

#### **Final Geotechnical Report**

Proposed Tower 'B' Multi-Level Building at the Corner of Parkdale Avenue and Bullman Street Ottawa, ON

Prepared for:

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# 1.0 Introduction

This report presents the results of the Geotechnical Investigation and recommendations carried out for the proposed 28-storey building near the corner of Parkdale Avenue and Bullman Street Ottawa, ON. This building will include six below grade parking levels.

The work was carried out in general accordance with our Proposal Number 1224-B11221, dated March 27, 2013.

This report has been prepared specifically and solely for the project described herein. It presents the factual results of the investigation and provides geotechnical recommendations for the design and construction of the proposed building.

Limitations associated with this report and its contents are provided in the statement of general conditions included in Appendix A.

# 2.0 Site Description and Background

It is understood that the proposed 28-storey building is to be located at the corner of Parkdale Avenue and Bullman Street west of Parkdale Avenue. The building will be approximately 91 m high with six underground parking levels. The site area is approximately 2382 m<sup>2</sup> and the total gross building floor area (above grade) is approximately 18 702 m<sup>2</sup>.

The location of the proposed building is shown on Drawing No. 1 in Appendix B.

Surficial soil maps indicate the soil conditions in the area consist of fill/glacial till over shallow bedrock within 3 m of ground surface.

# 3.0 Scope of Work

The scope of work for this investigation included the following:

- Advance five boreholes. Two boreholes were cored to the depths of 23 m below ground surface. The remaining boreholes terminated on shallow bedrock confirmed by auger refusal.
- Install two monitoring wells to measure groundwater levels in the two 23 m deep boreholes.
- Survey the ground surface elevations at the borehole locations with reference to a geodetic benchmark.
- Complete a geotechnical laboratory testing program to characterize the soil and rock.

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- Prepare a Geotechnical Report outlining the field observations, laboratory results and providing geotechnical recommendations for design and construction of the proposed building including:
  - Geotechnical resistance of rock for foundation design;
  - Lateral earth pressures for shoring systems;
  - Seismic site classification in accordance with 2006 Ontario Building Code;
  - Design recommendations for rock anchors extending to bedrock;
  - Groundwater levels and construction dewatering requirements.

# 4.0 Method of Investigation

Prior to carrying out the investigation, Stantec Consulting Limited (Stantec) personnel marked out the proposed borehole locations at the site. As a component of our standard procedures and due diligence, Stantec arranged to have the borehole locations cleared of both private and public underground utilities.

The field drilling program was carried out on May 9, 10, and 17, 2013. Four boreholes (13-1, MW13-3, 13-4 and MW 13-5) were advanced at the locations shown on Drawing No. 2 in Appendix B. The fifth borehole (13-2) could not be drilled due to property access issues. Boreholes BH 13-1, MW13-3, and MW13-5 were advanced with a truck mounted CME 55 auger drill rig. The subsurface stratigraphy encountered in each borehole was recorded in the field by Stantec personnel while performing Standard Penetration Tests (SPT). Split spoon samples were collected for surficial soil materials. Bedrock was cored with HQ size coring equipment in Boreholes MW13-3 and BH13-5 to the depths of 22.5 m below ground surface. A 2-man gasoline-powered auger was used to advance BH13-4 due to conflict with overhead power lines. Bulk soil samples were collected from the auger.

Following the investigation, BHs 13-1 and 13-4 were backfilled with augered material. 50 mm diameter monitoring wells were installed at 22.5 and 22.3 m below ground surface in MW13-3 and MW13-5, respectively. The monitoring wells were installed with flush mount well caps and backfilled with silica sand to approximately 0.5 m above screen, then to surface with bentonite hole plug.

Borehole locations were surveyed in the field by Stantec personnel using a Trimble Geo XH GPS. Geodetic ground surface elevations were obtained for all the borehole and are accurate to 0.1 m.

The ground surface elevations at the borehole locations are shown on the Borehole Records included in Appendix C.

Samples were returned to the laboratory and subjected to detailed visual examination and additional classification by a geotechnical engineer. Selected samples were tested for moisture content and intact rock core strength. Groundwater samples collected from the monitoring wells

were submitted to Paracel Laboratories Ltd. to measure pH, resistivity, chlorides, and sulphate content. Results of this testing are shown on the Borehole Records in Appendix C and laboratory test results in Appendix D.

Samples will be stored for a period of one (1) month after issuance of this report unless otherwise directed by the client.

# 5.0 Results of Investigation

# 5.1 SUBSURFACE INFORMATION

The subsurface conditions observed in the boreholes are presented in detail on the Borehole Records, Field Core Logs, and Bedrock Core Photos in Appendix C. An explanation of the symbols and terms used to describe the Borehole Records is also provided in Appendix C. In general, the observed stratigraphy consisted of fill material underlain by shallow bedrock.

A general overview of the soil, rock and groundwater conditions encountered in the boreholes is provided below.

## 5.1.1 Surficial Materials

Asphalt was encountered at the surface of BH13-4 and MW13-5. The asphalt varied from 50 to 70 mm in thickness.

Fill materials were observed in all the boreholes and varied from 0.6 m to 0.7 m in thickness. Fill material generally consisted of sandy gravel to gravelly sand, with the exception of a distinct secondary, basal layer of fill observed in BH13-4 consisting of silty sand. The moisture content of fill materials ranged from 3% to 13%.

# 5.1.2 Bedrock

Bedrock generally consisted of unweathered medium grey crystalline limestone of the Middle Ordovician Bobcaygeon Formation with pervasive dark grey shaley partings. A zone of heavily weathered limestone bedrock was encountered overlying intact, unweathered limestone bedrock in BH13-1, MWs13-3, and 13-5, at depths ranging from 0.7 and 0.8 m below ground surface. The thickness of the heavily weathered layer ranged from 0.3 to 1.0 m. Intact, unweathered limestone bedrock was encountered in all boreholes at depths ranging from 0.8 to 1.7 m below ground surface. The moisture content of the weathered bedrock ranged from 4% to 29%.

Occasional features of the limestone included stylolites, calcite veins and vugs, calcite-healed dipping to subvertical fractures, and shaley partings in sections of bedrock where the partings are not pervasive. A large section of medium grey crystalline limestone without pervasive shaley partings was encountered from 1.7 to 11.9 m below ground surface in MW13-3. A dolomitized

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bed was encountered in MW13-3 from 13.1 to 13.6 m below ground surface with pyrite and calcite replacement features.

The bedrock had three discontinuity sets; 1 bedding set and two joint sets. The bedding set had a very close to wide spacing and a generally flat orientation. Bedding discontinuity surfaces were generally oxidized to tight, with occasional swelling, soft clay filling. The joint sets were subvertical to dipping and were encountered relatively infrequently in the cored rock samples. One subvertical joint encountered in MW13-5 was infilled with coarse calcite crystals, and had a 7 mm aperture. Due to their infrequent occurrence, the spacing of the dipping and subvertical joint sets is indeterminate.

Generally bedrock quality was good to excellent; however, the top portion (down to 5.9 m and 2.9 m in MWs13-3 and 13-5, respectively) was observed to be of very poor to fair quality. The Rock Quality Designation (RQD) varied from 0% to 100%. The unconfined compressive strength of the rock, which is summarized below in Table 5.1, ranged from 74.6 MPa to 158.2 MPa, indicating a strong to very strong intact rock strength. Rock core logs and photos are shown in Appendix C.

Borehole	Depth (m)	Unconfined Compressive Strength (MPa)
	3.3	125.4
	8.1	90.5
MW13-3	12.6	102.2
	17.6	78.3
	22.1	94.0
	2.1	130.3
	6.9	156.3
MW13-5	11.3	158.2
	16.2	74.6
	23.3	88.4

 Table 5-1: Unconfined Compressive Strength of Rock Cores

A 'double-packer' test was conducted in MW13-3 on May 9, 2013 following its complete advancement to determine the hydraulic conductivity of the of the limestone rock mass. Hydraulic conductivity values ranged from  $1.27 \times 10^{-7}$  to  $2.47 \times 10^{-6}$  m/s, corresponding to semi-pervious, fractured bedrock. The results are summarized in Table 5-2.

Test No.	Test Interval Depth (m)	Test Interval Elevation (m)	Average hydraulic conductivity, k (m/s)	Minimum k (m/s)	Maximum k (m/s)
1	3.6-7.6	58.3-54.3	8.39x10 <sup>-7</sup>	4.89x10 <sup>-7</sup>	1.16x10 <sup>-6</sup>
2	9.6-11.6	52.3-50.3	1.52x10 <sup>-7</sup>	1.27x10 <sup>-7</sup>	1.69x10 <sup>-7</sup>
3	15.9-19.9	46.0-42.0	2.10x10 <sup>-6</sup>	1.79x10 <sup>-6</sup>	2.47x10 <sup>-6</sup>

#### Table 5-2: Packer Test Results Summary

## 5.2 **GROUNDWATER**

Groundwater was measured by means of monitoring wells installed in MWs 13-3 and 13-5. Groundwater was measured on May 22, 2013. At MW13-3, the groundwater level was measured at 8.5 m (elev. 53.4m) below ground surface. At MW13-5, the groundwater was measured at 8.7 m (elev. 53.4m) below ground surface.

Fluctuation in the groundwater level due to seasonal variations or in response to a particular precipitation event should be anticipated.

# 6.0 Discussion and Recommendations

The following geotechnical issues should be considered during design activities:

- Conventional spread footings founded on bedrock are appropriate for the design of the multi-storey building at this site.
- Groundwater was encountered at depths within the proposed depth of construction. It is anticipated that surface water run-off and groundwater can be controlled with sump and pump methods during construction.
- The bedrock on this site consists of limestone with a measured unconfined compressive strength ranging between 75 MPa to 158 MPa, which suggests strong to very strong rock.
- The soluble sulphate concentrations show that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. Type GU Portland Cement should therefore be suitable for use in concrete at this site.
- The recommended Site Classification for Seismic Site Response for the site is Site Class A in accordance with 2006 Ontario Building Code.

# 6.1 SITE GRADING AND PREPARATION

Restrictions to raising the grades at this site are not anticipated due to the granular nature of the surficial soil and shallow bedrock depth.

## 6.1.1 Building Footprint

Footings should be founded on sound bedrock. Exposed bedrock surfaces should be free of loose bedrock, soil, water, bedrock irregularities, bedrock pinnacles and sloping surfaces. Hand

cleaning and pressure washing of the bearing areas to remove any loose materials will be required to achieve the recommended geotechnical resistance.

Temporary frost protection should be provided for all footings if construction is carried out under winter conditions.

Prepared subgrade surfaces should be inspected by experienced geotechnical personnel prior to placement of either Structural Fill or concrete.

Structural Fill should conform to the requirements of Ontario Provincial Standard Specification (OPSS) Granular A. Structural Fill placed beneath building should contain no recycled materials such as concrete or asphalt. It should be compacted in lifts no thicker than 300 mm to at least 100% Standard Proctor Maximum Dry Density (SPMDD). This material should be tested and approved by a Geotechnical Engineer prior to delivery to the site.

Earth removals should be inspected by a geotechnical engineer to ensure that all unsuitable materials are removed prior to placement of fill or concrete. Inspection and testing services will be critical to ensure that all fill and concrete used is suitable and is placed competently.

## 6.1.2 Paved Areas

All vegetation, topsoil, existing asphalt and other deleterious material should be removed from beneath pavement areas. The subgrade should be proof rolled in the presence of geotechnical personnel. All soft areas revealed during proof rolling or subgrade inspections should be excavated to a maximum depth of 500 mm and replaced with compacted OPSS Granular B Type II.

# 6.2 FOUNDATIONS

The foundations for the proposed building may be supported on spread footings provided that the foundation preparation work described in Section 6.1 above is carried out. Spread footings should be placed on clean undisturbed sound bedrock.

Table 6-1 provides Geotechnical Resistances for shallow foundations on bedrock.

Foundation Type	Footing Width (m)	Geotechnical Resistance, ULS, (kPa)
Strip Footing	1.0 to 3.0	4,500
Square Footing	1.0 to 3.0	5,500

Table 6-1:	Geotechnical	Resistance	for Fo	oundations	on	Bedrock
				••••••••••••		

The factored geotechnical bearing resistance at ultimate limit states (ULS) incorporates a resistance factor of 0.5. The settlement of foundations founded on bedrock is expected to be negligible. The factored geotechnical resistance at ULS for footings founded on bedrock will govern, since failure within the bedrock mass is likely to occur before the serviceability limit state (SLS) deformation of 25 mm total settlement is realized.

The design frost depth is 1.8 m. All exterior spread footings and footings for unheated structures should be protected from frost action by a minimum soil cover of 1.8 m or equivalent insulation. Perimeter footings should be protected by a minimum soil cover of 1.5 m or equivalent insulation. Perimeter footings and interior footings within 1.5 m of perimeter walls of heated structures should be protected by a minimum soil cover of 1.5 m or equivalent insulation. Where proposed footings have insufficient soil cover for frost protection, the use of insulation will be required.

The base of all footing excavations should be inspected by a geotechnical engineer prior to placing concrete to confirm the design geotechnical resistance and to ensure that there is no disturbance of the founding soils.

Where construction is undertaken during winter conditions, all footing subgrades should be protected from freezing. Foundation walls and columns should be protected against heave due to soil adfreeze.

# 6.3 SEISMIC SITE CLASSIFICATION

Existing  $V_{S30}$  measurements around the study site were reviewed to determine the site class according to the 2006 Ontario Building Code. The measurements were obtained from the Geological Survey of Canada Surficial Boreholes for the National Capital Area. The data is accessible through the Carleton University website called the Interactive Surface Geography Map for the City of Ottawa. The selected boreholes are illustrated in Drawing No. 3 in Appendix B and the corresponding shear wave velocity information is shown in Table 6.2. This table provides the average shear wave velocity in top 30 m for the studied sites ( $V_{s30}$ ).

Based on  $V_{s30}$  values, the recommended site classification for seismic site response for the building is Site Class A in accordance with Table 4.1.8.4.A of the 2006 Ontario Building Code.

Borehole Name	Borehole ID	Bedrock Depth (m)	V <sub>s30</sub> (m/sec)	Bedrock Velocity Range (m/sec)
а	UGE05646	1.25	1944	1549-2333
b	UGE00166	1.68	1878	1486-2262
С	UGE00704	1.19	1954	1558 - 2343

Table 6-2: Shear Wave Velocity Information of Selected Boreholes

The location of the proposed building and known faults were evaluated. The location of the nearest faults are shown in Drawing No. 4 in Appendix B. The drawing indicates that the proposed building is not located on a fault.

# 6.4 GROUNDWATER CONTROL

The groundwater level was measured at elevation 53.4 m within both monitoring wells, MWs 13-3 and 13-5. The proposed below grade parking levels will be below the groundwater level.

The design of the below grade parking levels should consider the groundwater level. The below grade levels could be designed as a waterproof structure designed to resist the build up of hydrostatic pressure. Alternatively, a drainage system (perforated pipe) could be provided around the exterior perimeter of the building and the foundation walls backfilled with free draining granular material such as OPSS Granular B Type II. A second alternative includes the use of a proprietary drainage board in conjunction with the perimeter drainage system with the walls backfilled with OPSS Select Subgrade Material (SSM). The drainage system should be connected to a frost free outlet.

An underfloor drainage should also be provided. The subdrains should be founded at least 400 mm below the underside of the floor slab and should be connected to a frost free outlet. If subdrains are proposed, the floor slab should be supported on a 400 mm thick layer of clear stone for drainage. The underfloor drainage system and perimeter drainage system should be connected to separate outlets.

# 6.5 PIPE BEDDING AND BACKFILL

Bedding for utilities should be placed in accordance with the pipe design requirements. It is recommended that a minimum of 150 mm to 200 mm of OPSS Granular A be placed below the pipe invert as bedding material. Granular pipe backfill placed above the invert should consist of Granular A material. A minimum of 300 mm vertical and side cover should be provided. These materials should be compacted to at least 95% of SPMDD.

Backfill for service trenches in landscaped areas may consist of excavated material replaced and compacted in lifts. Where the service trenches extend below paved areas, the trench should be backfilled with OPSS SSM from the top of the pipe cover to within 1.2 m of the proposed pavement surface, placed in lifts and compacted to at least 95% of SPMDD. The material used within the upper 1.2 m and below the subgrade line should be similar to that exposed in the trench walls to prevent differential frost heave, placed in lifts and compacted to at least 95% of SPMDD. Different abutting materials within this zone will require a 3 horizontal to 1 vertical frost taper in order to minimize the effects of differential frost heaving.

Excavations for catch basins and manholes should be backfilled with compacted granular material. A 3 horizontal to 1 vertical frost taper should be built within the upper 1.2 m. The joints between catch basin or manhole sections must be wrapped with non-woven geotextile.

It should be noted that reuse of the site generated material will be highly dependent on the material's moisture content at time of placement.

Backfill should be compacted in lifts not exceeding 300 mm.

# 6.6 TEMPORARY EXCAVATIONS AND BACKFILLING

## 6.6.1 Excavations in Soil

The shallow sandy gravel to gravelly sand, and silty sand fill (maximum encountered thickness of 0.7 m) present at the site is considered Type 3 soil in accordance with the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. Temporary excavations in the overburden may be supported or should be sloped at 1 horizontal to 1 vertical from the base of the excavation and as per the requirements of OHSA. Alternatively, sheet piling or other support methods will be required. Excavations should be inspected regularly for signs of instability and flattened as required. The excavation support system should be designed to resist loads from traffic and foundations from adjacent structures.

## 6.6.2 Excavations in Bedrock

Drilling and blasting and hoe ramming techniques will be required to excavate bedrock. Temporary excavation in bedrock may be carried out at near vertical slopes, provided the trench sides are cleared of loose rock prior to workers entering the trench. If the bedrock is overly fractured such that the loose rock cannot be entirely removed, a temporary rock catchment system such as a wire mesh system should be used. The catchment system should be designed to contain and/or prevent loose rock particles from falling on workers within the excavation.

Bedrock excavation sidewalls adjacent to existing building foundations should be supported to ensure the stability of the existing buildings.

## 6.6.3 Groundwater

Groundwater was encountered during this geotechnical investigation within the depths of the anticipated excavations.

Packer tests were conducted to determine the hydraulic conductivity of the limestone bedrock. Hydraulic conductivity values ranged from  $1.27 \times 10^{-7}$  to  $2.47 \times 10^{-6}$  m/s, corresponding to semipervious, fractured bedrock. It is expected that dewatering of the excavations will be possible using conventional sump and pump techniques. It should be noted that groundwater elevations fluctuate seasonally. Dewatering of the excavation is not anticipated to cause settlement of soils due to groundwater lowering in the vicinity of the site.

# 6.7 LATERAL EARTH PRESSURES ON SHORING SYSTEMS AND BASEMENT WALLS

Earth pressures will need to be considered in the design of shoring systems for temporary excavations during construction and for basement walls. Table 6-3 gives the coefficients of lateral earth pressure for shoring systems and basement walls. These values are based on the assumption that a horizontal back slope will be utilized behind the shoring system and wall.

#### Static Lateral Earth Pressures

For walls that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied and unyielding structures, the at-rest earth pressure should be used for design. The unfactored soil parameters provided in Table 6-3 may be used for design of walls with a horizontal backfill. The effects of compaction should be accounted for by applying a compaction surcharge.

The total active ( $P_A$ ), passive ( $P_P$ ) and at-rest ( $P_O$ ) thrusts can be calculated using the following equations

 $\begin{aligned} \mathsf{P}_{\mathsf{A}} &= \frac{1}{2} \; \mathsf{K}_{\mathsf{a}} \; \gamma \; \mathsf{H}^2 \\ \mathsf{P}_{\mathsf{P}} &= \frac{1}{2} \; \mathsf{K}_{\mathsf{p}} \; \gamma \; \mathsf{H}^2 \\ \mathsf{P}_{\mathsf{O}} &= \frac{1}{2} \; \mathsf{K}_{\mathsf{o}} \; \gamma \; \mathsf{H}^2 \end{aligned}$ 

where H is the height of the wall and  $\gamma$  is the unit weight of the backfill soil. Preliminary values for K<sub>a</sub>, K<sub>p</sub>, K<sub>o</sub> and  $\gamma$  are provided below. The thrust acts at a point one third up the height of the wall.

Parameter	On Site Fill	OPSS Granular A	OPSS Granular B Type II
Unit Weight (kN/m <sup>3</sup> )	19.0	22.0	22.0
Angle of Internal Friction, $\Phi$	32°	35°	32°
Coefficient of Passive Earth Pressure, K <sub>p</sub>	3.25	3.69	3.25
Coefficient of at Rest Earth Pressure, $K_o$	0.47	0.43	0.47
Coefficient of Active Earth Pressure, K <sub>a</sub>	0.31	0.27	0.31

#### Table 6-3: Lateral Earth Pressure Parameters

#### Seismic Lateral Earth Pressures

Seismic earth pressures may be calculated using the parameters detailed in Table 6-4 below.

The total active and passive thrusts under seismic loading conditions can be calculated using the following equations:

- $P_{AE} = \frac{1}{2} K_{AE} \gamma H^2 (1 k_V)$
- $P_{PE} = \frac{1}{2} K_{PE} \gamma H^2 (1 k_V)$

where:

- K<sub>AE</sub> = active earth pressure coefficient (combined static and seismic)
- $K_{PE}$  = passive earth pressure coefficient (combined static and seismic)

H = height of wall

 $k_h$  = horizontal acceleration coefficient

 $k_v$  = vertical acceleration coefficient

 $\gamma$  = total unit weight of soil

For this site, the following design parameters were used to develop the recommended  $K_{AE}$  and  $K_{PE}$  values. A yielding wall was assumed.

•	Zonal Acceleration Ratio, A or PGA	0.42
•	Horizontal Acceleration Coefficient, k <sub>h</sub>	0.21
•	Vertical Acceleration Coefficient, kv	0.14
•	Horizontal Backslope to Wall	0°
•	Vertical Back of Wall	0°

The  $k_h$  value above corresponds to half of the A value for yielding walls. The  $k_v$  value corresponds to 0.67 of the  $k_h$  value. The angle of friction between the soil and the wall has been set at 0° to provide a conservative estimate.

Material	K <sub>AE</sub>	Height of Application of P <sub>AE</sub> from base as a ratio of wall height, (H)	K <sub>PE</sub>	Height of Application of P <sub>PE</sub> from base as a ratio of wall height, (H)	φ (friction angle)	Unit Weight (kN/m³)
OPSS Granular A	0.43	0.40	3.19	0.24	35°	22
OPSS Granular B Type II	0.48	0.40	2.78	0.24	32°	22
In-Situ Fills	0.48	0.40	2.78	0.24	32°	19

Table 6-4: Seismic Lateral Earth Pressure Parameters (Yielding Wall)

If the wall is designed as a non-yielding wall it could be designed based on values obtained from the Wood (1973) method;

$$\Delta P_{eq} = \gamma H^2 \frac{a_h}{g} F_p$$

 $\Delta P_{eq}$  : Steady state dynamic trust

 $\gamma$  : Bulk unit weight of soil

- H : Height of wall (m)
- g : Gravity  $(m/s^2)$
- $a_h$  : Amplitude of harmonic base acceleration
- $F_p$  : Dimensionless trust factor at  $\nu$ =0.5

$$h_{eq} = \frac{\Delta M_{eq}}{\Delta P_{eq}} \approx 0.63 H$$

## 6.8 SLIDING RESISTANCE

Sliding resistance can be calculated using the following unfactored friction coefficients, outlined in Table 6-5.

#### Table 6-5: Unfactored Friction Coefficients

Condition	Unfactored Friction Coefficient
Between Concrete and Structural Fill	0.55
Between Concrete and Clean Bedrock	0.60

## 6.9 ROCK ANCHORS

Rock anchors could be used to ensure stability of temporary shoring system and resist uplift forces. For the design of rock anchors extending into bedrock, the following design parameters may be considered for the rock mass.

- A rock to grout working bond stress of 1000 kPa may be used for holes grouted with nonshrink grout having a minimum compressive strength of 30 MPa.
- The minimum fixed anchor length (i.e. the length over which the rock to grout bond stress is developed) should be no less than 3 m.
- The unbonded length of anchor should be equal to the height of the rock cone and less half the bonded length.

To ensure against the possibility of a rock mass failure, the following design parameters should be used:

- Submerged unit weight of rock = 16 kN/m<sup>3</sup>
- A 90° (apex angle) failure cone with the apex located at the midpoint of the bonded length as shown on the sheet titled "Rock Anchor: Resistance to Rock Mass Failure" in Appendix E.

The bond stress used by the contractor for design should be confirmed by full scale testing of anchors.

# 6.10 FOUNDATION BACKFILL

Backfill within the footprint of the proposed buildings should consist of OPSS Granular A compacted to 100% SPMDD. Exterior foundation backfill should consist of a material meeting the requirements of OPSS Select Subgrade Material (SSM). Reference is made to Section 6.4 regarding additional comments for foundation wall backfill.

Exterior foundation backfill shall be placed in lifts no thicker than 300 mm and compacted using suitable compaction equipment to at least 95% of SPMDD. Care should be taken immediately adjacent to the foundation walls to avoid over-compaction of the soil which could result in damage to the walls.

# 6.11 CEMENT TYPE AND CORROSION POTENTIAL

Two representative groundwater samples were submitted to Paracel Laboratories Ltd. in Ottawa, Ontario, for pH, chloride, sulphate and resistivity testing. The test results are summarized in Table 6-6.

Borehole No.	рН	Sulphate (µg/g)	Resistivity (0.01 ohm.m)	Chloride (µg/g)
MW13-3	7.2	78	9.43	205
MW13-5	8.6	28	45.6	29

Table 6-6:	pH. Sulphate.	Chloride and Resistivity	/ Analysis Results
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The soluble sulphate ranges from 28-78  $\mu$ g/g. Soluble sulphate concentrations less than 1000  $\mu$ g/g generally indicate that a low degree of sulphate attack is expected for concrete in contact with soil and groundwater. Type GU Portland Cement should therefore be suitable for use in concrete at this site.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The soil pH was 7.2-8.6 which is within what is considered the normal range for soil pH of 5.5 to 9.0. The pH levels of the tested soil do not indicate a highly corrosive environment. The test results provided in the Table 6.5 can be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

# 6.12 PAVEMENT STRUCTURE RECOMMENDATIONS

It has been assumed that the parking areas will be used mostly by passenger vehicles and the access roads will be used by delivery trucks and fire vehicles.

The subgrade in paved areas should be prepared as described in Section 6.1 above. The following minimum pavement structures are recommended:

Material	Heavy Duty Parking Access Roads	Standard Duty Parking Area
SP 12.5 Asphaltic Concrete	40 mm	50 mm
SP 19 Asphaltic Concrete	50 mm	-
Granular Base Course, OPSS Granular A	150 mm	150 mm
Granular Subbase Course, OPSS Granular B Type II	400 mm	300 mm

#### Table 6-7: Recommended Pavement Design

It is estimated that the service life prior to major rehabilitation for the above pavement structures is 20 years provided they are properly maintained. The pavement surface and the underlying subgrade should be graded to direct runoff water towards suitable drainage.

All granular materials should be tested and approved by a geotechnical engineer prior to delivery to the site. Both base and subbase materials should be compacted to at least 100% SPMDD. Asphalt should be compacted to at least 97% Marshal bulk density.

It is recommended that the lateral extent of the subbase and base layers not be terminated in a vertical fashion immediately behind the curb line. A taper with a grade of 5 horizontal to 1 vertical is recommended in the subgrade line to minimize differential frost heave problems under sidewalks.

## 6.13 VIBRATIONS MONITORING AND PRE-CONSTRUCTION SURVEYS

The required construction activities for the proposed building will generate some vibrations that will be perceptible to nearby residents. The vibrations are expected to be greatest during bedrock excavation by blasting/mechanical methods. It is recommended that pre-construction surveys of all structures be carried out in accordance with OPSS 120 "General Specifications for the Use of Explosives".

It is recommended that construction vibrations generally be limited to a maximum peak particle velocity as outlined in OPSS 120. Should there be structures in the area sensitive to vibrations, more stringent specifications should be developed by a vibration specialist. For instance, the particle velocity should be limited to 10 mm/sec if there is any historic building in the area. Vibration monitoring should be carried out prior to and throughout the construction period.

No blasting should be carried out within a distance of 200 m from any water storage reservoir, pumping station, water works transformer station or water storage tank without prior approval by the owner of the facility.

# 7.0 Closure

Use of this report is subject to the Statement of General Conditions provided in Appendix A. It is the responsibility of Richcraft, who is identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Stantec should any of these note be satisfied. The Statement of General Conditions addresses the following:

- Use of the report
- Basis of the report
- Standard of care
- Interpretation of site conditions
- Varying of unexpected site conditions
- Planning, design or construction

This report has been prepared by Simon Harvey and reviewed by Susan Potyondy.

Respectfully submitted,

#### STANTEC CONSULTING LTD.

Fin Ham

Simon Harvey, B.Sc.(Eng.) Engineering Intern - Geotechnical Engineering

Susan Potyondy, P.Eng. Senior Geotechnical Engineer



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Statement of General Conditions

<u>USE OF THIS REPORT</u>: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec Consulting Ltd. and the Client. Any use which a third party makes of this report is the responsibility of such third party.

<u>BASIS OF THE REPORT</u>: The information, opinions, and/or recommendations made in this report are in accordance with Stantec Consulting Ltd.'s present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec Consulting Ltd. is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

<u>STANDARD OF CARE</u>: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

<u>INTERPRETATION OF SITE CONDITIONS</u>: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Consulting Ltd. at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

<u>VARYING OR UNEXPECTED CONDITIONS</u>: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec Consulting Ltd. must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec Consulting Ltd. will not be responsible to any party for damages incurred as a result of failing to notify Stantec Consulting Ltd. that differing site or subsurface conditions are present upon becoming aware of such conditions.

<u>PLANNING, DESIGN, OR CONSTRUCTION</u>: Development or design plans and specifications should be reviewed by Stantec Consulting Ltd., sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec Consulting Ltd. cannot be responsible for site work carried out without being present.



# **APPENDIX B**

Key Plan Borehole Location Plan  $V_{\text{S30}}$  Measurement Location Plan

Fault Location Plan









# **APPENDIX C**

Symbols and Terms Used on Borehole Records Borehole Records Field Core Logs Bedrock Core Photos

#### SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

#### SOIL DESCRIPTION

#### Terminology describing common soil genesis:

Topsoil	- mixture of soil and humus capable of supporting vegetative growth
Peat	- mlxture of visible and invisible fragments of decayed organic matter
Till	- unstratified glacial deposit which may range from clay to boulders
Fill	- material below the surface identified as placed by humans (excluding buried services)

#### Terminology describing soil structure:

Desiccated	- having visible signs of weathering by oxidization of clay minerals, shrinkage cracks, etc.
Fissured	<ul> <li>having cracks, and hence a blocky structure</li> </ul>
Varved	- composed of regular alternating layers of silt and clay
Stratified	- composed of alternating successions of different soil types, e.g. silt and sand
Layer	- > 75 mm in thickness
Seam	- 2 mm to 75 mm in thickness
Parting	- <2 mm in thickness

#### Terminology describing soil types:

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488). The classification excludes particles larger than 76 mm (3 inches). The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

#### Terminology describing cobbles, bouiders, and non-matrix materials (organic matter or debris):

Terminology describing materials outside the USCS, (e.g. particles larger than 76 mm, visible organic matter, construction debris) is based upon the proportion of these materials present:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 20%

#### Terminology describing compactness of cohesionless solis:

The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test N-Value (also known as N-Index). A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Terminology describing consistency of cohesive soils:

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests.

Consistence	Undrained St	near Strength
Consistency	kips/sq.ft.	kPa
Very Soft	<0.25	<12.5
Soft	0.25 - 0.5	12.5 - 25
Firm	0.5 - 1.0	25 - 50
Stiff	1.0 - 2.0	50 - 100
Very Stiff	2.0 - 4.0	100 - 200
Hard	>4.0	>200



#### **ROCK DESCRIPTION**

#### Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	Very Poor
25-50	Poor
50-75	Fair
75-90	Good
90-100	Excellent

Rock quality classification is based on a modified core recovery percentage (RQD) in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. RQD was originally intended to be done on NW core; however, it can be used on different core sizes if the bulk of the fractures caused by drilling stresses are easily distinguishable from *in situ* fractures. The terminology describing rock mass quality based on RQD is subjective and is underlain by the presumption that sound strong rock is of higher engineering value than fractured weak rock.

#### Terminology describing rock mass:

Spacing (mm)	Joint Classification	Bedding, Laminations, Bands
> 6000	Extremely Wide	-
2000-6000	Very Wide	Very Thick
600-2000	Wide	Thick
200-600	Moderate	Medium
60-200	Close	Thin
20-60	Very Close	Very Thin
<20	Extremely Close	Laminated
<6		Thinly Laminated

#### Terminology describing rock strength:

Strength Classification	Unconfined Compressive Strength (MPa)
Extremely Weak	<1
Very Weak	1-5
Weak	5 – 25
Medium Strong	25 – 50
Strong	50 – 100
Very Strong	100 – 250
Extremely Strong	> 250

#### Terminology describing rock weathering:

Term	Description
Fresh	No visible signs of rock weathering. Slight discolouration along major discontinuities
Slightly Weathered	Discolouration indicates weathering of rock on discontinuity surfaces. All the rock material may be discoloured.
Moderately Weathered	Less than half the rock is decomposed and/or disintegrated into soil.
Highly Weathered	More than half the rock is decomposed and/or disintegrated into soil.
Completely Weathered	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.





#### RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

#### **N-VALUE**

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (64 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (305 mm) into the soil. For split spoon samples where insufficient penetration was achieved and N-values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N value corrected for various factors such as overburden pressure, energy ratio, borehole dlameter, etc. No corrections have been applied to the N-values presented on the log.

#### **DYNAMIC CONE PENETRATION TEST (DCPT)**

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to A size drill rods with the same standard fail height and weight as the Standard Penetration Test. The DCPT value is the number of biows of the hammer required to drive the cone one foot (305 mm) into the soil. The DCPT is used as a probe to assess soil variability.

#### **OTHER TESTS**

S	Sieve analysis
Н	Hydrometer analysis
k	Laboratory permeability
Y	Unit weight
Gs	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
С	Consolidation
Qu	Unconfined compression
Iρ	Point Load Index ( $I_p$ on Borehole Record equals $I_p(50)$ in which the index is corrected to a reference dlameter of 50 mm)

Ţ	Single packer permeability test; test interval from depth shown to bottom of borehoie
I	Double packer permeability test; test interval as indicated
Î	Falling head permeability test using casing
ľ	Falling head permeability test using well point or piezometer



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# BOREHOLE RECORD N: 5 028 111 E: 442 731

PROJECT No. \_\_\_\_\_122410780

BOREHOLE No.

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Richcraft Group of Companies CLIENT \_\_\_\_

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-13		-Good to excellent rock mass quality Strong to year strong intact rock					10070	5270																			
		-Strong to very strong intact rock strength -Unweathered														             <del>   </del>											
		and 2 joint sets			HQ	12	100%	80%																			
-15-		Log)			HQ	13	100%	93%																			
2 - - -					-																						
- 17-					HQ	14	100%	87%								<u>}-</u>             											
- 18-										 	           			 		 <del>   </del>     	  -  -        					  -    		  +++-     		  - - - - - - - - - - - - - - - - - -	
- 19-					HQ	15	100%	91%																			
- 20 -		♀ Inferred Groundwater Levei								F	ieic Rem	l V	ideo	: T : T : V	est,	LL kP tr	a est,	LI kF	l l l L l Pa			pp'c		    <u>  </u>			
		Groundwater Level Measured in S	tandr	pipe						F	ock	cet	Per	setu	rom	ete	r T	est	. kF	)a	D	ate	_				1

# MONITORING WELL RECORD N: 5 028 105 E: 442 745

3 of 3 MW13-3

<u>MW13-3</u>

BOREHOLE No. \_

△ Pocket Penetrometer Test, kPa

Date

CLIENT	Richcraft	Group of	Companies
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LOCATION Ottawa, ON						PROJECT No. 122410780																			
D,	ATES: BO	RING <u>May 8/9, 2013</u> WAT	TER L	EVE	L		<u>May</u>	22, 20	)13				_	DA	TU	JM _					_	_		_	-
DEPTH (m)	elevation (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	түре	AS NUMBER	MPLES (mm)	N-VALUE OR ROD	WAT							HEAI		S 20 37	GTH 150	- kf ₩	•a	2 w	00       	Ĺ	
		7					œ		STA	NDAR	RD P	ENE	TRA		N TE	ST, E	BLOW	/S/0.	3m				•		
20 -									1	0	20	)	30	)	40		50		50	7	/0	8	0	9	0
		(Cont.) Medium grey crystalline LIMESTONE with shaley partings			HQ	16	100%	87%																	* * * * *
22-		(Refer to Field Bedrock Core Log)			HQ	17	97%	81%																	
	<u> </u>										1		1												-
23-		End of Borehole Monitoring Well Installed											         	                         		                         		                   							••••
																									•
24 -																									
25-									             <del>         </del>		i i t		     			i i i           <del> </del>									• • • •
l													      												
26-	2								╍╆╍┼╍┠╍	- <del>     </del>	+		+	 <del>     </del>		 <del>      </del> -				++-			+++	i++	-
	e e																								-
27-									╺ <del>╎╸</del> ┠╺┠╸ ┝		+	L II I + + + 	+	 <del>       </del>		 <del>     </del> 	┝╍┠╍┠╸	   <del>     </del>	-+-+-	÷++-	┝╌╂╌╂╴			- <u> -</u>	-
- 900																									
28-									- <mark>↓-↓-↓</mark> -	−↓↓↓ −↓↓↓↓	+	  -      	+		i l			44		<u>+</u> +-					-
29-											ļ													ļ	-
30 -																									
		V Inferred Groundwater Level								Field		ane	Te	st, k	Pa Ta		Da		A	الرا وي	ſ				
		- Interred Groundwater Level							l U l	ĸem	oul	aed	i Va	яЦG	168	si, K	ra		Ap	ъq	-			- 1	

🐺 Groundwater Level Measured in Standpipe

	6 Ju	antec	ЪU	N:	5 02	ノレ. 8 072	<b>E R</b> 2 <b>E</b> : 44	2 733	KD	E	H13-4
С	LIENT	Richcraft Group of Companies	i							BOREHOLE No.	BHI
Ľ	OCATION	Ottawa, ON					_			PROJECT No.	<u>I 22410</u>
D	ATES: BO	RING <u>May 17, 2013</u> w	ATER L	EVE	L					DATUM	
	Ê			╞╝		S/	MPLES		UNDR 50	AINED SHEAR STREN	GTH - kPa 50 700
E H	NOI		A PLC	LEVE		e e	Ϋ́	<u>س</u>	0.20	+	
DEPT	EVAT	SULDESCRIPTION	RAT/	ATER	TYPE	IMBE		VALU R RQ	WATER CONTENT &	ATTERBERG LIMITS	
-			SI	Ň		ž	RE	żŌ		TION TEST, BLOWS/0.3n	*
	67 74								10 20 3	0 40 50 6	om. ● 0 70 80
0-	62.2	70 mm ASPHALT	<i>[.</i>								
a i	62.0	F1LL: grey sandy gravel	.] 🗱		BS	1	-	-			
	61.4	FILL: brown silty sand	_ 🕅								
$1\frac{2}{3}$		-trace gravel									
1		End of Borehole									
		Refusal on Inferred Bedrock									
2 -											
1											
3 -											
-											
1											
4 -											
-											
51											
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1											
0											
3											
_											
7 -									<mark>╡╪┋┽╠╍┾┼┽┋╌┾╡╡┼╸</mark>	<del>╶╏╞╎┇╏╏┥┥┇╕╏╬╋╻</del>	
-											
-											
8 -									<mark>╶<del>╿╷╡┥</del>╶╌┼╋╄╴╞╪╪┹┚ ╎╎║╎</mark>	<mark>╶┨╶┨╶┨╴┨╶┨╶┥┥┥┥</mark> ╷╎╎╷╷╷╷╷╷╷╷╷╷╷	<mark>┉╂╍┨╺╉╍</mark> ╡┇╎╏ ┇╏╎╏
-											
9 -	Ş										
10							I				
		♀ Inferred Groundwater Level							Field Vane Te     Remoulded V	est, kPa 'ane Test, kPa	App'd
		▼ Groundwater Level Measured in	n Standr	bipe					△ Pocket Penetr	ometer Test, kPa	Date

#### 9 . t et l

#### FILOI E DECODD D

1 of 1

# MONITORING WELL RECORD N: 5 028 092 E: 442 776

PROJECT No. \_\_\_\_\_122410780

<u>MW13-5</u>

BOREHOLE No.

CLIENT \_\_\_\_\_ Richcraft Group of Companies

LOCATION Ottawa, ON

STAN-GEO 122410780 - PARKDALE DEVELOPMENT.GPJ SMART.GDT 5/27/13

D/	ATES: BO	RING <u>May 10, 2013</u> WAT	er Li	eve	L		<u>May</u>	<u>/ 22, 20</u>	013 DATUM
						SA	MPLES		UNDRAINED SHEAR STRENGTH - kPa
(E)	(LL) NO		PLOT	EVEL		m	۲۲		
E.	VATI	SOIL DESCRIPTION	ATA	ER	ΥΡΕ	MBEI	)) ME	ALUI	WP W WL WATER CONTENT & ATTERBERG LIMITS I OT
ă	ELEY		STR	M	F	INN	ы С	N-V NOR	DYNAMIC PENETRATION TEST, BLOWS/0.3m
	_						<u> </u>		STANDARD PENETRATION TEST, BLOWS/0.3m
	62.15								10 20 30 40 50 60 70 80 90
	62.1	\50 mm ASPHALT	***						
		FILL: brown gravelly sand with			BS	1	-	-	<b>D</b>
]	61.5	clay	$\boxtimes$						
- 1 -	61.2	Weathered LIMESTONE			<u>SS</u>	_2	100	50	
		fragments with clay			HQ	3	100%	/50 mm	
		Medium grey crystalline			-				
		LIMESTONE with shaley							
- 2 -	2	partings					0004	5002	
		-Very poor to excellent rock			PHQ	4	98%	29%	
S (7	6	mass quality							
	2	-Strong to very strong intact rock							
- 3 -		strength Slightly weathered to							
		unweathered							<u></u>
11 sz	2	-Discontinuities: 1 bedding set			HQ	5	100%	88%	
- 4 -	3	and 1 joint set							
8	S 18	(Defende Field Deduc de Com							
20 . <del>.</del>	5	(Refer to Field Bedrock Core	┝╌┰╾┙						
		205)	╞╼┰╼┙					1	
- 5 -					110	4	1000/	020/	
					U HŲ	o	100%	0,070	
1									
- 6 -	ġ.								
័ះ	2								
23	ś								
-					HQ	7	100%	78%	
- 7 -			H						
	C								
- 8 -	2.				HO	8	100%	82%	
. 3						0	100/0	0270	
				Υ.					
- 9 -									╺ <sub>┫</sub> ┙┙┙╧╗┙┙┙┙┙┙┙┙┙┙┙┙┙┙┙┙┙
- 2									
					HQ	9	100%	88%	
-10 -				1	L.II!			I	□ Field Vane Test. kPa
		♀ Inferred Groundwater Level							Remoulded Vane Test, kPa     App'd
		▼ Groundwater Level Measured in S	tandr	oipe					△ Pocket Penetrometer Test, kPa Date
					-	_			

🕉 Sta	antec	MONITORING WELL RECORD N: 5 028 092 E: 442 776
CLIENT	Richcraft Group of	Companies
LOCATION	Ottawa, ON	

LOCATION Ottawa, ON			PROJECT No. 122410	0780
DATES: BORING May 10, 2013	WATER LEVEL	May 22, 20	013 DATUM	
		SAMPLES	UNDRAINED SHEAR STRENGTH + kPa	

Bit Bit Bit Bit Bit Bit Bit Bit Bit Bit	DA	TES: BO	RING <u>May 10, 2013</u> WATI	er Li	EVE	L		May	22, 20	I3 DATUM	
SOIL DESCRIPTION         Soil US		_					S٨	MPLES		UNDRAINED SHEAR STRENGTH + kPa	
10       (Cont.) Medium grey crystalline LiMESTONE with shaley partings       11	DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR ROD	50         100         150         200           WATER CONTENT & ATTERBERG LIMITS         Wp         W         WL           DYNAMIC PENETRATION TEST, BLOWS/0.3m         *	
10       (Cont.) Medium grey crystalline LIMESTONE with shaley parings       11       10										STANDARD PENETRATION TEST, BLOWS/0.3m	00
11       LIMESTONE with shaley parings         11       (Refer to Field Bedrock Core Log)         12       HQ 10       100% 98%         HQ 11       100% 98%         HQ 12       100% 97%         HQ 13       100% 100%         HQ 14       98%         HQ 15       95% 98%         HQ 14       98% 98%         HQ 15       95% 93%         HQ 14       95% 93%         HQ 15       95% 93%         HQ 15       95% 93%         HQ 15       95% 93%         HQ 15       95% 93%         HQ 15       95% 93%         HQ 15       95% 93%         HQ 16       95% 93%         HQ 17       95% 93%         HQ 18       95% 93%         HQ 15       95% 93%         HQ 16       95% 93%         HQ 17       95% 93%         HQ 18       95% 93%         HQ 19       95% 93%         HQ 14       95% 93%         HQ 15       95% 93%         HQ 16       95% 93%         HQ 17       95% 93%         HQ 18       95% 93%         HQ 15       95% 93%	10 -		(Cont.) Medium grev crystalline								
11       Refer to Field Bedrock Core       HQ       10       100%       98%       HI <td></td> <td></td> <td>LIMESTONE with shaley</td> <td>╞╼┰╾┦</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>			LIMESTONE with shaley	╞╼┰╾┦							
11       (Refer to Field Bedrock Core Log)       HQ       10       100%       98%       HQ       10       100%       98%         13       HQ       11       100%       98%       HQ       11       100%       98%         14       HQ       11       100%       98%       HQ       11       100%       98%         14       HQ       12       100%       98%       HQ       12       100%       98%         14       HQ       12       100%       98%       HQ       12       100%       98%         14       HQ       12       100%       97%       FT       F			partings								
12       Image: Second conditional production conditional productinal productinal productional productional productional	<u>11-</u>		(Refer to Field Bedrock Core								
12         13         14         15         16         17         18         19         20         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓       Inferred Groundwater Level         ✓       Groundwater Level Measured in Standpipe			Log)			HQ	10	100%	98%		
12       HQ 11 100% 98%       HQ 11 100% 98%       HQ 11 100% 98%         14       HQ 12 100% 97%       HQ 12 100% 97%       HQ 13 100% 100%         16       HQ 13 100% 100%       HQ 14 98% 98%       HQ 14 98% 98%         18       HQ 15 95% 93%       HQ 15 95% 93%       HQ 15 95% 93%         19       HQ 15 95% 93%       HQ 15 95% 93%       HQ 15 95% 93%         19       Inferred Groundwater Level       D Field Vaar Test, kPa Appd         20       Image: State of the state of t	1.22		-								-
12       HQ       11       100%       98%         13       HQ       11       100%       98%         HQ       12       100%       97%         HQ       12       100%       97%         HQ       13       100%       100%         HQ       13       100%       100%         HQ       13       100%       100%         HQ       14       98%       98%         HQ       13       100%       100%         HQ       14       98%       98%         HQ       14       98%       98%         HQ       14       98%       98%         HQ       14       98%       98%         HQ       15       95%       93%         HQ       16       98%       11       11       11         10       Field Vanc Test, kPa       Appd       11       11         10       Field Vanc Test,											
13       HQ       11       100%       98%       11       100%       98%         14       HQ       12       100%       97%       11 <td>12-</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	12-										
13       HQ       11       100%       98%       III       IIII       IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII											ļĒ.
13       14         14       12       100%       97%         15       14         16       13       100%       100%         16       14       98%       98%         17       14       98%       98%         18       14       98%       98%         19       14       98%       98%         10       15       95%       93%         18       10       15       95%       93%         10       14       98%       98%       100%         10       15       95%       93%       100%         19       10       15       95%       93%       100%         10       15       95%       93%       100%       100%         10       14       98%       93%       100%       100%         10       14       98%       93%       100%       100%       100%         10       15       95%       93%       100%       100%       100%         10       15       95%       93%       100%       100%       100%       100%         10       16       1						HQ	11	100%	98%		
14         15         16         17         18         19         20         ✓ Inferred Groundwater Level         Y Groundwater Leve	13										
14         15         16         17         18         19         20         ✓ Inferred Groundwater Level         ✓ Groundwater Level         ✓ Groundwater Level         ✓ Groundwater Level         ✓ Groundwater Level	1) 11 11		19								*   -
14         15         16         17         18         19         20         Inferred Groundwater Level         Image: Second	·										
HQ 12 100% 97% $HQ 12 100% 97% $ $HQ 13 100% 100% $ $HQ 14 98% 98% $ $HQ 14 98% 98% $ $HQ 15 95% 93% $ $HQ 15 95% 93% $ $HQ 15 95% 93% $ $HQ 15 Field Vane Test, kPa App'd$	14										
15         16         17         18         19         20         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Groundwater Level         ✓         Inferred Groundwater Level         ✓         O         Pecket Penetrometer Test, kPa         Date	- T					HQ	12	100%	97%		
15       HQ       13       100%       100%       III       IIII       IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII											
15         16         17         18         19         20         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Pocket Penetrometer Test, kPa         Date	-			┝╼┵╼╕ ┝╼┯╼╛							
116         117         118         119         20         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Inferred Groundwater Level         ✓         Or Conduct         Inferred Groundwater Level         ✓         Inferred Groundwater Level	15										+[
116       HQ       13       100%       100%         117       HQ       14       98%       98%         118       HQ       14       98%       98%         119       HQ       15       95%       93%         110       HQ       15       95%       93%         110       HQ       15       95%       93%         110       HQ       15       95%       93%         111       HQ       16       HQ       16         119       HQ       15       95%       93%       HQ         110       HQ       15       95%       93%       HQ       HQ         110       HQ       15       95%       93%       HQ       HQ       HQ         110       HQ       15       95%       93%       HQ       HQ<											
16       14       98%       98%         17       14       98%       98%         18       14       98%       98%         19       14       95%       93%         19       10       10       11         20       ✓       Inferred Groundwater Level       □         ✓       Inferred Groundwater Level       □       □         ✓       Groundwater Level       △       Pocket Penetrometer Test, kPa         △       Pocket Penetrometer Test, kPa       Date						но	13	100%	100%		
17         18         19         20         ✓ Inferred Groundwater Level         ✓ Groundwater Level         ✓ Groundwater Level         ✓ Groundwater Level         ✓ Groundwater Level         ✓ Pocket Penetrometer Test, kPa         Determine         ✓ Decket Penetrometer Test, kPa         Decket Penetrometer Test, kPa	16-							100/0		╷╷╴┼╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷╷	[. +
17         18         19         20         ✓ Inferred Groundwater Level         ✓ Groundwater Level Measured in Standpipe											
<ul> <li>17-</li> <li>18-</li> <li>19-</li> <li>20-</li> <li>✓ Inferred Groundwater Level</li> <li>✓ Groundwater Level Measured in Standpipe</li> </ul>	- 64					· · · · ·					ŀ
HQ 14 98% 98% $HQ 14 98% 98%$ $HQ 14 98% 98%$ $HQ 14 98% 98%$ $HQ 15 95% 93%$											
$18$ $19$ $19$ $20$ $\qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad $	17-					LIO I	14	0.002	090/		1
18         .19         .19         .19         .19         .19         .19         .19         .19         .19         .19         .19         .19         .19         .19         .19         .19         .19         .19         .19         .110         .111 <td></td> <td></td> <td></td> <td>╞╾┷╼┚</td> <td></td> <td>ΠQ</td> <td>14</td> <td>90/0</td> <td>90 (0</td> <td></td> <td>1-</td>				╞╾┷╼┚		ΠQ	14	90/0	90 (0		1-
<ul> <li>18</li> <li>HQ 15 95% 93%</li> <li>HQ 15 95% 93%</li> <li>HQ 15 95% 93%</li> <li>HQ 15 95% P3%</li> <li>HQ 15 P5% P3%</li> <li>HQ 15 P5% P3%</li> <li>HQ 15 P5% P3%</li> <li>HQ 15 P5% P3%</li> <li>HQ 15 P5% P3%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ 15 P5%</li> <li>HQ</li></ul>	2 										
19       HQ 15 95% 93%       93%         20       Inferred Groundwater Level       Field Vane Test, kPa         ✓ Inferred Groundwater Level       Remouided Vane Test, kPa         ✓ Groundwater Level Measured in Standpipe       Pocket Penetrometer Test, kPa	18-			<mark> -+-1</mark>						┶╪╪┷┠┰┶┽╪╎┽┊┽╡╎┼┿┶┝┧┿╕╪┥╡┙┙╪┝╡┿┾╪	
19         20         ✓ Inferred Groundwater Level         ✓ Groundwater Level Measured in Standpipe	2										
19         20         ✓ Inferred Groundwater Level         ✓ Groundwater Level Measured in Standpipe							1.5	0.60	020		ŀ
20 ✓ Inferred Groundwater Level ✓ Groundwater Level Measured in Standpipe	19-					L HŐ	12	93%	95%		
20       Inferred Groundwater Levei       □       Field Vane Test, kPa         ✓       Groundwater Levei       □       Remouided Vane Test, kPa         ✓       Groundwater Levei       □       Pocket Penetrometer Test, kPa				╞╾┰╼┩							
20       Inferred Groundwater Level       □       Field Vane Test, kPa         ✓       Inferred Groundwater Level       □       Remouided Vane Test, kPa         ✓       Groundwater Level Measured in Standpipe       △       Pocket Penetrometer Test, kPa	1			<mark> ↓-</mark> ↓							
20       ✓ Inferred Groundwater Level       □ Field Vane Test, kPa         ✓ Groundwater Level Measured in Standpipe       □ Remouided Vane Test, kPa         ▲ Pocket Penetrometer Test, kPa       □ Date											
✓ Inferred Groundwater Level       □ Remouided Vane Test, kPa       App'd         ✓ Groundwater Level Measured in Standpipe       △ Pocket Penetrometer Test, kPa       Date	20			-T-				I		<ul> <li>Field Vane Test, kPa</li> </ul>	
Groundwater Level Measured in Standpipe			♀ Inferred Groundwater Level							Remoulded Vane Test, kPa     App'd	-
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2 of 3

MW13-5

BOREHOLE No. \_\_\_\_\_\_MWI3-5

# MONITORING WELL RECORD N: 5 028 092 E: 442 776

3 of 3 MW13-5

PROJECT No. \_\_\_\_\_122410780

BOREHOLE No.

UNDRAINED SHEAR STRENGTH - kPa

DATUM \_

<u>MW13-5</u>

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Optimize Extra Endining Lid.         Description         MV13-3 (Page 2 of 4)           Animate Extra Endining Lid.         Implementation         Implementation         Implementation           Animate Extra Endining Lid.         Implementation         Implementation         Implementation           Animate Extra Endining Lid.         Implementation         Implementation         Implementation           Animate Extra Endining Lid.         Implementation         Implementation         Implementation           Animate Extra Endining Lid.         Implementation         Implementation         Implementation           Animate Extra Endining Lid.         Implementation         Implementation         Implementation           Animate Extra Endining Lid.         Implementation         Implementation         Implementation           Animate Extra Endining Lid.         Implementation         Implementation         Implementation           Animate Endining Lid.         Implementation         Implementation         Implementation           Animate Endining Lid.         Implementation         Implementation         Implementation           Animate Endining Lid.         Implementation         Implementation         Implementation           Animate Endining Lid.         Implementation         Implementation         Implementation			Richer	aft Grot	up of Companies		1	žć	oject N		122410780	
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STRENGTH (MPa)DISCONTINUITY TYPEORIENTATIONnely Strong = > 250VW = Very Weak = 1-5B = Bedding Joint $F = Filat = 0.20^{\circ}$ $Calight, Hard$ nely Strong = > 250EW = Extremely Weak = <1	- 1				13.11 - 13.44 m: dark grey crystalline dolomite	-	2 >	R R	-	Я	catcite lenses	C.C-C=F1
ely Strong = > 250VW = Very Weak = 1-5B = Bedding JointF = Flat = 0-20°T = Tight, Hardrong = 100-250EW = Extremely Weak = <1				STRENGT	TH (MPa) DISCONTINUITY TYPE		ORIE	ENTATIO	N		FILT	ING
rong = 100-250EW = Extremely Weak = <1J = Cross JointD = Dipping = 20-50°O = Oxidized50-1005 = SteartV = n-Vertical = >50°S = Slightly Altered, Clay FreeS = Slightly Altered, Clay Free5 - 255 = Stear Plane $N = n-Vertical = >50°$ S = Sandy, Clay FreeS = Sandy, Clay Free5 - 255 = Stear Plane $N = n-Vertical = >50°$ S = Sandy, Clay FreeS = Sandy, Clay Free5 - 25 $N = NousN = Nough UndulatingN = Nousoft Ning ClayN = Nousoft Ning Clay5 - 25N = NoisN = Nough PlanarN = Nough PlanarN = Sonoth Undulating6 - OxidizedN = Moderate = 0.3-1 mS = Smoth VindulatingS = Swelling, Soft Clay6 - Sichi IkeN = SoioluredC = Close = 5-30 cmU = Slickensided Undulating6 - SoiolikeC = Close = 5-30 cmL = Slickensided Undulating6 - SoiolikeN = Soioth PlanarL = Slickensided Undulating6 - Soio-LikeN = Soioth PlanarL = Slickensided Undulating6 - Soioth IkeN = Soioth PlanarL = Slickensided Undulating7 - Soioth IkeN = Soioth PlanarN = Slickensided Undulating8 - Soioth IkeN = Soioth PlanarL = Slickensided Undulating8 - Soioth IkeN = Slickensided UndulatingN = Slickensided Planar9 - Soioth IkeN = Slickensided PlanarN = Slickensided Planar9 - Soioth IkeN = Slickensided PlanarN = Slickensided Planar9 - Soioth IkeN = Slickensided PlanarN = Slickensided PlanarN = N = Slicken$	Ē	aly Strong	; = > 250		VW = Very Weak = 1-5 Bedding Joint	= -	Flat = 0	-200			T = Tight, Hard	
: 50-100F = FaultV = n-Vertical = >50°S = Slightly Altered, Clay FreeIm Strong = 25-50S = Shear PlaneS = Sandy, Clay FreeS = Sandy, Clay FreeIm Strong = 25-50S = Sandy, Clay FreeS = Sandy, Clay FreeS = Sandy, Clay FreeIm Strong = 25-50S = Sandy, Clay FreeS = Sandy, Silty, Minor ClayN = Rough UndulatingIm Strong = 25-25S = Sandy, Silty, Minor ClayN = Rough UndulatingN = Sandy, Silty, Minor ClayIm Strong = 25-20S = Sandy, Silty, Minor ClayN = Rough PlanarN = Sonoth UndulatingN = Sonoth UndulatingIm Ely = DiscolouredM = Moderate = 0.3-1 mS = Smooth UndulatingS = Smooth UndulatingS = Smooth UndulatingIm Ely = DiscolouredC = Close = 5-30 cmU = Slickensided UndulatingU = Slickensided UndulatingIm Im Sciencing Ely = Sonoth ImageV = Nerv Close = S = S = S = Smooth PlanarU = Slickensided UndulatingIm Im Sciencing Ely = Sonoth ImageV = Slickensided UndulatingImageIm Im Sciencing Ely = Sonoth ImageV = Slickensided UndulatingImageIm ImageV = Verv Close = S = S = S = Since		ong = 10(	0-250		EW = Extremely Weak = < 1 J = Cross Joint	ō	Dippin	g = 20-5	00		0 = Oxidized	
Image: Second strong = 25-50Second strong = 25-50Second strong = 25-30 $= 5 - 25$ $= 5 - 25$ $\underline{ROUGHNESS}$ $S = 5 - 3 cm dy, Clay Free$ $= 5 - 25$ $\underline{SI} = 5 - 3 cm dy, Silty, Minor ClayNC = Non-softening Clay\underline{WEATHERING}NC = Nongh UndulatingNC = Non-softening Clay\underline{WEATHERING}VW = Very Wide = > 3 cm dy, Silty, Minor ClayNC = Non-softening Clay\underline{WEATHERING}VW = Very Wide = > 3 cm dy, PlanarNC = Non-softening Clay\underline{WEATHERING}VW = Wide = 1 - 3 cm dy, Ni = Nough PlanarS = 5 cm oth Undulating\underline{W} = Wide = 1 - 3 cm dy = 0.3 - 1 cm$		50-100			F = Fault	>	n-Verti	cal = >5	00		SA = Slightly Alte	ered, Clay Free
$F_{1} = 5 - 25$ $ROUGHNESS$ Si = Sandy, Silty, Minor Clay $WEATHERING$ $SI = Sandy, Silty, Minor ClayWEATHERINGRU = Rough UndulatingRU = Rough UndulatingWEATHERINGRP = Rough PlanarRP = Rough PlanarC = Costaited = N = 0.3 mSU = Smooth UndulatingSC = Swelling, Soft ClayM = Woderate = 0.3 mSU = Smooth UndulatingSC = Swelling, Soft ClayM = Woderate = 0.3 mSU = Smooth PlanarSC = Swelling, Soft ClayAtely = DiscolouredM = Moderate = 0.3 mSU = Smooth PlanarFriableC = Close = 5-30 cmLU = Slickensided UndulatingFeriableVC = Very Close = <5 cmLP = Slickensided Planar$	=	n Strong	= 25-50		S = Shear Plane						S = Sandy, Clay F	ree
WEATHERING     SPACING     RU = Rough Undulating     NC = Non-softening Clay       hered = No Signs     VW = Very Wide = >3m     RP = Rough Planar     SC = Swelling, Soft Clay       • Notized     VW = Very Wide = >3m     RP = Rough Planar     SC = Swelling, Soft Clay       • Oxidized     VW = Wide = 1-3 m     SU = Smooth Undulating     SC = Swelling, Soft Clay       • Stately = Discoloured     M = Wide = 1-3 m     SP = Smooth Undulating     SC = Swelling, Soft Clay       • Stately = Discoloured     Discoloured     LU = Slickensided Undulating       • Friable     VC = Close = 5-30 cm     LP = Slickensided Planar		5 - 25						<b>IOUGHI</b>	<u>VESS</u>		Si = Sandy, Silty,	Minor Clay
hered = No Signs     RP = Rough Planar     SU = Swelling, Soft Liay       = Oxidized     W = Wide = 1-3 m     SU = Smooth Undulating       = Oxidized     M = Wide = 1-3 m     SP = Smooth Planar       ately = Discoloured     R = Moderate = 0.3-1 m     SP = Smooth Planar       Friable     C = Close = 5-30 cm     LU = Slickensided Undulating       relv = Soil-like     VC = Very Close = <5 cm	~	VEATHER	DNI		SPACING	RU	= Rough	Undul	ating		NC = Non-soften	ning Clay
: Oxidized W = Wide = 1-3 W SU = Smooth Undulating N = Wide = 1-3 M SP = Smooth Planar Friable C = Close = 5-30 cm LU = Slickensided Undulating elv = Soil-like VC = Very Close = <5 cm LP = Slickensided Planar	·	iered = N	o Signs		VW = Very Wide = >3m	RP 2::	= Rough	i Planar	:		oc = owelling, oo	оп стау
itely = Discoloured Discoloured = U.3-1 m Discoloured = U.2 = Discoloured = U = Slickensided Undulating = VC = Very Close = <5 cm LP = Slickensided Planar	11	Oxidized			W = Wide = 1-3 m	29	= 5m001	th Plana	llating r			
telv = Slickensided Planar $VC = Very Close = <5 cm$ $LP = Slickensided Planar$	r6 .	tely = Uis Erishla	coloured		M = Moderate = 0.3-1 m C = Close = 5.30 cm	5 B	= Slicker	nsided	Indulati	ä		
	- Z	rudule viv = Snil-	like		VC = Varv Close = 25 cm	م	= Slicker	Isided F	lanar	5		

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Client:			Richc	raft Gr	oup of Companies	Project No.:	122410780	
Project:			Parkc	Jale De	velopment		May 8, 2013	
Contraci	tor:		Dowr	ning Es	tate Drilling Ltd.	Borehole No.:	MW13-3 (Page 3	of 4)
						Logger:	SH	
		кя				CONTINUITIES		
мояя нтяза	ои иол	% сове весоле	א אסס	DT HT430	GENERAL DESCRIPTION GENERAL DESCRIPTION STRENGTH WO. OF SETS NO. OF SETS NO. OF SETS ORIENTATION	SPACING ROUGHNESS APERTURE FILLING	OCCASIONAL FEATURES	DRILLING OBSERVATIONS
					13.44 - 13.64 m : Dark grey crystalline dolomite	M RU - T	calcite veins + vugs /	Mohe Unednore:
13.44	ξt	100%	80%	14.94	13.64 - 14.94 m: medium grey crystalline limestone U 3 J D	- RP - T	calcite and pyrite	H=3.5 5
	77			8	with shaley partings 1-3 mm thick	- RP - SC	replacement features	
	9					VC-M RP-RU - T	dianina coloite	Ache Undane:
14.94	μ Σ Σ Σ Σ	100%	93%	16.48				
	1							0.000-11
						C-M RU - T	dipping joint infilled	Mohe Undance:
16.48		100%	87%	18.01		- RP - T	with calcite / calcite	אכשווט זאח גווטואו א-ז-ג ג
	ţ						vugs + dipping veins	
	G					C-M RU-RP - T	calcite vilde /	Mohs Hardness:
18.01	<u>ר</u> ביי	100%	91%	19.48	Medium grey crystalline limestone U 1		chalev nartings	
	3							
EH = Ext VS = Ver S = Stroi MS = Mi W = We W = We U = Unw M = Moi H = High C = Com	remely v Stror ng = 50 ak = 5 - ak = 5 - ceather the = 6 - deratef beratef beratef beratef	/ Strong ng = 100 +100 Strong : -25 -25 -25 vithERIA red = Nu vidized = Nu vidized = nu vi = Disu	g = > 25 0-250 = 25-56 = 25-56 ο Signs o Signs colourε tike	STREN(	Discontinuity TYPE       F=FI         VW = Very Weak = 1-5       B = Bedding Joint       F = FI         VW = Very Weak = -1.5       B = Cross Joint       D = D         EW = Extremely Weak = <1	<u>ORIENTATION</u> at = 0-20° ipping = 20-50° Vertical = >50° ROUGHNESS Rough Undulating tough Planar mooth Planar inceensided Undulating lickensided Planar	FILL T = Tight, Hard O = Oxidized SA = Slightly Alte S = Sandy, Clay F Si = Sandy, Silty, NC = Non-soften SC = Swelling, So	ING red, Clay Free ree Minor Clay ing Clay ft Clay

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		4 of 4)	12		DRILLING OBSERVATIONS	Mohe Usednore -			Mohs Hardness :	H=3-5.5					<u>-LING</u>			tered, Clay Free	rree v. Minor Clav	ning Clay	oft Clay			
122410780	May 8, 2013	MW13-3 (Page	SH		OCCASIONAL FEATURES		calcite vugs			J					<u>FII</u>	T = Tight, Hard	O = Oxidized	SA = Slightly All	s = sandy, ciay Si = Sandv. Silty	NC = Non-softe	SC = Swelling, S			
•:		lo.:			FILLING	Т			⊢														50	
ct No		Nole N	er:		зяитязяа	•			•		Τ									ଥ <u>କ</u>	, n	Suc	dulatin	ē
Proje	Date:	Bore	Logge	JITIES	ROUGHNESS	ิ หบ-รม			RU-SU						ATION		20-500	= >50 <sup>0</sup>	CHNES	odulatii	anar	Jndulat lanar	led Und	54 I D
s	_			NTINU	SPACING	C-M			VC-M						ORIENT	= 0-20	ping =	ertical		Undan Ur	ugh Pla	nooth P 100th P	ckensid ckansid	
l				DISCO	ИОІТАТИЗІЯО	۳.			Ľ							F = Flat	D = Dip	∧-u = ∧		RU = Rc	RP = Rc	su = sn SP = Sn	LU = Sli LD = Sli	
					S/34YT	B			8												_			
					NO. OF SETS		-		,	-					<u>ΥΡΕ</u>						Зm	8	=	5
					меатневиис		∍		:	>						oint			2		ide = >	-3 m -3 m - 0 - 0		5e = <5
					нтоизятс				G	^					CONTIN	dding J	ss Join	rit T	ear Pla	0000		/ide = 1	Se = 5	ery Clo
					DESCRIPTION Colour, Texture, etc.)	tallias limostono with	ey shale 1 - 20 mm thick	2	talline limestone with	ey shale 1 - 20 mm thick					DIS	B = Be	= < 1 J = Cro	F = Fai			- MV	N = N		
oup of Companies	/elopment	ate Drilling Ltd.			GENERAL (Rock Type/s, %,	Madilum grou cours	interbeds of dark gr		Medium grey crys	interbeds of dark gr					TH (MPa)	VW = Very Weak = 1-5	EW = Extremely Weak =							
aft Gro	ale Dev	ing Est			ОЕ НІ 10		21.00		0 L C C	NC.22					STRENG	_						-	-	
Richcr	Parkd	Down			א אסס		87%		)010	%T0	†		1			= > 250	1-250		NC-C7 =	ġ	) Signs	olouror		ike
				кя	% сове весол		100%			212	1		T	-		<b>Y</b> Strong	ng = 100	0-100	- 25	ATHEBIA	red = Nc	Dxidized	riable	y = 5011-1
		ctor:			เดท ทบภ	C I	16		Å	17						xtremel	ery Stro	ong = 51	reak = 5	AVE.	weathe	thtly = ( oderate	shly = Fi	mpletei
Client:	Project	Contra			ОЕРТН FROM		19.48		, , ,	00.12						EH = E	VS = V	S = Str			n = Un	S = Slig M = M	H = H	0 = U

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÷;		Richc	craft Gr	oup of Companies			ā.	oject N		122410780		
		Park	dale De	velopment				ate:		May 10, 2013		
ijo		Dow	ning Est	tate Drilling Ltd.			Ô	orehole	No.:	MW13-5 (Page 1	l of 4)	
							Ľ	gger:		SH		- E
	КY					ISCON.	TINUL	'IES				
вли ио.	% СОВЕ ВЕСОЛЕ	א אסס	OT HT930	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.) WEATHERING NO. OF SETS NO. OF SETS	ZYPE/S		SPACING	коибниесс Аректике	FILLING	OCCASIONAL FEATURES	DRILLING OBSERVATIONS	
					8		υ 	<u>י</u> גר	<b>⊢</b>	coarse calcite		
HQ-3	100%	%0	1.42	Medium grey crystalline limestone	-	>	- -	RP 7mr		infilling vertical	Mons Hardness:	_
				·						joint		
		-			8	F V	Σ	- N	0 <u>-</u>	coarse calcite infilling	Make Head	_
HQ-4	98%	29%	2.92	Medium grey crystalline limestone VS U 2	-	>	•	RP 7mr	0	vertical joint / shaley	NUOLIS MARQUESS. H=3-5 5	
				•						partings 1-30 mm thick		
					8	F V(	C-M RI	- ns-r	⊢		Moha Unada	1
HQ-5	100%	88%	4.45							sildley partiligs <1 mm thick	иии в папитез». Н=3-5 5	
								_				
				Athen a straight and the straight and th	8	Р Х	C-M RI	- P-L	T-SC	subvertical calcite	Maha Unadaore	1
1Q-6	100%	83%	5.94							Veins I mm tnick/ shafee vertines <1	IVIUIS naturis.	
										mm thick	C.C+C=LI	· · ·
			STRENG	STH (MPa) DISCONTINUITY TYPE		OR	IENTA	NOL		FILI	ING	
reme	ly Stron	lg = > 2!	50	VW = Very Weak = 1-5 B = Bedding Joint	Ë	= Flat = (	0-20 <sup>0</sup>			T = Tight, Hard		
y Strc	nng = 1C	0-250		EW = Extremely Weak = < 1 J = Cross Joint	٥	= Dippir	16 = 20	°02,		0 = Oxidized		
ng = 5 edium	0-100 Strong	1 = 75-5	c	F = Fault S = Shear Plane	>	= n-Vert	tical = :	50°		SA = Slightly Alte S = Sandv. Clav F	ered, Clay Free Free	
ak = 5	- 25		2				ROUG	<u>INESS</u>		Si = Sandy, Silty,	Minor Clay	
WE	ATHERI	DNI		<u>SPACING</u>	R.	J = Roug	gh Und acla d	ulating		NC = Non-softer SC = Swelling. Sc	ning Clay oft Clav	_
veatht thv ≡ (	ered = f Dvidizer	Vo Sign: 4	s	VW = Very Veide = >3m W = Wirde = 1-3 m	s. S		oth Un	dulating		•		
derat	ely = Dis	scolour	ed	M = Moderate = 0.3-1 m	8 <u>-</u>	= Smoo	oth Plai	nar Ettindulat	au			
hly = F noletel	riable v = Snit	-like		C = Close = 5-30 cm VC = Verv Close = <5 cm	3 2	= Slicke	insided	Planar	2			

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Client:			Richc	raft Gr	oup of Companies		1	Proje	ct No.	••	122410780	
Project	22	ľ	Parkd	lale De	velopment		1	Date:		-	May 10, 2013	
Contra	ctor:	- 1	Dowr	ning Es	tate Drilling Ltd.		1	Bore	hole N	:	MW13-5 (Page 2	of 4)
								Loggi	::	1011	HS	
ľ		кяз				DISC	ONTIN	UITIES				
DEPTH FROM	้ ดง งกษ	х сове весол	א גסט	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.) STRENGTH NO. OF SETS NO. OF SETS	овіємтатіои	SPACING	ROUGHNESS	ЭЯИТЯЭ9А	EILLING	OCCASIONAL FEATURES	DRILLING OBSERVATIONS
					Medium arev crystalline limestone shalev	ш —	NC-M	RU-SU	ŀ	F	subvertical	Mohs Hardness
5.94	НQ-7	100%	78%	7.47	partings 1 - 20 mm thick VS U 1					Τ	calcite veins	H=3-5.5
						ш. 	VC-M	ิ เป-รม	,	⊢		
7,47	HQ-8	100%	82%	8.99	Integration grey crystalline littlestone with shaley U 1 U 1						subvertical calcite veins	Mons Hardness: H-3.5 5
												0.1-0-11
					80	ч	₽ Ċ	RU-SU	•		shaley partings 1 - 10	Atche Underer
8.99	6-0H	100%	88%	10.49	Medium grey crystalline limestone U 1						mm tnick / subvertical calcite	
											veins 1 mm thick	
10.40	Å	2001	7000	11 00	Medium grey crystalline limestone with black	<u>ч</u>	N V V	ß	•	⊢	subvertical	Mohs Hardness:
	10	200	2		shaley partings 1-50 mm thick						calcite venus /	H=3-5.5
EH = E	tremely	/ Strong	= > 25(	STRENG 0	STH (MPa)     DISCONTINUITY TYPE       VW = Very Weak = 1-5     B = Bedding Joint	F = Fla	$\frac{\text{ORIENT}}{\text{It} = 0-20^{\circ}}$	ATION 0			<u>Filtu</u> T = Tight, Hard	NG
S = Str	ong = 50	-100 -100	Nc2-4		EW = EXTREMELY WEAK = < 1 J = Cross Joint F = Fault	10 = 0 1-u = >	pping = Vertical	20-50° = >50°			0 = Oxidized SA = Slightly Alte:	red, Clay Free
M = 2M W = W	Aedium eak = 5 ·	Strong : - 25	= 25-50	_	S = Shear Plane		ROU	GHNES	2		S = Sandy, Clay Fi Si = Sandy, Silty, I	ree Minor Clay
n = U	<u>WE/</u> weathei	THERIN red = No	IG Signs		<u>SPACING</u> VW = Verv Wide = >3m	RU = R RP = R	tough Ui ough Pla	ndulatir mar	8		NC = Non-softeni SC = Swelling, So	ing Clay ft Clay
S = Slig M = M H = Hig	(htly = 0 oderate (hly = Fri	xidized ly = Disc iable	oloure	g	W = Wide = 1-3 m M = Moderate = 0.3-1 m C = Close = 5-30 cm	SU = S SP = SI LU = SI	mooth t mooth P lickensid	Jndulat lanar led Unc	ting Julating			
C = Co	mpletely	/= Soil-	ike		VC = Very Close = <5 cm	LP = 51	ickensid	ed Plar	lar			

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Client:		-1	Richcra	ft Grou	p of Companies	Project No.:	122410780	
Project		-1	Parkdal	le Deve	lopment	Date:	May 10, 2013	
Contrac	tor:		Downin	ng Estat	e Drilling Ltd.	Borehole No.:	MW13-5 (Page 3	3 of 4)
					×	Logger:	SH	
		YA:				DISCONTINUITIES		
МОЯЭ НТЧЭО	RUN NO.	% сове весоле	א אכס	DEPTH TO	GENERAL DESCRIPTION STRENGTH WEATHERING NO. OF SETS NO. OF SETS	ОЯІЕИТАТІОИ SPACING ROUGHNESS АРЕRТURE FILLING	OCCASIONAL FEATURES	DRILLING OBSERVATIONS
	Ц,				Madium areav ranstalling limestone with black	F VC-W SP-RP - T	subvertical	Mohe Handaoee
11.99	1	100%	98%	13.49	shaley partings 1-40 mm thick		calcite veins 1 mm thick	MUIN THUNESS. H=3-5.5
	, C H				Modium arou crustallino limostono with black	F C-M SU-SP - T		
13.49	11	100%	97%	14.99	shaley partings 1-20 mm thick U 1		ę	H=3-5.5
					Modium area to dark area courtalling	F C-M SP-RP - T		
14.99	<u>្ត</u>	%001	100%	16.51	limestone S U 1		mm thick	H=3-5.5
16.51	- H F	98%	98%	18.01	Medium grey crystalline limestone with black U 1 B	F C-M SP-SU - T	subvertical calcite veins 1	Mohs Hardness:
					sharey partings tu-zu mm thick		mm thick	ר.ל-ב=H
EH = Ex VS = Ve S = Strc MS = V W = We W = We M = Mc M = Mc H = Hig C = Con	tremely ry Stron ng = 50- ak = 5 - veathere tity = 0x derately joletely	Strong : g = 100- 100 = 100 25 = 25 26 = No ed = No idized 7 = Discc	= > 250 -250 -25-50 25-50 Signs Signs sloured	ETRENGT	H (MPa) W = Very Weak = 1-5 W = Very Weak = 1-5 S = Bedding Joint F = J = Cross Joint D = F = Fault V = V = Very Wide = >3m W = Wide = 1-3 m M = Moderate = 0.3-1 m C = Close = 5-30 cm U V = Very Close = <5 cm L U	ORIENTATION = Flat = 0-20° = Dipping = 20-50° = n-Vertical = >50° U = Rough Undulating P = Rough Planar J = Smooth Undulating ° = Smooth Planar Slickensided Undulating ° = Slickensided Planar	FILL T = Tight, Hard O = Oxidized SA = Slightly Alte S = Sandy, Clay F Si = Sandy, Silty, NC = Non-soften SC = Swelling, So	ING ared, Clay Free Free Minor Clay ing Clay oft Clay

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Client:			Richc	raft Gru	oup of Companies	Project No.:	122410780	
Project		'	Parkd	lale De	velopment	Date:	May 10, 2013	
Contra	ctor:		Down	ning Est	tate Drilling Ltd.	Borehole No.:	MW13-5 (Page 4 of 4)	
						Logger:	SH	
ľ		ЕВУ				DISCONTINUITIES		
ОЕРТН ЕВОМ	ON NUR	% СОВЕ ВЕСОЛ	% KOD	DEPTH TO	GENERAL DESCRIPTION (Rock Type/s, %, Colour, Texture, etc.) УУЕАТНЕЯІNC ИО. OF SETS	TYPE/S ORIENTATION SPACING ROUGHNESS PPERTURE	OCCASIONAL DI FEATURES OBSE	DRILLING ERVATIONS
	D L					B F C-M RU-SU - T	shaley partings 1 mm	
18.01	ភ្ល	95%	93%	19.51	Medium grey crystalline limestone U 1		calcite veins 1 mm Hick / Subverticat WONS	IS Haraness: H=3-5.5
	ĊH				Mediiim grev crystalline limestone with shalev	B F VC-M SP-RU 🗧 T	subvertical	e Hardnore
19.51	16	100%	92%	21.00	partings 1-10 mm thick		calcite veins 1 H	H=3.5.5
			- 2				mm thick	
	ģ				Madium grav revetallina limactona with hlack	B F C-M RP-RU + T	subvertical	
21.00	5	98%	75%	22.50	wiching beg u gataline minosofie with black 0 1		calcite veins 1-3 NIONS	IS Hardness:
							mm thick	D.D-D-1
EH=E VS=V VS=V MS=N W=W U=U U=U M=Mi H=Hig	xtremel ery Stro ong = 51 Aedium eak = 5 eak = 5 weathe htly = C oderate thly = Fr	y Strong ng = 100 0-100 - 25 ATHERIA Xidized = Nu ried = Nu ried = Su riable	g = > 25 0-250 = 25-50 = 25-50 o 5igns o 5igns	id STRENG	STH (MPa)       DISCONTINUITY TYPE         VW = Very Weak = 1-5       B = Bedding Joint         VW = Very Weak = <1	<u>ORIENTATION</u> F = Flat = 0-20° D = Dipping = 20-50° V = n-Vertical = >50° V = n-Vertical = >50° S = Smooth Undulating RP = Rough Planar S = Smooth Planar S = Smooth Planar L = Slickensided Undulating	T = Tight, Hard O = Oxidized SA = Slightly Altered, Cla S = Sandy, Clay Free Si = Sandy, Silty, Minor ( NC = Non-softening Clay SC = Swelling, Soft Clay	ay Free Clay V
C = CO	mpletel	y = Soil-	like		VC = Very Close = <5 cm	LP = Slickensided Planar		

V:\01224\active\1224107XX\122410780\2013\rock core photos + logs\BEDROCK Core Logs.xlsx







![](_page_48_Figure_0.jpeg)

![](_page_49_Figure_0.jpeg)

![](_page_50_Picture_0.jpeg)

![](_page_51_Figure_0.jpeg)

![](_page_52_Figure_0.jpeg)

![](_page_53_Picture_0.jpeg)

![](_page_54_Picture_0.jpeg)

# **APPENDIX D**

Laboratory Test Results

![](_page_56_Picture_0.jpeg)

#### ASTM-D7012

Compressive Strength and Elastic Moduli of Intact Rock Core Speciments under Varying States of Stress and Temperatures. Method C: Unconfined Compressive of Intact Rock Core Speciments. D4543/ Preparation

Client: Richcraft Group of Companies Inc.

Project: Parkdale Development

Date Drilled: May 8-10, 2113

Cored By: Simon Harvey

Project No.: 122410780

Date Rec'd: May 14,2013

Date Tested: 16-May-13

Tested By: Athir Nader

Sample Location	BH13-3 HQ5 10'9"	BH13-3 HQ8 26'7"	BH13-3 HQ11 41'5"	
Physical Description	As per Geo-tech Report	As per Geo-tech Report	As per Geo-tech Report	
Average Diameter (mm) (≥47.0)	62.00	62.00	62.00	
Specimen Length (mm)	149.00	150.00	151.00	4 11 4 1
L/D Ratio (2.0-2.5)	2.40	2.42	2.44	
Failure Load (lbs)	85135	61456	69356	
Compressive Strength (Mpa)	125.4	90.5	102.2	
Straightness by Procedure S1 (≤0.02inch)	<0.02	<0.02	<0.02	
Flatness by Procedure FP2 (≤0.001inch)	<0.001	<0.001	<0.001	
Parallelism by Procedure FP2 (≤0.25°)	-0.079	-0.062	-0.046	
Perpendicularity by Procedure P2 (≤0.0043)	<0.0043	<0.0043	<0.0043	
Moisture Condition	As-Received	As-Received	As-Received	
Description of Break D7012/11.1.13	Reasonable well formed cones on both ends	veni formed cone on one end, vertical cracks running through	vveil formed cone on one end, vertical cracks	i: Ti
Note				

Reviewed by:

Date:

\_\_\_\_

![](_page_57_Picture_0.jpeg)

#### ASTM-D7012

Compressive Strength and Elastic Moduli of Intact Rock Core Speciments under Varying States of Stress and Temperatures. Method C: Unconfined Compressive of Intact Rock Core Speciments. D4543/ Preparation

Client: Richcraft Group of Companies Inc.

Project: Parkdale Development

Date Drilled: May 8-10, 2113

Cored By: Simon Harvey

Project No.: 122410780

Date Rec'd: May 14,2013

Date Tested: 16-May-13

Tested By: Athir Nader

Sample Location	BH13-3 HQ14 57'7"	BH13-3 HQ17 72'4"		29
Physical Description	As per Geo-tech Report	As per Geo-tech Report		
Average Diameter (mm) (≥47.0)	62.00	62.00		
Specimen Length (mm)	146.00	137.00		
L/D Ratio (2.0-2.5)	2.35	2.21	89	
Failure Load (lbs)	53136	63778		
Compressive Strength (Mpa)	78.3	94.0		
Straightness by Procedure S1 (≤0.02inch)	<0.02	<0.02		
Flatness by Procedure FP2 (≤0.001inch)	<0.001	<0.001		
Parallelism by Procedure FP2 (≤0.25°)	-0.119	-0.087	£1	
Perpendicularity by Procedure P2 (≤0.0043)	<0.0043	<0.0043		
Moisture Condition	As-Received	As-Received	8	
Description of Break D7012/11.1.13	Diagonal fracture with cracks through one end	on one end, vertical cracks through caps		
Note				

Reviewed by:\_

Date:

![](_page_58_Picture_0.jpeg)

#### ASTM-D7012

Compressive Strength and Elastic Moduli of Intact Rock Core Speciments under Varying States of Stress and Temperatures. Method C: Unconfined Compressive of Intact Rock Core Speciments. D4543/ Preparation

Client: Richcraft Group of Companies Inc.

Project: Parkdale Development

Date Drilled: May 8-10, 2113

Cored By: Simon Harvey

Project No.: 122410780

Date Rec'd: May 14,2013

Date Tested: 16-May-13

Tested By: Athir Nader

Sample Location	BH13-5 HQ4 6'9''	BH13-5 HQ7 22'9"	BH13-5 HQ10 37'1"	0
Physical Description	As per Geo-tech Report	As per Geo-tech Report	As per Geo-tech Report	
Average Diameter (mm) (≥47.0)	62.00	62.00	62.00	
Specimen Length (mm)	151.00	150.00	148.00	
L/D Ratio (2.0-2.5)	2.44	2.42	2.39	
Failure Load (lbs)	88413	106101	107351	
Compressive Strength (Mpa)	<b>130</b> .3	156.3	158.2	
Straightness by Procedure S1 (≤0.02inch)	<0.02	<0.02	<0.02	
Flatness by Procedure FP2 (≤0.001inch)	<0.001	<0.001	<0.001	
Parallelism by Procedure FP2 (≤0.25°)	-0.078	-0.109	-0.089	×
Perpendicularity by Procedure P2 (≤0.0043)	<0.0043	<0.0043	<0.0043	
Moisture Condition	As-Received	As-Received	As-Received	
Description of Break D7012/11.1.13	on one end, vertical cracks	on one end, vertical cracks	on one end, vertical cracks	
Note			4	

\_\_\_\_\_

Date: \_\_\_\_\_

![](_page_59_Picture_0.jpeg)

#### ASTM-D7012

Compressive Strength and Elastic Moduli of Intact Rock Core Speciments under Varying States of Stress and Temperatures. Method C: Unconfined Compressive of Intact Rock Core Speciments. D4543/ Preparation

Client: Richcraft Group of Companies Inc.

Project: Parkdale Development

Date Drilled: May 8-10, 2113

Cored By: Simon Harvey

Project No.: 122410780

Date Rec'd: May 14,2013

Date Tested: 16-May-13

Tested By: Athir Nader

	BH13-5	BH13-5		
Sample Location	HQ13	HQ16	C	
	53'1"	67'0"		
	As per Geo-tech	As per Geo-tech		
Physical Description	Report	Report		
				i ∈
Average Diameter (mm) (≥47.0)	62.00	62.00		
	•			
Specimen Length (mm)	151.00	149.00		
		<i>G</i> 7		
L/D Ratio (2.0-2.5)	2.44	2.40		
Failure Load (Ibs)	50658	59993		
Compressive Strength (Mpa)	74.6	88.4		
Straightness by Procedure S1				
(≤0.02inch)	<0.02	<0.02		
Flatness by Procedure FP2				
(≤0.001inch)	<0.001	<0.001		
Parallelism by Procedure FP2	0.450	0.000		
(≤0.25°)	-0.159	-0.092		
Perpendicularity by Procedure P2	-0.0040	10.0040		
(≤0.0043)	<0.0043	<0.0043		
Mainture Condition	As Dessived	As Dessived		
	As-Received	As-Received		. A
	vveii tormed cone	Columnar vertical		
Description of Break	ion one end,	cracking through		
07012/11.1.13	rupping through	formed cone		
Note				

Reviewed by:\_

Date:

![](_page_60_Picture_0.jpeg)

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www.paracellabs.com

# **Certificate of Analysis**

# Stantec Consulting Ltd. (Ottawa)

1331 Clyde Avenue Suite 400 Ottawa, ON K2C 3G4 Attn: Simon Harvey

Client PO: Parkdale Development Project: 122410780.200 Custody: 8942 Phone: (613) 722-4420 Fax: (613) 738-0721

Repo	rt Date: 6-Jun-2013
Orde	er Date: 3-Jun-2013
	Order #: 1323037

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

 Paracel ID
 Client ID

 1323037-01
 MW13-3

 1323037-02
 MW13-5

Approved By:

Much Fisto

Mark Foto, M.Sc. For Dale Robertson, BSc Laboratory Director

Any use of these results implies your agreement that our total liability in connection with this work, however arising shall be limited to the amount paid by you for this work, and that our employees or agents shall not under circumstances be liable to you in connection with this work

6	Ρ	A	R	A	C	ΕL	
	1.3	1.04	1.0.1	1.4.1	12.1	110	

Client: Stantec Consulting Ltd. (Ottawa) Client PO: Parkdale Development

Project Description: 122410780.200

#### **Analysis Summary Table**

Analysis	Method Reference/Description	Extraction Date Analysis Date
Anions	EPA 300.1 - IC	3-Jun-13 3-Jun-13
pН	EPA 150.1 - pH probe @25 °C	6-Jun-13 6-Jun-13
Resistivity	EPA 120.1 - probe	6-Jun-13 6-Jun-13

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Page 2 of 7

#### Order #: 1323037

Report Date: 06-Jun-2013 Order Date:3-Jun-2013

#### Client: Stantec Consulting Ltd. (Ottawa)

Client PO: Parkdale Development

 Order

 Project Description: 122410780.200

 MW13-3
 MW13-5

# Order #: 1323037

Report Date: 06-Jun-2013 Order Date:3-Jun-2013

	Client ID:	MW13-3	MW13-5	-	-
	Sample Date:	03-Jun-13	03-Jun-13	-	-
	Sample ID:	1323037-01	1323037-02	•	-
	MDL/Units	Water	Water	-	-
General Inorganics					
рН	0.1 pH Units	7.2	8.6	-	-
Resistivity	0.01 Ohm.m	9.43	45.6	-	-
Anions	·				
Chloride	1 mg/L	205	29	-	-
Sulphate	1 mg/L	78	28	-	-

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5 ARNIA 1 #27 123 Christina St. N 1 633 Sama, ON N7T 517

Glory Crt DN L23 0A3

Page 3 of 7

Client: Stantec Consulting Ltd. (Ottawa) Client PO: Parkdale Development

Project Description: 122410780.200

#### Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions Chloride Sulphate	ND ND	1 1	mg/L mg/L						
Resistivity	ND	0.01	Ohm.m						

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Order #: 1323037

Report Date: 06-Jun-2013

Order Date:3-Jun-2013

Page 4 of 7

Client: Stantec Consulting Ltd. (Ottawa) Client PO: Parkdale Development

Project Description: 122410780.200

#### Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	281	1	mg/L	282			0.3	10	
Sulphate	45.6	1	mą/L	45.8			0.3	10	
General Inorganics									
pН	6.3	0.1	pH Units	6.3			0.5	10	
Resistivity	9.42	0.01	Ohm.m	9.43			0.2	20	

PI 1-800-749-1947 I PARACEL@PARACELLABS.COM WWW.PARACELLABS.COM OTTAHA 300-2319 St Laurent Bivd Ottaves ON K1G 438 MISSISSAUGA 6645 Kitmat Rd Unit 627 Miseisseuga, ON LIN 633 NEAGARA FALLS 5415 Morning Glory Cit Niagara Falls, ON L2J DA3

SARNIA 27 123 Christine St. N 13 Seroie, ON N77 517

Order #: 1323037

Report Date: 06-Jun-2013 Order Date:3-Jun-2013

Page 5 of 7

#### Client: Stantec Consulting Ltd. (Ottawa)

Client PO: Parkdale Development

Project	Description:	122410780.200
	a courplion.	1001001200

# Order #: 1323037

Report Date: 06-Jun-2013 Order Date: 3-Jun-2013

# Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions Chloride Sulphate	10.7 55.1		mg/L mg/L	0.92 45.8	97.4 93.0	78-112 75-111			

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SARNIA 123 Chriatina St. N Sernio, ON N7T 5T7

Page 6 of 7

# Client: Stantec Consulting Ltd. (Ottawa)

Client PO: Parkdale Development

Project Description: 122410780.200

# 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.

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SARNIA 123 Christine St. N Samia, DN N7T 517 Report Date: 06-Jun-2013 Order Date:3-Jun-2013

Order #: 1323037

Page 7 of 7

GPARACEL LABORATORIES LTD.	TRUSTED RESPONS RELIABLE	SIVE.	Head O ice 300-2319 St. Laurent Blvd Ottawa Onta K1G 4J8 p <sup>.</sup> 1 600-749-1947 e paracel paracellabs.co	Chain of Custody List De Only Nº 8942
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Client Name: Starthe Consulting	I da Pr	oject Reference. Parkdo	Le Deve la serve ut	
Contact Name Simon Horvey	7a. Q.	MC = 177410 IS	20	TAT [ Regular [] 3 Day
Address 1331 Clyde Are.	PC	200		Date Required:
Telephone: 613 - 727 - 4470	(CE	Simon, harvey	D stantec.com	Lane Meganeu.
Criteria: 140! Keg al SI TH Table 110. Reg 153/11/Cen	an Table _ 1-1 RSC Film	or (   O/Reg. 55800     P4/QU	L [CCME ] [SUB Shares - ] [SUB (	amery Musicipality: 11 Others
Matrix Type: S (Soil/Sed.) GW (Ground Water) SW (Surface Wate	) SS (Slorn/Sanitary Sever	P (Paint) A (Air) O (Other)		Required Analyses
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Chain of Custody (Blank) - Rev 0.0 December 2011

![](_page_68_Picture_1.jpeg)

Rock Anchor: Resistance to Rock Mass Failure

# **Rock Anchor**

**Resistance to Rock Mass Failure** 

Required Safety Factor for Resistance to Rock Mass Failure:  $W_R / P \ge 2.0$ 

**Design Considerations:** 

5

Use 60° or 90° apex angle as per recommendations in the 1. geotechnical report

![](_page_69_Figure_5.jpeg)

**Grouted Rock Anchors** 

![](_page_69_Figure_7.jpeg)

'n

Mechanical Rock Anchors

![](_page_69_Figure_10.jpeg)

Mechanical Rock Anchors

- Resultant of maximum axial anchor forces P -D
  - Height of rock cone  $\equiv$
- R Radius of rock cone =
- θ Appex angle =
- La **Bond length** =

YR = W<sub>R</sub>

- Submerged unit weight of bedrock
- Weight of rock cone ( $W_R = \frac{1}{2} \Pi R^2 D \gamma_R$ ) =