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Géotechnique, environnement et  
ingénierie des sols et matériaux

November 28, 2014

ARCOP/DFS/STGM Consortium of Architects  
530, boulevard de l'Atrium, bureau 100  
Québec (Québec) G1H 7H1

To the attention of Mr. Jean-Yves Montminy

**Subject:** Reconstruction of the Québec City Armoury  
Supplement to the geotechnical study report  
**File number:** 2499-03

2320, rue de Celles  
Bureau 100  
Québec (Québec)  
CANADA G2C 1X8  
Tél. : (418) 845-0858  
Télec. : (418) 845-0300  
info@leqttech.com

Dear Mr. Montminy,

As a supplement to our geotechnical study report issued on July 19, 2013 (Report No. 4956-00-01) and at your request, we hereby submit additional geotechnical recommendations that are relevant to the project's execution. The project plans to move water and sewer lines in an easement going through a parking lot belonging to the National Battlefields Commission (NBC), located in the southwestern section of the Armoury property, as well as Avenue Wilfrid-Laurier, in front of that same parking lot. You have requested our opinion regarding the road structure required for the reconstruction of Avenue Wilfrid-Laurier following the installation of the water and sewer lines.

In this regard, the boreholes drilled on August 20, 2014 as part of the *Environmental Characterization of Soils* study has provided samples that are representative of the fill material and bedrock on this site.

Soil stratigraphy at the borehole site is indicated in the appended borehole reports. The borehole location plan (Drawing No. 2499-03-01) is also enclosed with this letter. These documents are taken from the *Environmental Characterization of Soils* study, for which a report (Reference No. 2499-03-01) has recently been issued by our firm.

According to information from a representative of Tetratex Inc., the road structure presented in Table 1 below is currently being considered for the reconstruction of Avenue Wilfrid-Laurier:

Reconnaissance  
des sols  
Essais en chantier  
Essais en laboratoire  
Expertises diverses  
Litiges en construction  
Études géotechniques  
Stabilité de talus  
Ingénierie des sols  
et des matériaux  
Auscultation des  
ouvrages  
Études  
environnementales  
Mécanique des  
chaussées



Membre de l'Association  
des consultants  
et laboratoires experts



**TABLE I**  
**PROPOSED ROAD STRUCTURE**

Layer	Material	Thickness (mm)
Asphalt (Surface layer)	EB-10S	50
Asphalt (Base layer)	EB-20	80
Upper base	MG-20 crushed aggregate	300
Sub-base	MG-112 granular material	600

Given that the friable rock was encountered at a depth of 0.34 metres at borehole F-104 in Avenue Wilfrid-Laurier, we are of the opinion that the thickness of the sub-layer could be reduced to 300 millimetres.

Given their geotechnical similarities, excavation work required to install the underground lines must follow the prescriptions set forth in section 6.6 of Report No. 4956-00-01 issued in July 2013. Since the work will generally be carried out in an existing road structure (Avenue Wilfrid-Laurier or the NBC parking lot), it is important to emphasize the importance of incorporating appropriate transitions according to the nature of the soils used as backfill and other soils located at various points in the trench, so as to limit differential behaviours between the soils or the rock currently on site and the soils used as backfill.

In addition, in the event that excavated rock, friable rock or frost-resistant materials are used as backfill, given that the bedrock is located at a depth of less than 2 metres, it is suggested that a transition be made below the infrastructure line in order to prevent cracking in the asphalt, either as a result of differential heaving caused by frost or differential settlement between the rock and the trench.

The soil/rock transition along the length of the road must be given a slope set at 1.0 horizontally and 1.0 vertically (1.0 H:1.0V) and should be spread over a depth of 1.00 metre from the surface of the rock mass, or stop at a depth of 2.00 metres from the surface of the road structure, whichever comes first. Along the width of the street, if applicable, transitions set at 4.0 horizontally and 1.0 vertically should be implemented.

This report has been read and commented on by Mr. Raymond Juneau, senior geotechnical engineer.



We remain available to provide any additional information.

Yours truly,

**LABORATOIRES D'EXPERTISES DE QUÉBEC LTÉE**

A handwritten signature in blue ink, appearing to read 'Louis Morin', written in a cursive style.

Louis Morin, Eng.  
#OIQ: 5016616  
Project Manager

LM/mm

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# GENERAL

## EXPLANATION OF THE BOREHOLE RECORD FORM

FV-1003 (2011-05)

The object of the Borehole Record is to assemble all the field and laboratory data regarding the soil, bedrock and ground water conditions obtained during the investigation at each borehole.

### PROFILE

**Elevation:** This column gives the elevation of boundaries between various geological strata. The elevation refers to the datum given in the general heading.

**Description:** Each geological stratum is described using the standard classification given below.

The proportion of each constituent part of the soil as defined by the grain size range is denoted by the terms given below. The compactness of granular soils is defined by the Standard Penetration Value and the consistency of cohesive soils by the shear strength.

Classification	Particle sizes
Clay	smaller than 0.002 mm
Silt	0.002 to 0.08 mm
Sand	0.08 to 5.00 mm
Gravel	5.00 to 80 mm
Cobbles	80 to 300 mm
Boulders	larger than 300 mm

Descriptive terms	Proportion
"trace"	1 to 10%
"some"	10 to 20%
Adjective (e.g. gravelly, silty)	20 to 35%
"and" (e.g. sand and gravel)	35 to 50%

Compactness	Standard Penetration Test "N" Value (blows per 0.3 m)
Very loose	0 to 4
Loose	4 to 10
Medium or compact	10 to 30
Dense	30 to 50
Very dense	over 50

Consistency	Shear strength (kPa)
Very soft	less than 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	over 200

Degree of plasticity	Liquid limit
Low	less than 30%
Medium	between 30 and 50%
High	more than 50%

**Stratigraphy:** In this column the hatching symbols follow the symbols of the United Soil Classification System. The basic soil types are designated by the following symbols:



### GROUND WATER

The depth to ground water level as measured in the borehole is given in this column. The observation dates are given in the graph column at the right.

### SAMPLES

**Condition:** The location, length and condition of each sample is shown in this column. The sample condition is defined by the symbols in the general heading.

**Number & type:** Each sample of the borehole is designated by the number as shown in this column. The sample type is also shown by a symbol that refers to the legend given in the general heading.

**Recovery:** Soil sample and rock core recoveries are given in percent of the penetration of the sampler. The sample length is equal to the distance from the top of the sample to the cutting edge irrespective of whether the lower part of the sample is lost.

**R.Q.D.:** The Rock Quality Designation is obtained by summing up the total length of core recovered but counting only those pieces of core which are 10 cm in length or longer, given in per cent of the core run.

$$R.Q.D. = \frac{\sum li \geq 10 \text{ cm}}{Lcr}$$

### TESTS

Laboratory tests and results of *in-situ* tests are shown in this column at their corresponding depths.

Standard Penetration Test Values, commonly designated as "N" values, are given in this column. This value is obtained by dropping a 63,5 kg hammer onto the drill rods from a height of 760 mm. The number of blows necessary to produce the penetration of the last 305 mm of the 51 mm standard split spoon sampler is regarded as the "N" value.

### GRAPH

Any pertinent observations noted during drilling and in the laboratory are given in the column. Also shown graphically are the results of Atterberg limits and moisture content tests as well as those of the 51 mm cone dynamic penetration test when performed. This latter penetration test consists in the continuous driving of a 51 mm diameter 60 degrees cone under constant energy, generally 475 joules, and thus differs from the Standard Penetration Test.



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# BOREHOLE LOG

Number: 2499-03

Hole #: F-101

Elevation: 91,25 m

Date: 2014-08-20

**Project:** Environmental Characterisation of Soils - Québec City Armoury Lot 1  
**Location:** NBC Parking Area, Wilfrid-Laurier Avenue, Québec

Equipment used: Diedrich-50  
Casing si Auger, NW  
Hammer weight: 63,5 kg  
Drop: 760 mm

**Sample type**  
CF Split spoon sampler  
CR Diamond core  
LA Wash sample  
TA Auger sample  
TM Thin-wall sampler  
PS Fixed piston sampler

**Symbols**  
▽ Groundwater level  
Ach Chemical analysis  
Ag Grain size analysis (sieving)  
Sed Grain size analysis (sedimentation)  
Wc Natural water content  
Wl Liquid limit  
Wp Plastic limit

**Hydrocarbures**  
**Odour**  
No non-existent  
Li Light  
Mo Moderate  
Pe persistent  
**Visual aspect**  
No non-existent  
Sc scattered  
Sat Saturated

**Sample condition**

Disturbed Good Lost

Profile		Str	Ground water	Samples		Tests	Odour	visual Aspect	Notes
Depth (m)	Elev (m)			Description	Cond				
	91,25								
	91,16								
	90,96								
0,5	90,67								
	90,52								
	90,18								
1									
1,5									

An open 19 mm diameter tube was left in the borehole to determine groundwater level.

Date	Depth (m)
2014-08-20	Dry
2014-08-25	Dry



# BOREHOLE LOG

Number: 2499-03

Hole #: F-102

Elevation: 92,75 m

Date: 2014-08-20

**Project:** Environmental Characterisation of Soils - Québec City Armoury Lot 1  
**Location:** NBC Parking Area, Wilfrid-Laurier Avenue, Québec

Equipment used: Diedrich-50  
Casing si Auger, NW  
Hammer weight: 63,5 kg  
Drop: 760 mm

**Sample type**  
CF Split spoon sampler  
CR Diamond core  
LA Wash sample  
TA Auger sample  
TM Thin-wall sampler  
PS Fixed piston sampler

**Symbols**  
▽ Groundwater level  
Ach Chemical analysis  
Ag Grain size analysis (sieving)  
Sed Grain size analysis (sedimentation)  
Wc Natural water content  
Wl Liquid limit  
Wp Plastic limit

**Hydrocarbures**  
Odour  
No non-existent  
Li Light  
Mo Moderate  
Pe persistent  
**Visual aspect**  
No non-existent  
Sc scattered  
Sat Saturated

**Sample condition**

Disturbed Good Lost

Profile			Str	Samples			Tests	Odour	Visual Aspect	Notes
Depth (m)	Elev (m)	Description		Cond	No et type	Rec (%)				
	92,75									
	92,70	Asphalt.								
	92,53	(0.05 m)								
		Fill made up of gray sand and gravel, some silt.		1-CF	65	N=43, Ach		In	In	
0,5	92,23	(0.22 m)								
		Fill made up of grayish-black silty and gravelly sand.		2-CF	25	N=14, Ach		In	In	
		(0.52 m)								
1	91,62	Fill made up of grayish-brown silty sand, some gravel. Presence of incineration residue and organic materials (<2%)								
		(1.13 m)								
1,5		Gray friable bedrock.		3-CF	70	N=39		In	In	
	90,92	(1.83 m)								
2		Bedrock: Clayey limestone. Very poor to good quality.		4-CF	0	50/50mm Refusal		In	In	
				5-CR	100	RQD=51%		In	In	
2,5				6-CR	100	RQD=19%		In	In	
3				7-CR	95	RQD=81%		In	In	
	89,09	(3.66 m)								
		End of drilling.								



**BOREHOLE LOG**

Number: 2499-03

Hole #: F-103

Elevation: 92,77 m

Date: 2014-08-20

**Project: Environmental Characterisation of Soils - Québec City Armoury Lot 1**  
**Location: NBC Parking Area, Wilfrid-Laurier Avenue, Québec**

<b>Equipment used:</b> Diedrich-50 <b>Casing si Auger, NW</b> <b>Hammer weight:</b> 63,5 kg <b>Drop:</b> 760 mm	<b>Sample type</b> CF Split spoon sampler CR Diamond core LA Wash sample TA Auger sample TM Thin-wall sampler PS Fixed piston sampler	<b>Symbols</b> Groundwater level Ach Chemical analysis Ag Grain size analysis (sieving) Sed Grain size analysis (sedimentation) Wc Natural water content Wl Liquid limit Wp Plastic limit	<b>Hydrocarbures</b> <b>Odour</b> No non-existent Li Light Mo Moderate Pe persistent <b>Visual aspect</b> No non-existent Sc scattered Sat Saturated
<b>Sample condition</b> Disturbed  Good  Lost			

Profile		Str	Samples		Tests	Odour	Visual Aspect	Notes
Depth (m)	Elev (m)		Cond	No et type (%)				
	92,77							
	92,72							
	92,53							
0,5								
	92,08		1-CF	72	N=14, Ach	In	In	
			2-CF	54	N=18	In	In	
1								
	91,52		3-CF	67	50/30mm Refusal	In	In	
1,5								



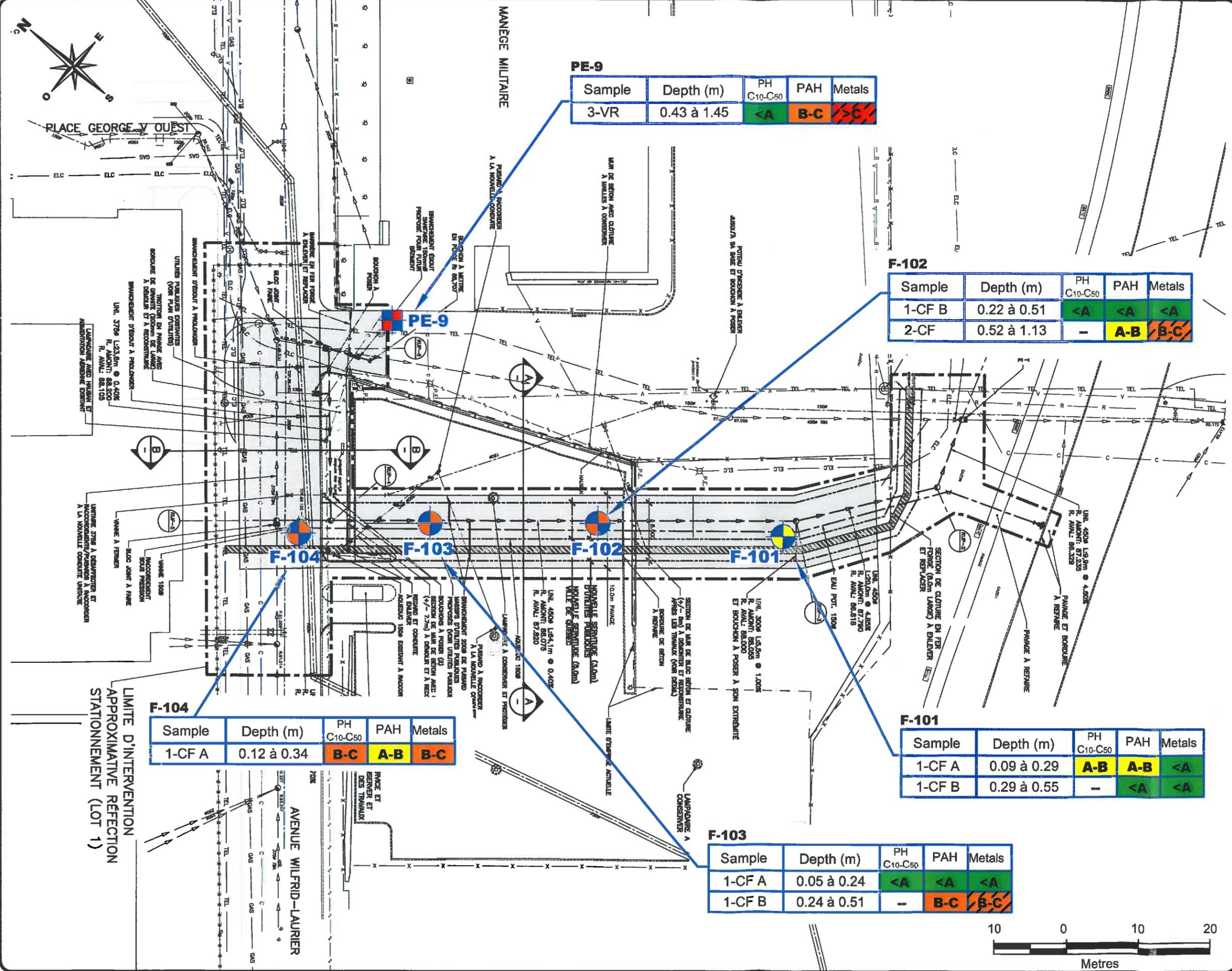
**Project: Environmental Characterisation of Soils - Québec City Armoury Lot 1**  
**Location: Wilfrid-Laurier Avenue, Québec**

<b>Equipment used:</b> Diedrich-50 <b>Casing si Auger, NW</b> <b>Hammer weight:</b> 63,5 kg <b>Drop:</b> 760 mm	<b>Sample type</b> CF Split spoon sampler CR Diamond core LA Wash sample TA Auger sample TM Thin-wall sampler PS Fixed piston sampler	<b>Symbols</b> Groundwater level Ach Chemical analysis Ag Grain size analysis (sieving) Sed Grain size analysis (sedimentation) Wc Natural water content Wl Liquid limit Wp Plastic limit	<b>Hydrocarbures</b> <b>Odour</b> No non-existent Li Light Mo Moderate Pe persistent <b>Visual aspect</b> No non-existent Sc scattered Sat Saturated
<b>Sample condition</b> Disturbed  Good  Lost			

Profile		Str	Ground water	Samples			Tests	Odour	visual Aspect	Notes
Depth (m)	Elev (m)			Description	Cond	No et type				
	92,36									
	92,24									
	92,02									
0,5										
	91,37									
1										
1,5										
2										
2,5	89,82									
3										

An open 19 mm diameter tube was left in the borehole to determine groundwater level.

Date	Depth (m)
2014-08-20	Dry
2014-08-25	Dry



**PE-9**

Sample	Depth (m)	PH C10-C50	PAH	Metals
3-VR	0.43 à 1.45	<A	B-C	>C

**F-102**

Sample	Depth (m)	PH C10-C50	PAH	Metals
1-CF B	0.22 à 0.51	<A	<A	<A
2-CF	0.52 à 1.13	-	A-B	B-C

**F-104**

Sample	Depth (m)	PH C10-C50	PAH	Metals
1-CF A	0.12 à 0.34	B-C	A-B	B-C

**F-101**

Sample	Depth (m)	PH C10-C50	PAH	Metals
1-CF A	0.09 à 0.29	A-B	A-B	<A
1-CF B	0.29 à 0.55	-	<A	<A

**F-103**

Sample	Depth (m)	PH C10-C50	PAH	Metals
1-CF A	0.05 à 0.24	<A	<A	<A
1-CF B	0.24 à 0.51	-	B-C	B-C

Legend:

**F-101** Borehole drilled in August 2014

**PE-9** Test Pit from June 2013 (L.E.Q. reference Itée No. 2499-01-01)

Plage de contamination


Prepared for:  
**ARCOP/DFS/STGM Consortium**

Prepared by:  
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Géotechnique, environnement et ingénierie des sols et matériaux

Seal:

Project Title:  
**Environmental Characterization of Soils Québec City Armoury Lot 1 - Relocation of Public Utilities Québec (Québec)**

Drawing Title:  
**Location of Soundings and Distribution of Contamination**

Drawing: D.S. / F.L.	Scale: 1:500	Project No.: 2499-03
Verified: F.L.	Date: November 2014	Drawing No.: 2499-03-01

