



LABORATOIRES
D'EXPERTISES
DE QUÉBEC LTÉE
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

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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, reading 'Louis Morin', is positioned above the printed name.

Louis Morin, Eng.
#OIQ: 5016616
Project Manager

LM/mm

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- | | |
|--|--------|
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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:

	Clay		Sand		Cobbles and/or boulders
	Silt		Gravel		Organic soil

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.

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

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 condition

Disturbed

Good

Lost



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

Profile

Depth (m)	Elev (m)	Description
	91,25	
	91,16	Asphalt. (0.09 m)
	90,96	Fill made up of gray gravelly sand, trace of silt. (0.29 m)
0,5	90,67	Fill made up of brownish- gray sand, some gravel and silt. Presence of incineration residue (<2%). (0.58 m)
1	90,52	
	90,18	Black silty and gravelly sand created by bedrock alteration. (0.73 m)
		Gray friable rock. (1.07 m)
1,5		Refusal upon reaching bedrock. End of drilling.

Str

Ground
water

Samples

Cond

No et
type

Rec
(%)

Tests

Odour

visual
Aspect

Notes

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



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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 condition

Disturbed

Good

Lost



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

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)			4-CF	0	50/50mm Refusal	In	In	
2		Bedrock: Clayey limestone. Very poor to good quality.			5-CR	100	RQD=51%	In	In	
					6-CR	100	RQD=19%	In	In	
2,5										
3					7-CR	95	RQD=81%	In	In	
	89,09	(3.66 m)								
		End of drilling.								



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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

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

Depth (m)	Elev (m)	Description
	92,77	
	92,72	Asphalt.
	92,53	(0.05 m)
0,5		Fill made up of brown gravelly sand, some silt. Presence of incineration residue, bricks, glass, and mortar (5%).
	92,08	(0.24 m)
1		Fill made up of black sandy silt, some gravel. Presence of incineration residue and pieces of bricks and mortar (2%).
	91,52	(0.69 m)
1,5		Black silty and gravelly sand created by bedrock alteration.
		(1.25 m)
		Refusal on probable bedrock.
		End of drilling.

Str

Samples

Cond No et type Rec (%)

Tests

Odour

Visual Aspect

Notes

BOREHOLE LOG

Number: 2499-03

Hole #: F-104

Elevation: 92.36 m

Date: 2014-08-20

Project: Environmental Characterisation of Soils - Québec City Armoury Lot 1

Location: Wilfrid-Laurier Avenue, Québec

Equipment used: Diedrich-50

Casing si Auger, NW

Hammer weight: 63,5 kg

Drop: 760 mm

Sample condition

Disturbed

Good

Lost



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

W1	Liquid limit
WU	Plastic limit

Wp Plastic limit

Hydrocarbures

Odour

No non-existent

Li Light

No Moderate

Pe persistent

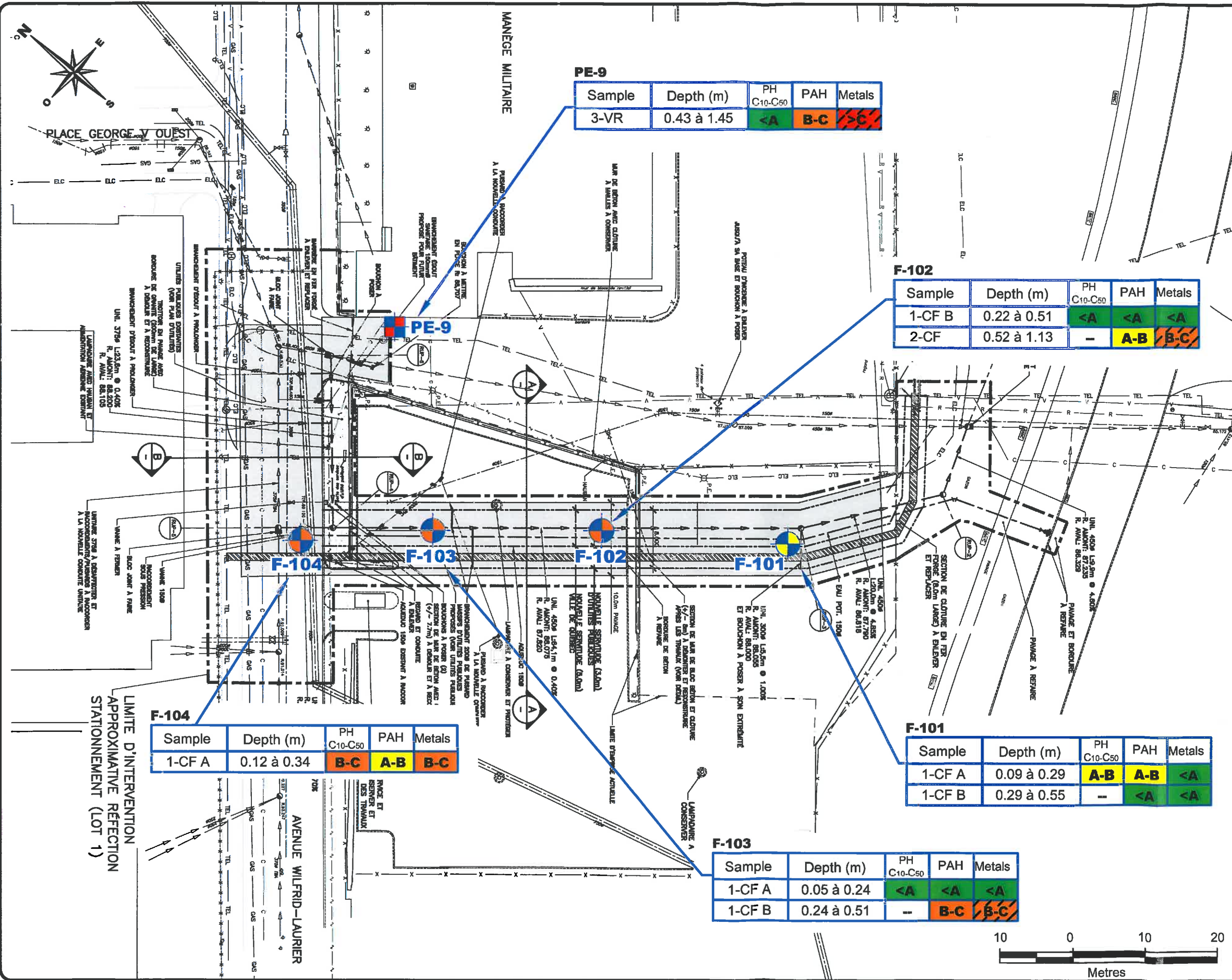
Visual aspect

No non-existent
Sc scattered

Sat Saturated

DATE _____

[illegible]



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

<A
 A-B

B-C
 >C

≥CCME

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