Appendix E

Geotechnical Assessment

GEOTECHNICAL INVESTIGATION REPORT
PROPOSED NEW PEDESTRIAN BRIDGE
WFCU CENTRE
WINDSOR, ONTARIO

Submitted to:

The Corporation of the City of Windsor
2450 McDougall Avenue, Windsor, Ontario, N8X 3N6
Attn: Mr. Trevor Duquette, Parks Technologist

Submitted by:

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Distribution:
- The Corporation of the City of Windsor – 1 Hard Copy & 1 Digital Copy
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Reference Number: SWW187089

Geotechnical Investigation Report

Proposed New Pedestrian Bridge, WFCU Centre
Windsor, Ontario

Project # SWW187089

Prepared for:
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16-Aug-18

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1.0 INTRODUCTION

Wood Environment & Infrastructure Solutions, a Division of Wood Canada Limited ("Wood") was retained by the Corporation of the City of Windsor (the "City" or the "Client") to conduct a geotechnical investigation for the proposed new pedestrian bridge to be located on the east side of the WFCU Centre, over Little River in Windsor, Ontario.

The project area is shown on the Key Plan, Figure 1. Based on this information and discussion with the Client, Wood understands that the project will include the following:

- A new pedestrian bridge will be constructed on the east side of the WFCU Centre property and extend over Little River; and
- The new pedestrian bridge will be supported on shallow spread footings.

The purpose of this investigation was to provide subsurface soil information, and based on this information, to provide geotechnical recommendations pertaining to the construction of the proposed pedestrian bridge.

The scope of the fieldwork for this geotechnical investigation included three (3) boreholes to depths ranging from 8.1 m to 9.6 m below existing grade in the footprint of the proposed pedestrian bridge.

This report contains the findings of Wood's geotechnical investigation, together with recommendations and comments. The recommendations and comments are based on factual information at the test location and intended primarily for use by design engineers. The number of boreholes may not be sufficient to determine all of the factors that may affect construction methods and costs. Subsurface and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations, and conditions may become apparent during construction that could not be detected or anticipated at the time of the site investigation.

The anticipated construction conditions are also discussed, but only to the extent that they may influence the design decisions. The feasible construction methods, however, express our opinion and are not intended to direct contractors on how they carry out construction. Contractors should also be aware that the data and their interpretation presented in this report may not be sufficient to assess all factors that may have effect upon construction.

This report has been prepared with the assumption that the design will be in accordance with good engineering practices, applicable regulations of jurisdictional authorities, and applicable standards and regulations. Further, the recommendations and opinions in this report are applicable only to the proposed project. Hydrogeological or environmental considerations were not included in this scope of work. The limitations of this report, as discussed in detail in Appendix A, constitute an integral part of this report.

There should be an ongoing liaison with Wood during both the design and construction phases of this project to ensure that the recommendations in this report have been adequately interpreted and implemented. Also, any further clarification and/or elaboration are needed concerning the geotechnical aspects of this project, Wood should be contacted immediately.

2.0 SITE DESCRIPTION AND GEOLOGICAL BACKGROUND

2.1 Site Description

The site was situated on the east side of the WFCU Centre property, south of McHugh Street and stretching across Little River. The Site was grass covered at the time of the investigation, and sloped downwards at the banks of Little River. Little River flows north towards the Detroit River.

The new proposed pedestrian bridge is expected to be constructed on shallow spread footings.

2.2 Geological Background

The Site is located within a geological formation known as Essex Clay Plain, which is an extensive clay plain with little relief and poor natural drainage. The plain is underlain by a relatively thick deposit of glaciolacustrine silty clay to clayey silt till. Occasional embedded pockets and lenses of sand and silt are present within the overburden clay. The clay deposit is underlain by limestone bedrock at a depth of 35 m to 45 m, based on available drift thickness mapping (Ontario Geological Survey, Preliminary Map P.3255, 1994).

The general low permeability characteristics of the clay deposit render this deposit as an "aquitard" where the groundwater is stored in the soil pores and moves extremely slowly. Perched water tables above the "aquitard" could cause significant fluctuations in the groundwater elevations locally, depending on the prevalent weather and precipitation conditions.

3.0 INVESTIGATION PROGRAM

3.1 Field Work

The scope of the geotechnical fieldwork included three (3) sampled boreholes designated as BH1 to BH3, and ranged in depth from 8.1 m to 9.6 m below grade. The location and depth of the boreholes were determined by Wood.

The location of the boreholes from the current geotechnical investigation are shown on Figure 2. The coordinates of the boreholes are shown on the Record of Borehole sheets attached in Appendix B. The coordinates at the borehole locations were recorded in the field using a hand held GPS device with a horizontal accuracy of ±3 m.

The borehole drilling program for the investigation was carried out on April 5th, 2018. The boreholes were advanced using a self-propelled drilling machine equipped with hollow stem augers and conventional soil sampling tools. Soil samples were taken at frequent intervals of depth following the Standard Penetration Test (ASTM D1586) procedure.

The drilling was conducted under the full-time supervision of Wood's engineering staff who directed the drilling and sampling operation, and logged the boreholes.

After completion of the boreholes, the augers were extracted, the boreholes were inspected for groundwater and caving, then backfilled using bentonite pellets and grout slurry.

All samples were field logged, placed in airtight containers, and transported to Wood's Windsor laboratory for further examination and testing.

Natural moisture content tests were carried out in accordance with ASTM D2216 on all the recovered soil samples. Two selected native soil samples were tested for the grain size distribution and Atterberg limit, in accordance with ASTM D6913, ASTM D7928 and ASTM D4318. The test results are included in Appendix C.

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Soil Conditions

The following is a brief summary of the subsurface soil conditions encountered in the boreholes. The results of laboratory testing carried out on select samples are also shown on the Record of Borehole sheets in Appendix B. The results of the laboratory testing can be found in Appendix C.

Surface Conditions

Topsoil was encountered in boreholes BH1 and BH3 to depths of 125 mm and 275 mm below grade, respectively. Borehole BH2 was advanced through the gravel pathway and encountered sand and gravel fill to a depth of 75 mm below existing grade.

Silty clay fill was encountered in boreholes BH2 and BH3 to depths of 2.2 m below grade. The fill contained organics and had moisture contents ranging from 12% to 21%.

Silty Clay

Underlying the topsoil, the borehole penetrated an extensive stratum of silty clay. This stratum generally divides into three general zones, the 'weathered' zone, the 'crust' and the grey zone.

The upper zone was generally weathered. Soils in the weathered zone are subjected to freeze-thaw cycles, and changes in moisture content caused by seasonal weather variations. This zone is characterized by fissures, with a mottled brown and grey appearance. The weathered zone extended to a depth ranging from 2.1 m to 2.9 m. The measured "N" values from Standard Penetration Test obtained in the weathered zone ranged from 7 blows to 8 blows per 0.3 m penetration, indicating a firm to stiff consistency. The moisture content of the weathered clay ranged from 15% to 18%.

Below the weathered zone was the crust. The crust was characterized by a brown colour, and a minor amount of fissures and oxidation. The crust extended to a depth ranging from 4.6 m to 4.9 m below existing grade. The measured "N" values from Standard Penetration Test obtained in the brown silty clay ranged from 7 blows to 22 blows per 0.3 m penetration, indicating a firm to very stiff. The moisture contents of the brown silty clay ranged from 12% to 27%.

Underlying the crust was the grey zone. This zone of the silty clay stratum was generally characterized by increased natural moisture contents, and virtually no fissures. All three boreholes terminated within the grey zone. The measured "N" values within the grey zone ranged from 3 blows to 8 blows per 0.3 m penetration, indicating a soft to stiff consistency. Field vane shear

testing was completed in the grey silty clay and the undrained shear strengths ranged from 31 kPa to greater than 70 kPa. The moisture contents of the grey silty clay ranged from 14% to 19%.

Grain size distribution analysis and Atterberg limit tests were carried out on one sample of brown silty clay and one sample of grey silty clay. The results of these tests are included on the borehole log sheets and attached in Appendix C.

Table 1: Results of Grain Size Analysis and Atterberg Limits Test

Borehole No. / Sample No.	Sample Depth (m)	Grain Size Distribution				Atterberg Limits			USCS Modified Group Symbol
		Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit (W_L)	Plastic Limit (W_P)	Plasticity Index (I_P)	
BH1 / SA5	3.8 to 4.3	3	30	36	31	31.2	16.9	14.3	CI
BH3 / SA 7	6.1 to 6.6	5	29	36	30	25.6	14.6	11.0	CL

4.2 Groundwater

Groundwater level observations and measurements in the borehole, and in-situ moisture contents of recovered soil samples are presented on the Record of Borehole sheets.

The boreholes were left open and remained dry for the relatively brief period between withdrawal of the augers and backfilling of the boreholes. Due to the low permeability of the clayey soil at the site, insufficient time had passed to allow stabilization of groundwater levels in the open boreholes.

Typically, the grey colour of the soils noted between 4.6 m and 4.9 m below grade is indicative of a permanent saturated condition, and therefore, fluctuation of the long-term groundwater should be anticipated near these depth levels. Within the Creek channel, it is expected that the long term groundwater level be near the existing Creek's water levels. However, during and after local precipitation events, groundwater that is 'perched' above the long-term levels may accumulate in the fills and weathered mottled/brown silty clays above the relatively more impervious grey silty clay. In addition, significant amounts of groundwater may be present within the layers/pockets of granular soils known to occur randomly within the overburden soils and within any fill materials around existing utilities that may be present.

Perched groundwater may rise to the ground surface following precipitation and snowmelt. In the absence of an active, engineered drainage system, the design should assume possible temporary groundwater levels rising to the ground surface.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 General

Based on the information provided to Wood by the Client, it is understood the project consists of constructing a new pedestrian bridge across Little River to the eastern portion of the WFCU Centre property.

No loading information has been provided at this time. For the purposes of this report, it has been assumed that no unusual foundation loads or settlement limitations will be encountered for the required project structures.

5.2 Shallow Foundations

Shallow strip or spread footings are considered feasible for the proposed pedestrian bridge. The topsoil and other organic materials which were encountered at surface on the Site, and the fill material encountered in boreholes BH2 and BH3, as well as softened or loosened native soils are not suitable to support foundations and should be sub-excavated until suitable material is encountered.

The foundations should be placed below the topsoil on undisturbed native brown silty clay at a depth ranging from 2.3 m to 2.5 m below the ground surface. The subgrade should be sub-excavated to accommodate a minimum of a 1.0 m thick mat comprised of a material meeting the specifications of OPSS 1010 Granular 'A'. The granular mat should be placed in lifts not more than 200 mm and compacted to 100% of Standard Proctor Maximum Dry Density (SPMDD).Strip or square footings founded at a depths ranging from 2.3 m to 2.5 m below existing grade on approved native subgrade, may be designed using a geotechnical reaction at Serviceability Limit States (SLS) of 160 kPa and Ultimate Limit States (ULS) of 240 kPa for vertical loads, and 100 kPa SLS and 150 kPa ULS for inclined loads not greater than 10 degrees.

The SLS resistance values are based on a maximum width of strip footings of 900 mm and an isolated column footing dimension of less than 2.5 m. The SLS is based on assumed maximum and differential settlement tolerances of 25 mm and 20 mm, respectively. Wood should be consulted should the foundation depths or sizes greater than those described be required. Wood should be contacted if higher ULS and SLS values are required for the design of the building foundations.

The Granular 'A' mat should extend beyond the outside edge of the footing area a minimum of 0.5 m to ensure that the granular material is properly compacted throughout its entire lateral extent within the zone of influence of the footing. Depending on the exposed subgrade condition,

additional sub excavation of the existing material and/or use of separation geotextile and reinforcing geogrid (Terrafix BX3000 or equivalent) may be required and should be used as directed by the geotechnical engineer.

The geotechnical pressure values listed above are for no eccentricity. The ULS values could be significantly less than stated if eccentric loading conditions exist. The foundation design must also consider load inclinations and eccentricity as per the applicable principles presented in the 2006 Canadian Foundation Engineering Manual (CFEM) or the Section 6.10.4 of the Canadian Highway Bridge Design Code (CHBDC). Wood would be pleased to provide detailed assistance in the required geotechnical calculations to satisfy these requirements.

Exterior footings and footings in unheated areas should be provided with a minimum 1.2 m of soil cover or equivalent thermal insulation for adequate frost protection. The footing excavation should be reviewed by a qualified geotechnical consultant to confirm that the bearing soil has adequate bearing capacity.

Loose or disturbed material should be removed from the footing excavation prior to the placement of concrete. Hand cleaning may be required to prepare an acceptable bearing surface. The footing subgrade should be protected at all times from rain, snow, freezing temperatures and the ingress of free water. Concrete should not be placed on frozen soil, nor should the soil beneath the footing be allowed to freeze after construction of the footing.

The footings must be placed at sufficient depth to provide frost and scour protection. Additional comments regarding scour protection are provided in Section 5.4 and 5.7 of this report.

5.3 Seismic Considerations

The 2012 OBC contains updated seismic analysis and design methodology. The 2012 OBC uses a site classification system defined by the average soil/bedrock properties in the top 30 m (100 ft) of the subsurface profile beneath the structure. Based on the site investigation and our experience in this area, the project site can be classified as Site Class 'E – Soft Soil 'in accordance with the 2012 OBC criteria in Division B, Part 4, Table 4.1.8.4.A.

The four values of the Spectral response acceleration Sa (T) for different periods and the Peak Ground Acceleration (PGA) can be obtained from 2012 OBC. The design values of Fa and Fv for the project site should be calculated in accordance to 2012 OBC.

5.4 Frost Depth

The upper stratigraphy of the soils are considered highly frost susceptible in the presence of water, and as such, frost effects should be considered for foundations or surface structure sensitive to movement.

In accordance with the Ontario Provisional Standard Drawing (OPSD 3090.101) the design frost depth below the ground surface for the general area is estimated to be 1.2 m. Therefore, a minimum permanent soil cover of 1.2 m or equivalent thermal insulation is required for frost protection of shallow foundations.

Where provision of the minimum depths of soil cover outlined above are not practical, rigid high density extruded polystyrene insulation could be used to reduce the required thickness of soil cover. Wood can provide recommended insulation details for specific development conditions upon request.

5.5 General Backfilling

All foundations should be backfilled using OPSS Granular 'A' or Granular 'B' Type I (OPSS 1010 specifications) material. This material should be placed in maximum 200 mm thick loose lifts and compacted to 95% of SPMDD. For settlement sensitive areas (i.e. slab-on-grade, sidewalks, etc.), the material should be compacted to minimum 98% of SPMDD.

The on-site native soil can also be used as general backfill material providing it is free from any organics and deleterious materials. To expedite compaction the native soils should have the moisture content less than 5% of the optimum moisture content. For structural backfill, the native silty clay should be within 3% of the optimum moisture content at the time of backfilling. Upon proper conditioning, the on-site cohesive soil should be placed in lifts not thicker than 200 mm in loose state and compacted to at least 95% of the SPMDD.

5.6 Earth Pressures

A distinction should be made between short-term earth pressures on temporary excavation support structures, and long-term retaining structures against compacted backfill.

As a preliminary guideline, the temporary shoring structures should be verified for conventional uniform earth pressures of at least 0.35 Pz, (Pz, in kPa, is the overburden pressure corresponding to the depth 'z' of excavation below the ground surface). For the in-situ soils a conservative unit weight of 22 kN/m3 should be used. Surcharges at the ground surface should be added in accordance with applicable soil mechanics methods such as described in the CFEM.

For permanent structures, unfactored earth pressure coefficients and associated unit weights are presented in Table 2.

Table 2: Soil Parameters for Earth Pressure Calculations

Backfill Type	Coefficient of Earth Pressure at Active Case	Coefficient of Earth Pressure at Passive Case	Coefficient of Earth Pressure at Rest Case	Design Bulk Unit Weight (kN/m^3)	Friction Angle (degrees)
Select Crushed Limestone (Granular 'A') (*)	0.27 to 0.30	3.3 to 3.7	0.43 to 0.46	22	33 to 35
Well Graded Sand (Granular 'B', Type I) (*)	0.31 to 0.35	2.9 to 3.2	0.47 to 0.52	21	29 to 32
Clayey Silt Fill (**)	0.33 to 0.45	2.2 to 3.0	0.50 to 0.62	20.5	22 to 30

(*) All granular compacted to at least 98% SPMDD
(**) Compacted to at least 95% SPMDD

The design earth pressures in compacted backfill should be augmented with the dynamic effects of the compaction efforts, which typically are taken as a uniform 12 kPa pressure over the entire depth below grade where the calculated earth pressure based on the above earth pressure factors is less than 12 kPa.

Surcharges at the ground surface should be considered in all cases.

For the calculation of the long-term earth pressures, consideration should be given to using the submerged weight plus the hydrostatic pressures where the soil is below the groundwater table unless a permanent dewatering system is installed.

The above coefficients apply to simple cases of retaining structures (wall not higher than typically 4.5 m, horizontal ground surface of the backfill, non-frost susceptible backfill etc.). In case of more complex conditions, Coulomb based methods should be used as indicated in the CFEM.

5.7 Erosion and Scour Recommendations

Provision should be made for scour and erosion protection if the foundations of the bridge are located within the floodplain area. In order to prevent surface water from flowing around the pedestrian bridge foundations (creating seepage through the embankment fill, and potentially causing erosion and loss of fine soil particles), a clay seal or concrete cut-off wall should be provided. If a clay seal is adopted, the clay material should meet the requirements of OPSS 1205

(Clay Seal), and the seal should extend from a depth of 1 m below the scour level to a minimum horizontal distance of 2 m on either side of the edge of the foundation, and a minimum vertical height equivalent to the high-water level.

If the creek flow velocities are sufficiently high, additional provision should be taken for scour and erosion protection such as placement of suitable non-woven geotextiles and/or rip-rap to prevent undermining of the shallow foundations. The requirements for and design of erosion protection measures for the bridge foundations should be provided by the hydraulic design engineer.

The Canadian Highway and Bridge Design code and/or the MTO drainage manual should be checked to confirm the potential for local and general scour. Particular attention should be given to the natural stream characteristics. A stream may be unstable due to meandering, degradation or aggradation.

Above the high-water level, placement of topsoil and seeding or pegged sod is recommended as soon as practicable after construction of any embankments in order to reduce the potential for erosion of the side slopes, due to surface water runoff. The erosion protection should be in accordance with OPSS 804 (Seed and Cover). Below the high-water level rip-rap should be provided to control surface erosion□

5.8 Temporary Excavation and Groundwater Control

All excavations should be carried out in accordance with the current Ontario Occupational Health and Safety Act and Regulations for Construction Projects (Regulation 234). The firm to stiff undisturbed native silty clay and fill can be classified as Type 3 soils. Excavations within Type 3 soils may be carried out with unsupported side slopes not steeper than 1V:1H. However, consideration should be given to the possibility of down rating of the soils should be excavation walls be exposed to weathering for several days without proper protection. Conditions for Type 4 soils may develop if excavations encounter flowing perched groundwater such as in live and abandoned utility trenches, or are advanced below the groundwater table. The excavations may require flatter slopes if sand or silt seams are encountered, particularly if they are water-filled.

Groundwater inflow into excavations in the clayey soils is expected to be low above the water table; however, significant 'perched' groundwater may be present within footing excavations below the creek level. It anticipated that dewatering will be required for excavations below the creek level. If the footings are too close to the creek channel, dewatering may require a cofferdam structure or temporary diversion of the creek.

Bottom heave/piping of excavations, if allowed to occur, will produce the potential for settlements after the completion of the construction. In these situations, positive dewatering should be considered to prevent disturbance of the subgrade. Typically, this may be accomplished from filtered wells/sumps installed below the invert of the trench base, however well points may be required depending on the level of ground water inflow. As an alternative to dewatering, the excavation base within saturated silts and sands can be confined within cut-off sheet pile walls properly locked into the deeper silty clay.

The soils identified are sensitive to disturbance by water. Groundwater and surface water run-off should be removed from excavations by means of pumping from strategically placed open sumps located within the excavation bottom but outside the zone of influence of any structures.

5.9 General Construction Considerations

The silty clay sub-grade soils identified in this report are extremely sensitive to disturbance from exposure to weathering and/or construction traffic (vehicular and pedestrian). Once the excavations have been completed to design elevations, the subgrade soils should be immediately inspected by the geotechnical consultant. Upon approval, the subgrade soil should be protected from further exposure. Cutting of the foundation and subgrade soils should be carried out using excavating buckets equipped with a smooth lip (blade) to reduce disturbance of the bearing surfaces.

Vehicular traffic over prepared subgrade soils, whether or not the granular fill is in place, should be strictly prohibited. Temporary construction routes should be established. These provisions are crucial particularly if the construction is scheduled during wet and/or cold seasons.

Winter construction should include provisions to prevent freezing of the foundation subgrade at all times.

6.0 CLOSURE

The limitations of this report, as discussed in detail in Appendix A, constitute an integral part of this report. We recommend the Geotechnical Consultant be retained to review drawings and the intended methods of construction prior to implementation in order to assure conformance with the geotechnical restrictions and assumptions.

We trust this report is complete within the terms of our reference. However, should questions arise concerning this report, do not hesitate to contact us.

Sincerely,

Wood Environment & Infrastructure Solutions,
a Division of Wood Canada Limited

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Reviewed By:

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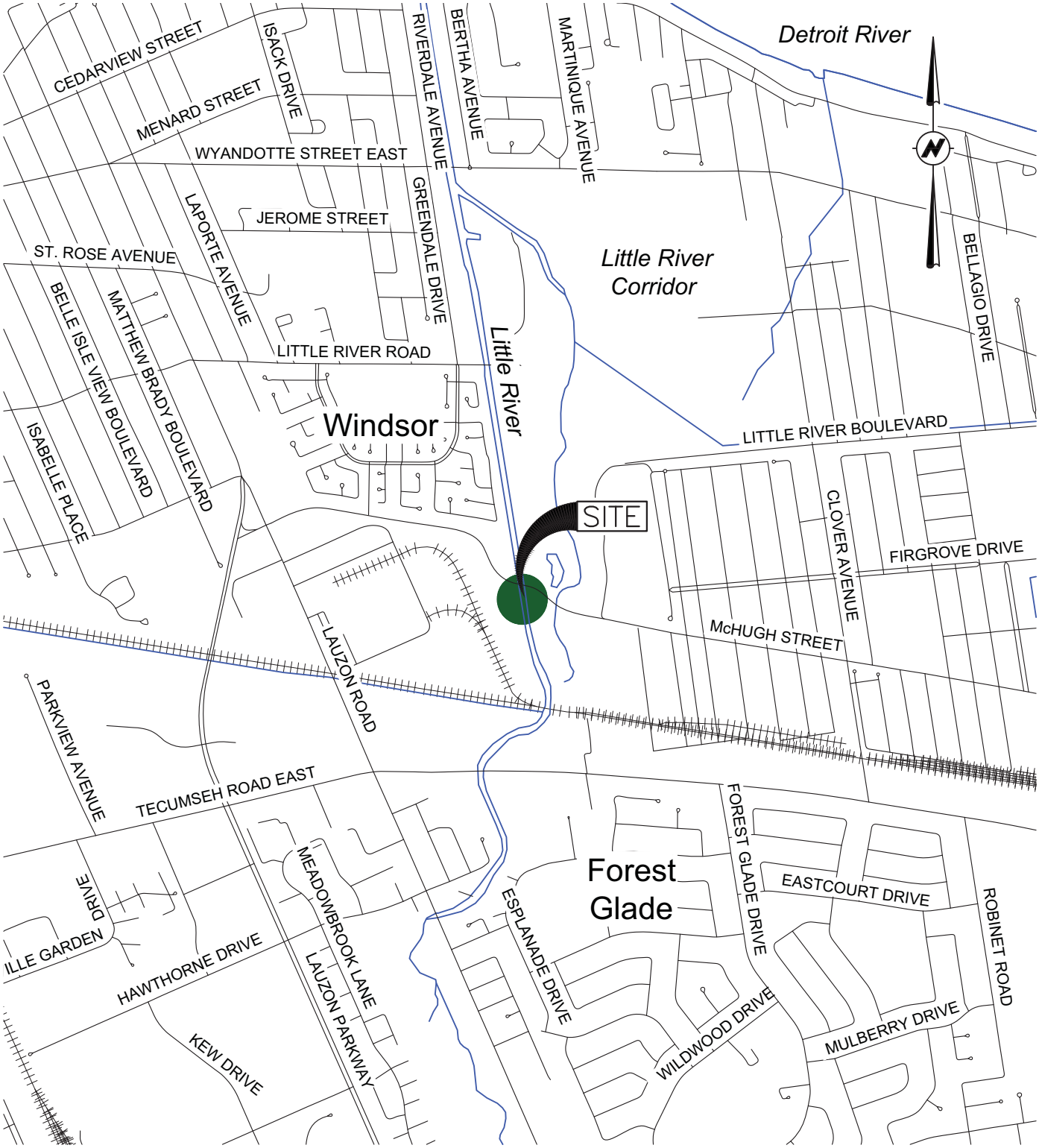
FIGURES



NOTES:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS REPORT No. SWW187089. ALL LOCATIONS ARE APPROXIMATE.

REFERENCES:
CANMAP STREETFILES V2008.4.

ORIGINAL PAPER SIZE: $8\frac{1}{2}$ x 11.

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DWN BY:	SJL
CHK'D BY:	AP
DATUM:	NAD83
PROJECTION:	UTM Zone 17
SCALE:	1:20000

PROJECT:
GEOTECHNICAL INVESTIGATION
PROPOSED NEW PEDESTRIAN BRIDGE
WFCU CENTRE ACROSS LITTLE RIVER
WINDSOR, ONTARIO

TITLE:
KEY PLAN

DATE:	APR. 23, 2018
PROJECT No:	SWW187089
REV No:	0
FIGURE No:	1

LEGEND:

BOREHOLE LOCATION

0 10 20 30m

SCALE 1:750

NOTES:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS REPORT No. SWW187089.

ALL LOCATIONS ARE APPROXIMATE. **ORIGINAL PAPER SIZE: 8$\frac{1}{2}$ x 11.**

REFERENCES:
2017 AERIAL PHOTOGRAPHS PROVIDED BY THE COUNTY OF ESSEX; CANMAP STREETFILES V2008.4.

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CHK'D BY:	AP
DATUM:	NAD83
PROJECTION:	UTM Zone 17
SCALE:	1:750

PROJECT:
GEOTECHNICAL INVESTIGATION
PROPOSED NEW PEDESTRIAN BRIDGE
WFCU CENTRE ACROSS LITTLE RIVER
WINDSOR, ONTARIO

TITLE:
BOREHOLE LOCATION PLAN

DATE:	APR. 23, 2018
PROJECT No:	SWW187089
REV No:	0
FIGURE No:	2

APPENDIX A

REPORT LIMITATIONS

REPORT LIMITATIONS

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environmental aspects of the Project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Geotechnical Engineer be retained during the construction to confirm that the subsurface conditions across the site do not deviate materially from those encountered in the testholes.

The design recommendations given in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

The comments made in this report relating to potential construction problems and possible methods of construction are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied.

The benchmark and elevations mentioned in this report were obtained strictly for use by this office in the geotechnical design of the project, and should not be used by any other party for any other purpose.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Wood Environment & Infrastructure Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

APPENDIX B

EXPLANATION OF RECORD OF BOREHOLE SHEETS AND RECORD OF BOREHOLE SHEETS BH1 TO BH3

GENERAL REPORT NOTES

DEFINITIONS OF PENETRATION RESISTANCE

Standard penetration resistance 'N' – The number of blows required to advance a standard split spoon sampler 30 cm into the subsoil, driven by means of a 63.5 kg hammer falling freely a distance of 76 cm.

Dynamic penetration resistance – The number of blows required to advance a 50 mm, 60 degree cone, fitted to the end of drill rods, 30 cm into the subsoil, the driving energy being 474.5 Joules per blow.

SAMPLE TYPE ABBREVIATIONS USED IN BOREHOLE LOGS

S.S.	Split spoon	T.W.	Thinwall open	R.C.	Rock core
A.U.	Auger sample	T.P.	Thinwall piston	W.S.	Washed sample
P.H.	Sample pushed hydraulically			P.M.	Sample pushed manually

SOIL TEST SYMBOLS USED IN BOREHOLE LOGS

○	Standard penetration resistance	▼	Laboratory Vane	□	Unconfined compression
●	Dynamic penetration resistance	▲	Field Vane	■	Undrained shear strength
		X	Penetrometer	S	Sensitivity

NOTE

The soil conditions, profiles, comments, conclusions and recommendations found in this report are based upon the samples recovered during the fieldwork. Soils are heterogeneous materials and, consequently, variations (possibly extreme) may be encountered at site locations away from boreholes. During construction, competent, qualified inspection personnel should verify that no significant variations exist from the conditions described in this report.

EXPLANATION OF BOREHOLE LOG

This form describes some of the information provided on the borehole logs, which is based primarily on examination of the recovered samples, and the results of the field and laboratory tests. Additional description of the soil/rock encountered is given in the accompanying geotechnical report.

GENERAL INFORMATION

Project details, borehole number, location coordinates and type of drilling equipment used are given at the top of the borehole log.

SOIL LITHOLOGY

Elevation and Depth

This column gives the elevation and depth of inferred geologic layers. The elevation is referred to the datum shown in the Description column.

Lithology Plot

This column presents a graphic depiction of the soil and rock stratigraphy encountered within the borehole.

Description

This column gives a description of the soil stratums, based on visual and tactile examination of the samples augmented with field and laboratory test results. Each stratum is described according to the *Modified Unified Soil Classification System*.

The compactness condition of cohesionless soils (SPT) and the consistency of cohesive soils (undrained shear strength) are defined as follows *(Ref. Canadian Foundation Engineering Manual):*

Compactness of Cohesionless Soils	SPT N-Value
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

Consistency of Cohesive Soils	Undrained Shear Strength kPa	Undrained Shear Strength psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	Over 200	Over 4000

Soil Sampling

Sample types are abbreviated as follows:

SS	Split Spoon	TW	Thin Wall Open (Pushed)	RC	Rock Core	GS	Grab Sample
AS	Auger Sample	TP	Thin Wall Piston (Pushed)	WS	Washed Sample	AR	Air Return Sample

Additional information provided in this section includes sample numbering, sample recovery and numerical testing results.

Field and Laboratory Testing

Results of field testing (e.g., SPT, pocket penetrometer, and vane testing) and laboratory testing (e.g., natural moisture content, and limits) executed on the recovered samples are plotted in this section.

Instrumentation Installation

Instrumentation installations (monitoring wells, piezometers, inclinometers, etc.) are plotted in this section. Water levels, if measured during fieldwork, are also plotted. These water levels may or may not be representative of the static groundwater level depending on the nature of soil stratum where the piezometer tips are located, the time elapsed from installation to reading and other applicable factors.

Comments

This column is used to describe non-standard situations or notes of interest.

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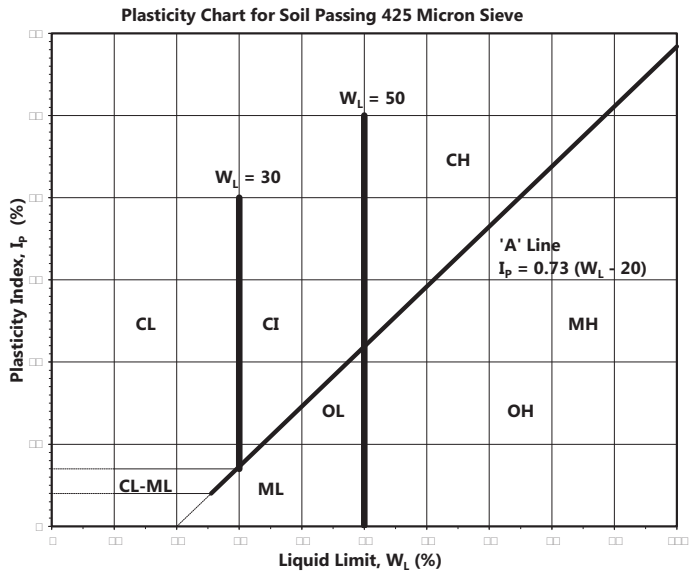
MODIFIED * UNIFIED CLASSIFICATION SYSTEM FOR SOILS

*The soil of each stratum is described using the Unified Soil Classification System (Technical Memorandum 36-357 prepared by Waterways Experiment Station, Vicksburg, Mississippi, Corps of Engineers, U.S Army. Vol. 1 March 1953.) modified slightly so that an inorganic clay of "medium plasticity" is recognized.

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75mm	CLEAN GRAVELS (TRACE OR NO FINES)	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 4$; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ = 1 to 3
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY GRAVELS (WITH SOME OR MORE FINES)	GM	SILTY GRAVELS, GRAVEL-SAND- SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I MORE THAN 4
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I MORE THAN 7
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75mm	CLEAN SANDS (TRACE OR NO FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 6$; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ = 1 to 3
			SP	POORLY GRADED GRAVELS, GRAVEL- SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY SANDS (WITH SOME OR MORE FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I MORE THAN 4
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	W_L < 50%	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)
		W_L < 50%	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	W_L < 30%	CL	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY OR SILTY CLAYS, LEAN CLAYS	
		30% < W_L < 50%	CI	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS	
		W_L < 50%	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
	ORGANIC SLITS & CLAYS BELOW "A" LINE	W_L < 50%	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	WHENEVER THE NATURE OF THE FINES CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", E.G SF IS A MIXTURE OF SAND WITH SILT OR CLAY
		W_L < 50%	OH	ORGANIC CLAYS OF HIGH PLASTICITY	
HIGH ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBROUS TEXTURE

SOIL COMPONENTS

FRACTION	U.S STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS		
		PASSING	RETAINED	PERCENT	DESCRIPTOR
GRAVEL	COARSE	76 mm	19 mm	35-50	AND
	FINE	19 mm	4.75 mm	20-35	Y/EY
				10-20	SOME
SAND	COARSE	4.75 mm	2.00 mm	1-10	TRACE
	MEDIUM	2.00 mm	425 µm		
	FINE	425 µm	75 µm		
FINES (SILT OR CLAY BASED ON PLASTICITY)		75 µm			
OVERSIZED MATERIAL					
ROUNDED OR SUBROUNDED: COBBLES 76 mm TO 200 mm BOULDERS > 200 mm				NOT ROUNDED: ROCK FRAGMENTS > 76 mm ROCKS > 0.76 CUBIC METRE IN VOLUME	



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Note 1: Soils are classified and described according to their engineering properties and behaviour.

Note 2: The modifying adjectives used to define the actual or estimated percentage range by weight of minor components are consistent with the Canadian Foundation Engineering Manual (4th Edition, Canadian Geotechnical Society, 2006.)

RECORD OF BOREHOLE No. BH1

Project Number: **SWW187089**
Project Client: **The Corporation of the City of Windsor**
Project Name: **WFCU Pedestrian Bridge**
Project Location: **WFCU Centre, Windsor, ON**
Drilling Location: **N4687085, E341287**

Drilling Method: **150 mm O.D. Hollow Stem Auger**
Drilling Machine: **Truck Mounted Drill**
Date Started: **05 Apr 2018** Date Completed: **05 Apr 2018**
Logged by: **NF** Compiled by: **SS**
Reviewed by: **AP** Revision No.: **0**

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)			
Lithology Plot	DESCRIPTION Local Ground Surface Elevation:	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; ■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80	Atterberg Limits W_P W W_L Plastic Liquid; ✳ Passing 75 um (%); ○ Moisture Content (%); ★ Unit Weight (KN/m3) 20 40 60 80	INSTRUMENTATION INSTALLATION	GR	SA	SI	CL
	TOPSOIL (125 mm thick)													
	SILTY CLAY 0.1 Trace sand, trace gravel, organic stained Mottled brown and grey Firm													
		SS	1	72	8	1		○	18					
							▽							
		SS	2	89	7			○	18					
						2								
	Brown Very stiff	SS	3	100	19			○	13					
						3								
		SS	4	100	16			○	14					
		SS	5	100	12	4		○	19		3	30	36	31
	Grey	SS	6	100	4			○	14					
						5								
		VT						▲ 35 △ 67						
						6								
	Firm	SS	7	100	3			○	18					
							■							
						7								

▽ Groundwater measured at a depth of 1.4 m upon completion of drilling.

■ Cave in measured at a depth of 6.7 m upon completion of drilling.

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Continued on Next Page

RECORD OF BOREHOLE No. BH1

Project Number: **SWW187089**
Project Client: **The Corporation of the City of Windsor**
Project Name: **WFCU Pedestrian Bridge**
Project Location: **WFCU Centre, Windsor, ON**
Drilling Location: **N4687085, E341287**

Drilling Method: **150 mm O.D. Hollow Stem Auger**
Drilling Machine: **Truck Mounted Drill**
Date Started: **05 Apr 2018** Date Completed: **05 Apr 2018**
Logged by: **NF** Compiled by: **SS**
Reviewed by: **AP** Revision No.: **0**

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; ■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80	Atterberg Limits W_P W W_L; Plastic Liquid; ✳ Passing 75 um (%); ○ Moisture Content (%); ★ Unit Weight (KN/m3); 20 40 60 80	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		SS	8	100	3	8		○	○ 17		
	END OF BOREHOLE 8.1 (no refusal)					9					
						10					
						11					
						12					
						13					
						14					
						15					

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▽ Groundwater measured at a depth of 1.4 m upon completion of drilling.

■ Cave in measured at a depth of 6.7 m upon completion of drilling.

RECORD OF BOREHOLE No. BH2

Project Number: **SWW187089**
Project Client: **The Corporation of the City of Windsor**
Project Name: **WFCU Pedestrian Bridge**
Project Location: **WFCU Centre, Windsor, ON**
Drilling Location: **N4687084, E341309**

Drilling Method: **150 mm O.D. Hollow Stem Augers**
Drilling Machine: **Truck Mounted Drill**
Date Started: **05 Apr 2018** Date Completed: **05 Apr 2018**
Logged by: **NF** Compiled by: **SS**
Reviewed by: **AP** Revision No.: **0**

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		
Lithology Plot	DESCRIPTION Local Ground Surface Elevation:	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	PenetrationTesting ○ SPT ● DCPT MTO Vane* △ Intact ▲ Remould Nilcon Vane* ◇ Intact ◆ Remould ■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80	Atterberg Limits W_P W W_L Plastic Liquid ✳ Passing 75 um (%) ○ Moisture Content (%) ★ Unit Weight (KN/m3) 20 40 60 80	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	FILL (75 mm thick) Sand and gravel 0.1										
	FILL Silty clay, with organics Brown and grey										
		SS	1	43	7	1		○	18		
		SS	2	78	9	2		○	12		
	SILTY CLAY 2.2 Trace sand, trace gravel Mottled brown and grey Firm	SS	3	89	7	3		○	18		
	Fissured Brown	SS	4	94	7	4		○	27		
	Very stiff	SS	5	101	22	5		○	12		
	Stiff Grey	SS	6	100	9	6		○	14		
		VT						△ 70			
		SS	7	100	4	7		○	16		
		VT						▲ 35 △ 56			

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▽ Groundwater measured at a depth of 2.3 m upon completion of drilling.

■ Cave in measured at a depth of 7.9 m upon completion of drilling.

Continued on Next Page

RECORD OF BOREHOLE No. BH2

Project Number: **SWW187089**
Project Client: **The Corporation of the City of Windsor**
Project Name: **WFCU Pedestrian Bridge**
Project Location: **WFCU Centre, Windsor, ON**
Drilling Location: **N4687084, E341309**

Drilling Method: **150 mm O.D. Hollow Stem Augers**
Drilling Machine: **Truck Mounted Drill**
Date Started: **05 Apr 2018** Date Completed: **05 Apr 2018**
Logged by: **NF** Compiled by: **SS**
Reviewed by: **AP** Revision No.: **0**

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; ■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80	Atterberg Limits W_P W W_L; Plastic Liquid; ✳ Passing 75 um (%); ○ Moisture Content (%); ★ Unit Weight (KN/m3) 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
		SS	8	39	5	8		○ 18			
		VT						▲ 18 △ 32			
						9					
		SS	9	100	8			○	○ 19		
	END OF BOREHOLE 9.6 (no refusal)					10					
						11					
						12					
						13					
						14					
						15					

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▽ Groundwater measured at a depth of 2.3 m upon completion of drilling.

■ Cave in measured at a depth of 7.9 m upon completion of drilling.

RECORD OF BOREHOLE No. BH3

Project Number: **SWW187089**
Project Client: **The Corporation of the City of Windsor**
Project Name: **WFCU Pedestrian Bridge**
Project Location: **WFCU Centre, Windsor, ON**
Drilling Location: **N4687087, E341349**

Drilling Method: **150 mm O.D. Hollow Stem Augers**
Drilling Machine: **Truck Mounted Drill**
Date Started: **05 Apr 2018** Date Completed: **05 Apr 2018**
Logged by: **NF** Compiled by: **SS**
Reviewed by: **AP** Revision No.: **0**

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)			
Lithology Plot	DESCRIPTION Local Ground Surface Elevation:	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	PenetrationTesting: ○ SPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; ■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80	Atterberg Limits W_P W W_L (Plastic – Liquid); ✳ Passing 75 um (%); ○ Moisture Content (%); ★ Unit Weight (KN/m3); 20 40 60 80	INSTRUMENTATION INSTALLATION	GR	SA	SI	CL
	TOPSOIL (280 mm thick)													
	FILL 0.3 Silty clay, with organics Brown and grey													
		SS	1	61	10	1		○	○ 17					
		SS	2	78	8	2		○	○ 21					
	SILTY CLAY 2.2 Trace sand, trace gravel Mottled brown and grey Stiff	SS	3	89	8		▽	○	○ 15					
						3								
	Fissured Brown Very stiff	SS	4	100	16			○	○ 14					
						4								
		SS	5	100	15			○	○ 12					
		SS	6	100	13			○	○ 14					
	Grey					5								
	Firm													
						6								
		SS	7	100	5			○	● 18		5	29	36	30
		VT				7		▲ 32 △ 53						

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▽ Groundwater measured at a depth of 2.3 m upon completion of drilling.

Continued on Next Page

RECORD OF BOREHOLE No. BH3

Project Number: **SWW187089**
Project Client: **The Corporation of the City of Windsor**
Project Name: **WFCU Pedestrian Bridge**
Project Location: **WFCU Centre, Windsor, ON**
Drilling Location: **N4687087, E341349**

Drilling Method: **150 mm O.D. Hollow Stem Augers**
Drilling Machine: **Truck Mounted Drill**
Date Started: **05 Apr 2018** Date Completed: **05 Apr 2018**
Logged by: **NF** Compiled by: **SS**
Reviewed by: **AP** Revision No.: **0**

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; ■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80	Atterberg Limits W_P W W_L; Plastic Liquid; ✳ Passing 75 um (%); ○ Moisture Content (%); ★ Unit Weight (KN/m3); 20 40 60 80	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		SS	8	100	4	8		○	○ 17		
	END OF BOREHOLE 8.1 (no refusal)					9					
						10					
						11					
						12					
						13					
						14					
						15					

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▽ Groundwater measured at a depth of 2.3 m upon completion of drilling.

APPENDIX C

GEOTECHNICAL LABORATORY TEST RESULTS

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ATTERBERG LIMITS
ASTM D-4318 or LS-703 / 704

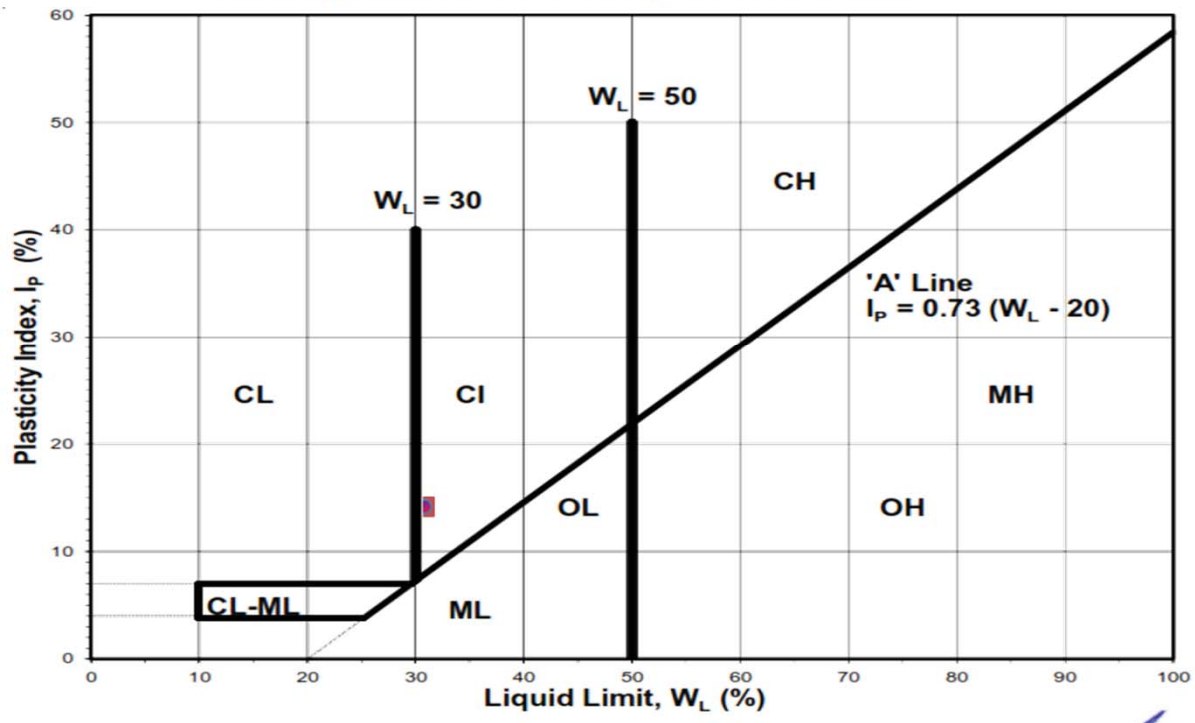
Project Number:	SWW187089	**Sampled by:**	NF	**Sampled on:**	05-Apr-18
Project Client:	City of Windsor	**Tested by:**	JP	**Received on:**	05-Apr-18
Project Name:	WFCU Pedstrian Bridge			**Tested on:**	10-Apr-18
Project Location:	Windsor				

Test Results

LAB NUMBER	198
BOREHOLE	1
SAMPLE	5
DEPTH (m)	3.8 - 4.3

PLASTIC LIMIT	**16.9**
LIQUID LIMIT	**31.2**
PLASTICITY INDEX	**14.3**

Plasticity Chart for Soil Passing 425 Micron Sieve



Signed by: _____
Justin Palmer, Lab Supervisor, C. Tech.

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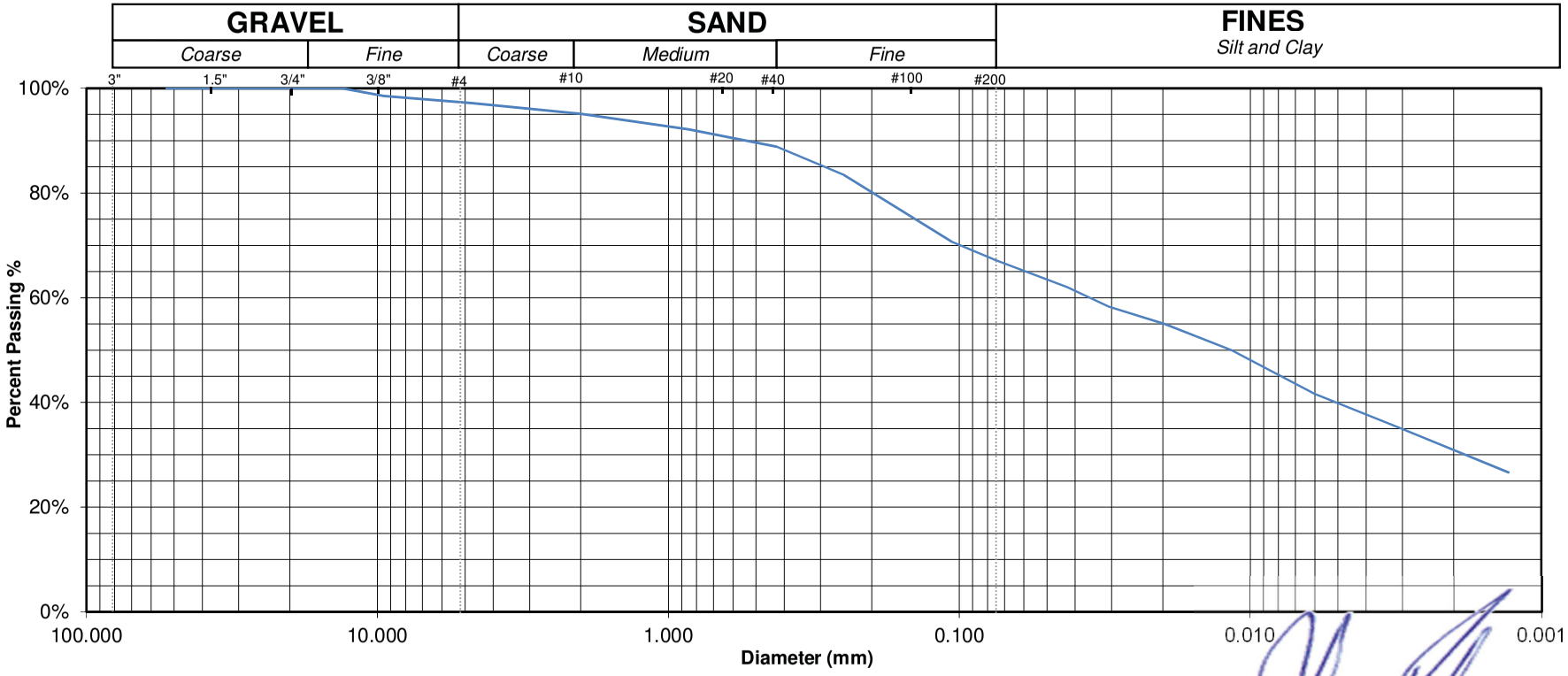
GRAIN SIZE DISTRIBUTION
MTO LS 702 / ASTM D7928 / ASTM D6913

Project Number:	SWW187089	**Sampled by:**	NF	**Sampled on:**	5-Apr-2018
Project Client:	City of Windsor	**Tested by:**	JP	**Received on:**	5-Apr-2018
Project Name:	WFCU Pedstrian Bridge			**Tested on:**	11-Apr-2018
Project Location:	Windsor				

Test Results

Sample Location:	Gravel	Sand	Silt	Clay	Soil Classification
BH 1, Sa. 5	2.8%	30.0%	36.3%	30.9%	CLAYEY SANDY SILT, trace gravel
Sample Identification: **199**					



Signed by: _____
Justin Palmer, Lab Supervisor, C. Tech.

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ATTERBERG LIMITS
ASTM D-4318 or LS-703 / 704

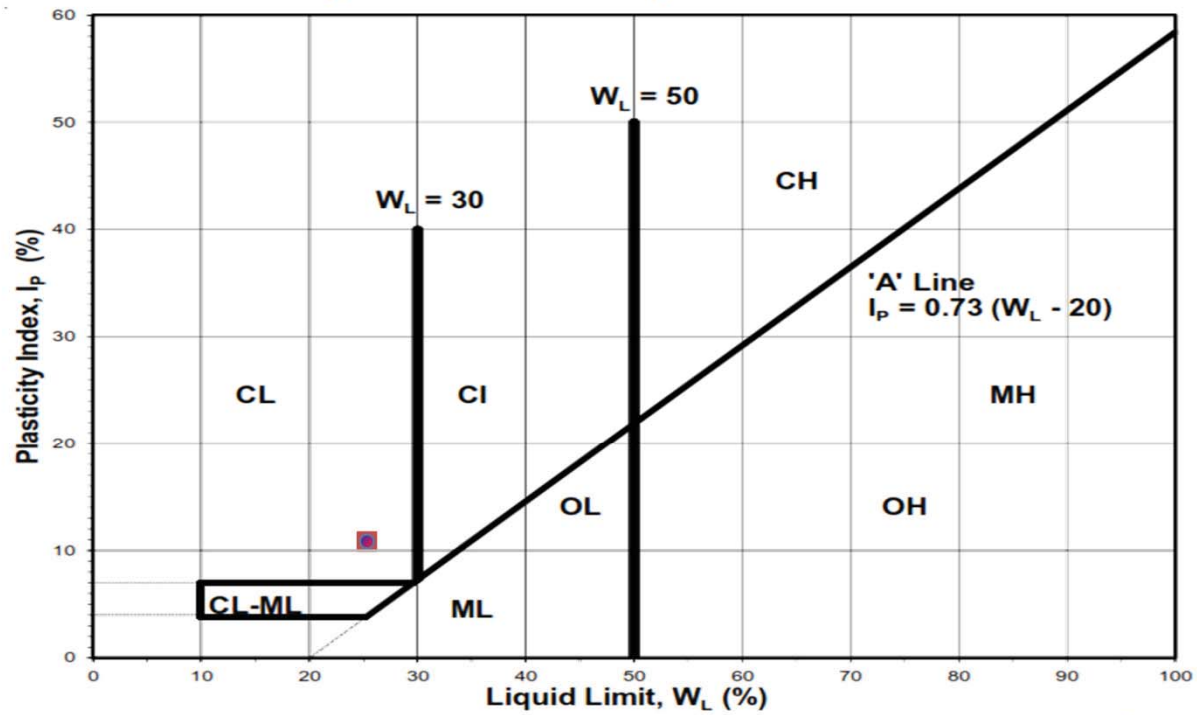
Project Number:	SWW187089	**Sampled by:**	NF	**Sampled on:**	05-Apr-18
Project Client:	City of Windsor	**Tested by:**	JP	**Received on:**	05-Apr-18
Project Name:	WFCU Pedstrian Bridge			**Tested on:**	10-Apr-18
Project Location:	Windsor				

Test Results

LAB NUMBER	200
BOREHOLE	3
SAMPLE	7
DEPTH (m)	6.1 - 6.6

PLASTIC LIMIT	**14.6**
LIQUID LIMIT	**25.6**
PLASTICITY INDEX	**11.0**

Plasticity Chart for Soil Passing 425 Micron Sieve



Signed by: _____
Justin Palmer, Lab Supervisor, C. Tech.

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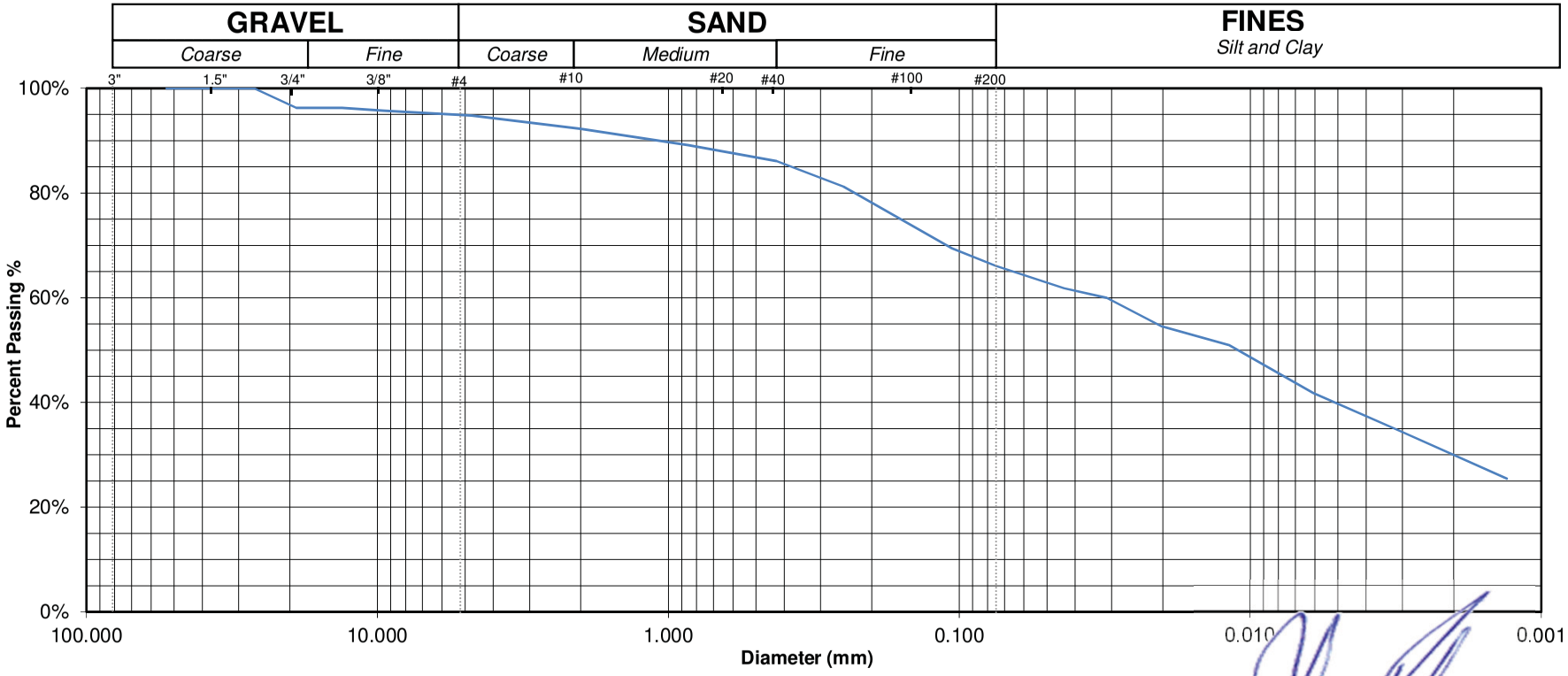
GRAIN SIZE DISTRIBUTION
MTO LS 702 / ASTM D7928 / ASTM D6913

Project Number:	SWW187089	**Sampled by:**	NF	**Sampled on:**	5-Apr-2018
Project Client:	City of Windsor	**Tested by:**	JP	**Received on:**	5-Apr-2018
Project Name:	WFCU Pedstrian Bridge			**Tested on:**	11-Apr-2018
Project Location:	Windsor				

Test Results

Sample Location:	Gravel	Sand	Silt	Clay	Soil Classification
BH 3, Sa. 7	5.2%	28.7%	36.1%	30.0%	CLAYEY SANDY SILT, trace gravel
Sample Identification: **201**					



Signed by: _____
Justin Palmer, Lab Supervisor, C. Tech.

GEOTECHNICAL INVESTIGATION REPORT
PROPOSED NEW HAWTHORNE PEDESTRIAN BRIDGE
WINDSOR, ONTARIO

Submitted to:

The Corporation of the City of Windsor
2450 McDougall Avenue, Windsor, Ontario, N8X 3N6
Attn: Mr. Trevor Duquette, Parks Technologist

Submitted by:

Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited
11865 County Road 42, Tecumseh, Ontario, N8N 2M1
Tel: (519) 735-2499 Fax: (519) 735-9669

Distribution:
- The Corporation of the City of Windsor – 1 Hard Copy & 1 Digital Copy
- Wood Environment & Infrastructure Solutions – 1 Copy

Reference Number: SWW187112

Geotechnical Investigation Report

Proposed New Hawthorne Pedestrian Bridge
Windsor, Ontario

Project # SWW187112

Prepared for:
Corporation of the City of Windsor
350 City Hall Square, 4th Floor, Windsor, Ontario
Attn: Mr. Trevor Duquette, Parks Technologist

Prepared by:
Wood Environment & Infrastructure Solutions, a Division of Wood Canada Limited
11865 County Road 42
Tecumseh, Ontario, N8N 2M1
Canada
T: 519-735-2499

29-Aug-18

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LIST OF APPENDICES

1.0 INTRODUCTION

Wood Environment & Infrastructure Solutions, a Division of Wood Canada Limited ("Wood") was retained by the Corporation of the City of Windsor (the "City" or the "Client") to conduct a geotechnical investigation for the proposed new pedestrian bridge to be located on the east side of Hawthorne Drive and crossing Little River in Windsor, Ontario.

The project area is shown on the Key Plan, Figure 1. Based on this information and discussion with the Client, Wood understands that the new pedestrian bridge will from the east side of Hawthorne Drive across Little River to the area south of the Rafih Auto Mall.

The purpose of this investigation was to provide subsurface soil information, and based on this information, to provide geotechnical recommendations pertaining to the construction of the proposed pedestrian bridge.

The scope of the fieldwork for this geotechnical investigation included two (2) boreholes to depths ranging from 8.1 m to 9.6 m below existing grade at the abutment locations for the proposed pedestrian bridge.

This report contains the findings of Wood's geotechnical investigation, together with recommendations and comments. The recommendations and comments are based on factual information at the test location and intended primarily for use by design engineers. The number of boreholes may not be sufficient to determine all of the factors that may affect construction methods and costs. Subsurface and groundwater conditions between and beyond the boreholes may differ from those encountered at the borehole locations, and conditions may become apparent during construction that could not be detected or anticipated at the time of the site investigation.

The anticipated construction conditions are also discussed, but only to the extent that they may influence the design decisions. The feasible construction methods, however, express our opinion and are not intended to direct contractors on how they carry out construction. Contractors should also be aware that the data and their interpretation presented in this report may not be sufficient to assess all factors that may affect construction.

This report has been prepared with the assumption that the design will be in accordance with good engineering practices, applicable regulations of jurisdictional authorities, and applicable standards and regulations. Further, the recommendations and opinions in this report are applicable only to the proposed project. Hydrogeological or environmental considerations will

be provided under separate cover. The limitations of this report, as discussed in detail in Appendix A, constitute an integral part of this report.

There should be an ongoing liaison with Wood during both the design and construction phases of this project to ensure that the recommendations in this report have been adequately interpreted and implemented. Also, if any further clarification and/or elaboration are needed concerning the geotechnical aspects of this project, Wood should be contacted immediately.

2.0 SITE DESCRIPTION AND GEOLOGICAL BACKGROUND

2.1 Site Description

The site was situated on the east side Hawthorne Drive and extends over Little River to the area behind the Rafih Auto Mall. The Site was grass covered at the time of the investigation, and the ground surface sloped downwards at the banks of Little River. Little River flows north towards the Detroit River.

2.2 Geological Background

The Site is located within a geological formation known as Essex Clay Plain, which is an extensive clay plain with little relief and poor natural drainage. The plain is underlain by a relatively thick deposit of glaciolacustrine silty clay to clayey silt till. Occasional embedded pockets and lenses of sand and silt are present within the overburden clay. The clay deposit is underlain by limestone bedrock at a depth of 35 m to 45 m, based on available drift thickness mapping (Ontario Geological Survey, Preliminary Map P.3255, 1994).

The general low permeability characteristics of the clay deposit render this deposit as an "aquitard" where the groundwater is stored in the soil pores and moves extremely slowly. Perched water tables above the "aquitard" could cause significant fluctuations in the groundwater elevations locally, depending on the prevalent weather and precipitation conditions.

3.0 INVESTIGATION PROGRAM

3.1 Field Work

The scope of the geotechnical fieldwork included two (2) sampled boreholes, designated as BH1 and BH2, that ranged in depth from 8.1 m to 9.6 m below grade. The location and depth of the boreholes were determined by Wood and are shown on the Borehole Location Plan, Figure No. 2.

The coordinates of the boreholes are shown on the Record of Borehole sheets attached in Appendix B. The coordinates at the borehole locations were recorded in the field using a hand-held GPS device with a horizontal accuracy of ±3 m.

The borehole drilling program for the investigation was carried out on April 5th, 2018. The boreholes were advanced using a self-propelled drilling machine equipped with hollow stem augers and conventional soil sampling tools. Soil samples were taken at frequent intervals of depth following the Standard Penetration Test (ASTM D1586) procedure.

The drilling was conducted under the full-time supervision of Wood's engineering staff who directed the drilling and sampling operation, and logged the boreholes.

After completion of the boreholes, the augers were extracted, the boreholes were inspected for groundwater and caving, then backfilled using bentonite pellets and grout slurry.

All samples were field logged, placed in airtight containers, and transported to Wood's Windsor laboratory for further examination and testing.

Natural moisture content tests were carried out in accordance with ASTM D2216 on all the recovered soil samples. Two selected native soil samples were tested for the grain size distribution and Atterberg limit, in accordance with ASTM D6913, ASTM D7928 and ASTM D4318. The test results are included in Appendix C.

4.0 SUBSURFACE CONDITIONS

4.1 Subsurface Soil Conditions

The following is a brief summary of the subsurface soil conditions encountered in the boreholes. The results of laboratory testing carried out on select samples are also shown on the Record of Borehole sheets in Appendix B. The results of the laboratory testing can be found in Appendix C.

Topsoil

Topsoil was encountered in boreholes BH1 and BH2 to depths of 125 mm and 150 mm below grade, respectively.

Silty Clay

Underlying the topsoil, the boreholes penetrated an extensive stratum of silty clay. This stratum generally divides into three general zones, the 'weathered' zone, the 'crust' and the grey zone.

The upper zone was generally weathered. Soils in the weathered zone are subjected to freeze-thaw cycles, and changes in moisture content caused by seasonal weather variations. This zone is characterized by fissures, with a mottled brown and grey appearance. The weathered zone extended to a depth of approximately 2.1 m. The measured "N" values from Standard Penetration Test obtained in the weathered zone ranged from 7 blows to 23 blows per 0.3 m penetration, indicating a firm to very stiff consistency. The moisture content of the weathered clay ranged from 13% to 18%.

Below the weathered zone was the crust. The crust was characterized by a brown colour, and a minor amount of fissures and oxidation. The crust extended to a depth ranging from 3.7 m to 5.5 m below existing grade. The measured "N" values from Standard Penetration Test obtained in the brown silty clay ranged from 11 blows to 18 blows per 0.3 m penetration, indicating a stiff to very stiff consistency. The moisture content of the brown silty clay ranged from 11% to 16%.

Underlying the crust was the grey zone. This zone of the silty clay stratum was generally characterized by increased natural moisture contents, and virtually no fissures. Both boreholes were terminated within the grey zone. The measured "N" values within the grey zone ranged from 3 blows to 5 blows per 0.3 m penetration. Field vane shear testing was completed in the grey silty clay and the undrained shear strengths ranged from 46 kPa to 60 kPa, indicating a firm to stiff consistency. The moisture contents of the grey silty clay ranged from 16% to 19%.

Grain size distribution analysis and Atterberg limit tests were carried out on one sample of brown silty clay and one sample of grey silty clay. The results of these tests are included on the borehole log sheets and attached in Appendix C.

Table 1: Results of Grain Size Analysis and Atterberg Limits Test

Borehole No. / Sample No.	Sample Depth (m)	Grain Size Distribution				Atterberg Limits			USCS Modified Group Symbol
		Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit (W_L)	Plastic Limit (W_P)	Plasticity Index (I_P)	
BH1 / SA5	3.8 to 4.3	2	30	37	31	32.9	16.0	16.9	CI
BH2 / SA7	6.1 to 6.6	2	29	37	32	25.6	15.0	10.6	CL

4.2 Groundwater

Groundwater level observations and measurements in the borehole, and in-situ moisture contents of recovered soil samples are presented on the Record of Borehole sheets.

The borehole was left open following the withdrawal of the augers. Water was measured ranging from 1.8 to 2.3 m below grade; however, this may have been due to the drilling process and not indicative of the actual conditions.

Typically, the grey colour of the soils noted between 3.7 m and 5.5 m below grade is indicative of a permanent saturated condition, and therefore, fluctuation of the long-term groundwater should be anticipated near these depth levels. However, during and after local precipitation events, groundwater that is 'perched' above the long-term levels may accumulate in the fills and weathered mottled/brown silty clays above the relatively more impervious grey silty clay. In addition, significant amounts of groundwater may be present within the layers/pockets of granular soils known to occur randomly within the overburden soils and within any fill materials around existing utilities that may be present.

Perched groundwater may rise to the ground surface following precipitation and snowmelt. In the absence of an active, engineered drainage system, the design should assume possible temporary groundwater levels rising to the ground surface.

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 General

Based on the information provided to Wood by the Client, it is understood the project consists of constructing a new pedestrian bridge across Little River from Hawthorne Drive to south of the Rafih Auto Mall.

No loading information has been provided at this time. For the purposes of this report, it has been assumed that no unusual foundation loads or settlement limitations will be encountered for the required project structures.

5.2 Shallow Foundations

Shallow strip or spread footings are considered feasible for the proposed pedestrian bridge. The topsoil and other organic materials which were encountered at surface on the Site, and softened or loosened native soils, if present, are not suitable to support foundations and should be sub-excavated until suitable material is encountered.

The foundations should be placed below the topsoil on undisturbed native mottled brown silty clay or brown silty clay at a depth 1.2 m or greater below the ground surface.

Square footings founded at a minimum depth of 1.2 m below existing grade on approved native subgrade, may be designed using a geotechnical reaction at Serviceability Limit States (SLS) of 110 kPa and a factored geotechnical resistance at Ultimate Limit States (ULS) of 170 kPa.

An alternative foundation may be placed on undisturbed native brown silty clay at a depth of approximately 2.2 m below existing grade. The subgrade should be sub-excavated to accommodate a minimum of a 1.0 m thick mat comprised of a material meeting the specifications of OPSS 1010 Granular 'A'. The granular mat should be placed in lifts not more than 200 mm and compacted to 100% of Standard Proctor Maximum Dry Density (SPMDD). Square footings founded at this depth and on the approved native subgrade, may be designed using a geotechnical reaction at SLS of 140 kPa and ULS of 210 kPa.

The SLS resistance values are based on a maximum footing dimension of less than 4.0 m. The SLS is based on assumed maximum and differential settlement tolerances of 25 mm and 20 mm, respectively. Wood should be consulted should the foundation depths or sizes greater than those described be required. Wood should be contacted if higher ULS and SLS values are required for the design of the building foundations.

The geotechnical pressure values listed above are for vertical loads (no inclination) and no eccentricity. The ULS values could be significantly less than stated if inclined or eccentric loading conditions exist. The foundation design must also consider load inclinations and eccentricity as per the applicable principles presented in the 2006 Canadian Foundation Engineering Manual (CFEM) and the Canadian Highway Bridge Design Code (CHBDC). Wood would be pleased to provide detailed assistance in the required geotechnical calculations to satisfy these requirements.

Exterior footings and footings in unheated areas should be provided with a minimum 1.1 m of soil cover or equivalent thermal insulation for adequate frost protection. The footing excavation should be reviewed by a qualified geotechnical consultant to confirm that the bearing soil has adequate bearing capacity.

Loose or disturbed material should be removed from the footing excavation prior to the placement of concrete. Hand cleaning may be required to prepare an acceptable bearing surface. The footing subgrade should be protected at all times from rain, snow, freezing temperatures and the ingress of free water. Concrete should not be placed on frozen soil, nor should the soil beneath the footing be allowed to freeze after construction of the footing.

5.3 Seismic Considerations

The 2012 OBC contains updated seismic analysis and design methodology. The 2012 OBC uses a site classification system defined by the average soil/bedrock properties in the top 30 m (100 ft) of the subsurface profile beneath the structure. Based on the site investigation and our experience in this area, the project site can be classified as Site Class 'E – Soft Soil 'in accordance with the 2012 OBC criteria in Division B, Part 4, Table 4.1.8.4.A.

The four values of the Spectral response acceleration Sa (T) for different periods and the Peak Ground Acceleration (PGA) can be obtained from 2012 OBC. The design values of Fa and Fv for the project site should be calculated in accordance to 2012 OBC.

5.4 Frost Depth

The upper stratigraphy of the soils are considered highly frost susceptible in the presence of water, and as such, frost effects should be considered for foundations or surface structure sensitive to movement.

In accordance with the Ontario Provisional Standard Drawing (OPSD 3090.101) the design frost depth below the ground surface for the general area is estimated to be 1.2 m. Therefore, a

minimum permanent soil cover of 1.2 m or equivalent thermal insulation is required for frost protection of shallow foundations.

Where provision of the minimum depths of soil cover outlined above are not practical, rigid high density extruded polystyrene insulation could be used to reduce the required thickness of soil cover. Wood can provide recommended insulation details for specific development conditions upon request.

5.5 General Backfilling

All foundations should be backfilled using OPSS Granular 'A' or Granular 'B' Type I (OPSS 1010 specifications) material. This material should be placed in maximum 200 mm thick loose lifts and compacted to 95% of SPMDD. For settlement sensitive areas (i.e. slab-on-grade, sidewalks, etc.), the material should be compacted to minimum 98% of SPMDD.

The on-site native soil can also be used as general backfill material providing it is free from any organics and deleterious materials. To expedite compaction the native soils should have the moisture content less than 5% of the optimum moisture content. For structural backfill, the native silty clay should be within 3% of the optimum moisture content at the time of backfilling. Upon proper conditioning, the on-site cohesive soil should be placed in lifts not thicker than 200 mm in loose state and compacted to at least 95% of the SPMDD.

5.6 Earth Pressures

A distinction should be made between short-term earth pressures on temporary excavation support structures, and long-term retaining structures against compacted backfill.

As a preliminary guideline, the temporary shoring structures should be verified for conventional uniform earth pressures of at least 0.35 Pz, (Pz, in kPa, is the overburden pressure corresponding to the depth 'z' of excavation below the ground surface). For the in-situ soils a unit weight of 22 kN/m^3 should be used. Surcharges at the ground surface should be added in accordance with applicable soil mechanics methods such as described in the CFEM.

For permanent structures, unfactored earth pressure coefficients and associated unit weights are presented in Table 2.

Table 2: Soil Parameters for Earth Pressure Calculations

Backfill Type	Coefficient of Earth Pressure at Active Case	Coefficient of Earth Pressure at Passive Case	Coefficient of Earth Pressure at Rest Case	Design Bulk Unit Weight (kN/m^3)	Friction Angle (degrees)
Select Crushed Limestone (Granular 'A') (*)	0.27 to 0.30	3.3 to 3.7	0.43 to 0.46	22	33 to 35
Well Graded Sand (Granular 'B', Type I) (*)	0.31 to 0.35	2.9 to 3.2	0.47 to 0.52	21	29 to 32
Clayey Silt Fill (**)	0.33 to 0.45	2.2 to 3.0	0.50 to 0.62	20.5	22 to 30
Firm to Very Stiff Site Generated Silty Clay (**)	0.41 to 0.51	2.0 to 2.5	0.58 to 0.67	22	19 to 25

(*) All granular compacted to at least 98% SPMDD
(**) Compacted to at least 95% SPMDD

The design earth pressures in compacted backfill should be augmented with the dynamic effects of the compaction efforts, which typically are taken as a uniform 12 kPa pressure over the entire depth below grade where the calculated earth pressure based on the above earth pressure factors is less than 12 kPa.

Surcharges at the ground surface should be considered in all cases.

For the calculation of the long-term earth pressures, consideration should be given to using the submerged weight plus the hydrostatic pressures where the soil is below the groundwater table unless a permanent dewatering system is installed.

The above coefficients apply to simple cases of retaining structures (wall not higher than typically 4.5 m, horizontal ground surface of the backfill, non-frost susceptible backfill etc.). In case of more complex conditions, Coulomb based methods should be used as indicated in the CFEM.

5.7 Temporary Excavation and Groundwater Control

All excavations should be carried out in accordance with the current Ontario Occupational Health and Safety Act and Regulations for Construction Projects (Regulation 234). The firm to stiff undisturbed native silty clay and fill can be classified as Type 3 soils. Excavations within Type 3 soils may be carried out with unsupported side slopes not steeper than 1V:1H. However, consideration should be given to the possibility of down rating of the soils should be excavation

walls be exposed to weathering for several days without proper protection. Conditions for Type 4 soils may develop if excavations encounter flowing perched groundwater such as in live and abandoned utility trenches, or are advanced below the groundwater table. The excavations may require flatter slopes if sand or silt seams are encountered, particularly if they are water-filled.

Groundwater inflow into excavations in the clayey soils is expected to be low above the water table; however, significant 'perched' groundwater may be present within utility trenches and abandoned utilities. This would especially be true during and after local precipitation events. In this case, the inflow into excavations may become significant.

The soils identified are sensitive to disturbance by water. Groundwater and surface water run-off should be removed from excavations by means of pumping from strategically placed open sumps located within the excavation bottom but outside the zone of influence of any structures.

5.8 General Construction Considerations

The silty clay sub-grade soils identified in this report are extremely sensitive to disturbance from exposure to weathering and/or construction traffic (vehicular and pedestrian). Once the excavations have been completed to design elevations, the subgrade soils should be immediately inspected by the geotechnical consultant. Upon approval, the subgrade soil should be protected from further exposure. Cutting of the foundation and subgrade soils should be carried out using excavating buckets equipped with a smooth lip (blade) to reduce disturbance of the bearing surfaces.

Vehicular traffic over prepared subgrade soils, whether or not the granular fill is in place, should be strictly prohibited. Temporary construction routes should be established. These provisions are crucial particularly if the construction is scheduled during wet and/or cold seasons.

Winter construction should include provisions to prevent freezing of the foundation subgrade at all times.

6.0 CLOSURE

The limitations of this report, as discussed in detail in Appendix A, constitute an integral part of this report. We recommend the Geotechnical Consultant be retained to review drawings and the intended methods of construction prior to implementation in order to assure conformance with the geotechnical restrictions and assumptions.

We trust this report is complete within the terms of our reference. However, should questions arise concerning this report, do not hesitate to contact us.

Sincerely,

Wood Environment & Infrastructure Solutions,
a Division of Wood Canada Limited

Prepared By:

Anthony Pusic, P.Eng.
Geotechnical Engineer

Reviewed By:

Ty Garde, M.Eng., P.Eng.
Principal Geotechnical Engineer

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FIGURES

NOTES:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS REPORT No. SWW187112. ALL LOCATIONS ARE APPROXIMATE.

ORIGINAL PAPER SIZE: $8\frac{1}{2}$ x 11.

REFERENCES:
CANMAP STREETFILES V2008.4.

The Corporation of the City of Windsor Parks & Recreation 2450 McDOUGALL AVENUE WINDSOR, ONTARIO, N8X 3N6		DWN BY: SJL CHK'D BY: AP	PROJECT: GEOTECHNICAL INVESTIGATION PROPOSED NEW PEDESTRIAN BRIDGE HAWTHORNE DRIVE ACROSS LITTLE RIVER WINDSOR, ONTARIO	DATE: APR. 23, 2018 PROJECT No: SWW187112
Wood Environment & Infrastructure Solutions 11865 COUNTY ROAD 42 TECUMSEH, ONTARIO N8N 2M1 519-735-2499		DATUM: NAD83 PROJECTION: UTM Zone 17 SCALE: 1:20000	TITLE: KEY PLAN	REV No: 0 FIGURE No: 1

DATE PLOTTED: 4/23/2018 4:07:19 PM
FILE LOCATION: \\wsr-fs1\projects$\2018\Geotechnical\Projects\SWW187112 - City of Windsor - Hawthorne Pedestrian Bridge\08_Drafting\AutoCAD files\SWW187112-R01001.dwg

LEGEND:

BOREHOLE LOCATION

0 10 20 30m

SCALE 1:750

NOTES:
THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE WOOD ENVIRONMENT & INFRASTRUCTURE SOLUTIONS REPORT No. SWW187112.

ALL LOCATIONS ARE APPROXIMATE. **ORIGINAL PAPER SIZE: $8\frac{1}{2}$ x 11.**

REFERENCES:
2017 AERIAL PHOTOGRAPHS PROVIDED BY THE COUNTY OF ESSEX; CANMAP STREETFILES V2008.4.

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N8N 2M1
519-735-2499

DWN BY:	SJL
CHK'D BY:	AP
DATUM:	NAD83
PROJECTION:	UTM Zone 17
SCALE:	1:750

PROJECT:
GEOTECHNICAL INVESTIGATION
PROPOSED NEW PEDESTRIAN BRIDGE
HAWTHORNE DRIVE ACROSS LITTLE RIVER
WINDSOR, ONTARIO

TITLE:
BOREHOLE LOCATION PLAN

DATE:	APR. 23, 2018
PROJECT No:	SWW187112
REV No:	0
FIGURE No:	2

APPENDIX A

REPORT LIMITATIONS

REPORT LIMITATIONS

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environmental aspects of the Project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Geotechnical Engineer be retained during the construction to confirm that the subsurface conditions across the site do not deviate materially from those encountered in the testholes.

The design recommendations given in this report are applicable only to the project described in the text, and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

The comments made in this report relating to potential construction problems and possible methods of construction are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices. No other warranty is expressed or implied.

The benchmark and elevations mentioned in this report were obtained strictly for use by this office in the geotechnical design of the project, and should not be used by any other party for any other purpose.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Wood Environment & Infrastructure Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

APPENDIX B

EXPLANATION OF RECORD OF BOREHOLE SHEETS AND RECORD OF BOREHOLE SHEETS BH1 TO BH2

GENERAL REPORT NOTES

DEFINITIONS OF PENETRATION RESISTANCE

Standard penetration resistance 'N' – The number of blows required to advance a standard split spoon sampler 30 cm into the subsoil, driven by means of a 63.5 kg hammer falling freely a distance of 76 cm.

Dynamic penetration resistance – The number of blows required to advance a 50 mm, 60 degree cone, fitted to the end of drill rods, 30 cm into the subsoil, the driving energy being 474.5 Joules per blow.

SAMPLE TYPE ABBREVIATIONS USED IN BOREHOLE LOGS

S.S.	Split spoon	T.W.	Thinwall open	R.C.	Rock core
A.U.	Auger sample	T.P.	Thinwall piston	W.S.	Washed sample
P.H.	Sample pushed hydraulically			P.M.	Sample pushed manually

SOIL TEST SYMBOLS USED IN BOREHOLE LOGS

○	Standard penetration resistance	▼	Laboratory Vane	□	Unconfined compression
●	Dynamic penetration resistance	▲	Field Vane	■	Undrained shear strength
		X	Penetrometer	S	Sensitivity

NOTE

The soil conditions, profiles, comments, conclusions and recommendations found in this report are based upon the samples recovered during the fieldwork. Soils are heterogeneous materials and, consequently, variations (possibly extreme) may be encountered at site locations away from boreholes. During construction, competent, qualified inspection personnel should verify that no significant variations exist from the conditions described in this report.

EXPLANATION OF BOREHOLE LOG

This form describes some of the information provided on the borehole logs, which is based primarily on examination of the recovered samples, and the results of the field and laboratory tests. Additional description of the soil/rock encountered is given in the accompanying geotechnical report.

GENERAL INFORMATION

Project details, borehole number, location coordinates and type of drilling equipment used are given at the top of the borehole log.

SOIL LITHOLOGY

Elevation and Depth

This column gives the elevation and depth of inferred geologic layers. The elevation is referred to the datum shown in the Description column.

Lithology Plot

This column presents a graphic depiction of the soil and rock stratigraphy encountered within the borehole.

Description

This column gives a description of the soil stratums, based on visual and tactile examination of the samples augmented with field and laboratory test results. Each stratum is described according to the *Modified Unified Soil Classification System*.

The compactness condition of cohesionless soils (SPT) and the consistency of cohesive soils (undrained shear strength) are defined as follows *(Ref. Canadian Foundation Engineering Manual):*

Compactness of Cohesionless Soils	SPT N-Value
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

Consistency of Cohesive Soils	Undrained Shear Strength kPa	Undrained Shear Strength psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	Over 200	Over 4000

Soil Sampling

Sample types are abbreviated as follows:

SS	Split Spoon	TW	Thin Wall Open (Pushed)	RC	Rock Core	GS	Grab Sample
AS	Auger Sample	TP	Thin Wall Piston (Pushed)	WS	Washed Sample	AR	Air Return Sample

Additional information provided in this section includes sample numbering, sample recovery and numerical testing results.

Field and Laboratory Testing

Results of field testing (e.g., SPT, pocket penetrometer, and vane testing) and laboratory testing (e.g., natural moisture content, and limits) executed on the recovered samples are plotted in this section.

Instrumentation Installation

Instrumentation installations (monitoring wells, piezometers, inclinometers, etc.) are plotted in this section. Water levels, if measured during fieldwork, are also plotted. These water levels may or may not be representative of the static groundwater level depending on the nature of soil stratum where the piezometer tips are located, the time elapsed from installation to reading and other applicable factors.

Comments

This column is used to describe non-standard situations or notes of interest.

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wood.

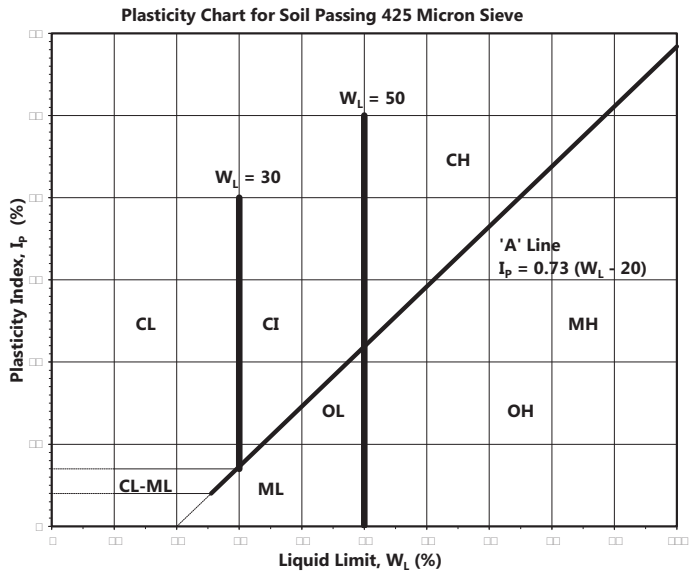
MODIFIED * UNIFIED CLASSIFICATION SYSTEM FOR SOILS

*The soil of each stratum is described using the Unified Soil Classification System (Technical Memorandum 36-357 prepared by Waterways Experiment Station, Vicksburg, Mississippi, Corps of Engineers, U.S Army. Vol. 1 March 1953.) modified slightly so that an inorganic clay of "medium plasticity" is recognized.

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75mm	CLEAN GRAVELS (TRACE OR NO FINES)	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 4$; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ = 1 to 3
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY GRAVELS (WITH SOME OR MORE FINES)	GM	SILTY GRAVELS, GRAVEL-SAND- SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I MORE THAN 4
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I MORE THAN 7
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75mm	CLEAN SANDS (TRACE OR NO FINES)	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 6$; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ = 1 to 3
			SP	POORLY GRADED GRAVELS, GRAVEL- SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS
		DIRTY SANDS (WITH SOME OR MORE FINES)	SM	SILTY SANDS, SAND-SILT MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I MORE THAN 4
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES	ATTERBERG LIMITS BELOW "A" LINE OR P.I MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	W_L < 50%	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)
		W_L < 50%	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	W_L < 30%	CL	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY OR SILTY CLAYS, LEAN CLAYS	
		30% < W_L < 50%	CI	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS	
		W_L < 50%	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
	ORGANIC SLITS & CLAYS BELOW "A" LINE	W_L < 50%	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	WHENEVER THE NATURE OF THE FINES CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", E.G SF IS A MIXTURE OF SAND WITH SILT OR CLAY
		W_L < 50%	OH	ORGANIC CLAYS OF HIGH PLASTICITY	
HIGH ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBROUS TEXTURE

SOIL COMPONENTS

FRACTION	U.S STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS		
		PASSING	RETAINED	PERCENT	DESCRIPTOR
GRAVEL	COARSE	76 mm	19 mm	35-50	AND
	FINE	19 mm	4.75 mm	20-35	Y/EY
				10-20	SOME
SAND	COARSE	4.75 mm	2.00 mm	1-10	TRACE
	MEDIUM	2.00 mm	425 µm		
	FINE	425 µm	75 µm		
FINES (SILT OR CLAY BASED ON PLASTICITY)		75 µm			
OVERSIZED MATERIAL					
ROUNDED OR SUBROUNDED: COBBLES 76 mm TO 200 mm BOULDERS > 200 mm				NOT ROUNDED: ROCK FRAGMENTS > 76 mm ROCKS > 0.76 CUBIC METRE IN VOLUME	



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Note 1: Soils are classified and described according to their engineering properties and behaviour.

Note 2: The modifying adjectives used to define the actual or estimated percentage range by weight of minor components are consistent with the Canadian Foundation Engineering Manual (4th Edition, Canadian Geotechnical Society, 2006.)

RECORD OF BOREHOLE No. BH1

Project Number: **SWW187112**
Project Client: **The Corporation of the City of Windsor**
Project Name: **Hawthorne Pedestrian Bridge**
Project Location: **Hawthorne Avenue, Windsor, ON**
Drilling Location: **N4686227, E341240**

Drilling Method: **150 mm O.D. Hollow Stem Augers**
Drilling Machine: **Truck Mounted Drill**
Date Started: **05 Apr 2018** Date Completed: **05 Apr 2018**
Logged by: **NF** Compiled by: **SS**
Reviewed by: **AP** Revision No.: **0**

wood.

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION Local Ground Surface Elevation:	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	PenetrationTesting: ○ SPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; ■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80	Atterberg Limits W_P W W_L Plastic Liquid; ✳ Passing 75 um (%); ○ Moisture Content (%); ★ Unit Weight (KN/m3) 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	TOPSOIL (125 mm thick)										
	SILTY CLAY 0.1 Trace sand, trace gravel Mottled brown and grey Firm										
		SS	1	67	7	1		○	18		-spoon hitting rock
		SS	2	7	23			○	13		
						2					
	Brown Very stiff						▽				
		SS	3	89	17			○	11		
						3					
		SS	4	89	18			○	15		
	Stiff										
		SS	5	100	14	4		○	14		
		SS	6	100	11			○	16		
						5					
	Grey Firm										
						6					
		SS	7	100	4			○	17		
		VT						▲ 39 △ 60			
	Stiff					7					

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▽ Groundwater measured at a depth of 2.3 m upon completion of drilling.

■ Cave in measured at a depth of 8.5 m upon completion of drilling.

Borehole details, as presented, do not constitute a thorough understanding of all potential conditions present and requires interpretive assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Continued on Next Page

RECORD OF BOREHOLE No. BH1

Project Number: **SWW187112**
Project Client: **The Corporation of the City of Windsor**
Project Name: **Hawthorne Pedestrian Bridge**
Project Location: **Hawthorne Avenue, Windsor, ON**
Drilling Location: **N4686227, E341240**

Drilling Method: **150 mm O.D. Hollow Stem Augers**
Drilling Machine: **Truck Mounted Drill**
Date Started: **05 Apr 2018** Date Completed: **05 Apr 2018**
Logged by: **NF** Compiled by: **SS**
Reviewed by: **AP** Revision No.: **0**

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	PenetrationTesting ○ SPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; ■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80	Atterberg Limits W_P W W_L; Plastic Liquid; ✳ Passing 75 um (%) ○ Moisture Content (%) ★ Unit Weight (KN/m3) 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
		SS	8	100	4	8		○	17		
								▲ 32 △ 46			
		VT									
						9					
	Soft	SS	9	100	3			○	19		
	END OF BOREHOLE 9.6 (no refusal)					10					
						11					
						12					
						13					
						14					
						15					

▽ Groundwater measured at a depth of 2.3 m upon completion of drilling.

■ Cave in measured at a depth of 8.5 m upon completion of drilling.

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RECORD OF BOREHOLE No. BH2

Project Number: **SWW187112**
Project Client: **The Corporation of the City of Windsor**
Project Name: **Hawthorne Pedestrian Bridge**
Project Location: **Hawthorne Avenue, Windsor, ON**
Drilling Location: **N4686246, E341276**

Drilling Method: **150 mm O.D. Hollow Stem Augers**
Drilling Machine: **Truck Mounted Drill**
Date Started: **05 Apr 2018** Date Completed: **05 Apr 2018**
Logged by: **NF** Compiled by: **SS**
Reviewed by: **AP** Revision No.: **0**

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		
Lithology Plot	DESCRIPTION Local Ground Surface Elevation:	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	PenetrationTesting: ○ SPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; ■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80	Atterberg Limits W_P W W_L; Plastic Liquid; ✳ Passing 75 um (%); ○ Moisture Content (%); ★ Unit Weight (KN/m3); 20 40 60 80	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	TOPSOIL (150 mm thick)										
	SILTY CLAY 0.2 Trace sand, trace gravel, with rootlets Mottled brown and grey Firm										
		SS	1	67	7	1		○	○ 14		
	Stiff										
		SS	2	83	9	2	▽	○	○ 14		
	Brown										
		SS	3	11	11	3		○	○ 15		
		SS	4	89	11			○	○ 14		
	Grey Firm					4					
		SS	5	100	5			○	○ 16		
		SS	6	100	5	5		○	○ 18		
		VT						▲ 35 △ 53			
	Stiff					6					
	Soft	SS	7	100	3			○	○ 17		
						7					

▽ Groundwater measured at a depth of 1.8 m upon completion of drilling.

■ Cave in measured at a depth of 7.3 m upon completion of drilling.

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Continued on Next Page

RECORD OF BOREHOLE No. BH2

Project Number: **SWW187112**
Project Client: **The Corporation of the City of Windsor**
Project Name: **Hawthorne Pedestrian Bridge**
Project Location: **Hawthorne Avenue, Windsor, ON**
Drilling Location: **N4686246, E341276**

Drilling Method: **150 mm O.D. Hollow Stem Augers**
Drilling Machine: **Truck Mounted Drill**
Date Started: **05 Apr 2018** Date Completed: **05 Apr 2018**
Logged by: **NF** Compiled by: **SS**
Reviewed by: **AP** Revision No.: **0**

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' Value	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; ■ Undrained Shear Strength (kPa) (from P. Penetrometer tests) 20 40 60 80	Atterberg Limits W_P W W_L; Plastic Liquid; ✳ Passing 75 um (%); ○ Moisture Content (%); ★ Unit Weight (KN/m3); 20 40 60 80	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
		SS	8	100	3	8		○	○ 19		
	END OF BOREHOLE 8.1 (no refusal)					9					
						10					
						11					
						12					
						13					
						14					
						15					

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▽ Groundwater measured at a depth of 1.8 m upon completion of drilling.

■ Cave in measured at a depth of 7.3 m upon completion of drilling.

APPENDIX C

GEOTECHNICAL LABORATORY TEST RESULTS

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ATTERBERG LIMITS
ASTM D-4318 or LS-703 / 704

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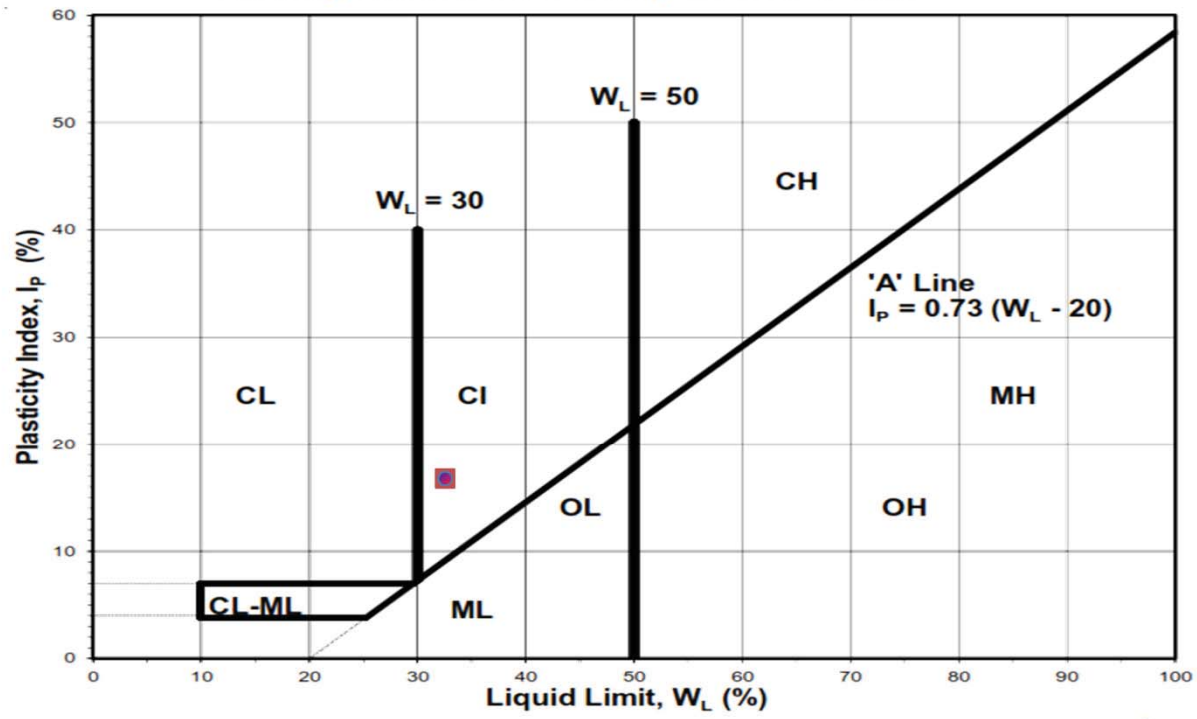
Project Number:	SWW187112.1000	**Sampled by:**	NF	**Sampled on:**	05-Apr-18
Project Client:	City of Windsor	**Tested by:**	JP	**Received on:**	05-Apr-18
Project Name:	Hawthrone Pedestrian Bridge			**Tested on:**	10-Apr-18
Project Location:	Windsor				

Test Results

LAB NUMBER	202
BOREHOLE	1
SAMPLE	5
DEPTH (m)	3.8 - 4.3

PLASTIC LIMIT	**16.0**
LIQUID LIMIT	**32.9**
PLASTICITY INDEX	**16.9**

Plasticity Chart for Soil Passing 425 Micron Sieve



Signed by: _____
Justin Palmer, Lab Supervisor, C. Tech.

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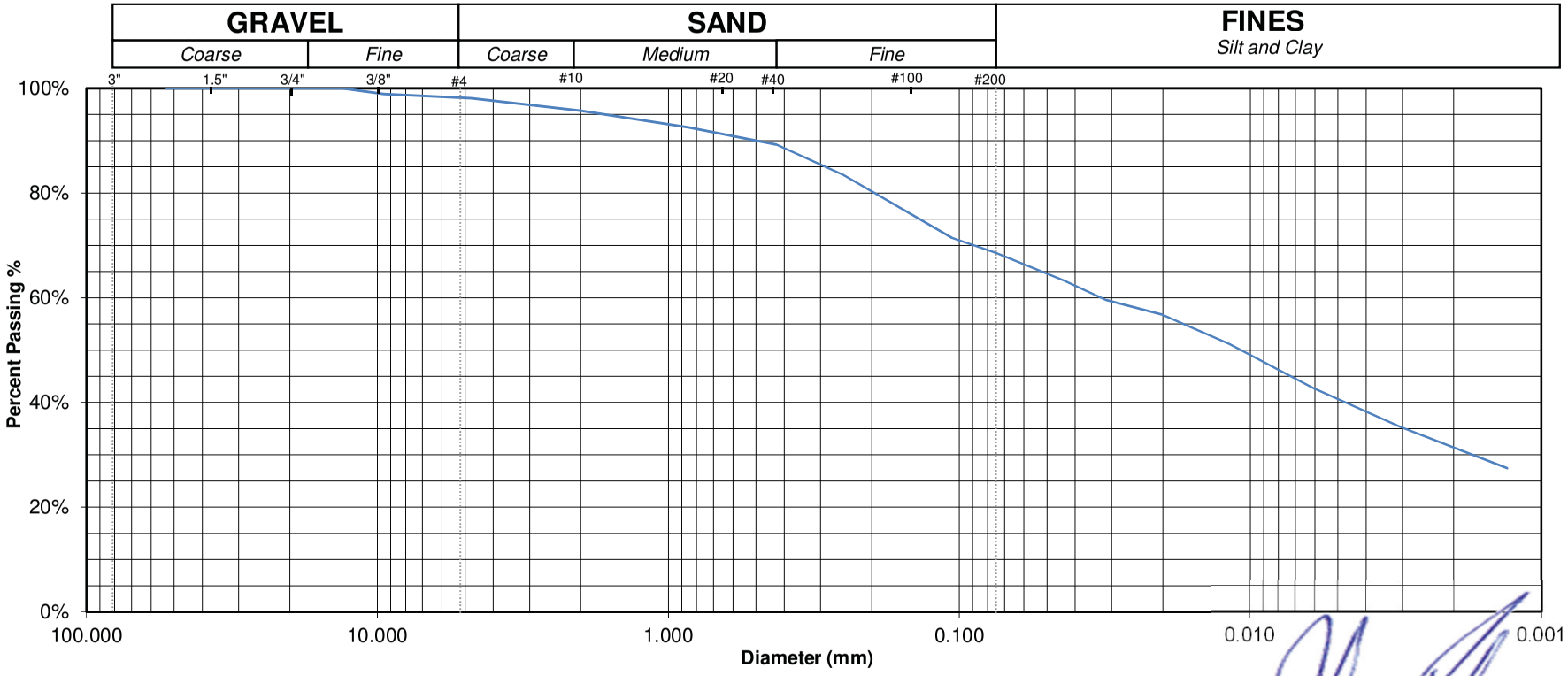
GRAIN SIZE DISTRIBUTION
MTO LS 702 / ASTM D7928 / ASTM D6913

Project Number:	SWW187112.1000	**Sampled by:**	NF	**Sampled on:**	5-Apr-2018
Project Client:	City of Windsor	**Tested by:**	JP	**Received on:**	5-Apr-2018
Project Name:	Hawthrone Pedestrian Bridge			**Tested on:**	11-Apr-2018
Project Location:	Windsor				

Test Results

		Gravel	Sand	Silt	Clay	Soil Classification
Sample Location:	**BH 1, Sa. 5**					
Sample Identification:	**203**	1.9%	29.5%	37.2%	31.4%	CLAYEY SANDY SILT, trace gravel



Signed by: _____
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ATTERBERG LIMITS
ASTM D-4318 or LS-703 / 704

wood.

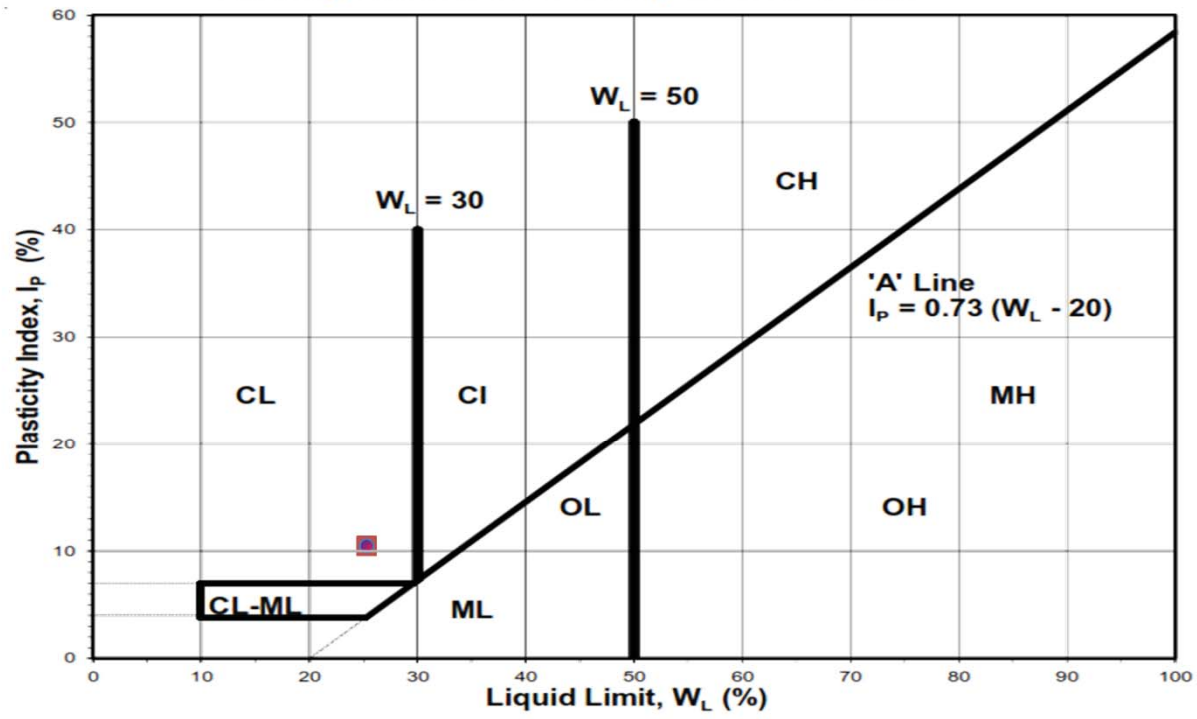
Project Number:	SWW187112.1000	**Sampled by:**	NF	**Sampled on:**	05-Apr-18
Project Client:	City of Windsor	**Tested by:**	JP	**Received on:**	05-Apr-18
Project Name:	Hawthrone Pedestrian Bridge			**Tested on:**	10-Apr-18
Project Location:	Windsor				

Test Results

LAB NUMBER	204
BOREHOLE	2
SAMPLE	7
DEPTH (m)	6.1 - 6.6

PLASTIC LIMIT	**15.0**
LIQUID LIMIT	**25.6**
PLASTICITY INDEX	**10.6**

Plasticity Chart for Soil Passing 425 Micron Sieve



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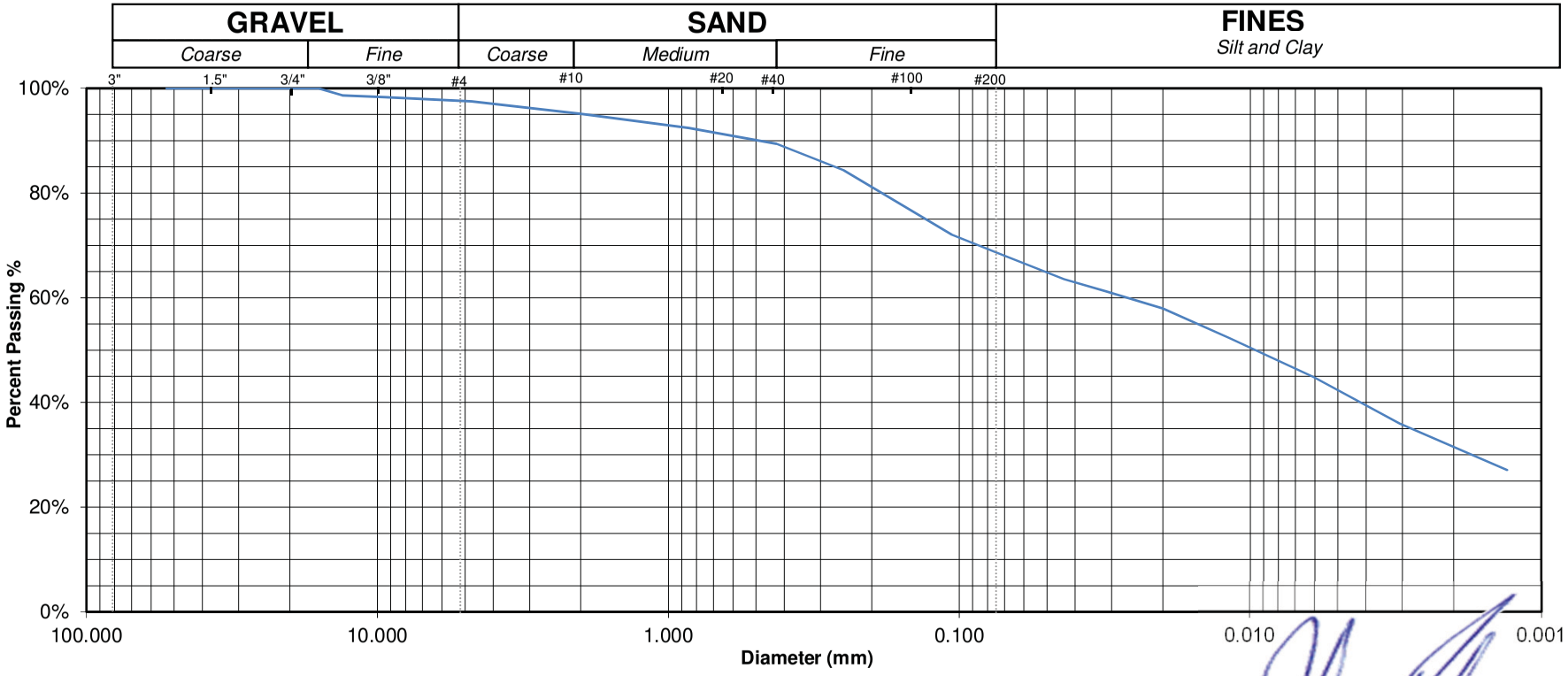
GRAIN SIZE DISTRIBUTION
MTO LS 702 / ASTM D7928 / ASTM D6913

wood.

Project Number:	SWW187112.1000	**Sampled by:**	NF	**Sampled on:**	5-Apr-2018
Project Client:	City of Windsor	**Tested by:**	JP	**Received on:**	5-Apr-2018
Project Name:	Hawthrone Pedestrian Bridge			**Tested on:**	11-Apr-2018
Project Location:	Windsor				

Test Results

		Gravel	Sand	Silt	Clay	Soil Classification
Sample Location:	**BH 3, Sa. 7**					
Sample Identification:	**205**	2.5%	28.8%	37.2%	31.5%	CLAYEY SANDY SILT, trace gravel



Signed by: _____
Justin Palmer, Lab Supervisor, C. Tech.

Appendix F

Design Drawings