Environment

Public Works and Government Services Canada

Geotechnical Investigation CSC Riverbend Institution 50 Bed Housing Unit Prince Albert, SK

Prepared by:

AECOM
200 – 6807 Railway Street SE | 403 254 3301 tel
Calgary, AB, Canada T2H 2V6 | 403 270 9196 fax
www.aecom.com

Project Number:

60217802

Date:

October, 2011

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("Consultant") for the benefit of the client ("Client") in accordance with the agreement between Consultant and Client, including the scope of work detailed therein (the "Agreement").

The information, data, recommendations and conclusions contained in the Report (collectively, the "Information"):

- is subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the "Limitations")
- represents Consultant's professional judgement in light of the Limitations and industry standards for the preparation of similar reports
- may be based on information provided to Consultant which has not been independently verified
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued
- must be read as a whole and sections thereof should not be read out of such context
- was prepared for the specific purposes described in the Report and the Agreement
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time

Consultant shall be entitled to rely upon the accuracy and completeness of information that was provided to it and has no obligation to update such information. Consultant accepts no responsibility for any events or circumstances that may have occurred since the date on which the Report was prepared and, in the case of subsurface, environmental or geotechnical conditions, is not responsible for any variability in such conditions, geographically or over time.

Consultant agrees that the Report represents its professional judgement as described above and that the Information has been prepared for the specific purpose and use described in the Report and the Agreement, but Consultant makes no other representations, or any guarantees or warranties whatsoever, whether express or implied, with respect to the Report, the Information or any part thereof.

The Report is to be treated as confidential and may not be used or relied upon by third parties, except:

- as agreed in writing by Consultant and Client
- as required by law
- for use by governmental reviewing agencies

Consultant accepts no responsibility, and denies any liability whatsoever, to parties other than Client who may obtain access to the Report or the Information for any injury, loss or damage suffered by such parties arising from their use of, reliance upon, or decisions or actions based on the Report or any of the Information ("improper use of the Report"), except to the extent those parties have obtained the prior written consent of Consultant to use and rely upon the Report and the Information. Any damages arising from improper use of the Report or parts thereof shall be borne by the party making such use.

This Statement of Qualifications and Limitations is attached to and forms part of the Report and any use of the Report is subject to the terms hereof.

AECOM
200 – 6807 Railway Street SE
Calgary, AB, Canada T2H 2V6
www.aecom.com

403 254 3301 tel
403 270 9196 fax

October 28, 2011

Charlie Fraser, P.Eng
Project Manager
Public Works and Government Services Canada
125-32nd Street West
Prince Albert, SK S6V-8E2

Dear Mr. Fraser:

Project No: 60217802

Regarding: Geotechnical Investigation
CSC Riverbend Institution – 50 Bed Housing Unit, Prince Albert, SK

This report presents the results of a geotechnical investigation conducted by AECOM Canada Ltd. to support the design and construction of a two storey building, 50-bed housing unit to be constructed at the Correctional Services Canada (CSC) Institution located in Prince Albert, SK.

This report provides a summary of the subsurface conditions and engineering properties of the soils encountered at the site and provides geotechnical recommendations to support the design and construction of the development. As part of the geotechnical investigation, topographic and subsurface utility surveys of the development were also performed. The results of the topographic and subsurface utility surveys are included in this report.

If you have any questions concerning this report please contact the undersigned at (403) 254-3301.

Sincerely,
AECOM Canada Ltd.

Kristen Tackney, P.Geol.
Geologist
kristen.tackney@aecom.com
KT:kt

Revision Log

Revision #	Revised By	Date	Issue / Revision Description
A	Kristen Tackney	August 11 , 2011	Issued for review
B	Kristen Tackney	October 28, 2011	Final Report

AECOM Signatures

PROFESSIONAL GEOLOGIST ALBERTA
KRISTEN TACKNEY
31 oct 2011

Report Prepared By:

Kristen Tackney, P.Geol.
Geologist
Kristen.tackney@aecom.com

PROFESSIONAL ENGINEER
A. MAJID
MEMBER 21058
2011 10 31
YR. MN. DAY
SASKATCHEWAN

Report Reviewed By:

Anwar Majid, M.ASc., P.Eng.
Senior Geotechnical Engineer
anwar.majid@aecom.com

Association of Professional Engineers & Geoscientists of Saskatchewan
CERTIFICATE OF AUTHORIZATION
AECOM Canada Ltd.
Number C1667
Permission to Consult held by:

Discipline	Sk. Reg. No.	Signature
GEOTECHNICAL	21058	

Table of Contents

List of Tables

Figures

Appendices

1. Introduction

1.1 General

This report presents the results of a geotechnical investigation conducted by AECOM Canada Ltd. (AECOM) to support the design and construction of a two storey, 50 bed housing unit at the Correctional Services Canada (CSC) Riverbend Institution located approximately 5 km west of Prince Albert, SK as shown on Figure 1. A topographic survey and subsurface utility survey were also conducted as part of the geotechnical site investigation. The results of the topographic and subsurface utility survey are also provided in this report.

The main objective of the geotechnical investigation was to determine subsurface conditions and engineering properties of the soils encountered at the site and provide geotechnical recommendations to support the design and construction of the development.

1.2 Geological Setting

A summary of the geological setting has been compiled from the Surficial Geology of the Prince Albert Area (Campbell, 1987). The Riverbend Institution is mainly located on an alluvial floodplain of the North Saskatchewan River with deposits mainly consisting of gravel, sand, silt, clay, and slump material. Portions of the site may also be located on a glacio-lacustrine flood plain consisting of sand, silt and clay deposits. Underlying the surficial soils at the site is bedrock of the Lea Park Mill and Milk River formation comprised of marine shale and muddy sandstone. The geological setting is shown on Figure 2.

1.3 Scope of Work

The scope of work for this project consisted of the following tasks:

1. Conduct a site investigation by drilling five testholes to maximum depth of 20 m or to refusal in bedrock;
2. Install standpipe piezometers in selected testholes to determine the depth of the groundwater table;
3. Conduct a topographic survey at the new building site and adjacent areas;
4. Conduct a subsurface utility survey to map all underground utilities (power, water, sewer, storm, phone, gas, communication lines, etc.) at the new building site;
5. Conduct a laboratory testing program on selected soil samples collected during the site investigation for soil classification and determination of engineering properties; and,
6. Prepare a geotechnical investigation report that documents findings from the site investigation and laboratory testing program, and provide geotechnical recommendations to support design and construction of the geotechnical elements of the project.

2. Method of Investigation

2.1 General

Prior to conducting the site investigation, all members of work crews (materials testing technicians, drillers, driller's helpers, surveyors, etc.) were required to receive clearance from the Institutional Access Canadian Police Information Centre (CPIC). For this purpose, clearance request forms were submitted to CPIC to obtain approval to work within the Institution. While on site, work crews were accompanied by a Commissionaire at all times as per Correctional Services Restrictions of access and use.

2.2 Topographic Survey

A topographic survey of the site was conducted by Mr. Gord Szwydky and Mr. Travis Leblanc of AECOM on July 6th and 7th, 2011. Prior to the site investigation, the testhole locations were staked on site. The locations and elevations of testholes were surveyed as part of the topographic survey. Testhole locations and topography of the site are shown on Figures 3 and 4, respectively.

2.3 Subsurface Utility Survey

A subsurface utility survey was conducted to locate underground utilities at the site. The subsurface utility survey was conducted by Mr. Gord Szwydky and Mr. Travis Leblanc of AECOM on July 6th and 7th, 2011. Invert information of select utilities in the vicinity of the proposed building site was obtained by hydro-vac. Hydro-vac services were provided by Dmyterko Enterprises Ltd. from July 4th to 6th, 2011. The results of the subsurface utility survey are presented on Figure 4.

2.4 Site Investigation

A site investigation was conducted from June 5th to 7th , 2011. The site investigation consisted of drilling five testholes using a truck mounted auger rig operated by Boss Drilling Ltd. of Saskatoon, Saskatchewan. The testholes were logged by Mr. Chris Kjarsgaard of AECOM. All five testholes were drilled to a depth of approximately 20 m. The locations of the testholes are shown on Figure 3.

The testholes were logged based on observations of drill cuttings, drill behaviour, and our experience with similar soils. This included visual classification of soils and interpretation of subsurface moisture and groundwater conditions. The soils were classified according to the modified Unified Soil Classification (USC) system. Standard Penetration Tests (SPT) were conducted at a 1.5 m interval by measuring blow counts for 300 mm penetration (SPT "N" blow counts). Soil samples were collected at regular intervals. The samples included representative disturbed grab samples from the auger and SPT split spoon samples.

Standpipes (25 mm diameter) were installed in two testholes to measure the depth of the groundwater table. The testholes were backfilled after completion with sand and drill cuttings overlain by a bentonite cap to reduce infiltration. The testhole logs are presented in Appendix A.

2.5 Laboratory Testing

Soil samples collected during the site investigation were tested in AECOM Laboratories in Calgary, AB for soil classification and determination of engineering properties of the encountered soils. The laboratory testing included determination of moisture contents, Atterberg Limits, grain size analysis (hydrometer), Standard Proctor Maximum Dry Density (SPMDD), and California Bearing Ratio (CBR). Soil samples were also sent to Access Analytical Laboratories Inc. in Calgary, AB to determine soluble sulphate contents, pH, and resistivity. The test results are shown on the testhole logs in Appendix A and are presented separately in Appendix B. Table 2-1 summarizes the number and location of the test results.

Table 2-1 Laboratory Testing

Tests	Number	Data Location
Moisture Content	67	Testhole Logs
Atterberg Limits	8	Testhole Logs & Appendix A
Grain Size Analysis	3	Testhole Logs & Appendix A
SPMDD	1	Testhole Logs & Appendix A
CBR	1	Appendix A
Soluble Sulphate Contents, pH, Resistivity	5	Testhole Logs & Appendix A

3. Subsurface Stratigraphy

3.1 General

The subsurface stratigraphy at the site generally consisted of a layer of topsoil or asphalt underlain by a layer of very loose to compact sand underlain generally by medium plastic clay. The only exception was testhole TH11-01 where high plastic clay was encountered under the sand.

Detailed descriptions of the subsurface conditions encountered at the testhole locations are provided on the testhole logs in Appendix A. A description of the terms and symbols used on the logs is also included in Appendix A. A summary of various soil units encountered and their general properties are presented in the following sections.

3.2 Subsurface Soil Units

3.2.1 Topsoil

A layer of topsoil, varying in thickness from 25 mm to 50 mm, was encountered at the surface of testholes TH11-03, TH11-04, and TH11-05 with an average thickness of approximately 35 mm.

3.2.2 Asphalt

A layer of asphalt, approximately 40 mm thick, was encountered at the surface in testhole TH11-01.

3.2.3 Granular Fill

A layer of granular fill, approximately 65 mm thick, was encountered below the asphalt in testhole TH11-01.

3.2.4 Sand

A layer of sand was encountered below granular fill in testhole TH11-01, at surface in testhole TH11-02, and below the topsoil in testholes TH11-03, TH11-04 and TH11-05. The sand layer ranged in thickness from 4.2 m to 4.4 m with an average thickness of approximately 4.3 m. The sand was described as brown and damp and contained trace amounts of silt and clay. The sand became wet at a depth of approximately 3 m in all testholes. The SPT “N” blow counts in the sand ranged from 5 to 21 with an average of 12 indicating that the sand is very loose to compact.

Moisture contents of 12 sand samples ranged from 4.3 % to 17.1 % with an average of 9.9 %. Grain size analyses (hydrometer) were conducted on two sand samples from testholes TH11-01 and TH11-03 to determine particle size distribution. The samples had 0 to 0.3 % gravel, 95.7 to 96.9 % sand, 1.3 to 0.8 % silt, and 2 to 3 % clay. Based on grain size analyses and observations during drilling the sand is classified as poorly graded sand (USC = SP)

3.2.5 Silt

A layer of sandy silt, approximately 1.9 m thick, was encountered below the sand in testhole TH11-05. The silt layer was grey, wet, and hard based on a single SPT “N” blow count of 33.

The moisture content of a silt sample was 23.4 %. Grain size analysis (hydrometer) was conducted on one sample. The sample had 0 % gravel, 33.2 % sand, 58.8 % silt and 8.0 % clay. Based on grain size analysis and observations during drilling the silt is classified as silt and sand (USC = ML).

3.2.6 Medium Plastic Clay

Medium plastic clay was the major soil unit encountered below the sand in testholes TH11-02 to TH11-05 at depths between 4.3 m and 6.1 m below ground surface. The clay was generally described as silty, grey and moist. The SPT "N" blow counts in the clay ranged from 7 to 17 with an average of 11 indicating that the clay is firm to stiff. The clay became very stiff at approximately 20 m depth in testholes TH11-02, TH11-03 and TH11-04 with SPT "N" blow counts of 17, 15, and 16 respectively.

Moisture contents were determined on 43 samples and Atterberg Limits were determined for 6 clay samples. A summary of the index properties is presented in Table 3-1.

Table 3-1 Index Properties of Medium Plastic Clay

Test	Minimum	Maximum	Average
Moisture Content (%)	26.7	40.9	32.1
Liquid Limit (%)	44.7	47.2	46.0
Plastic Limit (%)	17.4	19.4	18.2

Based on the Atterberg Limits and our observations during drilling the clay is classified as medium plastic clay (USC = CI).

3.2.7 High Plastic Clay

High plastic clay was the major most soil unit encountered below the sand in testhole TH11-01. The high plastic clay was generally described as silty, grey and moist. The SPT "N" blow counts in the high plastic clay ranged from 5 to 14 with an average of 10 indicating that the clay is firm to stiff.

Moisture contents were determined on 11 samples and Atterberg Limits were determined for 2 clay samples. A summary of the index properties of the clay is presented in Table 3-2.

Table 3-2 Index Properties of High Plastic Clay

Test	Minimum	Maximum	Average
Moisture Content (%)	27.6	42.9	34.0
Liquid Limit (%)	57.8	60.6	59.2
Plastic Limit (%)	19.7	22.7	21.2

Based on the Atterberg Limits and our observations during drilling the clay is classified as high plastic clay (USC = CH).

3.3 Groundwater Conditions

Standpipes were installed in two testholes drilled at the site. Groundwater levels were measured on August 9, 2011 and are summarized in Table 3-3.

Table 3-3 Groundwater Depths Measured on August 9, 2011

Testhole No.	Ground Elevation (m)	Groundwater Depth Below Ground Surface (m)	Groundwater Elevation (m)
TH11-01	435.45	11.30	424.15
TH11-05	435.51	3.78	431.73

The groundwater table should be expected to fluctuate seasonally, in response to climatic conditions (precipitation). Groundwater depths should be monitored periodically prior to construction to monitor seasonal fluctuations in groundwater elevations.

3.4 Soil Chemistry

Electrochemical tests were conducted on five soil samples to determine water soluble sulphate concentrations, pH and resistivity. A summary of test results, expected degree of corrosiveness and potential for sulphate attack of the subsurface soils are presented in Table 3-4. The potential for sulphate attack is in accordance with Canadian Standard Association Guidelines (CSA A23.1 and A23.2) and degree of corrosiveness is in accordance with Handbook of Corrosion Engineering (Roberge P.R., 1999).

Table 3-4 Summary of Soil Electrochemical Testing Results

Soil Unit	Depth (m)	Testhole No.	pH	Resistivity (ohm-cm)	Sulphate Content (%)	Degree of Corrosiveness	Potential for Sulphate Attack
Clay (CH)	6.1	TH11-01	7.5	1064	< 0.1	Highly Corrosive	Low
Sand (SP)	3.0	TH11-02	8.3	4610	< 0.1	Corrosive	Low
Clay (CI)	9.1	TH11-03	7.4	940	< 0.1	Extremely Corrosive	Low
Sand (SP)	3.0	TH11-04	8.2	5390	< 0.1	Moderately Corrosive	Low
Silt (ML)	4.6	TH11-05	7.6	1546	< 0.1	Highly Corrosive	Low

3.5 Frost Susceptibility

The soils encountered at the site primarily consist of poorly graded sand (SP), sandy silt (ML), and medium or high plastic clay (CI, CH). The qualitative frost susceptibility of a soil is typically assessed using guidelines developed by Casagrande (1932) on the basis of the percentage by weight of the soil finer than 0.02 mm and plasticity index. This classification system has been adapted by the U.S. Army Corps of Engineers and the Canadian Foundation Engineering Manual (CFEM 2006). Soils are classed as F1 though F4 in order of increasing frost susceptibility. The surficial poorly graded sand encountered at the site is classified as F2, medium and high plastic clays encountered below the sand are classified as F3, and the silt layer encountered under sand in testhole TH11-05 is classified as F4. Therefore, the soils at the site are moderately to highly frost susceptible (F2 to F4).

4. Considerations and Recommendations

4.1 General

The subsurface soils encountered at the site generally consisted of poorly graded sand underlain by medium to high plastic clay. The measured elevations of groundwater table vary from approximately 424.15 m to 431.73 m. Due to presence of loose to very loose sand in the upper 4 m, deep frost penetration depth within the sand, and the presence of the groundwater table at a depth of 3.8 m (TH11-05); shallow foundations (strip/spread footings) are not considered suitable for the proposed development. Slab-on-grade floors are also not recommended due to the presence of loose to very loose sand; therefore, structural slabs supported on piles are recommended.

Driven steel piles are considered suitable for the development considering the subsurface soil conditions. Alternatively, cast-in-place (CIP) concrete piles can be used provided certain precautions are taken. Sand encountered near surface in all testholes will slough in the pile holes if cast-in-place (CIP) concrete piles are used for the building foundations. The groundwater table is at a depth of approximately 3.8 m; therefore, seepage should also be expected in the pile holes. The contractor should be prepared to handle seepage and sloughing to maintain a clean pile hole if CIP piles are used to support the building. Detailed recommendations for driven steel piles and CIP concrete piles are provided in Section 4.2.

4.2 Deep Foundations

4.2.1 Driven Steel H Piles

Driven steel H piles may be designed using the parameters provided in Table 4-1 and Equation [4-1]. A resistance factor of 0.4 should be applied on ultimate (un-factored) pile capacity to obtain factored pile capacity. The recommended ultimate skin friction and end bearing parameters for pile design are provided in Table 4-1.

Table 4-1 Recommended Design Parameters for Driven Steel Piles

Soil Type	Depth (m)	Elevation (m)	Ultimate Skin Friction (kPa)	Ultimate End Bearing (kPa)
Seasonal Frost Zone	0 – 3.5	435.5 – 432.0	NA	NA
Compact Sand	3.5 – 4.5	432.0 – 431.0	35	NA
Stiff Clay	4.5 – 16	431.0 – 419.5	35	NA
Stiff Clay	16 – 20	419.5 – 415.5	40	650

Driven steel piles may be designed based on a combination of skin friction plus end bearing using Equation 4-1.

$$Q_u = q_s P_s L + q_t A_t \qquad [4\text{-}1]$$

where:

Q_u = ultimate pile capacity (kN);
q_s = ultimate skin friction between the pile and soil (kPa);
q_t = ultimate end bearing (kPa);
P_s = perimeter of the pile section (m) = 2 x (b + d); b is flange width and d is web height;
L = effective pile embedment length; and,
A_t = cross sectional area of the plugged steel pile (m^2) = b x d.

The end bearing in Equation 4-1 is based on the assumption that a plugged section will form for piles driven into stiff clay below a depth of 16 m. Driven steel piles are expected to penetrate through the compact sand and stiff clay and are not expected to meet refusal within the depth of exploration of 20 m. Due to the presence of firm clay at variable depths, we recommend driving piles below the elevation of 418 m.

Where lightly loaded piles are supporting un-heated structures, the pile lengths required to resist potential frost heave will likely govern the design. Minimum pile embedment below the finished grade, to resist uplift due to frost heave, should be approximately 14 m.

For axial pile capacity, the minimum center to centre spacing between piles should be 3 times the pile diameter. Group effects for axial pile capacity should be considered if piles are spaced at less than 3 times the pile diameter.

The proposed hammer, piling rig, and methodology should be approved in advance of construction and refusal criterion should be confirmed for the actual hammer and design load. This can be achieved by performing a wave equation analysis using commercially available software such as GRLWEAP.

For piles driven in the winter, increased driving resistance should be expected in the upper frozen layer, which may warrant pre-drilling through the frozen layer.

Pile driving should be stopped immediately if abrupt high resistance to penetration is encountered. In such cases, the driving record and depth of penetration should be carefully examined to determine if the pile has adequate bearing capacity. If the depth of penetration is inadequate, the need for additional piles should be evaluated.

After each pile is driven to its required depth or refusal, the elevation should be taken at the pile top or at a suitable mark on the side of the pile. This elevation should be checked periodically to measure potential heave caused by the driving of adjacent piles or any uplift forces. Piles that have heaved must be re-driven to at least their previous final elevation and final set.

The use of driving shoes may be required to improve the driveability of the piles and to reduce the likelihood of damage to pile tips.

Full time inspection by qualified geotechnical personnel during pile driving is recommended to maintain pile driving records. Recorded information should include pile dimensions, hammer type, rated energy, ram weight, anvil weight, cushion parameters, number of blows for each 0.25 m penetration, and final set. It is recommended that each pile be reviewed by the geotechnical engineer responsible for the design to assess that the required load capacity is achieved.

Strict control of pile location and orientation should be exercised to obtain accurate pile installation.

4.2.2 Drilled CIP Concrete Piles

Straight shaft CIP concrete piles can be used to support the building provided some precautions are taken during construction. The overburden soils encountered within the drilled depth generally consisted of sand and clay. The groundwater table was encountered at a depth of approximately 3.8 m in testhole TH11-05. As such, there is the potential for seepage and sloughing if CIP concrete piles are used. It is therefore recommended to have casing available on site to prevent sloughing of sandy soils and to maintain a clean and open pile hole. If slough is managed with casing but a high rate of seepage still occurs, it may be necessary to tremie concrete into the pile hole or dewater the pile hole prior to pouring concrete.

The drilled CIP concrete piles may be designed using the parameters in Table 4-2. A resistance factor of 0.4 should be applied on ultimate (unfactored) pile capacity to obtain factored pile capacity for piles designed based on the static parameters in Table 4-2.

Table 4-2 Recommended Design Parameters for Drilled CIP Piles

Soil Type	Depth (m)	Elevation (m)	Ultimate Skin Friction (kPa)	Ultimate End Bearing (kPa)
Seasonal Frost Zone	0 – 3.5	435.5 – 432.0	NA	NA
Compact Sand	3.5 – 4.5	432.0 – 431.0	30	NA
Stiff Clay	4.5 – 16.0	431.0 – 419.5	35	NA
Stiff Clay	15.0 – 20.0	419.5 - 415.5	40	500

The minimum pile embedment below the finished grade, to resist uplift due to frost heave, should be approximately 10 m.

All straight piles should have a minimum diameter of 400 mm. The base of the pile holes should be properly cleaned of all the debris and sloughed material after shaft completion and visually inspected prior to pouring concrete. Following drilling and cleaning, pile holes should be inspected to ensure that the base of the pile hole is adequately cleaned. End bearing will not be applicable if pile bases are not cleaned.

The tremie tube, if used, should be water tight and should have a minimum diameter of 200 mm. Small diameter tubes can be used with concrete pumps. The outlet of the tremie should be embedded at least 1 m below the concrete surface.

For axial pile capacity, the minimum center to centre spacing between piles should be 3 times the pile diameter. Group effects for axial pile capacity should be considered if piles are spaced at less than 3 times the pile diameter.

The minimum pile embedment below the finished grade, to resist uplift due to frost heave, should be approximately 8 m. The CIP piles should be reinforced as per structural requirements.

Pile installation should be monitored on a full time basis by qualified geotechnical personnel. A record of pile construction should be kept, including pile number, date and time of drilling, date and time of pouring concrete, depth of shaft, diameter of shaft, reinforcement details, length of casing (if used), groundwater seepage and sloughing, type of soil encountered, concrete and air temperatures, and any other unusual occurrences.

Pile design should be reviewed if conditions other than assumed during design are encountered.

4.2.3 Lateral Pile Capacity

The CIP piles may be subject to lateral loading. Lateral pile analysis involves required soil stiffness properties. Lateral pile analysis is performed using software such as LPile or by structural analysis where the modulus of subgrade reaction is used to determine spring constants for the pile design. The modulus of subgrade reaction can be determined using Equation [4-2]:

$$k_h = n_h \frac{z}{d} \qquad [4\text{-}2]$$

where:

k_h modulus of subgrade reaction (MPa/m);

n_h modulus of subgrade variation (MPa); and,
d pile diameter or flange width (m).

Recommended values for modulus of subgrade reaction and variation are provided in Table 4-3.

Table 4-3 Modulus of Subgrade Reaction and Subgrade Variation for Lateral Pile Analyses

Soil Type	Depth (m)	Modulus of Subgrade Reaction or Subgrade Variation (MPa/m)	
		Above Groundwater Table	Below Groundwater Table
Sand	0 – 4.5	n_h = 7	n_h = 5
Clay	4.5 – 20	k_h = 20/d	k_h = 20/d

The design of laterally loaded piles is generally governed by Serviceability Limit States limiting the top of pile movement to tolerable limits.

The design parameters provided in Table 4-3 may be utilized to calculate the ultimate lateral pile capacity. For Limit States Design methodology, an appropriate soil resistance factor should be applied on the ultimate lateral pile capacity to calculate the factored capacity. A resistance factor of 0.5 should be used on ultimate lateral capacity of pile to obtain the factored capacity.

The lateral capacity of individual piles is primarily affected by the spacing of piles, measured centre to centre along an alignment parallel to the lateral applied load (provided that the pile spacing perpendicular to the applied load is at least 3 times the pile diameter). Group effects diminish at a pile spacing of 6 times the pile diameter or greater in the direction of applied lateral load. Depending upon the pile spacing, it may be necessary to reduce the soil stiffness coefficients to account for group effects.

4.2.4 Pile Settlement

The settlement of a single pile will occur as the shaft friction and end bearing are mobilized under working loads. The total settlement is a combination of this movement to mobilize resistance of the soil as well as elastic shortening of the steel pile. The estimated settlement of a single pile is approximately 10 mm plus the elastic compression of the pile.

The interaction of pile group effects must also be considered from a settlement perspective, as the supporting soil for groups is much larger than for a single pile. Group effects on settlement diminish at a pile spacing of at least 7 times the pile diameter. Group effects on settlement should be considered if piles are spaced at less than 7 times the pile diameter.

AECOM can provide recommendations on pile group effects if piles are spaced less than 7 times the pile diameter.

4.2.5 Design for Tensile Loads

The piles will be subject to uplift forces due to frost heave, tensile forces due to lateral loading, overturning movements due to wind, etc. The piles should be designed to resist these uplift forces. The resistance to uplift will be provided by pile self weight, applied dead loads, and shaft friction. Factors such as seasonal frost depth, adfreezing forces at the soil to pile contact, seasonal frost depth, and soil type should be taken into account while designing the pile against uplift.

The resistance to uplift may be calculated using ultimate skin friction parameters provided in Sections 4.2.1 and 4.2.2. A resistance factor of 0.3 should be applied on ultimate parameters to obtain factored parameters.

4.2.6 Downdrag Loads

Downdrag (negative skin friction) loading should be considered in the pile design if any one of the following criteria is met.

- The thickness of the soft/compressible layer is greater than 10 m;
- The height of fill/embankment to be placed on the ground surface exceeds 2 m;
- The water table will be lowered by more than 4 m;
- The total settlement of the ground surface will be more than 100 mm; or
- The settlement of the ground surface after piles are installed will be greater than 10 mm.

It is understood that fill will not be placed on site and groundwater table will not be lowered; therefore, downdrag is not expected on the piles. AECOM should be informed to provide recommendations on the downdrag if fill thickness greater than 1 m is placed on site to raise the grade or groundwater is lowered.

4.3 Pavement Structure

4.3.1 General

Pavements will be required for service driveways to accommodate low to medium volume traffic including truck traffic. The subsurface soils at the site generally consisted of loose to compact sand (approximately 4 m thick) underlain by firm to stiff clay. The groundwater table is at a depth of approximately 3.8 m. Laboratory testing was conducted on a combined sand sample to determine soaked and un-soaked CBR values. The sample had soaked and un-soaked CBR values of 15 and 9, respectively. A CBR of 9 was used for the pavement design.

4.3.2 Pavement Design

The pavement structure design was based on low to medium volume traffic including trucks. The pavement was designed based on the procedure outlined in the Asphalt Institute Thickness Design (Manual Series MS-1). The pavement design is based on the following assumptions:

- Average Annual Daily Traffic of 500 vehicles;
- Heavy Vehicle Percentage of 50 %;
- Heavy Vehicle Distribution Factor of 90%;
- Design life of 20 years; and,
- Maximum Tandem Axle load of 18,000 lb (80 kN).

The recommended pavement structure is provided below:

- ACP thickness = 100 mm;
- Granular Base Course = 150 mm; and,
- Granular Subbase Course = 200 mm.

4.3.3 Subgrade Preparation

Any topsoil encountered within the pavement footprint should be removed. The exposed subgrade should be scarified to a minimum depth of 0.5 m, moisture conditioned, and compacted to at least 98 % of the Standard Proctor Maximum Dry Density (SPMDD) in compacted lifts not exceeding 150 mm. The prepared surface should be proof-rolled to identify any weak spots. Any weak spots indentified during proof rolling should be over-excavated and replaced with general engineered fill compacted to at least 98 % of the SPMDD. Locally excavated sand and low to medium plastic clay may be used as general engineered fill provided these soils do not contain deleterious material such as organics, roots, debris, etc. High plastic clay should not be used as general engineered fill.

Preparation of the subgrade should be carried out within restricted areas. This is to avoid loosening of the prepared areas by site traffic before placement and compaction of the granular material. The subgrade should not be exposed to precipitation and frost.

4.3.4 Drainage

The pavements should be sloped to a minimum of 2 % to shed water to the adjacent ditches or catch basins. Gradients less than 2 % may result in poor drainage and ponding that may cause pavement failure.

The native soils in the area are susceptible to erosion, therefore ditch gradients in excess of 2 % may cause ditch erosion and ditch gradient less than 0.5 % may result in inadequate longitudinal drainage. Longitudinal gradients less than 0.5 % may also result in localized ponding, growth of aquatic plants, odour from stagnant water, and insects. The lower longitudinal gradient will reduce erosion but will result in increased silt deposition within the ditches.

Erosion protection for ditch slopes can be provided through the application of a layer of topsoil and grass seed. Erosion protection mats may be required to reduce ditch erosion in the short term. Silt fences may also be required during construction to reduce silt flow into the water bodies.

4.4 Temporary Excavations and Dewatering

The composition and consistency of the surficial soils encountered at site were such that conventional hydraulic excavators should be able to excavate these materials, although a ripper may be required to excavate seasonally frozen soil.

Construction should be in accordance with good practice and should conform to Occupational Health and Safety guidelines. Bedrock excavation is not anticipated at this site. Excavations should be sloped or adequately shored. The appropriate side slopes for the excavations will depend on the soil type, controlling groundwater flow into the excavations and the time the trench is left open.

Temporary cuts in silty clay/high plastic clay should not be steeper than 1 horizontal:1 vertical (1H:1V) for excavations up to 3 m deep. Side slopes would need to be made flatter, under the direction of a qualified geotechnical engineer if localized instability of excavation walls occurs due to seepage and sloughing. Steeper slopes may be considered provided they are adequately shored and braced in accordance with the Occupational Health and Safety Regulations.

The above side slopes are for short term construction. The stability of cut slopes will deteriorate with time. Therefore, temporary side slopes should be monitored for any signs of deterioration especially after periods of rain and appropriate measures should be taken to mitigate the side slopes. Small earth falls from the side slopes are a potential source of danger to workers and must be guarded against.

The groundwater table is at or below elevation 431.73 m and is not expected to be an issue as long as the excavation base is above the groundwater table. AECOM should be given the opportunity to review our recommendations if during construction the groundwater table is encountered at a shallower depth than encountered during the current investigation.

Temporary surcharge loads such as construction materials, equipment, or excavated soils should not be allowed within a distance equal to the depth of excavation from the unsupported excavated face. Vehicles delivering material should be kept back from excavation faces at a safe distance.

4.5 Backfill and Compaction

4.5.1 General

Soils used for filling purposes may consist of general engineered fill. General engineered fill materials should comprise inorganic well-graded granular soils or inorganic low to medium plastic clay soils. High plastic clays should not be used as general engineered fill. Granular soils used as general engineered fills should consist of a clean, well graded mixture of sand and gravel (maximum size 75 mm). In general, fill material should be compacted within ± 2 % of Optimum Moisture Content (OMC).

Inorganic silty clay/clay obtained from excavations at the site may have natural moisture content different than their OMC, therefore soils should be properly moisture conditioned prior to use as fill.

Structural fill should be used in areas where the performance of the fill is more critical, such as under foundations, slab-on-grade floors, etc. Structural fill should consist of well graded sand and gravel having a maximum particle size of 25 mm and less than 5 % fines. Structural fill may be obtained from screened pit run or crushed material depending on specific requirements. The structural fill should be compacted to 100% of SPMDD.

The fill should be placed in layers not exceeding 150 mm in loose thickness. The fill should be compacted to at least 98 % of the SPMDD at or slightly above OMC unless otherwise specified. The fill should be placed in lifts that are compatible with the compaction equipment used. The ability of compaction equipment to uniformly compact layers thicker than 150 mm should be confirmed with a test strip program.

Fill materials should not be placed in a frozen state, or placed on a frozen subgrade. All lumps of materials should be broken down during placement. The maximum particle size in the fill material should not exceed half the layer thickness. Fill material should not contain deleterious materials such as debris, organics, coal particles, wood chunks, etc.

Bonding should be provided between backfill lifts, if the previous lift has become desiccated. For fine-grained materials the previous lift should be scarified to the base of the desiccated layer, properly moisture conditioned and re-compacted and bonded thoroughly to the succeeding lift. For granular materials, the surface of the previous lift should be scarified to about a 75 mm depth followed by proper moisture conditioning and re-compaction.

4.5.2 Backfill Around Grade Beams

Backfill should not be placed against the grade beams until the concrete has properly set and has sufficient strength to resist the lateral earth pressures.

The backfill should be compacted to 95 % of the SPMDD. The material should not be over-compacted as over-compaction could lead to excessively high lateral earth pressures against the foundation walls.

The upper 300 mm of the backfill should consist of compacted low to medium plastic clay till to prevent infiltration of surface water.

4.6 Permanent Dewatering

It is understood that the proposed development will not include a basement. The groundwater table is at a depth of 3.8 m (elevation 431.73 m) below the existing ground surface. The recommended foundation system is deep foundations (driven steel or CIP concrete piles) and structural slabs. Due to these reasons, permanent dewatering (weeping tile system) is not considered necessary as long as the base of the structural slab is at least 2 m above the groundwater table.

4.7 Seasonal Frost Penetration and Frost Design Considerations

4.7.1 General

The surficial sandy soils are moderately frost susceptible. The groundwater table was encountered at a depth of 3.8 m during the site investigation, but may fluctuate seasonally and in response to precipitation. Additionally, the groundwater table may be relatively high following site grading. Therefore, frost heave is a concern for un-insulated or unheated foundations and grade beams.

The seasonal frost penetration depth was calculated for different soils following the procedure described in the Canadian Foundation Engineering Manual (CFEM, 2006). A 50 year return period annual freezing index of 2,600 °C-days was used for the Prince Albert area. The seasonal frost penetration depth is estimated to be approximately 3.5 m for the surficial sandy soils and 2.2 m for the clay soils. The estimated frost depth assumes that there is no snow cover, peat or vegetation on surface. The presence of snow, vegetation, and peat may reduce the seasonal frost penetration depths.

In unheated areas the foundations and other infrastructure elements below the finished grade should be protected from frost heave by burial below the seasonal frost zone. The minimum burial depth of un-insulated utility lines, and water pipelines should not be less than seasonal frost penetration depths.

For heated buildings, the exterior grade beams should either be insulated or buried below the seasonal frost depth.

4.7.2 Pile Foundations and Grade Beams

Unheated Buildings - For unheated buildings, the piles should be designed to resist a design frost jacking force (adfreeze bond) of 65 kPa (concrete piles) and 100 kPa (steel piles), at the pile to soil interface, over the upper 2.0 m of the pile, unless measures are taken to protect the pile from frost. Resistance to frost jacking on the piles will be provided by the sustained vertical loads on the pile, the weight of the pile, and the ultimate skin friction along the pile using parameters given in Tables 4-1 and 4-2. The pile embedment should be sufficient to resist uplift due to frost jacking.

Grade beams and pile caps in unheated areas should be protected from frost heave by burial below the seasonal frost depth. Grade beams that do not have adequate soil cover should be protected from frost heave by providing a void form or a void space underneath them. Placing a compressible void form or providing a void space between the ground and the underside of the grade beams/pile caps will reduce the potential for frost heave forces. If a void space is used the minimum space between the bottom of the grade beams and ground surface should be 75 mm. If a compressible polyethylene product (void form) is used it should be at least 150 mm thick. A potential frost heave of 50 mm should be assumed resulting in a compression of 33 % of void form.

Another frost effect is adfreeze/uplift pressure acting on the sides of pile caps for unheated structures. This can be reduced by placing non frost susceptible soil (gravel with less than 5 % fines) around structures, providing good drainage, and applying a frost bond breaker to the faces of pile caps and grade beams.

Heated Buildings - To protect against possible frost heave movements, the installation of horizontal insulation around grade beams is recommended. The insulation should be of rigid polystyrene composition (Styrofoam HI-40 or equivalent). The insulation should be at least 75 mm thick. The insulation should be applied vertically to the outside of the grade beam and should extend horizontally outwards a minimum distance of 1.8 m. The insulation should be sandwiched between two layers of bedding sand, at least 75 mm in thickness, and should be sloped down away from the structure at 1%.

The finished grade adjacent to each grade beam and piles cap should be capped with a well-compacted, low to medium plastic clay layer (minimum 300 mm thick) and sloped away so that the surface runoff is not allowed to infiltrate and collect in the void spaces or in the void forms. If water accumulates in the void space under grade beams/pile caps or if the void forms gets saturated, frost heave will occur on the underside of the grade beams and pile caps.

4.8 Sulphate Attack and Corrosion

The potential degree of sulphate attack on concrete was low in five samples (Table 3-4). The potential degree of sulphate attack on concrete may be considered to be "low". Accordingly Type GU (formerly known as Type 20) ordinary Portland cement can be used for any concrete in contact with subsoils and groundwater. However, it is common practice to use Type HS (formerly known as Type 50) Sulphate Resistant cement for all concrete in contact with subsoil and groundwater, if it is reasonably available. The Sulphate Resistant cement should be used at a maximum water to cement ratio of 0.45 and a minimum 28-day compressive strength of 32 MPa. Air entrainment of 4 to 6 % by volume is recommended for all concrete exposed to freezing temperatures, native soil, and/or groundwater.

Resistivity values indicate that the subsoils at the site are corrosive. It is therefore recommended that all metals in contact with subsurface soils (such as driven steel piles) should be designed for a corrosive environment. Reported rates of steel corrosion in natural soils indicate a maximum rate of corrosion of 3 mm in 100 years, and an average rate of 1 mm in 100 years. Appropriate corrosion rates should be used in the design of steel piles.

4.9 Site Grading and Drainage

Final site grading should maintain positive drainage in the direction of natural drainage and should direct water away from the structures. Improper drainage and ponding of water near or under the structure could initiate foundation failure. Improper drainage may also result in swelling, softening and/or possible frost heaving of the clay subgrade. Future and existing development should be taken into consideration when directing drainage so as not to divert flow into adjacent developments.

AECOM recommends that the final grade within 3 m of the structures be sloped down, away from the building at a minimum of 2 %. It is also recommended that gravel or landscaped areas beyond this have a minimum grade of 1 percent.

4.10 Review of Design and Construction

AECOM should be given the opportunity to review details of the design and specifications related to geotechnical aspects of this project prior to construction.

All recommendations presented in this report are based on the assumption that an adequate level of monitoring will be provided during construction, and that all construction will be carried out by suitably qualified contractors, experienced in earthworks. Adequate levels of monitoring are considered to be:

- For deep foundations, full time monitoring of pile installation; and,
- For earthworks, full time monitoring and compaction testing.

Suitably qualified persons, independent of the contractor, should carry out all such quality assurance monitoring. One of the purposes of providing an adequate level of monitoring is to verify that the recommendations provided in this report, which are based on the findings at discrete testhole locations, are relevant to other areas of the site. AECOM will provide these services upon request.

5. References

Asphalt Institute, 1997.
Thickness Design: Asphalt Pavements for Highways and Streets, Asphalt Institute Manual Series MS-1.

Campbell, J.E., 1987.
Surficial Geology of the Prince Albert Area, Sedimentary Resources Map, Saskatchewan Research Council, Map SRC-73H.

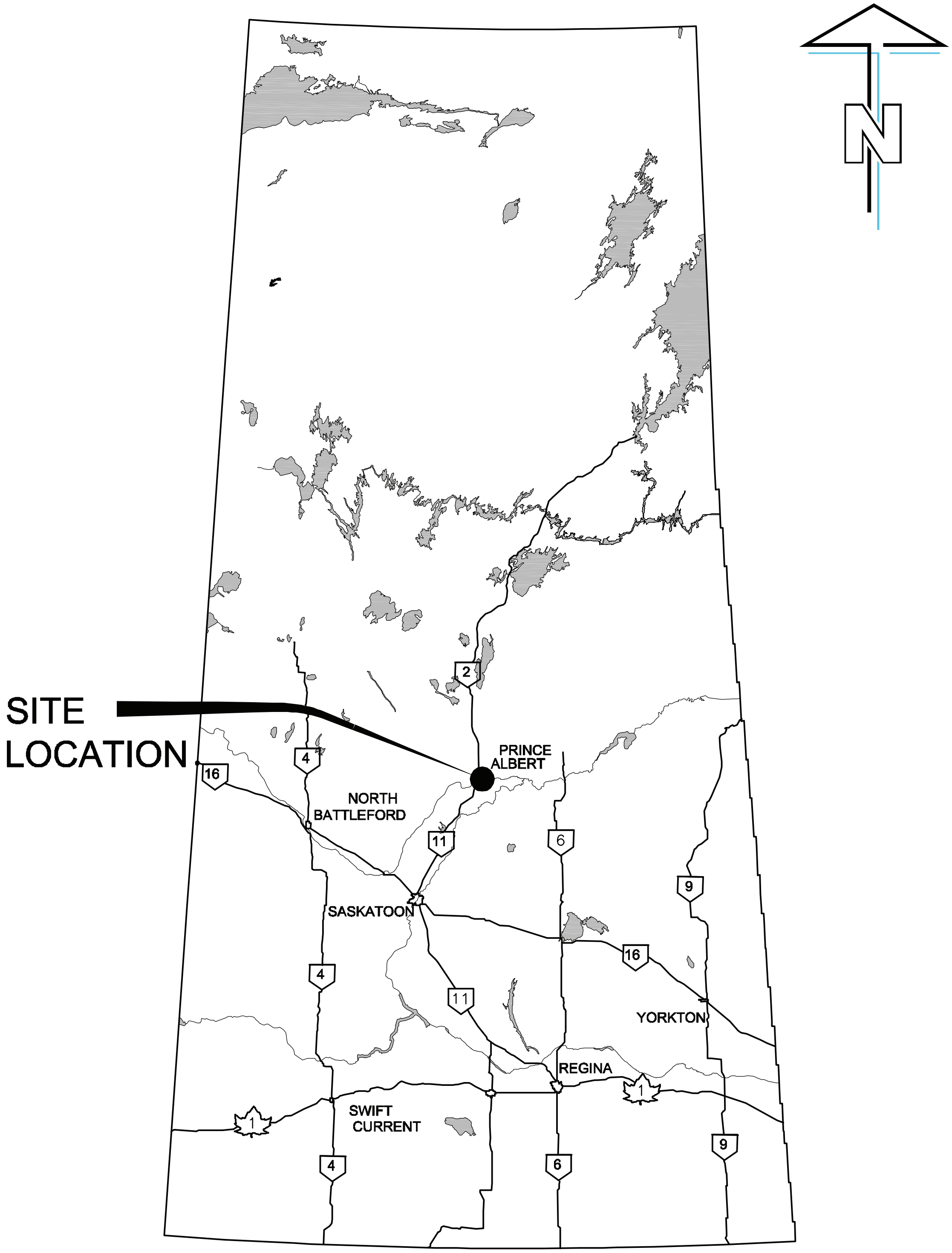
Canadian Standards Association, 2009.
CSA – A23.1-09, Concrete Materials and Methods of Concrete Construction.

CFEM, 2006. Canadian Foundation Engineering Manual. 4th Edition. Canadian Geotechnical Society, Technical Committee on Foundations, BiTech Publishers, Vancouver B.C.

Roberge, P.R., 1999.
Handbook of Corrosion Engineering. McGraw Hill, New York, NY.

Figures

Saskatchewan



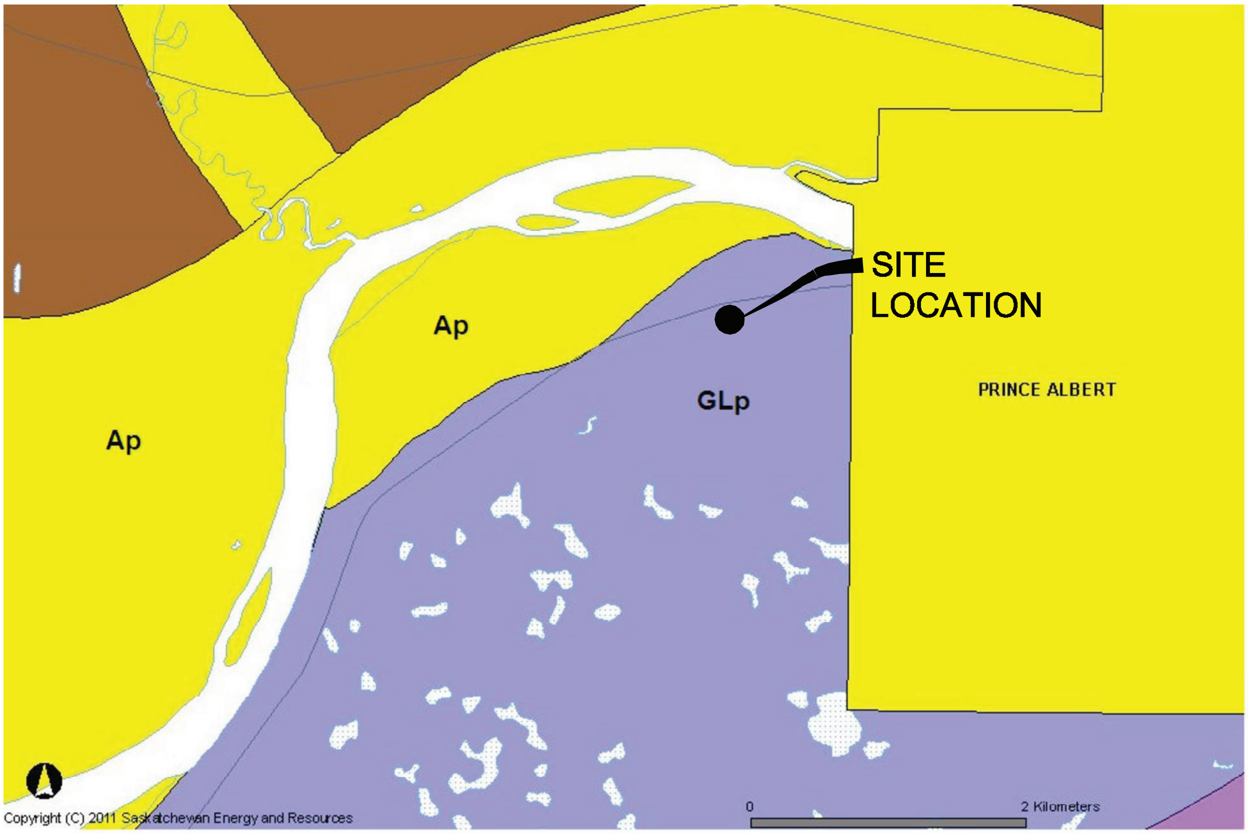
KEY MAP

PWGSC
CSC Riverbend Institution - 50 Bed Housing Unit
Geotechnical Investigation

AECOM

Site Location
Figure 1

ISS/REV:
AECOM FILE NAME: 60217802-01-C-F01-R0X.DWG   Saved By: kissickm2   PLOT: 05/08/2011 1:10:43 PM   A SIZE 8.5" x 11" (215.9mm x 279.4mm)



SURFICIAL GEOLOGY MAP OF SASKATCHEWAN

LEGEND

ALLUVIAL DEPOSITS: Gravel, sand, silt, clay, and slump material on floodplains and terraces of modern streams

Ap	Alluvial plain

GLACIOLACUSTRINE DEPOSITS: Sand, silt, and clay accumulations deposited in glacial lakes

GLp	Glaciolacustrine plain

SCALE: NTS

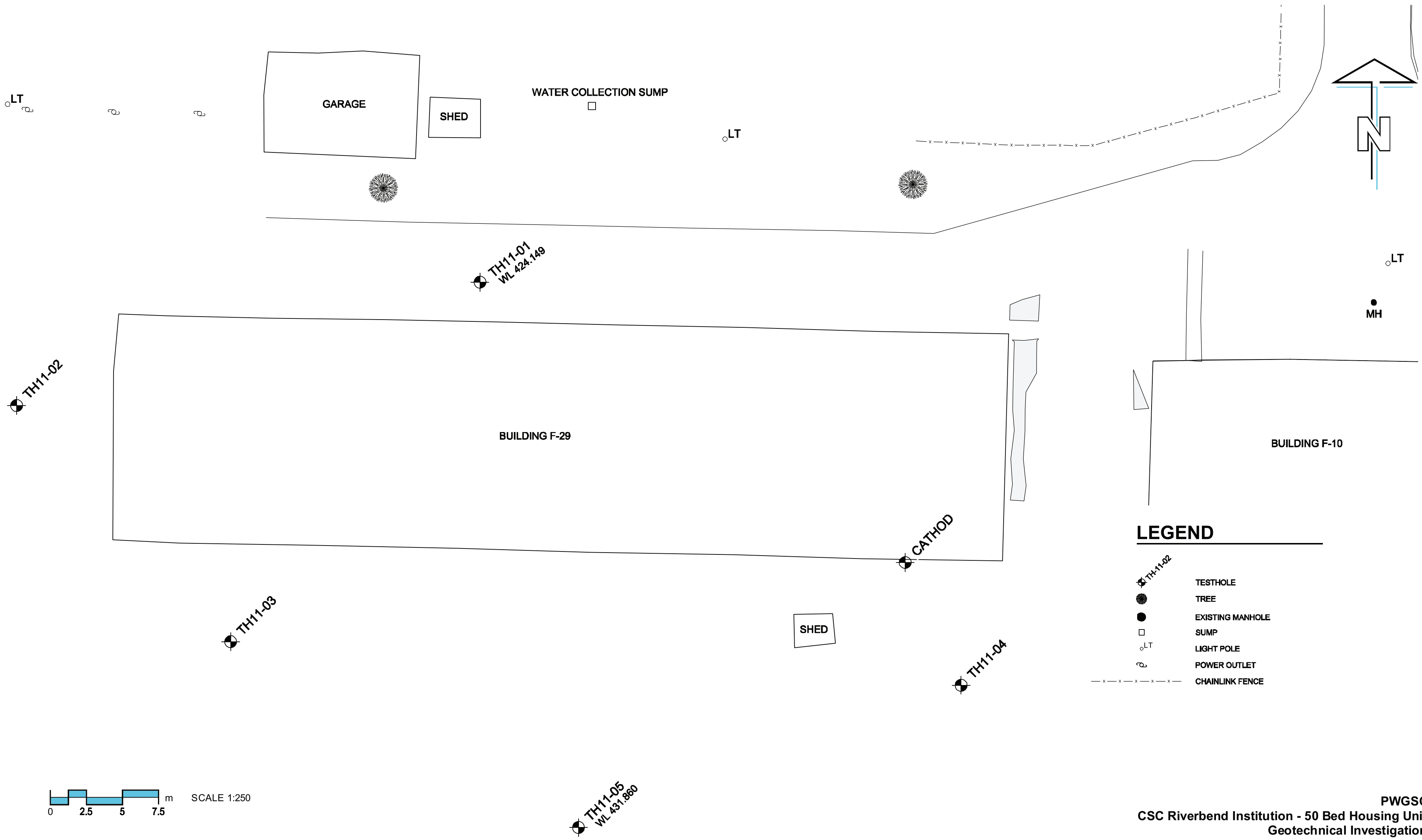
PWGSC
CSC Riverbend Institution - 50 Bed Housing Unit
Geotechnical Investigation

AECOM

Geological Setting
Figure 2

ISS/REV:
AECOM FILE NAME: 60217802-01-C-F02-R0X.DWG Saved By: kissickm2 PLOT: 05/08/2011 1:10:12 PM A SIZE 8.5" x 11" (215.9mm x 279.4mm)

ISS/REV:
AECOM FILE NAME: 60217802-01-C-F03-R0X.DWG   Saved By: KISSICKM2   PLOT: 28/10/2011 9:32:05 AM   B SIZE 11" x 17" (279.4mm x 431.8mm)

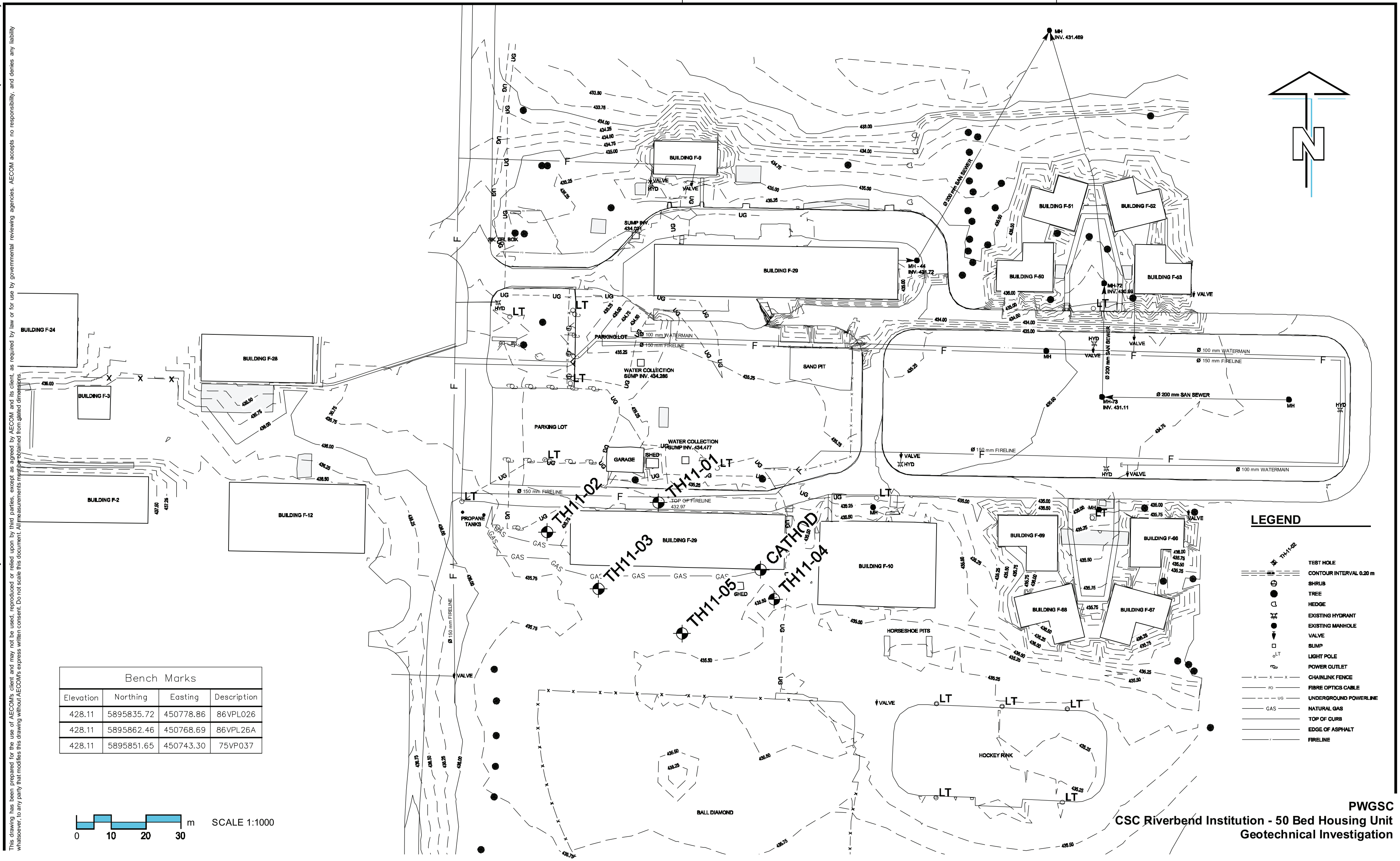


PWGSC
CSC Riverbend Institution - 50 Bed Housing Unit
Geotechnical Investigation

AECOM

Testhole Locations
Figure 3

ISS/REV:
AECOM FILE NAME: 60217802-01-C-F04-R0X.DWG Saved By: KISSICKM2 PLOT: 28/10/2011 9:32:58 AM B SIZE 11" x 17" (279.4mm x 431.8mm)



Bench Marks			
Elevation	Northing	Easting	Description
428.11	5895835.72	450778.86	86VPL026
428.11	5895862.46	450768.69	86VPL26A
428.11	5895851.65	450743.30	75VP037

0 10 20 30 m SCALE 1:1000

AECOM

PWGSC
CSC Riverbend Institution - 50 Bed Housing Unit
Geotechnical Investigation

Topographic & Utility Survey Plan
Figure 4

AECOM

Appendix A

Testhole Logs

EXPLANATION OF FIELD & LABORATORY TEST DATA

The field and laboratory test results, as shown for each hole, are described below.

1. NATURAL MOISTURE CONTENT

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 its natural moisture content and plotted on the Plasticity Chart in order to determine the soil classification.

2. SOIL PROFILE AND DESCRIPTION

Each soil strata is classified and described noting any special conditions. The Modified Unified Classification System (MUCS) is used. The soil profile refers to the existing ground level at the time the hole was done. Where available, the ground elevation is shown. The soil symbols used are shown in detail on the soil classification chart.

3. TESTS ON SOIL SAMPLES

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

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. Expressed in percent. Conducted primarily to determine requirements for the use of sulphate resistant cement. Further details on the water soluble sulphate content are given in Section 6.

γ_D - Dry Unit Weight. Usually expressed in kN/m^3.

γ_T - Total Unit Weight. Usually expressed in kN/m^3.

Q_U - Unconfined Compressive Strength. Usually expressed in kPa and may be used in determining allowable bearing capacity of the soil.

C_U - Undrained Shear Strength. Usually expressed in kPa. This value is determined by either a direct shear test or by an unconfined compression test and may also be used in determining the allowable bearing capacity of the soil.

C_{PEN} - Pocket Penetrometer Reading. Usually expressed in 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 separate sheets enclosed with the logs:

- Grain Size Analysis
- Standard or Modified Proctor Compaction Test
- California Bearing Ratio Test
- Direct Shear Test
- Permeability Test
- Consolidation Test
- Triaxial Test

4. SOIL DENSITY AND CONSISTENCY

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 Cohesive Soils

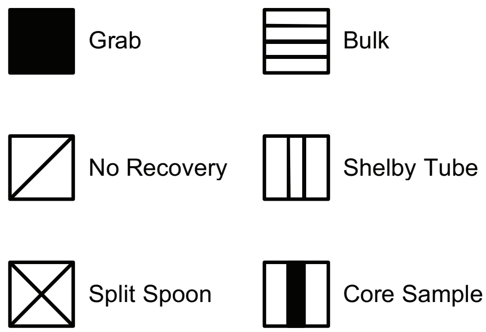
N	Consistency	C_u (kPa) approx.
0 - 1	Very Soft	<10
1 - 4	Soft	10 - 25
4 - 8	Firm	25 - 50
8 - 15	Stiff	50 - 100
15 - 30	Very Stiff	100 - 200
30 - 60	Hard	200 - 300
>60	Very Hard	>300

Table 2 Cohesionless Soils

N	Density
0 - 5	Very Loose
5 - 10	Loose
10 - 30	Compact
30 - 50	Dense
>50	Very Dense

5. SAMPLE CONDITION AND TYPE

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



6. WATER SOLUBLE SULPHATE CONCENTRATION

The following table, from CSA Standard A23.1-00, indicates the requirements for concrete subjected to sulphate attack based upon the percentage of water-soluble sulphate as presented on the logs. CSA Standard A23.1-00 should be read in conjunction with the table.

Table 3 Requirements For Concrete Subjected to Sulphate Attack*

Class of exposure	Degree of exposure	Water-soluble sulphate (SO_4) in soil sample, %	Sulphate (SO_4) in ground-water samples, mg/L	Minimum Specified 56 d compressive strength, MPa□	Maximum water/cementing materials ratio□	Air content category §	Cementing materials to be used **□□
S-1	Very severe	over 2.0	over 10,000	35	0.40	2	50
S-2	Severe	0.20 - 2.0	1,500 - 10,000	32	0.45	2	50
S-3	Moderate	0.10 - 0.20	150 - 1,500	30	0.50	2	20E‡‡, 40, or 50E

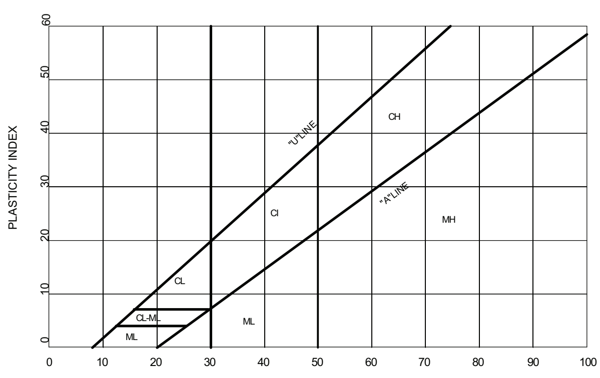
* For sea water exposure see Clause 15.4
† Where supplementary cementing materials are used, the owner may also specify other test ages.
‡ See Clause 15.1.4
§ For steel trowelled interior slabs on grade, subject to sulphate attack but not freeze-thaw, air entrainment is not required.
** See Clause 15.1.5
†† Cementing material combinations with equivalent performance may be used (see Clauses 3.2, 3.3, and 3.4)
‡‡ Type 20E cement with moderate sulphate resistance (see Clause 3.1.2)
Note: Type 50E cement shall not be used in reinforced concrete exposed to both chlorides and sulphates. Refer to Clause 15.4.

7. GROUNDWATER TABLE

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

AECOM

MAJOR DIVISION			UMA LOG SYMBOLS	MUCS	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS	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	$C_u = \frac{D_{60}}{D_{10}} > 4$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
				GP	POORLY GRADED GRAVELS AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		GRAVELS WITH 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	$C_u = \frac{D_{60}}{D_{10}} > 6$ $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
				SP	POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		SANDS WITH 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	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	
		$30 < W_L < 50$		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		
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	75	19	50 - 35	AND
	FINE	19	4.75		
SAND	COARSE	4.75	2.00	35 – 20	_____Y
	MEDIUM	2.00	0.425		
	FINE	0.425	0.080	20 – 10	SOME
SILT (non-plastic) or CLAY (plastic)		0.080		10 - 1	TRACE

OVERSIZE MATERIALS

ROUNDED OR SUB-ROUNDED	ANGULAR
COBBLES 75 mm TO 200 mm BOULDERS >200 mm	ROCK FRAGMENTS ROCKS > 0.75 m3 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

November 2009

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-01**
LOCATION: N 5894296.797 E445730.725		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid Stem Auger	ELEVATION (m): 435.449

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

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

DEPTH (m)	STANDPIPE	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80; PLASTIC M.C. LIQUID 20 40 60 80	COMMENTS	ELEVATION (m)
0		ASPH		ASPHALT						
		FILL		GRANULAR FILL						
		SP		SAND - trace clay, trace silt, brown, damp, loose						435
1										434
					SPLIT SPOON	57	9			
2				- OMC = 8.8 %, SPMDD = 1741 kg/m^3 (combined sample from testholes TH11-01 to TH11-05)						433
3				- wet, compact						
				- 0.3 % gravel, 96.9 % sand, 0.8 % silt, 2.0 % clay	SPLIT SPOON	58	16			432
4										431
		CH		CLAY - silty, grey, moist, stiff, high plastic						
5					SPLIT SPOON	59	10			430
6				- soluble sulphate content < 0.1 %, pH = 7.5, resistivity = 1064 ohm-cm	SPLIT SPOON	60	12			429
7										428
8					SPLIT SPOON	61	11			427
9					SPLIT SPOON	62	10			426
10										

AECOM

LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
REVIEWED BY: KT	COMPLETION DATE: 7/7/11
PROJECT ENGINEER:	

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-01**
LOCATION: N 5894296.797 E445730.725		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid Stem Auger	ELEVATION (m): 435.449

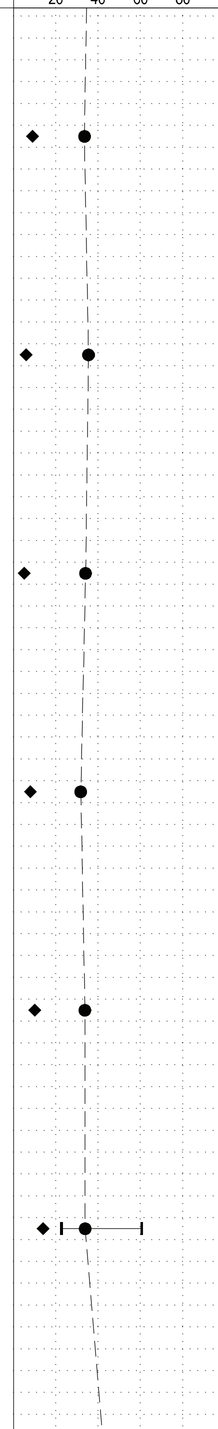
SAMPLE TYPE: GRAB, SHELBY TUBE, SPLIT SPOON, BULK, NO RECOVERY, CORE

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

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION (m)
10		CLAY - continued from previous page					425
10.9			Split spoon	63	9		
11							424
12		- firm					
12.4			Split spoon	64	6		423
13							422
14			Split spoon	65	5		421
15	CH						
15.5			Split spoon	66	8		420
16							419
17		- stiff	Split spoon	67	10		418
18							
18.5			Split spoon	68	14		417
19							416
20			Split spoon				

◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80

PLASTIC M.C. LIQUID 20 40 60 80



AECOM	LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
	REVIEWED BY: KT	COMPLETION DATE: 7/7/11
	PROJECT ENGINEER:	

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-01**
LOCATION: N 5894296.797 E445730.725		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid Stem Auger	ELEVATION (m): 435.449

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

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

DEPTH (m)	STANDPIPE	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	COMMENTS	ELEVATION (m)
20		CH		CLAY - continued from previous page	Split spoon	69	11			
				END OF TESTHOLE (20.27 m)						415
21										414
22										413
23										412
24										411
25										410
26										409
27										408
28										407
29										406
30										

LOG OF TESTHOLE 60217802 TESTHOLE LOGS (JULY2011).GPJ UMA.GDT 10/28/11

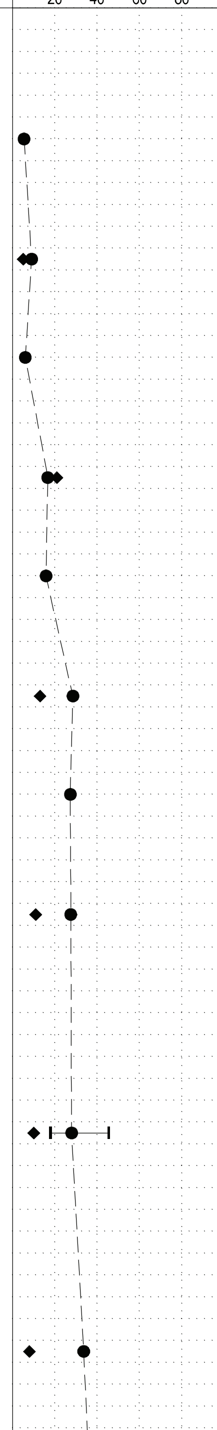
AECOM	LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
	REVIEWED BY: KT	COMPLETION DATE: 7/7/11
	PROJECT ENGINEER:	Page 3 of 3

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-02**
LOCATION: N 5894288.276 E 445698.661		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid/Hollow Stem Auger	ELEVATION (m): 435.587

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

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION (m)
0	SP	SAND - trace clay, trace silt, brown, damp, loose to very loose				Solid stem auger	
							435
1			GRAB	1			
							434
			SPLIT SPOON	2	5		
2		- OMC = 8.8 %, SPMDD = 1741 kg/m^3 (combined sample from testholes TH11-01 to TH11-05)					
			GRAB	3			
							433
3		- compact - free water - soluble sulphate content < 0.1 %, pH = 8.3, resistivity = 4610 ohm-cm	SPLIT SPOON	4	21		
							432
4			GRAB	5			
	CI	CLAY - silty, grey, moist, stiff, medium plastic					431
			SPLIT SPOON	6	13		
5							
			GRAB	7			430
6						Hollow stem auger	
			SPLIT SPOON	8	11		
							429
7							
							428
			SPLIT SPOON	9	10		
8							
							427
9							
			SPLIT SPOON	10	8		
							426
10							

◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80
PLASTIC M.C. LIQUID 20 40 60 80

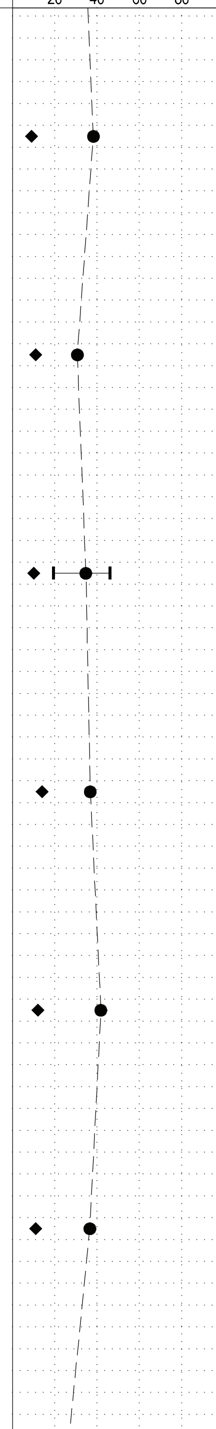


	LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
AECOM	REVIEWED BY: KT	COMPLETION DATE: 7/5/11
	PROJECT ENGINEER:	Page 1 of 3

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-02**
LOCATION: N 5894288.276 E 445698.661		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid/Hollow Stem Auger	ELEVATION (m): 435.587

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

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80; PLASTIC M.C. LIQUID 20 40 60 80	COMMENTS	ELEVATION (m)
10			CLAY - continued from previous page						
									425
11				SPLIT SPOON	11	9			
									424
12				SPLIT SPOON	12	11			
									423
13									
									422
14				SPLIT SPOON	13	10			
									421
15	CI								
				SPLIT SPOON	14	14			420
16									
									419
17				SPLIT SPOON	15	12			
									418
18									
				SPLIT SPOON	16	11			417
19									
									416
20				SPLIT SPOON					



AECOM	LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
	REVIEWED BY: KT	COMPLETION DATE: 7/5/11
	PROJECT ENGINEER:	Page 2 of 3

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-02**
LOCATION: N 5894288.276 E 445698.661		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid/Hollow Stem Auger	ELEVATION (m): 435.587

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

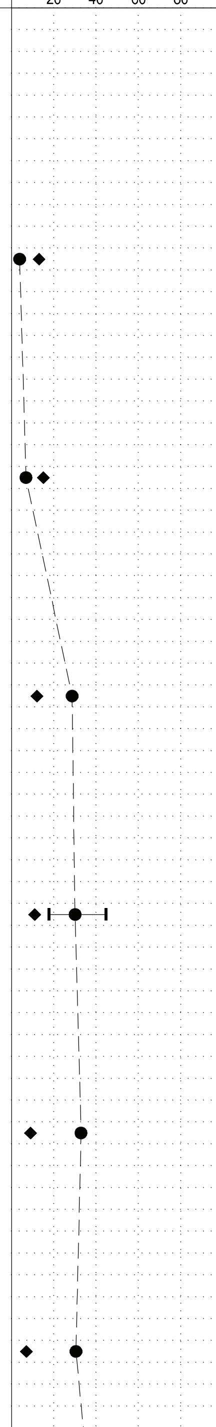
DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80; PLASTIC M.C. LIQUID 20 40 60 80	COMMENTS	ELEVATION (m)
20	CI		CLAY - continued from previous page	Split spoon	17	17			
			END OF TESTHOLE (20.27 m) - slough measured at 18.9 m depth upon completion of drilling - ground water measured at 7.6 m depth upon completion of drilling						415
21									414
22									413
23									412
24									411
25									410
26									409
27									408
28									407
29									406
30									

AECOM	LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
	REVIEWED BY: KT	COMPLETION DATE: 7/5/11
	PROJECT ENGINEER:	Page 3 of 3

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-03**
LOCATION: N 5894271.963 E 445713.471		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid Stem Auger	ELEVATION (m): 435.7

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

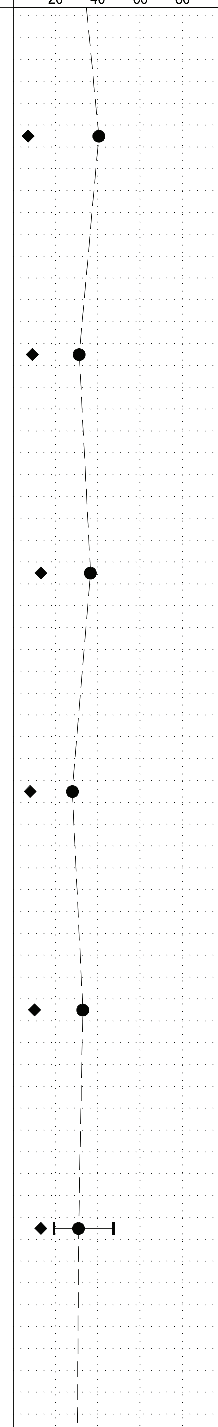
DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80; PLASTIC M.C. LIQUID 20 40 60 80	COMMENTS	ELEVATION (m)
0	OR		TOPSOIL						
	SP		SAND - trace clay, trace silt, brown, damp, compact						
1									435
			- 0 % gravel, 95.7 % sand, 1.3 % silt, 3.0 % clay	SPLIT SPOON	18	13			434
2			- OMC = 8.8 %, SPMDD = 1741 kg/m^3 (combined sample from testholes TH11-01 to TH11-05)						
3			- wet	SPLIT SPOON	19	15			433
4									432
	CI		CLAY - silty, grey, moist, stiff, medium plastic						
5				SPLIT SPOON	20	12			431
6									430
				SPLIT SPOON	21	11			429
7									
8				SPLIT SPOON	22	9			428
9									427
			- soluble sulphate content < 0.1 %, pH = 7.4, resistivity = 940 ohm-cm - wet sand lens, firm	SPLIT SPOON	23	7			426
10									



PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-03**
LOCATION: N 5894271.963 E 445713.471		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid Stem Auger	ELEVATION (m): 435.7

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

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80; PLASTIC M.C. LIQUID 20 40 60 80	COMMENTS	ELEVATION (m)
10			CLAY - continued from previous page						
									425
11				Split spoon	24	7			
									424
12			- stiff	Split spoon	25	9			
									423
13									
									422
14				Split spoon	26	13			
									421
15	CI								
			- seapage	Split spoon	27	8			
									420
16									
									419
17				Split spoon	28	10			
									418
18									
				Split spoon	29	13			417
19									
									416
20				Split spoon					



AECOM	LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
	REVIEWED BY: KT	COMPLETION DATE: 7/5/11
	PROJECT ENGINEER:	Page 2 of 3

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-03**
LOCATION: N 5894271.963 E 445713.471		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid Stem Auger	ELEVATION (m): 435.7

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

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80; PLASTIC M.C. LIQUID 20 40 60 80	COMMENTS	ELEVATION (m)
20	CI		CLAY - continued from previous page	SPLIT SPOON	30	15			
			END OF TESTHOLE (20.27 m)						
21									415
22									414
23									413
24									412
25									411
26									410
27									409
28									408
29									407
30									406

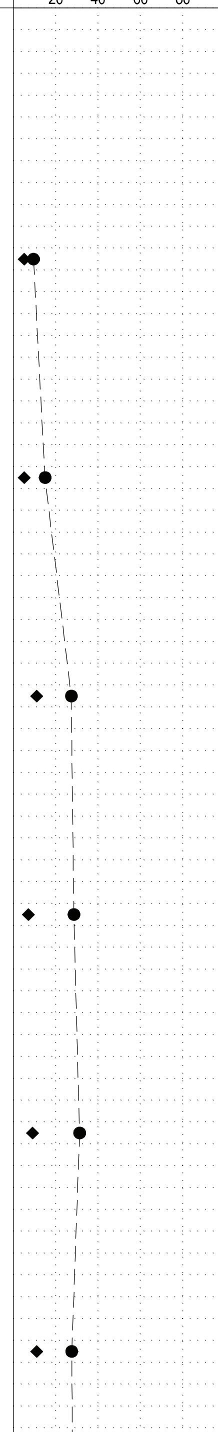
AECOM	LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
	REVIEWED BY: KT	COMPLETION DATE: 7/5/11
	PROJECT ENGINEER:	Page 3 of 3

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-04**
LOCATION: N 5894268.952 E 445764.021		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid Stem Auger	ELEVATION (m): 435.54

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

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION (m)
0	OR	TOPSOIL					
	SP	SAND - trace clay, trace silt, brown, damp, loose to very loose					435
1							434
			SPLIT SPOON	44	5		
2		- OMC = 8.8 %, SPMDD = 1741 kg/m^3 (combined sample from testholes TH11-01 to TH11-05)					433
3		- wet					
		- soluble sulphate content < 0.1 %, pH = 8.2, resistivity = 5390 ohm-cm	SPLIT SPOON	45	5		432
4	CI	CLAY - silty, grey, moist, stiff, medium plastic					431
			SPLIT SPOON	46	11		
5							430
6		- firm	SPLIT SPOON	47	7		429
7							428
		- stiff	SPLIT SPOON	48	9		
8							427
9		- seapage	SPLIT SPOON	49	11		426
10							

◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80
PLASTIC M.C. LIQUID 20 40 60 80



AECOM

LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
REVIEWED BY: KT	COMPLETION DATE: 7/6/11
PROJECT ENGINEER:	

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-04**
LOCATION: N 5894268.952 E 445764.021		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid Stem Auger	ELEVATION (m): 435.54

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

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80; PLASTIC M.C. LIQUID 20 40 60 80	COMMENTS	ELEVATION (m)
10			CLAY - continued from previous page						
									425
11				Split spoon	50	9		No recovery	
									424
12									
				Split spoon	51	10			423
13									
									422
14				Split spoon	52	14			
									421
15	CI								
				Split spoon	53	15			420
16									
									419
17				Split spoon	54	15			
									418
18									
			- open water	Split spoon	55	11			417
19									
									416
20				Split spoon					

AECOM

LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
REVIEWED BY: KT	COMPLETION DATE: 7/6/11
PROJECT ENGINEER:	

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-04**
LOCATION: N 5894268.952 E 445764.021		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid Stem Auger	ELEVATION (m): 435.54

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

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80; PLASTIC M.C. LIQUID 20 40 60 80	COMMENTS	ELEVATION (m)
20	CI		CLAY - continued from previous page	SPLIT SPOON	56	16			
			END OF TESTHOLE (20.27 m)						

Depth scale (m): 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

Elevation scale (m): 415, 414, 413, 412, 411, 410, 409, 408, 407, 406

LOG OF TESTHOLE 60217802 TESTHOLE LOGS (JULY2011).GPJ UMA.GDT 10/28/11

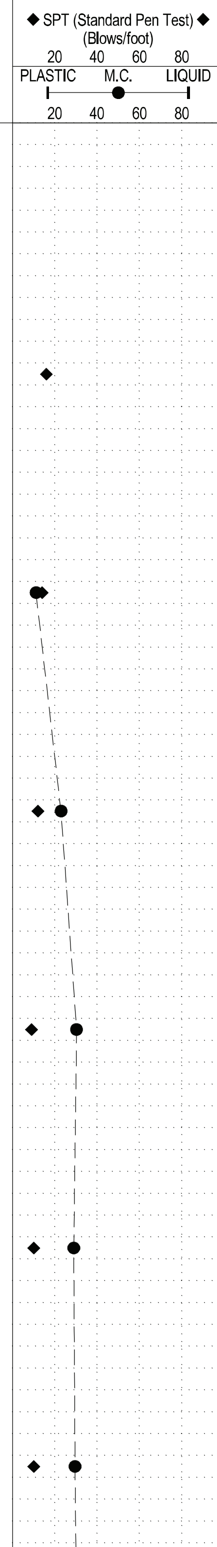
AECOM	LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
	REVIEWED BY: KT	COMPLETION DATE: 7/6/11
	PROJECT ENGINEER:	Page 3 of 3

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-05**
LOCATION: N5894259.102 E445737.227		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid Stem Auger	ELEVATION (m): 435.505

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
0	OR	TOPSOIL				
	SP	SAND - trace clay, trace silt, brown, damp, compact				
~1.8			Split spoon	31	16	
~2.0		- OMC = 8.8 %, SPMDD = 1741 kg/m^3 (combined sample from testholes TH11-01 to TH11-05)				
~3.1		- wet	Split spoon	32	14	
~4.3	ML	SILT - sandy, grey, wet, hard				
~4.8		- soluble sulphate content < 0.1 %, pH = 7.6, resistivity = 1546 ohm-cm - 0 % gravel, 33.2 % sand, 58.8 % silt, 8.0 % clay	Split spoon	33	12	
~6.1	CI	CLAY - silty, grey, damp, stiff, medium plastic	Split spoon	34	9	
~7.8			Split spoon	35	10	
~9.3			Split spoon	36	10	



ELEVATION (m): 435, 434, 433, 432, 431, 430, 429, 428, 427, 426

DEPTH (m): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

AECOM

LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
REVIEWED BY: KT	COMPLETION DATE: 7/6/11
PROJECT ENGINEER:	

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-05**
LOCATION: N5894259.102 E445737.227		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid Stem Auger	ELEVATION (m): 435.505

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)
10		CLAY - continued from previous page					
							425
			Split spoon	37	10		
11							
							424
12		- seapage					
			Split spoon	38	10		423
13							
							422
14			Split spoon	39	8		
							421
15	CI						
			Split spoon	40	15		420
16							
							419
17			Split spoon	41	11		
							418
18							
			Split spoon	42	12		417
19							
							416
20			Split spoon				

◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80

PLASTIC M.C. LIQUID 20 40 60 80

AECOM

LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
REVIEWED BY: KT	COMPLETION DATE: 7/6/11
PROJECT ENGINEER:	

PROJECT: CSC Riverbend Institution - 50 Bed Housing Unit	CLIENT: PWGSC	TESTHOLE NO: **11-05**
LOCATION: N5894259.102 E445737.227		PROJECT NO.: 60217802
CONTRACTOR: Boss Drilling Ltd.	METHOD: Solid Stem Auger	ELEVATION (m): 435.505

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

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

DEPTH (m)	STANDPIPE	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	◆ SPT (Standard Pen Test) ◆ (Blows/foot) 20 40 60 80; PLASTIC M.C. LIQUID 20 40 60 80	COMMENTS	ELEVATION (m)
20		CI		CLAY - continued from previous page	Split spoon	43	11			
				END OF TESTHOLE (20.27 m)						415
21										414
22										413
23										412
24										411
25										410
26										409
27										408
28										407
29										406
30										

AECOM

LOGGED BY: CK	COMPLETION DEPTH: 20.27 m
REVIEWED BY: KT	COMPLETION DATE: 7/6/11
PROJECT ENGINEER:	

Appendix B

Laboratory Test Results

GRAIN SIZE ANALYSIS

AECOM

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	58
TESTHOLE:	11-01	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	JS

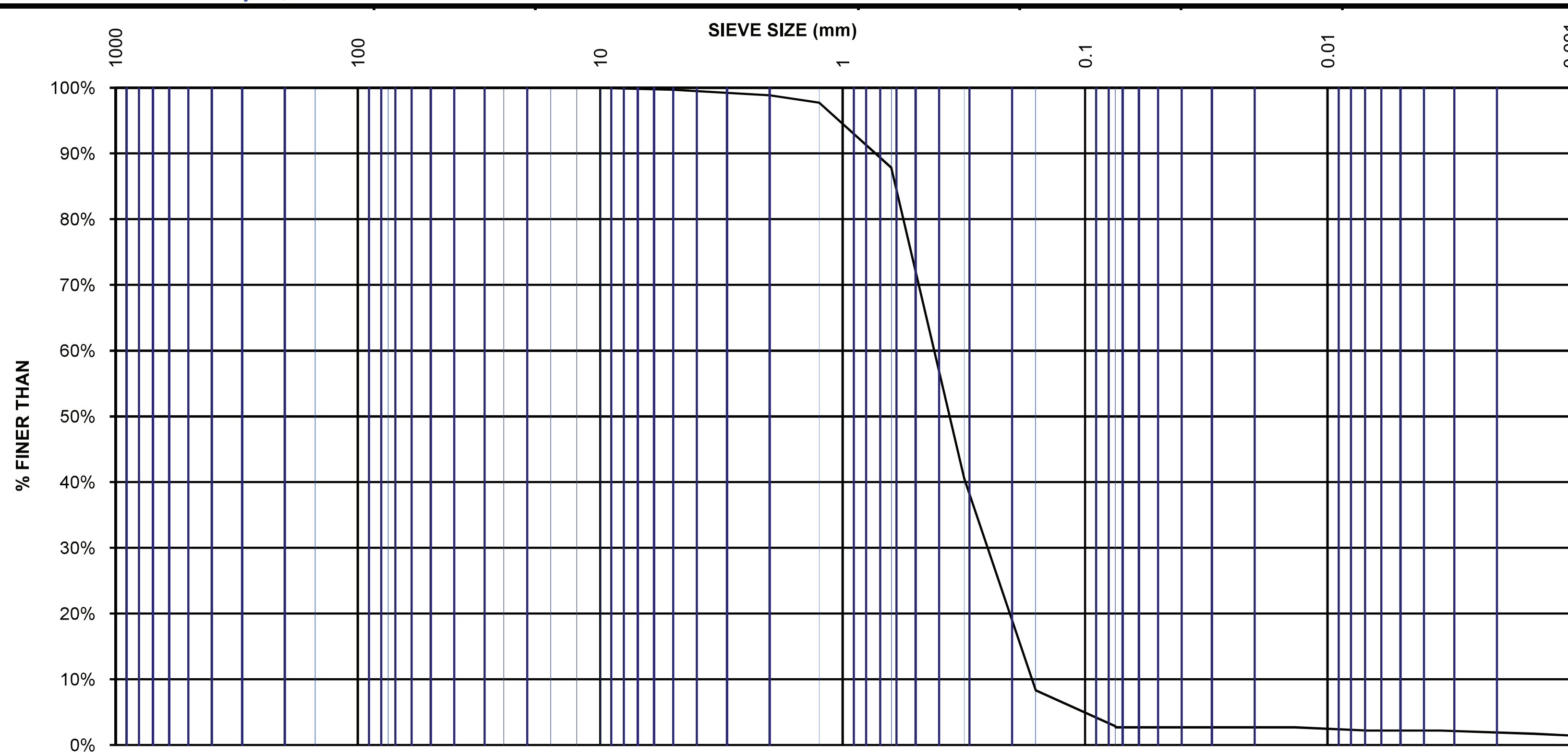
TOTAL DRY WEIGHT OF SAMPLE		SIEVE NO. (µm)	SIZE OF OPENING APPROX. INCHES	SIZE OF OPENING mm	WEIGHT RETAINED (g)	PERCENT RETAINED	PERCENT FINER THAN	REMARKS
Before Washing		150,000	6	150.0		0%	100%	
Wet + Tare		75,000	3	75.0		0%	100%	
Dry+Tare	351	50,000	2	50.0		0%	100%	
Tare	100	40,000	1 1/2	40.0		0%	100%	
Wt. Dry	251	25,000	1	25.0		0%	100%	
Moisture Content		20,000	3/4	20.0		0%	100%	
Wet + Tare		16,000	5/8	16.0		0%	100%	
Dry+Tare		12,500	1/2	12.5		0%	100%	
Tare		10,000	3/8	10.0		0%	100%	
MC (%)		5,000	0.185	5.0	0.8	0%	99.7%	
	Passing							
After Washing		2,000	0.0937	2.0	2.9	1%	98.8%	
Wt. Dry+Tare		1,250	0.0469	1.25	5.7	2%	97.7%	
Tare		630	0.0234	0.63	30.5	12%	87.8%	
Wt. Dry		315	0.0116	0.315	149.1	59%	40.5%	
Tare No.		160	0.0059	0.160	229.9	92%	8.3%	
		75	0.00295	0.075	243.7	97%	2.8%	
		PAN						

HYDROMETER DATA		READING	TIME (min)	DIAMETER (mm)	TEMP. (°C)	CORR. READING	PERCENT FINER THAN	REMARKS
Wt Dry+Tare	350.8	8	0.5	0.075	19	3	2.7%	
Wt Tare	100.0	8	1	0.053	19	3	2.7%	
Wt Dry	250.8	8	2	0.037	19	3	2.7%	
Sample Size :	100	8	5	0.024	19	3	2.7%	
Wt Retained 2 mm:	2.9	8	15	0.014	19	3	2.7%	
% Passing 2 mm:	98.8%	8	30	0.010	19	3	2.7%	
Specific Gravity :	2.70	7	60	0.007	19	2	2.2%	
Hydrometer No.:	43-9856	7	120	0.005	19	2	2.2%	
Solution (g/L) :	40	7	240	0.003	19	2	2.2%	
		7	1440	0.001	19	2	1.7%	
		7	2880	0.001	18	2	1.5%	

GRAIN SIZE ANALYSIS

AECOM

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	58
TESTHOLE:	11-01	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	JS



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

FORM: PWGSC-Riverbend hydro 1-58.xls
DATE: 8/5/2011

ATTERBERG LIMITS

AECOM

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	62
BOREHOLE:	TH11-01	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	LS

LIQUID LIMIT

Trial No.	1					
Number of Blows	22					
Container Number						
Wt. Sample (wet+tare)(g)	39.41					
Wt. Sample (dry+tare)(g)	30.88					
Wt. Tare (g)	16.13					
Wt. Dry Soil (g)	14.8					
Wt. Water (g)	8.5					
Water Content (%)	57.8%					

AVERAGE VALUES

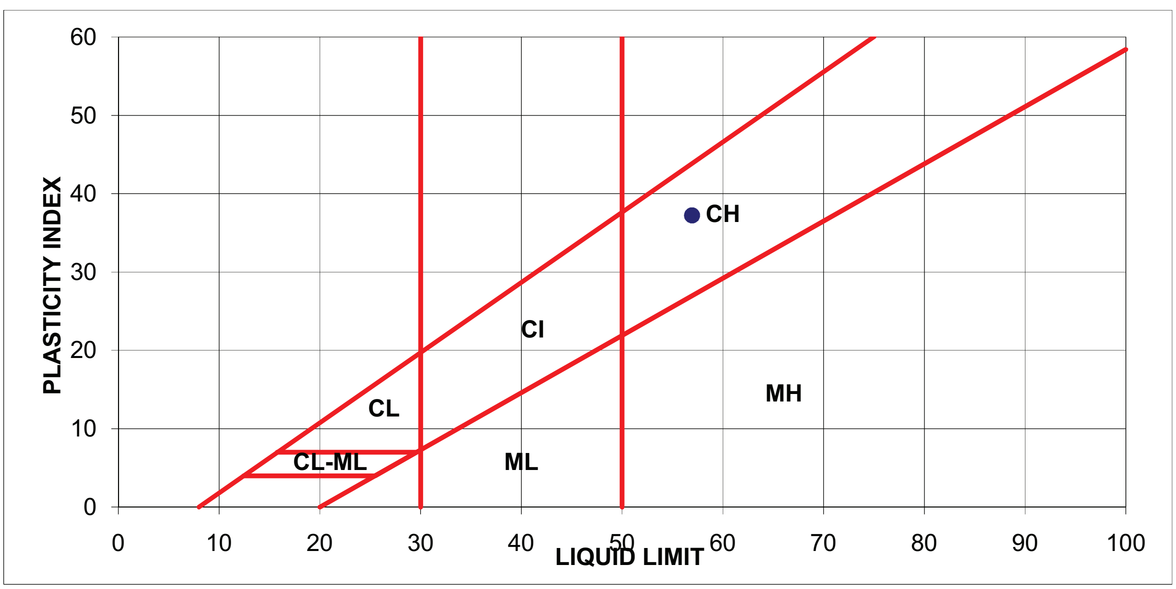
Liquid Limit	56.9
Plastic Limit	19.7
Plasticity Index	37.2

SAMPLE DESCRIPTION

Classification: **CH**

PLASTIC LIMIT

Trial No.	1		
Container Number			
Wt. Sample (wet+tare)(g)	21.22		
Wt. Sample (dry+tare)(g)	19.70		
Wt. Tare (g)	11.99		
Wt. Dry Soil (g)	7.7		
Wt. Water (g)	1.5		
Water Content (%)	19.7%		



FORM: PWGSC-Riverbend Atter 1-62.xls
DATE: 25/07/2011

ATTERBERG LIMITS

AECOM

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	68
BOREHOLE:	TH11-01	DEPTH :	
DATE :	July 20, 2011	TECHNICIAN :	LS

LIQUID LIMIT

Trial No.	1					
Number of Blows	27					
Container Number						
Wt. Sample (wet+tare)(g)	35.26					
Wt. Sample (dry+tare)(g)	26.51					
Wt. Tare (g)	12.07					
Wt. Dry Soil (g)	14.4					
Wt. Water (g)	8.8					
Water Content (%)	60.6%					

AVERAGE VALUES

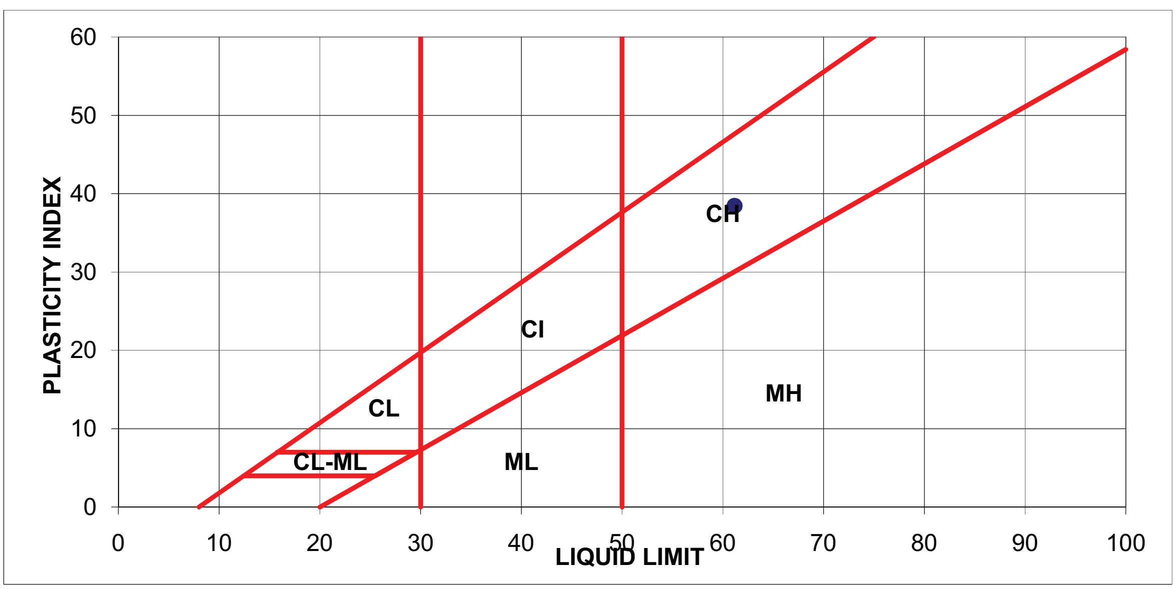
Liquid Limit	61.2
Plastic Limit	22.7
Plasticity Index	38.4

SAMPLE DESCRIPTION

Classification: **CH**

PLASTIC LIMIT

Trial No.	1		
Container Number			
Wt. Sample (wet+tare)(g)	26.38		
Wt. Sample (dry+tare)(g)	24.49		
Wt. Tare (g)	16.17		
Wt. Dry Soil (g)	8.3		
Wt. Water (g)	1.9		
Water Content (%)	22.7%		



FORM: PWGSC-Riverbend Atter 1-68.xls
DATE: 25/07/2011

ATTERBERG LIMITS

AECOM

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	9
BOREHOLE:	TH11-02	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	LS

LIQUID LIMIT

Trial No.	1					
Number of Blows	21					
Container Number						
Wt. Sample (wet+tare)(g)	46.96					
Wt. Sample (dry+tare)(g)	37.36					
Wt. Tare (g)	16.25					
Wt. Dry Soil (g)	21.1					
Wt. Water (g)	9.6					
Water Content (%)	45.5%					

AVERAGE VALUES

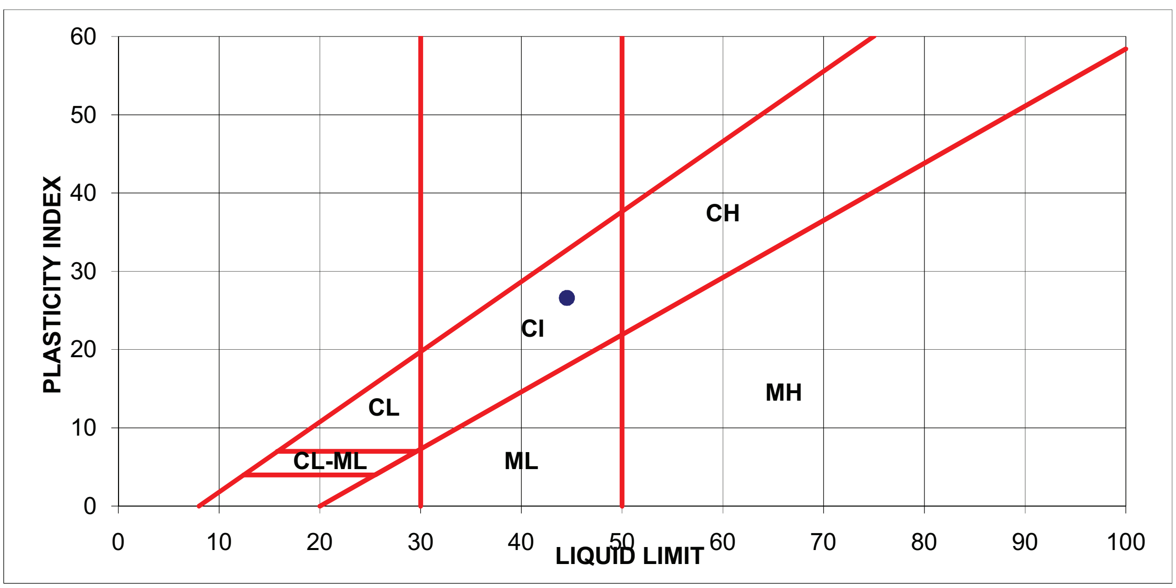
Liquid Limit	44.5
Plastic Limit	17.9
Plasticity Index	26.6

SAMPLE DESCRIPTION

Classification: **CI**

PLASTIC LIMIT

Trial No.	1		
Container Number			
Wt. Sample (wet+tare)(g)	23.29		
Wt. Sample (dry+tare)(g)	21.59		
Wt. Tare (g)	12.10		
Wt. Dry Soil (g)	9.5		
Wt. Water (g)	1.7		
Water Content (%)	17.9%		



FORM: PWGSC-Riverbend Atter 2-9.xls
DATE: 25/07/2011

ATTERBERG LIMITS

AECOM

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	13
BOREHOLE:	TH11-02	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	LS

LIQUID LIMIT

Trial No.	1					
Number of Blows	20					
Container Number						
Wt. Sample (wet+tare)(g)	34.39					
Wt. Sample (dry+tare)(g)	27.34					
Wt. Tare (g)	12.03					
Wt. Dry Soil (g)	15.3					
Wt. Water (g)	7.1					
Water Content (%)	46.0%					

AVERAGE VALUES

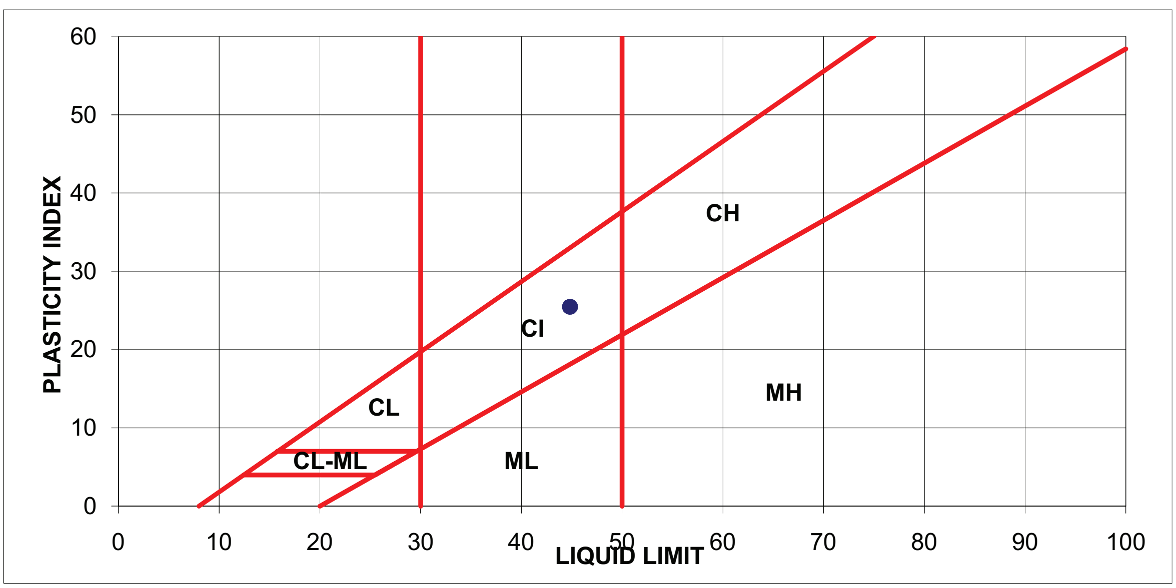
Liquid Limit	44.8
Plastic Limit	19.4
Plasticity Index	25.5

SAMPLE DESCRIPTION

Classification: **CI**

PLASTIC LIMIT

Trial No.	1		
Container Number			
Wt. Sample (wet+tare)(g)	26.45		
Wt. Sample (dry+tare)(g)	24.46		
Wt. Tare (g)	14.18		
Wt. Dry Soil (g)	10.3		
Wt. Water (g)	2.0		
Water Content (%)	19.4%		



FORM: PWGSC-Riverbend Atter 2-13.xls
DATE: 25/07/2011

GRAIN SIZE ANALYSIS

AECOM

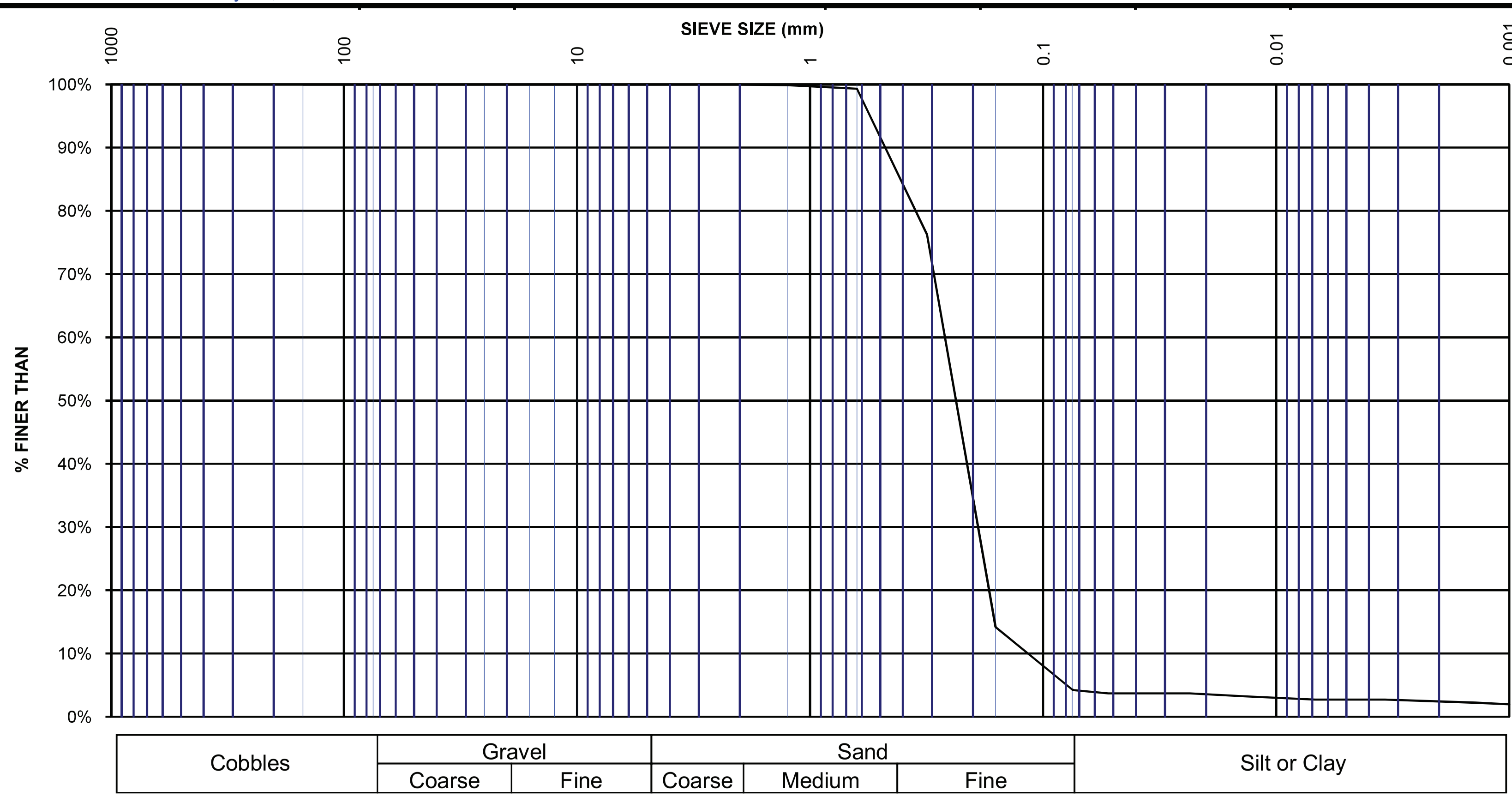
CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	18
TESTHOLE:	11-03	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	JS

TOTAL DRY WEIGHT OF SAMPLE		SIEVE NO. (µm)	SIZE OF OPENING APPROX. INCHES	SIZE OF OPENING mm	WEIGHT RETAINED (g)	PERCENT RETAINED	PERCENT FINER THAN	REMARKS
Before Washing		150,000	6	150.0		0%	100%	
Wet + Tare		75,000	3	75.0		0%	100%	
Dry+Tare	351	50,000	2	50.0		0%	100%	
Tare	100	40,000	1 1/2	40.0		0%	100%	
Wt. Dry	251	25,000	1	25.0		0%	100%	
Moisture Content		20,000	3/4	20.0		0%	100%	
Wet + Tare		16,000	5/8	16.0		0%	100%	
Dry+Tare		12,500	1/2	12.5		0%	100%	
Tare		10,000	3/8	10.0		0%	100%	
MC (%)		5,000	0.185	5.0	0.0	0%	100.0%	
	Passing							
After Washing		2,000	0.0937	2.0	0.0	0%	100.0%	
Wt. Dry+Tare		1,250	0.0469	1.25	0.3	0%	99.9%	
Tare		630	0.0234	0.63	1.8	1%	99.3%	
Wt. Dry		315	0.0116	0.315	59.5	24%	76.3%	
Tare No.		160	0.0059	0.160	215.4	86%	14.2%	
		75	0.00295	0.075	240.2	96%	4.3%	
		PAN						

HYDROMETER DATA		READING	TIME (min)	DIAMETER (mm)	TEMP. (°C)	CORR. READING	PERCENT FINER THAN	REMARKS
Wt Dry+Tare	351.0	9	0.5	0.074	19	4	4.2%	
Wt Tare	100.0	9	1	0.053	19	4	3.7%	
Wt Dry	251.0	9	2	0.037	19	4	3.7%	
Sample Size :	100	9	5	0.023	19	4	3.7%	
Wt Retained 2 mm:	0	8	15	0.014	19	3	3.2%	
% Passing 2 mm:	100.0%	8	30	0.010	19	3	2.7%	
Specific Gravity :	2.70	8	60	0.007	19	3	2.7%	
Hydrometer No.:	43-9856	8	120	0.005	19	3	2.7%	
Solution (g/L) :	40	8	240	0.003	19	3	2.7%	
		7	1440	0.001	19	2	2.2%	
		7	2880	0.001	18	2	2.0%	

GRAIN SIZE ANALYSIS

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	18
TESTHOLE:	11-03	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	JS



FORM: PWGSC-Riverbend hydro 3-18.xls
DATE: 8/5/2011

ATTERBERG LIMITS

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	21
BOREHOLE:	TH11-03	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	LS

LIQUID LIMIT

Trial No.	1					
Number of Blows	23					
Container Number						
Wt. Sample (wet+tare)(g)	38.16					
Wt. Sample (dry+tare)(g)	30.14					
Wt. Tare (g)	12.20					
Wt. Dry Soil (g)	17.9					
Wt. Water (g)	8.0					
Water Content (%)	44.7%					

AVERAGE VALUES

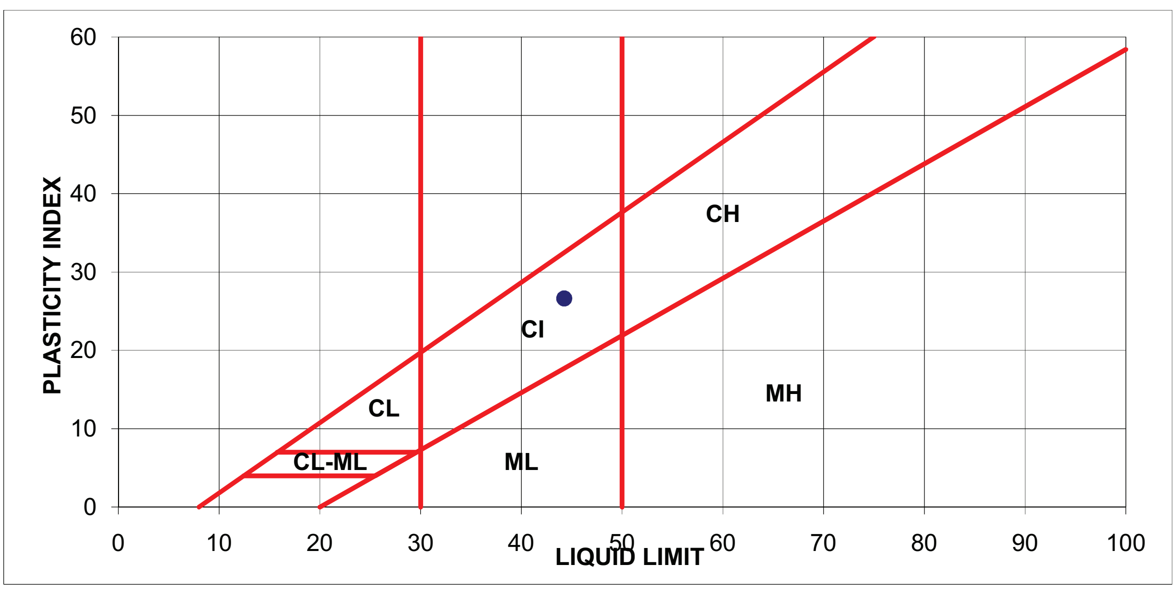
Liquid Limit	44.3
Plastic Limit	17.6
Plasticity Index	26.6

SAMPLE DESCRIPTION

Classification: **CI**

PLASTIC LIMIT

Trial No.	1		
Container Number			
Wt. Sample (wet+tare)(g)	27.19		
Wt. Sample (dry+tare)(g)	25.53		
Wt. Tare (g)	16.11		
Wt. Dry Soil (g)	9.4		
Wt. Water (g)	1.7		
Water Content (%)	17.6%		



FORM: PWGSC-Riverbend Atter 3-21.xls
DATE: 25/07/2011

ATTERBERG LIMITS

AECOM

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	29
BOREHOLE:	TH11-03	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	LS

LIQUID LIMIT

Trial No.	1					
Number of Blows	27					
Container Number						
Wt. Sample (wet+tare)(g)	30.85					
Wt. Sample (dry+tare)(g)	24.81					
Wt. Tare (g)	12.02					
Wt. Dry Soil (g)	12.8					
Wt. Water (g)	6.0					
Water Content (%)	47.2%					

AVERAGE VALUES

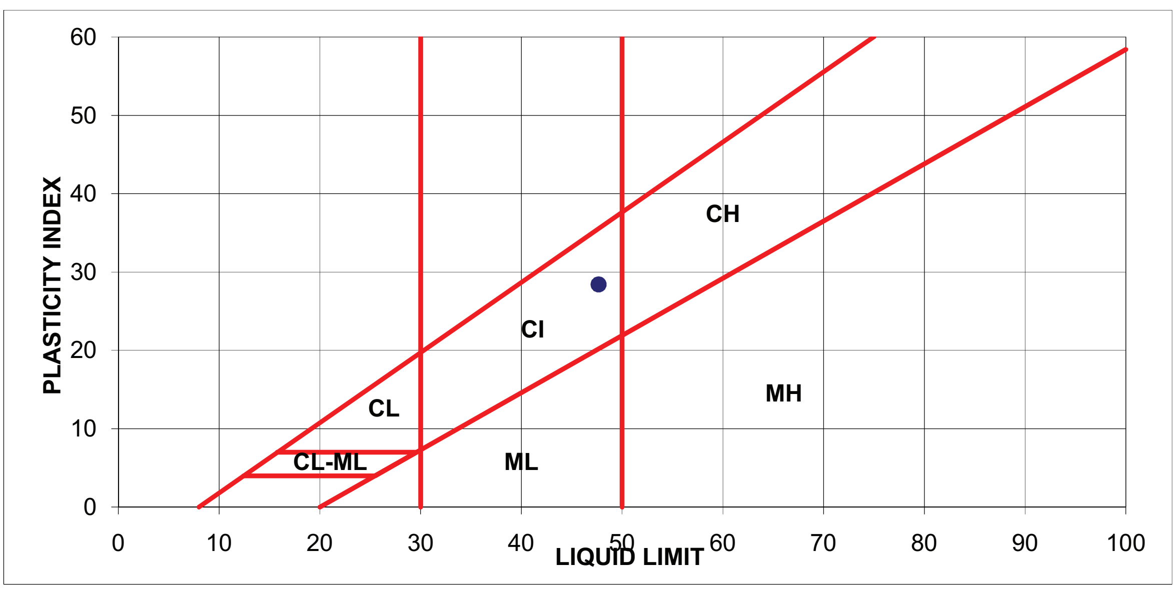
Liquid Limit	47.7
Plastic Limit	19.2
Plasticity Index	28.4

SAMPLE DESCRIPTION

Classification: **CI**

PLASTIC LIMIT

Trial No.	1		
Container Number			
Wt. Sample (wet+tare)(g)	28.63		
Wt. Sample (dry+tare)(g)	26.63		
Wt. Tare (g)	16.24		
Wt. Dry Soil (g)	10.4		
Wt. Water (g)	2.0		
Water Content (%)	19.2%		



FORM: PWGSC-Riverbend Atter 3-29.xls
DATE: 25/07/2011

ATTERBERG LIMITS

AECOM

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	52
BOREHOLE:	TH11-04	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	LS

LIQUID LIMIT

Trial No.	1					
Number of Blows	18					
Container Number						
Wt. Sample (wet+tare)(g)	44.89					
Wt. Sample (dry+tare)(g)	35.17					
Wt. Tare (g)	14.58					
Wt. Dry Soil (g)	20.6					
Wt. Water (g)	9.7					
Water Content (%)	47.2%					

AVERAGE VALUES

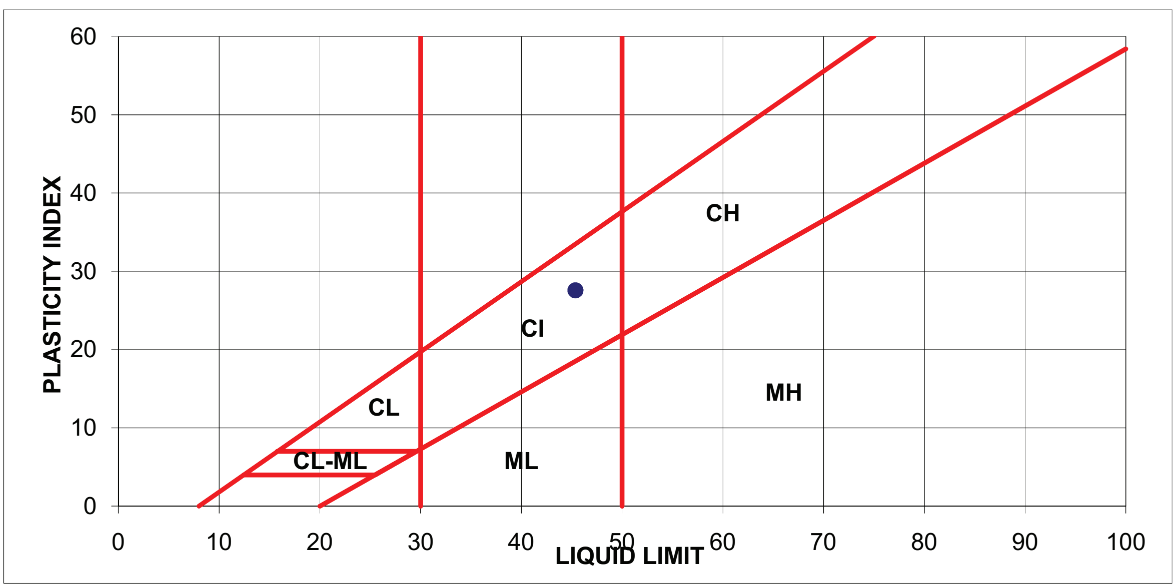
Liquid Limit	45.4
Plastic Limit	17.8
Plasticity Index	27.6

SAMPLE DESCRIPTION

Classification: **CI**

PLASTIC LIMIT

Trial No.	1		
Container Number			
Wt. Sample (wet+tare)(g)	22.10		
Wt. Sample (dry+tare)(g)	20.54		
Wt. Tare (g)	11.77		
Wt. Dry Soil (g)	8.8		
Wt. Water (g)	1.6		
Water Content (%)	17.8%		



FORM: PWGSC-Riverbend Atter 4-52.xls
DATE: 25/07/2011

GRAIN SIZE ANALYSIS

AECOM

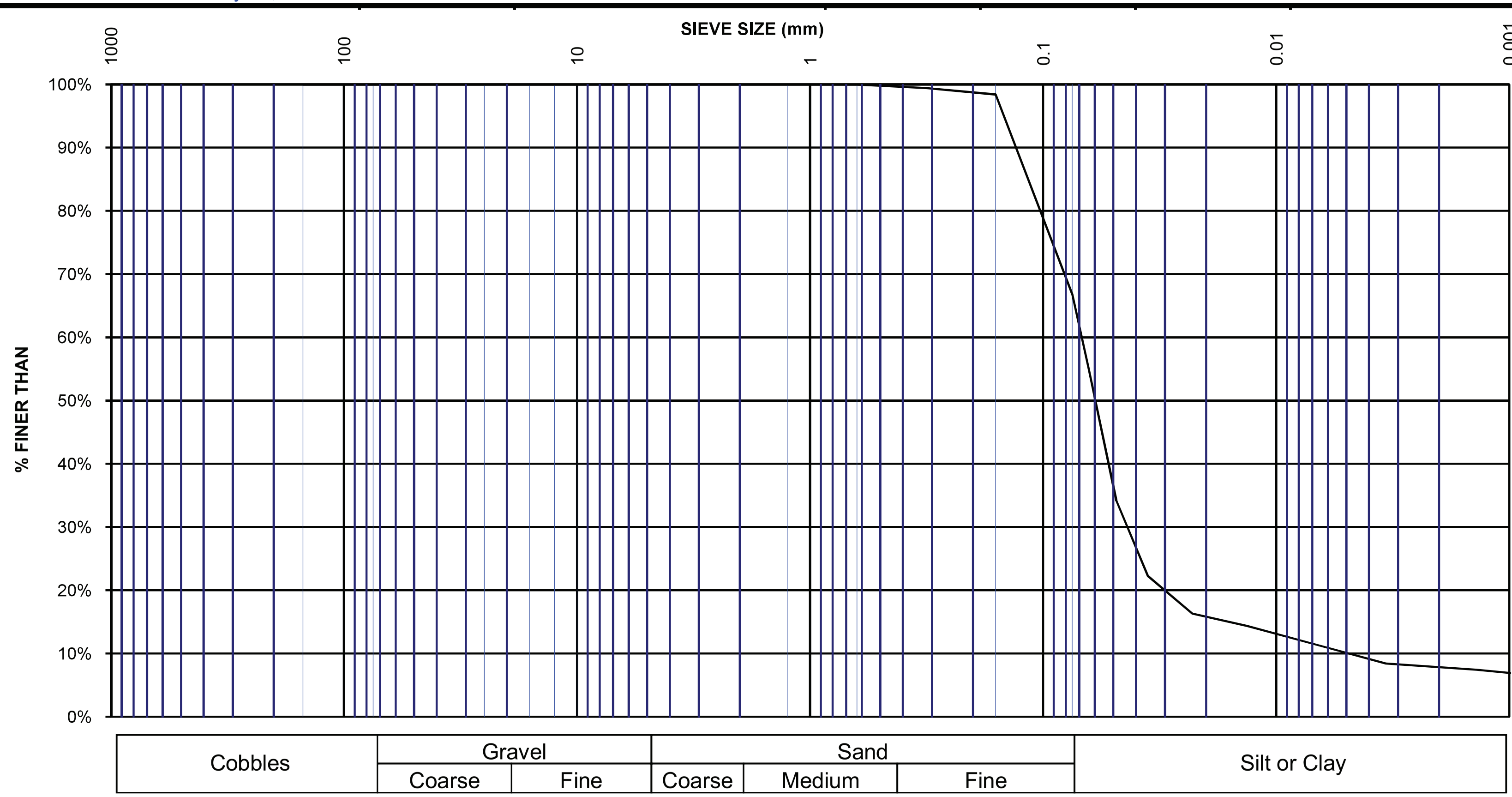
CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	33
TESTHOLE:	11-05	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	JS

TOTAL DRY WEIGHT OF SAMPLE		SIEVE NO. (μm)	SIZE OF OPENING APPROX. INCHES	SIZE OF OPENING mm	WEIGHT RETAINED (g)	PERCENT RETAINED	PERCENT FINER THAN	REMARKS
Before Washing		150,000	6	150.0		0%	100%	
Wet + Tare		75,000	3	75.0		0%	100%	
Dry+Tare	312	50,000	2	50.0		0%	100%	
Tare	100	40,000	1 1/2	40.0		0%	100%	
Wt. Dry	212	25,000	1	25.0		0%	100%	
Moisture Content		20,000	3/4	20.0		0%	100%	
Wet + Tare		16,000	5/8	16.0		0%	100%	
Dry+Tare		12,500	1/2	12.5		0%	100%	
Tare		10,000	3/8	10.0		0%	100%	
MC (%)		5,000	0.185	5.0	0.0	0%	100.0%	
	Passing							
After Washing		2,000	0.0937	2.0	0.0	0%	100.0%	
Wt. Dry+Tare		1,250	0.0469	1.25	0.0	0%	100.0%	
Tare		630	0.0234	0.63	0.0	0%	100.0%	
Wt. Dry		315	0.0116	0.315	1.3	1%	99.4%	
Tare No.		160	0.0059	0.160	3.4	2%	98.4%	
		75	0.00295	0.075	70.5	33%	66.8%	
		PAN						

HYDROMETER DATA		READING	TIME (min)	DIAMETER (mm)	TEMP. (°C)	CORR. READING	PERCENT FINER THAN	REMARKS
Wt Dry+Tare	312.2	33	0.5	0.064	19	28	54.9%	
Wt Tare	100.0	22	1	0.048	19	17	34.2%	
Wt Dry	212.2	16	2	0.036	19	11	22.3%	
Sample Size :	50	13	5	0.023	19	8	16.3%	
Wt Retained 2 mm:	0	12	15	0.013	19	7	14.4%	
% Passing 2 mm:	100.0%	12	30	0.009	19	7	13.4%	
Specific Gravity :	2.70	11	60	0.007	19	6	11.4%	
Hydrometer No.:	43-9856	10	120	0.005	19	5	10.4%	
Solution (g/L) :	40	9	240	0.003	19	4	8.4%	
		9	1440	0.001	19	4	7.4%	
		9	2880	0.001	18	4	6.9%	

GRAIN SIZE ANALYSIS

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	33
TESTHOLE:	11-05	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	JS



FORM: PWGSC-Riverbend hydro 5-33.xls
DATE: 8/5/2011

ATTERBERG LIMITS

AECOM

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution-50 bed housing unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	38
BOREHOLE:	TH11-05	DEPTH :	
DATE :	July 25, 2011	TECHNICIAN :	LS

LIQUID LIMIT

Trial No.	1					
Number of Blows	30					
Container Number						
Wt. Sample (wet+tare)(g)	38.21					
Wt. Sample (dry+tare)(g)	30.05					
Wt. Tare (g)	12.06					
Wt. Dry Soil (g)	18.0					
Wt. Water (g)	8.2					
Water Content (%)	45.4%					

AVERAGE VALUES

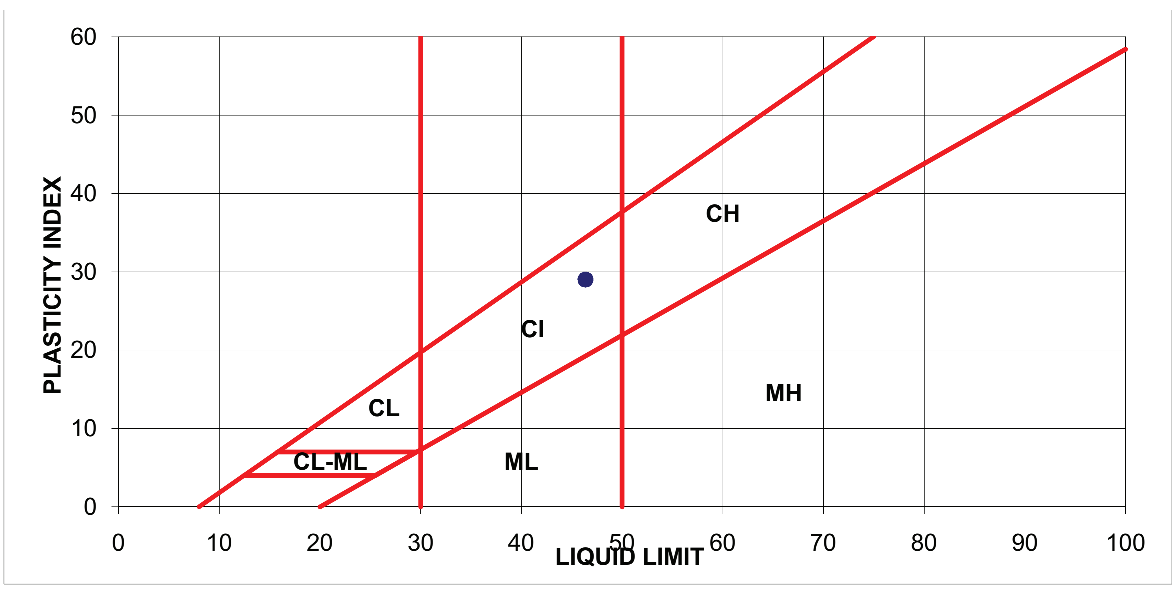
Liquid Limit	46.4
Plastic Limit	17.4
Plasticity Index	29.0

SAMPLE DESCRIPTION

Classification: **CI**

PLASTIC LIMIT

Trial No.	1		
Container Number			
Wt. Sample (wet+tare)(g)	24.73		
Wt. Sample (dry+tare)(g)	23.14		
Wt. Tare (g)	13.98		
Wt. Dry Soil (g)	9.2		
Wt. Water (g)	1.6		
Water Content (%)	17.4%		



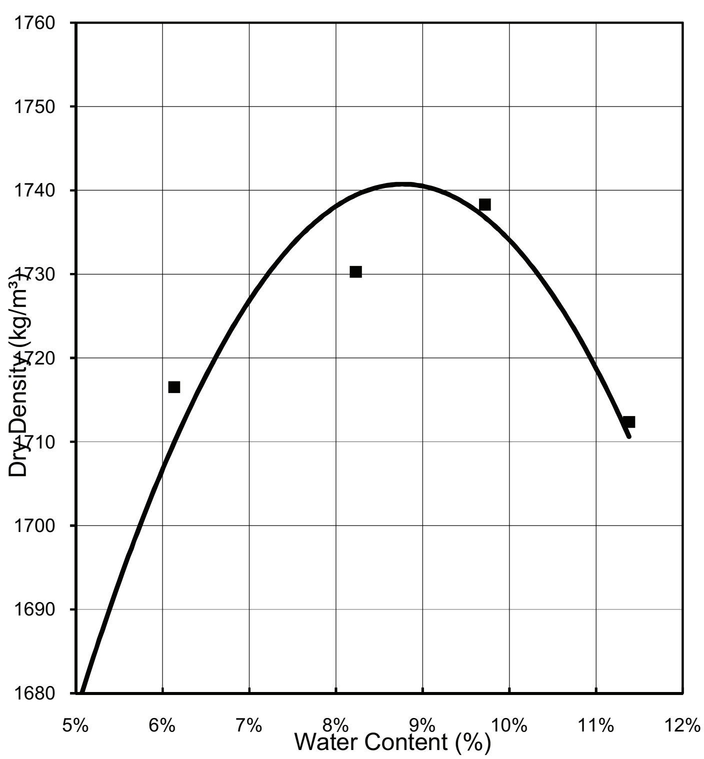
FORM: PWGSC-Riverbend Atter 5-38.xls
DATE: 25/07/2011

PROCTOR TEST

AECOM

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution - 50 bed Housing Unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	combined sand
BOREHOLE:		DEPTH :	
DATE :	July 22, 2011	TECHNICIAN :	JS/LS

TRIAL No.	1	2	3	4		
DENSITY DETERMINATION						
Mould Number						
Volume of Mould (cm³)	940.0	940.0	940.0	940.0		
Wt. Sample (wet+mould)(g)	5918.6	5966.4	5998.9	5998.9		
Wt. Mould (g)	4206.1	4206.1	4206.1	4206.1		
Wet Density (kg/m³)	1822	1873	1907	1907		
Dry Density (kg/m³)	1717	1730	1738	1712		
WATER CONTENT DETERMINATION						
Tare Number						
Wt. Sample (wet+tare)(g)	239.4	351.6	327.9	328.3		
Wt. Sample (dry+tare)(g)	226.5	326.1	300.3	296.4		
Wt. Tare (g)	16.2	16.2	16.3	16.1		
Wt. Dry Soil (g)	210.3	309.9	284	280.3		
Wt. Water (g)	12.9	25.5	27.6	31.9		
Water Content (%)	6.1%	8.2%	9.7%	11.4%		



At Optimum:

Water Content	8.8%
Dry Density (kg/m³)	1741

Method of Compaction:	D-698
Dia. of Mould (cm):	10
No. of Layers:	3
No. Blows per Layer:	25
Ht. of Free Fall (cm):	30
Wt. of Tamper (g)	2500
Shape of Tamping Face:	FLAT

Description of Sample:
Fine sand

Rock Corrections:

% Rock	Density	Optimum

Remarks:

FORM: PWGSC-Riverbend proctor combined sand July 2011.xls
DATE: 8/5/2011

C.B.R. TEST

AECOM

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution - 50 bed Housing Unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	combined sand samples
BOREHOLE:	combined samples TH11-01 to TH11-05	DEPTH :	2.0 m
DATE :	August 4, 2011	TECHNICIAN :	RGD

Density Determination		Water Content Determination	Before	After
Mould Number				
Wt. Sample (wet+mould) (g)	8147.7	Wt. Sample (wet+tare) (g)	529.2	1756.2
Wt. Mould (g)	4188.2	Wt. Sample (dry+tare) (g)	487.0	1577.2
Wt Sample (wet) (g)	3959.5	Wt. Tare	16.4	328.8
Volume of Mould	2124.0	Wt. Dry Soil (g)	471	1248
Wet Density (kg/m³)	1864	Wt. Water (g)	42	179
Dry Density (kg/m³)	1711	Water Content (%)	9.0%	14.3%

Expansion Test				Water Content Data - Soaked Sample Top 25 mm	
Expansion (mm)	Reading (0.001 in)	Date	Elapsed Time	Tare Number	
				Wt. Sample (wet+tare) (g)	1386.0
NA	0	29-Aug-11	0	Wt. Sample (dry+tare) (g)	1230.4
NA	0	30-Aug-11	24	Wt. Tare	238.8
NA	0	31-Aug-11	48	Wt. Dry Soil (g)	992
NA	0	1-Aug-11	72	Wt. Water (g)	156
NA	0	2-Aug-11	96	Moisture Content (%)	15.7%

Penetration Test Data

Before Soaking				After Soaking			
Dial Reading	Penetration (in)	Load (N)	Pressure (MPa)	Dial Reading	Penetration (in)	Load (N)	Pressure (MPa)
0	0.000	3	0.00	0	0.000	3	0.00
104	0.025	281	0.14	131	0.025	353	0.18
195	0.050	524	0.27	275	0.050	739	0.38
320	0.075	859	0.44	482	0.075	1290	0.67
450	0.100	1205	0.62	763	0.100	2033	1.05
600	0.125	1603	0.83	1041	0.125	2753	1.42
742	0.150	1978	1.02	1288	0.150	3382	1.75
900	0.175	2391	1.23	1485	0.175	3878	2.00
1090	0.200	2875	1.48	1700	0.200	4431	2.29
1535	0.300	4001	2.07				
1560	0.400	4062	2.10				
1360	0.500	3565	1.84				
C.B.R. Value Unsoaked:			9.0	C.B.R. Value Soaked:			15.2

SUMMARY

Before Soaking		After Soaking	
CBR at 0.1" Penetration	9.0	CBR at 0.1" Penetration	15.2
Surcharge (lb)	10	Surcharge (lb)	10
Method of Compaction	STD	Soaked for (days)	2
RING #	3491	Swell (mm)	0.0
Moisture Content (%)	9.0%	Moisture Content (%)	14.3%
Dry Density (kg/m³)	1711	Dry Density (kg/m³)	1630

SAMPLE DESCRIPTION :
Sand, trace silt

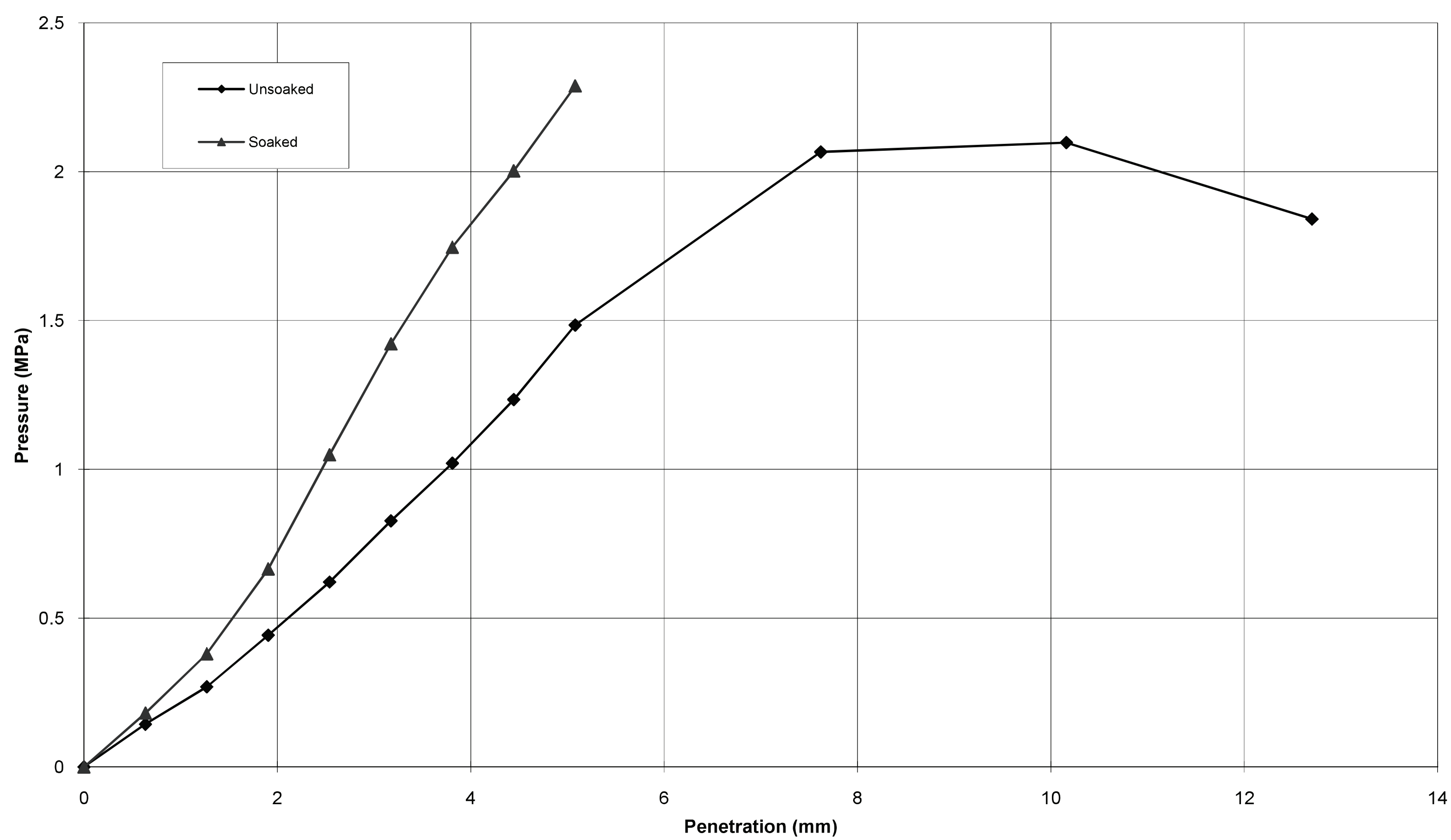
REMARKS :

FORM: PWGSC-Riverbend CBR combined sand July 2011.xls
DATE: 8/9/2011

C.B.R. TEST

AECOM

CLIENT :	PWGSC		
PROJECT :	CSC Riverbend Institution - 50 bed Housing Unit		
JOB No. :	60217802		
LOCATION :		SAMPLE:	combined sand samples
BOREHOLE:		DEPTH :	
DATE :	August 4, 2011	TECHNICIAN :	RGD



FORM : PWGSC-Riverbend CBR combined sand July 2011.xls
DATE : 8/9/2011

Name:	AECOM Canada Ltd.	**Workorder:**	**33585**
Address:	2540 Kensington Road N.W. Calgary AB T2N 3S3	**COC:**	55696
		Project:	
		Legal Desc:	
Contact:	Chris Keeley	**Date Received:**	Jul 20, 2011
Phone:	(403) 270-9255	**Date Reported:**	Aug 3, 2011
Fax:	(403) 270-0399	**Samples:**	5 Soil

Guidelines for Stabilization of Soils Containing Sulphates

Lab #:			**33585-01**	**33585-02**	**33585-03**	**33585-04**
Date Sampled:			**20-Jul-11**	**20-Jul-11**	**20-Jul-11**	**20-Jul-11**
	Detection Limit	**Units**	**1-60**	**2-4**	**3-23**	**4-45**
Physical Descriptions						
pH (1:1)	1.0	pH Units	7.5	8.3	7.4	8.2
Resistivity		ohm/cm	1064	4610	940.0	5390
Soluble Salts (Anions)						
Sulfate	0.1	%	< 0.1	< 0.1	< 0.1	< 0.1
Risk			low	low	low	low

Lab #:			**33585-05**
Date Sampled:			**20-Jul-11**
	Detection Limit	**Units**	**5-33**
Physical Descriptions			
pH (1:1)	1.0	pH Units	7.6
Resistivity		ohm/cm	1546
Soluble Salts (Anions)			
Sulfate	0.1	%	< 0.1
Risk			low

Total Water Soluble Sulfate Ratings:*

Levels (%)	***Risk***
< 0.3	Low
0.3 - 0.5	Moderate
0.5 - 0.8	Moderate to High
> 0.8	High

Sulphates/Chlorides - 10 parts water : 1 part soil
Radiometer CDM230 Resistivity meter - 1:1 extraction
Radiometer: pH + Resistivity - 1:1, soil: water
Dionex Ion Chromatography was used to determine water soluble sulfates
* Reference: Technical Memorandum August 2000 - Texas Department of Transportation

Access Analytical Laboratories Inc.

Per: ______________________
John Paul, Ch.T.
Analyst

Name:	AECOM Canada Ltd.	**Workorder:**	**33585**
Address:	2540 Kensington Road N.W. Calgary AB T2N 3S3	**COC:**	55696
		Project:	
		Legal Desc:	
Contact:	Chris Keeley	**Date Received:**	Jul 20, 2011
Phone:	(403) 270-9255	**Date Reported:**	Aug 3, 2011
Fax:	(403) 270-0399	**Samples:**	5 Soil

Method References

pH (1:1 in RO Water)

Modified from Soil Sampling and Methods of Analysis, Edited by Martin R. Carter for Canadian Society of Soil Science, 1993, 16.2, pp 141 and method 4500-H+-B. Electrometric Method for pH. Pg. 4-90. Standards Methods for the Examination of Water and Wastewater, 21st Ed. 2005. APHA, AWWA, WEF.

*Results relate only to the items tested.
*Parameters reported in italics designates non-accreditation.