APPENDIX A

GEOTECHNICAL REPORT

DYREGROV ROBINSON INC.
Consulting Geotechnical Engineers

KILDONAN PARK MAINTENANCE BUILDING

GEOTECHNICAL INVESTIGATION

2015 MAIN STREET

WINNIPEG, MANITOBA

Prepared for:

City of Winnipeg
Winnipeg, Manitoba

February 2017 **File #163998**

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DYREGROV ROBINSON INC.
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February 7, 2017

File No. 163998

City of Winnipeg
Planning, Property and Development Department
Third Floor – 65 Gary Street
Winnipeg, MB
R3C 4K4

Attn: Iain Currie, Project Coordinator

Dear Mr. Currie:

RE: Kildonan Park Maintenance Building
Geotechnical Investigation – 2015 Main Street

Dyregrov Robinson Inc. is pleased to submit our final report for the geotechnical investigation completed at 2015 Main Street for the proposed Kildonan Park Maintenance Building project.

If we can be of further assistance, please contact the undersigned directly.

Sincerely,

DYREGROV ROBINSON INC.

Gil Robin

Gil Robinson, M.Sc., P.Eng
President / Senior Geotechnical Engineer

Distribution List

# of Hard Copies	PDF Required	Association / Company Name
3	Yes	City of Winnipeg

Dyregrov Robinson Inc.

Report Prepared By:

Gil Robinson

Gil Robinson, M.Sc., P.Eng.
President / Senior Geotechnical Engineer

PROVINCE OF MANITOBA
GGR
G.G.B.
ROBINSON
7 Feb 2017
REGISTERED PROFESSIONAL ENGINEER

APEGM
Certificate of Authorization
Dyregrov Robinson Inc.
No. 86 **Date:** 7 Feb 2017

Table of Contents

1.0 INTRODUCTION

As requested, Dyregrov Robinson Inc. has undertaken a geotechnical investigation for the proposed Kildonan Park Maintenance Building project at 2015 Main Street in Winnipeg, Manitoba. The purpose of the investigation was to evaluate the subsurface conditions in order to provide limit state design recommendations for foundations along with recommendations for other geotechnically related aspects of the development such as floor slabs and pavement design. Authorization to proceed with the investigation was provided by the City of Winnipeg (Purchase Order #454020).

2.0 PROPOSED DEVELOPMENT

It is understood that the new building be about 6,000 ft^2 (approximate) in size and will have office, work shop and storage space areas. The building will be a single storey steel framed structure with masonry walls supported on piles and grade beam, no basement or crawl space is planned. The anticipated foundation service loads range from 250 to 450 kN. The yard area will be paved and will include some parking stalls. No other details of the development were provided.

3.0 SITE CONDITIONS

The project site is located in Kildonan Park on the east side of Main Street and is currently used by the City of Winnipeg Parks Department. There are two existing buildings on the site along with some storage sheds and equipment pads. The site flat lying and much of the surface area if paved with asphalt. We understand that the existing buildings and other infrastructure will be demolished to make room for the new building. We understand that some site remediation was previously to remove some contaminated soil.

4.0 FIELD INVESTIGATION

Four test holes were drilled on December 6, 2016 at the locations illustrated on Figure 1. The test Holes were drilled by Paddock Drilling Ltd. of Winnipeg, Manitoba using a truck mounted Acker MP5 drill rig equipped with 125 mm diameter solid stem augers and 200 mm diameter hollow stem augers. Hollow stem augers were used to drill Test Hole 1 below a depth of 3 m due to the presence of sand fill material which was caving into the test hole.

The subsurface conditions were visually logged during drilling by Dyregrov Robinson Inc. Disturbed (auger cuttings, split barrel sampler) and undisturbed (Shelby tube) soil samples were recovered at regular depth intervals. The test holes were backfilled with auger cuttings and bentonite chips.

All samples were taken to our Soils Testing Laboratory for additional visual classification and testing. The testing included determining the moisture contents of all samples and measurement of bulk unit weights and undrained shear strengths on the Shelby tube samples. A copy of the test hole logs are attached in Appendix A. The test hole logs summarize the subsurface conditions encountered, results of the laboratory testing and notes on the observations made during drilling.

5.0 SUBSURFACE CONDITIONS

The general stratigraphy encountered in the test holes from grade includes asphalt, granular base, sand fill, organic clay, silt, silty clay and glacial silt till. The asphalt pavement was typically 25 mm thick. The main stratigraphic units are described as follows:

5.1 Granular Base & Sand Fill

Granular base was encountered below the asphalt in Test Holes 1 to 3. In Test Holes 1 and 3, the granular base is crushed limestone (19mm down gradation) that is 1000 mm and 400 mm thick, respectively. In Test Hole 2 the granular base is sand that is 300 mm thick.

Sand fill was encountered below the granular base in Test Holes 1 and 3 and it is about 2.9 m thick. The sand is fine grained, has traces of gravel and is brown in color. The sand is moist becoming wet below a depth of about 3 m. The moisture content is about 7 percent for the moist sand and the wet sand has a moisture content around 12 percent. We understand that the sand fill was placed after some site remediation work. The thickness of the sand fill may vary from what was encountered in the test holes. The extent of the sand backfill area was not determined.

5.2 Organic Clay

A layer of organic clay, 2.4 m thick, was encountered below the asphalt in Test Hole 4. It is black to dark grey in color, dry to moist with a stiff consistency and contains traces of sand and organics. The moisture content is around 33 percent.

5.3 Silt

A shallow silt layer (400 mm thick) was encountered below the organic clay in Test Hole 4 at a depth of 2.4 m. The silt is grey in color, loose and moist to wet with a moisture content around 25 percent. The silt has a petroleum odour.

5.4 Silty Clay

The usual thick deposit of Lake Agassiz lacustrine silty clay was encountered beneath the sand fill in Test Holes 1 to 3 and beneath the silt in Test Hole 4. In Test Hole 2, the clay was encountered at a depth of 0.3 m below grade and in the other test holes the clay was encountered at depths ranging from 2.8 to 4 m below grade. The clay is mottled brown and grey to a depth of about 6 m where it turns to grey. It is moist with a stiff consistency to a depth of about 9 m. Below 9 m the clay is moist with a firm to stiff consistency. Below 14 m the clay contains traces of sand and gravel and has a firm consistency. The clay also has high plasticity and contains trace silt inclusions.

To a depth of about 3 m, the moisture content of the clay ranges from 30 to 40 percent. Below 3 m, the moisture content of the clay ranges from about 40 to 60 percent with an average around 50 percent.

The undrained shear strength of the clay was measured using Torvane, penetrometer and unconfined compressive strength tests. The clay has undrained shear strengths ranging from about 35 to 90 kPa. The bulk unit weight of the clay is about 17.5 kN/m^3.

5.5 Silt Till

Glacial silt till was encountered below the silty clay at a depth of 17.4 m in Test Hole 2. The glacial till deposit in the Winnipeg area is typically a heterogeneous mixture of sand, gravel, cobble and boulder size materials within a predominantly silt matrix that has a low but variable clay content.

The silt till encountered in Test Hole 2 contains traces of sand and gravel. No cobbles or boulders were confirmed with the small diameter augers used to drill the test hole. It is brown in color, moist and is compact. The moisture content from one sample was 10.3 percent. Auger refusal occurred at a depth of 19.5 m.

5.6 Test Hole Stability and Groundwater Conditions

No seepage or sloughing conditions were observed during drilling of Test Holes 2 and 4.

During drilling of Test Holes 1 and 3, seepage was observed from the sand fill below a depth of 3 m. Sloughing of the sand occurred in Test Hole 1 and required the use of hollow stem augers to complete the test hole.

Groundwater conditions should be expected to vary seasonally, from year to year and possibly as a result of construction activities.

6.0 DISCUSSION AND RECOMMENDATIONS

We understand that the existing buildings will be demolished in order to construct the new building. The details of the existing buildings (e.g. foundation type, presence of crawl spaces or basements) were not provided. Amongst other considerations, the design will need to consider the potential for existing foundations to be conflicting with the proposed foundations.

The extent of the sand fill encountered in Test Holes 1 and 3 was not determined and the thickness of the sand fill may vary from what was encountered in the test holes. The presence of the sand may affect installation of the new foundations and possibly the subgrade preparation for floor slabs and pavement.

6.1 Foundations

The subsurface conditions at this site are suitable for two types of foundations including cast-in-place concrete friction piles and driven end bearing, precast prestressed concrete hexagonal (PPCH) piles.

6.1.1 Cast-In-Place Concrete Friction Piles

Cast-in-place concrete friction piles under axial compressive loading can be designed in accordance to the current Manitoba Building Code (i.e. NBC 2010) using the service limit state (SLS) shaft adhesion values provided in Table 1 below. For the ultimate limit state (ULS) case, the piles can be designed with the factored shaft adhesion values and the factored end bearing pressure provided in Table 1. A resistance factor of 0.4 was used to calculate the factored ULS design values. Under the SLS loads, pile settlements are expected to be around 6 mm with differential settlements between piles around 3 to 6 mm.

Table 1: Design Parameters for CIP Concrete Friction Piles

Depth Below Existing Site Grade	SLS Shaft Adhesion	Factored ULS	
		Shaft Adhesion	End Bearing
(m)	(kPa)	(kPa)	(kPa)
0 to 4 (see Note 1)	0	0	0
4 to 9	20.0	24.0	160
9 to 14	15.0	18.0	160
14 to 15.5	11.6	14.0	125

Note 1: When determining effective pile lengths, the upper 4 m of the pile shaft below existing site grade should be ignored to account for the presence of fill materials, silt layers and the potential for soil shrinkage away from the pile. The extent and depth of the backfill conditions will not be known until the time of construction.

The pile length should be limited to 15.5 m below existing site grade to avoid drilling into the softer clay soil and the glacial till layer.

Piles should have a minimum diameter of 400 mm and a minimum spacing of 3 pile diameters on centre. This spacing also applies to new piles installed near existing piles. Where this spacing cannot be achieved DRI should be contacted for additional input. Small pile groups (maximum of 3 piles) can be considered for moderately high column loads.

Concrete should be placed as soon as possible after each pile hole is completed. Temporary steel sleeves should be on site and used where sloughing/caving of the pile borings occur and/or if groundwater seepage is encountered. Some of the pile foundations may be located in or near the soil remediation area(s) which were backfilled with sand. The thickness of the sand fill may vary from what was encountered in the test holes.

Piles that are subjected to freezing conditions must be protected from potential frost heave effects by using minimum pile lengths of 7.6 m and installing full length reinforcement. The use of flat lying rigid insulation, such as Styrofoam HI, can also be used to minimize frost penetration into the soil around the piles if the minimum pile length cannot be achieved. A greased, polyethylene wrapped sonotube could also be placed around the upper 1.8 m of the pile shaft to act as a bond breaker and provide additional protection against frost heave.

6.1.2 Driven Precast Prestressed Concrete Hexagonal Piles

Driven end bearing precast prestressed concrete hexagonal (PPCH) piles driven to practical refusal into dense to very dense glacial silt till, or limestone bedrock if encountered, can be designed in accordance to the current Manitoba Building Code (i.e. NBC 2010) using the SLS and factored ULS pile capacities provided in Table 2. Under the SLS loads, pile settlements are expected to be around 6 mm with differential settlements between piles around 3 to 6 mm.

Table 2: PPCH Pile Capacities – Axial Compressive Loads

PPCH Pile Size	**Pile Capacities**				
	SLS	**Unfactored ULS**	**Factored ULS Capacities**		
			ϕ = 0.4	**ϕ = 0.5**	**ϕ = 0.6**
(mm)	(kN)	(kN)	(kN)	(kN)	(kN)
300	**445**	1100	440	550	**660**
350	**625**	1560	624	780	**936**
400	**800**	2000	800	1000	**1200**

We recommend that a resistance factor of 0.6 be used for design provided that dynamic load testing with CAPWAP analysis is performed during foundation installation. If dynamic testing is not performed a resistance factor of 0.4 should be used. Dynamic load testing will provide data on the driving energy delivered to the pile and the driving stresses (tensile and compressive) in the piles. The CAPWAP analysis will utilize the data collected to provide a mobilized static pile resistance that can be compared to the unfactored and factored ULS pile capacities. The details of the dynamic load testing program can be finalized once the foundation layout has been established. Approximately 3 percent of the piles should be tested during pile installation under restrike conditions however; the number of piles to be tested will depend on the size of the building area and the number and sizes of piles to be installed. The piles to be tested will need at least 1.2 m of pile shaft above local grade around the pile to facilitate the testing.

The piles can be driven with diesel pile hammers having a rated energy of not less than 40 kilojoules. Hydraulic drop hammers can also be used provided they have a rated energy not less than 19.5 kilojoules. The rated energy for hydraulic drop hammers is less than for diesel hammers due to the high efficiency of this type of pile hammer. The driving stresses (compressive and tensile) in the piles should not exceed the limits specified by the pile manufacturer.

The pile driving criteria should be confirmed once the type of pile hammer proposed for use on this project is provided. Conventionally, practical refusal has been defined as final penetration resistance sets of 5, 8 and 12 blows per 25 mm (or less) for the 300, 350 and 400 mm diameter pile sizes, respectively. At least three consecutive sets should be obtained for each pile. If followers are used, the final penetration resistance should be increased by 50 percent; that is, 8, 12 and 18 blows per 25 mm for 300, 350 and 400 mm diameter pile sizes, respectively.

Pile spacing for these piles should not be less than 2.5 pile diameters, centre to centre. No reduction in individual pile capacity is necessary for reasons related to group action provided that pile heave is monitored, measures are undertaken to minimize pile heave (i.e. preboring) and redriving is completed when pile heave greater than 6 mm is measured. Redriving of all piles in groups or clusters should be specified along with the requirement to monitor for pile heave.

Construction practice in Winnipeg normally includes preboring at driven PPCH pile locations. The prebore holes are usually drilled to diameters that are 50 mm larger than the pile size and to depths of about 3 m. Preboring is effective in reducing pile heave and contributes positively to pile verticality.

The depth to practical refusal will likely vary across the site and may be deeper than interpreted from the test hole logs. Some piles may be driven out of alignment and/or damaged during driving if boulders are present in the glacial till.

6.1.3 Foundation Inspection and Dynamic Testing

Based on Sub-Sections 4.2.2.3 Field Review and 4.2.2.4 Altered Subsurface Condition (ref: NBC 2010 Section 4.2 Foundations) and as the Geotechnical Engineers of record for this project we recommend that the deep foundations be inspected on a full time basis by geotechnical personnel from our firm who are familiar with the subsurface conditions at this site, the foundation design considerations and the installation of major foundations.

If driven end bearing PPCH piles are to be installed, the dynamic testing and CAPWAP analysis should be performed by DRI.

6.2 Pile Caps and Grade Beams

A void separation of at least 150 mm should be provided under grade beams and pile caps.

6.3 Floor Slabs

It is understood that the building will have work shop, storage and office space. In areas where there is minimal tolerance for floor slab movement, such as in office space areas, it is recommended that structural floor slabs over a void space be considered as a preferred option due to the presence of fill materials and high plastic (i.e. expansive) clay soils at the site. Structural floor slabs will minimize the potential for movement of the floor slab due to heave or swelling of the underlying clay soils. It is possible that the total amount of heave and swelling could be as much as 100 to 150 mm in the long term. A void separation between the structural floor slab and underlying soil should be at least 150 mm thick. A vapour barrier should be provided below the floor slab.

Where a slab on grade floor is to be considered it must recognized that the floor slab will undergo some movements overtime due to volumetric changes of the underlying clay soils. Vertical movements on the order of 25 to 50 mm should be expected and in the longer term could reasonably be on the order of 100 to 150 mm. The movements will be differential in nature and are not expected to be uniform across the floor slab. A major factor impacting the magnitude of floor slab movements, which should be expected, are the climatic effects during construction which might impact changes in the sub-soil moisture conditions. For these reasons, it is not possible to assess the amount of soil movement which will occur with any degree of accuracy.

If used, slab-on-grade floors could be isolated from fixed building components (e.g. grade beams) in an effort to allow for some floor slab movements to occur without affecting the structure. A vapour barrier should be provided below the floor slab. The floor slab should not be placed against frozen soil and should be supported on at least 300 mm of compacted granular base material placed on a prepared subgrade consisting of compacted clay soil. The floor slab can be designed using modulus of subgrade reaction of 54 MPa/m for the granular base material and 20 MPa/m for the compacted clay subgrade material. Additional thickness (i.e. more than 300 mm) of granular base may be required to meet the floor slab design requirements.

The granular base should consist of a minimum 100 mm thick top layer of 19 mm down crushed limestone material compacted to 98 percent of the Standard Proctor Maximum Dry Density (SPMDD). A coarser crushed limestone material (e.g. 50 mm down gradation) compacted to 98 percent SPMDD could be utilized for the balance of the granular base. The minimum thickness of the coarser granular base material should not be less than 3 times the maximum particle size (diameter) to allow for sufficient interlocking of the aggregate.

Topsoil, fill, and other deleterious materials should be stripped from the subgrade area before subgrade preparation begins. During construction, the subgrade soils should not be permitted to dry excessively, which could be done by periodic watering. In addition, water should not be allowed to pond on the subgrade soils. The subgrade should be graded smooth, scarified to a depth of approximately 150 mm below grade and then uniformly re-compacted to 95 percent of the SPMDD. The compacted subgrade should be proof rolled in a grid pattern with a fully loaded tandem gravel truck to check for and delineate the extent of weak / soft areas.

Areas identified as being weak or soft during subgrade preparation and/or proof rolling should be stabilized by additional re-working and compaction or removal and replacement with suitable material. If encountered, silt can be over excavated and replaced with suitable material (i.e. compacted clay or granular sub-base) or bridged with additional granular base and non-woven geotextile to provide separation and some reinforcement. The amount of additional granular base should be determined at the time of construction to suit the conditions encountered. The geotextile should meet the requirements of the City of Winnipeg's Standard Construction Specifications, CW 3130 for the Supply and Installation of Geotextile Fabrics.

6.4 Below Grade Walls

The earth pressure acting on below grade walls can be checked on the basis of the following conventional relationship which produces a triangular pressure distribution:

$$P = K \gamma D$$

Where:
P = lateral earth pressure at depth D (kPa)
K = earth pressure coefficient (0.5)
γ = backfill unit weight 17.3 (kN/m^3)
D = depth from surface to point of pressure calculation (m)

The backfill material can be a clean, well graded pit run sand and gravel with a maximum particle size of 50 mm. Other material types and gradations can be considered and reviewed. The material should be compacted to 92 percent of the standard Proctor maximum dry density. The base of the wall should be provided with a filter-protected positive drainage system to prevent the build-up of hydrostatic pressure against the wall. A 600 mm thick clay cap could be provided around exterior walls to reduce the potential for water infiltration into the granular backfill. The clay cap material can be compacted to 92 percent of the standard Proctor maximum dry density.

6.5 Pavements

Some vertical movements of the pavements are unavoidable and should be expected. Regular maintenance of the pavement surfaces will help to provide longer life and serviceability of the surfaces. The thick sand fill encountered in Test Holes 1 and 3 may need special consideration at the time of construction if the material cannot be properly compacted to be used as the subgrade.

The following pavement sections can be placed on a prepared subgrade consisting of high plastic silty clay soils. A non-woven geotextile should be placed on the prepared subgrade to provide separation between the clay subgrade and granular materials.

- Standard duty asphalt pavements can be designed using 50 mm of asphalt placed on 300 mm of granular base material or 100 mm of granular base and 200 mm of granular sub-base.

- Heavy duty asphalt pavements can be designed using 75 mm of asphalt placed on 150 mm of granular base material and 300 mm of granular sub-base material.

- For heavy duty traffic areas, such as refuse pick up areas, the pavement section should consist of 150 to 200 mm of reinforced concrete over 150 mm of granular base course and 200 mm of granular sub-base material. The reinforcing should be designed based on the anticipated loads.

The material selection and construction requirements should meet the City of Winnipeg's Standard Construction Specifications. The granular base should be a 19 mm down crushed limestone material and the granular sub-base material should be a 50 mm down crushed limestone that is placed over a uniformly prepared subgrade. Where significantly more than 300 mm of sub-base material is required to achieve the design grades, a 100 mm or 150 mm down crushed limestone can be considered to build up the sub-base to the underside of the sub-base material recommended above. The geotextile should meet the requirements of the City of Winnipeg's Standard Construction Specifications, CW 3130 for the Supply and Installation of Geotextile Fabrics.

Fill, topsoil and deleterious materials should be stripped from the sub-grade surface prior to preparation. The clay sub-grade should be graded smooth, scarified to a depth of approximately 150 mm and then uniformly re-compacted to 95 percent of the Standard Proctor Maximum Dry Density (SPMDD) before the granular sub-base material is placed. The subgrade should be proof rolled in a grid pattern with a fully loaded tandem gravel truck to check for weak / soft areas.

Areas identified as being weak or soft during subgrade preparation and/or proof rolling should be stabilized by additional re-working and compaction or removal and replacement with suitable material. If encountered, silt can be over excavated and replaced with suitable material (i.e. compacted clay or granular sub-base) or bridged with additional granular base and non-woven geotextile and geogrid to provide separation and reinforcement. The amount of additional granular base should be determined at the time of construction to suit the conditions encountered. The geotextile should meet the requirements of the City of Winnipeg's Standard Construction Specifications, CW 3130 for the Supply and Installation of Geotextile Fabrics. The geogrid should meet the requirements of the City of Winnipeg's Standard Construction Specifications, CW 3135 for the Supply and Installation of Geogrid.

6.6 Excavations

All excavation work should be completed by the Contractor in accordance with the current Manitoba Workplace Health and Safety Regulations to suit the planned and expected construction activities and schedule.

6.7 Demolition and Backfilling

We understand that the existing buildings will be demolished in order to construct the new building. The details of the existing buildings (e.g. foundation type, presence of crawl spaces or basements) were not provided. In general, it is recommended that all shallow foundations be removed during demolition along with below grade walls and floor slabs. If pile foundations are encountered, they should be cut off 1.5 m below site grade and all of the pile locations surveyed so the locations can be reviewed against the proposed pile foundation locations.

Excavations resulting from the demolition work should be backfilled with compacted clay. The side slopes of the excavation should be cut back to an angle no steeper than 2H:1V and the clay compacted in lifts not exceeding 150 mm in thickness. The clay should be compacted to 95 percent of the Standard Proctor maximum dry density at a moisture content that is at the optimum moisture content or up to 2 percent above optimum.

6.8 Other

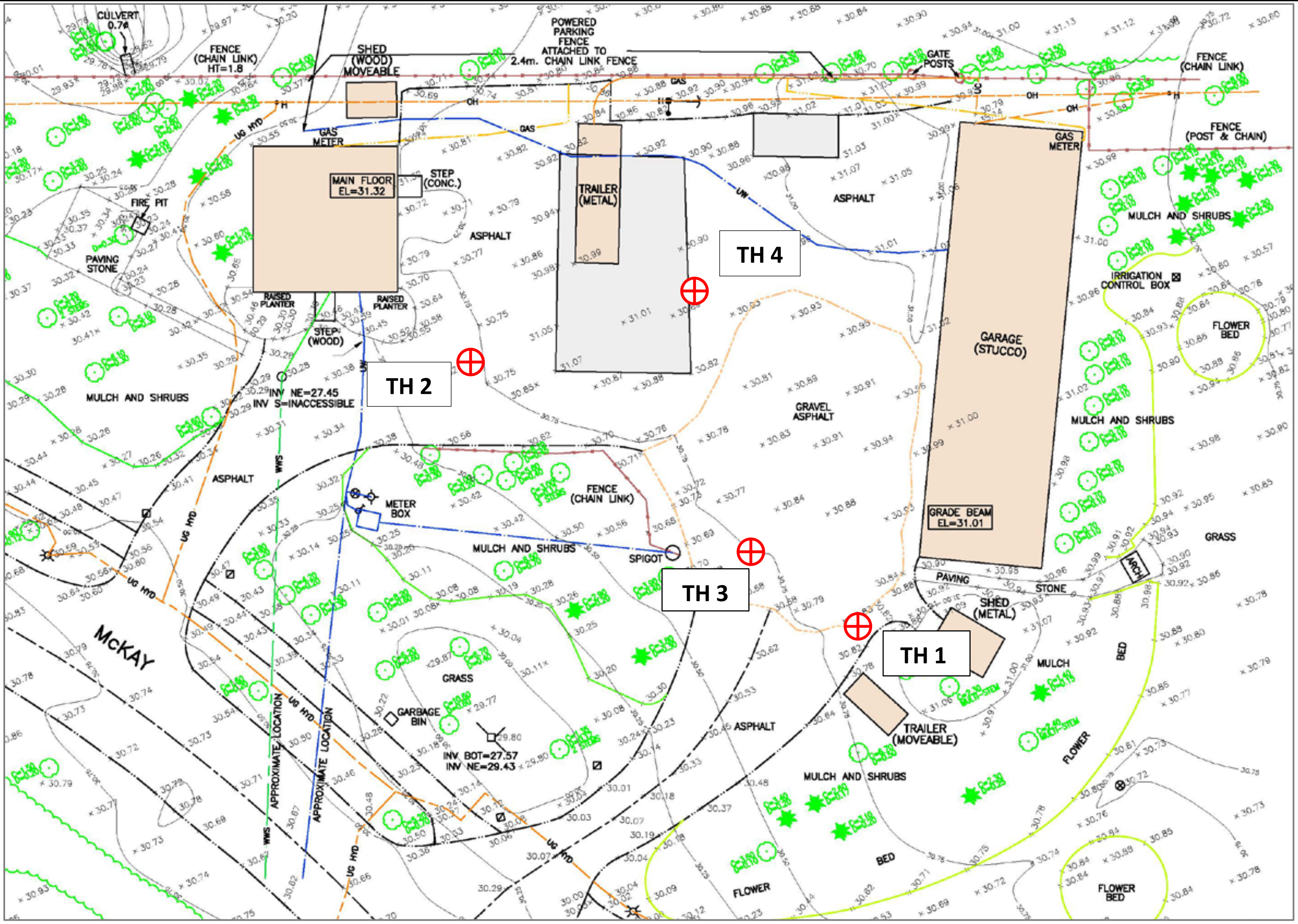
Positive drainage should be provided away from the structures at gradients of at least 2 percent. Flow from downspouts and rain leaders should be directed on to splash pads that will direct runoff away from the perimeter of the building.

The potential for sulphate attack is considered to be severe (Exposure Class S-2). All concrete in contact with soil should be made with sulphate resistance cement (Type HS) in accordance with the Building Code and relevant CSA standards.

7.0 CLOSURE

This report and its findings were prepared based on the subsurface conditions encountered in the random representative sample of test holes drilled on December 6th, 2016 for the sole purpose of this geotechnical investigation and our understanding of the proposed development at the time of this report. Subsurface conditions are inherently variable and should be expected to vary across the site.

This report was prepared for the sole and exclusive use of the City of Winnipeg for the Kildonan Park Maintenance Building project located at 2015 Main Street in Winnipeg, MB. The information and recommendations contained in this report are for the benefit of the City of Winnipeg only and no other party or entity shall have any claim against the author nor may this report be used for any other projects, including but not limited to changes in this proposed development without the consent of the author. The findings and recommendations in this report have been prepared in accordance with generally accepted geotechnical engineering principles and practises. No other warranty, expressed or implied, is provided.



Test Hole (TH) Location

Image cropped from
Phillips & Stevens Topographic Survey
Plan dated August 10, 2016

DYREGROV ROBINSON INC.
CONSULTING GEOTECHNICAL ENGINEERS

Kildonan Park Maintenance Yard
Test Hole Location Plan

SCALE:	MADE BY:	CHKD BY:	PROJECT NO.	DATE:	
NTS	CR	GR	163998	December 2016	**FIGURE 1**

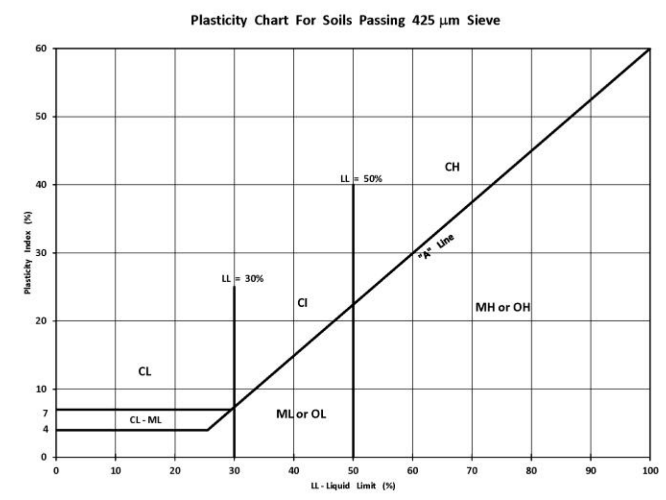
APPENDIX A

Test Hole Logs

EXPLANATION OF TERMS & SYMBOLS

Description				TH Log Symbols	USCS Classification	Laboratory Classification Criteria: Fines (%)	Grading	Plasticity	Notes
COARSE GRAINED SOILS	GRAVELS (More than 50% of coarse fraction of gravel size)	CLEAN GRAVELS (Little or no fines)	Well graded gravels, sandy gravels, with little or no fines		GW	0-5	$C_U > 4$ $1 < C_C < 3$		Dual symbols if 5-12% fines. Dual symbols if above “A” line and $4<W_P<7$ $C_U = \frac{D_{60}}{D_{10}}$ $C_C = \frac{(D_{30})^2}{D_{10} x D_{60}}$
			Poorly graded gravels, sandy gravels, with little or no fines		GP	0-5	Not satisfying GW requirements		
		DIRTY GRAVELS (With some fines)	Silty gravels, silty sandy gravels		GM	> 12		Atterberg limits below “A” line or $W_P<4$	
			Clayey gravels, clayey sandy gravels		GC	> 12		Atterberg limits above “A” line or $W_P<7$	
	SANDS (More than 50% of coarse fraction of sand size)	CLEAN SANDS (Little or no fines)	Well graded sands, gravelly sands, with little or no fines		SW	0-5	$C_U > 6$ $1 < C_C < 3$		
			Poorly graded sands, gravelly sands, with little or no fines		SP	0-5	Not satisfying SW requirements		
		DIRTY SANDS (With some fines)	Silty sands, sand-silt mixtures		SM	> 12		Atterberg limits below “A” line or $W_P<4$	
			Clayey sands, sand-clay mixtures		SC	> 12		Atterberg limits above “A” line or $W_P<7$	
FINE GRAINED SOILS	SILTS (Below ‘A’ line negligible organic content)	$W_L<50$	Inorganic silts, silty or clayey fine sands, with slight plasticity		ML			Classification is Based upon Plasticity Chart	
		$W_L>50$	Inorganic silts of high plasticity		MH				
	CLAYS (Above ‘A’ line negligible organic content)	$W_L<30$	Inorganic clays, silty clays, sandy clays of low plasticity, lean clays		CL				
		$30<W_L<50$	Inorganic clays and silty clays of medium plasticity		CI				
		$W_L>50$	Inorganic clays of high plasticity, fat clays		CH				
	ORGANIC SILTS & CLAYS (Below ‘A’ line)	$W_L<50$	Organic silts and organic silty clays of low plasticity		OL				
		$W_L>50$	Organic clays of high plasticity		OH				
HIGHLY ORGANIC SOILS			Peat and other highly organic soils		Pt	Von Post Classification Limit		Strong colour or odour, and often fibrous texture	

	Asphalt		Glacial Till		Bedrock (Igneous)	
	Concrete		Clay Shale		Bedrock (Limestone)	DYREGROV ROBINSON INC. CONSULTING GEOTECHNICAL ENGINEERS
	Fill				Bedrock (Undifferentiated)	



FRACTION		**PARTICLE SIZE** (mm) Min.	Max.
Boulders		>300	
Cobbles		75	300
Gravel	Coarse	19	75
	Fine	4.75	19
Sand	Coarse	2.0	4.75
	Medium	0.425	2.0
	Fine	0.075	0.425
Silt (non-plastic) or Clay (plastic)		< 0.075 mm	

RELATIVE PROPORTIONS (by weight)	
Percent	Descriptor
>35%	main fraction
35 - 50	"and"
20 – 35	Adjective e.g. silty, clayey
10 – 20	"some"
1 - 10	"trace"

Soil Classification Example

Clay 50% (main fraction), Silt 25%, Sand 17%, Gravel 8%

Clay – silty, some sand, trace gravel

TERMS and SYMBOLS

Laboratory and field tests are identified as follows:

Unconfined Comp.: undrained shear strength (kPa or psf) derived from unconfined compression testing.

Torvane: undrained shear strength (kPa or psf) measured using a Torvane

Pocket Pen.: undrained shear strength (kPa or psf) measured using a pocket penetrometer.

Unit Weight bulk unit weight of soil or rock (kN/m^3 or pcf).

SPT – N Standard Penetration Test: The number of blows (N) required to drive a 51 mm O.D. split barrel sampler 300 mm into the soil using a 63.5 kg hammer with a free fall drop height of 760 mm.

DCPT Dynamic Cone Penetration Test. The number of blows (N) required to drive a 50 mm diameter cone 300 mm into the soil using a 63.5 kg hammer with a free fall drop height of 760 mm.

M/C insitu soil moisture content in percent

PL Plastic limit, moisture content in percent

LL Liquid limit, moisture content in percent

The undrained shear strength (Su) of cohesive soil is related to its consistency as follows:

Su (kPa)	Su (psf)	CONSISTENCY
<12	250	very soft
12 – 25	250 – 525	soft
25 – 50	525 – 1050	firm
50 – 100	1050 – 2100	stiff
100 – 200	2100 – 4200	very stiff
200	4200	hard

The SPT - N of non-cohesive soil is related to compactness condition as follows:

N – Blows / 300 mm	COMPACTNESS
0 - 4	very loose
4 - 10	loose
10 - 30	compact
30 - 50	dense
50 +	very dense

References:

ASTM D2487 – Classification of Soils For Engineering Purposes (Unified Soil Classification System)

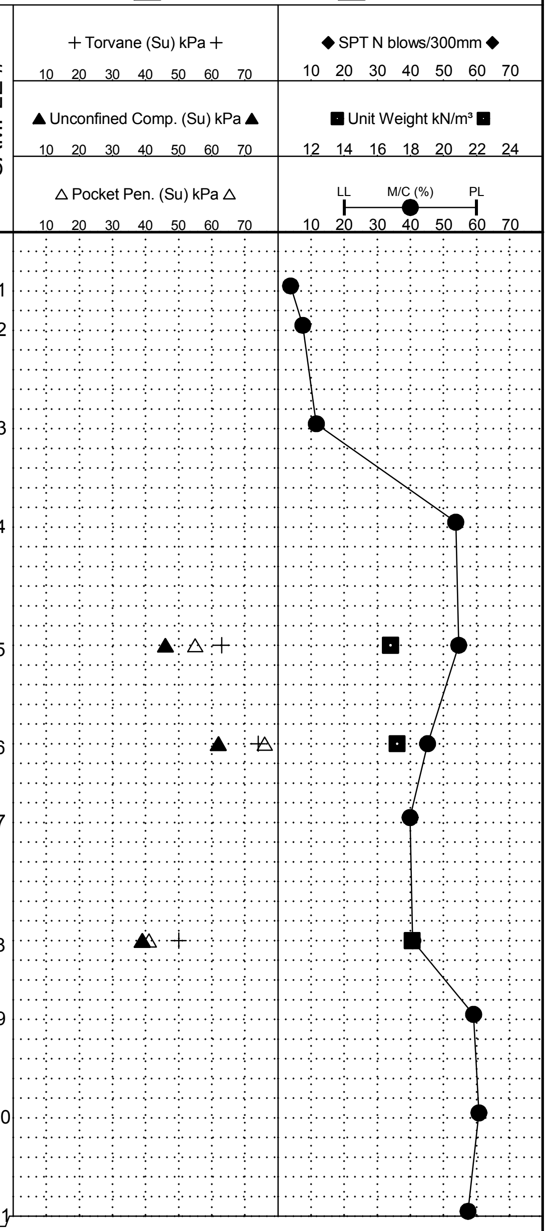
Canadian Foundation Engineering Manual, 4th Edition, Canadian Geotechnical Society, 2006

PROJECT: Kildonan Park Staff House	CLIENT: City of Winnipeg	TEST HOLE NO: **1**
LOCATION: 5 m west and 5 m south from south west corner of garage		PROJECT NO.: 163998
CONTRACTOR: Paddock Drilling Ltd.	METHOD: Acker MP8 Drill - 125mm SS and 200 mm HS augers	ELEVATION (m): 230.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
	0	ASPHALT (50mm thick)		
230	1	GRANULAR BASE - 19mm down crushed limestone - dry	GRAB	G1
229	2	SAND (FILL) - trace gravel - brown, moist - wet below 3 m - fine grained	GRAB	G2
228	3		GRAB	G3
227	4	CLAY - silty - brown - stiff, moist - high plasticity - trace silt inclusions	SPLIT SPOON	S4
225	6	- grey below 6 m	SHELBY TUBE	T5
223	8		SHELBY TUBE	T6
222	9		SPLIT SPOON	S7
220	11		SHELBY TUBE	T8
219	12		SPLIT SPOON	S9
217	14		SPLIT SPOON	S10
216	15		SPLIT SPOON	S11



END OF TEST HOLE AT 15.2 m IN CLAY

NOTES:

1. Sloughing and seepage of sand fill.
2. Switched to hollow stem augers at 3m.
3. Test hole backfilled with auger cuttings and bentonite chips.

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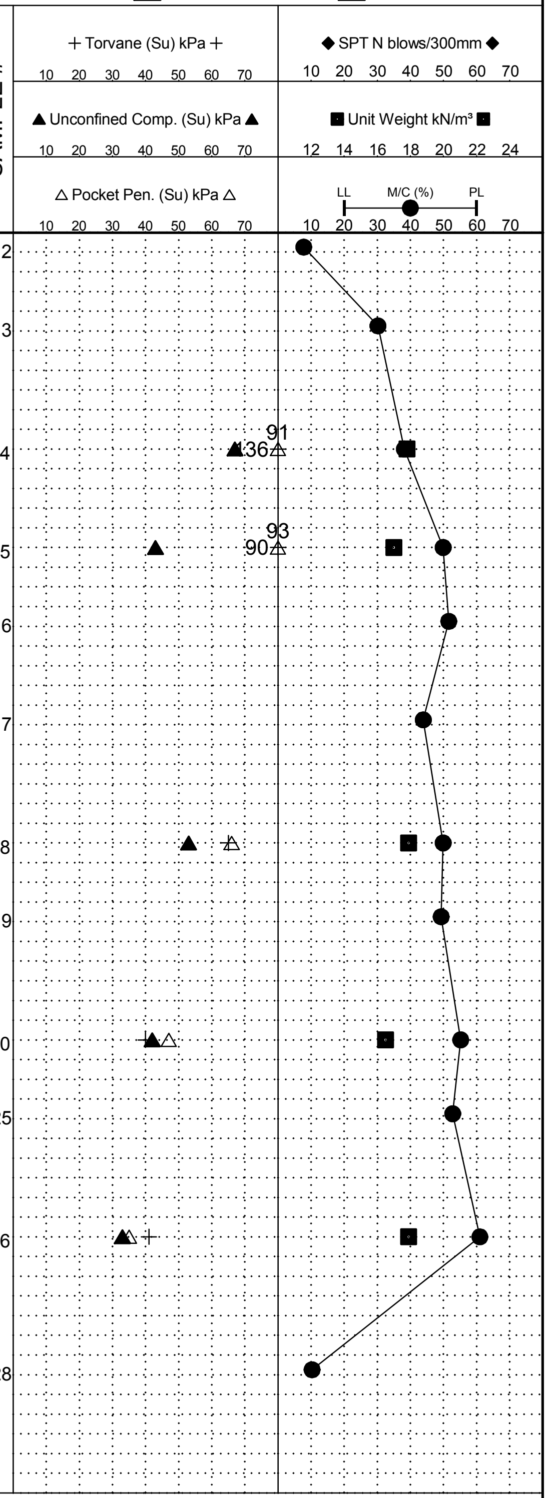
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Kildonan Park Staff House	CLIENT: City of Winnipeg	TEST HOLE NO: **2**
LOCATION: 5 m south and 5 m east from south east corner of smaller building		PROJECT NO.: 163998
CONTRACTOR: Paddock Drilling Ltd.	METHOD: Acker MP8 Drill - 125mm SS augers	ELEVATION (m): 230.7

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

ELEVATION (m)	DEPTH (m)	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
230.7	0	ASPHALT (25mm thick)	GRAB	G12
		SAND (FILL - 300 mm thick) - trace gravel, brown, moist		
		CLAY - silty - mottled brown/grey - stiff, moist - high plasticity - trace silt inclusions	GRAB	G13
			SHELBY TUBE	T14
			SHELBY TUBE	T15
			GRAB	G16
			GRAB	G17
		- grey, firm to stiff below 9 m	SHELBY TUBE	T18
			GRAB	G19
			SHELBY TUBE	T20
			GRAB	G25
		Below 14 m: - firm - trace sand and gravel	SHELBY TUBE	T26
		SILT (TILL) - trace sand, trace gravel - brown, moist, compact	GRAB	G28



END OF TEST HOLE AT 19.5 m IN SILT (TILL) (AUGER REFUSAL)

NOTES:

1. No sloughing or seepage observed.
2. Test hole backfilled with auger cuttings and bentonite chips

BH GEOTECH PLOTS-AUGUST 2013 163998 KILDONAN PARK_TH LOGS.GPJ DATA TEMPLATE - AUGUST 2, 2013.GDT 7/2/17

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REVIEWED BY: GR	COMPLETION DATE: 12/6/16
PROJECT ENGINEER: Gil Robinson	Page 1 of 1

PROJECT: Kildonan Park Staff House	CLIENT: City of Winnipeg	TEST HOLE NO: **3**
LOCATION: 6 m east from water spigot		PROJECT NO.: 163998
CONTRACTOR: Paddock Drilling Ltd.	METHOD: Acker MP8 Drill - 125mm SS augers	ELEVATION (m): 230.7

SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

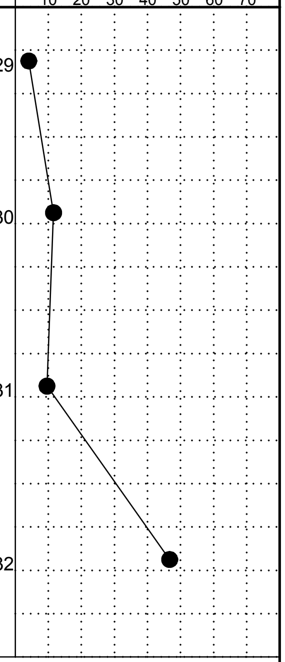
BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

ELEVATION (m)	DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
			ASPHALT (25mm thick)		
			GRANULAR BASE- 19mm down crushed limestone, dry		
230	1		SAND (FILL) - trace gravel - brown, moist becoming wet with depth - fine grained	GRAB	G29
229	2			GRAB	G30
228	3			GRAB	G31
227	4		CLAY - silty - mottled brown/grey - stiff, moist - high plasticity - trace silt inclusions	GRAB	G32

◆ SPT N blows/300mm ◆
10 20 30 40 50 60 70

■ Unit Weight kN/m³ ■
12 14 16 18 20 22 24

LL M/C (%) PL
10 20 30 40 50 60 70



END OF TEST HOLE AT 4.6 m IN CLAY
NOTES:
1. Sloughing and seepage from sand and gravel fill.
2. Test hole backfilled with auger cuttings.

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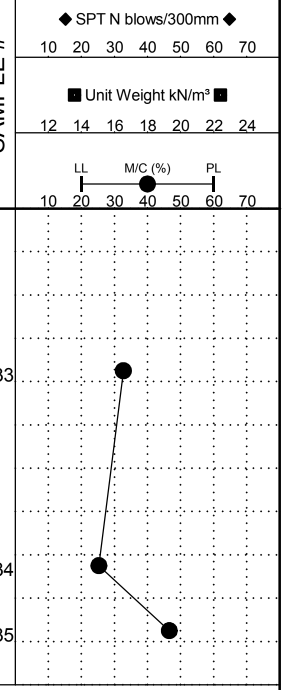
DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 4.57 m
	REVIEWED BY: GR	COMPLETION DATE: 12/6/16
	PROJECT ENGINEER: Gil Robinson	

PROJECT: Kildonan Park Staff House	CLIENT: City of Winnipeg	TEST HOLE NO: **4**
LOCATION: 18 m north and 2m east from water spigot		PROJECT NO.: 163998
CONTRACTOR: Paddock Drilling Ltd.	METHOD: Acker MP8 Drill - 125mm SS augers	ELEVATION (m): 230.9

SAMPLE TYPE	GRAB	SHELBY TUBE	SPLIT SPOON	BULK	NO RECOVERY	CORE
BACKFILL TYPE	BENTONITE	GRAVEL	SLOUGH	GROUT	CUTTINGS	SAND

ELEVATION (m)	DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #
			ASPHALT (25mm thick)		
			CLAY - silty, trace sand & organics - black / dark grey - dry to moist, stiff		
230	1			GRAB	G33
229	2				
			SILT - trace clay, grey, moist to wet, loose - petroleum smell	GRAB	G34
228	3		CLAY - silty - mottled brown/grey, stiff, moist, high plasticity	GRAB	G35



END OF TEST HOLE AT 3.4 m IN CLAY
NOTES:
1. No sloughing or seepage observed.
2. Test hole backfilled with auger cuttings.

DYREGROV ROBINSON INC. Consulting Geotechnical Engineers	LOGGED BY: CR	COMPLETION DEPTH: 3.35 m
	REVIEWED BY: GR	COMPLETION DATE: 12/6/16
	PROJECT ENGINEER: Gil Robinson	Page 1 of 1