TECHNICAL MEMORANDUM

DATE October 17, 2015 **PROJECT No.** 1418381-4000

TO Lisa Dalla Rosa
Cardel Homes

FROM Stephen Dunlop, P.Eng. **EMAIL** stdunlop@golder.com

SUPPLEMENTAL GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL SUBDIVISION
5873 PERTH STREET
OTTAWA (VILLAGE OF RICHMOND), ONTARIO

This technical memorandum presents the results of a supplemental geotechnical investigation for a proposed residential subdivision to be located at 5873 Perth Street in Ottawa (Village of Richmond), Ontario.

This supplemental geotechnical investigation included an assessment of the general subsurface conditions in the area of the proposed development by means of two additional boreholes advanced at the site by Golder Associates and subsurface information previously collected by others. Based on an interpretation of the factual information obtained, a general description of the subsurface conditions is presented. These interpreted subsurface conditions and available project details were used to carry out a geotechnical assessment of the grade raise restrictions for the site.

The reader is referred to the "Important Information and Limitations of This Report" which follows the text but forms an integral part of this document.

Description of Project and Site

Plans are currently being prepared for the construction of a new residential subdivision to be located on the east side of Shea Road and north of Perth Street in Ottawa, Ontario. The following information is known about the site and the proposed development:

- The site is roughly rectangular in shape and measures about 130 metres by 445 metres in plan area;
- The property is currently unused farmland;
- The ground surface is relatively flat;
- The residential lots will be serviced with individual on-site water wells; and,
- The development will be serviced with storm and sanitary sewers.

SPL Consultants (SPL) carried out a preliminary geotechnical investigation for the development in 2013/2014. The results of the previous investigation were provided in a report titled "Preliminary Geotechnical Investigation, Proposed Subdivision at 5831 to 5837 Perth Street and 2770 Eagleson Road, Ottawa, Ontario", dated February 2014. The previous investigation included two boreholes (numbered 13-5 and 13-6) on the west-side portion of the property (i.e., within the current study area). The approximate locations of the previous boreholes are shown on the attached Site Plan (Figure 1). The previous boreholes indicate that the subsurface conditions on this site consist of a 7 to 11 metre thick deposit of sensitive silty clay overlying glacial till.

Investigation Procedure

The fieldwork for the supplemental investigation was carried out on August 13, 2015. At that time, two boreholes (numbered 15-1 and 15-2) were advanced to about 12.3 and 10.9 metres depth, respectively, at the approximate locations shown on the attached Site Plan (Figure 1). The boreholes were advanced using a truck-mounted hollow-stem auger drill rig supplied and operated by Marathon Drilling of Ottawa, Ontario.

Standard penetration tests were carried out within the boreholes at regular intervals of depth and soil samples were recovered using split-spoon sampling equipment. In situ vane testing was carried out, where possible, in the silty clay to determine the undrained shear strength of this soil unit. In addition, a total of three 73 millimetre diameter thin-walled Shelby tube samples of the "softer" silty clay were obtained using a fixed piston sampler.

Monitoring wells were sealed into boreholes 15-1 and 15-2 to allow for subsequent measurement of the groundwater levels. The groundwater levels were measured in the monitoring wells on August 24, 2015.

The fieldwork was supervised by experienced personnel from our geotechnical staff who directed the drilling and in situ testing operations, logged the boreholes and samples, and took custody of the samples retrieved. On completion of the drilling operations, soil samples obtained from the boreholes were transported to our laboratory for examination by the project engineer and for laboratory testing, including natural water content, Atterberg limits, a Swedish fall cone test, and an oedometer consolidation test.

The boreholes were selected, marked in the field, and subsequently surveyed by Golder Associates personnel. The borehole coordinates and ground surface elevations were determined using a Trimble R8 GPS survey unit. The geodetic reference system used for the survey is the North American datum of 1983 (NAD83). The borehole coordinates are based on the Universal Transverse Mercator (UTM Zone 18) coordinate system. The elevations are referenced to Geodetic datum (CGVD28).

Subsurface Conditions

Information on the subsurface conditions is presented as follows:

- Record of Borehole Sheets from the current investigation are provided in Attachment A.
- Borehole logs and consolidation test results from the previous investigation by SPL are provided in Attachment B.
- Results of the Swedish fall cone test from the current investigation are provided in Attachment C.
- Results of in situ vane testing (undrained shear strength versus elevation) are provided on the Record of Borehole Sheets and are summarized on Figure 2.
- Results of the laboratory oedometer consolidation testing from the current investigation are provided on Figure 3.
- Results of the laboratory natural water content and Atterberg limits testing carried out for the current investigation are provided on the Record of Borehole Sheets.

In general, the subsurface conditions on this site consist of topsoil overlying a thick deposit of sensitive silty clay that extends to about 7 to 12 metres depth. The deposit is described as varying from silty clay to clay and is interbedded with clayey silt near the base of the deposit (hereafter the deposit is collectively referred to as silty clay).

The upper portion of the deposit has been weathered to a grey brown crust that extends to about 3.1 to 3.9 metres depth. Standard penetration tests carried out within the weathered crust gave N values of 3 to 13 blows per 0.3 metres of penetration. The results of in situ vane testing carried out in the lower portions of the weathered crust gave undrained shear strengths of about 55 and 70 kilopascals. The results of this in situ testing indicate a stiff to very stiff consistency for the weathered crust. The measured water content of the weathered crust ranges from about 25 to 40 percent.

Beneath the depth of weathering, the silty clay is grey in colour. The results of in situ vane testing in the grey silty clay generally gave undrained shear strengths ranging from about 23 to 65 kilopascals, indicating a soft to stiff (but typically firm) consistency. A plot of undrained shear strength versus elevation is provided on Figure 2.

The results of Atterberg limit testing carried out on samples of the grey silty clay gave plasticity index values ranging from about 18 to 38 percent and liquid limit values ranging from 38 to 62 percent, indicating intermediate to high plasticity soil. The measured water content of the grey silty clay ranges from about 30 to 70 percent, which is generally higher than the measured liquid limits.

As part of the current investigation, laboratory oedometer consolidation testing was carried out on one thin-walled Shelby tube sample of the grey silty clay. The results of that testing are provided on Figure 3. One consolidation test was also carried out as part of the previous investigation by SPL, the results of which are provided in Attachment B. The consolidation test results from both the current and previous investigation are summarized in the table below.

Borehole/Sample Number	Sample Depth/Elevation (m)	Unit Weight (kN/m^3)	σ'_p (kPa)	σ'_{vo} (kPa)	C_c	C_r	e_0	OCR
15-1 / 6	8.1 / 85.6	15.6	110	80	1.03	0.027	1.98	1.4
13-5 / 6	4.6 / 88.9	-	125	67	1.0	0.02	1.56	1.9

σ'_p - Apparent preconsolidation pressure
σ'_{vo} - Computed existing vertical effective stress
C_c - Compression index
C_r - Recompression index
e_o - Initial void ratio
OCR - Overconsolidation ratio

In addition to the oedometer consolidation testing, a Swedish fall cone test was carried out on a sample of the grey silty clay. The results of that testing are provided in Attachment C.

The deposit of silty clay is underlain by glacial till. The glacial till consists of a heterogeneous mixture of gravel, cobbles, and boulders in a matrix of silty sand. Practical refusal to sampler advancement was encountered at about 12.3 and 10.9 metres in boreholes 15-1 and 15-2, respectively. Sampler refusal could represent the bedrock surface, or it could represent cobbles or boulders within the glacial till.

The groundwater levels measured during the current and previous investigation are summarized in the following table:

Borehole	Ground Surface Elevation (m)	Groundwater Depth (m)	Groundwater Elevation (m)	Date of Measurement
15-1	93.72	2.33	91.39	August 24, 2015
15-2	93.57	1.84	91.73	August 24, 2015
13-6	93.7	1.1 1.6	92.6 92.1	January 17, 2014 August 28, 2013

Groundwater levels are expected to fluctuate seasonally. Higher groundwater levels are expected during wet periods of the year, such as spring.

Discussion

The site is underlain by a relatively thick deposit of generally firm unweathered grey silty clay. The silty clay beneath this site has a limited capacity to support additional stress, such as could be imposed by:

- The foundation loads of buildings/houses;
- The weight of grade raise fill placed on the site; and,
- The effects of groundwater level lowering (which reduces the buoyant forces that act between the soil particles), which could result from servicing and development of the site.

An increase in stress, if excessive (i.e., increasing the magnitude of stress above, or even close to, the silty clay's preconsolidation pressure), could lead to significant consolidation settlement. Due to the low hydraulic conductivity of the silty clay and the need to expel water for settlement to occur, the settlement would be long-term in nature, possibly taking many months or years to complete. Grade raises on areas underlain by compressible silty clay will therefore need to be restricted, based on leaving sufficient remaining capacity for the silty clay to also support foundation loads and the effects of groundwater level lowering, without being overstressed. If the grade is raised excessively, then significant consolidation settlement will occur.

Based on the subsurface conditions encountered, the site has been divided into two assessment areas, Area A and Area B, as shown on the attached Site Plan (Figure 1).

Based on a geotechnical assessment carried out using data from the current and previous investigations, the maximum permissible grade raise for this site, assuming conventional backfill materials (i.e., clay or sand with a maximum unit weight of 19.5 kilonewtons per cubic metres), is 0.9 and 2.0 metres for Area A and Area B, respectively. This limitation has been assessed based on leaving sufficient remaining capacity in the silty clay deposit such that strip footings up to 0.6 metres in width can be designed using a maximum allowable bearing pressure of 75 kilopascals, consistent with design in accordance with Part 9 of the Ontario Building Code.

If the grading restrictions cannot be accommodated, it is anticipated that the most feasible methods of increasing the permissible grade raise will be to use lighter backfill materials within the garage, such as clear stone or Geofoam lightweight fill. The permissible grade raise for each type of backfill material is provided in the following table:

Type of Backfill within Garage	**Permissible Grade Raise**	
	Area A	**Area B**
Sand (max. 19.5 kN/m^3)	0.9	2.0
Clear Stone (max. 17.5 kN/m^3)	1.1	2.3
Geofoam lightweight fill	1.5	2.8

In terms of increasing the permissible grade raise, the following options could also be considered:

- Preloading the site with fill to above the required site grading, and allowing settlement to occur prior to construction;
- Using Geofoam lightweight fill to backfill around the foundations of the entire house; or,
- Deep foundations (i.e., driven piles).

Further guidance with respect to the options listed above can be provided, if requested.

Closure

We trust that this memo provides sufficient information for your present requirements. If you have any questions concerning this memo, please don't hesitate to contact us.

Yours truly,

GOLDER ASSOCIATES LTD.

LICENSED PROFESSIONAL ENGINEER
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SD/TMS/ob
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Attachments: Important Information and Limitations of This Report
Figure 1 – Site Plan
Figure 2 – Summary of Undrained Field Vane Shear Strengths vs. Elevation
Figure 3 – Consolidation Test Results – Current Investigation
Attachment A – List of Abbreviations and Symbols
Record of Borehole Sheets – Current Investigation
Attachment B – Borehole Logs and Consolidation Test Results – Previous Investigation
Attachment C – Results of Swedish Fall Cone Testing

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client, **Cardel Homes.** The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then the client may authorize the use of this report for such purpose by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process, provided this report is not noted to be a draft or preliminary report, and is specifically relevant to the project for which the application is being made. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client cannot rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder cannot be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT (cont'd)

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

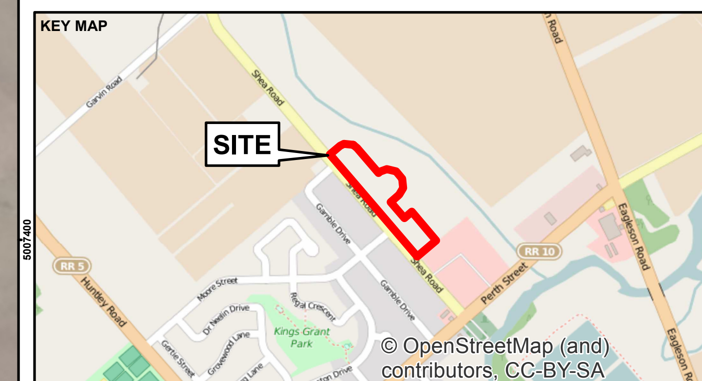
Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

LEGEND

- APPROXIMATE BOREHOLE LOCATION, CURRENT INVESTIGATION
- APPROXIMATE BOREHOLE LOCATION, PREVIOUS INVESTIGATION BY OTHERS
- ROADWAY
- WATERCOURSE
- WATERBODY
- WETLAND
- LIMITS OF ASSESSMENT AREAS
- SITE

KEY MAP



0 30 60 120

1:3,000 METRES

NOTE(S)

1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. TECHNICAL MEMORANDUM NO. 1418381-4000

REFERENCE(S)

1. LAND INFORMATION ONTARIO (LIO) DATA PRODUCED BY GOLDER ASSOCIATES LTD. UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2014
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 18 VERTICAL DATUM: CGVD28

CLIENT
CARDEL HOMES

PROJECT
SUPPLEMENTAL GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL SUBDIVISION, 5873 PERTH STREET
OTTAWA (VILLAGE OF RICHMOND), ONTARIO

TITLE
SITE PLAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-08-14
DESIGNED	----
PREPARED	JEM
REVIEWED	SD
APPROVED	TMS

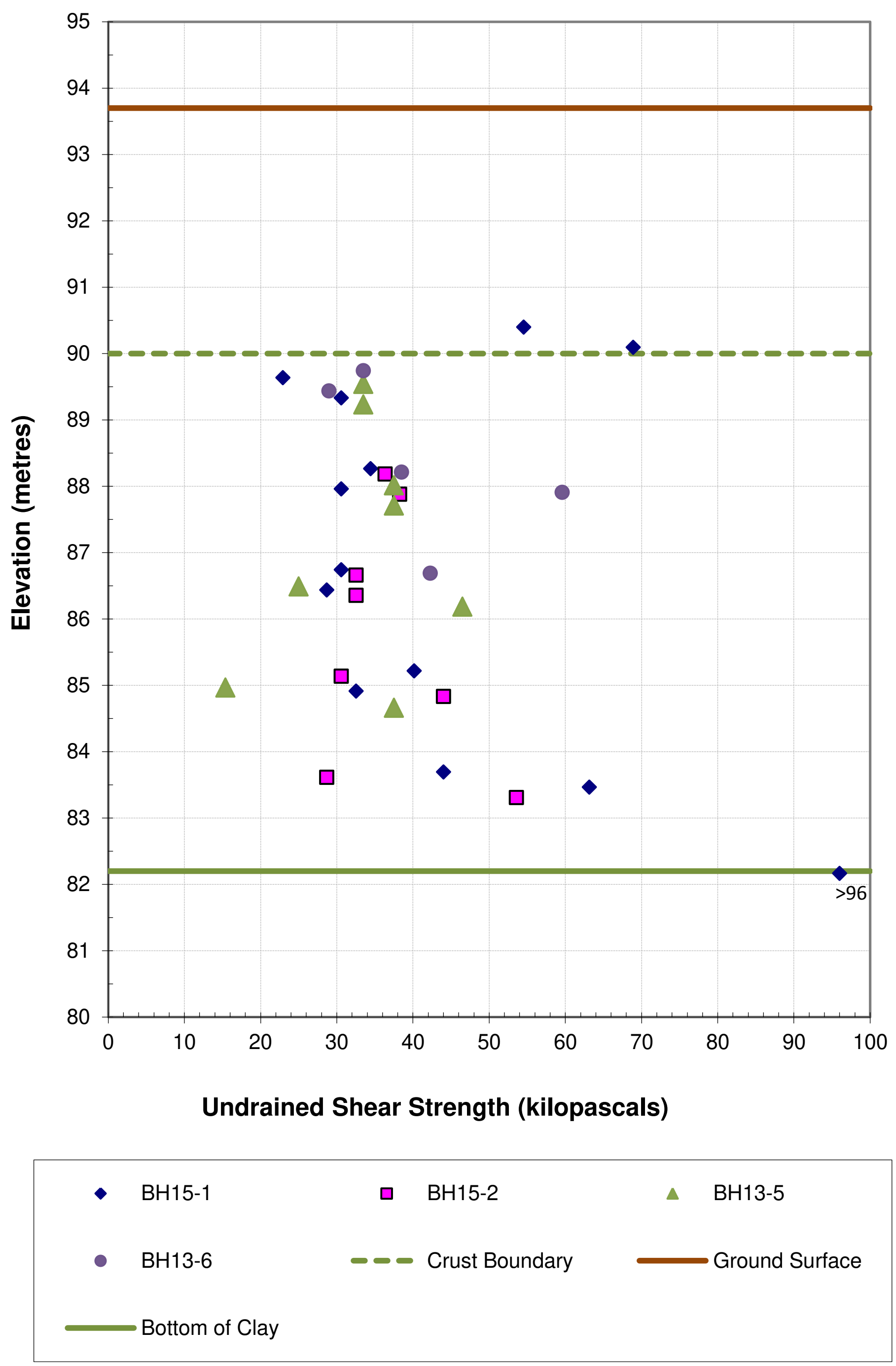
PROJECT NO.	PHASE	REV.	FIGURE
1418381	4000	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: N:\Active\Spatial_IM\Cardel_Custom_Homes\5873_Perth_St\99_PROJ\1418381_Cardel_Hydro_Env\40_PROD\Phase4000_Geotech\1418381-4000-01.mxd

SUMMARY OF UNDRAINED FIELD VANE SHEAR STRENGTHS VS. ELEVATION

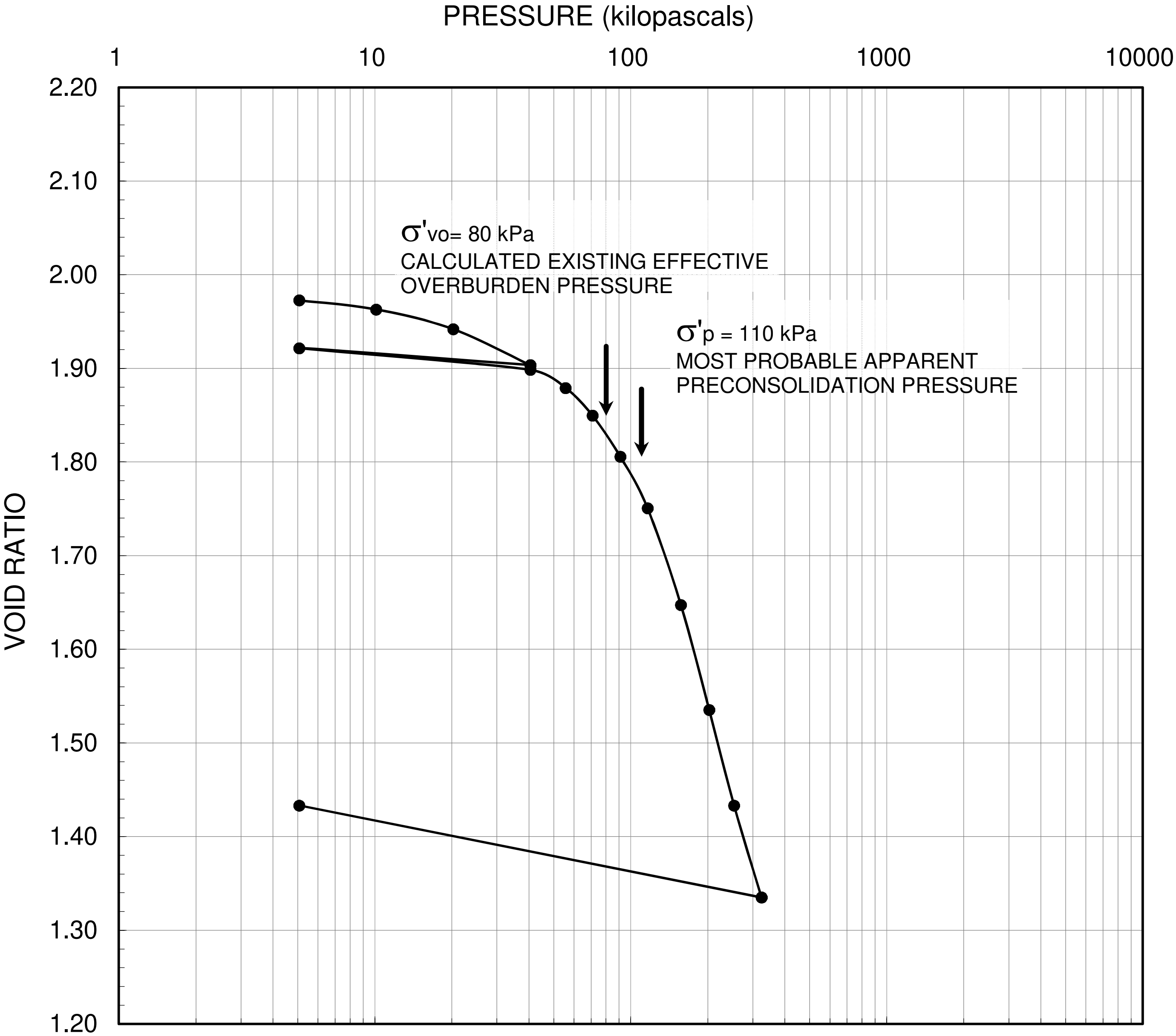
FIGURE 2



Date October 13, 2015
Project 1418381

Golder Associates

Drawn SD
Chkd TMS



LEGEND

Borehole: 15-1	w_i = 70%	S_o = 98%	γ = 15.6 kN/m³
Sample: 6	w_f = 50%	e_o = 1.98	G_s = 2.80
Depth (m): 8.1	w_l = 48%	C_c = 1.03	
Elevation (m): 85.6 m	w_p = 22%	C_r = 0.027	

Golder Associates

SCALE	AS SHOWN	TITLE	CONSOLIDATION TEST RESULTS
DATE	09/30/15		
CADD	N/A		
ENTERED	MI		
FILE No. Consolidation summary	CHECK CNM		
PROJECT No. 1418381 REV. 1	REVIEW SD	FIGURE	3

Attachment A

List of Abbreviations and Symbols
Record of Borehole Sheets – Current Investigation

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL, SAND and CLAY)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.).

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

Dynamic Cone Penetration Resistance (DCPT); N_d:
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 - 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
2. Definition of compactness descriptions based on SPT 'N' ranges from Terzaghi and Peck (1967) and correspond to typical average N_{60} values.

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\,\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma$ - u)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index $= (w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index $= (w - w_p) / I_p$
I_C	consistency index $= (w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength (ϕ = 0 analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

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

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

PROJECT: 1418381

RECORD OF BOREHOLE: 15-1

LOCATION: N 5006081.4 ;E 434541.2

BORING DATE: August 13, 2015

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	93.72
TOPSOIL	0.05
(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, highly fissured, (Weathered Crust); cohesive, w>PL, very stiff to stiff	
(CI/CH) SILTY CLAY to CLAY; grey with black mottling; cohesive, w>PL, soft to firm	89.84 3.88
(CI and ML) SILTY CLAY and CLAYEY SILT; grey, laminated to thinly bedded; cohesive, w>PL	83.43 10.29
(SM) SILTY SAND, some gravel; grey, (GLACIAL TILL); non-cohesive, wet	82.14 11.58
End of Borehole Sampler Refusal	81.43 12.29

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	10	
2	SS	6	
3	SS	5	
4	SS	1	
5	SS	WH	
6	TP	PH	C
7	TP	PH	
8	SS	WH	
9	SS	>50	

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ : 20 40 60 80

>96

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢ ○W ⊣ Wl : 20 40 60 80

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

PIEZOMETER OR STANDPIPE INSTALLATION

- Bentonite and Cuttings
- Bentonite Seal
- Silica Sand
- 51 mm Diam. PVC #10 Slot Screen
- Bentonite and Sand
- W.L. in Screen at Elev. 91.39 m on August 24, 2015

DEPTH SCALE 1 : 75

Golder Associates

LOGGED: HEC

CHECKED: SD

RECORD OF BOREHOLE: 15-2

PROJECT: 1418381
SHEET 1 OF 1

LOCATION: N 5005998.2 ;E 434616.1
BORING DATE: August 13, 2015
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	93.57					
	TOPSOIL	0.05					
	(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, highly fissured, (Weathered Crust); cohesive, w>PL, very stiff						
1			1	SS	13		
2			2	SS	7		Bentonite and Cuttings
3			3	SS	4		
			4	SS	3		
4	(CI/CH) SILTY CLAY; grey with black mottling; cohesive, w>PL, firm	89.84 / 3.73	5	TP	PH	FALL CONE	
5			6	SS	WH		Bentonite Seal; Silica Sand
6							51 mm Diam. PVC #10 Slot Screen
7			7	SS	WH		
8			8	SS	WH		
9							Bentonite and Sand
	(CI and ML) SILTY CLAY and CLAYEY SILT; grey, laminated to thinly bedded; cohesive, w>PL, firm to stiff	84.43 / 9.14	9	SS	WR		
10							W.L. in Screen at Elev. 91.73 m on August 24, 2015
	(SM) SILTY SAND, some gravel; grey, (GLACIAL TILL); non-cohesive, wet	82.90 / 10.67	10	SS	>50		
11	End of Borehole Sampler Refusal	10.87					
12–15							

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl (20 40 60 80)

DEPTH SCALE
1 : 75

Golder Associates

LOGGED: HEC
CHECKED: SD

Attachment B

Borehole Logs and Consolidation Test Results – Previous Investigation

LOG OF BOREHOLE BH13-5

PROJECT: Geotechnical Investigation - 5831/5873 Perth St. & 2770 Eagleson Rd.
CLIENT: Cardel Homes
PROJECT LOCATION: 5831/ 5873 Perth St. and 2770 Eagleson Rd., Ottawa
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 5006070 E 434540

DRILLING DATA
Method: Hollow Stem Augers
Diameter: 203mm
Date: Aug/06/2013

REF. NO.: 1776-710
ENCL NO.:

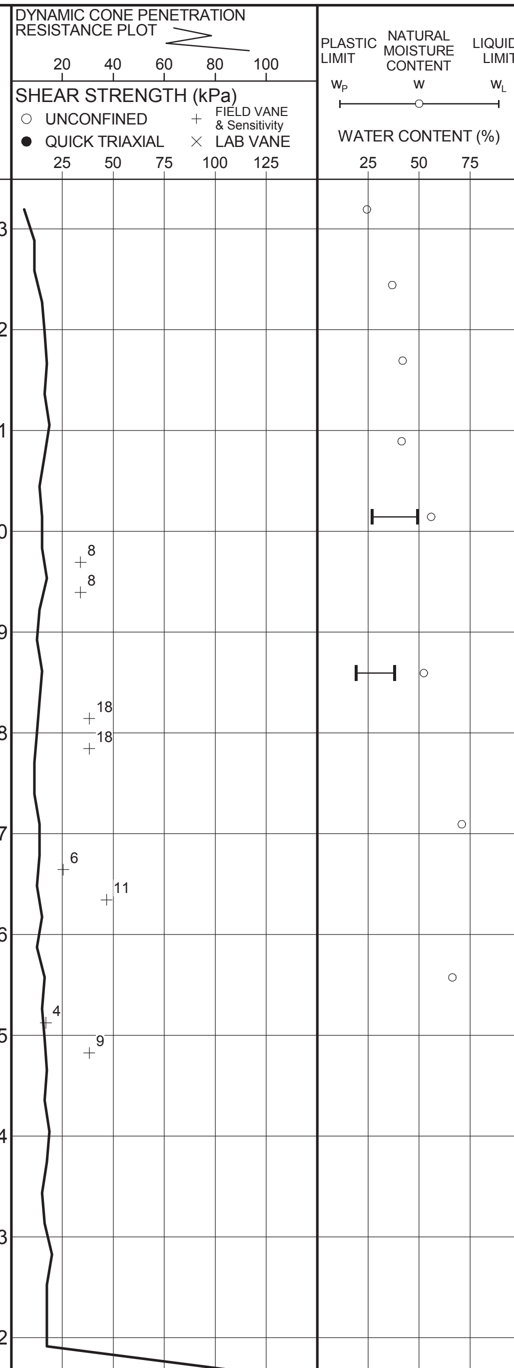
SOIL PROFILE

ELEV (m)	DEPTH (m)	DESCRIPTION
93.5		
93.3	0.2	**Topsoil** 225 mm
	0.3	**Silty Clay** brown, moist, firm to stiff, (weathered crust)
90.4	3.1	**Silty Clay** grey, wet, firm, medium plasticity
81.9		
81.6	11.6	**Till** (Infered from DCPT)
	11.9	**END OF BOREHOLE**

Notes:
1) Upon completion, standing water 3.0 m BSL
2) DCPT refusal at 11.9 m

SAMPLES

NUMBER	TYPE	"N" BLOWS/0.3 m	FIELD VANE (Sensitivity)	NATURAL UNIT WT (KN/m³)	GR	SA	SI	CL
1	SS	9						
2	SS	4						
3	SS	5		17.8				
4	SS	3						
5	TW				0	1	42	58
	VANE		8					
	VANE		8					
6	TW							
	VANE		18					
	VANE		18					
7	SS	WH		16.0				
	VANE		6					
	VANE		11					
8	SS	WH						
	VANE		4					
	VANE		9					



GRAPH NOTES: + 3, × 3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

LOG OF BOREHOLE BH13-6

PROJECT: Geotechnical Investigation - 5831/5873 Perth St. & 2770 Eagleson Rd.
CLIENT: Cardel Homes
PROJECT LOCATION: 5831/ 5873 Perth St. and 2770 Eagleson Rd., Ottawa
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan N 5005854 E 434736

DRILLING DATA
Method: Hollow Stem Augers
Diameter: 203mm
Date: Aug/06/2013

REF. NO.: 1776-710
ENCL NO.:

SOIL PROFILE

ELEV (m) / DEPTH	DESCRIPTION
93.7	
93.5 / 0.2	**Topsoil** 200 mm
	Silty Clay, brown, moist, firm to stiff, (weathered crust)
90.7 / 3.1	**Silty Clay** grey, wet, firm
86.6 / 7.1	**Sand and Gravel** trace silt, grey, wet, very dense
86.3 / 7.4	**END OF BOREHOLE**

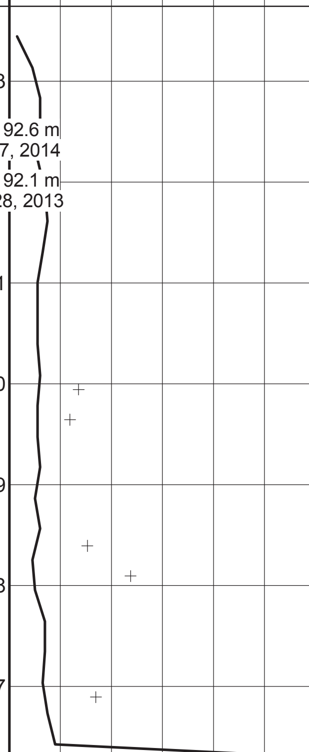
SAMPLES

NUMBER	TYPE	"N" BLOWS / 0.3 m	Natural Moisture (approx. %)	Shear Strength (Field Vane)	Natural Unit Wt (kN/m³)	Remarks (GR SA SI CL)
1	SS	9	○			
2	SS	5	○ (Wp–WL shown)		17.9	
3	SS	3	○			
4	SS	3	○			
5	TW		○ (Wp–WL shown)			
	VANE			+		
	VANE			+	16.9	
6	SS	WH	○			
	VANE			+		
	VANE			+		
7	SS	3	○			
	VANE			+		
8	SS	50/ 12mm	○			37 56 (8)

GROUND WATER CONDITIONS: W. L. 92.6 m Jan 17, 2014; W. L. 92.1 m Aug 28, 2013

ELEVATION: 93, 92, 91, 90, 89, 88, 87

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100



SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE & Sensitivity, ● QUICK TRIAXIAL, × LAB VANE — 25 50 75 100 125

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 25 50 75

POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (KN/m³) | REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

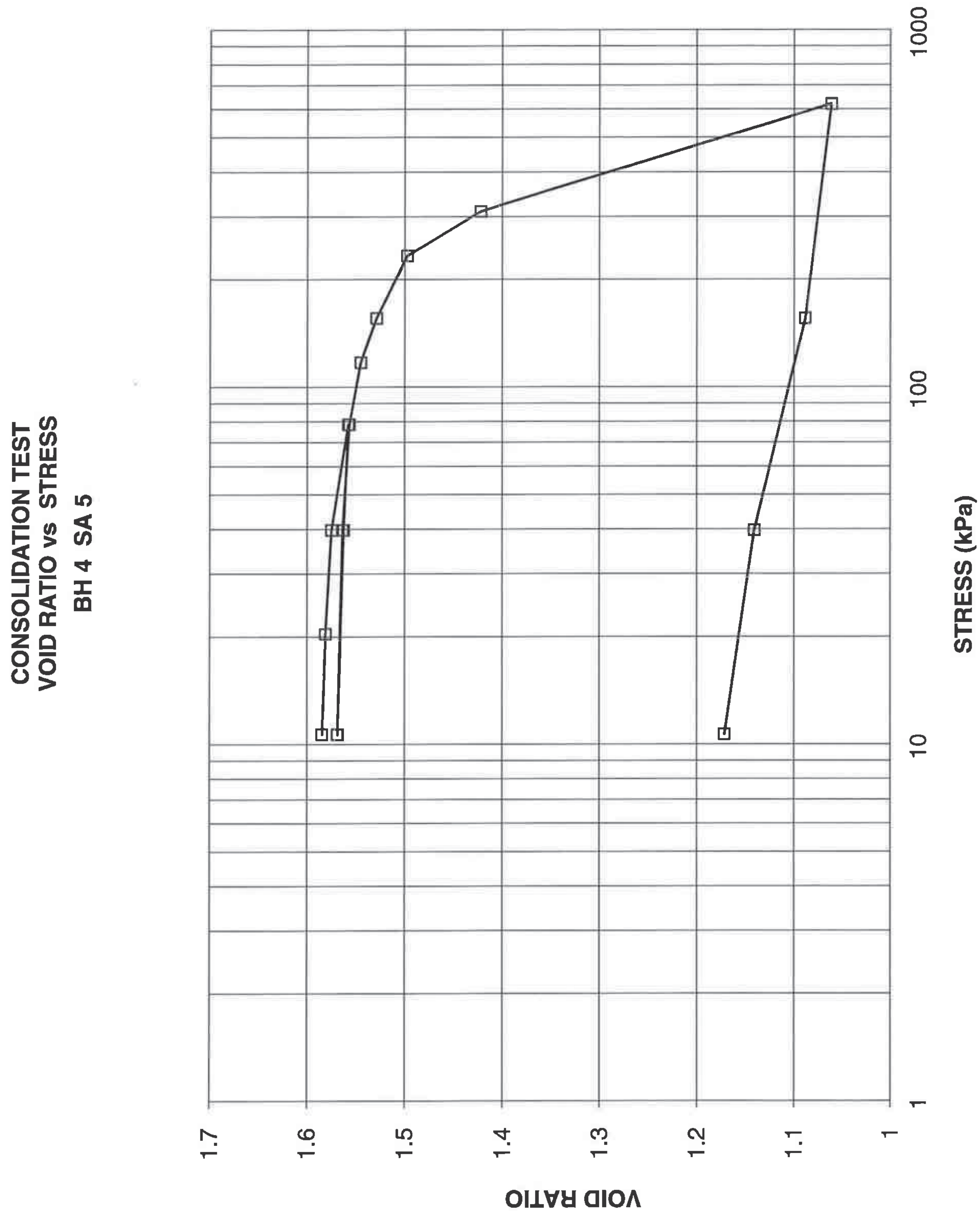
Notes:
1) Upon completion, standing water level 3.6 m BSL
2) DCPT refusal at 7.4 m
3) Auger refusal at 7.4 m
4) 19mm dia. piezometer was installed in the borehole upon completion
5) Depth of Water

Date	Depth
28/08/2013	1.6 m
17/01/2014	1.1 m

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES: + 3, × 3 : Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

CONSOLIDATION TEST VOID RATIO VS LOG STRESS	FIGURE



Project No. 13-1183-0092

Prepared By: LG

Golder Associates

Checked By:

Attachment C

Results of Swedish Fall Cone Testing

SUMMARY OF SWEDISH FALL CONE TEST RESULTS

(CAN/BNQ 2501-110)

PROJECT NUMBER	1418381 /4000
PROJECT NAME	Cardel / Hydrogeology / Richmond
DATE TESTED	17-Aug-15

Borehole No.	Sample No.	Depth (m)	Fall Cone Penetration P_{100} [(1)] (mm)	Fall Cone Penetration P_{60} [(2)] (mm)	Water Content (%)	Shear Strength Intact (kPa)	Shear Strength Remoulded (kPa)	Sensitivity	Estimated Pre-Consolidation Pressure - P'_C [(3)] (kPa)
15-2	5	3.81-4.37	6.9	12.3	57.4%	20.3	1.17	17	84

Notes:

(1) = Or equivalent if 400g cone used (½P_{400}).

(2) = Or equivalent if 10g cone used (P_{10}*sqrt(6)).

(3) = Pre-consolidation pressures were estimated from the Swedish Fall Cone as outlined in the paper " Estimation of some properties of Champlain clays with the Swedish fall cone", by R. Garneau and J. P. LeBihan, Can. Geotech. Journal, Vol. 14, 1977.