canada, 146 Colonnade Road, Unit #8, Ottawa, ON, K2E 7Y1

(3) Offsite analysis requires that subcontracted moisture be reported.



Your Project #: 21466052
Site Location: LVIV BLVD
Your C.O.C. #: 847598-101-01

Attention: Anastasia Poliacik

Golder Associates Ltd
100 Scotia Crt
Whitby, ON
CANADA L1N 8Y6

Report Date: 2021/10/20
Report #: R6860459
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1T4258

Received: 2021/10/08, 16:16

(4) Oxidation-Reduction Potential (ORP) values are determined using a Ag/AgCl reference electrode.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ema Gitej, Senior Project Manager

Email: emese.gitej@bureauveritas.com

Phone# (905)817-5829

=====

This report has been generated and distributed using a secure automated process.

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation please refer to the Validation Signature Page.



SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		QWX562		
Sampling Date		2021/10/01 13:55		
	UNITS	SA-5	RDL	QC Batch
Calculated Parameters				
Resistivity	ohm-cm	930		7629010
Inorganics				
Soluble (20:1) Chloride (Cl-)	ug/g	610	20	7639043
Conductivity	umho/cm	1080	2	7639215
Available (CaCl2) pH	pH	7.98		7639421
Soluble (20:1) Sulphate (SO4)	ug/g	34	20	7639052
Sulphide	mg/kg	1.4 (1)	0.5	7642246
Physical Testing				
Moisture-Subcontracted	%	7.6	0.30	7647533
RDL = Reportable Detection Limit QC Batch = Quality Control Batch (1) Sample contained greater than 10% headspace at time of extraction. Sample extracted past method-specified hold time. Analyzed past method specified hold time				



BUREAU
VERITAS

Bureau Veritas Job #: C1T4258

Report Date: 2021/10/20

Golder Associates Ltd

Client Project #: 21466052

Site Location: LVIV BLVD

Sampler Initials: JU

TEST SUMMARY

Bureau Veritas ID: QWX562

Sample ID: SA-5

Matrix: Soil

Collected: 2021/10/01

Shipped:

Received: 2021/10/08

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7639043	2021/10/15	2021/10/15	Avneet Kour Sudan
Conductivity	AT	7639215	2021/10/15	2021/10/15	Massarat Jan
Moisture (Subcontracted)	BAL	7647533	N/A	2021/10/15	Lasindu Abeywardene
Sulphide in Soil	SPEC	7642246	N/A	2021/10/15	Bailey Morrison
pH CaCl2 EXTRACT	AT	7639421	2021/10/15	2021/10/15	Taslima Aktar
Resistivity of Soil		7629010	2021/10/15	2021/10/15	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7639052	2021/10/15	2021/10/15	Avneet Kour Sudan
Redox Potential	COND	7644943	2021/10/19		Ankita Bhalla



GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	9.3°C
-----------	-------

Results relate only to the items tested.



QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
7639043	AKD	Matrix Spike	Soluble (20:1) Chloride (Cl-)	2021/10/15		NC	%	70 - 130
7639043	AKD	Spiked Blank	Soluble (20:1) Chloride (Cl-)	2021/10/15		106	%	70 - 130
7639043	AKD	Method Blank	Soluble (20:1) Chloride (Cl-)	2021/10/15	<20		ug/g	
7639043	AKD	RPD	Soluble (20:1) Chloride (Cl-)	2021/10/15	2.0		%	35
7639052	AKD	Matrix Spike	Soluble (20:1) Sulphate (SO4)	2021/10/15		110	%	70 - 130
7639052	AKD	Spiked Blank	Soluble (20:1) Sulphate (SO4)	2021/10/15		99	%	70 - 130
7639052	AKD	Method Blank	Soluble (20:1) Sulphate (SO4)	2021/10/15	<20		ug/g	
7639052	AKD	RPD	Soluble (20:1) Sulphate (SO4)	2021/10/15	NC		%	35
7639215	MI1	Spiked Blank	Conductivity	2021/10/15		100	%	90 - 110
7639215	MI1	Method Blank	Conductivity	2021/10/15	<2		umho/cm	
7639215	MI1	RPD	Conductivity	2021/10/15	2.2		%	10
7639421	TAK	Spiked Blank	Available (CaCl2) pH	2021/10/15		100	%	97 - 103
7639421	TAK	RPD	Available (CaCl2) pH	2021/10/15	0.11		%	N/A
7642246	BYM	Matrix Spike	Sulphide	2021/10/15		63 (1)	%	75 - 125
7642246	BYM	Spiked Blank	Sulphide	2021/10/15		86	%	75 - 125
7642246	BYM	Method Blank	Sulphide	2021/10/15	<0.5		mg/kg	
7642246	BYM	RPD	Sulphide	2021/10/15	6.8		%	30
7647533	LAB	Method Blank	Moisture-Subcontracted	2021/10/15	<0.30		%	

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.



BUREAU
VERITAS

Bureau Veritas Job #: C1T4258

Report Date: 2021/10/20

Golder Associates Ltd

Client Project #: 21466052

Site Location: LVIV BLVD

Sampler Initials: JU

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Brad Newman, B.Sc., C.Chem., Scientific Service Specialist

Veronica Falk, B.Sc., P.Chem., QP, Scientific Specialist, Organics

Maria Magdalena Florescu, Ph.D., P.Chem., QP, Inorganics Manager

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Your Project #: 21466052
Site Location: LVIV
Your C.O.C. #: 847598-18-01

Attention: Anastasia Poliacik

Golder Associates Ltd
100 Scotia Crt
Whitby, ON
CANADA L1N 8Y6

Report Date: 2021/11/15
Report #: R6902994
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: C1W7780

Received: 2021/11/08, 14:17

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date	Date	Laboratory Method	Analytical Method
		Extracted	Analyzed		
Chloride (20:1 extract)	1	2021/11/12	2021/11/12	CAM SOP-00463	SM 23 4500-Cl E m
Conductivity	1	2021/11/12	2021/11/12	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	1	2021/11/11	2021/11/11	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	1	2021/11/09	2021/11/12	CAM SOP-00414	SM 23 2510 m
Sulphate (20:1 Extract)	1	2021/11/12	2021/11/12	CAM SOP-00464	EPA 375.4 m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.

Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.

This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.



Your Project #: 21466052
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Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Ema Gitej, Senior Project Manager

Email: emese.gitej@bureauveritas.com

Phone# (905)817-5829

=====

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BUREAU
VERITAS

Bureau Veritas Job #: C1W7780
Report Date: 2021/11/15

Golder Associates Ltd
Client Project #: 21466052
Site Location: LVIV
Sampler Initials: MB

SOIL CORROSIVITY PACKAGE (SOIL)

Bureau Veritas ID		REB714			REB714		
Sampling Date		2021/11/07 11:15			2021/11/07 11:15		
COC Number		847598-18-01			847598-18-01		
	UNITS	STM-2-SA6	RDL	QC Batch	STM-2-SA6 Lab-Dup	RDL	QC Batch
Calculated Parameters							
Resistivity	ohm-cm	4100		7690163			
Inorganics							
Soluble (20:1) Chloride (Cl-)	ug/g	38	20	7696567			
Conductivity	umho/cm	243	2	7696604			
Available (CaCl2) pH	pH	7.62		7694302			
Soluble (20:1) Sulphate (SO4)	ug/g	79	20	7696586	66	20	7696586
RDL = Reportable Detection Limit QC Batch = Quality Control Batch Lab-Dup = Laboratory Initiated Duplicate							



BUREAU
VERITAS

Bureau Veritas Job #: C1W7780

Report Date: 2021/11/15

Golder Associates Ltd

Client Project #: 21466052

Site Location: LVIV

Sampler Initials: MB

TEST SUMMARY

Bureau Veritas ID: REB714
Sample ID: STM-2-SA6
Matrix: Soil

Collected: 2021/11/07
Shipped:
Received: 2021/11/08

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	7696567	2021/11/12	2021/11/12	Alina Dobreanu
Conductivity	AT	7696604	2021/11/12	2021/11/12	Kien Tran
pH CaCl2 EXTRACT	AT	7694302	2021/11/11	2021/11/11	Taslima Aktar
Resistivity of Soil		7690163	2021/11/12	2021/11/12	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	7696586	2021/11/12	2021/11/12	Alina Dobreanu

Bureau Veritas ID: REB714 Dup
Sample ID: STM-2-SA6
Matrix: Soil

Collected: 2021/11/07
Shipped:
Received: 2021/11/08

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Sulphate (20:1 Extract)	KONE/EC	7696586	2021/11/12	2021/11/12	Alina Dobreanu



GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	7.0°C
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Sample REB714 [STM-2-SA6] : Sample has been analyzed for Chloride, Sulphate, pH and Conductivity/Resistivity as per client request.

Results relate only to the items tested.



BUREAU
VERITAS

Bureau Veritas Job #: C1W7780

Report Date: 2021/11/15

Golder Associates Ltd

Client Project #: 21466052

Site Location: LVIV

Sampler Initials: MB

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
7694302	TAK	Spiked Blank	Available (CaCl ₂) pH	2021/11/11		100	%	97 - 103
7694302	TAK	RPD	Available (CaCl ₂) pH	2021/11/11	0.64		%	N/A
7696567	ADB	Matrix Spike	Soluble (20:1) Chloride (Cl ⁻)	2021/11/12		NC	%	70 - 130
7696567	ADB	Spiked Blank	Soluble (20:1) Chloride (Cl ⁻)	2021/11/12		105	%	70 - 130
7696567	ADB	Method Blank	Soluble (20:1) Chloride (Cl ⁻)	2021/11/12	<20		ug/g	
7696567	ADB	RPD	Soluble (20:1) Chloride (Cl ⁻)	2021/11/12	2.0		%	35
7696586	ADB	Matrix Spike [REB714-01]	Soluble (20:1) Sulphate (SO ₄)	2021/11/12		NC	%	70 - 130
7696586	ADB	Spiked Blank	Soluble (20:1) Sulphate (SO ₄)	2021/11/12		104	%	70 - 130
7696586	ADB	Method Blank	Soluble (20:1) Sulphate (SO ₄)	2021/11/12	<20		ug/g	
7696586	ADB	RPD [REB714-01]	Soluble (20:1) Sulphate (SO ₄)	2021/11/12	18		%	35
7696604	KIT	Spiked Blank	Conductivity	2021/11/12		100	%	90 - 110
7696604	KIT	Method Blank	Conductivity	2021/11/12	<2		umho/cm	
7696604	KIT	RPD	Conductivity	2021/11/12	1.4		%	10

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)



BUREAU
VERITAS

Bureau Veritas Job #: C1W7780

Report Date: 2021/11/15

Golder Associates Ltd

Client Project #: 21466052

Site Location: LVIV

Sampler Initials: MB

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Brad Newman, B.Sc., C.Chem., Scientific Service Specialist

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APPENDIX D

Non-Standard Special Provisions

VIBRATION MONITORING – Item No.

Special Provision

Vibration monitoring during pile driving (as may be applicable) and/or installation of temporary protection systems at the Simcoe Street Underpass and along Lviv Boulevard, and during compaction operations within X m of heritage building at 597 Albert Street, will be completed by the Contractor Administrator as described herein. Prior to commencement of vibration monitoring, the Contractor shall submit the proposed pile driving (if required) and temporary protection system installation methods to the Contract Administrator for review to confirm that the proposed installation methods meets the requirements outlined herein.

The approximate locations of the vibration monitoring equipment are provided in Table 1. The actual locations of the vibration monitoring equipment may be field-adjusted when agreed in writing between the Contract Administrator and Contractor, based on access and Contractor's working areas.

Table 1: Approximate Locations of Vibration Monitoring Equipment

Purpose	Monitoring Station	Latitude	Longitude
Monitoring during construction of Storm Sewer along Lviv Boulevard	#1	43.882448°	-78.854085°
	#2	43.882412°	-78.854288°
	#3	43.882269°	-78.854833°
	#4	43.881956°	-78.856053°
	#5	Mobile location adjacent to the section of storm sewer under construction	
Monitoring during construction of Simcoe Street Underpass	#4	43.881956°	-78.856053°
	#6	43.881164°	-78.855964°

The Contractor shall adequately protect the monitoring equipment such that each instrument is accessible, is not damaged during construction, and is secured against vandalism and/or theft. The Contractor shall be responsible for all costs associated with the repair and/or replacement of damaged or missing vibration monitoring equipment.

The applicable vibration limits at the monitoring stations are provided in Table 2.

Table 2: Applicable Vibration Limits

Frequency of Vibration (Hz)	Peak Particle Velocity (mm/s)		
	For Buildings	For Heritage Buildings (597 Albert St)	For Utilities
Less than 4	8	4	50
4 to 10	15	7	50
More than 10	25	12	50

The Contractor will be notified by the Contractor Administrator should the peak particle velocity thresholds noted above be exceeded at any one of the monitoring stations. Once notification has been received, the

Contractor shall suspend and investigate construction activities producing excessive vibration. The Contractor is to submit to the Contractor Administrator a mitigation strategy detailing altered procedures and/or equipment so that vibrations remain within acceptable levels. The mitigation strategy shall only be implemented upon approval by the Contract Administrator.

PRE-CONSTRUCTION AND POST-CONSTRUCTION CONDITION SURVEY – Item No.

Special Provision

TABLE OF CONTENTS

1.0	SCOPE
2.0	REFERENCES - Not Used
3.0	DEFINITIONS
4.0	DESIGN AND SUBMISSION REQUIREMENTS
5.0	MATERIALS - Not Used
6.0	EQUIPMENT - Not Used
7.0	CONSTRUCTION
8.0	QUALITY ASSURANCE - Not Used
9.0	MEASUREMENT FOR PAYMENT - Not Used
10.0	BASIS OF PAYMENT

1.0 SCOPE

This special provision describes requirements for Pre- and Post-Condition Survey associated with construction of the following components of the Contract:

- Simcoe Street Underpass
- Storm sewer replacement along Lviv Boulevard

3.0 DEFINITIONS

For the purposes of this specification, the following definitions apply:

Pre-Construction Condition Survey means a detailed record, accompanied by film or video, as necessary, of the condition of private or public property, prior to the commencement of vibratory or vibration-inducing construction operations.

Post-Construction Condition Survey means a detailed record, accompanied by film or video, as necessary, of the condition of private or public property, following the completion of vibratory or vibration-inducing construction operations.

4.0 DESIGN AND SUBMISSION REQUIREMENTS

4.1 Submission Requirements

The Contractor shall submit details of the Pre- and Post-Construction Condition Survey plan to the Contract Administrator for information purposes. The submittals shall, at a minimum, contain the following specific information:

- a) Qualifications of condition survey specialist.
- b) Details of equipment and methods used by the Contractor to perform the work that may cause undue vibration.
- c) Details of equipment and methods to be used for the Pre- and Post-Construction Condition Surveys.

7.0 CONSTRUCTION

7.1 Pre- and Post-Construction Condition Surveys

A Pre-Construction Condition Survey and Post-Construction Condition Survey shall be prepared for all buildings, structures, and facilities within about 50 m of the proposed construction activities for the Simcoe Street Underpass and the storm sewer along Lviv Boulevard. The surveys shall be prepared for all buildings, structures, and facilities at the following addresses:

- a) 589 and 597 Simcoe Street
- b) 589, 597, 627, and 630, 632 to 638 Albert Street
- c) 8, 34, 38, 42, and 68 Lviv Boulevard
- d) 2, 44, 62, and 72 Bloor Street East
- e) 592, 594, and 598 Front Street

7.1.1 Pre-Construction Condition Surveys

The standard inspection procedure shall include the provision of an explanatory letter to the owner or occupant and owner with a formal request for permission to carry out an inspection.

The Pre-Construction Condition Survey at each structure/facility identified above shall be completed a minimum of two (2) weeks prior to commencement of vibration-inducing construction activity. Only one (1) Pre-Construction Condition Survey per structure or facility is required to be carried out in advance of construction activities that may cause undue vibration, unless more than six (6) months will elapse between these operations, in which case an interim inspection will be required.

The Pre-Construction Condition Survey shall include, as a minimum, the following information:

- f) Type of structure, including type of construction and if possible, the date when built.
- g) Identification and description of existing differential settlements, including visible cracks in walls, floors, and ceilings, including a diagram, if applicable, room-by-room. All other apparent structural and cosmetic damage or defects shall also be noted. Defects shall be described, including dimensions, wherever possible.
- h) Digital photographs or digital video or both, as necessary, to record areas of significant concern.

Photographs and videos shall be clear and shall accurately represent the condition of the property. Each photograph or video shall be clearly labelled with the location and date taken.

A copy of the Pre-Construction Construction Survey limited to a single residence or property, including copies of any photographs or videos that may form part of the report, shall be provided to the owner of that residence or property, upon request.

7.1.2 Post-Construction Condition Surveys

The standard inspection procedure shall include the provision of an explanatory letter to the owner or occupant and owner with a formal request for permission to carry out an inspection.

A Post-Construction Condition Survey at each structure/facility identified above is required within two (2) months of completion of vibration-inducing construction activity.

The Post-Construction Condition Survey shall include, as a minimum, the following information:

- a) Identification and description of existing differential settlements, including visible cracks in walls, floors, and ceilings, including a diagram, if applicable, room-by-room. All other apparent structural and cosmetic damage or defects shall also be noted. Defects shall be described, including dimensions, wherever possible.
- b) Digital photographs or digital video or both, as necessary, to record areas of significant concern.
- c) Comparison between Pre-Construction Condition Survey documented concerns and Post-Construction Condition concerns.

Photographs and videos shall be clear and shall accurately represent the condition of the property. Each photograph or video shall be clearly labelled with the location and date taken.

A copy of the Post-Construction Condition Survey limited to a single residence or property, including copies of any photographs or videos that may form part of the report, shall be provided to the owner of that residence or property, upon request. The report shall confirm that there have been no changes to the property between the Pre-Construction Condition Survey and the Post-Construction Condition Survey as a result of construction activities that may result in undue vibration.

7.2 Records

The Contractor shall submit details of the Pre- and Post-Construction Condition Survey to the Contract Administrator as follows:

- a) An interim report containing all relevant data including the Pre-Construction Condition Survey prior to the start of vibration inducing construction activity.
- b) A final report containing all relevant data including vibration monitoring and Pre- and Post-Construction Condition Surveys within two (2) weeks upon completing the Post-Condition Survey.

10.0 BASIS OF PAYMENT

Payment at the Contract price for the above tender item shall be full compensation for all labour, equipment and material required to do the work.



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