Public Works and Government Services Canada

Geotechnical Investigation for the Proposed Bowden Institution Building Development

Prepared by:

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Project Number:

60154500

Date:

July, 2010

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July 19, 2010

Bill Gagnon, CET
Project Manager
Public Works and Government Services Canada
5th Floor Telus Plaza North
10025 Jasper Avenue
Edmonton, AB T5J 1S6

Dear Mr. Gagnon:

Project No: **60154500**

Regarding: **Geotechnical Investigation for the Proposed Bowden Institution Building Development**

AECOM is pleased to submit our final report outlining the results and recommendations from the Geotechnical Investigation for the proposed Bowden Institution Building Development.

We thank you for the opportunity to complete this work on behalf of Public Works and Government Services Canada. Should you have any questions or require any additional information, please contact the undersigned at 780.486.7000.

Sincerely,
AECOM Canada Ltd.

Faris Alobaidy, M.Sc., P.Eng.
Senior Geotechnical Engineer
faris.alobaidy@aecom.com

SLM:slm

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	Faris Alobaidy	July 5, 2010	Draft
2	Faris Alobaidy	July 19, 2010	Final

AECOM Signatures

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PROFESSIONAL ENGINEER F. ALOBAIDY ALBERTA July 21, 2010

PERMIT TO PRACTICE
AECOM CANADA LTD.
Signature
Date July 21/10
PERMIT NUMBER: P10450
The Association of Professional Engineers, Geologists and Geophysicists of Alberta.

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1. Introduction

AECOM was retained by Public Works and Government Services Canada (PWGSC) to conduct an intrusive geotechnical investigation for the proposed expansion of minimum security housing units and an administration building within the Bowden Institution property. The Bowden Institution is located approximately 5 km north of the Town of Bowden, and just west of Highway 2, Alberta. The general site layout is included on Figure 1.0 in Appendix A.

The area investigated for the development is located near the existing low security housing units. It is our understanding that the proposed expansion will include the addition of a one-story administration building and multiple low-security residence buildings.

The purpose of geotechnical investigation was to assess the soil and groundwater conditions at the site and to provide geotechnical recommendations and preliminary design parameters for housing and administration building structures.

2. Methodology

2.1 Field Program

Three testholes were drilled (TH10-04 to 06) to a depth of 9.1 metres below ground surface (mBGS) at strategic locations within the area of the proposed development. The testholes were drilled using a track mounted solid stem auger drilling rig, which was contracted from Val's Drilling. The drilling took place on May 11, 2010. A site plan showing the proposed development and testhole locations are included as Figure 2.0 in Appendix A.

Soil samples were classified in the field by AECOM personnel using the Modified Unified Classification System for Soils. Standard Penetration Tests (SPT) were performed at regular intervals in each testhole. Distributed grab samples from auger cuttings and split spoon samples were obtained at select intervals.

Standard 25 mm diameter PVC pipe piezometers were installed in each testhole to assess groundwater conditions on the site. Along the length of the slotted section of pipe, the annulus was backfilled with sand, and the remaining section was backfilled with drill cuttings. A bentonite plug was placed at the surface to seal the testhole, minimizing infiltration of surface water. Lockable steel casings were installed to protect the well from damage.

Detailed information for the testholes and piezometer installation is shown on the testhole logs in Appendix B.

2.2 Laboratory Testing Program

The natural moisture content was determined for all samples retrieved from the testholes. Select samples were chosen for Atterberg Limits testing, Hydrometer grain size analysis and water soluble sulphate testing. The laboratory test results have been attached in Appendix C and a summary can be viewed in the testhole logs in Appendix B.

3. Subsurface Conditions

3.1 Soil Profile

The general soil profile at the proposed site consists of topsoil, overlying clay fill, overlying silt or clay. The following section describes the various soil types encountered on this site. More detailed soil descriptions can be found on the testhole logs provided in Appendix B.

3.1.1 Topsoil

Topsoil was encountered at ground surface in all of the testholes and varied in thickness from 360 to 760 mm. Moisture contents of the topsoil ranged from 24.5 to 35.9%. The thickness of the topsoil is expected to vary across the site.

3.1.2 Clay Fill

In testholes TH10-04 and TH10-05 clay fill was found directly below the topsoil at a depth of 0.76 and 0.36 mBGS, respectively. The clay fill layer varied from 0.85 to 1.05 m in thickness. The clay fill was silty, low plastic, moist and black to brown in colour. Trace organics and trace white inclusions were also found in select locations. Moisture contents of the clay fill ranged from 27.1 to 31.6%.

SPT ‘N” blow counts per 300 mm penetration were measured in the clay fill and found to be 4.0 indicating a soft consistency.

3.1.3 Silt

Silt was found underlying the clay fill in testholes TH10-04 and TH10-05 and directly underlying the topsoil in testhole TH10-06. The silt layer extended to the maximum depth of investigation of 9.1 mBGS. The silt is described as containing some clay to clayey, low plastic and very soft to soft. The silt was moist to wet with moisture content ranging from 25.1 to 35.8%. Most of the silt encountered was brown in colour with red and white inclusions. SPT “N” values ranged from 1 to 4 which indicating a very soft to soft in consistency. Thin clay and sand layers were noted within the silt stratum. A grain size analysis was conducted on a sample of the silt from TH10-06, and resulted in a particle size distribution of 0% gravel, 0% sand, 71.2% silt, and 28.8% clay. The silt had Atterberg liquid limits between 37.2 and 39.5%, and plastic limits between 14.4 and 17.8%.

3.2 Groundwater Conditions

Standpipes were installed in each of the testholes, to monitor groundwater conditions within the area. In testholes TH10-05 and TH10-06, the groundwater was noted at the completion of drilling. The groundwater levels in the standpipes were approximately 2.72 to 3.66 mBGS on May 25, 2010. In TH10-04, squeezing had occurred in the silt layers preventing a measurement of the groundwater upon completion of drilling. The testhole elevations are obtained relative to the elevation of an arbitrary point (northing and easting co-ordinates are 5762745 and 705882, respectively) located north of the entrance gate. The elevation of this point was assumed as 100.0 m.

Groundwater observations are summarized in Table 1.0 below, and standpipe details are provided on the testhole logs attached in Appendix B.

Table 1. Groundwater Level Observations

Testhole No.	Ground Elevation (m)	Groundwater Level Measurement (mBGS)		Groundwater Level Elevation (m)
		On Completion	May 25, 2010	
TH10-04	99.3	-	2.72	96.6
TH10-05	97.4	5.18	3.49	93.9
TH10-06	100.7	5.49	3.46	97.2

It should be noted that the groundwater level observations outlined above are relatively short term and may not be representative of stable groundwater conditions. Groundwater levels can vary in response to seasonal factors and precipitation and the actual groundwater conditions at the time of construction may vary from those recorded in this investigation. Further groundwater monitoring will be required prior to construction to confirm the actual groundwater conditions.

4. Geotechnical Recommendations

4.1 General

Based on the testhole logs, the general soil stratigraphy within the site consisted of 360 mm to 760 mm organic topsoil, overlying clay fill, overlying silt or clay. The silt and clay fill were found to be soft to very soft with SPT"N" values in the range of 1 to 4. Measured groundwater levels in the standpipes were approximately 2.72 to 3.46 mBGS.

Based on the field investigation results and laboratory testing program, the project is feasible from a geotechnical standpoint, and can be developed provided the recommendations presented in this report are incorporated in the design and construction of the project. The primary geotechnical concerns are:

- Site settlement due to the soft ground conditions; and
- Shallow groundwater.

The underlying soft clay fill and silt soils are not suitable for the support of the building structures by shallow spread footing foundations, as they would experience large settlement. Therefore, we recommend that the proposed structure be supported on driven piles along with a structurally supported ground floor.

The feasible pile types that could be considered include driven steel piles and straight shaft cast-in-place concrete piles; however, the suitability of straight shaft cast-in-place piles may not be feasible due to the presence of thick silt deposits and high groundwater levels. Driven precast concrete or continuous flight auger cast piles may also be considered for the site. Belled concrete piles are considered to be unsuitable at the site, due to relatively low allowable soil bearing pressures at the depths where bells could be formed.

Should any other foundation types be considered for this project, AECOM should be contacted to provide additional design parameters.

All recommendations presented in this report are based on the assumption that full time inspection, monitoring, and control testing are provided during construction, foundation installation, and site grading. Recommendations are provided for driven steel piles. The site preparation and foundation design parameters are discussed in the following sections.

4.2 Site Preparation

Topsoil, organics, fill materials, and any deleterious materials should be stripped and removed from within the building pad areas.

After stripping and cutting to design grade if required, the exposed surface should be scarified to a depth of 150 mm, moisture conditioned to 2% above optimum moisture content, and compacted to 98% of SPMDD. Proof-rolling should be performed to isolate any remaining soft spots within the building area. Soils from within any soft areas should be over-excavated to a depth of at least 600 mm or to a firm base, and backfilled to 98% of SPMDD using suitable engineered fill.

It is recommended to backfill the building areas to design grade, or to backfill over-excavated areas, using only suitable engineered fill comprised of low to medium plastic clay fill or granular fill, in order to reduce the risk of long-term swelling. The suitable engineered fill should be moisture conditioned to 2% above optimum moisture content and compacted to 100% of SPMDD in 150 mm thick compacted lifts.

4.3 Site Settlement Consideration

If new fills are placed for site grading, consolidation settlement of the soft soils will occur. The actual amount of settlement will depend on the thickness and weight of fill placed and thickness of the soft layer at the location of interest. Settlement analyses indicate that in the order of 150 mm and 205 mm of settlement will occur under 1 m to 1.5 m of new fill respectively, where the soft layer is about 8.4 m thick on the western portion of the site. Approximately 90% of the total settlement due to new fills will occur within 6 to 9 years.

4.4 Mitigation of Settlements

Several mitigation measures are available for reducing total and differential settlements of the site due to existing or new fills. We recommend keeping site grade as close to existing grade as possible. Excess soils from on-site excavations should be placed as landscape fills where settlement is not a concern.

Other mitigation measures for reducing total and differential site settlements include limiting the thickness of new fills, using light weight fill, and fill surcharging prior to construction. Due to the varying thickness of the soft layer, differential settlements of the ground surface will occur across the site. Differential settlement could cause structural distress, including cracking of pavement and concrete slabs on grade. In addition, consolidation of the soft layer and settlement of the overlaying fills will exert down drag loads on the piles.

Where placement of fills is necessary, light weight fill could be used to reduce future ground settlements. The most effective way to reduce future settlements due to fill placement would be to preconsolidate the site using a fill surcharge. The surcharging period could last anywhere between weeks to months. Vertical wick drains placed into the soft soil layer would facilitate water movement out of the soft soil thus reducing the surcharge period.

4.5 Building Foundation

It is anticipated the axial loads will be light to moderate, and therefore the use of friction type piles is envisaged. A variety of friction type piles may be considered including driven steel piles. Should any other foundation types be considered for this project, AECOM should be contacted to provide additional design parameters. For preliminary design purposes, driven steel piles may be designed and constructed according to the following recommendation:

- The steel piles may be designed based on skin friction only; and
- The skin friction values are shown in Table 2.

Table 2. Skin Friction Values for Driven Steel Piles

Depth (mBGS)	Ultimate Skin Friction (kPa)	Factored ULS Skin Friction in Compression (kPa)*
0 to 2.0	0	0
2.0 to 9.1	20	8

* *Using a resistance factor of 0.4*

- Skin friction should be neglected for the upper 2.0 m of the pile below grade to account for soil desiccation, or for the depth of fill, whichever is greater.
- The final depth of pile embedment will be determined based on applied building loads and uplift forces.
- For pipe piles, only the exterior surface area of the pile in contact with soil should be used in calculation of the frictional resistance.
- For steel H piles, the surface area should include the exterior sides of the two flanges plus twice the depth of the web.

- The vertical load capacity of the steel piles determined using the recommended shaft parameters should be limited to no more than the fibre stress of the steel, which should be determined by multiplying the cross sectional area of the steel by 0.35 f_y, where f_y is the yield strength of the steel.
- Steel piles should be driven with a piling hammer of appropriate size and rated energy, depending on the pile design load requirements, and can be determined using wave equation analysis.
- Preliminary sizing of hammers for steel piles should not be driven beyond practical refusal, which may be taken as 10 to 12 blows per 25 mm of penetration for the last 250 mm of penetration.
- The minimum allowable centre to centre pile spacing should be 3 pile diameters (3D).
- Heave of adjacent pile is a concern where groups of piles installed at about 3D spacing or less and should be monitored throughout the driving process. All piles indicating heave should be re-driven. When piles are re-driven, they should achieve additional penetration approximately equal to the amount of heave originally recorded.
- If piles are installed after placement of fill for raising grades, negative skin friction should be considered in determining the capacity of the pile. It is recommended that an average negative skin friction value of 3.5Z be used, where z is the thickness of the ground fill and soft soil in m.
- Monitoring of the pile installation by qualified personnel is recommended to verify that the piles are installed in accordance with design assumptions.
- The recommendations provided herein, for the design and construction of pile foundations should be reviewed and revised as required once final grade elevations and loading on the building have been identified and established.

4.5.1 Foundation Inspection

The performance of the foundations will depend on the quality of workmanship during construction. This is particularly important for foundation installations where variations in soil conditions could occur. Therefore, it is recommended that inspection be provided by experienced geotechnical personnel during foundation installation to confirm that the piles are installed in competent material and that stratigraphy is similar to that which has been assumed for the design.

4.6 Grade Beam

If pile foundations are used, grade beams are generally required to transfer wall loads to the top of the piles. To prevent heaving of the pile caps or the grade beams due to frost or swelling of the underlying soils, a compressible material with a maximum thickness of 100 mm should be considered, such as Ethaforms. The uplift pressure on the underside of the pile caps or the grade beams may be taken as the crushing strength of the compressible medium.

4.7 Grade-Supported Floor Slabs

The design of floor slabs will be dependent on final site grading plans and subgrade conditions at that level. The proposed slab-on-grade may be underlain by existing fill or soft silt soils which is not suitable for support of the slabs. Some settlements and cracking could result from differential settlements of the consolidation of soft soils. Consequently, we recommend that structural ground floor slabs be used for the proposed structures. If surcharging is used to mitigate post-construction settlements and the remaining settlements are within the tolerable limits, a slab-on-grade could be considered.

Specific recommendations for floor slabs will be provided once final grade elevations have been identified and established. However, the followings are preliminary recommendations for grade supported floor slabs:

- Excessive drying of the subgrade soils should be prevented to minimize the swelling potential.

- Insulation may be required underneath the floor slab if the building will not be heated. The insulation will help prevent frost penetration beneath the building and will reduce movement and settlement associated with freeze-thaw cycles.
- Floor slabs should rest on a minimum of 300 mm of well graded, free draining granular base compacted to 98% of the SPMDD at optimum moisture content. The granular base fill is best compacted with vibratory, smooth drum, compaction equipment.
- Interior partition walls resting on the floor slab should be designed to accommodate movements in the order of 20 mm. If interior partitions cannot tolerate these movements then consideration should be given to supporting the walls on independent foundations.
- Floor slab movements of approximately 1 to 2% of the fill thickness can still be expected for engineered fill greater than 2 m thick. Floor slab movement can be reduced by using granular fill. If the expected amount of movement cannot be tolerated, considerations should be given to using a structurally supported floor slab.
- Mechanical equipment placed on the slab-on-grade floor should be designed to permit some relevelling should the equipment be susceptible to small changes in level. Piping and electrical conduit connections should be laid out to permit some flexibility, as vertical movement of such equipment as water meters, furnaces and electric equipment may cause distress in the piping.
- Proper jointing is required to prevent shrinkage cracks. Heating ducts beneath floor slabs should be insulated with an appropriate thickness of rigid insulation to prevent drying and shrinking of the clay. If possible, water lines should not be placed beneath slab-on-grade floors. Wastewater lines beneath slab-on-grade floors should be of rigid plastic with cemented joints. Wastewater lines with butt joints and flexible rubber connections should not be permitted under the floor slab.
- Maintenance of exterior slabs should be anticipated where settlements are expected to occur.

4.8 Cement Type

The water-soluble sulphate content of a soil sample was determined in the laboratory. The test showed the presence of less than 0.5 mg/L water-soluble sulphate (SO4) content in the soil samples, indicating that there is no potential for sulphate attack on the subsurface concrete. It is recommended that additional soil samples to be tested during construction to confirm the cement type.

In addition, if imported material is required to be used at the site and will be in contact with concrete, it is recommended that the fill soil be tested for sulphate content to determine whether the above-stated recommendations remain valid.

4.9 Precaution to mitigate Frost Action

The native silt deposits are susceptible to frost action. Buried water lines should have a minimum frost cover of 3.3 m if granular backfill is used. For cohesive backfill including native deposits, the frost cover should be a minimum of 2.4 m. For construction below the groundwater table, dewatering of portions of the site may be necessary. Groundwater should be lowered to at least 600 mm below the bottom of excavation.

4.10 Excavation

All excavations should be carried out in accordance with Alberta Occupational Health and Safety Regulations (part 32). Excavations with temporary cut slopes should have side slopes no steeper than 3H:1V (horizontal:vertical) up to a maximum height of 3 m. Temporary slopes must not be left open unattended during construction downtime. If excessive seepage encountered or excavations are left open for extended periods of time, flatter side slopes or some form of shoring may be required to provide a safe work environment.

Temporary surcharge loads, such as excavated material, construction materials and equipment, should be placed such that the toe of the surcharge is at a minimum distance equal to the depth of the excavation. Vehicles delivering materials should be kept back from the edge of the excavation by at least one-half of the depth of the excavation. All excavations should be protected from surface runoff and checked regularly for signs of sloughing, especially after periods of precipitation. Small earth falls from the side slopes are a potential source of danger to workers and must be guarded against.

4.11 Grading and Drainage

Excess water should be drained from the site as quickly as possible, both during and after construction. The finished grade should be laid out so that surface waters are drained away from the buildings and other structures.

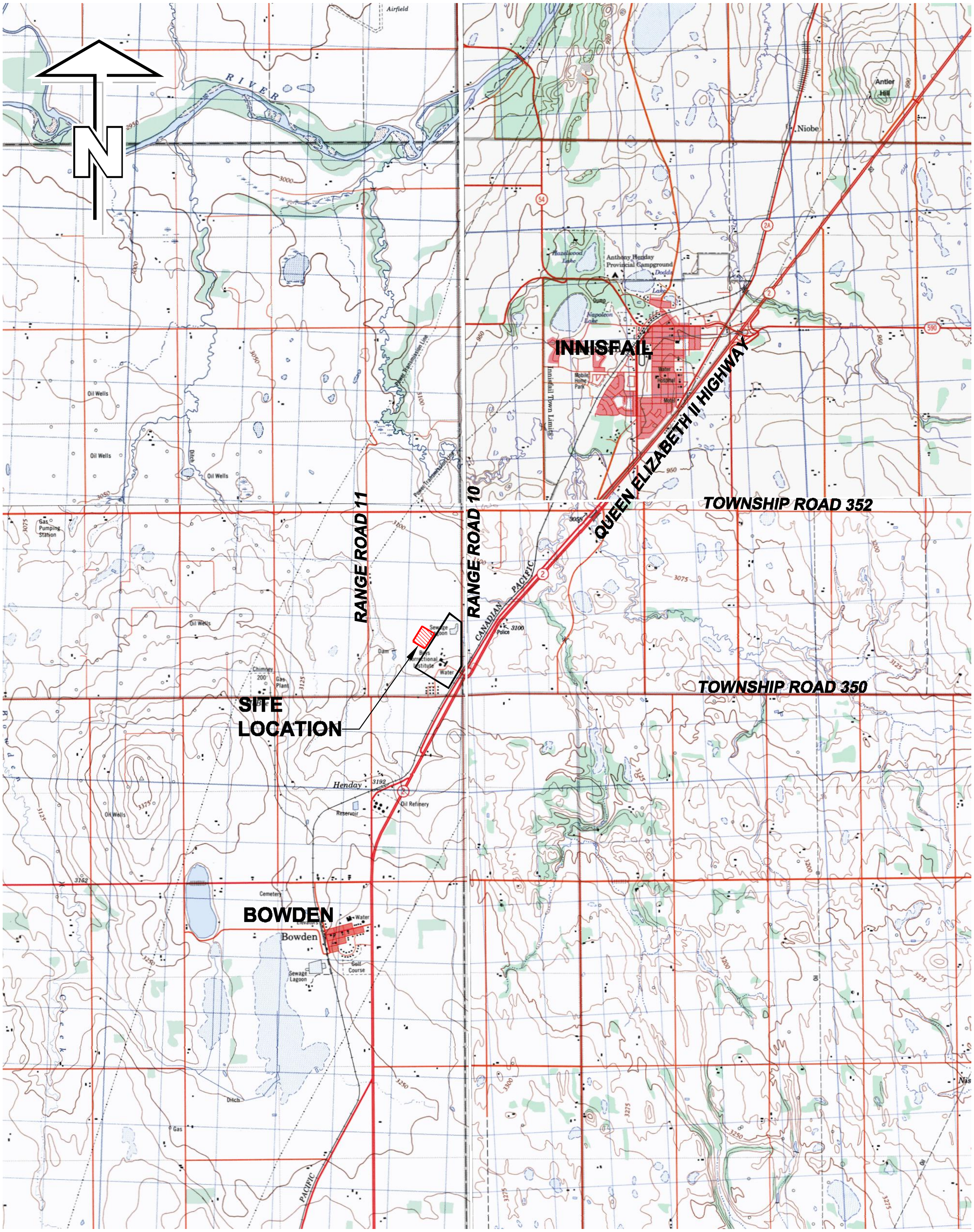
Considerable care should be taken where downspouts discharge onto hard surfaced areas (pavement or concrete) due to the high probability of ice forming in the winter. Within 2 m of the building perimeter, the hard surfacing (asphalt or concrete) should be graded to slope away from the building at a gradient of at least 3%. Landscaped areas should be graded at least 5% to promote runoff away from buildings. Asphalt or concrete surfaced areas should be provided with a minimum grade of 2% to promote runoff and minimize ponding.

4.12 Additional Geotechnical Investigation

Due to the soft soil conditions which extend up to the maximum depth of investigation of 9.1 m, a site specific design-phase geotechnical investigation is recommended to address foundation related design and construction issues. Two to three additional testholes at the proposed building locations should be advanced to a depth of 15 m to 20 m to confirm the thickness of soft soil within the site.

Appendix A

Figures



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LEGEND

BOWDEN INSTITUTION

SITE LOCATION

Public Works and Government Services Canada
Bowden Sewage Lagoon Study

Proposed Building Expansion
Site Location Plan
Figure 1.0

ISS/REV: 0A
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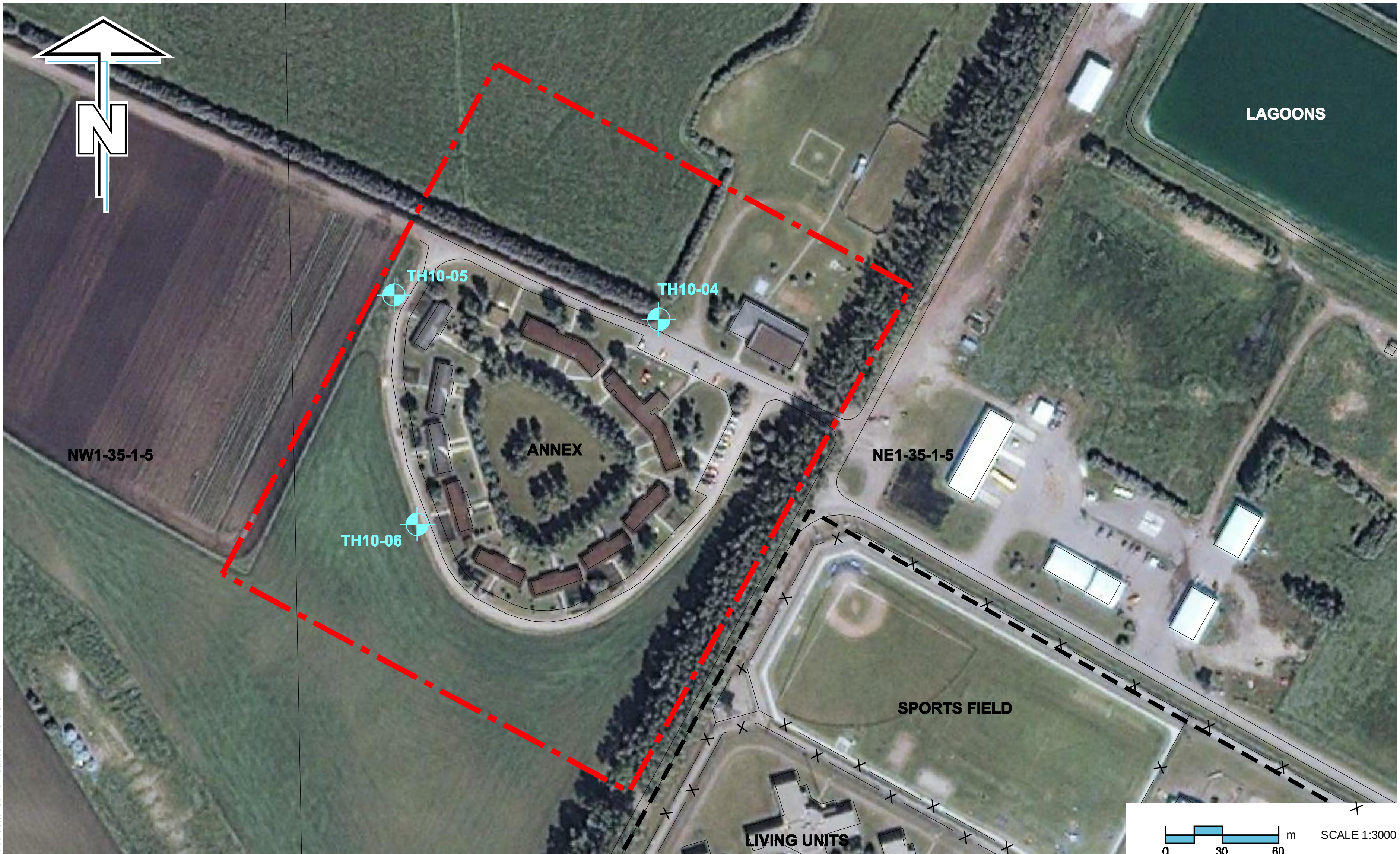


LEGEND

SITE BOUNDARY
MAIN INSTITUTION
TH10-XX APPROXIMATE TESTHOLE LOCATION

AECOM

Public Works and Government Services Canada
Bowden Sewage Lagoon Capacity Study

Proposed Building Expansion
Testhole Location Plan
Figure 2.0

Appendix B

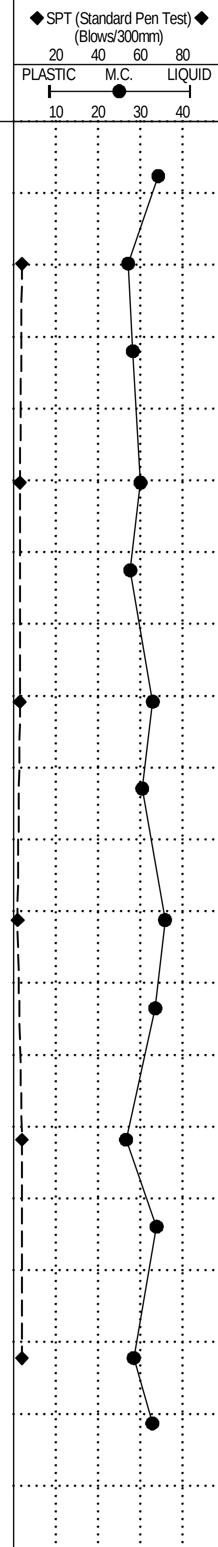
Testhole Logs, Modified Unified Classification System for Soils, Explanation of Field and Laboratory Test Data, and General Statement; Normal Variability Of Subsurface Conditions

PROJECT: Bowden Institution - Buildings	CLIENT: PWGSC	TESTHOLE NO.: TH10-04
LOCATION: Approximate Location N5762968 E0705278		PROJECT NO.: 60154500
CONTRACTOR: Val's Drilling	METHOD: Solid Stem Auger	ELEVATION (m): 99.3

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

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

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)
0	OL	TOPSOIL - organics, clayey, loose, moist, black	GRAB	1	
~0.75	FILL	CLAY FILL - silty, low plastic, soft, moist, mottled brown with trace white inclusions	SPLIT SPOON	2	4
			GRAB	3	
~1.8	ML	SILT - some clay, low plastic, soft, wet, brown	SPLIT SPOON	4	3
		- alternating clay layers approximetly 100 to 150 mm thick every 200 to 300 mm CLAY - silty, medium plastic, firm, moist, brown	GRAB	5	
			SPLIT SPOON	6	3
			GRAB	7	
			SPLIT SPOON	8	2
			GRAB	9	
		- firm	SPLIT SPOON	10	4
			GRAB	11	
		- grey - 100mm sand layer	SPLIT SPOON	12	4
			GRAB	13	
9.14		END OF TEST HOLE AT 9.14 mBGS - squeezing at 2.44 mBGS - no water above squeezing upon completion - groundwater measured at 2.72 mBGS on May 25, 2010.			



ELEVATION (m): 99, 98, 97, 96, 95, 94, 93, 92, 91, 90

COMMENTS

AECOM	LOGGED BY: CDN	COMPLETION DEPTH: 9.14 m
	REVIEWED BY: FA	COMPLETION DATE: 11/5/2010
	PROJECT ENGINEER: CDN	Page 1 of 1

LOG OF TESTHOLE 60154500 (BOWDEN INSTITUTION-BUILDINGS).GPJ UMA.GDT PRINT: 19/7/10 By:jalotak

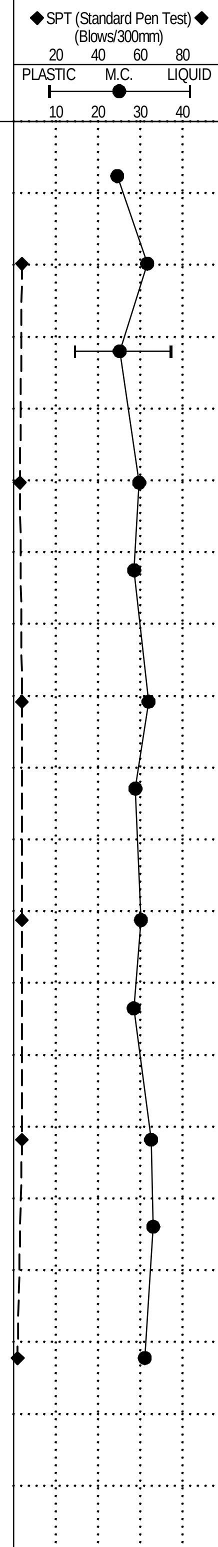
PROJECT: Bowden Institution - Buildings	CLIENT: PWGSC	TESTHOLE NO.: TH10-05
LOCATION: Approximate Location N5762981 E0705135		PROJECT NO.: 60154500
CONTRACTOR: Val's Drilling	METHOD: Solid Stem Auger	ELEVATION (m): 97.4

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

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

DEPTH (m)	USC	SOIL DESCRIPTION
0	OL	TOPSOIL - organics, clayey, moist, black
	FILL	CLAY FILL - some silt, trace organics, low plastic, firm, moist, black
1	ML	SILT - clayey, low plastic, soft, moist, brown
2		- wet
3		- alternating layers of clay approximetly 100-150 mm thick every 200 to 300 mm CLAY - silty, medium plastic, firm to stiff, wet, brown
4		- trace red inclusions
7		- 50mm sand layer
		- grey
8		- 50mm sand layer
9		END OF TESTHOLE AT 9.14 mBGS - water at 5.18 m BGS upon completion - squeezing at 6.10 mBGS - groundwater measured at 3.49 mBGS on May 25, 2010.

SAMPLE #	SAMPLE TYPE	SPT (N)
1	GRAB	
2	SPLIT SPOON	4
3	GRAB	
4	SPLIT SPOON	3
5	GRAB	
6	SPLIT SPOON	4
7	GRAB	
8	SPLIT SPOON	4
9	GRAB	
10	SPLIT SPOON	4
11	GRAB	
12	SPLIT SPOON	2
13	GRAB	



COMMENTS

ELEVATION (m): 97, 96, 95, 94, 93, 92, 91, 90, 89, 88

AECOM

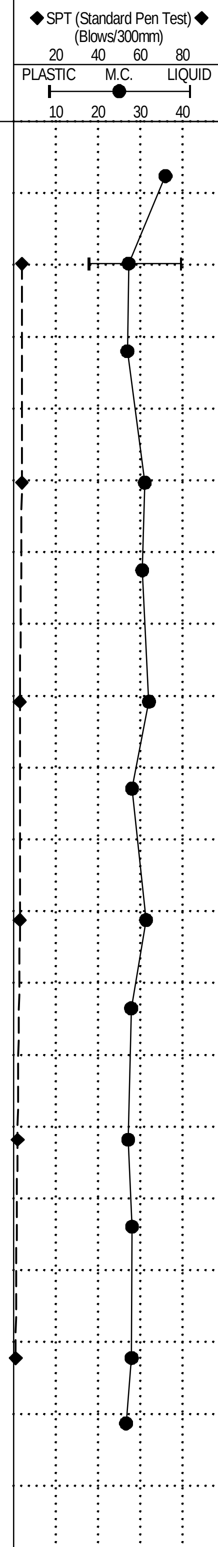
LOGGED BY: CDN	COMPLETION DEPTH: 9.14 m
REVIEWED BY: FA	COMPLETION DATE: 11/5/2010
PROJECT ENGINEER: CDN	Page 1 of 1

PROJECT: Bowden Institution - Buildings	CLIENT: PWGSC	TESTHOLE NO.: TH10-06
LOCATION: Approximate Location N5762852 E0705144		PROJECT NO.: 60154500
CONTRACTOR: Val's Drilling	METHOD: Solid Stem Auger	ELEVATION (m): 100.7

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

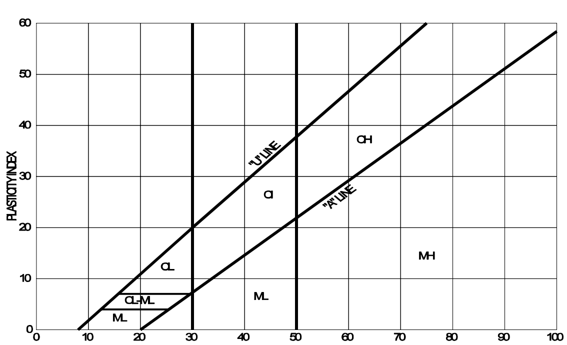
BACKFILL TYPE: BENTONITE, GRAVEL, SLOUGH, GROUT, CUTTINGS, SAND

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION (m)
0	OL	TOPSOIL - organics, clayey, moist, black	GRAB	1			
		SILT - clayey, low plastic, firm, moist, brown					100
1			SPLIT SPOON	2	4		
		- trace white inclusions	GRAB	3		Gravel - 0.0% Sand - 0.0% Silt - 71.2% Clay 28.8%	99
2		- wet	SPLIT SPOON	4	4		98
3		- alternating clay layers approximetly 150 to 200 mm thick every 200 to 300 mm	GRAB	5			
		CLAY - silty, medium plastic, firm, wet, brown					97
4			SPLIT SPOON	6	3		
			GRAB	7			96
5	ML		SPLIT SPOON	8	3		95
6		- trace orange inclusions	GRAB	9			94
7		- soft	SPLIT SPOON	10	2		
			GRAB	11			93
8		- 50mm sand layer					
		- grey, very soft	SPLIT SPOON	12	1		92
9		- staurated	GRAB	13			
		END OF TESTHOLE AT 9.14 mBGS - water at 5.49 mBGS upon completion - squeezing at 6.10 mBGS - groundwater measured at 3.46 mBGS on May 25, 2010.					91
10							



AECOM	LOGGED BY: CDN	COMPLETION DEPTH: 9.14 m
	REVIEWED BY: FA	COMPLETION DATE: 11/5/2010
	PROJECT ENGINEER: CDN	Page 1 of 1

MAJOR DIVISION			LOG SYMBOLS	MUCS	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED	GRAVELS (MORE THAN HALF COARSE GRAINS LARGER THAN 4.75 mm)	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL GRADED GRAVELS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 4$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
				GP	POORLY GRADED GRAVELS AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW 'A' LINE W_P LESS THAN 4
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE 'A' LINE W_P MORE THAN 7
	SANDS (MORE THAN HALF COARSE GRAINS SMALLER THAN 4.75 mm)	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 6$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
				SP	POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW 'A' LINE W_P LESS THAN 4
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE 'A' LINE W_P MORE THAN 7
FINE GRAINED SOILS	SILTS (BELOW 'A' LINE NEGLIGIBLE ORGANIC CONTENT)	$W_L < 50$		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)	
		$W_L > 50$		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS		
	CLAYS (ABOVE 'A' LINE NEGLIGIBLE ORGANIC CONTENT)	$W_L < 30$		CL	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS		
		$30 < W_L < 50$		CI	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS		
		$W_L > 50$		CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS (BELOW 'A' LINE)	$W_L < 50$		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY		
		$W_L > 50$		OH	ORGANIC CLAYS OF HIGH PLASTICITY	WHENEVER THE NATURE OF THE FINE CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER 'F'. E.G. SF IS A MIXTURE OF SAND WITH SILT OR CLAY	
HIGHLY ORGANIC SOILS				Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBROUS TEXTURE	
BEDROCK				BR	SEE REPORT DESCRIPTION		



SOIL COMPONENTS

FRACTION		SIEVE SIZE (mm) PASSING	SIEVE SIZE (mm) RETAINED	DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS: PERCENT	IDENTIFIER
GRAVEL	COARSE FINE	75 19	19 4.75	50 - 35	AND
SAND	COARSE MEDIUM FINE	4.75 2.00 0.425	2.00 0.425 0.080	35 - 20	___Y
				20 - 10	SOME
SILT (non plastic) or CLAY (plastic)		0.080		10 - 1	TRACE

OVERSIZE MATERIALS

ROUNDED OR SUBROUNDED	ANGULAR
COBBLES 75 mm to 200 mm BOULDERS > 200 mm	ROCK FRAGMENTS > 75 mm ROCKS > 0.75 m^3 IN VOLUME

NOTE:
1. BOUNDARY CLASSIFICATION POSSESSING CHARACTERISTICS OF TWO GROUPS ARE GIVEN GROUP SYMBOLS, E.G. GW-GC IS A WELL GRADED GRAVEL MIXTURE WITH CLAY BINDER BETWEEN 5% AND 12%

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

JUNE, 1995

1.0 Explanation of Field and Laboratory Test Data

The field and laboratory test results, as shown on the logs, are briefly described below.

1.1 Natural Moisture Content and Atterberg Limits

The relationship between the natural moisture content and depth is significant in determining the subsurface moisture conditions. The Atterberg Limits for a sample should be compared to the natural moisture content and should be on the Plasticity Chart in order to determine their classification.

1.2 Soil Profile and Description

Each soil strata is classified and described noting any special conditions. The Modified Unified Soils Classification System (MUSCS) is used. The soil profile refers to the existing ground level. When available, the existing ground elevation is shown. The soil symbols used are shown in detail on the soil classification chart.

1.3 Tests on Soil Samples

Laboratory and field tests on the logs are identified by the following:

N (Standard Penetration Test (SPT) Blow Count) - The SPT is conducted in the field to assess the in situ consistency of cohesive soils and the relative density of non-cohesive soils. The N value recorded is the number of blows from a 63.5 kg hammer dropped 760 mm which is required to drive a 51 mm split spoon sampler 300 mm into the soil.

SO_4 (Water Soluble Sulphate Content) - Conducted primarily to determine requirements for the use of sulphate resistant cement. Further details on the water soluble sulphate content are given in Section 1.6.

γ_D (Dry Unit Weight) kN/m^3 and γ_T (Total Unit Weight) kN/m^3.

Q_U (Unconfined Compressive Strength) kPa - May be used in determining allowable bearing capacity of the soil.

C_U (Undrained Shear Strength) kPa - This value is determined by an unconfined compression test and may also be used in determining the allowable bearing capacity of the soil.

C_{PEN} (Pocket Penetrometer Reading) kPa - Estimate of the undrained shear strength as determined by a pocket penetrometer.

The following tests may also be performed on selected soil samples and the results are given on the borehole logs: Grain Size Analysis; Standard or Modified Proctor Compaction Test; California Bearing Ratio; Unconfined Compression Test; Permeability Test; Consolidation Test; Triaxial Test

1.4 SOIL DENSITY AND CONSISTENCY

Table 1.1 Cohesive Soils		
N	**Consistency**	**C_U (kPa) (approx.)**
0 - 1	Very Soft	<10
1 - 4	Soft	10 - 25
4 - 8	Firm	25 - 50
8 - 15	Stiff	50 - 100
15 - 30	Very Stiff	100 - 200
30 - 60	Hard	200 - 300
>60	Very Hard	>300

The SPT test described above may be used to estimate the consistency of cohesive soils and the density of cohesionless soils. These approximate relationships are summarized in the following tables:

Table 1.2 Cohesionless Soils	
N	**Density**
0 - 5	Very Loose
5 - 10	Loose
10 - 30	Compact
30 - 50	Dense
>50	Very Dense

1.5 SAMPLE CONDITION AND TYPE

The depth, type, and condition of samples are indicated on the borehole logs by the following symbols:

■	Grab Sample	▤	A-Casing
◿	Shelby Tube	▥	No Recovery
☒	SPT Sample	▌	Core Sample

1.6 WATER SOLUBLE SULPHATE CONCENTRATION

The following table has been adapted from Tables 2 and 3 of the CSA Standard A23.1-09. The table indicates the class of exposure for concrete subjected to sulphate attack based upon the percentage of water soluble sulphate as presented on the borehole logs. It is intended that CSA Standard A23.1-09 be read in conjunction with this table.

Table 1.3
Concrete Subjected to Sulphate Attack – Class of Exposure

Class of Exposure	Degree of Exposure	Water-Soluble Sulphate (SO_4) in Soil Sample %
S-1	Very severe	over 2.0
S-2	Severe	0.20 - 2.0
S-3	Moderate	0.10 - 0.20

Refer to A23.1-09 Tables 2 and 3 for requirements for concrete subject to sulphate attack.

1.7 GROUNDWATER TABLE

The groundwater table is indicated by the equilibrium level of standing water in a standpipe installed in a borehole. This level is generally taken at least 24 hours after installation of the standpipe. The groundwater level is subject to seasonal variations and its highest level usually occurs in spring. The symbol on the borehole logs indicating the groundwater level is an inverted solid triangle (▼).

AECOM Canada Ltd.

General Statement; Normal Variability Of Subsurface Conditions

The scope of the investigation presented herein is limited to an investigation of the subsurface conditions as to suitability of the site for the proposed project. This report has been prepared to aid in the general evaluation of the site and to assist the design engineer in the conceptual design for the area. The description of the project presented in this report represents the understanding by the geotechnical engineer of the significant aspects of the project relevant to the design and construction of the subdivision, infrastructure and similar. In the event of any changes in the basic design or location of the structures, as outlined in this report or plan, AECOM should be given the opportunity to review the changes and to modify or reaffirm in writing the conclusions and recommendations of this report.

The analysis and recommendations represented in this report are based on the data obtained from the test holes drilled at the locations indicated on the site plans and from other information discussed herein. This report is based on the assumption that the subsurface conditions everywhere on the site are not significantly different from those encountered at the test locations. However, variations in soil conditions may exist between the test holes and, also, general groundwater levels and condition may fluctuate from time to time. The nature and extent of the variations may not become evident until construction. If subsurface conditions, different from those encountered in the test holes are observed or encountered during construction or appear to be present beneath or beyond the excavation, AECOM should be advised at once so that the conditions can be observed and reviewed and the recommendations reconsidered where necessary.

Since it is possible for conditions to vary from those identified at the test locations and from those assumed in the analysis and preparation of recommendations, a contingency fund should be included in the construction budget to allow for the possibility of variations which may result in modifications of the design and construction procedures.

Appendix C

Laboratory Results

ATTERBERG
(ASTM D4318-98)

AECOM

MATERIALS LABORATORY
AECOM
99 Commerce Dr., Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 **fax** (204) 284-2040

JOB No.:	60154500
CLIENT:	PWGSC
PROJECT:	Bowden Institution
LOCATION:	

DATE:	19-May-10
TEST HOLE:	TH-10-05
SAMPLE:	G3
DEPTH:	5.0'
TECH.:	BR

Liquid Limit

WATER CONTENT

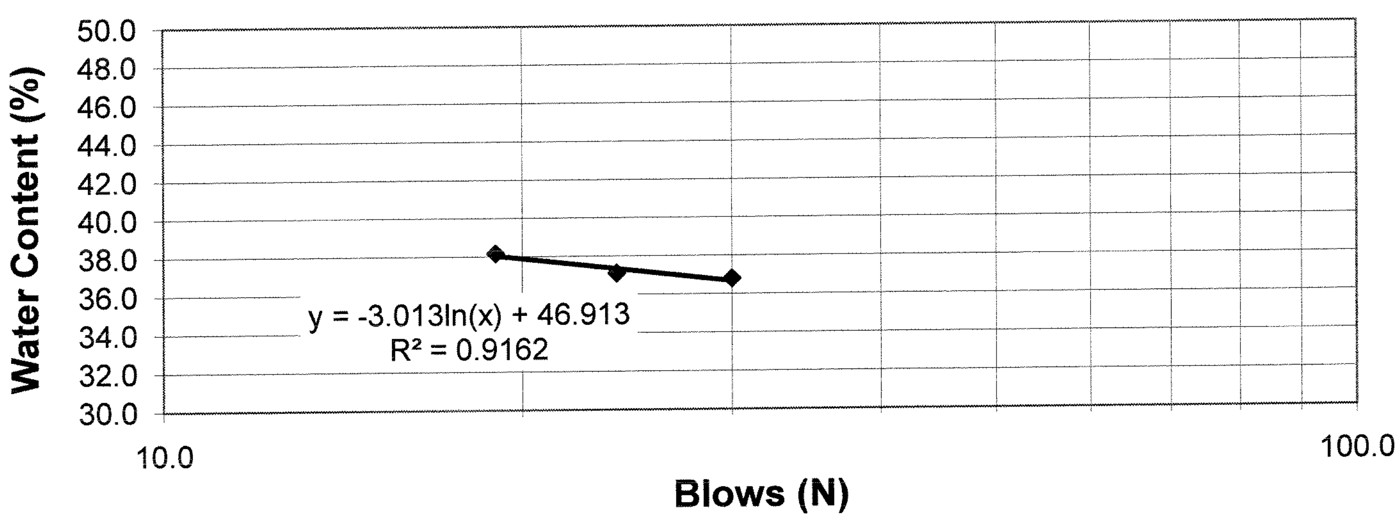
Blows	30	24	19		
WT. SAMPLE WET + TARE (gr)	122.567	124.591	119.232		
WT. SAMPLE DRY + TARE (gr)	120.612	122.187	116.992		
WT. TARE (gr)	115.298	115.707	111.122		
WT. WATER (gr)	1.955	2.404	2.240		
WT. DRY SOIL (gr)	5.314	6.480	5.870		
MOISTURE CONTENT (%)	36.790	37.099	38.160		

Plastic Limit

WATER CONTENT

WT. SAMPLE WET + TARE (gr)	122.222	121.185			
WT. SAMPLE DRY + TARE (gr)	121.518	120.470			
WT. TARE (gr)	116.672	115.429			
WT. WATER (gr)	0.704	0.715			
WT. DRY SOIL (gr)	4.846	5.041			
MOISTURE CONTENT (%)	14.527	14.184			

LIQUID LIMIT



Liquid Limit =	37.2	Plastic Limit =	14.4	Plasticity Index =	22.9

ATTERBERG
(ASTM D4318-98)

MATERIALS LABORATORY
AECOM
99 Commerce Dr., Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 **fax** (204) 284-2040

JOB No.:	60154500
CLIENT:	PWGSC
PROJECT:	Bowden Institution
LOCATION:	

DATE:	20-May-10
TEST HOLE:	TH10-06
SAMPLE:	S2
DEPTH:	2.5 - 4.0'
TECH.:	JG

Liquid Limit

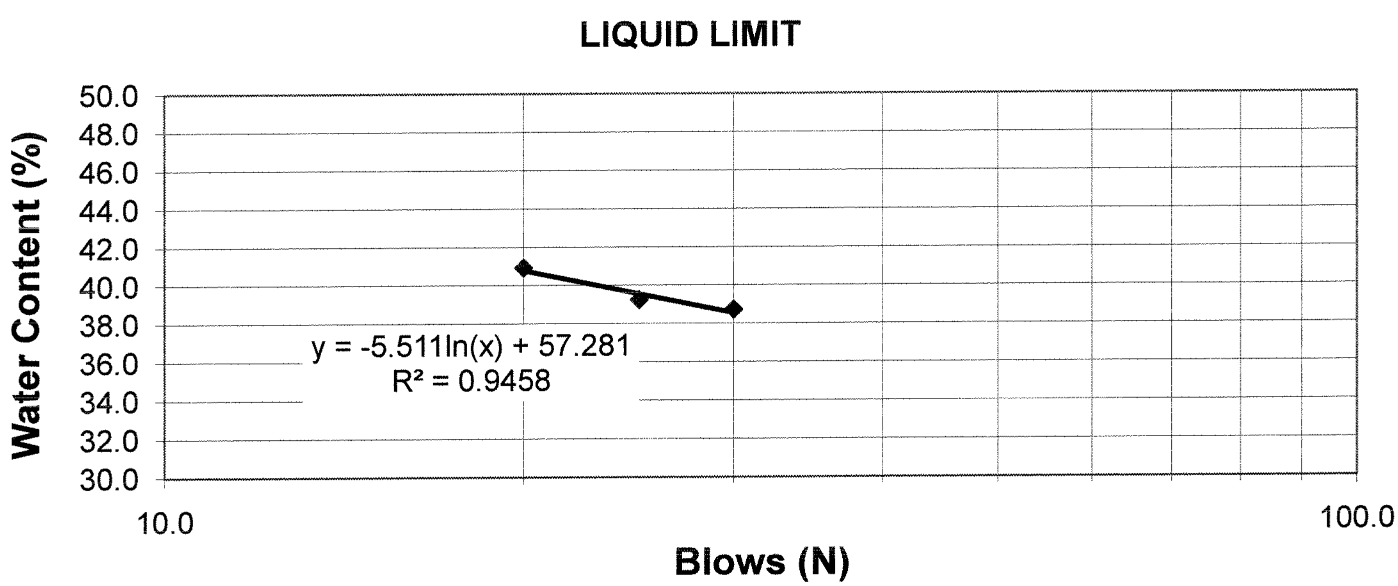
WATER CONTENT

Blows	30	25	20		
WT. SAMPLE WET + TARE (gr)	122.103	122.554	123.465		
WT. SAMPLE DRY + TARE (gr)	119.772	120.557	120.996		
WT. TARE (gr)	113.750	115.467	114.961		
WT. WATER (gr)	2.331	1.997	2.469		
WT. DRY SOIL (gr)	6.022	5.090	6.035		
MOISTURE CONTENT (%)	38.708	39.234	40.911		

Plastic Limit

WATER CONTENT

WT. SAMPLE WET + TARE (gr)	117.301	116.636			
WT. SAMPLE DRY + TARE (gr)	116.250	115.620			
WT. TARE (gr)	110.314	109.947			
WT. WATER (gr)	1.051	1.016			
WT. DRY SOIL (gr)	5.936	5.673			
MOISTURE CONTENT (%)	17.706	17.909			



Liquid Limit = 39.5	Plastic Limit = 17.8	Plasticity Index = 21.7

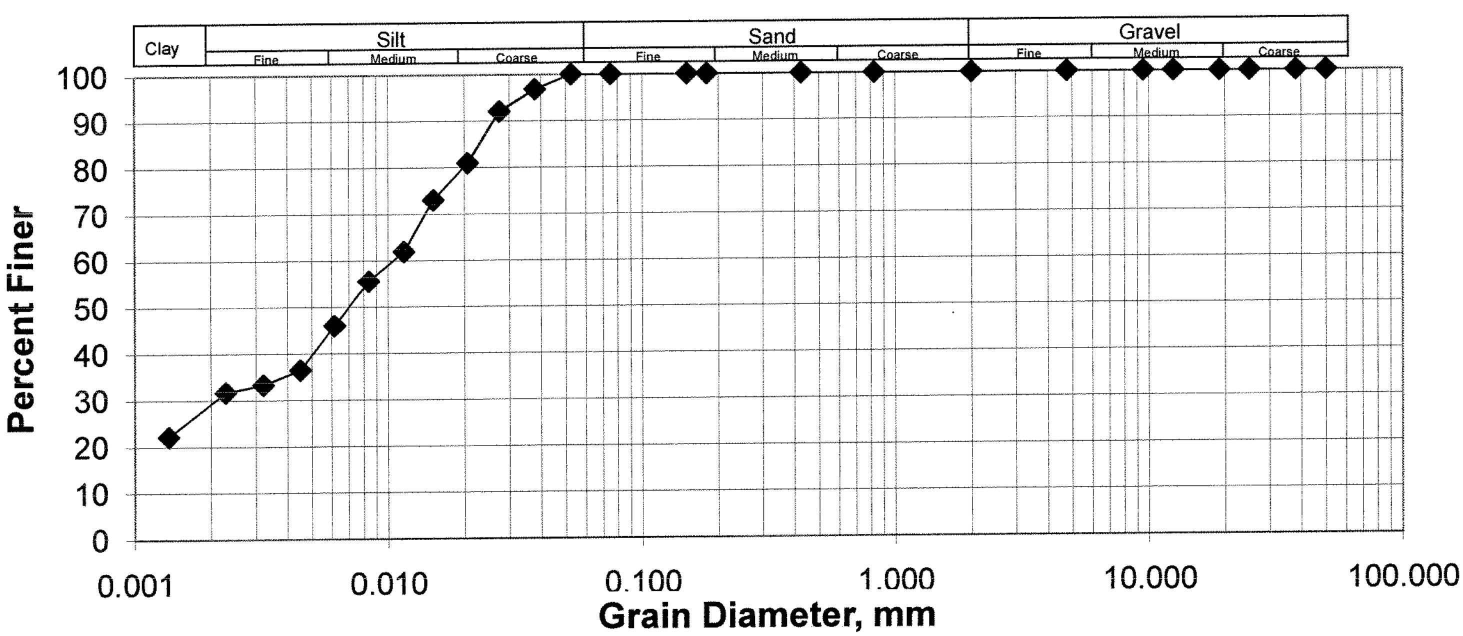
GRAIN SIZE DISTRIBUTION

MATERIALS LABORATORY
AECOM
99 Commerce Dr., Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 **fax** (204) 284-2040

Job No.:	60154500	Sample No.	G3
Client:	PWGSC	Hole No.	TH10-06
Project :	Bowden Institution	Depth:	5.0'
Date Tested:	18-May-10	Date Sampled:	11-May-10
Tested By:	JG	Sampled By:	CN

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	2.00	100.0	0.0750	100.0
38.0	100.0	0.83	100.0	0.0525	100.0
25.0	100.0	0.43	100.0	0.0378	96.8
19.0	100.0	0.18	100.0	0.0275	92.1
12.5	100.0	0.15	100.0	0.0206	80.9
9.5	100.0	0.075	100.0	0.0151	73.0
4.75	100.0			0.0116	61.9
2.00	100.0			0.0084	55.5
				0.0061	46.0
				0.0045	36.5
				0.0032	33.3
				0.0023	31.7
				0.0014	22.2

GRAIN SIZE DISTRIBUTION CURVE



Gravel	**0.0%**	**Silt**	**71.2%**
Sand	**0.0%**	**Clay**	**28.8%**

** Note: Soil Classification based on Grain Size from Canadian Foundation Engineering Manual, 3rd edition (1992).

Certificate of Analysis

AECOM CANADA LTD.
ATTN: STEPHEN PETSCHE
99 COMMERCE DRIVE
WINNIPEG MB R3P 0Y7

Report Date: 25-MAY-10 12:39 (MT)
Version: FINAL

Lab Work Order #: L887595 **Date Received:** 18-MAY-10

Project P.O. #: NOT SUBMITTED
Job Reference: 60154500.2
Legal Site Desc:
CofC Numbers:

Other Information:

Comments:

Robert S. Kitlar
Account Manager

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L887595-1	TH10-04,S4, DEPTH 7.5-9.0'							
Sampled By:	CLIENT on 11-MAY-10							
Matrix:	SOIL							
Miscellaneous Parameters								
Sulphate (SO4)		221		0.50	mg/L		22-MAY-10	R1260508

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
SO4-1:2-CL	Soil	Sulfate (SO4)	APHA 4110 B-Ion Chromatography

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
CL	ALS LABORATORY GROUP - CALGARY, ALBERTA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mk/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

ALS Laboratory Group Quality Control Report

Workorder: L887595 Report Date: 25-MAY-10

Client: AECOM CANADA LTD.
99 COMMERCE DRIVE
WINNIPEG MB R3P 0Y7
Contact: STEPHEN PETSCHE

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SO4-1:2-CL	**Soil**							
Batch R1260508								
WG1108635-1 MB								
Sulphate (SO4)			<0.50		mg/L		0.5	22-MAY-10

ALS Laboratory Group Quality Control Report

Legend:

Limit	99% Confidence Interval (Laboratory Control Limits)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.