Subsurface Conditions Baseline Report

Watermain Installation at Station 17+035, QEW Widening from West of Mississauga Road to West of Hurontario Street, City of Mississauga, Ministry of Transportation, Ontario, GWP 2002-13-00

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (MH) on behalf of the Ministry of Transportation, Ontario (MTO) to prepare this Subsurface Conditions Baseline Report (SCBR) for the watermain installation crossing the Queen Elizabeth Way (QEW) at about Station 17+035, associated with the widening of the QEW from west of Mississauga Road to west of Hurontario Street in the City of Mississauga, Ontario. This report consolidates and summarizes the results of geotechnical explorations and testing carried out at the site. This report is to be read together with the Contract Drawings and Specifications (Contract Documents) prepared by the project designers (MH) and the MTO. Bidders shall refer to the Contract Documents for the order of precedence in the event of conflicting information.

The purpose of this report is to describe and summarize the subsurface conditions anticipated at the project site and to establish the baseline subsurface conditions for the Contract. It forms the basis on which to judge whether the conditions encountered during construction are materially different from those anticipated at the time of bidding.

This report provides figures that summarize data and presents baseline subsurface conditions and geotechnical engineering parameters. For individual test results, the bidder is to refer to the Foundation Investigation Report (FIR) for this watermain installation site, prepared by Golder (GEOCRES No. 30M12-450, dated July 30, 2019). Where alignments and stations are shown on the figures or referenced in the text, they are based on the General Arrangement drawings provided by MH. The stations referred to in this SCBR are approximate and the Contractor is expected to refer to the Contract Documents for the exact station, coordinates and details of existing and proposed features, structures and buried utilities.

This SCBR is intended to:

- provide a subsurface conditions baseline for bidding the work;
- assist the project Owner in reviewing the Contractor's submittals; and
- establish a subsurface conditions baseline that will be used to resolve disputes and claims related to subsurface conditions.

This SCBR has been prepared for a Design-Bid-Build construction contract for the installation of the primary liner and the watermain at the above-noted site and does not provide discussions on the anticipated ground behaviour in relation to specific construction means and methods because the Contractor is responsible for and will select the construction means and methods. This report does describe anticipated natural soil behaviour in the absence of any support or modification provided by the Contractor's means and methods. Therefore, the content of this report departs from typical practice, and this SCBR is not to be considered the equivalent of a Geotechnical Baseline Report, as defined in ASCE (2007).

The provision of baseline conditions in the Contract is not a warranty that the baseline conditions will be encountered; rather, the baseline conditions represent a contractual basis for the Owner and the Contractor to use when interpreting the differing site conditions clause in the General Conditions and Special Conditions of the Contract. The Contractor is to rely on this report for bidding and construction planning purposes related to anticipated ground and groundwater conditions and the Contractor is to plan construction and select equipment to fully address the expected baseline conditions identified in this report.

This SCBR is applicable only to the watermain installation section that will cross beneath the QEW using tunnelling methods and is not applicable to other elements of the QEW Widening from west of Mississauga Road to west of Hurontario Street or other sections of the watermain.

2.0 SITE AND PROJECT DESCRIPTION

The proposed watermain installation at Station 17+035 is located approximately 200 m east of the Credit River in the City of Mississauga, Ontario (see Drawing 1). The proposed watermain will cross under the widened Premium Way from area the connection to Stavebank Road on the north side of the QEW and the QEW extending for an overall length of about 81 m. The QEW and, Premium Way, and Pinetree Way are oriented in a northeast-southwest direction which, for the purpose of this report, is considered as a west-east orientation, and Stavebank Road and the proposed crossing are oriented in a northwest-southeast direction, to approximately 38 m north of Pinetree Crescent on the south side of the QEW.

The QEW is comprised of three eastbound lanes (Toronto) and three westbound lanes (Hamilton), while Premium Way, Pinetree Way and Stavebank Road are comprised of one lane in each direction. Residential areas are located on south side of the QEW and along most of the north of Premium Way; greenspace and hydro poles/overhead electrical lines occupy the area at the north and of the watermain and greenspace and pump station occupy the area at the south end of the watermain. The existing ground surface along the alignment of the relocated watermain varies from about Elevation 96.5 m at the north end to about Elevation 94.5 m at the south end.

3.0 SOURCES OF INFORMATION

The documents listed in this section have been used in developing the SCBR, but these are not to be considered part of the SCBR and publications are referenced herein for information purposes only.

Where precise determination of deposit boundaries or geotechnical engineering parameters are necessary for the safety and stability of the works, or for other construction concerns, or in instances where specialized geotechnical engineering properties of soils or bedrock are required but are not presented in the SCBR, these boundaries and parameters are to be identified and determined by supplementary investigations and testing by the Contractor prior to construction. This SCBR provides baseline conditions only for the physical subsurface conditions and does not provide baseline conditions for the chemistry of the soil, bedrock or groundwater.

3.1 Subsurface Data

Subsurface data gathered from multiple sources have been used in development of this report. The principal source of data is the FIR, referenced below. The subsurface materials as characterized in the FIR were defined at specific sample locations within the boreholes, and the Contractor is expected to review the specific subsurface data available in the FIR. However, the interpretation of geotechnical engineering properties and parameters for the deposits and the stratigraphy as interpreted between samples provided in this SCBR are the baselines for this project. In the event of conflict between the FIR and the SCBR, the SCBR shall be given precedence for the purpose of tendering and evaluating claims related to ground conditions.

- Golder Associates Ltd. “Foundation Investigation Report, Watermain Installation, Station 17+035, QEW Widening from West of Mississauga Road to West of Hurontario Street, Mississauga, Ministry of Transportation, Ontario, GWP 2002-13-00”, dated July 30, 2019, GEOCRES No. 30M12-450.

3.2 Geological References

The geological publications referenced in this document and listed below are for general information purposes only.

- Brennand, T. A. “Urban Geology of Toronto and Surrounding Area” in *Urban Geology of Canadian Cities*. GAC Special Paper 42, pp. 323-352. Karrow, P.F., and White O.L., Editors, Geological Association of Canada Special Paper 42, Geological Association of Canada, Newfoundland, 1998.
- Chapman, L.J. and Putnam, D.F. *The Physiography of Southern Ontario*. 3rd Edition, Ontario Geological Survey, Special Volume 2, 1984. Ontario Ministry of Natural Resources.

3.3 Publications

The publications referenced in this document, as listed below, are for general information purposes only.

- ASCE (2007). *Geotechnical Baseline Reports for Construction: Suggested Guidelines.* The Technical Committee on Geotechnical Reports of the Underground Technology Research Council, R.J. Essex, chairman, ASCE, Reston, VA, 62 pp.
- Boone, S.J., Westland, J., Busbridge, J.R., and Garrod, B. (1998). “Prediction of Boulder Obstructions”, In *Tunnels and Metropolises, Proceedings of World Tunnel Congress 1998*, Sao Paulo, Brazil. A. Negro and A. Ferreira, Editors, Balkema, Rotterdam, pp. 817-822.
- Canadian Geotechnical Society (2006). *Canadian Foundation Engineering Manual*, 4th Edition. BiTech Publishers Ltd., Richmond, British Columbia.
- Heuer, R. E. (1974). “Important Ground Parameters in Soft Ground Tunneling”, in *Proceedings Specialty Conference on Subsurface Explorations for Underground Excavations and Heavy Construction*, ASCE, Reston, VA., pp. 152-167.
- Kulhawy, F.H. and P.W. Mayne. (1990). *Manual on Estimating Soil Properties for Foundation Design*. Report EPRI-EL6800. Palo Alto, CA, Electric Power Research Institute.
- Ministry of the Environment Ontario (2005). Water Well Information System, Version 2.01. Hydrogeology of Southern Ontario, Second Edition. http://www.ene.gov.on.ca/envision/techdocs/4800e_index.htm
- Poot, S., Boone, S.J., Westland, J., and Pennington, B. (2000). “Predicted Boulder Frequency Compared to Field Observations During Construction”, in *Proceedings of the 50th Canadian Geotechnical Conference*, Montreal, pp. 47-54.

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

The interpreted and simplified stratigraphic profile shown on Drawing 2 is the baseline stratigraphy for this project and is a simplification of the subsurface conditions encountered at and between the borehole locations.

Although interpreted strata boundaries are illustrated on Drawing 2, it must be understood that the stratigraphic boundaries illustrated on Drawing 2 are inferred from non-continuous sampling, observations of drilling progress and results of Standard Penetration Tests, and, therefore represent transitions between soil types rather than exact planes of geological change; actual contacts between deposits will typically be gradational as a result of natural geologic processes. Further, the boundaries shown on Drawing 2 are illustrated for the indicated section line and are based on projection of the subsurface data onto this line. Variations in the deposit boundaries and the boundaries of major intra-deposit zones from those illustrated must be anticipated both along and perpendicular to the profile line. Therefore, selection of construction equipment and procedures must be made to accommodate variations in the deposit boundaries as described in this SCBR. Where precise determination of deposit boundaries is necessary for the safety and stability of the works, or for other construction concerns, they are to be verified by supplementary investigations and testing by the Contractor prior to construction.

In summary, the stratigraphy encountered at the various borehole locations typically consists of surficial layers of asphalt / concrete pavement or topsoil underlain by non-cohesive fill underlain by a sandy silt to silty sand deposit, in turn underlain by an interlayered deposit of silt to clayey silt to silty clay. The cohesive deposit is underlain by a cohesive till deposit, underlain by deposits of sand to sand and gravel in one borehole. In places the sandy silt and cohesive till deposits are underlain by a cohesive deposit of residual soil and in the deeper boreholes shale bedrock was encountered.

Within this SCBR, the stratigraphy is defined and described based on the likely geologic origin, grain size distribution, plasticity characteristics and relative elevation. This approach is used to avoid geologic unit classifications based on geologic age or stage of glacial advance. In some instances, geologic nomenclature, although correct in defining the geologic origin and age of a particular layer, does not necessarily convey indications of material type or potential engineering behaviour. Precedence in this SCBR has therefore been given to naming the different soil layers based on relative elevation, grain size distribution and plasticity characteristics.

4.2 Baseline Engineering Characteristics of Soil

This section of the SCBR provides baseline geotechnical engineering parameters to be used for design of temporary works and for selection of equipment and construction methods. The baseline geotechnical engineering parameters presented are those considered relevant for the proposed installation of a protective outer casing for a watermain. Baseline values are provided consistent with 10^{th}, 50^{th}, and 90^{th} percentiles, as a means for quantitatively describing the statistical distribution of the parameter values and their natural variability. In some cases, the percentiles are based directly on statistical evaluation of available data and, in other cases, these values are supplemented by judgement based on local and regional experience with these soil and bedrock types. While the 50^{th} percentile value can be used for some design purposes, the range represented by the 10^{th} to 90^{th} percentiles must also be considered as variability in physical properties is intrinsic to the nature of earth materials and is to be taken into account for estimating quantities, selection of equipment, and selection of construction means and methods.

Engineering Classes A to E, specific to this report and identified with colours on the baseline stratigraphic profile, group soil types in relation to anticipated natural behaviour during construction if exposed and in the absence of support or other modification provided through the Contractor's means and methods. The Engineering Classes used in this report are described in Table A following the text of this SCBR and in subsequent sections of this SCBR.

4.2.1 Pavement

Where boreholes were advanced through the existing pavement structures, an approximately 150 mm and 300 mm thick layer of asphalt pavement was encountered at ground surface in Boreholes PED-01 and C4-2, respectively. A 250 mm thick layer of concrete was encountered underlying the asphalt pavement in Borehole C4-2. While asphalt pavement materials were encountered within some of the boreholes, this SCBR does not provide baseline characterizations of thicknesses, extents or locations of pavement materials.

4.2.2 Topsoil

An approximately 50 mm and 150 mm thick layer of topsoil was encountered at ground surface in Boreholes PED-05 and NW3-1, respectively. Materials designated as topsoil in this report were classified solely based on visual and textural evidence. Testing of organic content or for other nutrients was not carried out. Therefore, the use of materials classified as topsoil cannot be relied upon for support and growth of landscaping vegetation. While material designated as topsoil was encountered within some of the boreholes, this SCBR does not provide baseline characterizations of thicknesses, extents or locations of topsoil materials.

4.2.3 Fill (Class A)

Approximately 1.3 m to 5.4 m thick layer of fill comprised of sandy silt to silt and sand to silty sand to sand, trace to some clay, trace organics was encountered at ground surface in Boreholes C4-1 and C4-3 and underlying the asphalt/concrete pavement or topsoil in Boreholes NW3-1, PED-01, PED-05 and C4-2. The surface of the fill layer was encountered between Elevations 96.3 m and 94.3 m and extends to depths of between 1.5 m and 5.6 m below ground surface (between Elevations 95.0 m and 90.7 m). In Borehole PED-01 from 0.2 m below ground surface (Elevation 96.1 m) to 2.7 m below ground surface (Elevation 93.6 m) the fill was found to be gravelly, and trace rootlets, asphalt fragments and clayey silt pockets were encountered. The fill is considered associated with the local road structure, QEW construction and nearby utility trenches.

A baseline grain size distribution envelope of Fill (Class A) is presented on Figure 1. Baseline classification and engineering parameters for Fill (Class A) are provided in Table 1 below. SPT N values and water content percentages are based on field sampling and lab testing.

Table 1: Baseline Geotechnical Parameters for Fill (Class A)

Parameter	10th Percentile[1.]	50th Percentile[1.]	90th Percentile[1.]
SPT "N"-Value[2.]	2	8	24
Water Content, w_n (%)	5	15	28
Gravel (%) [3.]	0	0	16
Sand (%) [3.]	49	64	78
Fines (%) [4.]	22	32	50

Parameter	10th Percentile1.	50th Percentile1.	90th Percentile1.
D_{10} (mm)	0.005	0.042	0.05
D_{60} (mm)	0.088	0.100	438
Coefficient of Uniformity, Cu	1.8	2.8	45
Wet Unit Weight, kN/m^3	18	21	22
Effective Angle of Internal Friction, φ' (degrees)	30	33	35
Estimated Permeability, k (m/s)	4.0x10^{-8}	2.5 x10^{-5}	4.9 x10^{-5}

1) While for any given sample, percentages of gradation categories (e.g., gravel, sand, fines) will add to 100 per cent, percentile values do not necessarily add to 100 per cent because these statistics represent ranges of separate measurement parameters.
2) Baseline blow counts are based on SPT "N"-values measured for 0.3 m of penetration; for this soil class, 1 out of 100 SPT values is greater than 100 blows per 0.3 m penetration, and 8 out of 100 SPT values is 0 blows, or weight of hammer.
3) Total weight of particles as compared to the total sample weight.
4) "Fines" content refers to the total weight of particles passing the 0.075 mm sieve opening size as compared to the total sample weight.

4.2.4 Granular Deposits (Class B)

Granular Deposits (silt to sandy silt, silt and sand, silty sand) ranging in total thickness from 0.8 m to 5.7 m were encountered underlying the fill in Boreholes C4-1, C4-3, PED-05 and NW3-1, and underlying the fill material the clayey silt layer in Borehole PED-05. Granular deposits were also found interlayered within the Class C deposits Borehole C4-1 at depths of between about 1.5 m and 6.8 m below ground surface and within the cohesive deposit in Borehole C4 2.. Underlying the till deposit in Borehole PED-01 the granular deposits were found to be about 9.6 m thick. Relatively thin (i.e., on the order of 1 m thick or less) interbeds of clayey silt and silty clay were also encountered within the overall Granular Deposits, as illustrated on the baseline stratigraphic profile.

A baseline grain size distribution envelope of the Granular Deposits (Class B) is presented on Figure 2. Baseline classification and engineering parameters for the Granular Deposits Soils (Class B) are provided in Table 2 below, based on the site-specific data as well as experience with similar native deposits in the project vicinity. Baseline SPT N values provided within Table 2 are for samples where a full 457 mm of penetration could be accomplished and appropriate hammer blows summed for the last 300 mm of penetration. The baseline SPT N values provided in Table 2 below are, therefore, considered representative of the soil matrix. For baseline purposes, it is expected that within the Granular Deposits approximately ten per cent of the values will be indicative of an N value of zero (i.e., weight of hammer or weight of rods), particularly at below groundwater levels assuming that drilling is completed using a head of water within the borehole consistent with static ground water levels. Further, it is expected that 5 per cent of all SPT N values will not achieve full penetration and exhibit more than 50 hammer blows for less than 0.3 m of penetration, considered representative of driving the sampler on very dense soil, gravel, cobbles and/or boulders. The presence of cobbles and boulders in the granular deposits has been inferred based on local knowledge of this geologic layer. Baseline characterization of cobbles and boulders is provided in a later section of this SCBR.

Table 2: Baseline Geotechnical Parameters for Native Granular Deposits (Class B)

Parameter	10th Percentile[1.]	50th Percentile[1.]	90th Percentile[1.]
SPT "N"-Value[2.]	6	25	51
Saturated Water Content, w_n (%)	14	19	26
Gravel (%) [3.]	1	10	49
Sand (%) [3.]	10	48	77
Fines (%) [4.]	17	48	90
D_{10} (mm)	0.002	0.02	0.09
D_{60} (mm)	0.04	0.1	7
Coefficient of Uniformity, Cu	1.3	8.7	38
Wet Unit Weight, kN/m^3	18	20	21
Effective Angle of Internal Friction, φ' (degrees)	30	34	39
Estimated Permeability, k (m/s)	$8.1\text{x}10^{-7}$	$1.0\ \text{x}10^{-6}$	$1.0\ \text{x}10^{-5}$

1) While for any given sample, percentages of gradation categories (e.g., gravel, sand, fines) will add to 100 per cent, percentile values do not necessarily add to 100 per cent because these statistics represent ranges of separate measurement parameters.
2) Baseline blow counts are based on SPT "N"-values measured for 0.3 m of penetration;.
3) Total weight of particles as compared to the total sample weight.
4) "Fines" content refers to the total weight of particles passing the 0.075 mm sieve opening size as compared to the total sample weight.

4.2.5 Cohesive Deposits (Class C)

A deposit of clayey silt to silty clay, trace sand to sandy, trace to some gravel was encountered underlying the Class B deposits in Boreholes C4-1, C4-2, PED-05 and NW3-1 and underlying the Class A deposit in Borehole PED-01. The cohesive deposit is interlayered in places with silt to sandy silt interlayers as described in Section 4.2.4 and as illustrated on the baseline stratigraphic profile. The surface of the deposit was encountered at depths between about 4.3 m and 7.2 m below ground surface.

The baseline grain size distribution envelope for the cohesive deposit (Class C) deposit is presented on Figure 3. The baseline envelope for Atterberg Limits is presented on Figure 4, which indicates that these materials are have low to medium plasticity. Baseline values for other geotechnical engineering parameters for the cohesive deposit are provided in Table 3 below.

Table 3: Baseline Geotechnical Parameters for cohesive deposits (Class C)

Parameter	10th Percentile[1.]	50th Percentile[1.]	90th Percentile[1.]
SPT "N"-Value[2.]	3	13	64
Water Content, w_n (%)	12	20	30
Gravel (%) [3.]	1	3	17
Sand (%) [3.]	2	13	31
Fines (%) [4.]	68	82	98
Plastic Limit, PL (%)	14	19	21
Liquid Limit, LL (%)	22	32	45
Plasticity Index, PI	5	15	24
D_{10} (mm)	0.0001	0.0005	0.004
D_{60} (mm)	0.007	0.03	0.09
Coefficient of Uniformity, Cu	10	64	225
Wet Unit Weight, kN/m^3	17	19	22
Effective Angle of Internal Friction, φ' (degrees)	30	32	38
Undrained Shear Strength S_u (kPa)	15	60	400
Estimated Permeability, k (m/s)	4.0×10^{-10}	2.5×10^{-9}	1.0×10^{-8}

1) While for any given sample, percentages of gradation categories (e.g., gravel, sand, fines) will add to 100 per cent, percentile values do not necessarily add to 100 per cent because these statistics represent ranges of separate measurement parameters.
2) Baseline blow counts are based on SPT "N"-values measured for 0.3 m of penetration..
3) Total weight of particles as compared to the total sample weight.
4) "Fines" content refers to the total weight of particles passing the 0.075 mm sieve opening size as compared to the total sample weight.

4.2.6 Glacial Till (Class D)

A cohesive till deposit was encountered underlying the Class C deposit in Boreholes C4-1, PED-01, and NW3-1, and underlying the Class B deposits in Boreholes C4-3 and PED-05 at depths between about 5.6 m and 9.3 m below ground surface. The till deposit consists of clayey silt with sand to sandy clayey silt to clayey silt, trace to some gravel, and containing shale fragments and cobbles in Borehole C4-1. Baseline SPT N values provided within Table 4 are for samples where a full 457 mm of penetration could be accomplished and appropriate hammer blows summed for the last 300 mm of penetration. The baseline SPT N values provided in Table 4 below are, therefore, considered representative of the soil matrix. For baseline purposes, it is expected that within the Glacial Till Deposits approximately 30 per cent of all SPT N values will not achieve full penetration and exhibit more than 100 hammer blows for less than 0.3 m of penetration, considered representative of driving the sampler on very dense soil, gravel, cobbles and/or boulders. For baseline purposes, it is expected that the top 1 m to 1.5 m of this deposit, below the interface with the overlying saturated Granular Deposits and Cohesive Deposits, will be softer with stiffness increasing with depth, hence the relatively wide range in baseline SPT N values.

The baseline grain size distribution envelope for the Glacial Till (Class D) deposit is presented on Figure 5. The baseline envelope for Atterberg Limits is presented on Figure 6, which indicates that these materials are have low to medium plasticity. Above the groundwater level, the Glacial Till will be fissured and have a blocky structure when exposed. Baseline values for other geotechnical engineering parameters for the Glacial Till are provided in Table 4 below.

The presence of cobbles and boulders in the Glacial Till has been inferred based on observations during drilling and local knowledge of this geologic layer. Baseline characterization of cobbles and boulders is provided in a later section of this SCBR.

Table 4: Baseline Geotechnical Parameters for Glacial Till (Class D)

Parameter	10th Percentile[1.]	50th Percentile[1.]	90th Percentile[1.]
SPT "N"-Value[2.]	4	15	77
Water Content, w_n (%)	8	13	19
Gravel (%) [3.]	3	8	18
Sand (%) [3.]	21	29	55
Fines (%) [4.]	32	63	75
Plastic Limit, PL (%)	14	15	19
Liquid Limit, LL (%)	19	24	30
Plasticity Index, PI	6	9	13
D_{10} (mm)	0.0001	0.0006	0.03
D_{60} (mm)	0.008	0.04	1.1
Coefficient of Uniformity, Cu	36	70	81
Wet Unit Weight, kN/m^3	19	21.5	22.5
Effective Angle of Internal Friction, φ' (degrees)	30	34	38
Estimated Permeability, k (m/s)	$1.0x10^{-10}$	$4.9\ x10^{-9}$	$4.0\ x10^{-8}$

5) While for any given sample, percentages of gradation categories (e.g., gravel, sand, fines) will add to 100 per cent, percentile values do not necessarily add to 100 per cent because these statistics represent ranges of separate measurement parameters.

6) Baseline blow counts are based on SPT "N"-values measured for 0.3 m of penetration.

7) Total weight of particles as compared to the total sample weight.

8) "Fines" content refers to the total weight of particles passing the 0.075 mm sieve opening size as compared to the total sample weight.

4.2.7 Residual Soil (Class E)

A layer of materials categorized in this report as Residual Soil was encountered underlying the Class D deposit in Boreholes C4-3, PED-05 and NW3-1, and underlying the Class B interlayer in Borehole C4-2, at depths between about 8.4 m and 10.1 m below ground surface. Within this report. Residual Soil is a heterogeneous mix of fully weathered bedrock that is disintegrated into a soil like material that no longer retains the structure of parent bedrock.. Samples that could be subjected to grain size distribution testing wold be classified as sandy gravelly clayey silt to sandy clayey silt to clayey silt with these samples also containing some shale fragments. Baseline SPT N values provided within Table 5 are for samples where a full 457 mm of penetration could be accomplished and appropriate hammer blows summed for the last 300 mm of penetration. The baseline SPT N values provided in Table 5 below are, therefore, considered representative of the soil matrix. For baseline purposes, it is expected that within the Residual Soil Deposits approximately 50 per cent of all SPT N values will not achieve full penetration and exhibit more than 100 hammer blows for less than 0.3 m of penetration, considered representative of driving the sampler on very dense soil, gravel, cobbles and/or boulders.

A baseline grain size distribution envelope of the Residual Soil (Class E) is presented on Figure 7 noting, however, that this envelope is representative of materials that could be obtained by split-spoon sampling (i.e., the soil-like matrix materials) and that larger fragments of weathered rock will also be encountered within this material. The baseline envelope for Atterberg Limits is presented on Figure 8 indicates that these materials are generally low to medium plasticity. Baseline classification and engineering parameters for the residual soil deposit are provided in Table 5 below, based on the site-specific data.

The presence of cobbles and boulders and cobble and boulder sized bedrock fragments in the residual soil has been inferred based on observations during drilling and local knowledge of this geologic layer. Baseline characterization of cobbles and boulders is provided in a later section of this SCBR.

Table 5: Baseline Geotechnical Parameters for Residual Soil (Class E)

Parameter	10th Percentile[1.]	50th Percentile[1.]	90th Percentile[1.]
SPT "N"-Value[2.]	19	44	65
Water Content, w_n (%)	7	11	17
Gravel (%) [3.]	5	16	42
Sand (%) [3.]	12	27	42
Fines (%) [4.]	33	55	80
Plastic Limit, PL (%)	15	20	22
Liquid Limit, LL (%)	23	33	35
Plasticity Index, PI (%)	7	12	15
D_{10} (mm)	0.0004	0.001	0.005
D_{60} (mm)	0.011	0.090	5.6

Parameter	10th Percentile[1.]	50th Percentile[1.]	90th Percentile[1.]
Coefficient of Uniformity, Cu	23	90	1300
Wet Unit Weight, kN/m^3	18	20	22
Effective Angle of Internal Friction, φ' (degrees)	34	36	38
Estimated Permeability, k (m/s)	$1x10^{-11}$	$1x10^{-10}$	$1x10^{-9}$

1) While for any given sample, percentages of gradation categories (e.g., gravel, sand, fines) will add to 100 per cent, percentile values do not necessarily add to 100 per cent because these statistics represent ranges of separate measurement parameters.
2) Baseline blow counts are based on SPT "N"-values measured for 0.3 m of penetration;
3) Total weight of particles as compared to the total sample weight.
4) "Fines" content refers to the total weight of particles passing the 0.075 mm sieve opening size as compared to the total sample weight.

4.2.8 Shale Bedrock (Class F)

Bedrock was encountered and bedrock core samples were recovered in Boreholes PED-01, PED-05 and NW3-1 at depths of 9.5 m to 22.3 m below ground surface (Elevations 86.0 m to 74.0 m). The bedrock is described as slightly weathered to fresh, thinly laminated to medium bedded, very fine to fine grained, faintly porous, weak, grey, shale, with slightly weathered to fresh, thinly bedded, grey, fine grained, faintly porous, medium strong to very strong limestone interbeds at varying intervals of depth. The strong limestone layers range in thickness from about 10 mm to 290 mm, with an average thickness of about 55 mm. The stronger layers generally make up about 16 per cent by thickness of the bedrock cored.

Baseline values for engineering parameters for the shale bedrock are provided in Table 6 below.

Table 6: Baseline Parameters for Shale Bedrock

Parameter	10th Percentile[1.]	50th Percentile[1.]	90th Percentile[1.]
Total Core Recovery (TCR), %	92	95	100
Solid Core Recovery (SCR), %	90	95	100
Rock Quality Designation (RQD), %	85	90	100
Unconfined Compressive Strength (UC), MPa	11	18	25
Axial Point Load Index (Is_{50})	0.17	0.48	0.75

4.2.9 Groundwater Conditions

Water levels were observed in the open boreholes upon completion of drilling operations and were dry upon completion (Boreholes C4-2, PED-01 and PED-05) to between 2.7 m and 9.4 m below ground surface (between Elevations 92.2 m and 86.7 m) in Boreholes C4-1, C4-3 and NW3-1). However, the water level observed in the open boreholes during and/or upon completion of drilling does not necessarily represent the longer-term, stabilized groundwater level at the site. Standpipe piezometers were installed in Boreholes C4-1 and C4-3 and measured groundwater levels in the standpipe piezometers are summarized in Table 7:

Table 7: Recorded Groundwater Levels in Standpipe Piezometers

Borehole No.	Depth to Water Level (m)	Groundwater Elevation (m)	Date of Measurement
C4-1	4.7	91.4	February 22, 2019
	3.5	92.6	March 13, 2019
C4-3	3.4	91.5	February 27, 2019
	2.8	92.1	March 13, 2019
	3.7	91.2	March 21, 2019

A baseline groundwater level is provided on Drawing 2. For baseline purposes, groundwater levels are to be expected to fluctuate seasonally in response to changes in precipitation and snow melt to as much as 1 m above or below the baseline groundwater level. Any water infiltrating through the roadway and embankment fill is also expected to be inhibited by and therefore perched within the Fill and Granular Deposits overlying the Cohesive or Glacial Till deposits.

4.3 Cobbles, Boulders and Other Obstructions

Except for processed (crushed and screened) sand and gravel road base and the residual soil, the materials through which construction will be performed are glacially derived and therefore will contain cobbles and boulders. Cobbles are defined as rock fragments that cannot pass through a screen with 75 mm square openings, but that are less than 300 mm in maximum dimension. Boulders are defined as rock fragments with their maximum dimension equal to or greater than 300 mm. Boulders and cobbles were not sampled or cored in the boreholes advanced at the site; however, instances of auger/casing grinding were recorded during drilling in some boreholes and it is inferred that the native granular soils and glacial till soils contain cobbles and/or boulders at this site and the residual soils will contain cobble and boulder sized fragments of partially weathered or unweathered rock.

Based on past experience within the Greater Toronto Area, the combined total volume of individual boulders, known as the Boulder Volume Ratio (BVR), within glacial derived soils typically ranges between 0.15 per cent and 0.3 per cent of the excavated volume. Typically, the size distribution of boulders is such that between 5 and 10 boulders of varying sizes are found for every cumulative cubic metre of boulder rock. The number of boulders per cubic metre of cumulative boulder volume encountered is the Boulder Number Ratio (BNR). For baseline purposes, the BVR, BNR and Boulder Maximum Size values are provided in Table 8 below.

Table 8: Baseline Boulder Parameters

Parameter	Granular Deposits (Class B)	Glacial Till and Clayey Silt Residual Soils (Class D and E)
Boulder Volume Ratio (BVR)	0.1%	0.3%
Boulder Number Ratio (BNR)	10	10
Boulder Maximum Size (m^3)	0.4	1.0

For example, using the BVR and BNR provided above for an excavated volume of 100 cubic metres (m^3) of Glacial Till (Class D) (by drilling or other excavation equipment), a cumulative 0.3 m^3 of boulder rock manifested in approximately 3 boulders will be anticipated. For baseline purposes, where calculations result in a fractional number of boulders, the number is to be rounded up to the nearest integer. The Contractor is to consider penetration, breaking, or removal of cobbles routine requirements of construction and not to be accounted for separately. For baseline purposes, as part of the boulder volumes given in Table 8 above, one boulder with a diameter between 0.8 m and 1.0 m should be expected to be encountered along the tunnel alignment.
For baseline purposes, the cobbles and boulders will be composed of gneissic and dioritic rocks of the Canadian Shield. The uniaxial compressive strength of the rock forming cobbles and boulders will range from about 120 MPa to 200 MPa (10th and 90th percentiles) with a 50th percentile value of about 180 MPa.

The date of construction of the original QEW, Stavebank Road and Premium Way fill placement is unknown; as well, typical construction practices with regards to clearing and grubbing of the site prior to fill placement at the time of construction are unknown. No records of construction of the highway or local roadways (site records/journals, photographs, as-constructed drawings, etc.) were available at the time of writing this SCBR. For baseline purposes it is to be expected that where construction penetrates fill materials there will be debris consisting of broken concrete, reinforcing bars, logs, stumps and brush from previous clearing and grubbing operations and cobbles and boulders buried in the fill. The contractor must select a construction method that is capable of removing these types of obstructions in fill materials and at the transition between native and fill materials.

5.0 EXISTING UTILITIES

Utilities present along the project alignment, including but not limited to lighting, communications cables, storm sewers, and natural gas pipelines, must be accurately located and either protected or relocated. Depending upon the location, utilities relocated to avoid the trenchless construction could be affected by the settlement trough created by excavations required for trenchless construction. The Contractor is responsible for protecting existing and newly relocated utilities from settlement and horizontal displacement. Protection of utilities, support of excavations, instrumentation and monitoring have been specified elsewhere in the Contract Documents to control, measure and document the amount of displacement at these sites.

For baseline purposes, it is to be expected that utilities will be bedded in and backfilled with Class B Granular materials. These materials will conduct water and where these are within surrounding lower permeability soils or rock and/or below the baseline piezometric levels they will be saturated.

6.0 CLASSIFICATION OF ANTICIPATED GROUND BEHAVIOUR

This section of the SCBR describes the Engineering Classes of the various soil types as identified along the proposed watermain alignment, and their anticipated behaviour if exposed and unsupported. The interpreted baseline stratigraphy and the baseline piezometric level along the watermain alignment are shown on Drawing 1.

The anticipated ground behaviour presented in this report is described using the Ground Behaviour Classification System provided below in Table 9. The Tunnelman's Ground Classification System (Heuer, 1974), as derived from the original system by Terzaghi (1950), has been used as a basis to describe the anticipated behaviour of the ground. No account is taken in the given classifications of the supporting pressure provided to the face by tunneling equipment and fluids or to the response of the ground to support or modifications that are selected and implemented by the Contractor (e.g., dewatering, shoring, tunneling systems, etc.); the intent of using the Engineering Classes is to describe the behaviour of the material if exposed during excavation and tunneling without provision of support or ground modifications.

Table 9: Ground Behaviour Classification

Classification and Descriptive Terms	Sub-Classification	Behaviour
Firm		Excavation face(s) can be cut without initial support
Ravel, Raveling	Slow raveling	Chunks or flakes of material begin to drop out of the excavation face(s) sometime after the ground has been exposed, due to loosening, overstress, fissures, and “brittle” fracture (ground separates or breaks along distinct surfaces, as opposed to squeezing ground). In fast raveling ground, the process starts within a few minutes; otherwise the ground is slow raveling.
	Fast raveling	
Squeeze, Squeezing		Ground squeezes or extrudes plastically from excavation face(s) without visible fracturing or loss of continuity, without perceptible increase in water content, and exhibits ductile plastic yield and flow.
Run, Running	Cohesive-running	Apparent cohesion in moist sand, silt, or mixtures of these, or weak cementation in any non-cohesive soil, allows the material to stand for a brief period of raveling, before it breaks down and degrades to running or flowing behaviour.
	Running	Dry non-cohesive materials without cohesion are unstable at a slope greater than their angle of repose (approximately 30 to 35 degrees). When exposed at steeper slopes, the soils run like granulated sugar or dune sand until the slope flattens to the angle of repose. Soil exhibiting such behaviour is running.
Flow, Flowing		A mixture of soil and water flows from excavation face(s) like a viscous fluid. The material can flow for great distances, completely filling excavations or tunnels in some cases.

In granular soils, face stability is commonly assessed using groundwater conditions, soil gradation, variability in gradation and in situ density. The "fines content" (combined silt and clay-size fraction of soil) for the Class A through E soils is described in Section 4.2. While the fines content is conventionally useful for assisting with interpretation of soil behaviour, in the Greater Toronto Area granular soils can commonly include a significant "fines" content and yet also run, ravel or flow (depending on water content) contrary to conventional interpretations of likely behaviour. because the "fines" can consist primarily of relatively uniformly graded silt. Therefore, the baseline behaviour descriptions and classifications provided in this report have been developed specifically for this project.

Excavation through the Glacial Till (Class D) and Residual Soils (Class E) will also encounter water-bearing granular layers that will flow upon initial exposure where these are below the baseline groundwater level. Excavation difficulties such as lumping, balling and sticking to equipment are to be expected where zones/lenses with higher silt and clay contents are encountered within the cohesive deposits (Class C), Glacial Till (Class C) and Residual Soils (Class D).

7.0 CLOSURE

This Subsurface Conditions Baseline Report was prepared by Golder Associates Ltd., with input and consultation by the project designer, Morrison Hershfield Limited., on behalf of the Ministry of Transportation, Ontario for the proposed realignment of the watermain located under the QEW from Stavebank Road to Premium Way, in Mississauga, Ontario. It is intended for use by bidders of MTO Contract 2019-2016.

Golder Associates Ltd.

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MWK/SMM/SJB/rb

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https://golderassociates.sharepoint.com/sites/11176g/shared documents/07-reporting/foundations/17 to 19 - peel crossing scbr/scbr - crossing 4/3 - final/1662333 final scbr 2019july31 qew credit river peel crossing 4.docx

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TABLE A: Description of Engineering Soil Classes

Engineering Soil Class	Colour Code	Soil Type Description	Description of Engineering Class	Major Deposits	Behaviour of Engineering Classes
A		■ Sandy Silt Fill ■ Silt and Sand Fill ■ Silty Sand Fill ■ Sand Fill ■ Construction and demolition debris	■ Near-surface materials placed by man-made processes, with random and broad compositions ■ Fill can include natural and man-made materials related to highway/roadway embankment construction, containing varying fractions of gravel silt, sand and clay, along with organic material and other debris.	■ Fill	■ Above groundwater levels, slow raveling. ■ Below groundwater levels, fast raveling. ■ Groundwater flows from and within coarser layers will decrease following exposure. ■ Rapid support of these materials and groundwater control are required to control the behaviour of these materials. ■ Sand and gravel components of material are abrasive.
B		■ Sandy Silt ■ Silt and Sand ■ Silty Sand ■ Silt ■ Sand ■ Sand and Gravel	■ Uniformly and poorly graded to well graded silt, silt and sand, sand, and sand and gravel containing trace to some clay. ■ Fines content between about 8% and 98%, content of clay-size fraction equal to or less than about 18%. ■ Non-plastic. ■ Cobbles and boulders are expected within these soil types.	■ Granular Deposit	■ Above groundwater levels, running. ■ Below groundwater levels, cohesive-running to flowing. ■ Rapid support of these materials and groundwater control are required to control the behaviour of these materials. ■ Sand and gravel components of material are abrasive.

TABLE A: Description of Engineering Soil Classes

Engineering Soil Class	Colour Code	Soil Type Description	Description of Engineering Class	Major Deposits	Behaviour of Engineering Classes
C		▪ Clayey Silt ▪ Silty Clay	▪ Well graded, low to medium plasticity silts and clays, trace sand to sandy, trace to some gravel. ▪ The plasticity index of this soil class will range between about 4 per cent and 22 per cent.	▪ Cohesive Deposit	▪ Above groundwater levels, firm. ▪ Below groundwater levels, firm to squeezing. ▪ Material behaviour in exposed areas will be sensitive to variation in water content and construction traffic. ▪ Sand and gravel components of material are abrasive.
D		▪ Clayey Silt to Clayey Silt with Sand Glacial Till	▪ Well graded, low plasticity soils ranging from clayey silt to clayey silt with sand, containing trace to some gravel and rock fragments. ▪ Above groundwater levels, the glacial till is anticipated to be fissured from various weathering processes, and have a “blocky” structure when exposed. ▪ The plasticity index of this soil class will range between about 4 per cent and 15 per cent. ▪ The material varies in permeability and contains fissures ▪ Cobbles and boulders are expected within these soils.	▪ Glacial Till	▪ Above groundwater levels, firm to slow raveling ▪ Below groundwater levels, fast raveling. ▪ Material behaviour in exposed areas will be sensitive to variation in water content and construction traffic. ▪ Sand and gravel components are abrasive.

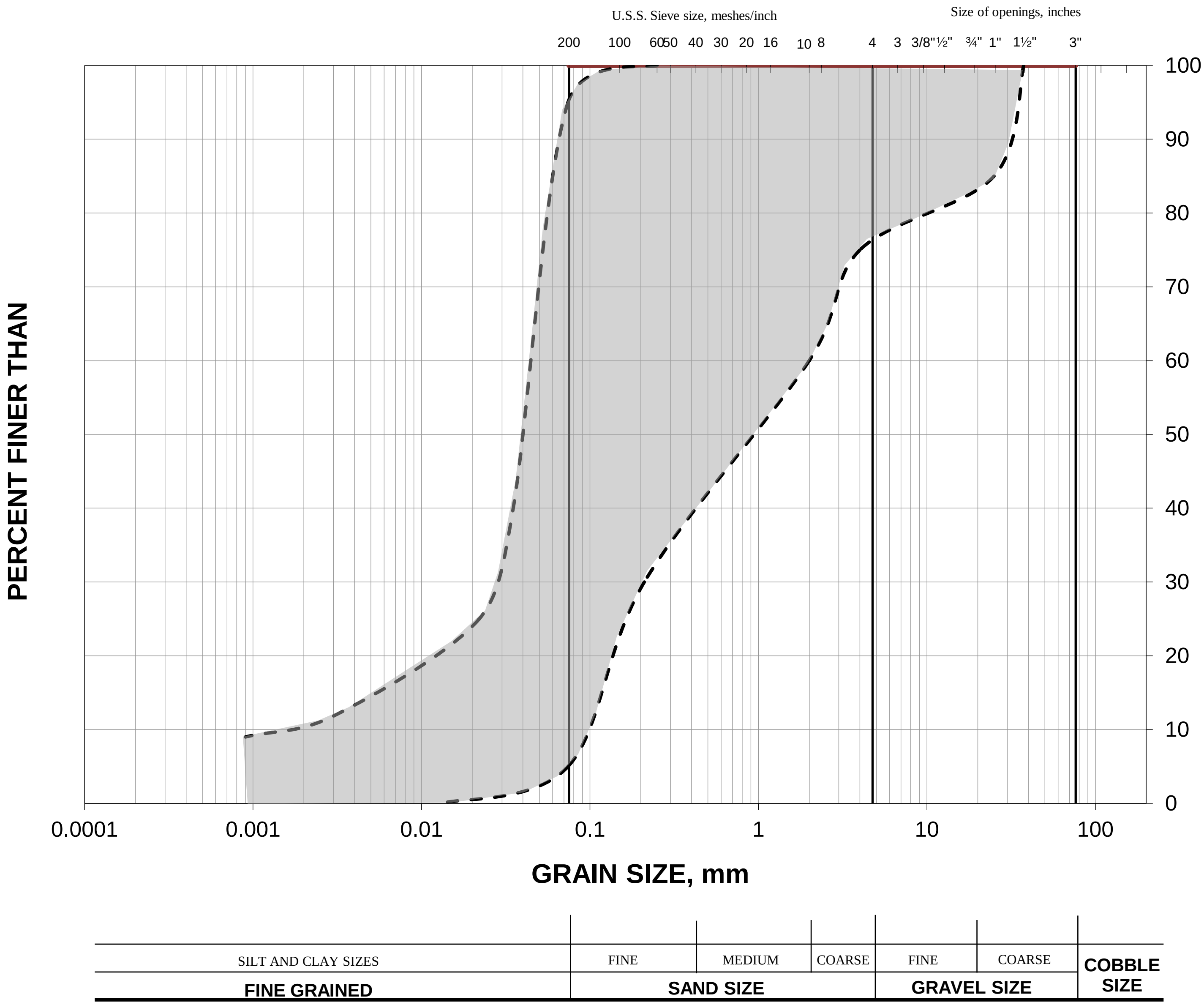
TABLE A: Description of Engineering Soil Classes

Engineering Soil Class	Colour Code	Soil Type Description	Description of Engineering Class	Major Deposits	Behaviour of Engineering Classes
E		■ Clayey Silt (Residual Soils)	■ Broadly-graded, low plasticity clayey silt, containing 30% to 45% gravel and shale rock fragments, content of clay-size fraction equal to or less than 15%. ■ The plasticity index of this soil class will range between about 3 per cent and 8 per cent. ■ The material varies in permeability and contains shale fragments from sand to boulder-size. ■ Cobbles and boulders are expected within these soils.	■ Residual Soils	■ Above groundwater levels, firm to slow raveling ■ Below groundwater levels, firm to fast raveling. ■ Material behaviour in exposed areas will be sensitive to variation in water content and construction traffic. ■ Sand and gravel components are abrasive.

Figures

Baseline Grain Size Distribution
Sandy Silt to Silt and Sand to Silty Sand to Sand (Fill)
(Class A)

FIGURE 1

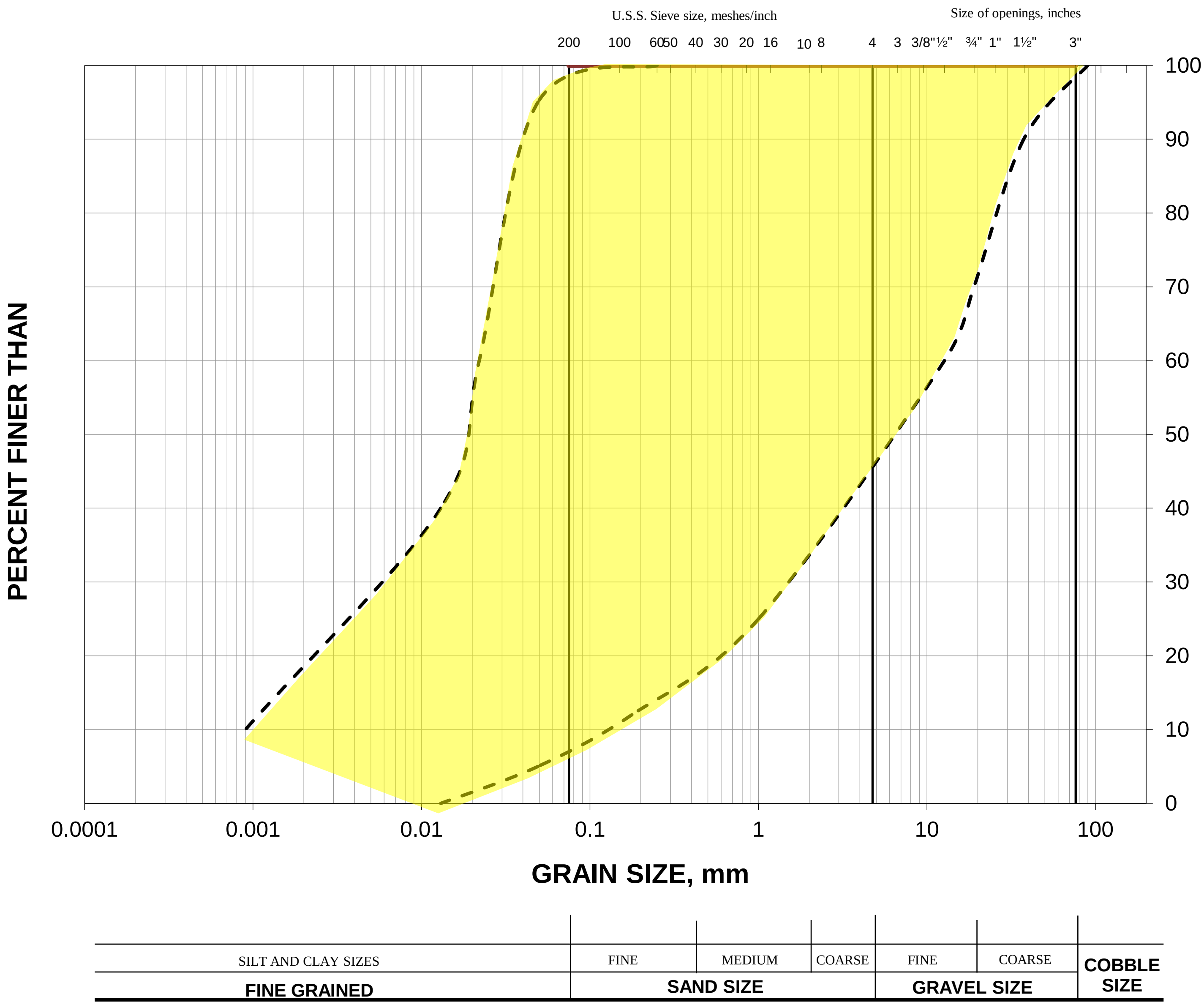


Date: April, 2019
Project: 1662333

Golder Associates

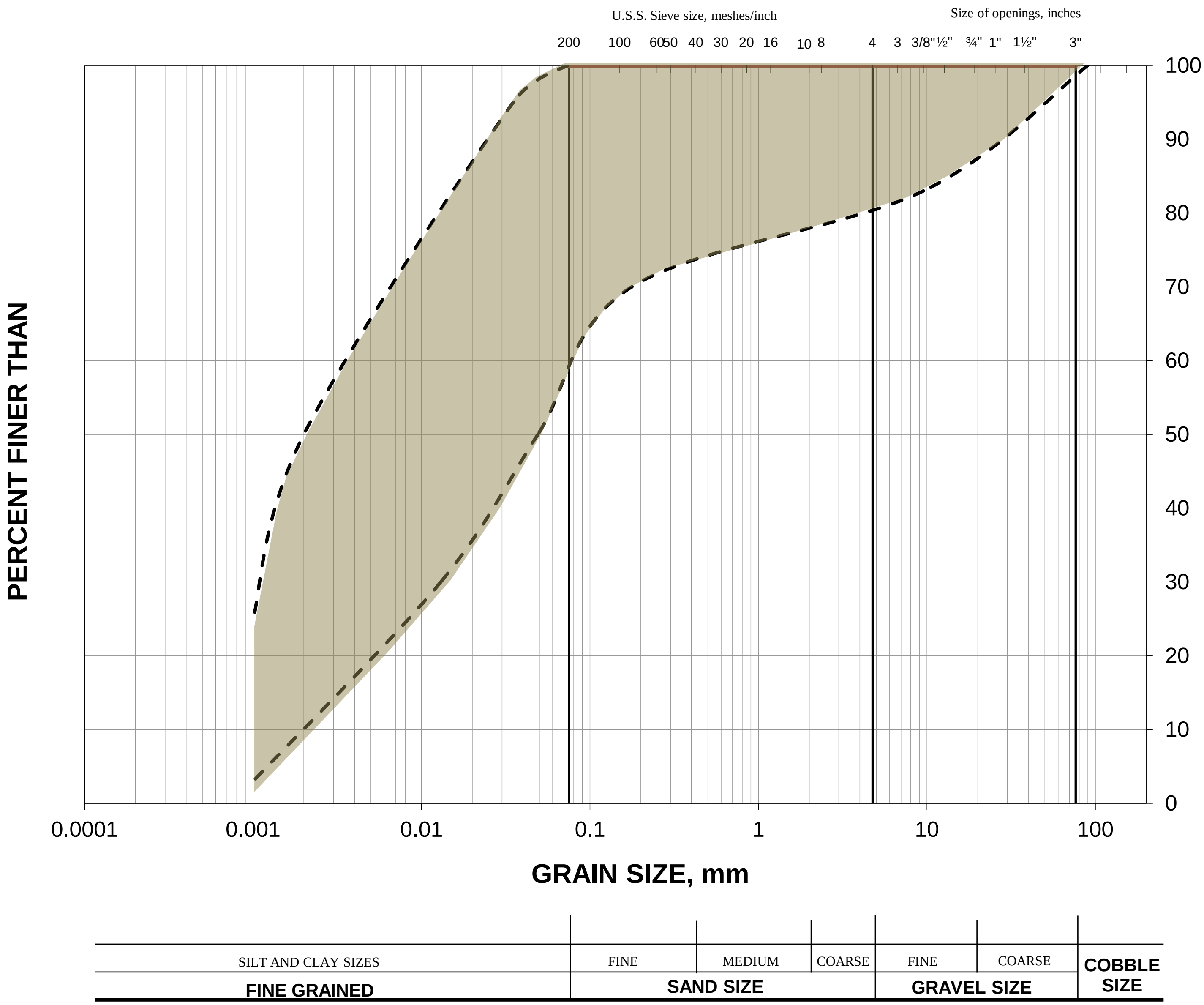
Drawn: MWK
Checked: SM

Baseline Grain Size Distribution Granular Deposits (Class B)	FIGURE 2



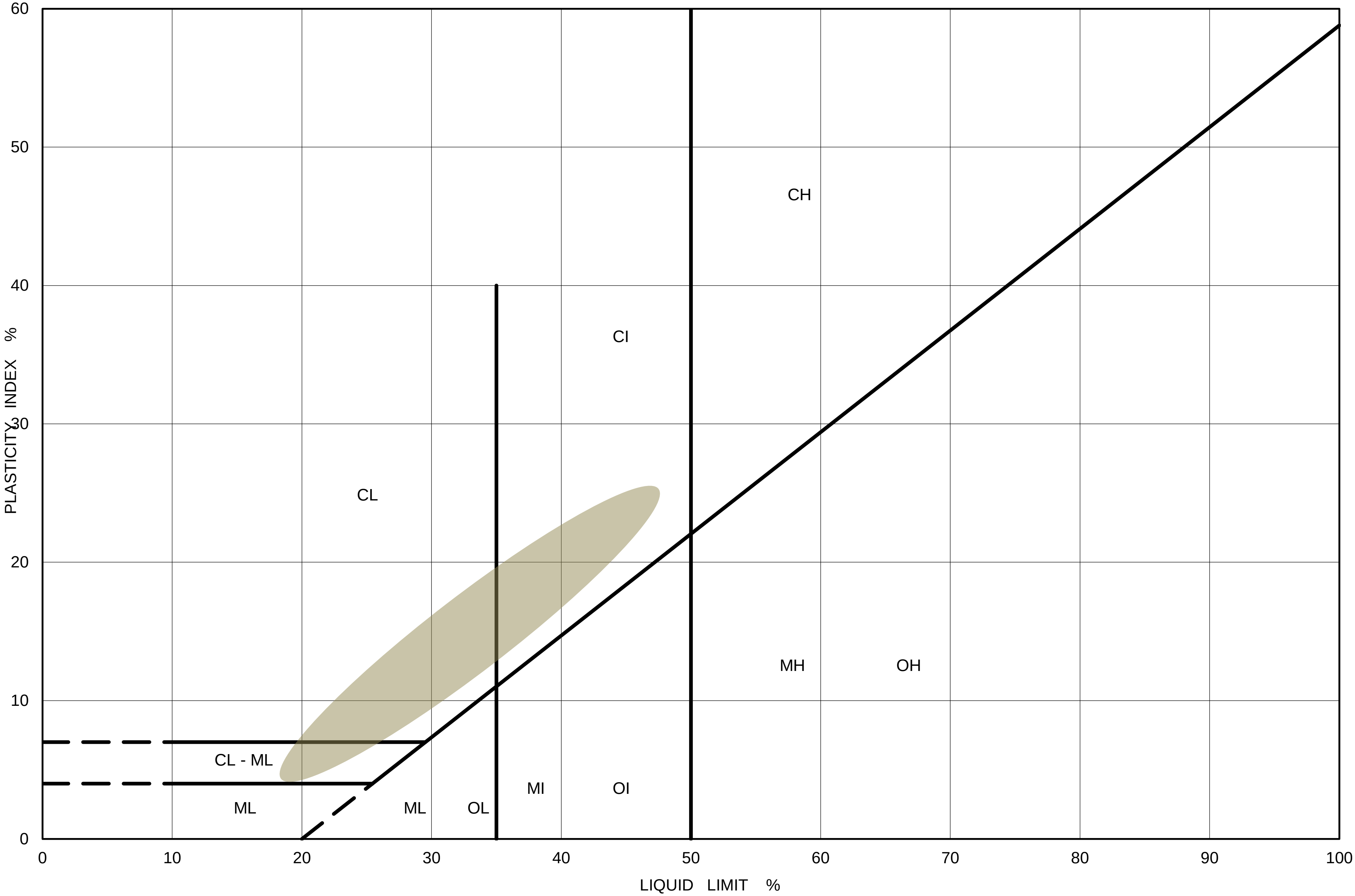
Date: April, 2019		Drawn:	MWK
Project: 1662333	**Golder Associates**	Checked:	SM

Baseline Grain Size Distribution Cohesive Deposits (Class C)	FIGURE 3



Date:	April, 2019		Drawn:	MWK
Project:	1662333	**Golder Associates**	Checked:	SM

Oct 75, FF-S-21



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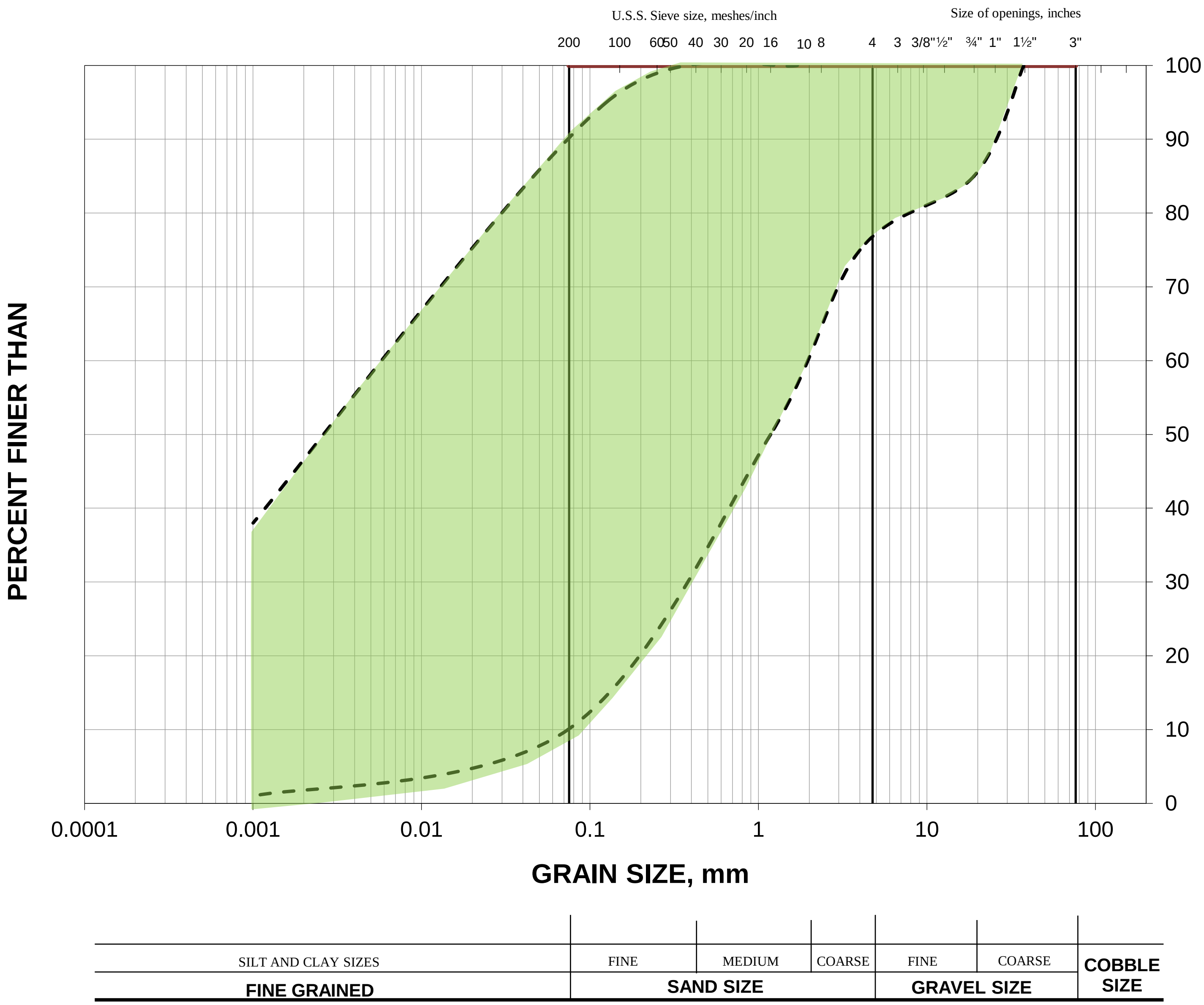
PLASTICITY CHART
Cohesive Deposits (Class C)

Figure No. 4

Project No. 1662333

Checked By: SM

Baseline Grain Size Distribution Glacial Till Deposits (Class D)	FIGURE 5

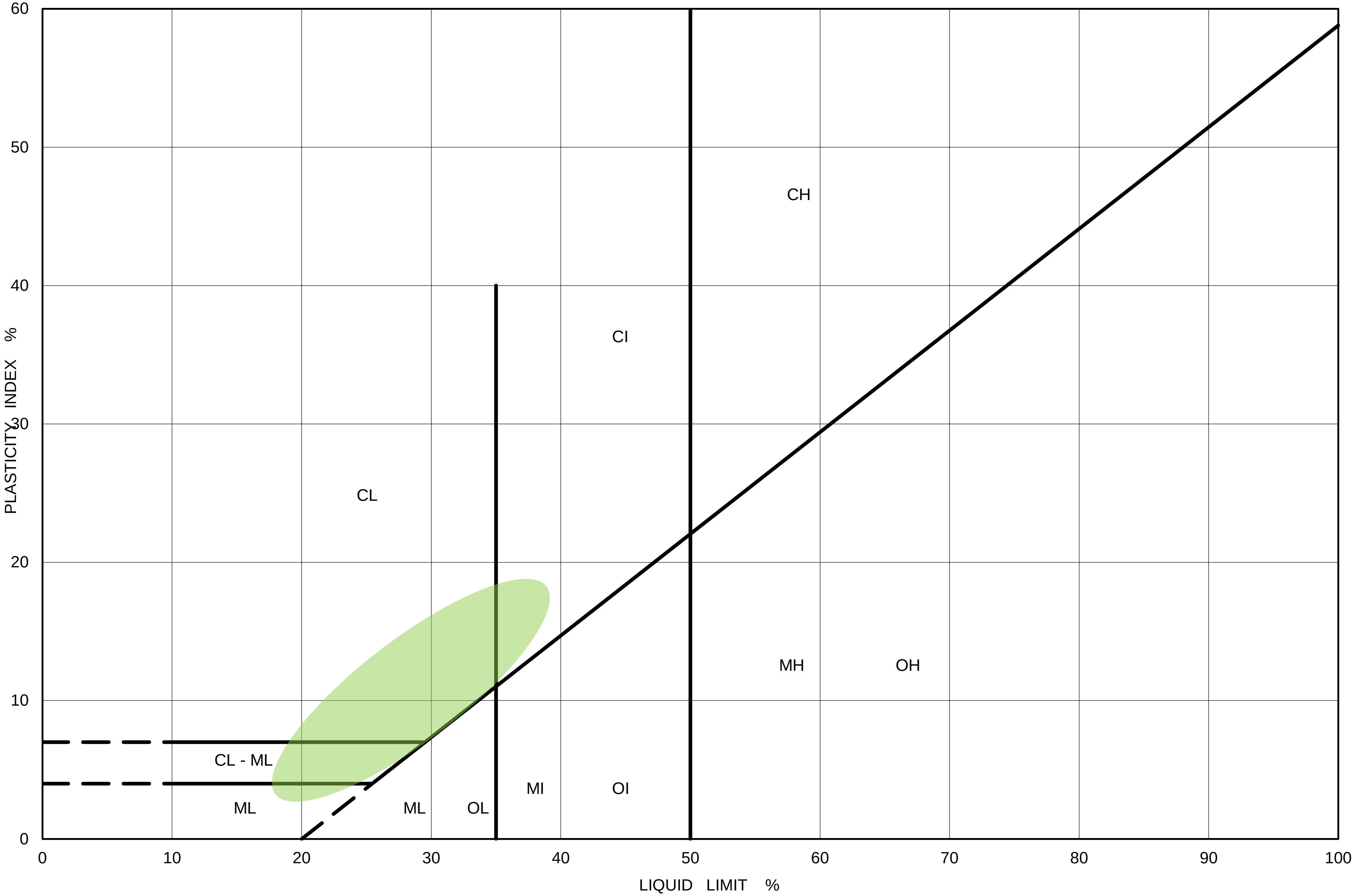


Date: April, 2019
Project: 1662333

Golder Associates

Drawn: MWK
Checked: SM

Oct 75, FF-S-21



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Ontario

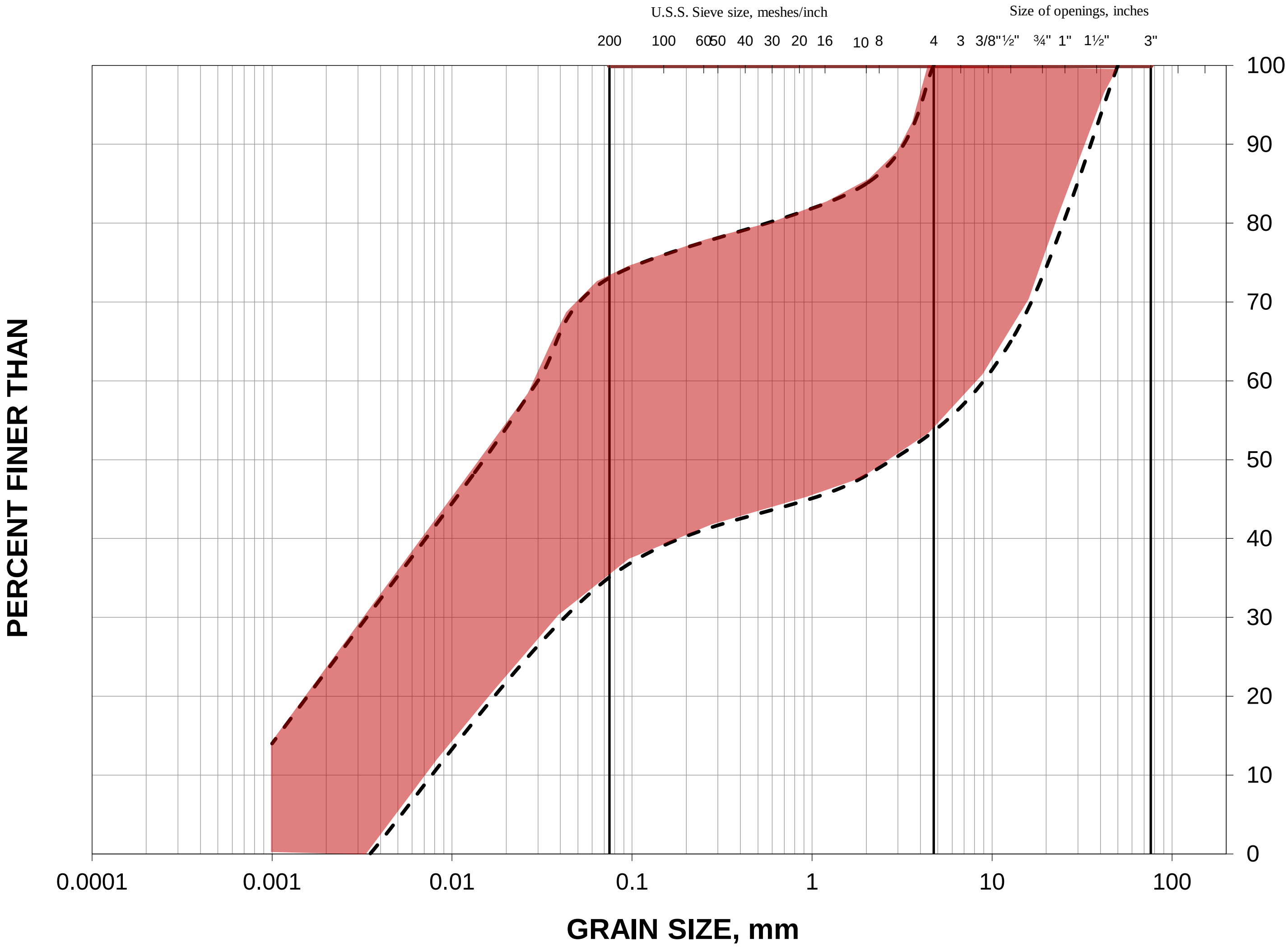
PLASTICITY CHART
Glacial Till Deposits (Class D)

Figure No. 6

Project No. 1662333

Checked By: SM

Baseline Grain Size Distribution Residual Soil (Class C)	FIGURE 7



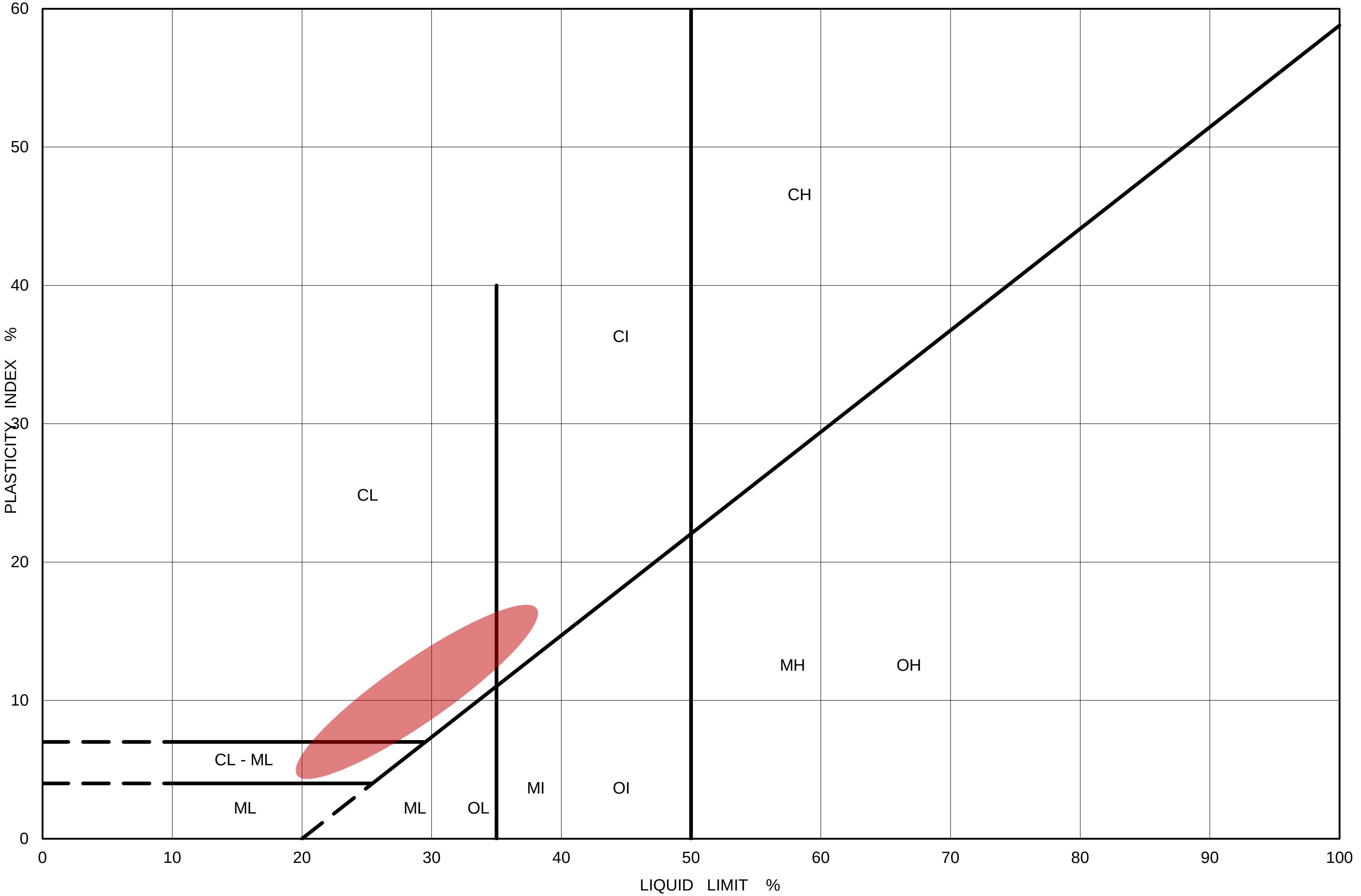
SILT AND CLAY SIZES	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND SIZE			GRAVEL SIZE		

Date: April, 2019
Project: 1662333

Golder Associates

Drawn: AB
Checked: SM

Oct 75, FF-S-21



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PLASTICITY CHART
Residual Soil (Class D)

Figure No. 8

Project No. 1662333

Checked By: SM

Drawings

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

CONT No.
GWP No. 2002-13-00

SHEET

QEW WIDENING – MISSISSAUGA RD TO HURONTARIO ST
WATERMAIN INSTALLATION STATION 17+035

BOREHOLE LOCATIONS

GOLDER

PLAN
SCALE
10 0 10 20 m

KEY PLAN
SCALE
2 0 2 4 km

LEGEND

● Borehole

BOREHOLE CO-ORDINATES (MTM NAD 83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
C4-1	96.1	4824290.3	295984.8
C4-2	95.5	4824285.8	296023.4
C4-3	94.9	4824269.8	296043.5
NW3-1	96.5	4824275.8	295959.8
PED-01	96.3	4824314.1	295977.3
PED-05	94.4	4824275.4	296047.1

LICENSED PROFESSIONAL ENGINEER M.W.KELLY July 30, 2019 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER S.J.BOONE 90559733 July 30, 2019 PROVINCE OF ONTARIO

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.

REFERENCE

Base plans provided in digital format by MH, drawing file nos. X11609340Base.dwg, X-Final Merged Util.dwg, X-PROP-UTIL.dwg, Existing Property.dwg, 11609340 – QEW Prop Util-Dickson & Lynchmere – C3D 2017.dwg, 11609340 – QEW Prop Util-IndianGroveAve – C3D 2017.dwg, 11609340 – QEW Prop Util-Stavebank Rd – C3D 2017.dwg, 11609340 – QEW Prop Util-Knareswood Dr – C3D 2017.dwg, and x1160934_Align.dwg, received March 25, 2019.

NO.	DATE	BY	REVISION

Geocres No. 30M12-453

HWY. QEW	PROJECT NO. 1662333		DIST. CENTRAL
SUBM'D. AB/EJ	CHKD. MWK	DATE: 07/30/2019	SITE:
DRAWN: DD	CHKD. SMM	APPD. SJB	DWG. 1

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

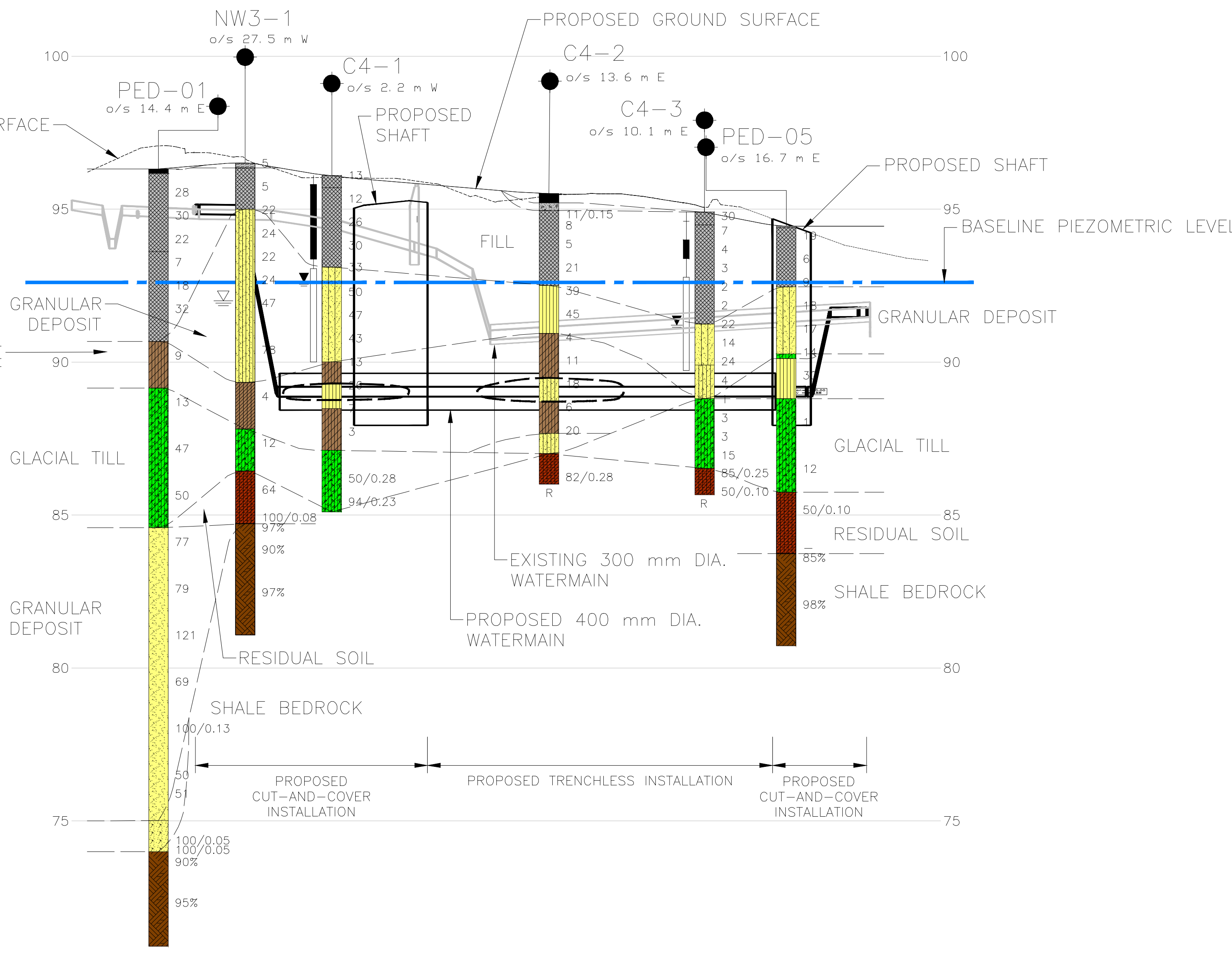
CONT No.
GWP No. 2002–13–00

QEW WIDENING – MISSISSAUGA RD TO HURONTARIO ST
WATERMAIN INSTALLATION STATION 17+035

BASELINE STRATIGRAPHIC PROFILE

SHEET

GOLDER



(A–A') PROFILE A–A' – WATERMAIN – STATION 17+035

Class A	FILL	Fill; Organics/Topsoil
Class B	GRANULAR DEPOSIT	Silt; Sandy Silt; Sand and Silt; Silty Sand; Sand; Sand and Gravel
Class C	COHESIVE DEPOSIT	Clayey Silt with Sand to Clayey Silt
Class D	GLACIAL TILL	Clayey Silt (TILL)
Class E	RESIDUAL SOIL	Sandy Gravelly Clayey Silt to Clayey Silt (Residual Soil)
Class F	SHALE BEDROCK	Shale (BEDROCK)
	— — — — — — —	Baseline Major Soil Deposit or Bedrock Boundary
	——— – ———	Interpreted Piezometric Water Level

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 Contract Documents.

This drawing is to be read in conjunction with the report titled "Subsurface Conditions Baseline Report, Watermain Installation Station 17+035, QEW Widening From West of Mississauga Road to West of Hurontario Strret, Mississagua, Ontario, Ministry of Transportation Ontario, GWP 2002–13–00, Dated May X, 2019.

This interpreted stratigraphy is a simplification of the subsurface conditions. Detailed descriptions of the conditions encountered at the borehole locations are found on the records of boreholes in the Foundation Investigation Report referenced in this report.

Major soil deposit and rock formations are delineated by the boundary line identified above. The boundary established represents the baseline ground conditions; however, variation in the boundaries from those illustrated must be anticipated both parallel and perpendicular to the section line.

The characteristics and variability anticipated with the major soil deposits are described in the text of this report. Significant layers, interlayers, and lenses within the major deposits are illustrated where identified on the borehole logs. The boundaries so illustrated are intended to highlight the variability within the deposits that will exhibit gradual transitions from one soil type to another. In addition, lenses and interlayers not detected by the subsurface investigation will be present between boreholes.

Construction equipment and procedures must be selected to accommodate variation in the deposit boundaries as well as variations within the deposits as described in the report text. Where precise determination of deposit boundaries and deposit variability are critical for safety and stability they should be verified by investigation during design and construction.

The ground surface profile and plan and profile of proposed construction are approximate and shown for illustrative purposes only. Refer to Contract Drawings for dimensions and limits of the work.

Borehole width in profile is not to scale.

VERTICAL SCALE
10 0 10 20 m

HORIZONTAL SCALE
10 0 10 20 m

KEY PLAN
SCALE
2 0 2 4 km

LEGEND

●	Borehole
▮	Seal
▯	Piezometer
N	Standard Penetration Test Value
16	Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
R	Refusal
100%	Rock Quality Designation (RQD)
▼	WL in piezometer MAR 13 and 21, 2019
▽	WL upon completion of drilling

BOREHOLE CO–ORDINATES (MTM NAD 83 ZONE 10)

No.	ELEVATION	NORTHING	EASTING
C4–1	96.1	4824290.3	295984.8
C4–2	95.5	4824285.8	296023.4
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NO.	DATE	BY	REVISION

Geocres No. 30M12–453

HWY. QEW		PROJECT NO. 1662333	DIST. CENTRAL
SUBM'D. AB/EJ	CHKD. MWK	DATE: 07/30/2019	SITE:
DRAWN: DD	CHKD. SMM	APPD. SJB	DWG. 2

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