Geotechnical Investigation
RCMP Air Services Hangar
Ottawa, ON

Stantec

Prepared for:
SNC-Lavalin Operations & Maintenance Inc.
for
Public Works and Government Services Canada

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for the proposed additions to the RCMP Air Services Hangar, located at the Ottawa International Airport. The work was carried out in general accordance with our proposal number 1224-B11159 dated August 25th, 2011.

This report has been prepared specifically and solely for the project described herein. This report presents the factual results of the geotechnical investigation as well as recommendations for the design and construction of the project.

2.0 PROJECT DESCRIPTION

In 1989, Jacques Whitford Limited (now Stantec) carried out a geotechnical investigation (Report No. O-19359) for the design of the existing hangar, located at 2000 Research Road, approximately 600 m west of the Uplands Drive and Airport Parkway interchange. The existing building is supported with concrete expanded base piles.

It is understood that two additions are planned for the existing facility. The first, a two storey VIP lounge and passenger access facility, will be located on the east side of the existing hangar. This addition will have a footprint of 180 m^2. The second addition is to consist of a single storey storage facility, with a footprint of 150 m^2, located on the west side of the existing hangar.

Drawing No. 1 in Appendix B illustrates the location of the site. The location of the boreholes is shown on Drawing No. 2 in Appendix B.

3.0 SCOPE OF WORK

The scope of work for this geotechnical investigation included the following:

- Carry out a field drilling investigation for the proposed additions, consisting of one (1) borehole at each addition location. Advance one deep borehole to determine the Site Classification for Seismic Site Response. Advance the second borehole to 6 m (or refusal, if shallower). Perform standard penetration tests (SPT) while collecting soil samples at regular intervals. Perform field vane shear tests at regular intervals within cohesive material, if encountered, to evaluate the undrained shear strength and remoulded shear strength.
- Measure water levels in open boreholes.
- Survey the boreholes relative to a geodetic benchmark provided to us.
- Assess the characteristics of the site soils by laboratory tests, which may include moisture contents, Atterberg Limits, gradation analyses and sulfate resistance.

- Prepare an engineering report for the hangar additions with geotechnical recommendations for the following:
  - Soil conditions;
  - Limit states bearing resistances;
  - Modulus of subgrade reaction for slab-on-grade construction;
  - Excavation and backfilling requirements;
  - Groundwater levels and construction dewatering requirements;
  - Seismic Site Classification in accordance with 2010 National Building Code of Canada (NBCC) and assessment of liquefaction potential.

4.0 METHOD OF INVESTIGATION

4.1 FIELD INVESTIGATION

Prior to the commencement of the investigation, Stantec personnel made arrangements to verify the locations of underground utilities near the proposed borehole locations.

Borehole number BH11-1 was advanced within the footprint of the proposed storage facility to the west of the existing hangar. Borehole BH11-2 was advanced within the footprint of the proposed VIP lounge and passenger access facility. The boreholes were drilled between September 28th and 30th using a truck mounted drill rig. The borehole locations are presented on Drawing No. 2 in Appendix B.

The boreholes were drilled to depths of 16.8 m and 32.0 m for BH11-1 and BH11-2, respectively. Split spoon soil samples were collected at regular intervals during the performance of Standard Penetration Tests (SPT) and the subsurface stratigraphy encountered in the boreholes was recorded in the field by our geotechnical personnel. A dynamic cone penetration test was carried out between 21.9 m and 32.0 m depth (geodetic elevations 91.3 m and 81.2 m) in BH11-2. Following completion of the tests, it was noted that the rods had bent during driving.

The water level in each borehole was measured in the open borehole at the completion of drilling. All boreholes were backfilled with augured material tamped in place; BH11-2 was topped with cold-patch asphalt. All samples were stored in moisture-proof bags and were returned to our laboratory for detailed classification and laboratory testing.

4.2 SURVEYING

Borehole locations were established in the field by Stantec personnel relative to existing site features and surveyed relative to a benchmark located at the top of spindle of the fire hydrant located to the north of the existing hangar. The elevation assigned to this benchmark was 113.53 m. The location of this benchmark is shown on Drawing No. 2 in Appendix B.

4.3 LABORATORY TESTING

All samples returned to the laboratory were subjected to a detailed visual classification by a geotechnical engineer. Selected samples were tested for moisture content and gradation analysis. Tests were also performed to measure the pH, resistivity and soluble sulfate and chloride content of the soil.

Samples remaining after testing have been placed in storage for a period of one month after issuance of this report. Following this period, the samples will be discarded unless we are otherwise directed.

5.0 RESULTS OF THE INVESTIGATION

The subsurface conditions consisted of a layer of fill over silty sand to sandy silt, overlying till. Bedrock was not encountered during the course of this investigation.

The subsections below describe the encountered subsurface conditions in the 2011 boreholes and the results of the investigation. The subsurface conditions observed at the borehole locations are presented on the Borehole Records in Appendix C, along with an explanation of the symbols and terms used to describe the Borehole Records.

The borehole records from the 1989 hangar investigation are also provided in Appendix C. The 1989 investigation encountered a layer of Fill over a deposit of sand with varying quantities of silt and gravel. The 2011 subsurface profile is consistent with the 1989 results.

5.1 EXISTING SITE CONDITIONS

5.1.1 Surficial Materials

The surface of BH11-1 was grass-covered, underlain by 430 mm of topsoil.

The surface at BH11-2 was paved with 95 mm of asphalt, underlain by 385 mm of grey gravelly sand fill.

5.1.2 Fill

Fill was encountered beneath the surficial materials in both boreholes. The fill extended to between 3.1 m and 3.5 m below ground surface, or between elevations 109.9 m and 109.7 m.

Laboratory testing carried out on representative samples of this material indicated moisture contents ranging from 5% to 16%. A grain size analysis carried out on one sample yielded 8% gravel, 72% sand and 20% silt- and clay-sized particles. The fill may be classified as a silty sand (SM) with trace gravel according to the Unified Soil Classification System (USCS). The test results are shown on Figure 3 in Appendix D.

5.1.3 Silty Sand (SM)

A layer of silty sand was encountered beneath the fill materials. This material had a varying silt content, and included several layers of varying color. This soil layer extended to between 12.2 m and 17.3 m below ground surface, or between elevations 100.8 m and 95.9 m. SPT N-values indicate this material is in a loose to very dense condition.

Laboratory testing carried out on representative samples of this material indicated moisture contents ranging from 4% to 22%, with an average of 11%. Grain size analysis tests were carried out on one sample, and are summarized in Table 5.1. This material may be classified as silty sand (SM) according to the Unified Soil Classification System (USCS). The test results are shown on Figure 2 in Appendix D.

Table 5.1: Grain Size Analysis Results – Silty Sand (SM)

Sample	Gravel	Sand	Silt	Clay
BH11-1 SS13	0%	60%	40%	

5.1.4 Sandy Silt (ML)

Within Borehole BH11-1 a layer of brownish grey sandy silt with trace gravel was encountered within the deposit of silty sand. SPT N-value indicates this material is in a compact to dense condition.

Grain size analysis tests were carried out on one sample, and are summarized in Table 5.2. This material may be classified as sandy silt (ML) according to the USCS. The test results are shown on Figure 2 in Appendix D.

Table 5.2: Grain Size Analysis Results - Sandy Silt (ML)

Sample	Gravel	Sand	Silt	Clay
BH11-1 SS11	0%	30%	66%	4%

5.1.5 Till

A layer of till was encountered underlying the sand deposit. The recorded SPT 'N' and Dynamic Core Penetration test resistance values indicate this material is in a compact to very dense condition. Several cobbles and large boulders were encountered. Testing terminated in the till at depths of 16.8 m and 32.0 m (geodetic elevation 96.2 m and 81.2 m) for BH11-1 and BH11-2, respectively.

Laboratory testing carried out on representative samples of this material indicated moisture contents ranging from 9% to 17%. A grain size analysis on the till showed it to contain 21% gravel, 68% sand and 11% silt- and clay-sized particles. The till has been classified as poorly-graded sand (SP-SM) with gravel and silt according to the USCS.

5.1.6 Bedrock

Bedrock was not encountered during the course of this investigation. Soil mapping of the area shows that it likely consists of limestone.

5.2 GROUNDWATER

Groundwater levels were measured in the open boreholes at the completion of drilling. The water level was 12.2 m below ground surface in both boreholes. Fluctuations due to seasonal variations or precipitation events should be expected.

6.0 DISCUSSION AND RECOMMENDATIONS

6.1 GEOTECHNICAL ASSESSMENT

Based on the borehole information, the subsurface soils in the area of the proposed additions consist of a layer of fill over a deposit of sandy silt to silty sand over till.

The following geotechnical issues should be considered during design activities:

- Conventional spread footings founded on native material are appropriate for the design of structures at this site. A 3.1 m to 3.5 m thick layer fill was encountered. The existing fill material is not suitable for the support of footings and will require sub-excavation.
- Differential movement between the existing structure and proposed additions may occur. The connection between the existing building and proposed additions should be designed to accommodate 19 mm of differential settlement.
- Groundwater was encountered at depths lower than the proposed depth of construction. It is anticipated that surface water run-off and groundwater can be control with sump and pump methods.
- The recommended Site Classification for Seismic Site Response for the site is Site Class D.
- The existing pile foundations will need to be supported/protected during the excavation for the proposed footings. The location and pile cap elevation of the existing piles should be confirmed.

6.2 SITE GRADING AND PREPARATION

6.2.1 Beneath Spread Footings and Slabs-on-Grade

It is recommended that spread footings be placed on native soils or Structural Fill overlying suitable native soils.

All vegetation, topsoil, asphalt, existing fill and other deleterious materials should be removed from within the influence zone of the foundations. The influence zone is defined by a line drawn at 1 horizontal to 1 vertical outward and downward from the edge of the footings to competent soil. The exposed subgrade surfaces should be surface compacted to 98% Standard Proctor

Maximum Dry Density and inspected by geotechnical personnel. The existing building foundation will need to be supported/protected during excavation.

The existing fill may remain beneath the floor slabs provided:

- Topsoil and asphalt are removed.
- The subgrade is surface compacted in the presence of Geotechnical personnel and any loose or disturbed areas are sub-excavated and replaced.

6.2.2 General Site Preparation

Structural Fill should consist of granular material meeting the requirements of OPSS Granular B Type I or Type II. No recycled materials (asphalt, concrete, etc.) should be included in Structural Fill placed within the addition footprints.

Subgrade Fill should consist of material meeting the requirements of OPSS Select Subgrade Material. The native soils will be suitable for re-use as Subgrade Fill provided the moisture content at the time of placement will allow compaction.

Structural Fill should be compacted to at least 98% Standard Proctor maximum dry density (SPMDD). The degree of compaction may be reduced to 95% SPMDD for Subgrade Fill in parking areas. Where Subgrade Fill is dissimilar to the existing material on site, the edges of the existing fill should be graded to slope no steeper than three horizontal to one vertical prior to placing the new subgrade fill.

Earth removal should be inspected by geotechnical personnel to ensure that all unsuitable materials are removed prior to placement of Structural/Subgrade Fill. Any soft areas observed during the inspection should be subexcavated and backfilled as directed by the geotechnical engineer. Inspection and testing of materials should be conducted to ensure that all fill is placed and compacted to the required degree.

6.3 SPREAD FOOTINGS

Footings placed on undisturbed native soils or on Structural Fill placed on native soil may be designed using the design parameters indicated in Table 6.1.

Table 6.1: Geotechnical Bearing Resistances for Shallow Foundations

Foundation Type	Footing Dimensions	ULS (kPa)	SLS (kPa)
Strip Footing	0.6 m to 1.0 m	510	265
Spread Footing	0.6 m x 0.6 m to 2.0 m x 2.0 m	760	210

The ultimate limit states (ULS) bearing resistance includes a resistance factor of 0.5 and assumes a minimum footing embedment of 1.8 m. ULS bearing resistances will need to be reduced if less embedment is provided.

The serviceability limit states (SLS) bearing resistance corresponds to total settlement of 25 mm. Differential settlement will depend on the foundation sizes, loads and founding elevations but are generally expected to be less than 19 mm for foundations sized based on the above bearing resistances. It is estimated that a maximum of 19 mm of differential settlement could occur between the existing structure and the proposed additions due to the transition from pile foundations to strip footings.

All perimeter footings and interior footings located within 1 m distance from the exterior walls will require a minimum frost protection equivalent to a soil cover of 1.5 m for protection against frost action. Footings in unheated areas or exterior footings such as for retaining walls, signs and light standards should have a minimum frost protection equivalent to a soil cover of at least 1.8 m for frost protection.

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

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

6.4 SLAB-ON-GRADE

A layer of free draining granular material such as OPSS Granular A at least 200 mm in thickness should be placed immediately beneath the floor slab for leveling and support purposes. This material should be compacted to at least 100% SPMDD. Perimeter drains should be installed at locations where the final grades around the building are higher than the underside of the slab.

Floor slabs constructed as recommended above may be designed using a soil modulus of subgrade reaction, k, of 40 MPa/m.

Construction joints should be placed in the floor slab around load bearing walls to allow minor movements to take place without cracking the slab.

Where construction is undertaken during winter conditions, the floor slab subgrade should be protected from freezing. Alternatively, the floor slab subgrade should be completely thawed, then proof rolled prior to placing concrete.

6.5 EXCAVATION AND BACKFILLING

The site soil can be classified as a Type 3 soil as per the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects and local regulations. Temporary excavations in the overburden should be sloped at 1 horizontal to 1 vertical from the base of the excavation and. Excavations should be inspected regularly for signs of instability and flattened as required.

Groundwater is not anticipated within the proposed depth of excavation. If encountered during excavation and construction, it is expected that groundwater and any surface run-off water may be controlled by sump and pumping methods.

Foundation backfill should be placed and compacted in lifts. Foundation backfill within buildings should consist of Structural Fill placed as described in Section 6.2.2. Exterior foundation backfill should consist of a Subgrade Fill material as described in Section 6.2.2 and compacted as described for Subgrade Fill in Section 6.2.2. Care should be taken immediately adjacent to walls to avoid over compaction of the soil which could result in damage to the walls.

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

Backfill for service trenches in landscaped areas may consist of excavated material replaced and compacted in lifts. Where the service trenches extend below paved areas, the trench should be backfilled with Subgrade Fill material as defined in Section 6.2.2 from the top of the pipe cover to within 1.2 m of the proposed pavement surface, placed in lifts and compacted to at least 95% of SPMDD. The material used within the upper 1.2 m and below the subgrade line should be similar to that exposed in the trench walls to prevent differential frost heave, placed in lifts and compacted to at least 95% of SPMDD. Different abutting materials within this zone will require a 3 horizontal to 1 vertical frost taper in order to minimize the effects of differential frost heaving.

6.6 EARTHQUAKE CONSIDERATIONS

An assessment for seismic liquefaction has been carried out for this site. Seismic liquefaction is the sudden loss in stiffness and strength of soil due to the loading effects of an earthquake. Liquefaction can cause significant settlements and structural failure.

The analysis followed was the one set forth in the Canadian Foundation and Engineering Manual, 2006 (CFEM). For the analysis a magnitude 6.1 earthquake, typical of the Ottawa area, was used. A Peak Ground Acceleration (PGA) of 0.32g and an amplification of 1.3 was assumed. Based on the SPT N values and our design parameter values for the soil plots of Factor of Safety Against Liquefaction (FSL) with depth were developed for the site. The analysis indicates that a thin section near the top of the soil profile may be susceptible to liquefaction (i.e. the Factor of Safety against liquefaction is less than one). However, due to the relative thinness of the layer, its liquefaction potential is not considered to have any considerable impact on settlement at the site. The FSL profile for the site is included in Appendix E of this report.

As outlined in the 2010 National Building Code of Canada (NBCC), buildings and their foundations must be designed to resist a minimum earthquake force. In accordance with Table

4.1.8.4.A of the 2010 NBCC the seismic site response for the site is Site Class D. The site class is based on the following design parameters:

Table 6.2: Parameters for Seismic Site Classification

Depth	Soil Layer	'N_{60}' Value
1.8 m – 3.5 m	Fill	15
3.5 m – 17.3 m	Sandy Silt to Silty Sand	30
17.3 m – 23.2 m	Till	40
23.2 m – 31.8 m	Till	100
N_{60}		37

The seismic site class is in general agreement with the City of Ottawa Seismic Site Classification Map From Combined Geological/Geophysical Data (published by Carleton University and Natural Resources Canada), which is attached in Appendix E. Data from the map suggests sites at the Ottawa Airport are typically classed as Site Class C or Site Class D.

6.7 CEMENT TYPE AND CORROSION POTENTIAL

Two representative soil samples (one from each borehole) were submitted to Paracel Laboratories Ltd. in Ottawa, Ontario, for pH, chloride, sulphate and resistivity testing. The test results are summarized in Table 6.3.

Table 6.3: pH, Sulphate, Chloride and Resistivity Analysis Results

Borehole/ Sample No.	pH	Sulphate	Resistivity	Chloride
BH11-1/ SS3	7.3	8 µg/g	117 ohm•m	<5 µg/g
BH11-2/ SS2	7.8	36 µg/g	82.4 ohm•m	9 µg/g

The soluble sulphate result indicates that a negligible degree of sulphate attack is expected for concrete in contact with the soil and groundwater. A normal Type GU Portland cement should, therefore, be suitable for use in concrete at this site.

The pH, resistivity and concentration of chloride are indicators of corrosion potential. These results should be considered when selecting protective coatings for buried steel objects.

7.0 CLOSURE

Use of this report is subject to the Statement of General Conditions provided in Appendix A. It is the responsibility of SNC-Lavalin Operations & Maintenance Inc., who is identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Stantec Consulting Ltd. should any of these not be satisfied. The Statement of General Conditions addresses the following:

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

This report has been prepared by Laura Bostwick and reviewed by Chris McGrath.

Respectfully submitted,

STANTEC CONSULTING LTD.

DRAFT

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APPENDIX A

Statement of General Conditions

STATEMENT OF GENERAL CONDITIONS

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

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

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

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

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

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

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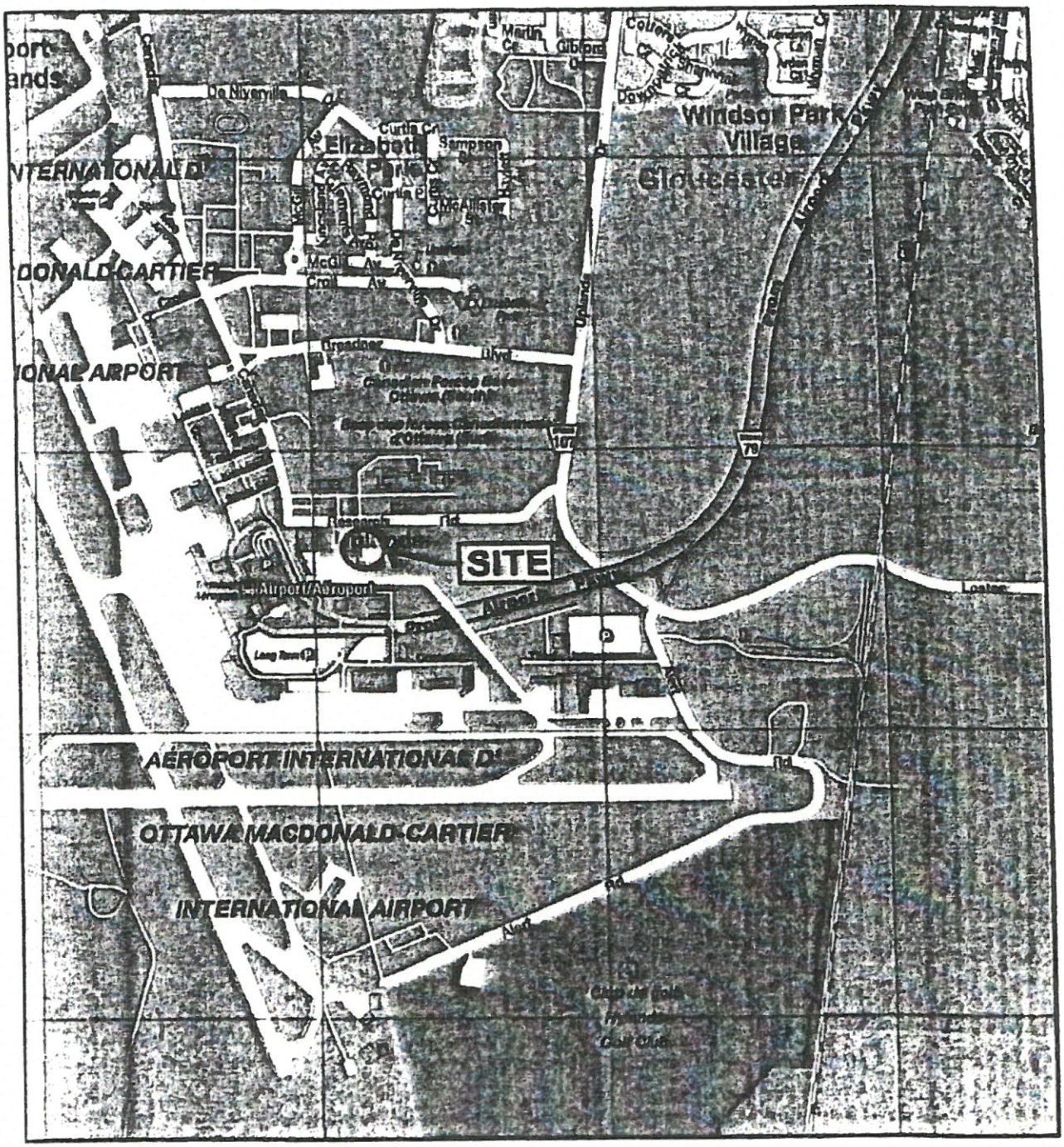
APPENDIX B

Key Plan

Borehole Location Plan



GRAPHIC SCALE

200 0 200 400 600 800 m

1 : 20 000

REFERENCE: MAP ART

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC CONSULTING LTD. REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

KEY PLAN

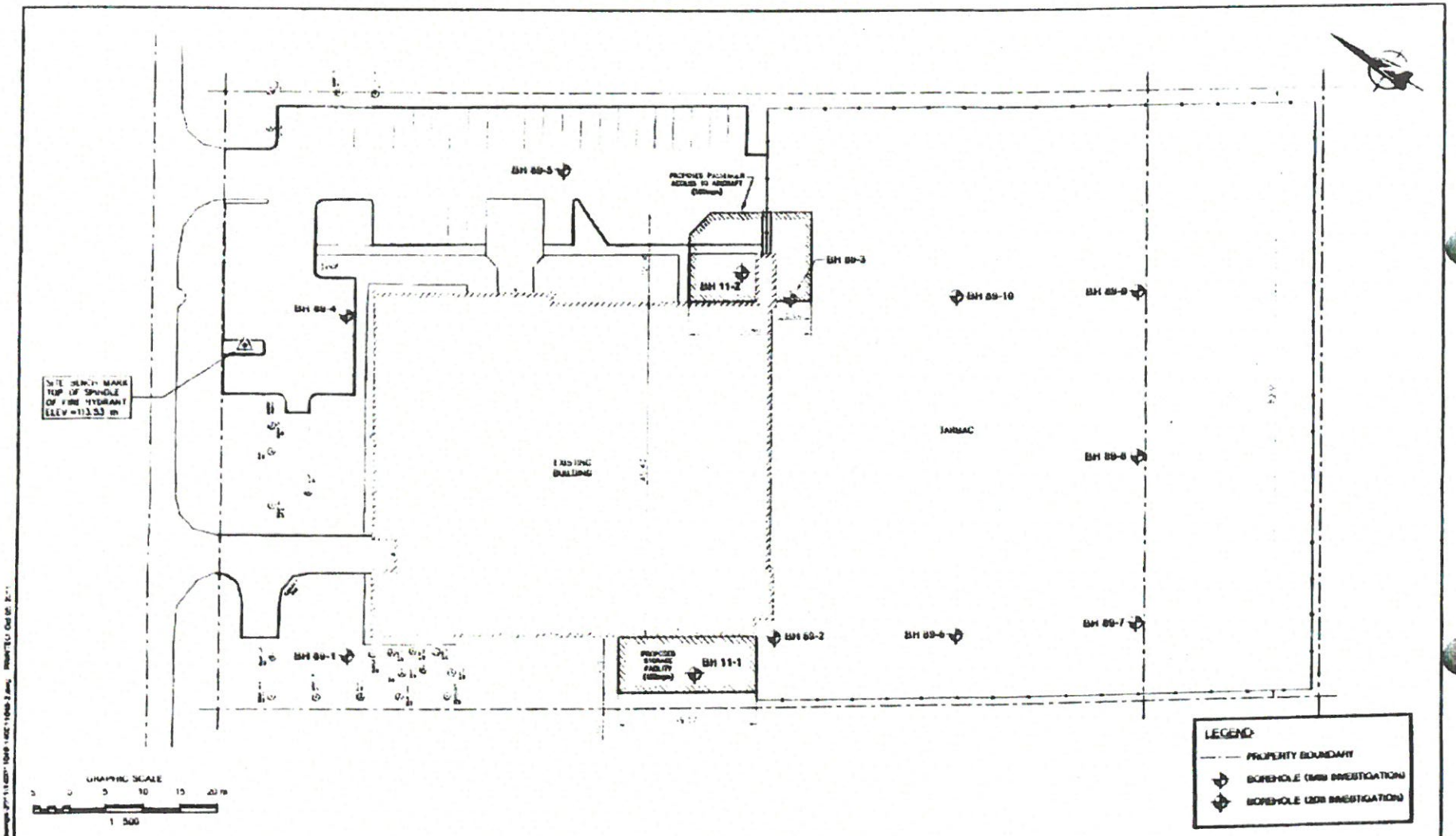
GEOTECHNICAL INVESTIGATION
RCMP AIR SERVICES HANGAR, OTTAWA, ONTARIO

Job No.:	140011048
Scale:	1 : 20 000
Date:	11/10/05
Dwn. By:	GBB
App'd By:	

Dwg. No.: 1

Client: SNC-LAVALIN E & M FOR PUBLIC WORKS AND GOVERNMENT SERVICES CANADA

Stantec



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Reference:	Job No.: 140011048 Scale: 1 : 500 Date: 11/10/06 Dwn. By: GBB App'd By:	Client: SNC LAVALIN O & M FOR PUBLIC WORKS AND GOVERNMENT SERVICES CANADA Site Address: RCMP AIR SERVICES HANGAR OTTAWA, ONTARIO	GEOTECHNICAL INVESTIGATION	BOREHOLE LOCATION PLAN	Dwg. No.: 2

APPENDIX C

Symbols and Terms Used on the Borehole Records

Borehole Records

Borehole Records from Jacques Whitford Limited 1989 Investigation

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

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

Terminology describing soil structure:

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

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

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

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

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

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

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

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

ROCK DESCRIPTION

Terminology describing rock quality:

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

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

Terminology describing rock mass:

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

Terminology describing rock strength:

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

Terminology describing rock weathering:

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

STRATA PLOT

Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.

Boulders, Cobbles, Gravel | Sand | Silt | Clay | Organics | Asphalt | Concrete | Fill | Igneous Bedrock | Metamorphic Bedrock | Sedimentary Bedrock

SIMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
WS	Wash sample
WQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

WATER LEVEL MEASUREMENT

measured in standpipe, piezometer, or well

inferred

RECOVERY

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

N VALUE

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

DYNAMIC CONE PENETRATION TEST (DCPT)

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

OTHER TESTS

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

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

Stantec

BOREHOLE RECORD

BH11-1

CLIENT SNC Lavalin O & M Inc.

LOCATION RCMP Air Services Hanger, Ottawa, ON

DATES: BORING September 29, 2011 WATER LEVEL

BOREHOLE No. BH11-1

PROJECT No. 140011048

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
0	113.00							
	112.6	430 mm TOPSOIL						
		FILL: Brown silty sand trace gravel			SS	1	500	13
1					SS	2	475	21
2					SS	3	475	7
3	109.9				SS	4	150	9
		Loose to dense grey silty SAND (SM) trace gravel			SS	5	475	5
4					SS	6	470	9
5					SS	7	475	22
6	106.9				SS	8	475	38
		Compact to dense brownish grey sandy SILT (ML) trace gravel			SS	9	520	11
7					SS	10	125	12
8					SS	11	560	22
	104.2							
9		Dense to very dense light brown silty SAND (SM) trace gravel			SS	12	465	47
10					SS	13	475	40

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS w_P w w_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

App'd

Date

STAN-GEO 140011048 - RCMP ASH HANGAR.GPJ SMART.GDT 10/6/11

Stantec BOREHOLE RECORD BH11-1

CLIENT SNC Lavalin O & M Inc. BOREHOLE No. BH11-1

LOCATION RCMP Air Services Hanger, Ottawa, ON PROJECT No. 140011048

DATES: BORING September 29, 2011 WATER LEVEL DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
10								
11		Compact to very dense light brown silty SAND (SM) trace gravel			SS	14	475	65
12	100.8			▽				
13		Dense brown poorly graded sand with silt and gravel (SP-SM), frequent cobbles and boulders, TILL			SS	15	375	47
14		-boulders						
15								
16	96.2							
17		End of borehole						
18								
19								
20								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS w_P w w_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m

STANDARD PENETRATION TEST, BLOWS/0.3m

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▽ Groundwater Level Measured in Standpipe

□ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

App'd

Date

STAN-GEO 140011048 - RCMP ASH HANGAR.GPJ SMART.GDT 12/06/11

Stantec

BOREHOLE RECORD

BH11-2

CLIENT SNC Lavalin O & M Inc.
BOREHOLE No. BH11-2
LOCATION RCMP Air Services Hanger, Ottawa, ON
PROJECT No. 140011048
DATES: BORING September 29, 2011 WATER LEVEL
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	ASPHALT PLUG	WATER LEVEL	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY (mm)	N-VALUE OR RQD
0	113.21							
	113.1	50 mm ASPHALT						
	112.6	FILL: Grey gravelly sand						
1		FILL: Brown to dark grey silty sand with gravel			SS	1	150	28
2					SS	2	450	27
3					SS	3	450	8
	109.7				SS	4	500	15
4		Loose to very dense orangey brown silty SAND (SM) with gravel			SS	5	450	9
5					SS	6	450	61
	107.9							
6		Compact to dense light brown silty SAND (SM) trace gravel			SS	7	450	34
					SS	8	450	14
7					SS	9	450	36
8					SS	10	450	39
9								
					SS	11	450	42
10								

UNDRAINED SHEAR STRENGTH - kPa
50 100 150 200
WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST, BLOWS/0.3m
STANDARD PENETRATION TEST, BLOWS/0.3m
10 20 30 40 50 60 70 80 90

Inferred Groundwater Level
Groundwater Level Measured in Standpipe

Field Vane Test, kPa
Remoulded Vane Test, kPa
Pocket Penetrometer Test, kPa

App'd
Date

STAN-GEO 140011048 - RCMP ASH HANGAR.GPJ SMART.GDT 10/6/11

Stantec

BOREHOLE RECORD

BH11-2

CLIENT SNC Lavalin O & M Inc.

LOCATION RCMP Air Services Hanger, Ottawa, ON

DATES: BORING September 29, 2011 WATER LEVEL

BOREHOLE No. BH11-2

PROJECT No. 140011048

DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY (mm)	N-VALUE OR RQD
10								
	102.5							
11		Compact to very dense brownish grey to brown silty SAND (SM) trace gravel			SS	12	420	45
12				▽	SS	13	420	25
13								
14					SS	14	450	29
15								
16					SS	15	500	16
17	95.9				SS	16	500	53
		Compact to dense grey poorly graded sand with silt and gravel (SP-SM), occasional cobbles and boulders, TILL						
18								
19					SS	17	150	29
20								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m

STANDARD PENETRATION TEST, BLOWS/0.3m

10 20 30 40 50 60 70 80 90

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

□ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

App'd

Date

STAN-GEO 140011048 - RCMP ASH HANGAR.GPJ SMART.GDT 10/06/11

Stantec BOREHOLE RECORD BH11-2

CLIENT SNC Lavalin O & M Inc.
LOCATION RCMP AirServices Hanger, Ottawa, ON
DATES: BORING September 29, 2011 WATER LEVEL

BOREHOLE No. BH11-2
PROJECT No. 140011048
DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY (mm)	SAMPLES N-VALUE OR RQD
20		Compact to dense grey poorly graded sand with silt and gravel (SP-SM), occasional cobbles and boulders, TILL			SS	18	200	16
21								
	91.3				SS	19	300	39
22		Start of Dynamic Penetration Test Inferred loose to very dense TILL						
23								
24								
25								
26								
27								
28								
29								
30								

UNDRAINED SHEAR STRENGTH - kPa
50 100 150 200
WATER CONTENT & ATTERBERG LIMITS w_P w w_L
DYNAMIC PENETRATION TEST, BLOWS/0.3m
STANDARD PENETRATION TEST, BLOWS/0.3m
10 20 30 40 50 60 70 80 90

145
108
254
165
220
190
110
100
92
107
113
124

▽ Inferred Groundwater Level
▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa
□ Remoulded Vane Test, kPa
△ Pocket Penetrometer Test, kPa

App'd
Date

STAN-GEO 140011048 - RCMP ASH HANGAR.GPJ SMART.GDT 10/06/11

Stantec BOREHOLE RECORD BH11-2

CLIENT SNC Lavalin O & M Inc. BOREHOLE No. BH11-2

LOCATION RCMP Air Services Hanger, Ottawa, ON PROJECT No. 140011048

DATES: BORING September 29, 2011 WATER LEVEL DATUM Geodetic

DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY (mm)	SAMPLES: N-VALUE OR RQD
30								
31		Inferred dense to very dense TILL						
32	81.2	End of borehole Note: Bottom 9 m of Dynamic Penetration Test rods were obsereved to be bent.						
33								
34								
35								
36								
37								
38								
39								
40								

UNDRAINED SHEAR STRENGTH - kPa

50 100 150 200

WATER CONTENT & ATTERBERG LIMITS w_P w w_L

DYNAMIC PENETRATION TEST, BLOWS/0.3m ★

STANDARD PENETRATION TEST, BLOWS/0.3m ●

10 20 30 40 50 60 70 80 90

135 148 182 220 236 260

▽ Inferred Groundwater Level

▼ Groundwater Level Measured in Standpipe

■ Field Vane Test, kPa

□ Remoulded Vane Test, kPa

△ Pocket Penetrometer Test, kPa

App'd

Date

STANGEO 140011048 - RCMP ASH HANGAR.GPJ SMART.GDT 10/06/11

BOREHOLE RECORD

BOREHOLE No 89-1

CLIENT Public Works Canada
LOCATION Proposed RCMP Hangar, Ottawa Airport
DATES BORING 1989-08-14 WATER LEVEL 1989-08-18

PROJECT No 0-19359
CASING SIZE Auger
DATUM Geodetic

DEPTH (FT)	DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY mm	SAMPLES N-VALUE OR ROD %	OTHER TESTS
	0	112.4								
			75mm ROOTMAT							
	1		Loose to compact, brown, sand, some silt and gravel, trace roots: FILL			SS	1	450	27	
	2					SS	2	425	18	S
	3					SS	3	600	5	
		108.9				SS	4	500	22	
	4		Compact, light brown, SAND, some silt, trace gravel							
	5					SS	5	550	22	
	6					SS	6	600	26	
	7									
	8					SS	7	600	24	
	9									
		102.6				SS	8	600	25	
			End of Borehole							

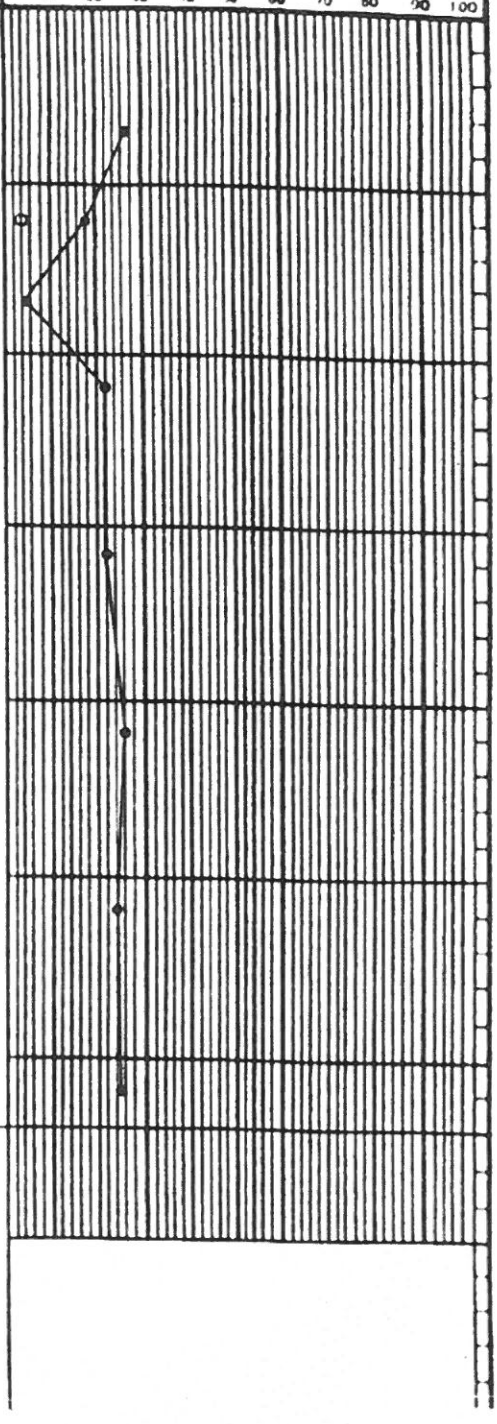
UNDRAINED SHEAR STRENGTH

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST

STANDARD PENETRATION TEST N VALUE

10 20 30 40 50 60 70 80 90 100



BOREHOLE RECORD

BOREHOLE No 89-2

CLIENT Public Works Canada

LOCATION Proposed RCMP Hanger, Ottawa Airport

PROJECT No 0-19359

DATES: BORING 1989-08-14 WATER LEVEL 1989-08-18

CASING SIZE Auger

DATUM Geodetic

DEPTH (FT)	DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY mm	SAMPLES N-VALUE OR RQD %	OTHER TESTS
	0	112.8								
			100mm ROOTMAT							
	1		Very loose to compact, brown, sand, some silt and gravel, trace roots: FILL			SS	1	600	10	
	2					SS	2	575	3	
	3	109.8				SS	3	250	9	
	4		Compact, light brown, SAND, some silt, trace gravel			SS	4	450	12	
	5					SS	5	600	23	
	6	106.8				SS	6	600	4	
	7		Very stiff, grey, SILTY CLAY							
	8	104.8				SS	7	600	5	
	9		Dense, light brown, SAND, some silt							
		103.8				SS	8	500	37	
	10		End of Borehole							

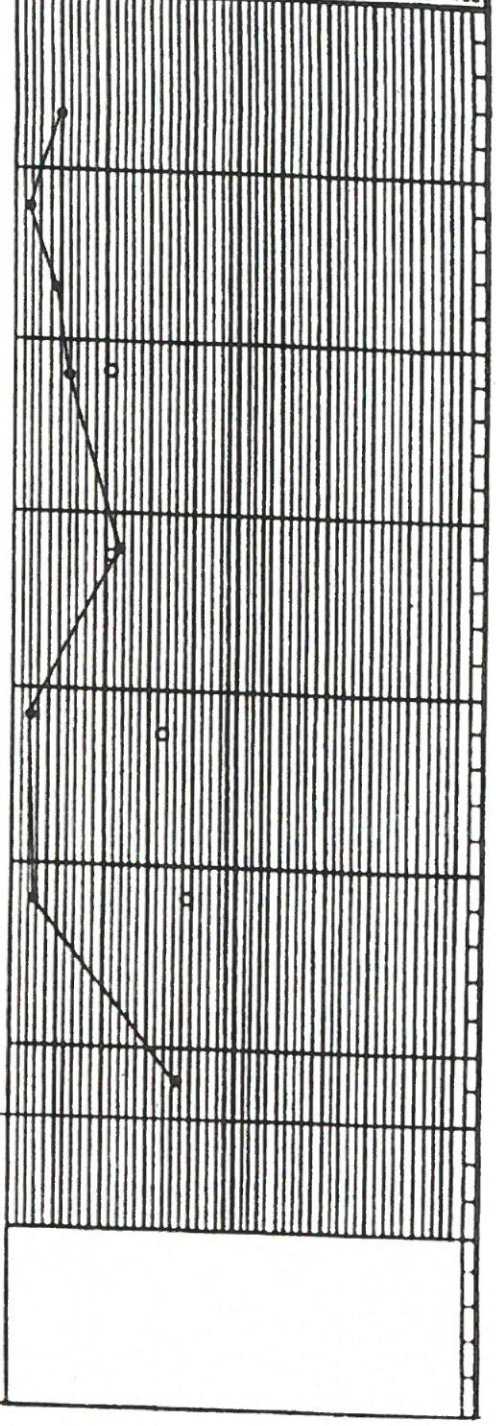
UNDRAINED SHEAR STRENGTH-

WATER CONTENT & ATTERBERG LIMITS Wp W WL

DYNAMIC PENETRATION TEST

STANDARD PENETRATION TEST N VALUE

10 20 30 40 50 60 70 80 90 100



BOREHOLE RECORD

BOREHOLE No 89-3

CLIENT Public Works Canada
LOCATION Proposed RCMP Hangar, Ottawa Airport
DATES: BORING 1989-08-14 WATER LEVEL --

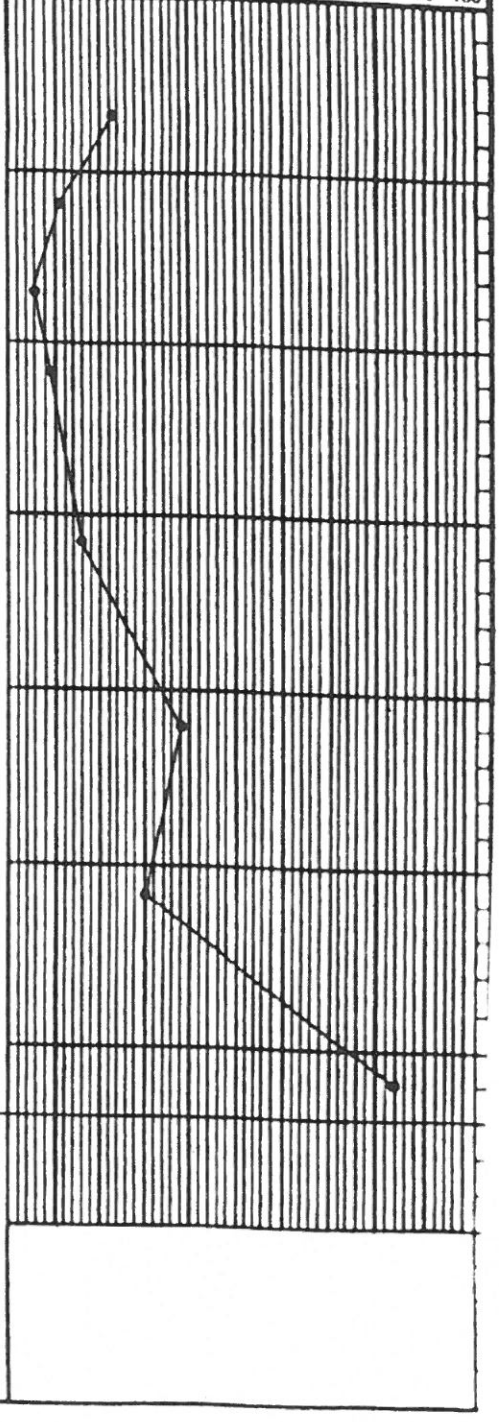
PROJECT No 0-19359
CASING SIZE Auger
DATUM Geodetic

DEPTH (FT)	DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY mm	SAMPLES N VALUE OR ROD %	OTHER TESTS
	0	112.7								
			100mm ROOTMAT							
	1		Loose to compact, brown, sand, some silt and gravel, trace roots: FILL			SS	1	500	23	
	2					SS	2	450	11	
						SS	3	600	6	
	3	109.6								
			Loose to compact, light brown, fine grained SAND, some silt, trace gravel			SS	4	525	9	
	4									
	5					SS	5	600	16	
		107.2								
	6		Dense to very dense, light brown, GRAVELLY SAND, trace silt			SS	6	500	39	
	7									
	8					SS	7	475	30	
	9									
		102.9				SS	8	150	84	
	10		End of Borehole							

UNDRAINED SHEAR STRENGTH-

WATER CONTENT & ATTERBERG LIMITS Wp W WL
DYNAMIC PENETRATION TEST
STANDARD PENETRATION TEST N VALUE

10 20 30 40 50 60 70 80 90 100



BOREHOLE RECORD

BOREHOLE No 89-4

CLIENT Public Works Canada

LOCATION Proposed RCMP Hangar, Ottawa Airport — PROJECT No. 0-19359

DATES: BORING 1989-08-14 — WATER LEVEL --- — CASING SIZE Auger — DATUM Geodetic

DEPTH (FT)	DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY mm	SAMPLES N VALUE OR RQD %	OTHER TESTS
	0	112.3	75mm ROOTMAT							
	1		Loose to compact, brown, gravelly sand some silt, trace roots: FILL			SS	1	400	15	
	2					SS	2	500	18	S
	3					SS	3	450	13	
	4	108.3				SS	4	450	4	
	5		Compact to dense, light brown, SAND some silt, trace gravel			SS	5	475	13	
	6					SS	6	600	22	
	7									
	8					SS	7	575	26	
	9									
	10	102.5	End of Borehole			SS	8	475	32	

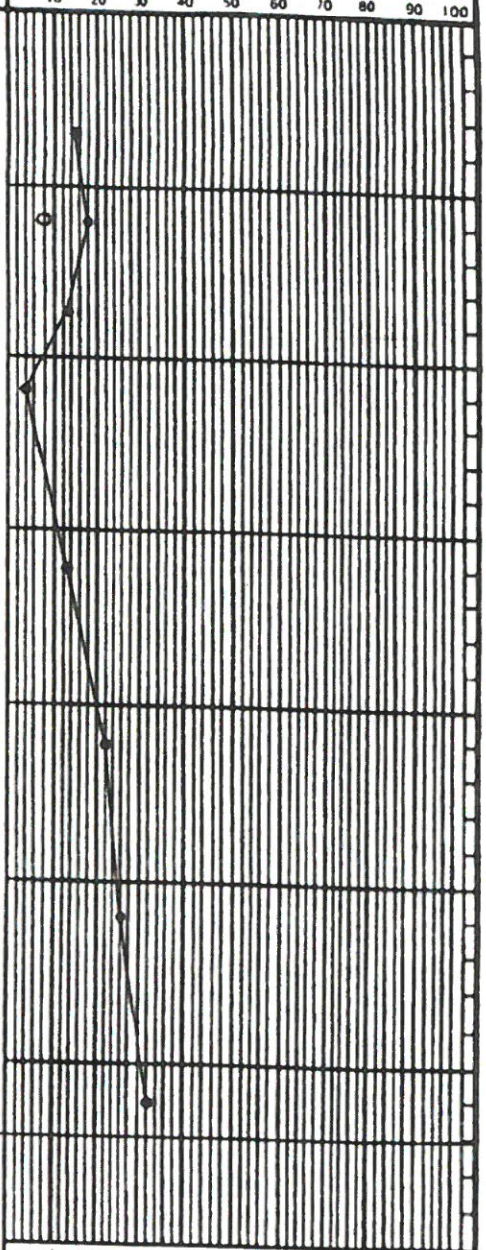
UNDRAINED SHEAR STRENGTH

WATER CONTENT & ATTERBERG LIMITS — Wp W WL

DYNAMIC PENETRATION TEST — X

STANDARD PENETRATION TEST N VALUE — ●

10 20 30 40 50 60 70 80 90 100



BOREHOLE RECORD

BOREHOLE No 89-5

CLIENT Public Works Canada
LOCATION Proposed RCMP Hangar, Ottawa Airport
DATES: BORING 1989-08-14 WATER LEVEL --

PROJECT No. 0-19359
CASING SIZE Auger
DATUM Geodetic

DEPTH (FT)	DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY mm	SAMPLES N-VALUE OR RQD %	OTHER TESTS
	0	112.5								
			50mm ROOTMAT			SS	1	500	11	
	1		Compact, brown, sand, some silt and gravel, occasional cobbles: FILL			SS	2	575	17	
	2	110.4				SS	3	600	26	
			End of Borehole							

UNDRAINED SHEAR STRENGTH

WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST
STANDARD PENETRATION TEST N-VALUE ●

10 20 30 40 50 60 70 80 90 100

BOREHOLE RECORD

BOREHOLE No 89-6

CLIENT Public Works Canada

LOCATION Proposed RCMP Hangar, Ottawa Airport — PROJECT No 0-19359

DATES: BORING 1989-08-15 — WATER LEVEL -- — CASING SIZE Auger — DATUM Geodetic

DEPTH (FT)	DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY mm	SAMPLES N VALUE OR RQD %	OTHER TESTS
	0	113.0								
			60mm TOPMAT			SS	1	150	47	
	1		Compact to dense, brown, sand, some silt and gravel, trace roots: FILL			SS	2	450	24	
	2	110.9				SS	3	450	19	
			End of Borehole							
	3									

UNDRAINED SHEAR STRENGTH

WATER CONTENT & ATTERBERG LIMITS Wp W WL

DYNAMIC PENETRATION TEST

STANDARD PENETRATION TEST N-VALUE ●

10 20 30 40 50 60 70 80 90 100

BOREHOLE RECORD

BOREHOLE No 89-7

CLIENT Public Works Canada

LOCATION Proposed RCMP Hangar, Ottawa Airport

DATES BORING 1989-08-14

WATER LEVEL --

PROJECT No 0-19359

CASING SIZE Auger

DATUM Geodetic

DEPTH (FT)	DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY	SAMPLES: N-VALUE OR ROD %	OTHER TESTS
	0	113.1						mm		
			50mm ROOTMAT			SS	1	450	18	
	1		Compact to dense, brown, sand, some silt and gravel, trace roots: FILL			SS	2	375	35	
	2	111.0				SS	3	400	15	
			End of Borehole							
	3									

UNDRAINED SHEAR STRENGTH-

WATER CONTENT & ATTERBERG LIMITS W_P W W_L

DYNAMIC PENETRATION TEST x

STANDARD PENETRATION TEST, N VALUE ●

10 20 30 40 50 60 70 80 90 100

BOREHOLE RECORD

BOREHOLE No 89-8

CLIENT Public Works Canada

LOCATION Proposed RCMP Hangar, Ottawa Airport

PROJECT No 0-19359

DATES: BORING 1989-08-14

WATER LEVEL --

CASING SIZE Auger

DATUM Geodetic

DEPTH (FT)	DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY mm	SAMPLES N VALUE OR ROD %	OTHER TESTS
	0	113.1								
			70mm ROOTMAT			SS	1	450	11	
	1		Compact to dense, brown, silty gravelly sand, trace roots: FILL			SS	2	475	90	S
	2	111.0				SS	3	475	19	
			End of Borehole							
	3									

UNDRAINED SHEAR STRENGTH

WATER CONTENT & ATTERBERG LIMITS Wp W WL

DYNAMIC PENETRATION TEST

STANDARD PENETRATION TEST N-VALUE ●

10 20 30 40 50 60 70 80 90 100

BOREHOLE RECORD

BOREHOLE No. 89-9

CLIENT Public Works Canada
LOCATION Proposed RCMP Hangar, Ottawa Airport
DATES: BORING 1989-08-14 WATER LEVEL --

PROJECT No. 0-19359
CASING SIZE Auger
DATUM Geodetic

DEPTH (FT)	DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY mm	SAMPLES N-VALUE OR RQD %	OTHER TESTS
	0	113.0								
			100mm ROOTMAT			SS	1	450	10	
	1		Compact to dense, brown, sand, some silt and gravel, trace roots: FILL			SS	2	325	48	
	2	110.9				SS	3	550	19	
			End of Borehole							
	3									

UNDRAINED SHEAR STRENGTH-

WATER CONTENT & ATTERBERG LIMITS W_P W W_L
DYNAMIC PENETRATION TEST
STANDARD PENETRATION TEST, N-VALUE

10 20 30 40 50 60 70 80 90 100

BOREHOLE RECORD

BOREHOLE No 89-10

CLIENT Public Works Canada

LOCATION Proposed RCMP Hangar, Ottawa Airport — PROJECT No. 0-19359

DATES. BORING 1989-08-14 — WATER LEVEL --- — CASING SIZE Auger — DATUM Geodetic

DEPTH (FT.)	DEPTH (m)	ELEVATION (m)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY mm	SAMPLES N-VALUE OR ROD %	OTHER TESTS
	0	112.8								
			75mm ROOTMAT			SS	1	500	11	
	1		Compact, brown, sand, some silt and gravel: FILL			SS	2	550	16	
	2	110.7				SS	3	550	15	
			End of Borehole							
	3									

UNDRAINED SHEAR STRENGTH.

WATER CONTENT & ATTERBERG LIMITS Wp W WL

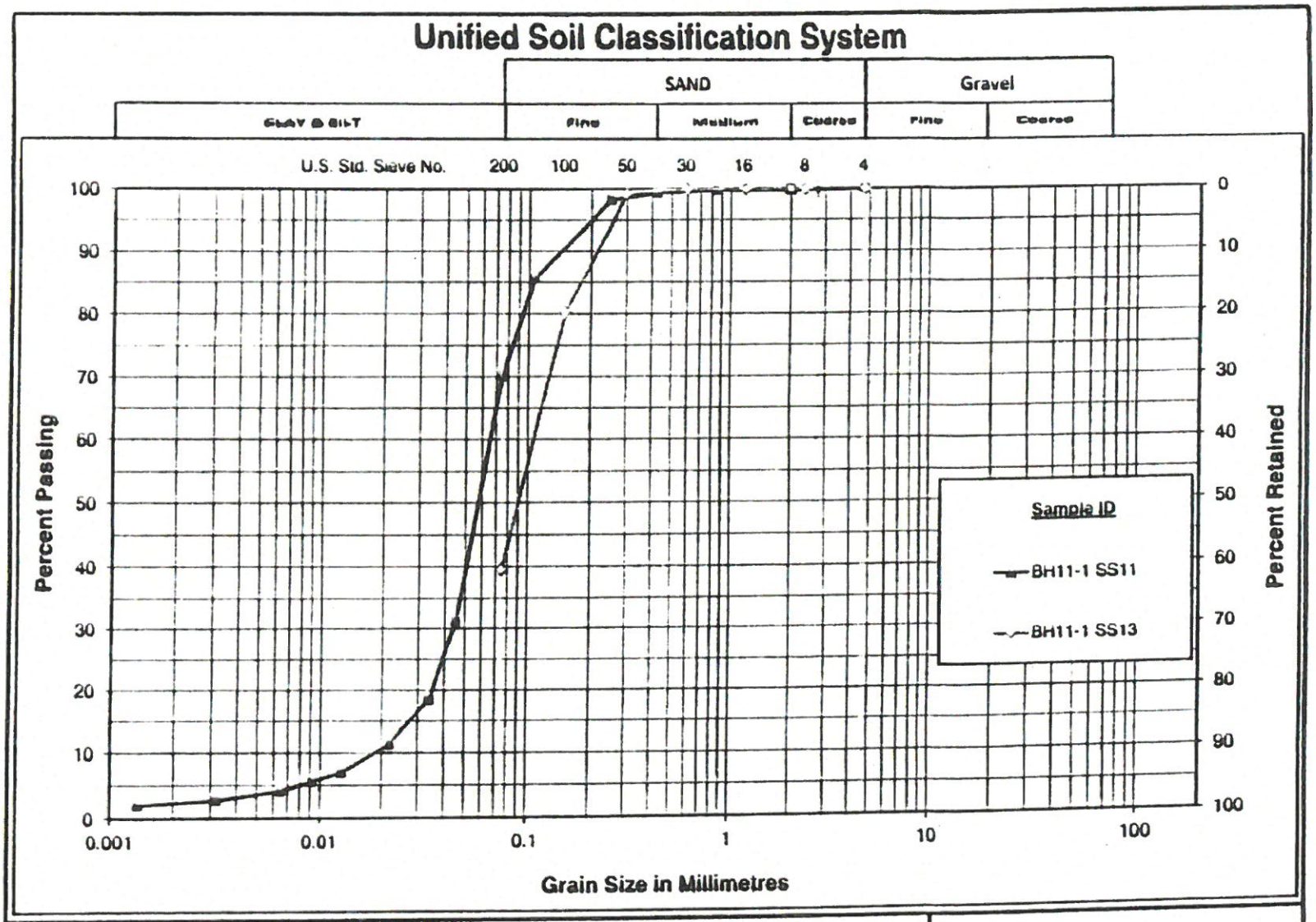
DYNAMIC PENETRATION TEST

STANDARD PENETRATION TEST, N-VALUE

10 20 30 40 50 60 70 80 90 100

APPENDIX D

Laboratory Test Results



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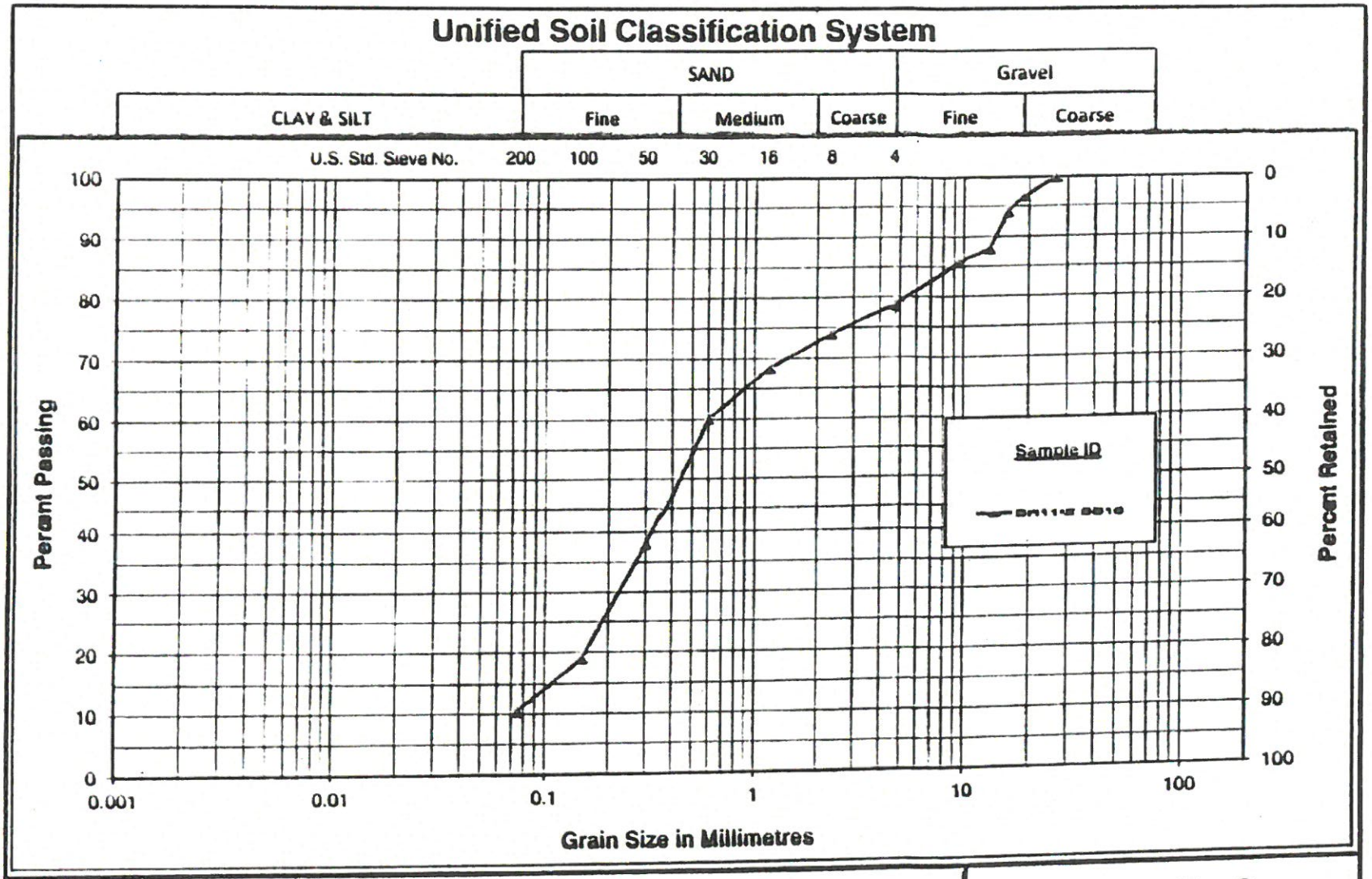
GRAIN SIZE DISTRIBUTION

Sandy SILT (ML) to Silty SAND (SM)

Figure No. 1

Project No. 140011048



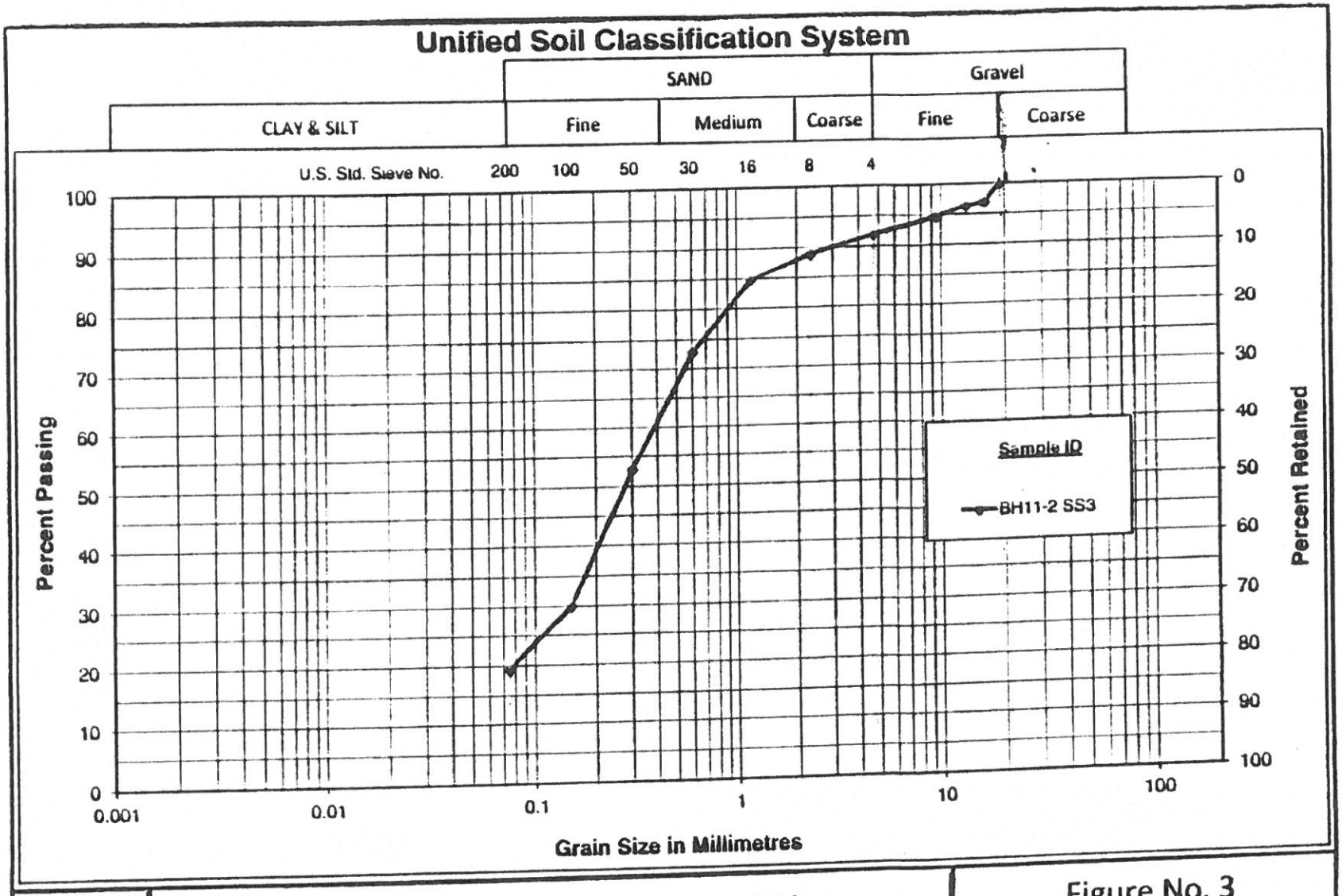
Stantec

GRAIN SIZE DISTRIBUTION

Poorly graded sand (SP-SM) with gravel and silt (TILL)

Figure No. 2

Project No. 140011048



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GRAIN SIZE DISTRIBUTION

FILL: Silty sand trace gravel

Figure No. 3

Project No. 140011048

APPENDIX E

2010 National Building Code Seismic Hazard Calculation

Factor of Safety Against Liquefaction (FSL) with Depth Profiles

City of Ottawa Seismic Site Classification Map From Combined Geological/Geophysical Data

2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 993-5838
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: Laura Bostwick, Stantec Consulting Ltd. October 05, 2011

Site Coordinates: 45.3287 North 75.664West

User File Reference: 2000 Research Rd, Ottawa, ON

National Building Code ground motions:
2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
0.633	0.308	0.137	0.048	0.323

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shearwave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. ***These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.088	0.247	0.384
Sa(0.5)	0.043	0.121	0.185
Sa(1.0)	0.017	0.055	0.087
Sa(2.0)	0.008	0.018	0.028
PGA	0.038	0.121	0.199

References

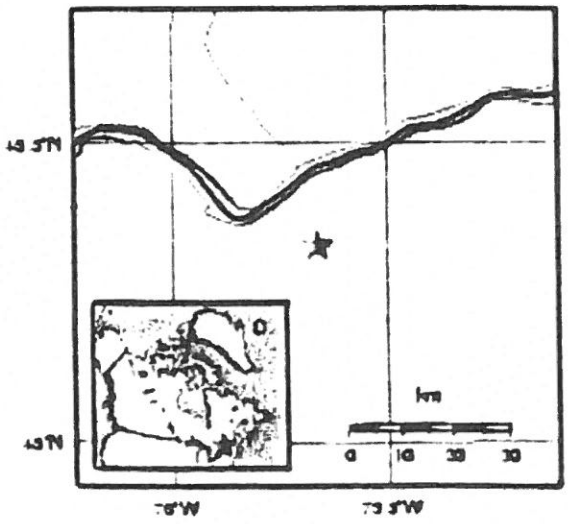
National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page 611 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. XXXXX (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

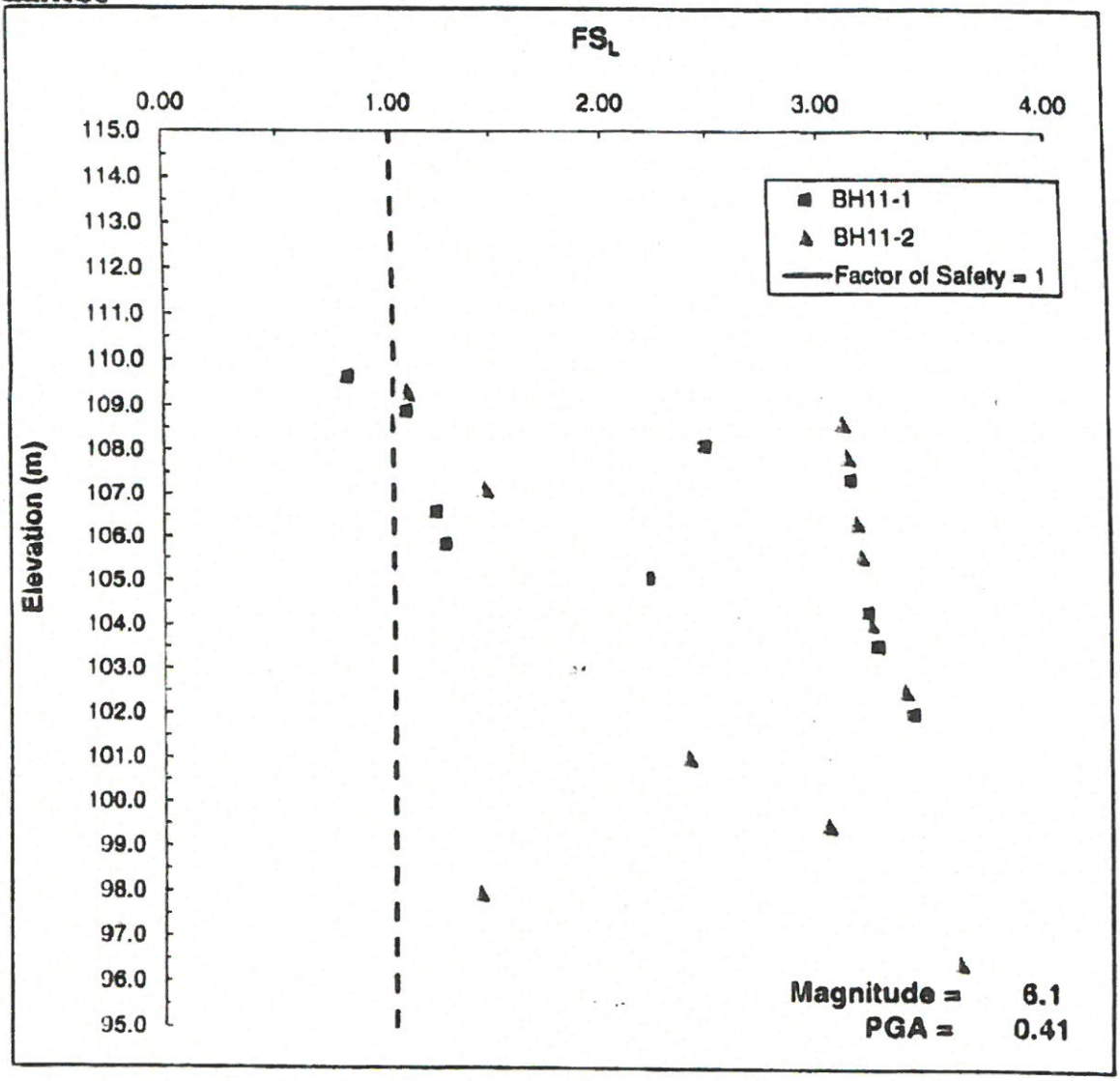
See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



Santec

CHARACTERIZATION OF LIQUEFACTION RESISTANCE

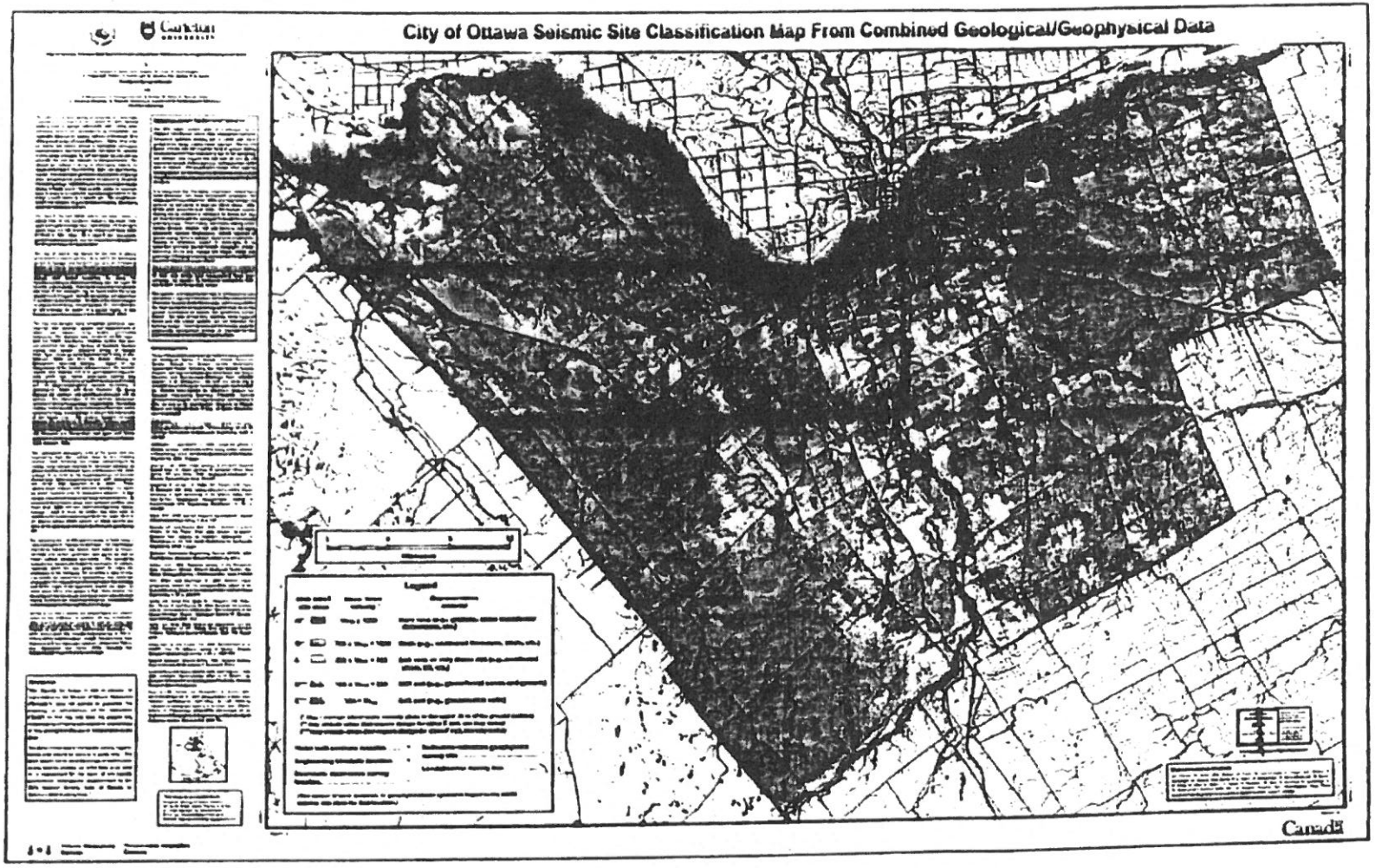


FS_L = Factor of Safety against Liquefaction

The Canadian Foundation Engineering Manual defines FS_L as the "soil deposit's cyclic resistance ratio (CRR)" divided by the "earthquake induced cyclic stress ratio (CSR)"

Assessment Method based on the Summary Report from the 1996 and 1998 NCEER/NSF Workshop on Evaluation of Liquefaction Resistance of Soils

Job No. 140011048


City of Ottawa Seismic Site Classification Map From Combined Geological/Geophysical Data
Canada