McElhanney Consulting Services Ltd.
12-556 North Nechako Rd.
Prince George, BC V2K 1A!
Tel: 250.561.2229.
www.mcelhanney.com

McElhanney **M E M O R A N D U M**

MEMORANDUM	Rock Creek Campground & Day Use Area Grasslands National Park, Saskatchewan Geotechnical Assessment
Report Date:	**Revised June 28, 2016**
McElhanney No.	**2711-16012-00**

To: **Kelly Wilkinson**
Project Manager
kwilkinson@mcelhanney.com

Nathan Grimson
ngrimson@mcelhanney.com

1.0 INTRODUCTION

This memorandum presents a summary of the subsurface conditions observed during field drilling program and geotechnical recommendations for the Grasslands National Park, Rock Creek Campground and Day Use Area project being completed by McElhanney for Public Works and Government Services (PWGSC) and Parks Canada Agency (PCA).

The Rock Creek Campground is located adjacent to the Rock Creek Day Use Area and Visitor Centre, which is to be located at the north end of the proposed Badlands Scenic Road. Based on conceptual design information, the proposed campground upgrade consists of several campsites including walk-in sites, back-in and pull through recreation vehicle parking sites, equestrian camping sites, and a washroom building. The campground will also consist of utility servicing, water and sanitary and electrical for all proposed vehicle accessed sites, and electrical hook-ups for all sites (including walk-in). The geotechnical field assessment for the campground was completed in conjunction with the drilling assessment for the Badlands Scenic Road, which has been reported under a separate documents.

The geotechnical assessment for the Rock Creek Campground was completed to support civil engineering services for the design and construction of the Rock Creek Campground in Grasslands National Park in Saskatchewan. The geotechnical assessment was completed to assess the subsurface conditions for the campground sites and access road design, and geotechnical design parameters for the campground washroom facility.

In conducting the geotechnical assessment for the project, McElhanney has:

- Completed a drilling assessment, which included five (5) boreholes throughout the campground generally along the access roads;
- Completed two sets of percolation tests to assess field saturated hydraulic conductivities;
- Completed geotechnical laboratory testing on representative samples;
- Prepared this memorandum providing a summary of the subsurface conditions encountered and geotechnical recommendations for:

- Campground road preparation;
- Foundation recommendations, including bearing capacities and field-saturated soil hydraulic conductivity parameters for the washroom facility.

2.0 FIELD ASSESSMENT AND LABORATORY TESTING

McElhanney completed a field drilling assessment for the campground in conjunction with the Badlands Scenic Road project. The intent of the field program was to characterize the existing subsurface conditions and soil draining properties. The drilling assessment was carried out on January 22, 2016 and consisted of five boreholes (BH16-31 through BH16-35). The boreholes were drilled using a track-mounted drill rig and solid stem auger methods and ranged in depth from 2.0 to 3.5 meters below ground surface (mbgs).

Two additional boreholes (PT16-01 and PT16-02) were drilled to assist in the estimation of field-saturated soil hydraulic conductivity measured from two sets of field percolation testing in the location/vicinity of the campground washroom facility. Two percolation holes were drilled to an approximate depth of 0.5 m and water was deployed from a set reservoir and the rate of infiltration in the soil was estimated based on the rate of depletion in the reservoir (difference in reservoir level versus time).

McElhanney supervised the drilling, logged and sampled the boreholes (BH16-31 through BH16-35). Soil conditions in the percolation boreholes (PT16-01 and PT16-02) where observed and sampled; however, no borehole logs where completed. The subsurface soils were sampled primarily from auger flights or Standard Penetration Tests (SPT). A summary of the subsurface conditions encountered are provided on the borehole summary logs included in Appendix A. Following completion of the boreholes, the holes were backfilled with cuttings to ground surface.

Soil samples were transported to McElhanney's laboratory in Prince George, BC where selected samples were submitted for index testing including moisture content, gradation sieve analysis, hydrometer grain size analysis and Atterberg Limits. The laboratory results are included on the borehole logs (Appendix A) and detailed results are included in Appendix B. The soils encountered were classified in accordance with the Modified Unified Classification System for soils included in Appendix A.

3.0 FIELD ASSESSMENT OBSERVATIONS

3.1 GEOLOGIC SETTING

McElhanney had previously completed a preliminary geology review and site review for the proposed road and campground projects, results of which were included on the detailed conceptual design report for the project provided to PCA dated January 6, 2016.

Based on review of available surficial geology mapping form the Saskatchewan Water Security Agency and Saskatchewan Research Council for the Grasslands National Park East Block the proposed road alignment and campground is located in the vicinity of two main types of surficial materials as summarized in Table 3-1.

Table 3-1: Surficial Geology

Type	Description	Topography
Glacial Drift	Till and stratified deposits. Till consists of unsorted mixture of clay, silt, sand and gravel, and boulders, deposited by ice. Stratified drift consists of sand, gravel, silt and clay deposited by water	Flat to undulating
Bedrock	Frenchman-Eastend formations: the Eastend Formation is composed of greyish and greenish sand, silt and clay, with thin coal seams in the upper part. The Frenchman Formation is composed of sand and clays.	Hummocky to near vertical slopes

The topography along the proposed alignment ranges from flat to gently undulating plain. The surficial soils in exposed areas appeared to consist predominantly of silty clay to silt.

The soils at the site are considered highly erodible, which was visible particularly where vegetative cover was not present and silty clay and silt was visible. Slopes to the valley below the proposed trail did show some signs of surficial instability; likely due to saturation of the fine grained soils from surface runoff resulting in erosional type failures.

3.2 SUBSURFACE OBSERVATIONS

In general, the soils encountered during field drilling program were fine-grained deposits consisting of sand and clay, silty clay , sandstone, mudstone or clay shale. The specific units are detailed below.

- **SAND and CLAY:** Sand and Clay with trace gravel was encountered in two of the boreholes, from surface to 2.7 mbgs overlaying sandstone bedrock in BH16-31 and from 0.3 mbgs to termination of the boreholes at 3.0 mbgs in BH16-34.

- **SANDSTONE:** A generally weathered, very weak unit of Sandstone Bedrock was identified in three of the boreholes at variable depths, overlaid by the Sand and Clay unit at 2.1 mbgs in BH16-31, from surface to 2.1 mbgs in BH16-32, and from 0.6 to as much as 3.5 mbgs in BH16-33.

- **SILTY CLAY:** Silty Clay was encountered near surface in three of the boreholes (BH16-33, BH16-34 and BH16-35) from surface to 0.6 mbgs. The clay was silty with trace sand, low plastic, moist and brown in colour with trace oxidation staining in BH16-33.

- **CLAY SHALE:** Clay shale was identified in one borehole (BH16-32) between 2.1 and 3.5 mbgs, which appeared to be slightly weathered, very weak and dark grey in colour.

- **MUDSTONE:** A mudstone deposit was identified in one borehole (BH16-35) between 0.3 and 2.0 mbgs. The mudstone was observed to include some silt, trace coal and iron content, and was very weak, moist and brown in colour.

A summary of the sieve analyses and Atterberg Limits testing completed on representative samples is included in Tables 3.2 and 3.3. Note the Atterberg limits testing was completed only on the portion of material finer than 425 µm particle size in the sand sample.

Table 3-2: Grain Size Analysis

Borehole	Sample Depth (m)	Group Symbol	Gradation (%)		
			Gravel	Sand	Fines (Silt and/or Clay)
BH16-31	1.5	SC	0.9	61.0	38.1

Table 3-2: Atterberg Limits Testing

Bore Hole Number	Sample Depth (m)	Atterberg Limits		Moisture Content (%)	Soil Classification
		Liquid Limit (%)	Plastic Limit (%)		
BH16-34	1.5	48.2	19.7	12.1	CI

Groundwater was not encountered within the depths of termination (up to 5.0 mbgs) of the boreholes at the time of the field assessment. It should be noted that the drilling assessment was completed in the winter months, which is likely a season with low groundwater levels. Groundwater levels could during fluctuate due to seasonal variations such as after periods of heavy rainfall or snow melt.

3.3 SUBSURFACE OBSERVATIONS AT THE PROPOSED WASHROOM FACILITY

In general, the soil conditions encountered in the two percolation test holes (PT16-01 and PT16-02) consisted of silty clayey fine-grained sands with trace to no gravel.

A summary of Atterberg Limits and Hydrometer Grain Size Analysis testing is summarized below on Tables 3.4 and 3.5, respectively.

Table 3-4: Atterberg Limits Testing

Bore Hole Number	Sample Depth (m)	Atterberg Limits		Moisture Content (%)	Soil Classification
		Liquid Limit (%)	Plastic Limit (%)		
PT16-01	0.6 - 1.0	28.9	19.8	11.5	CL
PT16-02	0.6 - 1.0	28.0	21.1	10.9	CL-ML

Table 3-5: Grain Size Analysis

Borehole	Sample Depth (m)	Group Symbol	Gradation (%)			
			Gravel	Sand	Silt	Clay
PT16-01	0.6 - 1.0	SC	1.0	39.5	25.3	34.2
PT16-02	0.6 - 1.0	SC	0.0	53.2	22.3	24.5

4.0 GEOTECHNICAL CONSIDERATIONS AND RECOMMENDATIONS

4.1 ACCESS ROAD

It is understood that the access roads for the campground will be constructed of gravel surfacing above existing ground surface after subgrade preparation. Based on the borehole information obtained, the subgrade soils appear to consist of predominantly low to intermediate plastic fine grained soils consisting of sand and clay and/or silty clay.

The following sections provide geotechnical comments and recommendations as input to the access road design for the project. It is important to understand that the recommendations provided in this report should be read in conjunction, unless otherwise noted, with the Saskatchewan Ministry of Highways and Infrastructure (MoHI) Standard Specifications Manual, and with the final detailed geometric design drawings by McElhanney.

Subgrade Preparation

The following recommendations for subgrade preparation for the access roads are provided:

1. In the footprint of the proposed road structures stripping of organic soils and sub-excavation of loose/soft, weathered subgrade soils will be required. Any existing loose/soft, wet, weathered soils at or immediately below subgrade elevations should be removed to compact and/or stiff subgrade conditions.

2. All stripped and/or sub excavated foundation subgrades should be reviewed in the field by a geotechnical engineer or their representative, to confirm that loose/soft, wet, weakened and organic soils have been appropriately removed prior to road construction.

3. Subject to field review at the time of construction, any completed sub-excavated areas should be backfilled with fill to be approved by the geotechnical engineer. The fill material may be compacted in to a minimum of 98% Standard Proctor Maximum Dry Density (SPMDD), unless identified differently in subsequent sections of this report.

4. The upper 300 mm beneath the road structure should be stratified and compacted to 100% SPMDD.

5. The finished subgrade should be crowned or sloped at a minimum 2% cross fall to promote drainage.

Road Structure

The following road structure is provided for a seasonal (June to October), gravel surfaced road. If the road is to be paved and utilized during spring thaw the geotechnical engineer should be consulted to adjust the structure accordingly.

Table 4-1 Recommended Road Structure

Structure Layer	Minimum Thickness	Geosynthetics Specification
Road Structure - Unstabilized		
Granular Base Course	300 mm	N/A
Road Structure - Stabilized		
Granular Base Course	200 mm	Geogrid Tensar Tri-Axial 160 or approved equivalent

It is understood that seasonal maintenance of the gravel surface is anticipated to take place, i.e. surface re-grading and repair of soft areas. Precautions should be taken while surface re-grading work is being conducted in order to keep the geogrid structure underneath 200 mm thick gravel layer intact. If the geogrid is found exposed or damaged, immediate repair is recommended.

Granular Base Course should meet MoHI specifications as summarized in Table 4-2, or an approved equivalent.

Table 4-2 Recommended Gradation Granular Base Course

Sieve Designation (mm)	Granular Base Course	
	Type 31 (31.5 mm Minus)	Type 33 (18.0 mm Minus)
31.5	100	-
18.0	75-90	100
12.5	65-83	75-100
5.0	40-69	50-75
2.0	26-47	32-52
0.9	17-32	20-35
0.4	12-22	15-25
0.16	7-14	8-15
0.071	6-11	6-11

Base course shall be placed not to exceed a compacted lift thickness of 150 mm and within 3% of the optimum moisture conditions as determined by the optimum moisture-soil density relationship (ASTM D698) and compacted to at a minimum 100% SPMDD.

Frequency and locations of testing shall be under the direction of the Engineer. All fill placement and compaction operations should be observed by the geotechnical engineer or their representative and confirm to the Standard Specifications for Highway Construction.

A medium grade non-woven geotextile (Nilex 4551 or approved equivalent) should be installed if fine grained subgrade soils are encountered to provide separation from the granular base course.

The non-woven geotextile should meet the following specifications:

- Grab Tensile Strength (N)(1) >710
- Mullen Burst Strength (kPa)(2) >2100
- Puncture Strength (N)(3) >420
- Equivalent Opening Size (µm)(4) 120<EOS<220

Notes:
1. ASTM D-4632*
2. ASTM D-3786*
3. ASTM D-4833*
4. ASTM D-4751

* Based on Minimum Average Roll Values (ASTM C-4759)

Given the fine grained subgrade conditions encountered during the drilling assessment the road structure will have reduced drainage potential; however, based on the road being gravel surfaced with seasonal use (restricted use during spring thaw) drainage of the road structure may not be critical. Annual maintenance of the gravel surface will likely be required (i.e. surface grading, repair of soft areas as required).

4.2 CAMPGROUND WASHROOM FACIILTY

Foundation Recommendations

Shallow foundations are considered suitable to support the proposed washroom facility. These foundations may consist of either pad with spread footings or an expanded edge slab-on-grade. The bearing surfaces from these foundations must be constructed to bear on engineered fill or undisturbed, non-frozen, native sand and silt or silty clay soils. These shallow foundation bases if constructed on compact and/or stiff native soils should be designed for a maximum factored soil bearing resistance of 150 kPa.

The bearing resistance was calculated assuming that the loads will be vertical and concentric and that the footing will be situated on a level subgrade which is not in proximity to a slope. If the structural loads are to be inclined, or result in eccentric loading, then the bearing resistances will be lower than those presented in this section and should be checked by the geotechnical engineer using the actual design loads, eccentricities and inclinations.

The following additional recommendations are provided for all shallow foundations:

1. Footings should be founded within naturally deposited, undisturbed soil at a minimum depth of 1.5 m below finished grade to provide protection against frost action. Alternately, the footings could be based at a higher elevation (minimum depth of 1 m below finished grade) if protected against frost action with strategically located, rigid polystyrene insulation. In this case, a continuous layer of rigid polystyrene insulation (100 mm thickness, minimum) should be placed over the exterior face of the foundation, extending vertically a minimum distance of 300 mm above grade and laterally a minimum distance of 1.8 m away from the foundation. The insulation should be covered with a minimum of 300 mm of soil cover (low permeability material) to provide protection against damage, and should be positively sloped away from the foundation.

2. All stripped and/or sub excavated foundation subgrades should be reviewed in the field by a geotechnical engineer or their representative, to confirm that loose/soft, wet, weakened and organic soils have been appropriately removed prior to the construction of foundation structure.

3. Subject to field review at the time of construction, any completed sub-excavated areas should be backfilled with fill to be approved by the geotechnical engineer. The fill material should be compacted in to a minimum of 100% Standard Proctor Maximum Dry Density (SPMDD), unless identified differently in subsequent sections of this report.

4. The foundation soils may experience loss of bearing strength upon exposure to moisture. Seepage or surface runoff should not be allowed to enter the excavations. Any water or snow that collects I foundation excavations must be removed and the excavated surface must be dried prior to construction of foundation structure.

5. The finished grade must be landscaped to provide for positive site drainage away from the foundation.

Field-Saturated Soil Hydraulic Conductivity (K_{fs})

Based on the field percolation test results and laboratory test results, the field-satruated soil hydraulic conductivity, K_{fs} is estimated as follows for the design of the proposed sewage disposal system.

Soil Description	Field-Saturated Soil Hydraulic Conductivity, K_{fs}		
Clayey Sand	Upper Limit	73 mm/day	8E -7 m/sec
	Lower Limit	36 mm/day	4E -7 m/sec
	Average	53 mm/day	6E -7 m/sec

It should be note that the field percolation test was performed within the soil layer in the following conditions:

a) Overall moisture conditions of the soil layers at the site show dry; and
b) The soil layer tested was immediate below frost depth at the site.

Actual K_{fs} may vary depending on weather and moisture conditions during service life period; therefore, a conservative approach is recommended when sewage disposal design is conducted

5.0 CLOSURE

This report has been prepared by McElhanney Consulting Services Ltd. for the benefit of Public Works and Government Services Canada and Parks Canada Agency. This report is based on the results of geotechnical drilling assessment and limited laboratory testing completed at the project site as noted. Note that possibly different and/or poorer soil conditions than those described in this report may be encountered between the test locations and in areas not specifically tested. The information and data contained herein represent McElhanney's best professional judgment in light of the knowledge and information available to McElhanney at the time of preparation. Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by the client, its officers and employees.

McElhanney Consulting Services Ltd. denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this document or any of its contents without the express written consent of McElhanney and Parks Canada Agency.

This document was prepared in accordance with generally accepted geotechnical engineering principles and practice. No other warranty, expressed or implied, is made.

Should you have any queries or comments, please do not hesitate to contact the undersigned.

Respectfully submitted,

McElhanney Consulting Services Ltd.

Reviewed By:

Sey Choi, P.Eng (AB, BC)
Geotechnical Engineer
schoi@mcelhanney.com

Shiloh Carlson, P.Eng (AB, BC, SASK)
Division Manager, Geotechnical
scarlson@mcelhanney.com

SGC/SMC

ATTACHMENTS:
Borehole Plan (Drawing 2711-16012-G01)
Borehole Logs (BH16-31 through BH16-35)
Laboratory Test Results

McElhanney

McElhanney Consulting Services Ltd.

Drawn: SMC	PARKS CANADA AGENCY GRASSLANDS NATIONAL PARK, SASK		Client Proiect No: -
Date: MAR 2016	BOREHOLE PLAN ROCK CREEK CAMPGROUND & DAY USE AREA GEOTECHNICAL ASSESSMENT		MCSL Project No: 2711-16012-00
Scale: NTS			Drawing No: 2711-16012-G01 Revision: -

BH16-31

McElhanney Consulting Services Ltd.

CLIENT Parks Canada
PROJECT NAME Campground Geotechnical Assessment
PROJECT NUMBER 2711-16012-0
PROJECT LOCATION Grasslands National Park, Saskatchewan
DATE STARTED 1/22/16 **COMPLETED** 1/22/16
GROUND ELEVATION _____ **HOLE SIZE** 150 mm
DRILLING CONTRACTOR Tundra Drilling
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY S.Choi **CHECKED BY** S.Carlson
AT END OF DRILLING ---
NOTES Coordinates: Zone 12N, 5436472N 388399 E
AFTER DRILLING ---

DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN (Su) (kPa)	Dry Density (kg/m3)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES (%)
0		SAND and CLAY: fine grained, some silt, trace gravel, compact, light brown, dry.										
1		- Sieve Analysis: Gravel = 1%, Sand = 61%, Fines = 38%.	SPT 1	67	5-6-5 (11)			8				
2		SANDSTONE: very weak, weathered, dry, light grey in colour										
3			SPT 2	0	7-10-12 (22)							

No groundwater or seepage encountered at time of completion.
Bottom of borehole at 3.50 meters.

BH16-32

McElhanney Consulting Services Ltd.

CLIENT Parks Canada
PROJECT NAME Campground Geotechnical Assessment
PROJECT NUMBER 2711-16012-0
PROJECT LOCATION Grasslands National Park, Saskatchewan
DATE STARTED 1/22/16 **COMPLETED** 1/22/16
GROUND ELEVATION _____ **HOLE SIZE** 150 mm
DRILLING CONTRACTOR Tundra Drilling
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY S.Choi **CHECKED BY** S.Carlson
AT END OF DRILLING ---
NOTES Coordinates: Zone 12N, 5436545N 388627 E
AFTER DRILLING ---

DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN (Su) (kPa)	Dry Density (kg/m3)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES (%)
		SANDSTONE: silty, compact, fine grained, weathered, very weak, light grey, trace rootlets.										
1		- Dark grey.	SPT 1	67	5-7-10 (17)			23				
2		CLAY SHALE: very weak, some weathered, high plasticity, dry to damp, dark grey in colour										
3			SPT 2	0	5-7-9 (16)							

No groundwater or seepage encountered at time of completion.
Bottom of borehole at 3.50 meters.

BH16-33

McElhanney Consulting Services Ltd.

CLIENT Parks Canada
PROJECT NAME Campground Geotechnical Assessment
PROJECT NUMBER 2711-16012-0
PROJECT LOCATION Grasslands National Park, Saskatchewan
DATE STARTED 1/22/16 **COMPLETED** 1/22/16
GROUND ELEVATION _____ **HOLE SIZE** 150 mm
DRILLING CONTRACTOR Tundra Drilling
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY S.Choi **CHECKED BY** S.Carlson
AT END OF DRILLING ---
NOTES Coordinates: Zone 12N, 5436602N 388738 E
AFTER DRILLING ---

DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN (Su) (kPa)	Dry Density (kg/m3)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES (%)
		CLAY: silty, trace sand and rootlets.										
1		SANDSTONE: trace iron, coal and clay inclusions, very weak, dry, and light grey in colour										
		- Trace coal.	SPT 1	67	5-4-5 (9)			11				
2												
3			SPT 2	0	3-5-8 (13)							

No groundwater or seepage encountered at time of completion.
Bottom of borehole at 3.50 meters.

BH16-34

McElhanney Consulting Services Ltd.

CLIENT Parks Canada
PROJECT NAME Campground Geotechnical Assessment
PROJECT NUMBER 2711-16012-0
PROJECT LOCATION Grasslands National Park, Saskatchewan
DATE STARTED 1/22/16 **COMPLETED** 1/22/16
GROUND ELEVATION **HOLE SIZE** 150 mm
DRILLING CONTRACTOR Tundra Drilling
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY S.Choi **CHECKED BY** S.Carlson
AT END OF DRILLING ---
NOTES Coordinates: Zone 12N, 5436422N 388724 E
AFTER DRILLING ---

DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN (Su) (kPa)	Dry Density (kg/m3)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES (%)
		CLAY: silty, trace rootlets, low plasticity, and brown in colour										
		SAND and CLAY: fine grained, some silt, compact, dry to damp, and brown in colour										
1		- clayey, medium plasticity	SPT 1	67	6-5-6 (11)			12	48	20	28	
2		- loose	SPT 1	0	4-4-5 (9)							
3												

No groundwater or seepage encountered at time of completion.
Bottom of borehole at 3.00 meters.

BH16-35

McElhanney Consulting Services Ltd.

CLIENT Parks Canada
PROJECT NAME Campground Geotechnical Assessment
PROJECT NUMBER 2711-16012-0
PROJECT LOCATION Grasslands National Park, Saskatchewan
DATE STARTED 1/22/16 **COMPLETED** 1/22/16
GROUND ELEVATION _____ **HOLE SIZE** 150 mm
DRILLING CONTRACTOR Tundra Drilling
GROUND WATER LEVELS:
DRILLING METHOD Solid Stem Auger
AT TIME OF DRILLING ---
LOGGED BY S.Choi **CHECKED BY** S.Carlson
AT END OF DRILLING ---
NOTES Coordinates: Zone 12N, 5436337N 388777 E
AFTER DRILLING ---

DEPTH (m)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN (Su) (kPa)	Dry Density (kg/m3)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES (%)
0		CLAY: silty, brown, stiff to hard, low plasticity, damp to moist, and brown in colour										
		MUDSTONE: some silt, trace coal and iron, very weak, damp, and brown in colour										
1			SPT 1	67	8-9-12 (21)			27				
2												

No groundwater or seepage encountered at time of completion.
Bottom of borehole at 2.00 meters.

MODIFIED UNIFIED CLASSIFICATION SYSTEMS FOR SOILS

MAJOR DIVISION			GROUP SYMBOL		TYPICAL SOIL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
COARSE GRAINED SOILS (more than 50% larger than 75 µm)	GRAVELS	Clean Gravels (< 5% Fines)	GW		Well graded gravels, sandy gravels, trace or no fines	$C_u=D_{60}/D_{10}>4$, $C_C=(D_{30})^2/D_{10}D_{60}=1$ to 3
			GP		Poorly graded gravels, sandy gravels, trace or no fines	Not meeting the GW requirements.
		Dirty Gravels (> 12% Fines)	GM		Silty gravels, silty sandy gravels	Plasticity below A-Line or I_P <4
			GC		Clayey gravels, clayey sandy gravels	Plasticity above A-Line or I_P >7
	SANDS	Clean Sands (< 5% Fines)	SW		Well graded sands, gravelly sand, trace or no fines	$C_u=D_{60}/D_{10}>4$, $C_C=(D_{30})^2/D_{10}D_{60}=1$ to 3
			SP		Poorly graded sands, gravelly sand, trace or no fines	Not meeting the SW requirements.
		Dirty Sands (> 12% Fines)	SM		Silty sands, sand and silt mixtures	Plasticity below A-Line or I_P <4
			SC		Clayey sands, sand and clay mixtures	Plasticity above A-Line or I_P >7
FINE GRAINED SOILS (more than 50% smaller than 75 µm)	SILTS	W_L<50%	ML		Inorganic silts, sandy silts with slight plasticity	Classifcations are based upon Plasticity Chart.
		W_L>50%	MH		Inorganic silts of high plasticity	
	CLAYS	W_L<30%	CL		Inorganic clay, silty clays of low plasticity	
		30%<W_L<50%	CI		Inorganic clay, silty clays of intermediate plasticity	
		W_L>50%	CH		Inorganic clay, silty clays of high plasticity	
	ORGANIC SILTS AND CLAYS	W_L<50%	OL		Organic silts and silty clays of low plasticity	
		W_L>50%	OH		Organic silts and silty clays of high plasticity	
	HIGHLY ORGANIC		PT		Peat and other highly organic soils	

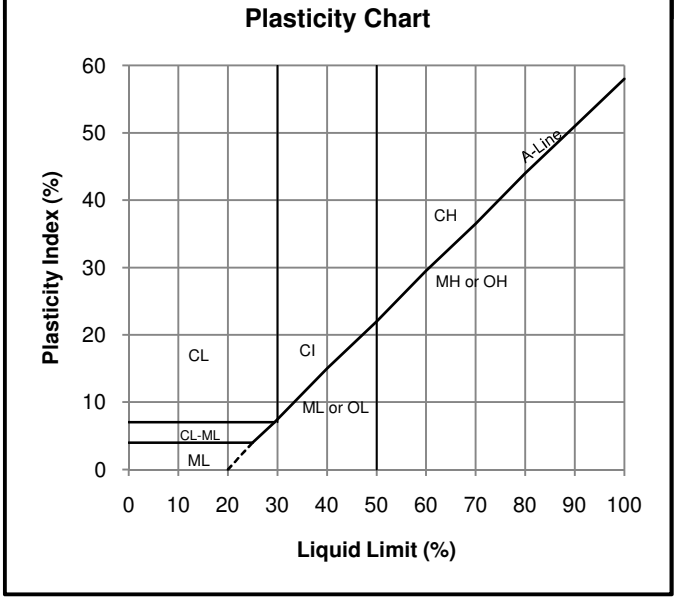
SOIL COMPONENTS

Fraction	U.S. Standard Sieve Size		Percentage (by weight)	Description
	Passing	Retained		
Gravel				
Coarse	76 mm	19 mm	35-50	AND
Fine	19 mm	4.75 mm		
Sand			20-35	Y/EY
Coarse	4.75 mm	2.00 mm		
Medium	2.00 mm	425 µm	10-20	SOME
Fine	425 µm	75 µm		
Fines (Silt or Clay)	75 µm		1-10	TRACE

Oversize Material		
	Cobbles	76 mm to 200 mm
	Boulders	> 200 mm

RELATIVE DENSITY AND CONSISTENCY

Cohesionless Soils		Cohesive Soils	
Relative Density	SPT (N) Value	Consistency	Undrained Shear Strength (kPa)
Very Loose	0-4	Very Soft	0-10
Loose	4-10	Soft	10-25
Compact	10-30	Firm	24-50
Dense	30-50	Stiff	50-100
Very Dense	>50	Very Stiff	100-200
		Hard	>200



Notes:

1. Use dual symbols for coarse grained soils with 5 to 12% fines (i.e. GP-GM)
2. All sieves are U.S. Standard ASTM E11

McElhanney

McElhanney Consulting Services Limited

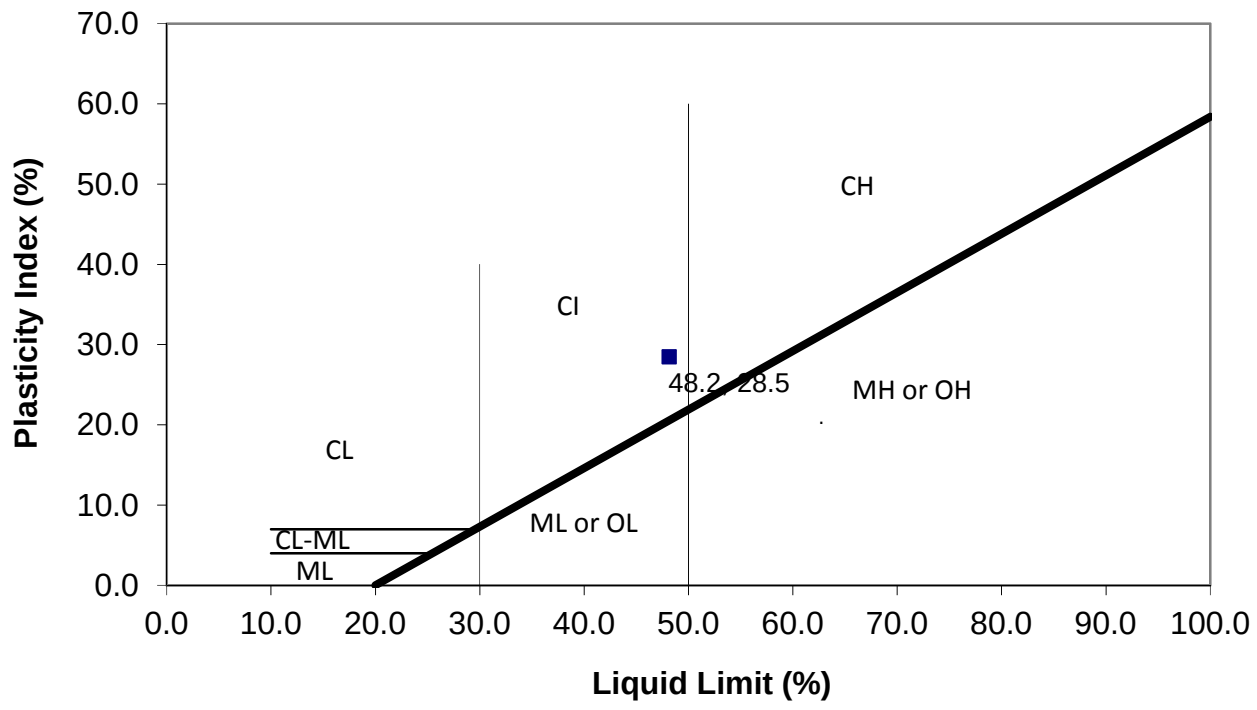
McElhanney Consulting Services Ltd.
1633 First Ave.
Prince George, BC, Canada, V2L 2Y8
Tel: 250-561-2229 Fax: 250-563-1941

ATTERBERG LIMITS
Laboratory Analysis Report

PROJECT NAME: GNP Campground Geotech
PROJECT NO. 2711-16012-0
DATE SAMPLED: January 26, 2016 **DATE TESTED:** December 1, 2015

Sample I.D.	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Soil Classification	Natural Water Content (%)	Soil Description / Comments
BH16-34, SA #01	48.2	19.7	28.5	CI	12.1	

Plasticity Chart



Tested by: Ryan Fenske Reviewed by:

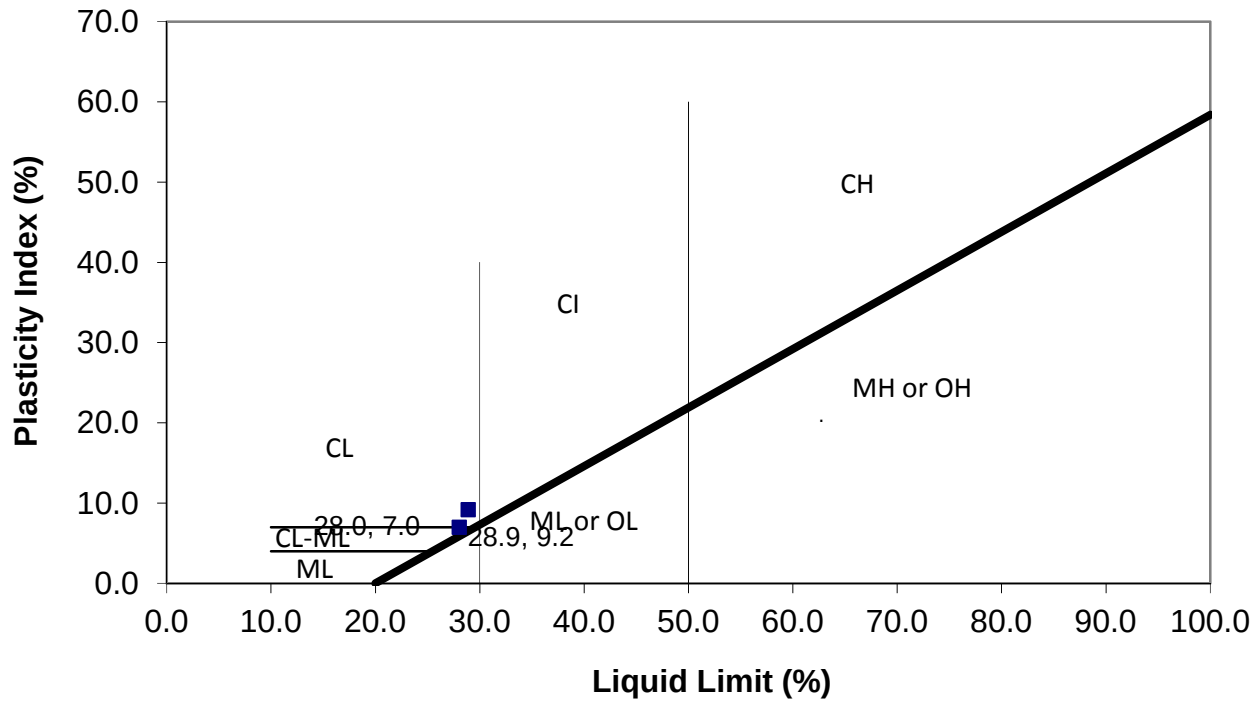
McElhanney Consulting Services Ltd.
1633 First Ave.
Prince George, BC, Canada, V2L 2Y8
Tel: 250-561-2229 Fax: 250-563-1941

ATTERBERG LIMITS
Laboratory Analysis Report

PROJECT NAME: GNP Campground Geotech
PROJECT NO. 2711-16012-0
DATE SAMPLED: January 26, 2016 **DATE TESTED:** December 1, 2015

Sample I.D.	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Soil Classification	Natural Water Content (%)	Soil Description / Comments
PT16-01, SA #01	28.9	19.8	9.2	CL	11.5	
PT16-02, SA #01	28.0	21.1	7.0	CL-ML	10.9	

Plasticity Chart



Tested by: Ryan Fenske Reviewed by:

McElhanney

McElhanney Consulting Services Ltd.

12-556 North Nechako Rd
Prince George BC
Canada V2K 1A1

Tel 250 561 2299
Fax 250 563 1941
www.mcelhanney.com

HYDROMETER ANAYLSIS REPORT

Laboratory Analysis Report

ASTM D422

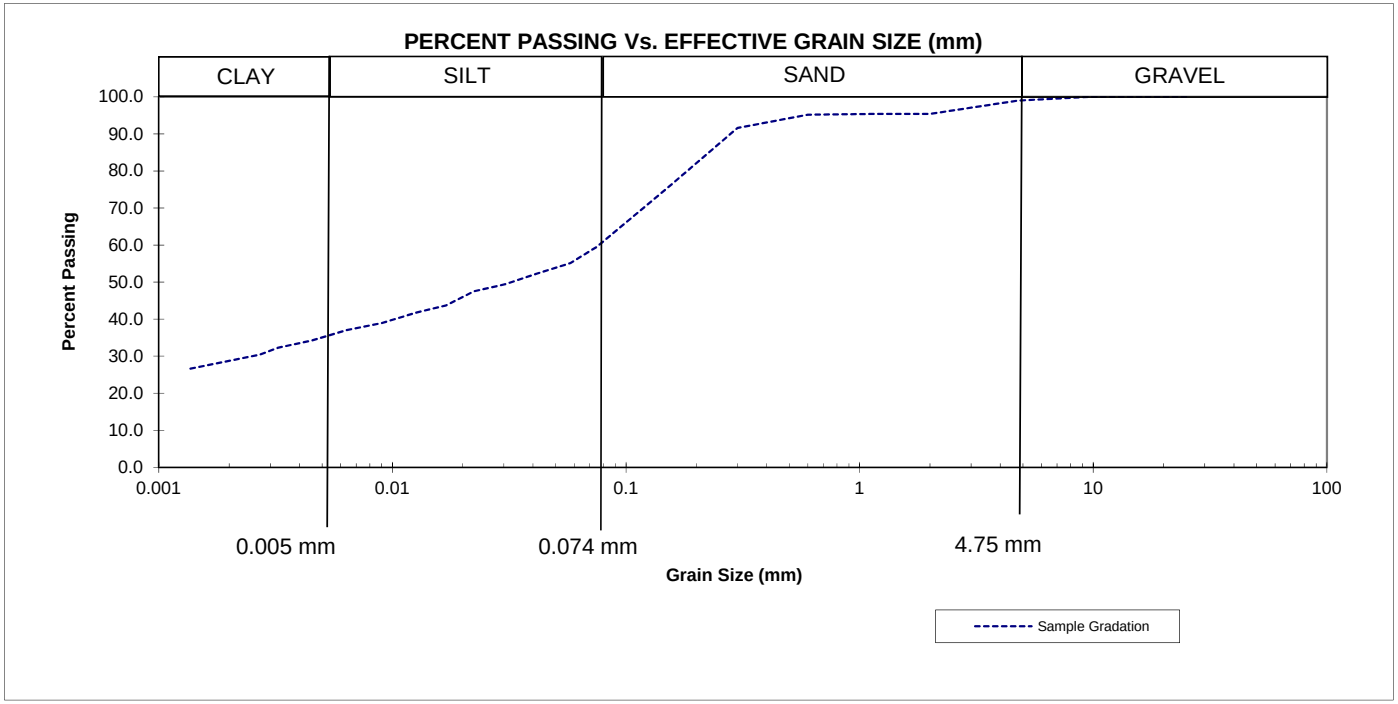
PROJECT NAME:	GNP Campground Geotech	**DATE SAMPLED:**	Jan 26, 2016
PROJECT NO.	2711-16012-0	**SAMPLED BY:**	S. Choi
CLIENT:	Parks Canada	**DATE TESTED:**	Feb 4, 2016
SOURCE:	PT16-01	**TESTED BY:**	R. Fenske
SAMPLE:	SA#1		
DEPTH:	0.6-1.0m		

Mechanical Analysis

Sieve Size (mm)	Percent Passing
25.0	**100.0**
19.0	**100.0**
12.5	**100.0**
9.5	**100.0**
4.75	**99.0**
2.00	**95.4**
1.18	**95.4**
0.600	**95.2**
0.300	**91.6**
0.150	**75.4**
0.075	**59.5**

Hydrometer Analysis

Effective Particle Diameter (mm)	Percent Passing
0.0577	**55.1**
0.0414	**52.3**
0.0303	**49.4**
0.0223	**47.5**
0.0170	**43.7**
0.0127	**41.8**
0.0090	**39.0**
0.0064	**37.1**
0.0045	**34.2**
0.0033	**32.3**
0.0027	**30.4**
0.0014	**26.6**



COMMENTS: Gravel 1.0%, Sand 39.5%, Silt 25.3%, Clay 34.2%

PREPARED BY: R. Fenske

REVIEWED BY:

McElhanney

McElhanney Consulting Services Ltd.

12-556 North Nechako Rd
Prince George BC
Canada V2K 1A1

Tel 250 561 2299
Fax 250 563 1941
www.mcelhanney.com

HYDROMETER ANAYLSIS REPORT

Laboratory Analysis Report

ASTM D422

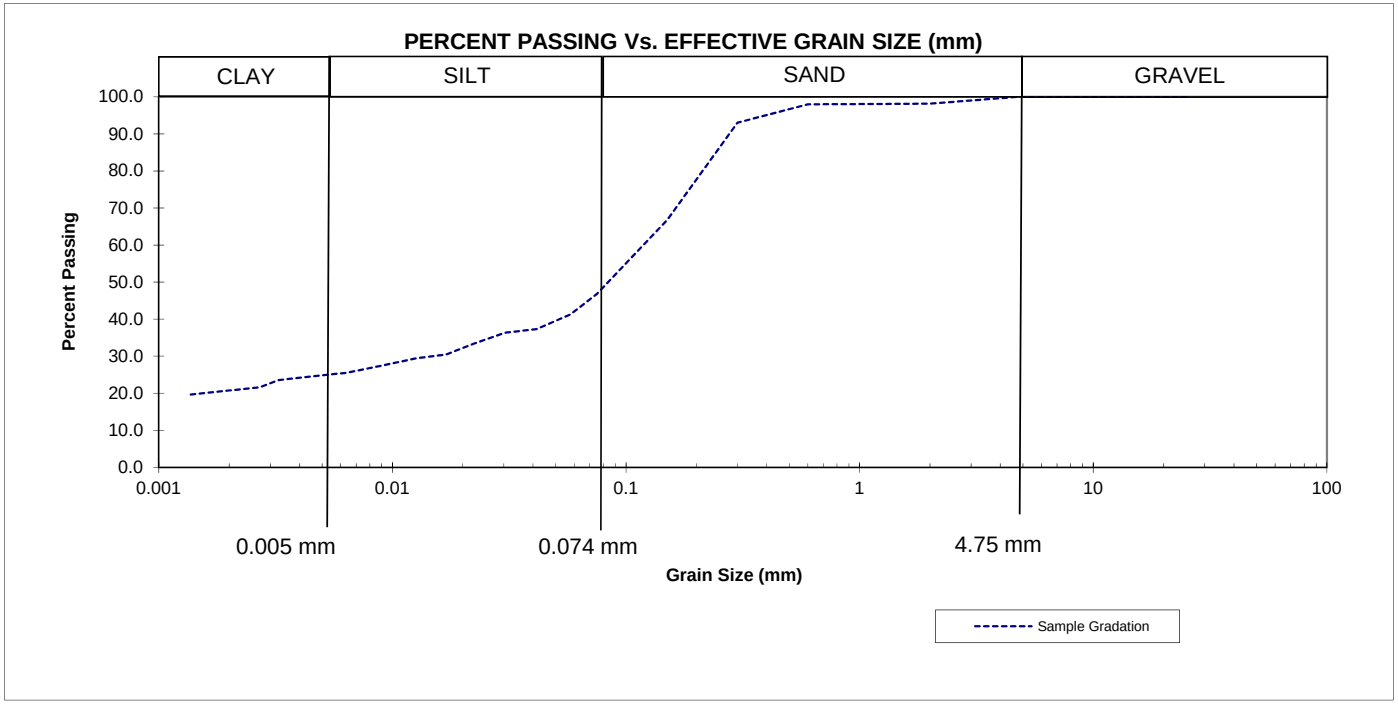
PROJECT NAME:	GNP Campground Geotech	**DATE SAMPLED:**	Jan 26, 2016
PROJECT NO.	2711-16012-0	**SAMPLED BY:**	S. Choi
CLIENT:	Parks Canada	**DATE TESTED:**	Feb 5, 2016
SOURCE:	PT16-02	**TESTED BY:**	R. Fenske
SAMPLE:	SA#1		
DEPTH:	0.6-1.0m		

Mechanical Analysis

Sieve Size (mm)	Percent Passing
25.0	**100.0**
19.0	**100.0**
12.5	**100.0**
9.5	**100.0**
4.75	**100.0**
2.00	**98.2**
1.18	**98.1**
0.600	**98.0**
0.300	**93.0**
0.150	**66.8**
0.075	**46.8**

Hydrometer Analysis

Effective Particle Diameter (mm)	Percent Passing
0.0577	**41.2**
0.0414	**37.3**
0.0303	**36.3**
0.0223	**33.4**
0.0170	**30.4**
0.0127	**29.4**
0.0090	**27.5**
0.0064	**25.5**
0.0045	**24.5**
0.0033	**23.6**
0.0027	**21.6**
0.0014	**19.6**



COMMENTS: Gravel: 0%, Sand: 53.2%, Silt: 22.3%, Clay: 24.5%

PREPARED BY: R. Fenske

REVIEWED BY: