105-109 HENDERSON ROAD GEOTECHNICAL REPORT

Project No.: CP-17-0638

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McINTOSH PERRY

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105-109 Henderson Road, Ottawa, Ontario

1.0 INTRODUCTION

This report presents the factual findings obtained from a geotechnical investigation performed at the above-mentioned site, for the proposed construction of three-story apartment building with a basement, in the neighborhood of Sandy Hill in Ottawa, Ontario. It is understood the existing residential homes will remain in place, and the proposed construction will be in the backyard of these properties. The field work was carried out on January 31, 2018 and comprised of two boreholes advanced to a maximum depth of 17.2 m below existing ground surface.

The purpose of the investigation was to explore the subsurface conditions at this site and to provide anticipated geotechnical conditions influencing the design and construction of the proposed building.

McIntosh Perry Consulting Engineers Ltd (McIntosh Perry) carried out the investigation at the request of TC United.

2.0 SITE DESCRIPTION

The property under consideration for proposed development is located at 105 and 109 Henderson Avenue in the Sandy Hill neighbourhood of Ottawa. Henderson Avenue is a southbound one-way avenue containing high density residential properties. The property to the south of 109 Henderson is a Hydro Ottawa building, with multiplexes bordering the East and North property lines of both properties. The properties have very minimal vegetation and the grade is relatively flat. 109 Henderson Avenue has a garage at the rear of the property bordering the fence line with 105 Henderson Avenue. At the south end of Henderson Avenue at Somerset Street, grade drops significantly to the South.

It is understood based on the concept plans provided, the proposed structure will be a 3-story building, with a basement. The proposed building will be surrounded with an asphalt parking lot.

Location of the property is shown on Figure 1, included in Appendix B.

3.0 FIELD PROCEDURES

Staff of McIntosh Perry Consulting Engineers (McIntosh Perry) visited the site before the drilling investigation to mark out the proposed borehole locations. Utility clearance was carried out by USL-1 on behalf of McIntosh Perry. Public and private utility authorities were informed and all utility clearance documents were obtained before the commencement of drilling work.

The equipment used for drilling was owned and operated by George Downing Estate Drilling Ltd. of Hawkesbury, Ontario. Boreholes were advanced using hollow and solid stem augers aided by track-mounted LC-55 drilling rig. Boreholes were advanced to a maximum depth of 17.2 m below the ground level. Soil samples were obtained at 0.75 m intervals of depth in boreholes using a 50 mm outside diameter split spoon sampler in accordance with the Standard Penetration Test (SPT) procedure. MTO 'N' vane tests were taken to measure in-situ shear strength of cohesive material. In boreholes BH18-1, the investigation was advanced beyond the sampled depth with Dynamic Cone Penetration Tests (DCPT) to the termination depth. Boreholes were backfilled with auger cuttings. All boreholes were restored to match the original surface. Borehole locations are shown on Figure 2, included in Appendix B.

4.0 LABORATORY TEST PROCEDURES

Laboratory testing on representative SPT samples was performed at McIntosh Perry geotechnical lab included moisture content, and Atterberg Limit Testing. Atterberg Limit test and moisture content was done on retrieved SPT samples, was tested by LRL Ltd. The laboratory tests to determine index properties were performed in accordance with CCIL test procedures, which follow American Society for Testing Materials (ASTM) test procedures.

The rest of the soil samples recovered will be stored in McIntosh Perry storage facility for a period of one month after submission of the final report. Samples will be disposed after this period of time unless otherwise requested in writing by the Client.

Laboratory tests are included in Appendix C.

5.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

5.1 Site Geology

Based on published physiography maps of the area (Ontario Geological Survey) the site is located within the Ottawa Valley Clay Plains. Surficial geology maps of southern Ontario identify the property as on older alluvial deposits.

The Ottawa Valley between Pembroke and Hawkesbury, Ontario consists of clay plains interrupted by ridges of rock or sand. It is naturally divided into two parts, above and below Ottawa, Ontario. Within the valley, the bedrock is further faulted so that some of the uplifted blocks appear above the clay beds. The sediments themselves in the valley are deep silty clay. Although the clay deposits are grey in color like the lime stones that underlies them in part, they are only mildly calcareous and likely derived from the more acidic rock of the Canadian Shield.

5.2 Subsurface Conditions

In general, the site stratigraphy consists of a topsoil, underlain by fill material, followed by a silty clay. The soils encountered at this site can be divided into two different zones.

a) Fill
b) Clay

The soils encountered during the course of the investigation, together with the field and laboratory test results are shown on the Record of Borehole sheets included in Appendix C. Description of the strata encountered are given below.

5.2.1 Fill

At the top of both boreholes a layer of topsoil was observed, the thickness of the topsoil was observed to be between 150 and 300 mm. Under the topsoil was silty sand fill, observed to have trace to some clay, and trace gravel. The fill was observed to be loose, brown and moist. SPT 'N' values were observed to be between 3 to 6 blows/300mm. The fill was observed to extend to a depth of 1.5 m.

5.2.2 Clay

The clay was observed to be stiff to firm, moist to wet and grey. Moisture content within the weathered crust was an average of 51%. Within the weathered clay crust SPT 'N' values ranged from 4 to 11 blows/300 mm, below the crust SPT 'N' values ranged from 0 to 2 blows/300 mm, with an average moisture content of 51%. Boreholes BH17-4 and BH17-5, were advanced with DCPT, values were observed to be between 0 and 16 blows/300mm. MTO N-sized vane tests were conducted which estimated the in-situ shear strength of the layer ranged from 38 kPa to 102 kPa (firm to stiff), with an average of 70kPa, and sensitivity ranging between 13 and 3, indicating non-sensitive to highly sensitive clay. Three Atterberg Limit test were conducted on representative samples and found to be clay of high-plasticity (CH). Results showed the liquid limit values range from 80% to 81% and the plastic limit range from 27% to 30%. Test results are shown on Figure 3, included in Appendix B. Moisture content of sample tested below the weathered crust for Atterberg Limits, indicate the natural moisture content of the sample is close to the liquid limit of the sample, indicating the layer is in a sensitive state. The thickness of the clay layer was observed to be 15.7 m, terminating at a depth of 17.2 m from the existing ground surface (El. 82.2 m). Bottom of the clay layer was determined to be at DCPT refusal on probable bedrock.

5.3 Groundwater

Groundwater was not observed in open boreholes. Moisture content of the clay was observed to increase at an approximate depth of 3.5-4.0 m. Groundwater level may be expected to fluctuate due to seasonal changes.

5.4 Chemical Analysis

The chemical test results conducted by Paracel Laboratories in Ottawa, Ontario, to determine the resistivity, pH, sulphate and chloride content of representative soil sample are shown in Table 5-1 below:

Table 5-1: Soil Chemical Analysis Results

Borehole	Sample	Depth / El. (m)	pH	Sulphate (%)	Chloride (%)	Resistivity (Ohm-cm)
BH18-1	SS-3	1.5-2.1	7.25	0.0016	0.0009	9,190

6.0 DISCUSSIONS AND RECOMMENDATIONS

6.1 General

This section of the report provides recommendations for the design of the proposed building behind 105 and 109 Henderson Road in Ottawa, Ontario. The recommendations are based on interpretation of the factual information obtained from the boreholes advanced during the subsurface investigation. The discussions and recommendations presented are intended to provide sufficient information to the designer of the proposed building to select the suitable type of foundation to support the structure.

The comments made on the construction are intended to highlight aspects which could have impact or affect the detailed design of the building, for which special provisions may be required in the Contract Documents. Those who requiring information on construction aspects should make their own interpretation of the factual data presented in the report. Interpretation of the data presented may affect equipment selection, proposed construction methods, and scheduling of construction activities.

6.2 Project Design

6.2.1 Existing Site Condition

Detailed site condition is provided in Section 2. The site contains two existing two-story residential structures and is located in the middle of a residential subdivision. The location of the site is shown on Figure 1 included in Appendix B.

6.2.2 Proposed Development

It is understood that the proposed development will be a three-storey apartment building with a basement, and will likely be a conventional slab on grade with shallow footing foundation.

Finished grade was not provided at the time of this report, it is expected construction will occur at the existing grade and no grade raise are expected.

6.3 Frost Protection

Based on applicable building codes, a minimum earth cover of 1.8 m, or the thermal equivalent of insulation, should be provided for all exterior footings to reduce the effects of frost action.

6.4 Site Classification for Seismic Site Response

Table 4.2 of CHBDC shall be consulted for the purpose of seismic design. Selected spectral responses in the general vicinity of the site for 10% chance of exceedance in 50 years (475 years return period) are as indicated in Table 6-3, shown below;

Table 6-1: Selected Seismic Spectral Responses (10% in 50 Yrs)

Sa(0.2)	Sa(0.5)	Sa(2.0)	PGA	PGV
0.161	0.124	0.021	0.102	0.068

The site can be classified as a Site Class "E" based on the clay consistency for the purposes of site-specific seismic response to earthquakes based on Table 4.1.8.4.A OBC 2012.

6.5 Engineered Fill

It is understood there are no plans for grade raise at this site.

If engineered fill is required, any topsoil or soft and spongy material should be removed before placing the engineered fill. The fill should be placed in horizontal lifts of uniform thickness of no more than 300 mm before compaction. It should be placed at appropriate moisture content and compacted to the specified density. The requirements for fill material and compaction may be addressed with a note on the structural drawing for foundation or grading drawing and/or with a Non-Standard Special Provision (NSSP). In any location where the engineered fill is to support any structural element, including pavement structure, minimum 100% Standard Proctor Maximum Dry Density (SPMDD) should be achieved. In other cases, minimum 96% SPMDD is adequate.

6.6 Slabs-on-Grade

Slabs-on-grade should be supported on minimum 200 mm of Granular A compacted to 100% SPMDD. In case the subgrade needs to be raised Granular B type II or granular A needs to be compacted to minimum 96% SPMDD.

All subgrades should be proof-rolled under the supervision of a geotechnical representative prior to placement of the Granular "A" and slab-on-grade.

6.7 Shallow Foundations

Based on the proposed building concept and architectural sketches, it is the authors' understanding that the building foundation level may fall close to the interface of the weather crust and the soft clay. Based on the in-situ undrained shear test results of the clay and laboratory test results for plasticity index, a pre-consolidation pressure of 150 kPa was considered in settlement calculations.

The structure is expected to be a light-weight wood frame with or without steel or concrete components. Considering the order of structural loads expected at the foundation level, provision of conventional strip footings will be adequate. If necessary, pad footings can be also used in the design, however the dimensions of isolated pad footing shall not exceed 2 m. Footings are expected to be buried to resist overturning and sliding and also to provide protection against frost action.

The excavation should extended to the top of the native clay, care must be taken not to disturb the clay. From the final stage of the excavation to placement of footings, construction traffic over the sensitive clay shall be minimized. Placement of mud-slab immediately after excavation can reduce the risk of subgrade degradation. Excavation into the clay layer should be limited. If adequate frost cover is not provided, the deficit of earth cover should be compensated by application of synthetic insulation material. A minimum of 0.6m of the clay crust should remain intact.

6.7.1 Bearing Capacity

Assuming the strip footings are constructed through excavating the fill and exposing the native clay crust, the following bearing capacity values can be used for structural design;

Factored beading pressure at Ultimate Limit State (ULS): 115 kPa

Serviceability Limit State (SLS): 75 kPa (1 m to 1.5 m wide strip footings)

If strip footings wider than 1.5 m are required, then authors of this report should be informed to verify the compatibility of the design with settlement criteria. Footings narrower than 0.6 m are not recommended due to the risk of punching failure. Following above note recommendations, total settlements are expected to remain between 25 mm to 35 mm. The structural designer shall note that wider strip footings with the same applied pressure will trigger larger settlements. When designing footings on clay, it is the best practice to keep the footing sizes and bearing pressures as similar as possible to reduce the risk of differential settlements.

6.8 Protection of Subgrade

Inspection and approval of the footing subgrade are required. This requirement may be addressed with a note on the structural drawing for foundation and/or with a Non-Standard Special Provision (NSSP). If the constructor can ensure there won't be any traffics on the subgrade, protection can be done through temporary covering. To limit disturbance, subgrade should be protected from freezing or precipitation.

6.9 Lateral Earth Pressure

Free draining material should be used as backfill material for foundation walls. If the proper drainage is provided "at rest" condition may be assumed for calculation of earth pressure on foundation walls. The following parameters are recommended for the granular backfill.

Table 6-1: Backfill Material Properties

Borehole	Granular "A"	Granular "B"
Effective Internal Friction Angle, ϕ'	35°	30°
Unit Weight, γ (kN/m^3)	22.8	22.8

6.10 Cement Type and Corrosion Potential

Sample from subgrade soil was submitted to Parcel laboratories for testing of chemical properties relevant to exposure of concrete elements to sulphate attacks as well as potential soil corrosivity effects on buried metallic structural element. Test results are presented in Tables 5-1.

The potential for sulphate attack on concrete structures is low. Therefore Type GU Portland cement may be adequate to protect buried concrete elements in the subsurface conditions encountered.

The soil pH is slightly on the basic side, high resistivity and relatively low chloride content determines the environment for buried steel elements is within the non-aggressive range.

7.0 CONSTRUCTION CONSIDERATIONS

Any organic or topsoil material, and existing fill material of any kind, should be removed from the footprint of the footing. If grade raise above the native clay subgrade is required suitable fill material to conform to specifications of OPSS Granular A should be placed over a layer of geotextile.

The founding level is expected above the groundwater level encountered at this site and no dewatering problems are anticipated. However, the excavated subgrade must be kept dry at all time to minimize the disturbance of the subgrade. Groundwater elevation is expected to fluctuate seasonally.

A geotechnical engineer or technician should attend the site to confirm the type of the material and level of compaction.

Foundation walls should be backfilled with free-draining material such as OPSS Granular material. The native clay is not a suitable material for backfilling. Sub-drains with positive drainage to the City sewer should be provided at foundation level.

Based on the proposed site layout there is not adequate room for sloped excavation. The contractor shall retain a professional engineer to provide excavation and shoring design to protect the existing buildings adjacent to the proposed excavation.

Groundwater table is expected to be lower than the proposed excavation (2.0 ± 0.3 m depth below existing ground) and the chance of water draw down due to the proposed excavation is minimal. Since the proposed excavation will be relatively close to the neighboring properties, the contractor should consider the addition of an instrumentation and monitoring program to their excavation plan. A baseline should be established and documented by surveying structural monitoring points and photographing exterior and interior of the adjacent buildings before the start of construction activities.

Given the age of the existing structure, the primary position of its consolidation settlement for the current load should have been achieved. The proposed building will undergo settlements as described in Section 6.7. In order to accommodate the expected varying levels of settlement between the two structures, it is best practice to separate the exiting and the proposed buildings. If there has to be connected structural components such as links or corridors, between the existing and proposed buildings, a provision of an expansion joint will be necessary.

The applied surcharge from the proposed building on the subgrade may also cause some settlement of the existing buildings. The magnitude of this settlement is a function of the distance, depth, and existing in-situ stress under each of the adjacent structures. The above noted instrumentation program can be used to measure or rule-out such effects and to quantify or reject potential claims by the owners of neighboring properties.

8.0 SITE SERVICES

At the subject site, the burial depth of water-bearing utility lines is typically 2.4 m below ground surface. If this depth is not achievable due to design restrictions, equivalent thermal insulation should be provided. The contractor should retain a professional engineer to provide detailed drawings for excavation and temporary support of the excavation walls during construction.

Utilities should be supported on minimum of 150 mm bedding of Granular A compacted to minimum 96% of SPMDD. Since the native subgrade is fine grained, it is recommended to separate the subgrade from the bedding material by a layer of geotextile to prevent cross migration of materials. Utility cover can be Granular A or Granular B type II compacted to 96% SPMDD. All covers are to be compacted to 100% SPMDD if intersecting structural elements.

Cut-off walls should be provided for utility trenches running below the groundwater level to mitigate the settlement risk due to groundwater lowering.

9.0 PAVEMENT STRUCTURE

It is understood the site plan contains an asphalt driveway to include room for two parking spaces. If this parking area is to be part of the new construction, the pavement structure detailed in the table below should be followed. The proposed pavement structure is suitable for construction on native subgrade or raised grade through engineered fill.

Table 9-1: Proposed Pavement Structure for Residential Driveways

Material		Thickness (mm)
Surface	Superpave 12.5, Design Category C, PG 58-34	50
Base	OPSS Granular A	250

10.0 CLOSURE

We trust this geotechnical investigation and foundation design report meets requirements of your project. The "Limitations of Report" presented in Appendix A are an integral part of this report. Please do not hesitate to contact the undersigned should you have any questions or concerns.

McIntosh Perry Consulting Engineers Ltd.

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REFERENCES

Canadian Geotechnical Society, “Canadian Foundation Engineering Manual”, 4th Edition, 2006.

Ontario Ministry of Natural Resources (OMNR), Ontario Geological Survey, Special Volume 2, “The Physiography of Southern Ontario”, 3rd Edition, 1984.

Google Earth, Google, 2015.

MTO – Pavement Design and Rehabilitation Manual

105 – 109 HENDERSON AVENUE

APPENDIX A
LIMITATIONS OF REPORT

LIMITATIONS OF REPORT

McIntosh Perry Consulting Engineers Ltd. (McIntosh Perry) carried out the field work and prepared the report. This document is an integral part of the Foundation Investigation and Design report presented.

The conclusions and recommendations provided in this report are based on the information obtained at the borehole locations where the tests were conducted. Subsurface and groundwater conditions between and beyond the boreholes may differ from those encountered at the specific locations where tests were conducted and conditions may become apparent during construction, which were not detected and could not be anticipated at the time of the site investigation. The benchmark level used and borehole elevations presented in this report are primarily to establish relative differenced in elevations between the borehole locations and should not be used for other purposes such as to establish elevations for grading, depth of excavations or for planning construction.

The recommendations presented in this report for design are applicable only to the intended structure and the project described in the scope of the work, and if constructed in accordance with the details outlined in the report. Unless otherwise noted, the information contained in this report does not reflect on any environmental aspects of either the site or the subsurface conditions.

The comments or recommendation provided in this report on potential construction problems and possible construction methods are intended only to guide the designer. The number of boreholes advanced at this site may not be sufficient or adequate to reveal all the subsurface information or factors that may affect the method and cost of construction. The contractors who are undertaking the construction shall make their own interpretation of the factual data presented in this report and make their conclusions, as to how the subsurface conditions of the site may affect their construction work.

The boundaries between soil strata presented in the report are based on information obtained at the borehole locations. The boundaries of the soil strata between borehole locations are assumed from geological evidences. If differing site conditions are encountered, or if the Client becomes aware of any additional information that differs from or is relevant to the McIntosh Perry findings, the Client agrees to immediately advise McIntosh Perry so that the conclusions presented in this report may be re-evaluated.

Under no circumstances shall the liability of McIntosh Perry for any claim in contract or in tort, related to the services provided and/or the content and recommendations in this report, exceed the extent that such liability is covered by such professional liability insurance from time to time in effect including the deductible therein, and which is available to indemnify McIntosh Perry. Such errors and omissions policies are available for inspection by the Client at all times upon request, and if the Client desires to obtain further insurance to protect it against any risks beyond the coverage provided by such policies, McIntosh Perry will co-operate with the Client to obtain such insurance.

McIntosh Perry prepared this report for the exclusive use of the Client. Any use which a third party makes of this report, or any reliance on or decision to be made based on it, are the responsibility of such third parties. McIntosh Perry accepts no responsibility and will not be liable for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

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105 – 109 HENDERSON AVENUE

APPENDIX B
FIGURES

McINTOSH PERRY

450 225 0 450

Scale 1:15,000 Metres

LEGEND

- Site Location
- Local Road
- Major Road
- Wooded Area
- Watercourse
- Waterbody

REFERENCE

GIS data provided by the Ontario Ministry of Natural Resources and Forestry, 2018.

CLIENT:	TC UNITED
PROJECT:	GEOTECHNICAL INVESTIGATION 105-109 HENDERSON AVE.
TITLE:	SITE LOCATION

McINTOSH PERRY

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PROJECT NO:	CP-17-0638	FIGURE:
Date	Feb., 01, 2018	1
GIS	JD	
Checked By	MG	

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7 3.5 0 7

Scale 1:300 Metres

LEGEND

Borehole Location

Approximate Property Boundary

REFERENCE

GIS data provided by the Ontario Ministry of Natural Resources and Forestry, 2018.

CLIENT: TC UNITED

PROJECT: GEOTECHNICAL INVESTIGATION 105-109 HENDERSON AVE.

TITLE: BOREHOLE LOCATIONS

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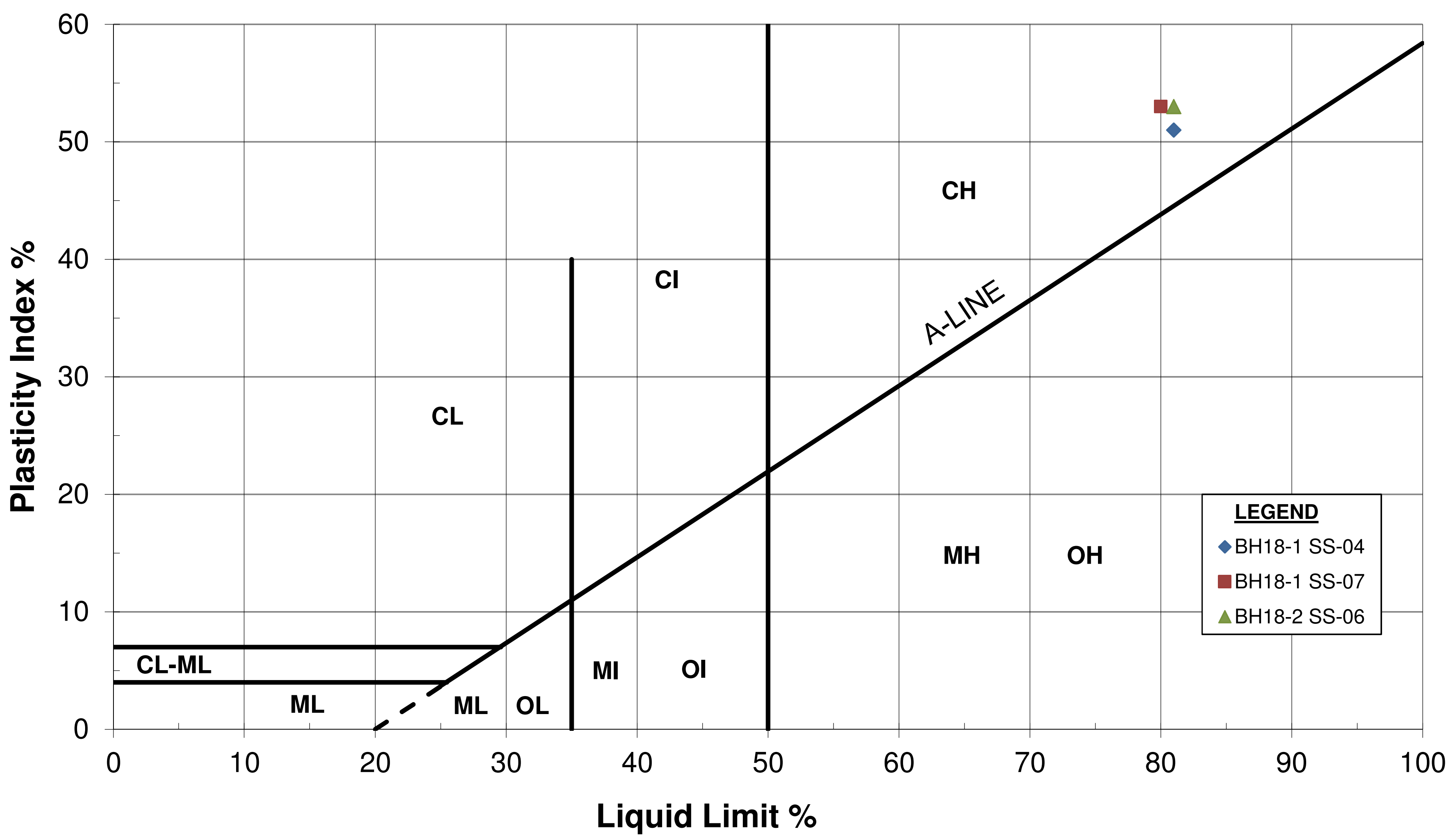
PROJECT NO:	CP-17-0638
Date	Feb., 01, 2018
GIS	JD
Checked By	MG

FIGURE: 2

H:\01 Project - Proposals\2017 Jobs\CP\0CP-17-0638 TCU_20 Unit Apartment Building_105-109 Henderson Avenue\Phase 1 ESA\05 GIS\mxd\0CP-17-0638_Geotechnical02_BoreholeLocationsHenderson.mxd



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PLASTICITY CHART

CLAY

105-109 Henderson Road

Figure No. 3

CP-17-0638

105 – 109 HENDERSON AVENUE

APPENDIX C
BOREHOLE LOGS

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EXPLANATION OF TERMS USED IN REPORT

N-VALUE: THE STANDARD PENETRATION TEST (SPT) N-VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS $\overline{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

<u>CONSISTENCY</u>: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

<u>DENSENESS</u>: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 – 5	5 – 10	10 – 30	30 – 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSION AND STRUCUTRAL FEATURES AND/OR STRENGTH.

<u>RECOVERY</u>: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

<u>MODIFIED RECOVERY</u>: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

<u>JOINT AND BEDDING</u>:

SPACING	50mm	50 – 300mm	0.3m – 1m	1m – 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_l, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ε	%	LINEAR STRAIN
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICALL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
c_c	1	COMPRESSION INDEX
c_s	1	SWELLING INDEX
c_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
Φ'	$-^o$	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
Φ_u	$-^o$	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1,%	VOID RATIO	e_{min}	1,%	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1,%	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1,%	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
ρ	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m^3	UNIT WEIGHT OF SOIL	w_P	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_P	%	PLASTICITY INDEX = $(W_L – W_L)$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(W – W_P)/ I_P$	i	1	HYDAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $(W_L – W) / 1_P$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERED SOIL	$e_{,max}$	1,%	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

McINTOSH PERRY

RECORD OF BOREHOLE No 18-1

DATE:	31/01/2018 - 31/01/2018	**LOCATION:**	105-109 Henderson Avenue ()	**ORIGINATED BY:**	Phil Hulan
ID:	CP-17-0638-HENDERSON	**COORDINATES:**	Lat: 45.423615 , Lon: -75.679798	**COMPILED BY:**	Mary-Ellen Gleeson
CLIENT:	TC United	**DATUM:**	Local	**CHECKED BY:**	N'eem Tavakkoli
ELEVATION:	99.4 m	**REMARK:**	No water observed in open borehole.	**REPORT DATE:**	07/03/2018

SOIL PROFILE

ELEVATION - m / DEPTH - m	DESCRIPTION
99.4	Natural ground surface
0.0	Topsoil
99.1 / 0.3	Fill. Silty sand, brown, moist, loose.
97.9 / 1.5	Silty clay, grey, moist to wet, stiff, weathered.
95.6 / 3.8	Silty clay, grey, wet, firm.

SAMPLES

TYPE AND NUMBER	RECOVERY	"N" or RQD
SS-01	79	3
SS-02	54	6
SS-03	83	7
SS-04	83	5
SS-05	92	3
SS-06	100	0
SS-07	100	2
SS-08	100	0
SS-09	75	1

SHEAR STRENGTH (kPa) — Vane test

Remolded	Intact
5.0	68.0
27.0	81.0
8.0	68.0
11.0	59.0
11.0	38.0
7.0	49.0

DYNAMIC CONE PEN. RESISTANCE PLOT: 20 40 60 80

SHEAR STRENGTH (kPa): Vane test ◇ Intact ◆ Remolded; Lab vane □ Intact ■ Remolded; 20 40 60 80 100

WATER CONTENT and LIMITS (%): W_P W W_L; 25 50 75

REMARKS & GRAIN SIZE DISTRIBUTION (%): G S M C

Column headings: DEPTH - feet; DEPTH - meters; SYMBOL; STATE; GROUNDWATER CONDITIONS

DEPTH - feet: 5, 10, 15, 20, 25, 30

DEPTH - meters: 1, 2, 3, 4, 5, 6, 7, 8, 9

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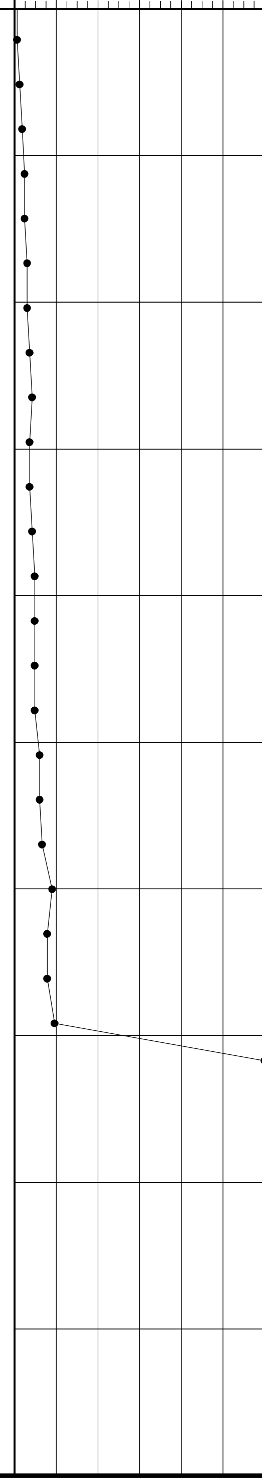
McINTOSH PERRY

RECORD OF BOREHOLE No 18-1

DATE:	31/01/2018 - 31/01/2018	**LOCATION:**	105-109 Henderson Avenue ()	**ORIGINATED BY:**	Phil Hulan
ID:	CP-17-0638-HENDERSON	**COORDINATES:**	Lat: 45.423615 , Lon: -75.679798	**COMPILED BY:**	Mary-Ellen Gleeson
CLIENT:	TC United	**DATUM:**	Local	**CHECKED BY:**	N'eem Tavakkoli
ELEVATION:	99.4 m	**REMARK:**	No water observed in open borehole.	**REPORT DATE:**	07/03/2018

DEPTH - feet	DEPTH - meters	SOIL PROFILE: ELEVATION - m / DEPTH - m	SOIL PROFILE: DESCRIPTION	SYMBOL	SAMPLES: TYPE AND NUMBER	SAMPLES: STATE	SAMPLES: RECOVERY	SAMPLES: "N" or RQD	GROUNDWATER CONDITIONS	DYNAMIC CONE PEN. RESISTANCE PLOT (20 40 60 80) / SHEAR STRENGTH (kPa) Vane test: ◇ Intact ◆ Remolded; Lab vane: □ Intact ■ Remolded (20 40 60 80 100)	WATER CONTENT and LIMITS (%) W_P W W_L (25 50 75)	REMARKS & GRAIN SIZE DISTRIBUTION (%) G S M C
35	11											
40	12											
	13											
45	14											
	15											
50	16											
55	17	82.2 17.2	**END OF BOREHOLE**									
	18											
60	19											



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McINTOSH PERRY

RECORD OF BOREHOLE No 18-2

DATE:	31/01/2018 - 31/01/2018	**LOCATION:**	105-109 Henderson Avenue ()	**ORIGINATED BY:**	Phil Hulan
ID:	CP-17-0638-HENDERSON	**COORDINATES:**	Lat: 45.423555 , Lon: -75.679717	**COMPILED BY:**	Mary-Ellen Gleeson
CLIENT:	TC United	**DATUM:**	Local	**CHECKED BY:**	N'eem Tavakkoli
ELEVATION:	99.5 m	**REMARK:**	No water observed in open borehole.	**REPORT DATE:**	07/03/2018

SOIL PROFILE

ELEVATION - m / DEPTH - m	DESCRIPTION
99.5	Natural ground surface
0.0	150 mm Topsoil.
99.3 / 0.2	Fill. Silty sand, trace to some clay, trace gravel, brown, dry to moist, loose.
98.0 / 1.5	Silty clay, grey with iron staining, moist, stiff to firm, weathered.
96.1 / 3.4	Silty clay, grey, moist to wet, stiff to firm.
93.7 / 5.8	**END OF BOREHOLE**

SAMPLES

TYPE AND NUMBER	RECOVERY	"N" or RQD
SS-01	8	5
SS-02	54	6
SS-03	83	11
SS-04	92	7
SS-05	100	4
SS-06	100	2

GROUNDWATER CONDITIONS

DYNAMIC CONE PEN. RESISTANCE PLOT: 20 40 60 80

SHEAR STRENGTH (kPa): Vane test ◇ Intact ◆ Remolded; Lab vane □ Intact ■ Remolded; 20 40 60 80 100

Remolded (Vane test)	Intact (Vane test)
19.0	102.
21.0	72.0
19.0	85.0
18.0	81.0

WATER CONTENT and LIMITS (%): W_P W W_L; 25 50 75

REMARKS & GRAIN SIZE DISTRIBUTION (%): G S M C

DEPTH - feet: 5, 10, 15, 20, 25, 30

DEPTH - meters: 1, 2, 3, 4, 5, 6, 7, 8, 9

105 – 109 HENDERSON AVENUE

APPENDIX D
LAB RESULTS

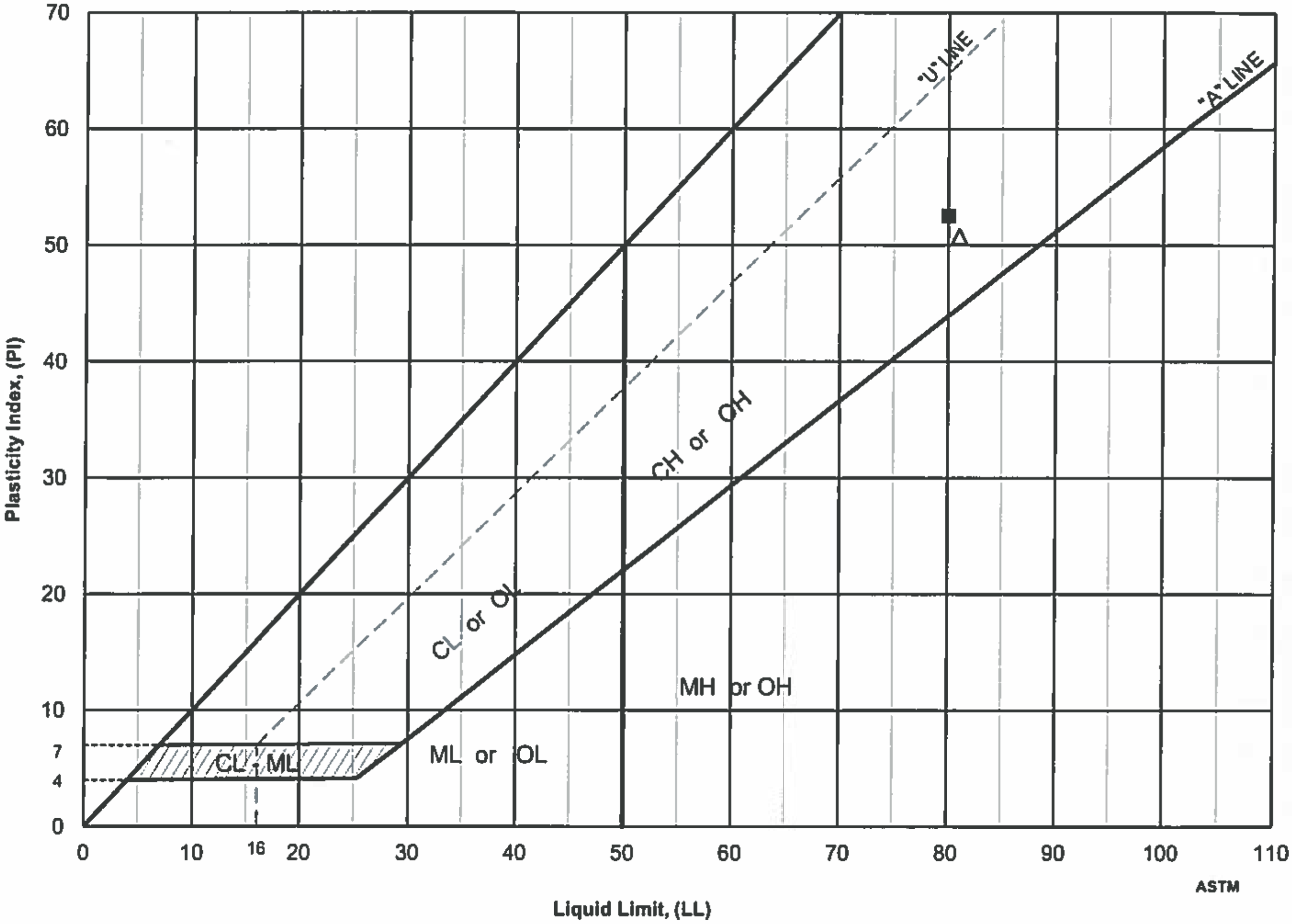
LRL Associates Ltd.

PLASTICITY INDEX

ASTM D 4318 / LS-703/704

Client:	McIntosh Perry Consulting Engineers	Reference No.:	CP-17-0638
Project:	Materials Testing	File No.:	170496-20
Location:	Henderson	Report No.:	1

Plasticity Chart



	Location	Sample	Depth, m	Moisture Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Activity Number	USCS
△	BH 18-1	SS-04	2.29 - 2.90	54	81	30	51	0.47	n/d	CH
■	BH 18-1	SS-07	5.33 - 5.94	75	80	27	53	0.90	n/d	CH

Date Issued: February 7, 2018

Reviewed By: W.A.McLaughl

W.A.M^{c}Laughlin, Geo.Tech., C.Tech.

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Certificate of Analysis

McIntosh Perry Consulting Eng. (Carp)

115 Walgreen Road
RR#3 Carp, ON K0A 1L0
Attn: Mary Ellen Gleeson

Client PO: Henderson CP-17-0638
Project: CP-17-0638
Custody: 34160

Report Date: 12-Feb-2018
Order Date: 6-Feb-2018

Order #: 1806215

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1806215-01	CP-17-0638 BH18-1 SS-03

Approved By: Mark Foto

Mark Foto, M.Sc.
Lab Supervisor

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	8-Feb-18	9-Feb-18
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	6-Feb-18	7-Feb-18
Resistivity	EPA 120.1 - probe, water extraction	9-Feb-18	10-Feb-18
Solids, %	Gravimetric, calculation	7-Feb-18	7-Feb-18

PARACEL LABORATORIES LTD.

Order #: 1806215

Certificate of Analysis

Client: McIntosh Perry Consulting Eng. (Carp)

Client PO: Henderson CP-17-0638

Report Date: 12-Feb-2018

Order Date: 6-Feb-2018

Project Description: CP-17-0638

	Client ID:	CP-17-0638 BH18-1 SS-03	-	-	-
	Sample Date:	31-Jan-18	-	-	-
	Sample ID:	1806215-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	75.2	-	-	-
General Inorganics					
pH	0.05 pH Units	7.25	-	-	-
Resistivity	0.10 Ohm.m	91.9	-	-	-
Anions					
Chloride	5 ug/g dry	9	-	-	-
Sulphate	5 ug/g dry	16	-	-	-

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Resistivity	ND	0.10	Ohm.m						

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	14.4	5	ug/g dry	17.3			18.5	20	
Sulphate	15.7	5	ug/g dry	15.6			0.6	20	
General Inorganics									
pH	7.84	0.05	pH Units	7.89			0.6	10	
Resistivity	401	0.10	Ohm.m	395			1.4	20	
Physical Characteristics									
% Solids	90.0	0.1	% by Wt.	86.5			3.9	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	108	5	ug/g	17.3	90.5	78-113			
Sulphate	118	5	ug/g	15.6	103	78-111			

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

APPENDIX E
SEISMIC HAZARD CALCULATION

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

February 14, 2018

Site: 45.4236 N, 75.6799 W   User File Reference: 105-109 Henderson Road

Requested by: , McIntosh Perry

National Building Code ground motions: 2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.05)	Sa(0.1)	**Sa(0.2)**	Sa(0.3)	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**	**PGA (g)**	**PGV (m/s)**
0.447	0.523	**0.439**	0.334	**0.237**	**0.118**	**0.056**	**0.015**	**0.0054**	**0.281**	**0.197**

Notes. Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC 2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are specified in **bold** font. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. ***These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.05)	0.044	0.149	0.247
Sa(0.1)	0.061	0.187	0.300
Sa(0.2)	0.055	0.161	0.255
Sa(0.3)	0.044	0.124	0.195
Sa(0.5)	0.031	0.088	0.138
Sa(1.0)	0.015	0.044	0.070
Sa(2.0)	0.0061	0.021	0.033
Sa(5.0)	0.0012	0.0047	0.0081
Sa(10.0)	0.0006	0.0019	0.0032
PGA	0.033	0.102	0.163
PGV	0.021	0.068	0.111

References

National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

User's Guide - NBC 2015, Structural Commentaries NRCC no. xxxxxx (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

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