



**RURAL MUNICIPALITY OF BROKENHEAD**  
**Geotechnical and Topographic Investigation**  
**for the**  
**Wastewater Treatment Lagoon Expansion**  
**on the SE1/4 of 15-13-6 EPM**



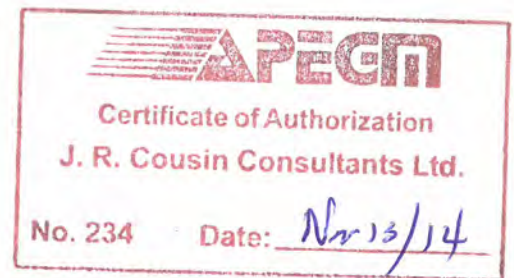
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President

November 2014



### **ACKNOWLEDGMENTS**

To prepare this report various sources of information were investigated and researched. The firm of JR Cousin Consultants Ltd. wishes to thank the RM of Brokenhead who assisted with organization and onsite works.

### **REMARKS**

Conclusions reached in this report are based upon the generalization of data available to us at the time of forming our opinions. Information in this document may rely on previous studies, investigative work and data by others. JRCC cannot be responsible for actual site conditions proved to be at variance with any generalized data. This report was completed in accordance with generally accepted professional engineering principles and practice. Any use of this report by a third party is the responsibility of the third party, JRCC accepts no responsibility for third party decisions or actions based on the report. No other warranty or guarantee expressed, implied or statutory is made.

# TABLE OF CONTENTS

Section	Page
<b>1.0 INTRODUCTION .....</b>	<b>1</b>
<b>2.0 BACKGROUND.....</b>	<b>1</b>
2.1 Past Geotechnical Investigation by JRCC in 2002 .....	1
2.2 Past Geotechnical Investigation by JRCC in 2012 .....	1
2.3 GW Driller’s Well Logs .....	2
<b>3.0 TOPOGRAPHIC INVESTIGATION.....</b>	<b>2</b>
<b>4.0 GEOTECHNICAL FIELD INVESTIGATION.....</b>	<b>2</b>
4.1 Soil Profile.....	3
4.2 Groundwater.....	3
<b>5.0 LABORATORY TESTING AND ANALYSIS AND DISCUSSION .....</b>	<b>4</b>
<b>6.0 LAGOON LINER REQUIREMENTS .....</b>	<b>5</b>
6.1 Current Guidelines.....	5
6.2 Typical Lagoon Liner Construction Options .....	5
6.3 Liner for the RM of Brokenhead Lagoon Expansion (Site 2).....	5
<b>7.0 RECOMMENDATIONS AND CLOSURE .....</b>	<b>6</b>
7.1 Recommendations .....	6
7.2 Closure.....	7

## **APPENDIX**

Plan 1: Test Hole Locations and Existing Contour Lines

Test Hole Logs

2002 Past Test Hole Logs

2012 Past Test Hole Logs

Stantec Consulting Ltd. Test Results, dated November 7, 2014

GW Driller’s Well Logs

## 1.0 INTRODUCTION

JR Cousin Consultants Ltd. (JRCC) conducted a topographic and geotechnical investigation at the SE  $\frac{1}{4}$  of 15-13-06 EPM for the proposed wastewater treatment lagoon expansion for the Rural Municipality of Brokenhead Garson/Tyndall/Henryville lagoon. A previous geotechnical and topographic investigation was completed east of the existing lagoon within the NW and SW  $\frac{1}{4}$  of 15-13-06 EPM. Additional land was purchased by the RM and therefore this investigation was completed. For ease of discussion the previously tested site on the NW and SW  $\frac{1}{4}$  of 15-13-06 EPM will be referred to as Site 1 and the site on the SE  $\frac{1}{4}$  of 15-13-6 EPM will be referred to as Site 2. Nine test holes were drilled at Site 2 and one additional test hole was drilled at Site 1 to confirm the soil profile from the previous investigation. Test hole locations from Site 1 and Site 2 are shown on Plan 1 attached in the Appendix.

This report outlines the findings of the geotechnical and topographic investigation at the proposed lagoon expansion site and evaluates the soils to determine their suitability for use as a lagoon liner as well as any potential difficulties associated with construction.

## 2.0 BACKGROUND

The existing RM of Brokenhead lagoon has a primary cell and two secondary cells located in the NW and SW  $\frac{1}{4}$  of Section 15-13-06 EPM. The existing lagoon is overloaded and requires expansion.

### 2.1 Past Geotechnical Investigation by JRCC in 2002

A geotechnical investigation for construction of the existing RM of Brokenhead lagoon site was performed by JRCC in January of 2002. Seven test holes were excavated and representative soil samples were sent to Eng Tech Consulting Ltd. for analysis. The report found the soil profile in the test holes consisted of topsoil followed by a minimum of 4.6 m of high plastic clay with varying levels of silt. The laboratory analysis confirmed the clay would be suitable for use as a lagoon liner in the insitu conditions or when re-worked and re-compacted.

Past test hole locations are shown on Plan 1 attached in the Appendix. Past test hole logs are included in the Appendix.

### 2.2 Past Geotechnical Investigation by JRCC in 2012

A geotechnical and topographic investigation was completed by JRCC in March of 2012 on the land east of the existing lagoon within the NW and SW  $\frac{1}{4}$  of 15-13-06 EPM (Site 1). Twelve test holes were drilled at the site. Test hole locations are shown on Plan 1 attached in the Appendix and past test hole logs are attached in the Appendix. The report recommended that the south end of the lagoon expansion site be lined with insitu clay soils and the north end of the site be lined with re-worked and re-compacted clay soils. The till layer at the north end of the site was observed 3.0 m below surface in TH5, 2.7 m in TH11 and 2.0 m in TH12. This would provide very little safety factor on the depth of liner, depending on the final cell floor elevations determined during final design. In addition, the entire soil profile of TH6 was deemed

not suitable for use as a clay liner and would have to be excavated and replaced with suitable high plastic clay.

Based on the poor test results at the north end of the site, the current geotechnical investigation was initiated to potentially save on construction costs of re-working and re-compacting a portion of the liner.

### **2.3 GW Driller's Well Logs**

There were four driller's well logs reviewed from 15-13-06 EPM. The well logs indicated the soil profile consisted of clay followed by till underlain by gravel and limestone. The clay layer extended to an average depth of 8.9 m below the ground surface. The layer of till extended from 8.9 m to 22.9 m below the ground surface followed by the limestone layer to a maximum observed depth of 54.9 m.

The static groundwater level recorded in the wells was 18.3 m above the ground surface in one of the wells, 0.6 m below the ground surface in two of the wells and was not reported on the fourth well.

GW Driller's Well logs are included in the Appendix.

## **3.0 TOPOGRAPHIC INVESTIGATION**

A topographic GPS survey of the test hole locations and existing ground locations across the proposed lagoon expansion Site 2 was completed on October 14, 2014 along with the geotechnical investigation. Additional information was collected on October 30, 2014. The existing ground at the proposed expansion site is relatively flat. From the topographic survey data, the existing ground elevations varied from 236.58 m to 240.01 m with an average elevation of approximately 238.08 m. The ground slopes from east to west at an average slope of approximately 0.88%.

The existing ground elevation on the SW  $\frac{1}{4}$  of Site 1 (directly west of Site 2) is 236.10 m. The existing ground elevation on the NW  $\frac{1}{4}$  of Site 1 (northwest of Site 2) is 236.43 m. The average existing lagoon top of dike elevation is approximately 237.22 m.

The average elevation of Site 2 is approximately 2.0 m higher than Site 1.

Contour lines from the topographic survey are shown on Plan 1 in the Appendix.

## **4.0 GEOTECHNICAL FIELD INVESTIGATION**

The onsite geotechnical investigation for the proposed lagoon expansion site was conducted on October 14, 2014. Maple Leaf Drilling Ltd. was employed to conduct the test holes using a track-mounted drill rig under direct supervision by JRCC's field representative.

There were ten test holes (TH1 – TH10) drilled during the geotechnical investigation. The test holes TH1 – TH9 were drilled at Site 2 and TH10 was drilled at Site 1 to confirm the soil profile determined during the previous

investigation. The test holes were drilled to a depth of 6.1 m (20 ft) or auger refusal. Test hole locations are shown on Plan 1, attached in the Appendix.

The subsurface soil profile within each test hole was logged, water conditions were noted and representative soil samples were collected as the soils varied along the profile. The samples were visually field-classified. Eleven selected bagged soil samples from the test holes were sealed and submitted to Stantec Consulting Ltd. for laboratory testing. There were two Shelby tube samples (TH3 2.1 m – 2.7m and TH6 0.9 m – 1.5 m) sent to the laboratory to determine the insitu hydraulic conductivity. Details of the laboratory analysis are provided in Section 5.0 of this report. Following completion of drilling, an assessment of the short term groundwater conditions was completed. All test holes were then backfilled with bentonite mixed with the auger cuttings.

#### 4.1 Soil Profile

Details of each individual soil profile, including depth and description of each layer as well as comments on groundwater infiltration and caving of the test holes can be found in the test hole logs attached in the Appendix. The following is a summary of the soil profile at the proposed lagoon expansion Site 2 (TH1 - TH9):

- 0 to 0.1 m Black, high plastic clay topsoil silty, some sand with organics and roots from 0 – 0.1 m
- 0.1 to 0.3 m Black high plastic clay, silty, some sand
- 0.3 to (1.5 – 5.3 m) Brown high plastic clay, some silt inclusions, some sand, moist, stiff
- (1.5 – 5.3) to (TH termination) Tan, low plastic sandy, silt till, clayey with some gravel, soft, wet.

Test holes were terminated due to auger refusal from boulders in TH2 – TH6. Caving of the test holes was observed in TH1 at 3.0 m, TH5 at 4.3 m and TH6 at 4.0 m.

The soil profile of TH10 consisted of 0.05 m of black topsoil followed by brown high plastic clay from 0.05 to 6.1 m.

#### 4.2 Groundwater

Short-term groundwater conditions were assessed in each test hole by observing standing water elevations in the holes prior to backfilling. One test hole (TH2) was left open for approximately 4.5 hours to evaluate longer term groundwater conditions. Caving and sloughing of the test hole walls was also observed and recorded. Standing water was observed in TH3 at 2.7 m, TH5 at 3.7 m, TH6 at 2.7 m and TH7 at 5.8 m. TH2 had a standing water elevation at 2.3 m below surface immediately after excavation and after 4.5 hours the standing water elevation was at 1.8 m below surface. There was no standing water observed in the remainder of the test holes.

Groundwater in the test holes depends on high static groundwater conditions and on seasonal conditions, i.e. snowmelt and rainy seasons. Other assumptions relating to the groundwater elevation cannot be made at this time, as water levels will normally fluctuate seasonally.

Contractors will be made aware of the geotechnical conditions encountered onsite, as dewatering and trench stabilization may be required during construction, depending on the depth of excavation determined during final design.

## 5.0 LABORATORY TESTING AND ANALYSIS AND DISCUSSION

Representative soil samples from the proposed lagoon site were submitted to Stantec Consulting Ltd. for testing and analysis. The testing and analysis included determining the following:

- Atterberg Limits (plastic limit, liquid limit, and plasticity index, ASTM D4318)
- Soil Classification (ASTM D2487)
- Moisture Content (ASTM D2216)
- Particle Size Analysis (Hydrometer test, ASTM D422)
- Visual Classification.

The Shelby tube samples were subjected to a Hydraulic Conductivity test (ASTM D5084).

Laboratory classification analysis of the bagged soil samples indicated that 8 of the samples were CH (fat clay), 1 sample was CH (fat clay with sand) and 2 samples were CL (sandy lean clay). The Plasticity Index of the samples classified as CH varied between 44 and 74 and the percentage of clay varied between 58.8% and 91.6%. The Plasticity Index of the samples classified as CL varied between 8 and 18 and the percentage of clay varied between 26.9% and 35.7%.

The laboratory commented *“Based upon previous testing conducted in our laboratory, homogeneous soil samples with a plasticity index greater than 25 and a clay content greater than 50% will typically have a hydraulic conductivity of  $1.0 \times 10^{-7}$  cm/sec or less.”* Therefore all samples classified as CH were deemed suitable for use as a lagoon liner and all samples classified as CL were deemed not suitable for use as a lagoon liner.

The laboratory also indicated *“Our comments regarding the potential use of the material as a liner are based upon the soil being homogeneous with no preferential flow paths. It should be noted that estimating the hydraulic conductivity of a soil based upon classification test results (plasticity index and particle size analysis) alone might be misleading if the soil contains layers of sand, silt, or organic material.”*

The Shelby tube samples from (TH3 2.1 – 2.7 m) and (TH6 0.9 – 1.5 m) achieved hydraulic conductivities ( $k_{20}$ ) of  $5.8 \times 10^{-9}$  cm/sec and  $6.8 \times 10^{-9}$  cm/sec, respectively. This hydraulic conductivity is lower than the Manitoba Conservation requirement of  $1 \times 10^{-7}$  cm/sec and therefore both samples are deemed suitable for use as an insitu clay lagoon liner.

Details of Stantec Consulting Ltd. test results and analysis, dated November 7, 2014 are attached in the Appendix.

## 6.0 LAGOON LINER REQUIREMENTS

### 6.1 Current Guidelines

Manitoba Conservation guidelines require that a standard wastewater treatment lagoon clay liner be 1.0 metre in thickness and have a hydraulic conductivity (i.e. the potential rate of fluid movement through the soil) of  $1 \times 10^{-7}$  cm/sec or less. This low rate is to protect the underlying groundwater from lagoon seepage. Generally, the higher a soil's plasticity the more likely a soil can achieve a hydraulic conductivity of  $1 \times 10^{-7}$  cm/sec.

### 6.2 Typical Lagoon Liner Construction Options

The liner of a lagoon can be constructed by using the insitu (undisturbed) soils if the soils can consistently achieve a hydraulic conductivity of  $1 \times 10^{-7}$  cm/sec or less in their insitu conditions.

If the insitu soils cannot be used, the liner can be constructed by excavating and re-compacting suitable high plastic clay soils to form the liner.

If the clay content of the soils is so low that even when excavated and re-compacted, the soils cannot consistently achieve a hydraulic conductivity of  $1 \times 10^{-7}$  cm/sec, a liner constructed of high plastic clay from a borrow pit, or a synthetic geomembrane liner would be required.

### 6.3 Liner for the RM of Brokenhead Lagoon Expansion (Site 2)

Based on the laboratory analysis, all of the bagged soil samples classified as fat clay (CH) will be suitable for use as an insitu clay liner or when re-worked and re-compacted. The soils deemed unsuitable for use as a lagoon liner begin at a depth of 1.5 m – 5.3 below surface. The start of unsuitable material at each test hole and the elevation is shown on the following table:

**Table 1: Start of Unsuitable Material**

Test Hole	Depth Below Surface	Elevation
TH1	5.3 m	231.6 m
TH2	3.4 m	234.0 m
TH3	3.0 m	235.4 m
TH4	1.8 m	238.1 m
TH5	1.5 m	237.6 m
TH6	3.4 m	234.6 m
TH7	4.0 m	233.2 m
TH8	1.5 m	237.1 m
TH9	1.8 m	237.0 m

The highest elevation of unsuitable liner material was found in TH4, which will likely be beyond the limits of an expansion cell. The next highest elevations are found in TH5, TH8 and TH9. Depending on the final depths of cell excavation and final layout of the expansion cell, excavation and re-working a small portion of the liner compared to the north part of site 1 may be required.



It is recommended that the lagoon expansion cell be designed so that the area near TH5, TH8 and TH9 are avoided to save the capital costs of re-working and re-compacting a portion of the liner. The remainder of the site could be constructed with an insitu clay liner, depending on the final elevations of the cells.

For all new perimeter dikes, a 3.0 m wide vertical cut-off wall will have to be constructed extending a minimum of 1.0 m into the horizontal liner surrounding the entire lagoon. If at any point along the vertical cut-off wall, the till layer is discovered to be within the liner elevation, the extent of the till material within the liner elevations must be excavated and re-compacted with suitable high plastic clay to ensure a minimum 1.0 m liner exists across the cell.

## 6.4 Utilization of Soils for Lagoon Construction

Based on visual soil classification during test hole drilling and subsequent laboratory analysis, the following table describes the potential use of the excavated soils for lagoon construction at the site.

**Table 2: Utilization of Soils for Lagoon Construction**

Average Depth	Soil Layer	Possible Use for Lagoon Construction
0 to 0.1 m	Black, high plastic clay topsoil silty, some sand with organics and roots	<ul style="list-style-type: none"> <li>• Topsoil dressing</li> <li>• Mixed into outer dike slopes</li> </ul>
0.1 to 0.3 m	Black high plastic clay, silty, some sand	<ul style="list-style-type: none"> <li>• Suitable for vertical cut-off walls</li> <li>• Suitable for inner and outer dike slopes</li> </ul>
0.3 to (1.5 – 5.3 m)	Brown high plastic clay, some silt inclusions, some sand, moist, stiff	<ul style="list-style-type: none"> <li>• Suitable for insitu horizontal clay liner</li> <li>• Suitable for vertical cut-off walls</li> <li>• Suitable for inner and outer dike slopes</li> </ul>
(1.5 – 5.3) to (TH termination)	Tan, low plastic sandy, silt till, clayey with some gravel, soft, wet	<ul style="list-style-type: none"> <li>• Not suitable for clay liner</li> <li>• If discovered within the 1m thick insitu clay liner, soils must be removed and replaced with high plastic clay soils</li> </ul>

The lagoon design specifications and plans should reference the above construction materials. Depth of excavation may vary based on calculated cut and fill requirements, to be determined during the detailed design phase.

## 7.0 RECOMMENDATIONS AND CLOSURE

### 7.1 Recommendations

Based on the soil conditions encountered during the geotechnical investigation and the results of the laboratory analysis it is recommended the flat bottom liner of the RM of Brokenhead lagoon expansion cells on Site 2 be constructed with the insitu high plastic clay soils. It is recommended that the lagoon

expansion cell be designed so that the area near TH5, TH8 and TH9 are avoided to save the capital costs of re-working and re-compacting a portion of the liner. Depending on the final depths of cell excavation and final layout of the expansion cell, excavation and re-working a portion of the liner may be required if till material is discovered within the 1.0 m thick insitu clay liner.

It is recommended for all new perimeter dikes, a 3.0 m wide vertical cut-off wall be constructed extending a minimum of 1.0 m into the horizontal liner surrounding the entire lagoon.

## 7.2 Closure

The conclusions and recommendations in this report are based on the results of the site investigation and laboratory analysis. In addition, soil and groundwater conditions between test hole locations were generalized to provide an overall assessment of the geotechnical site conditions. If conditions that appear different from those encountered at the test hole locations as described in this report, or if the assumptions stated herein are not in agreement with the design, JRCC should be informed so the recommendations can be reviewed and adjusted as required.

The geotechnical investigation and topographic review was conducted for identifying geotechnical and topographic conditions suitable for construction of the RM of Brokenhead lagoon expansion. Although no environmental issues were identified during the geotechnical investigation and topographic review, it does not necessarily follow that such issues do not exist. If the client or any other parties have any environmental concerns regarding the proposed site and works, an appropriate environmental assessment must be conducted.

It is not uncommon for soil conditions to be highly variable across a site. Previous construction activities and placement of fill at a site can augment the variability of soil conditions, especially surficial soil conditions. A contingency must be included in any construction budget to allow for potential variations in soil conditions, which may result in modification of the design and construction procedures.

## **APPENDIX**

Plan 1: Test Hole Locations and Existing Contour Lines

Test Hole Logs

2002 Past Test Hole Logs

2012 Past Test Hole Logs

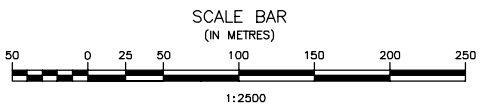
Stantec Consulting Ltd. Test Results, dated November 7, 2014

GW Driller's Well Logs

Plan 1: Test Hole Locations and Existing Contour Lines



Nov. 13, 2014 - 10:50am T:\2014\246.11 - Lagoon Geotech Investigation\04 Drawings\04\Geotechnical\01 Test Hole Locations.dwg



No.	REVISIONS	DATE	INITIALS

B.M. EL.

LOCATIONS OF UNDERGROUND STRUCTURES/UTILITIES AS SHOWN ARE BASED ON AVAILABLE INFORMATION BUT NO GUARANTEE IS GIVEN OR IMPLIED THAT ALL EXISTING UNDERGROUND STRUCTURES/UTILITIES ARE SHOWN OR THAT THE GIVEN LOCATIONS ARE EXACT. CONFIRMATION OF EXISTENCE AND EXACT LOCATION OF ALL UNDERGROUND STRUCTURES/UTILITIES MUST BE OBTAINED FROM THE APPROPRIATE AUTHORITY/OWNER, BY THE CONTRACTOR, BEFORE PROCEEDING WITH CONSTRUCTION.

ENGINEER'S SEAL

**PRELIMINARY**

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CODE: B-246.11	PROJECT: RM OF BROKENHEAD GTH LAAGOON GEOTECHNICAL INVESTIGATION
DESIGNED BY: JC	TITLE: TEST HOLE LOCATIONS AND EXISTING CONTOUR LINES
DRAWN BY: BM	SCALE: 1:2500
REVIEWED BY: JC	DATE: 14/11/13
PLAN: 1	SHEET: 1 of 1

## Test Hole Logs

**J. R. Cousin Consultants Ltd.**  
**TEST HOLE LOGS**

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**SYMBOL INDEX**



GW. : Well graded gravels and gravel sand mixtures, little or no fines



GP. : Poorly graded gravels, gravel - sand mixtures,  
little or no fines



GM. : Silty gravels, gravel-sand-silt mixtures



GC. : Clayey gravels, gravel-sand-clay mixtures



SW. : Well graded sands, gravelly sands, little or no fines



SP. : Poorly graded sands, or gravelly sands, little or no fines



SM. : Silty sands, sand-silt mixtures



SC. : Clayey sands, sand-clay mixtures



ML. : Inorganic silts and very fine sands, rock flour, silty or clayey fine sands,  
or clayey silts with slight plasticity



CL. : Inorganic clays of low plasticity, gravelly clays, sandy or silty  
clays, lean clays



OL. : Organic silts and organic silty clays of low plasticity



CI. : Inorganic clays of medium or intermediate plasticity



MH. : Inorganic silts, fine sandy or silty soils



CH. : Inorganic clays of high plasticity, fat clays



OH. : Organic clays of medium to high plasticity, organic silts



Pt. : Peat, humus, swamp soils with high organic contents



TOPSOIL

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil logs represent our opinions. J. R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

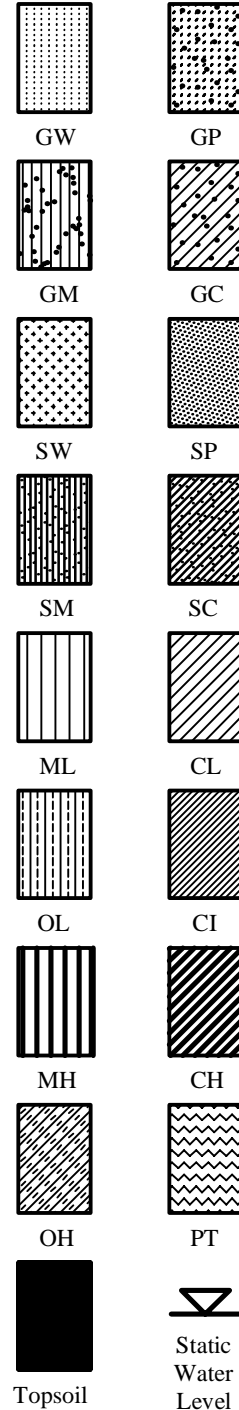
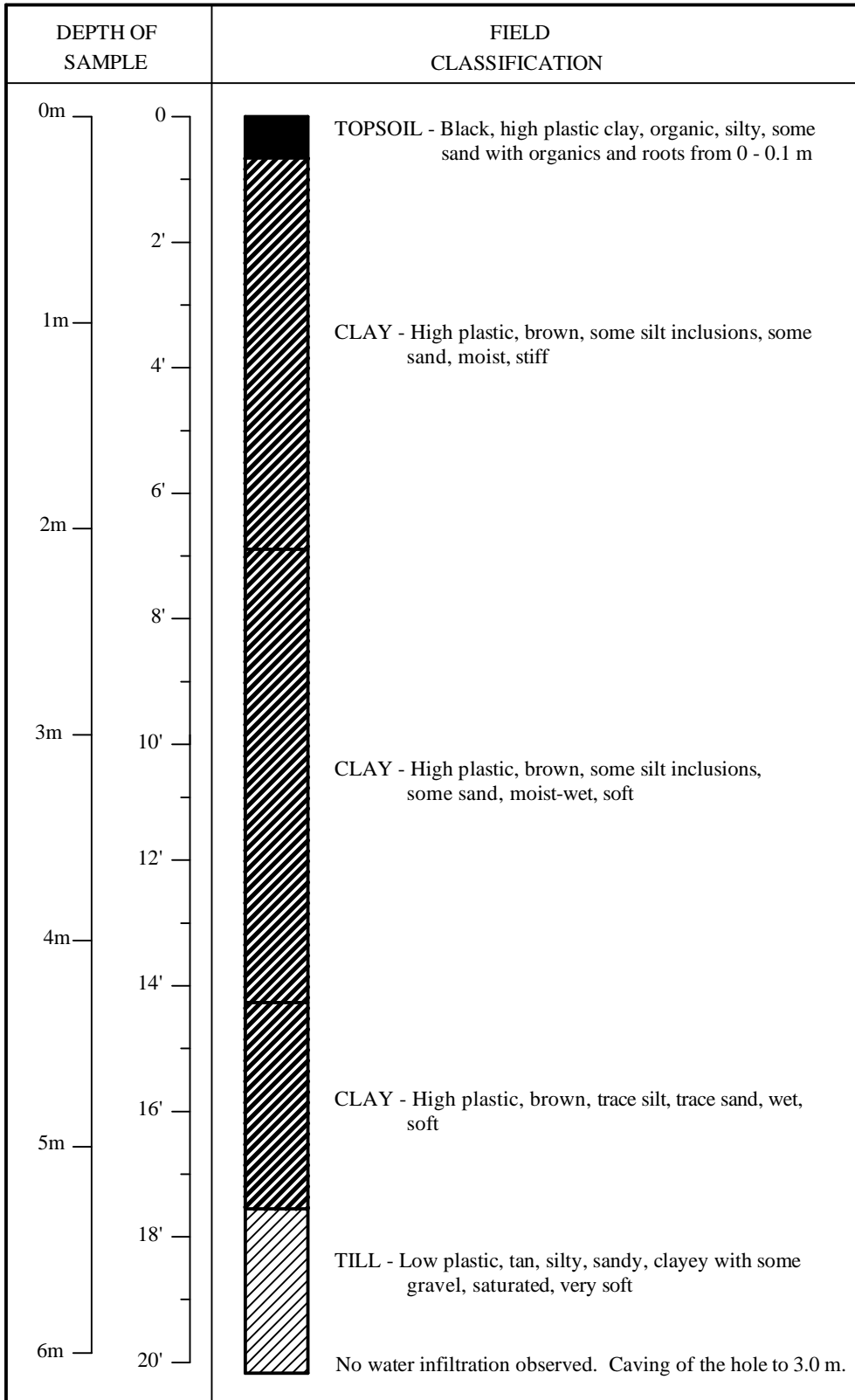
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DATE : October 14, 2014

ELEVATION: 236.886 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 1



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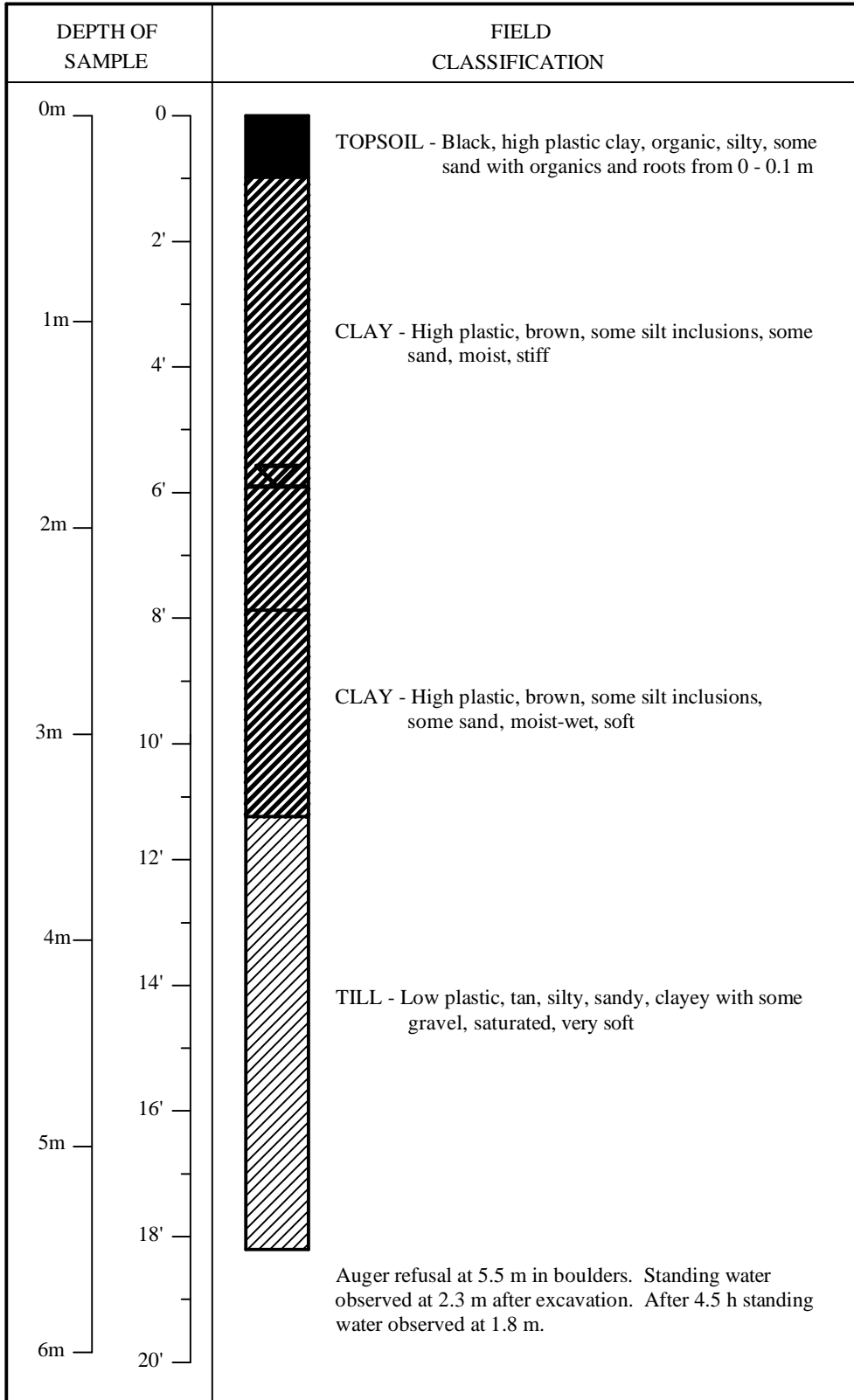
LOCATION : R.M. of Brokenhead - Site 2

DATE : October 14, 2014

ELEVATION: 237.377 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 2



GW	GP
GM	GC
SW	SP
SM	SC
ML	CL
OL	CI
MH	CH
OH	PT
Topsoil	Static Water Level

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of a unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

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## TEST HOLE LOG SHEET

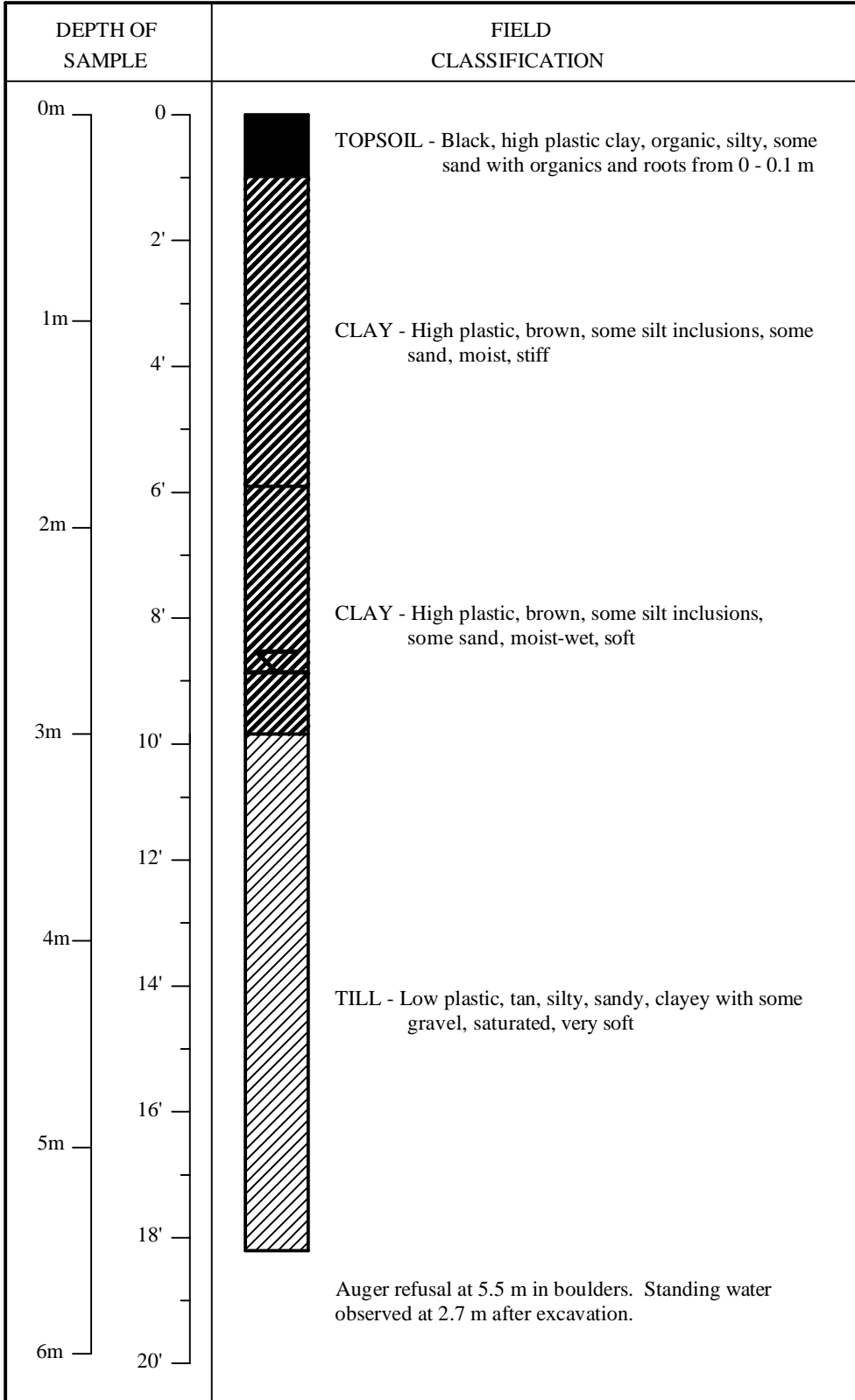
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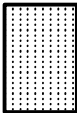
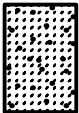

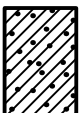

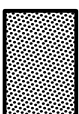

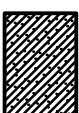
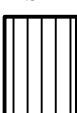
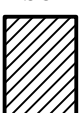

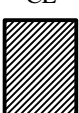

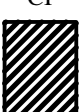
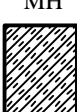



DATE : October 14, 2014

ELEVATION: 238.440 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 3



	
GW	GP
	
GM	GC
	
SW	SP
	
SM	SC
	
ML	CL
	
OL	CI
	
MH	CH
	
OH	PT
	
Topsoil	Static Water Level

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of a unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

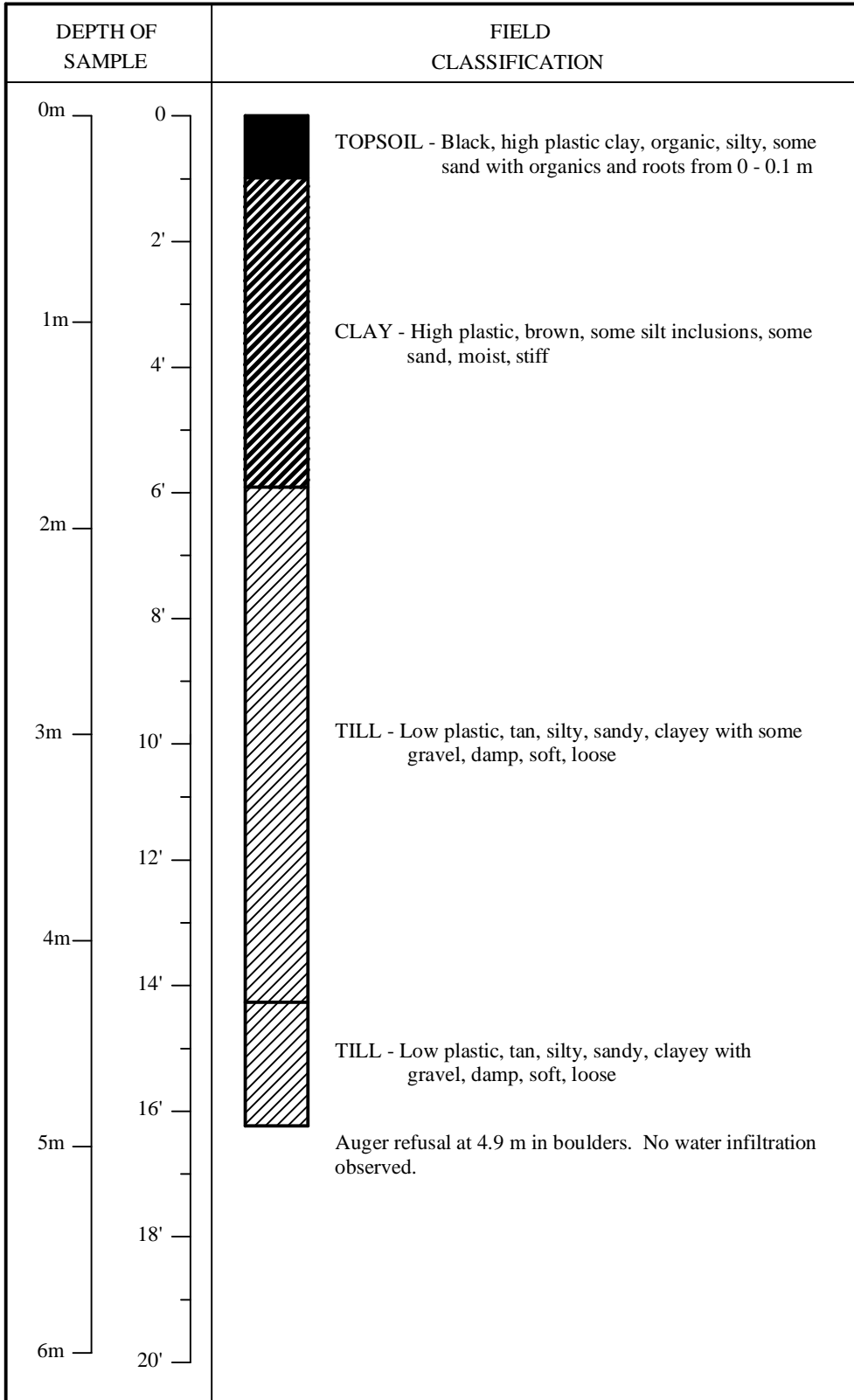
LOCATION : R.M. of Brokenhead - Site 2

DATE : October 14, 2014

ELEVATION: 239.925 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 4



GW	GP
GM	GC
SW	SP
SM	SC
ML	CL
OL	CI
MH	CH
OH	PT
Topsoil	Static Water Level

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

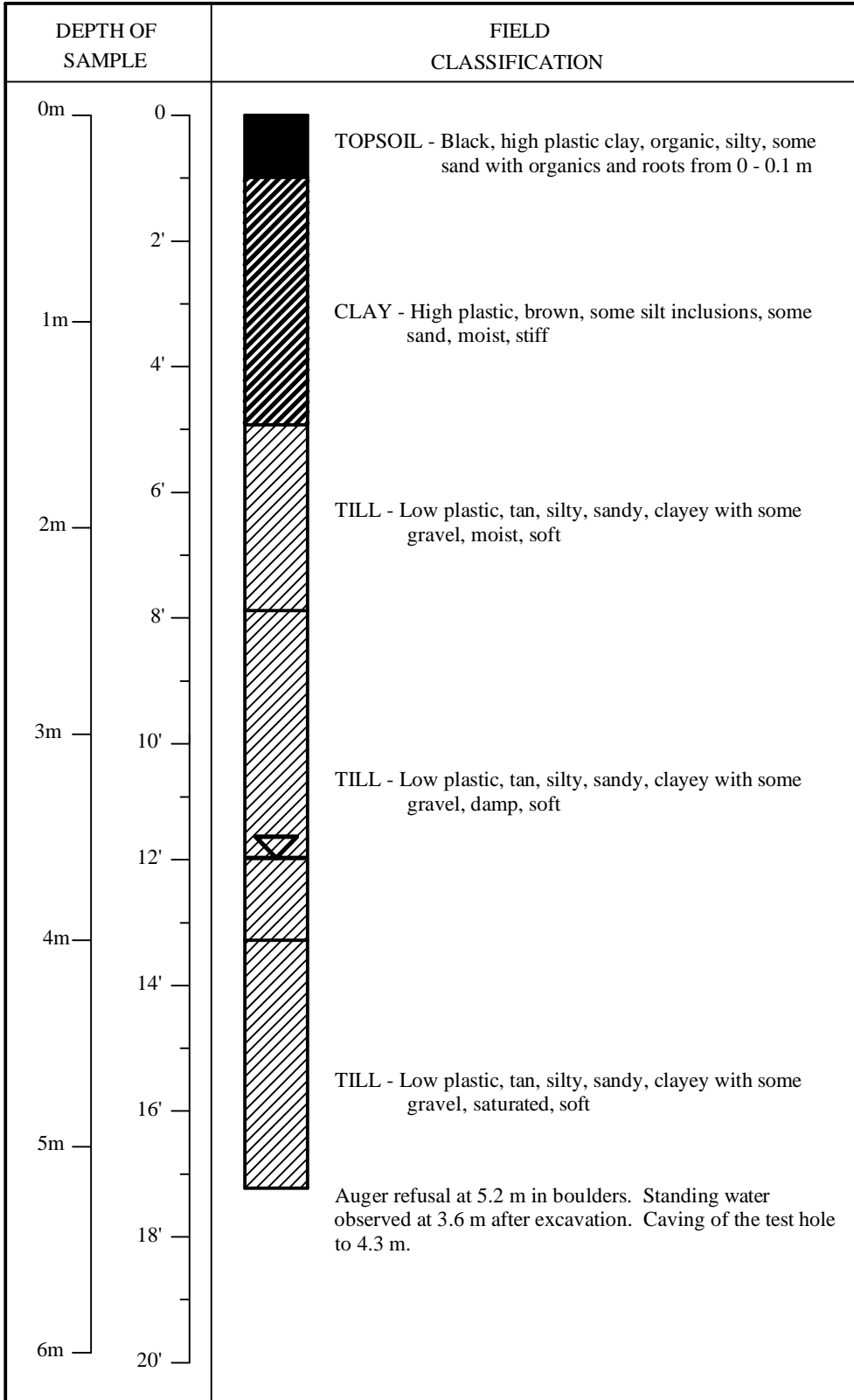
LOCATION : R.M. of Brokenhead - Site 2

DATE : October 14, 2014

ELEVATION: 239.171 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 5



GW	GP
GM	GC
SW	SP
SM	SC
ML	CL
OL	CI
MH	CH
OH	PT
Topsoil	Static Water Level

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

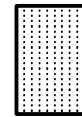
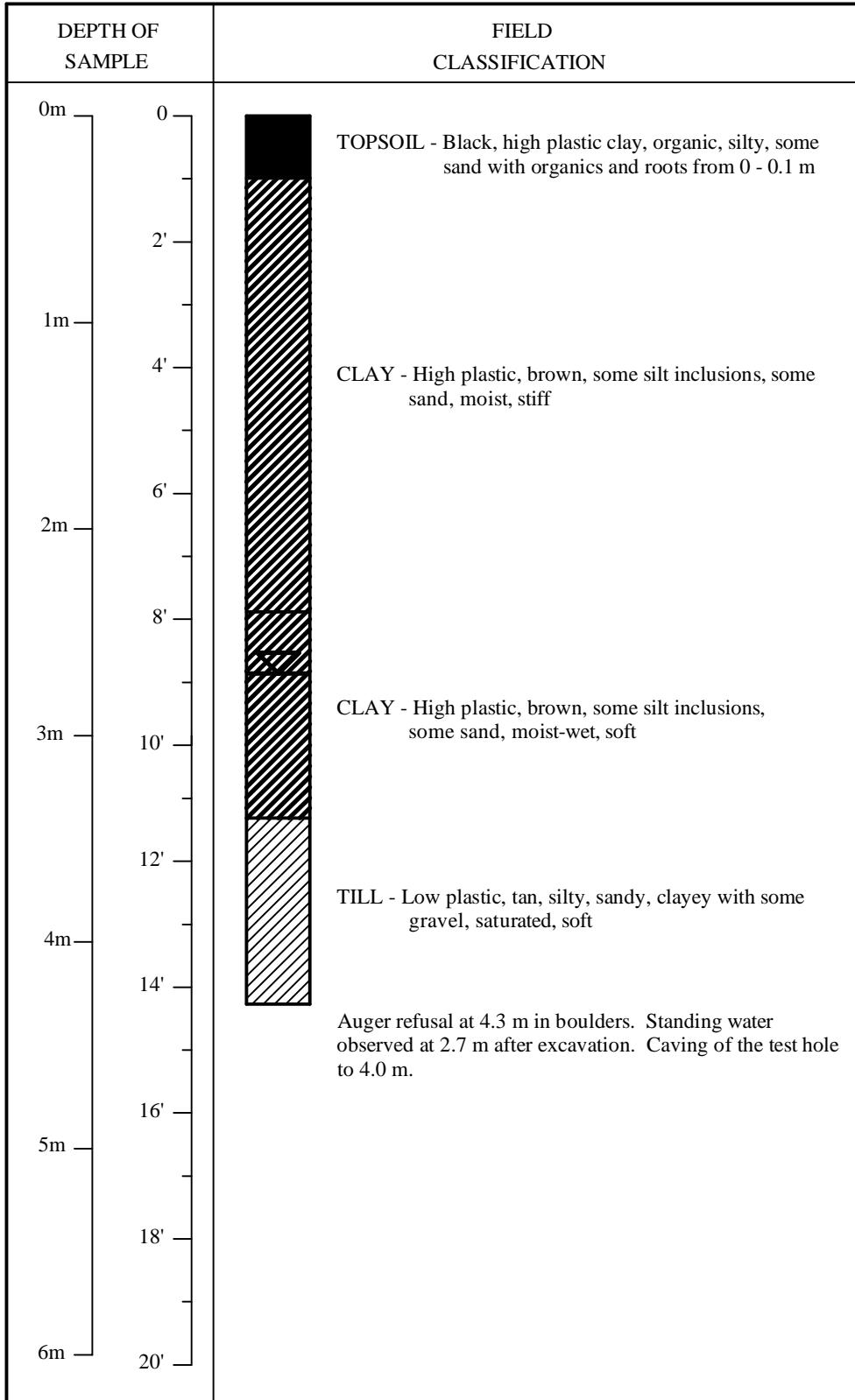
LOCATION : R.M. of Brokenhead - Site 2

DATE : October 14, 2014

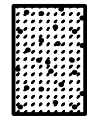
ELEVATION: 237.988 m

PROJECT : GTH Lagoon Geotechnical Investigation

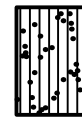
TEST HOLE # 6



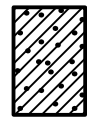
GW



GP



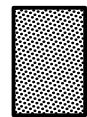
GM



GC



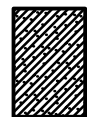
SW



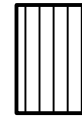
SP



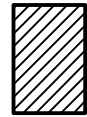
SM



SC



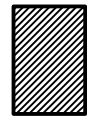
ML



CL



OL



CI



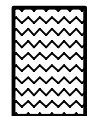
MH



CH



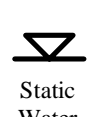
OH



PT



Topsoil



Static Water Level

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of a unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

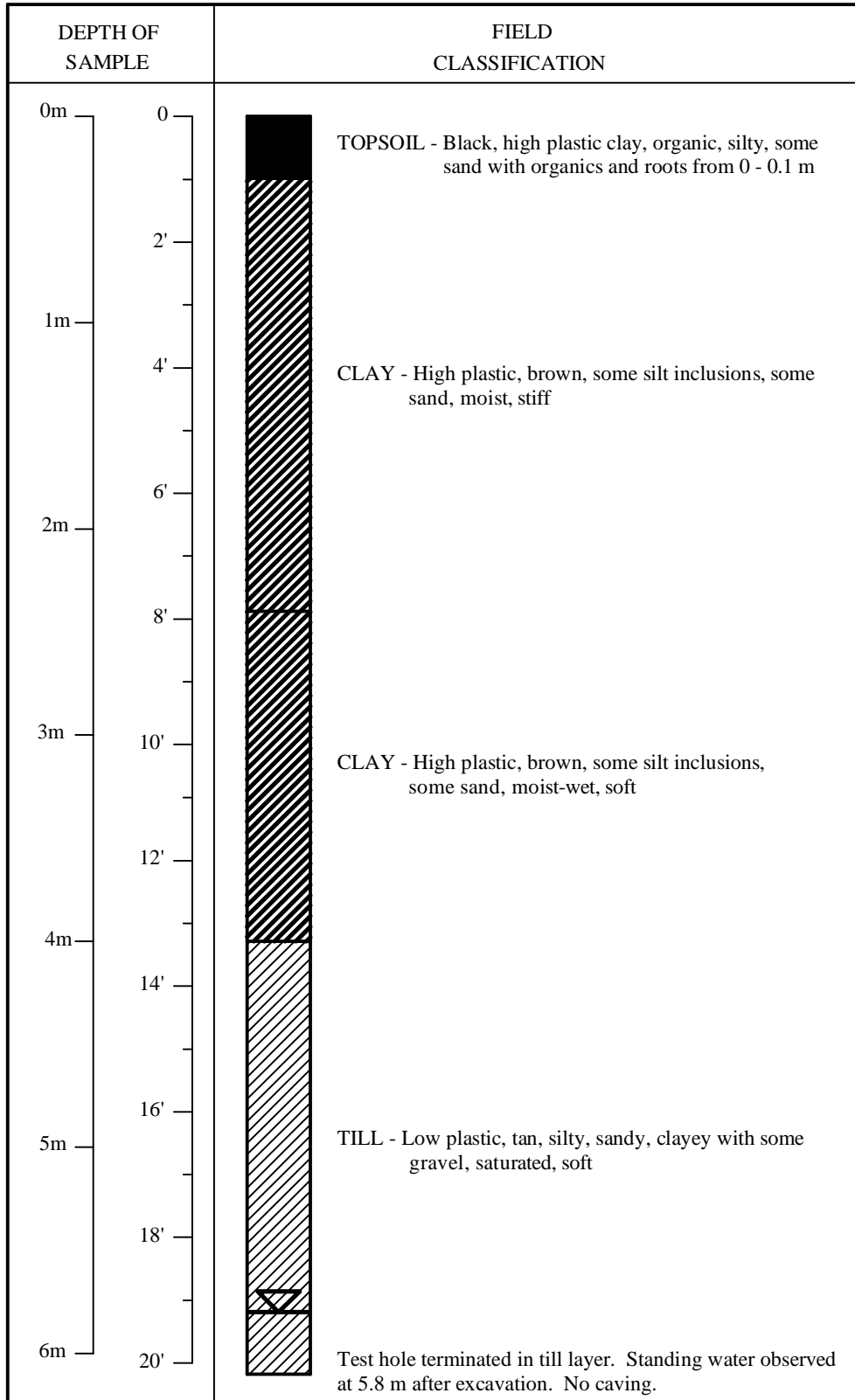
LOCATION : R.M. of Brokenhead - Site 2

DATE : October 14, 2014

ELEVATION: 237.172 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 7



GW	GP
GM	GC
SW	SP
SM	SC
ML	CL
OL	CI
MH	CH
OH	PT
Topsoil	Static Water Level

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

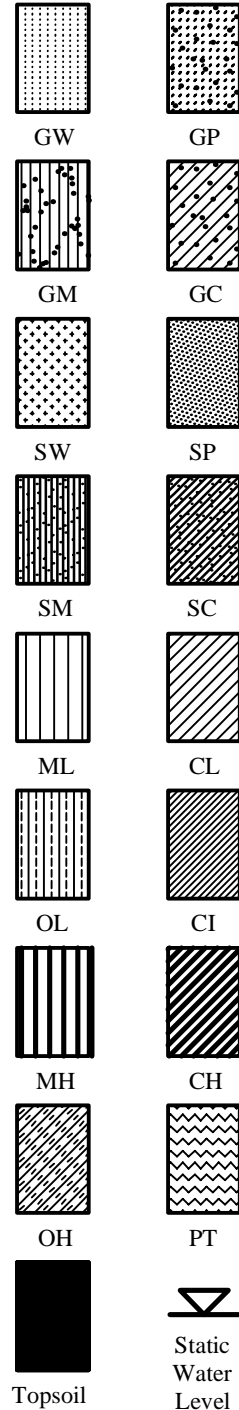
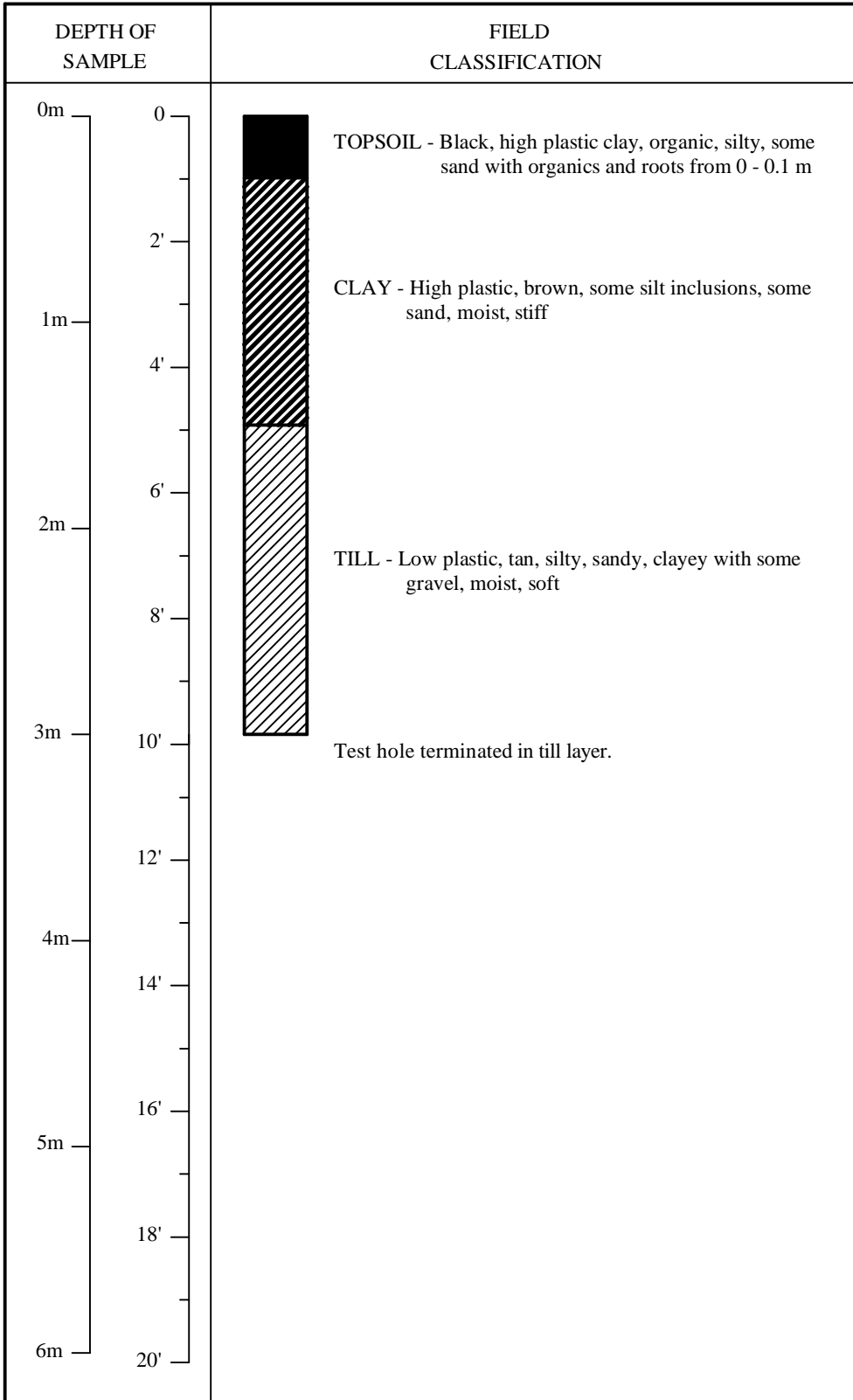
LOCATION : R.M. of Brokenhead - Site 2

DATE : October 14, 2014

ELEVATION: 238.625 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 8



The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

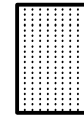
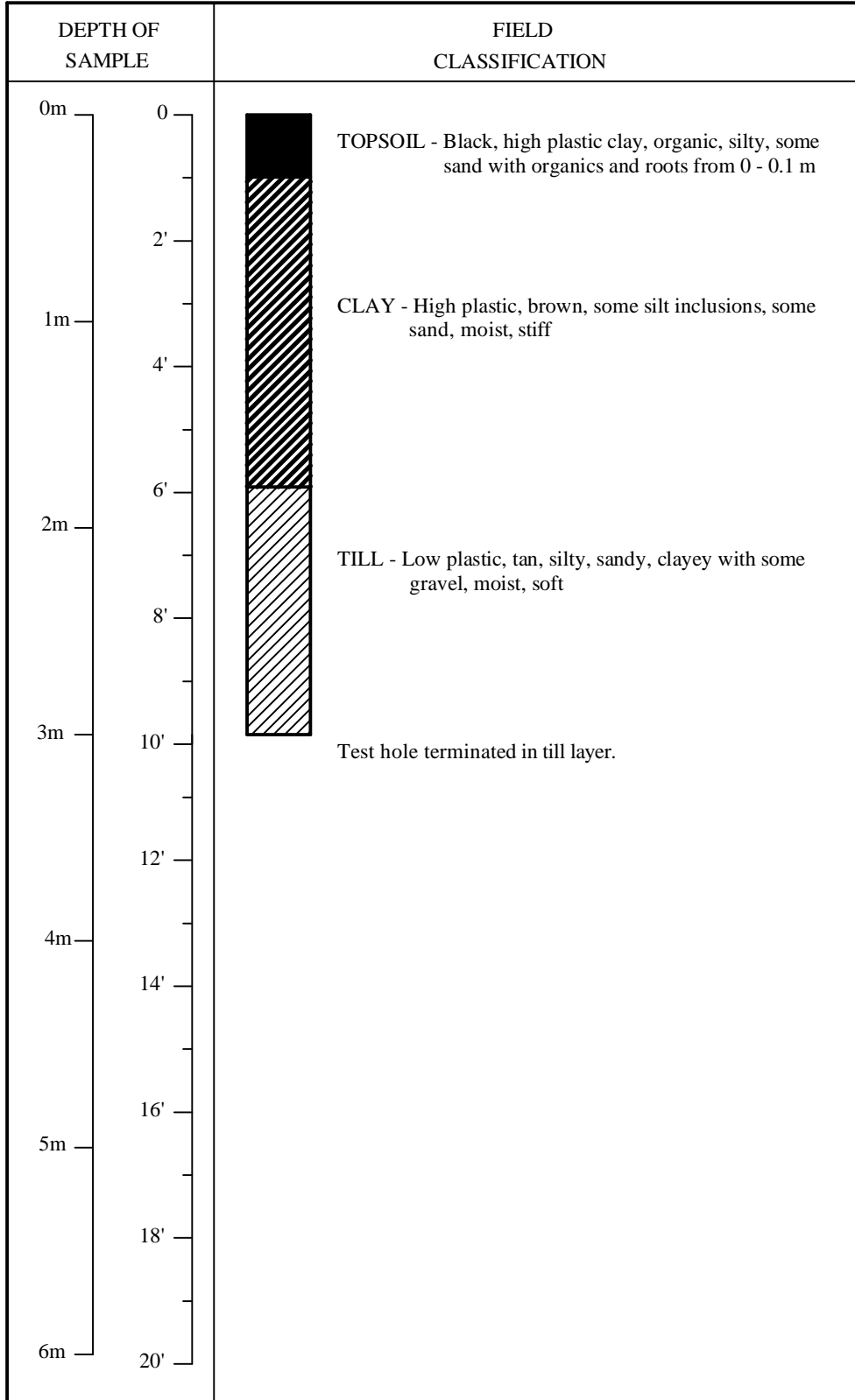
LOCATION : R.M. of Brokenhead - Site 2

DATE : October 14, 2014

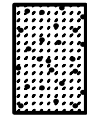
ELEVATION: 238.798 m

PROJECT : GTH Lagoon Geotechnical Investigation

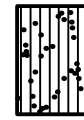
TEST HOLE # 9



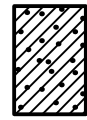
GW



GP



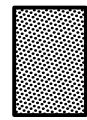
GM



GC



SW



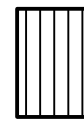
SP



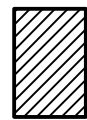
SM



SC



ML



CL



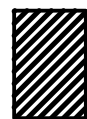
OL



CI



MH



CH



OH



PT



Topsoil



Static Water Level

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.



# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

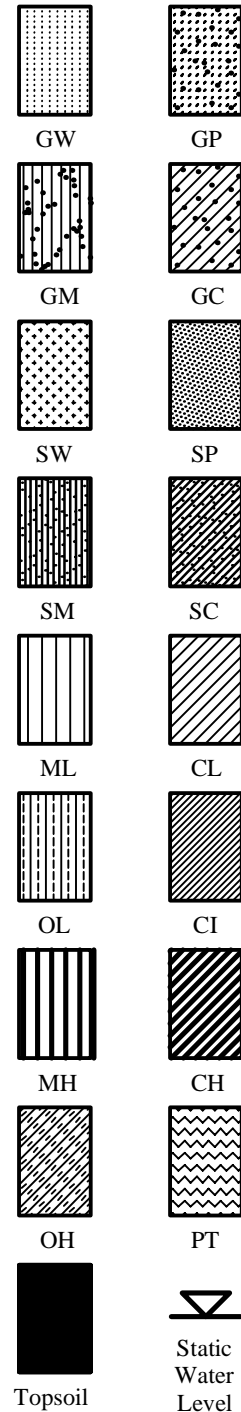
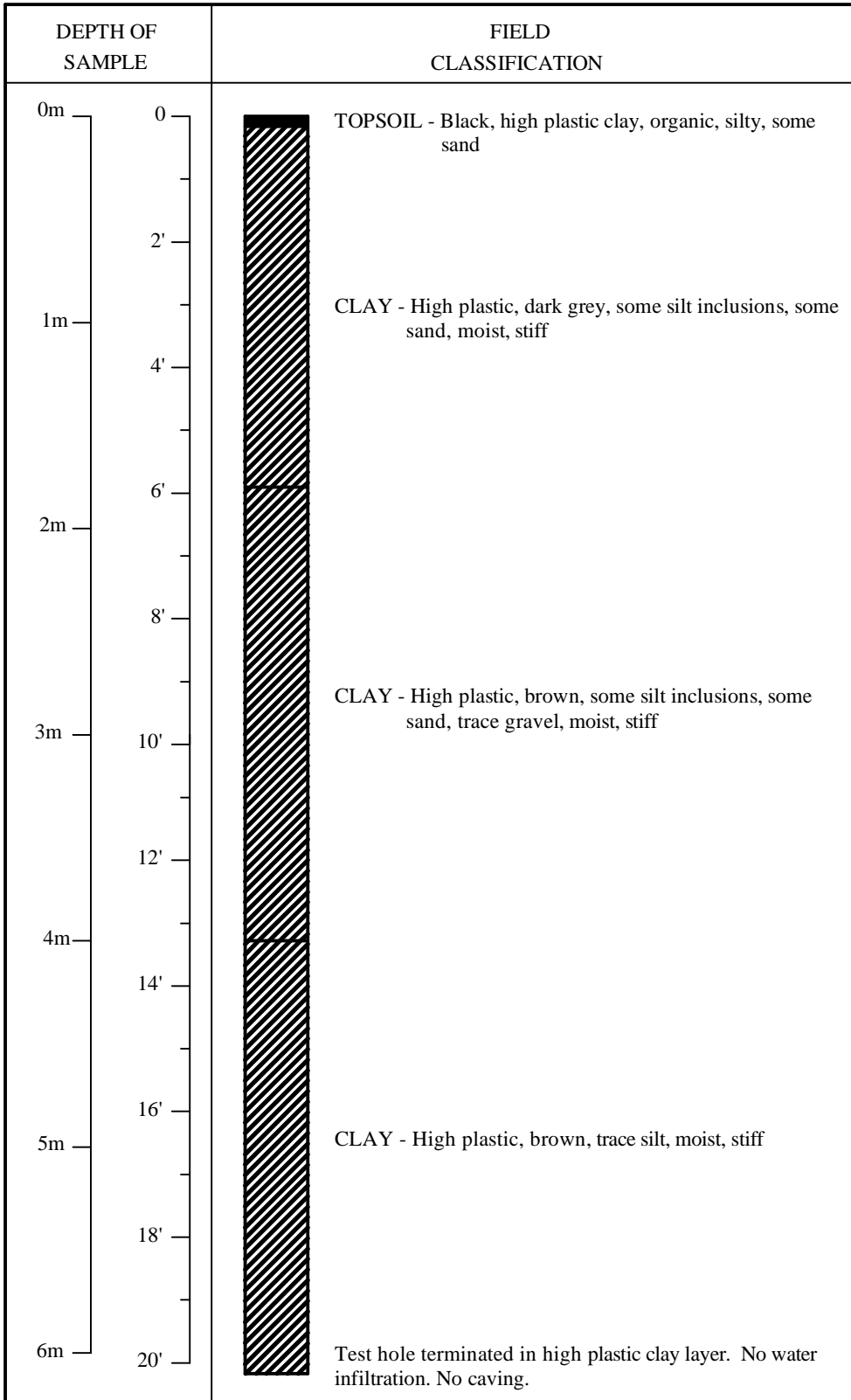
LOCATION : R.M. of Brokenhead - Site 2

DATE : October 14, 2014

ELEVATION: 235.994 m

PROJECT : GTH Lagoon Geotechnical Investigation

TEST HOLE # 10



The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

## 2002 Past Test Hole Logs

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

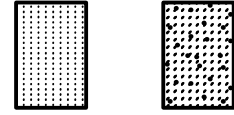
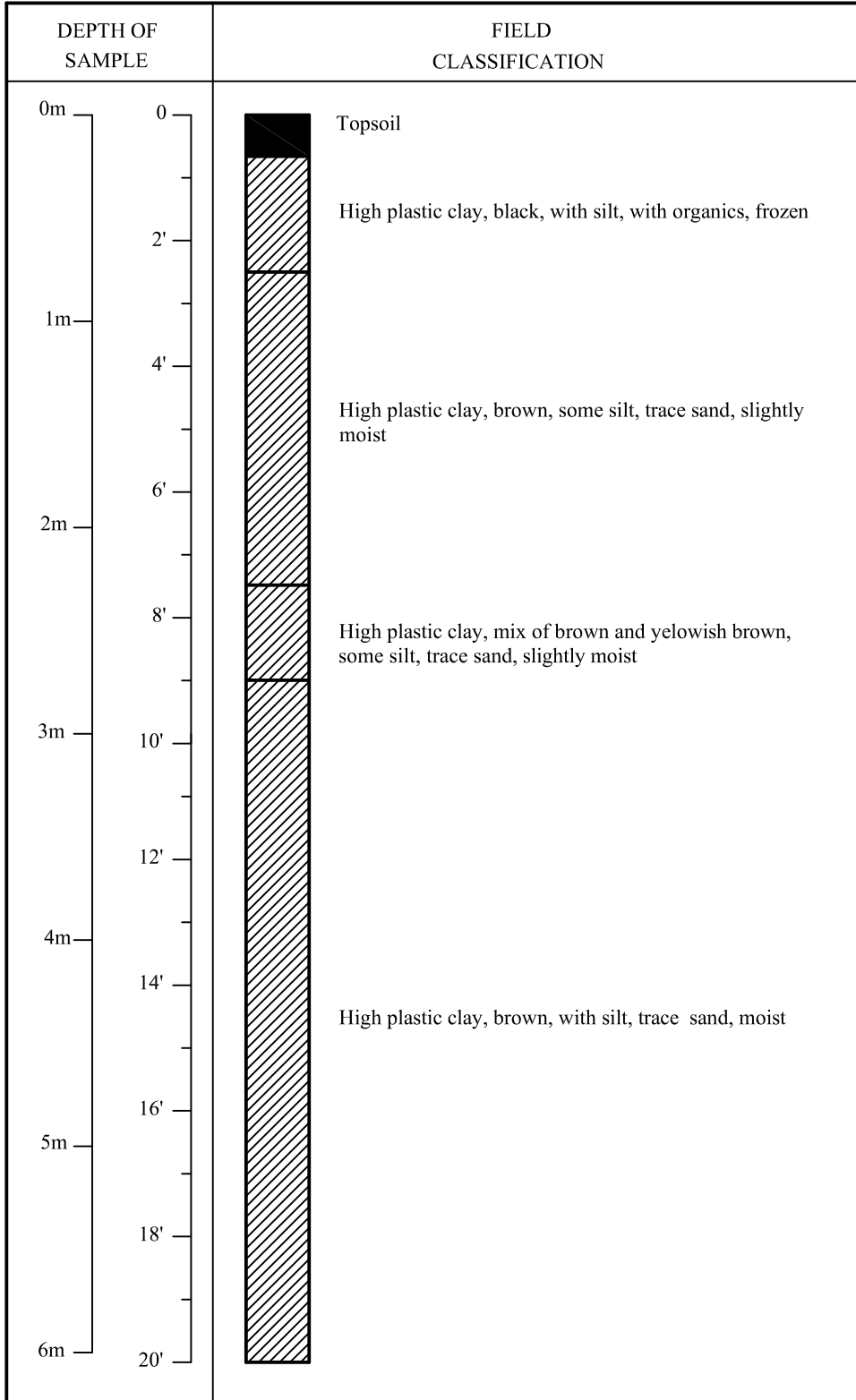
LOCATION : RM of Brokenhead

DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

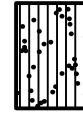
PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 1

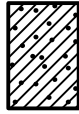


GW

GP



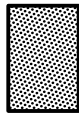
GM



GC



SW



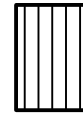
SP



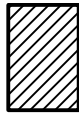
SM



SC



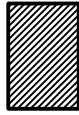
ML



CL



OL



CI



MH



CH



OH



PT



Topsoil

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# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

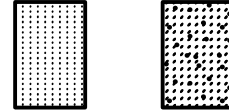
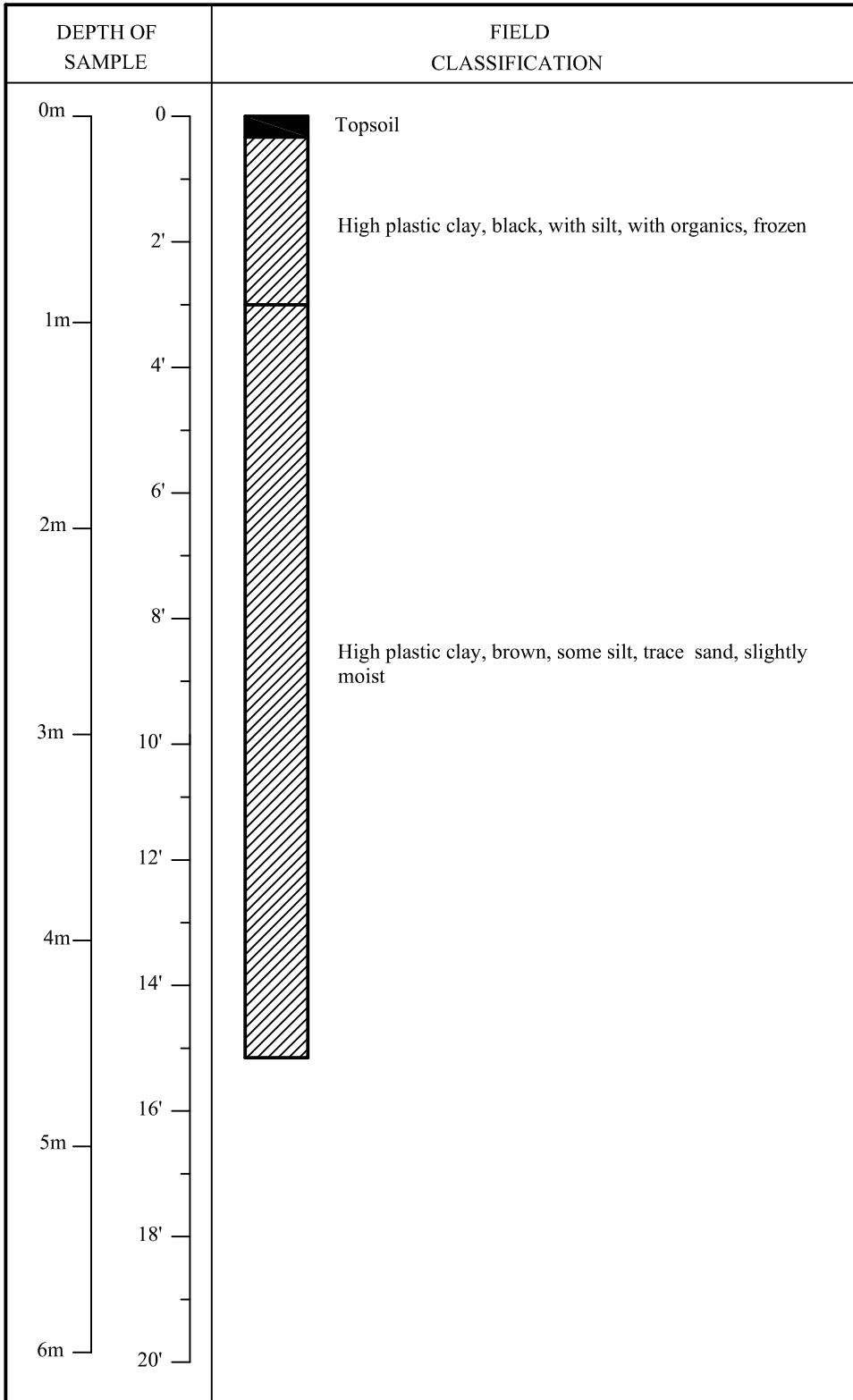
LOCATION : RM of Brokenhead

DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

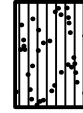
PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 2

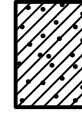


GW

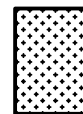
GP



GM



GC



SW



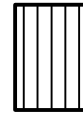
SP



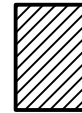
SM



SC



ML



CL



OL



CI



MH



CH



OH



PT



Topsoil

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# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

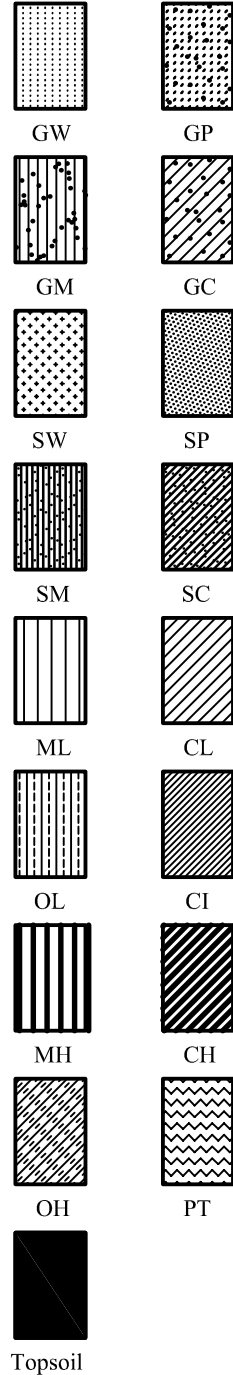
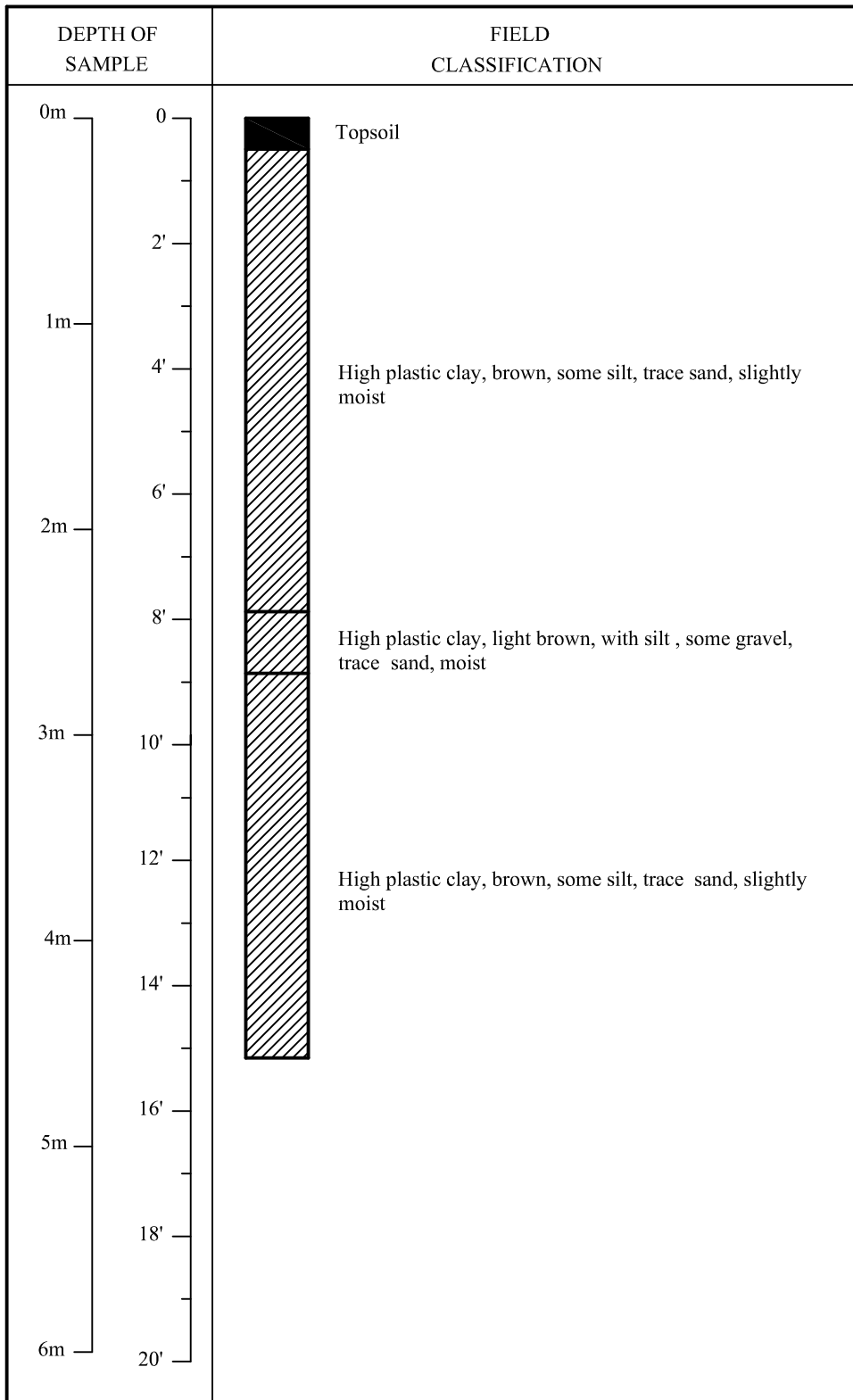
LOCATION : RM of Brokenhead

DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 3



The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas do to the limited number of test holes as compared to that of a unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

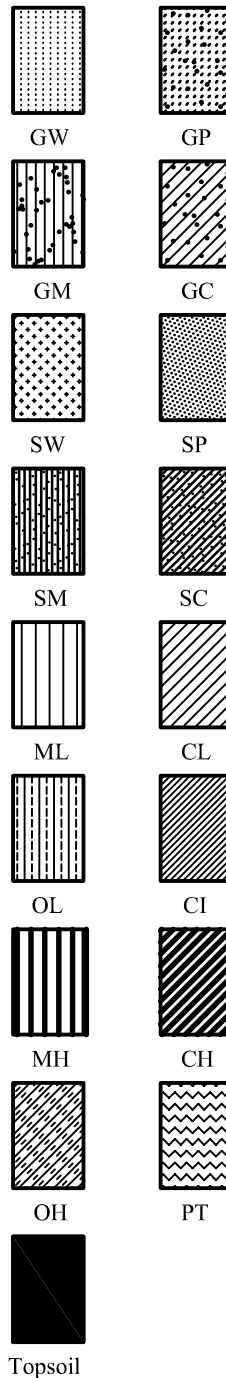
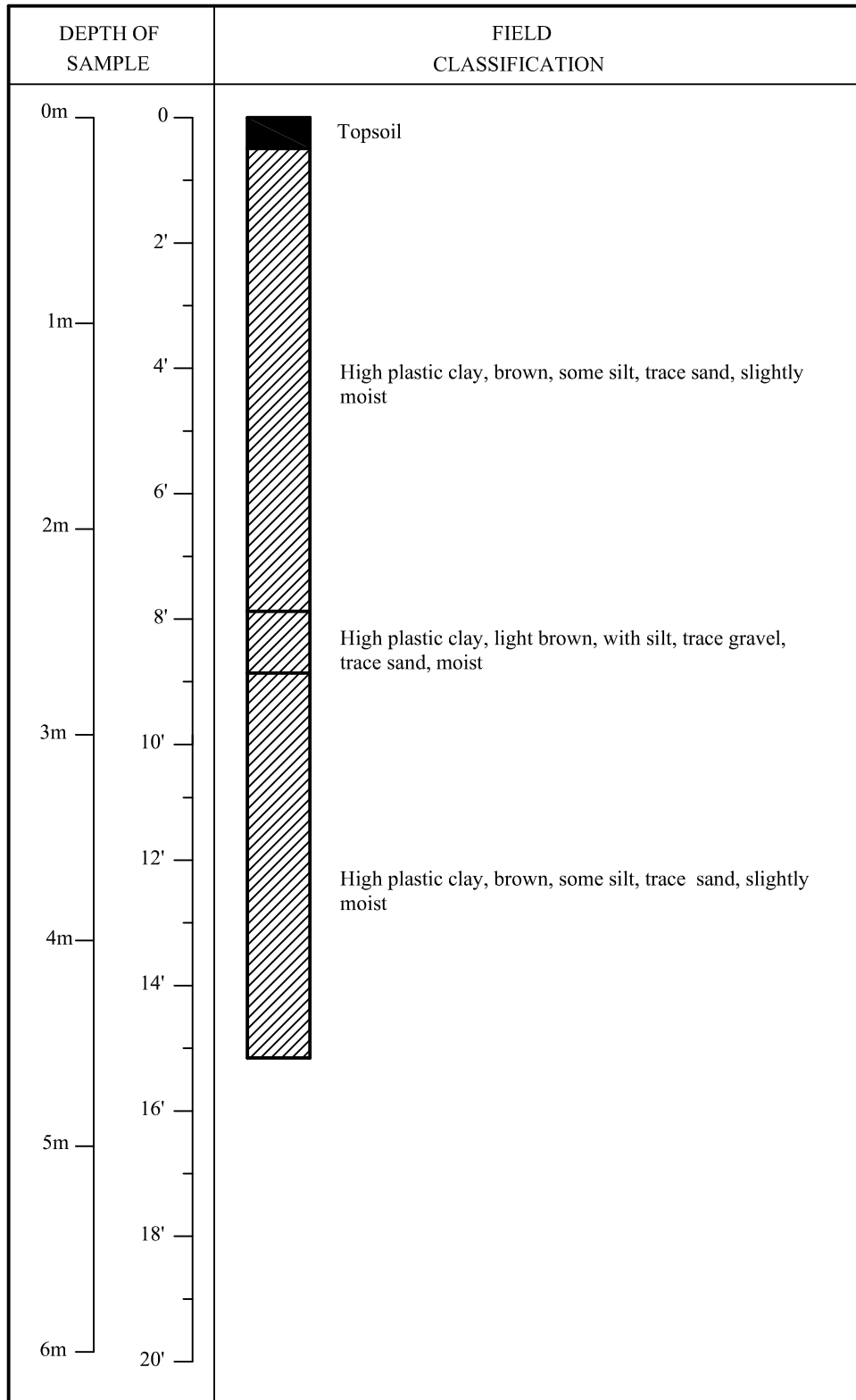
LOCATION : RM of Brokenhead

DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 4



The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas do to the limited number of test holes as compared to that of a unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

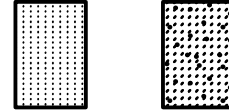
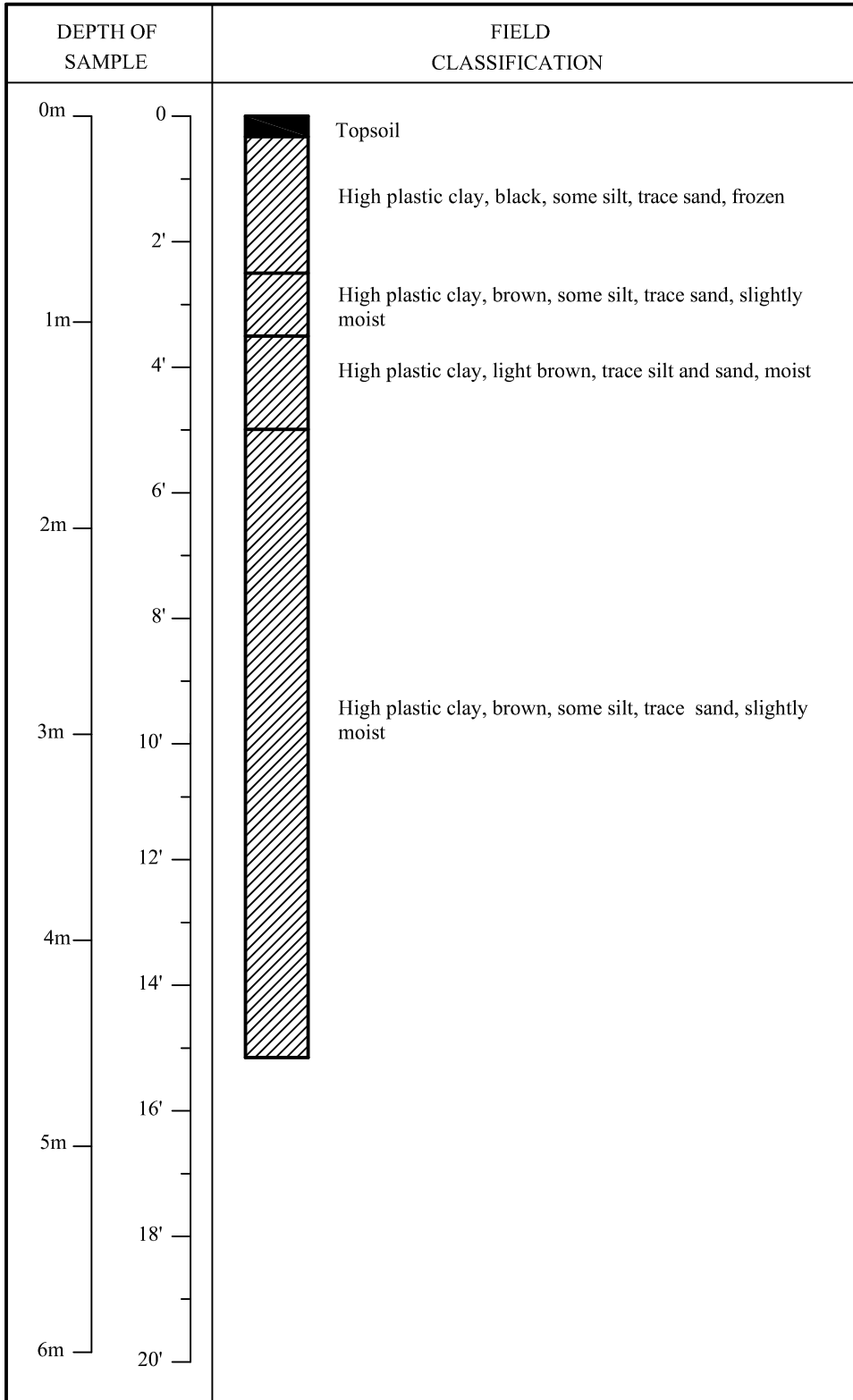
LOCATION : RM of Brokenhead

DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

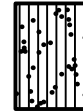
PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 5

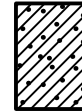


GW

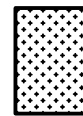
GP



GM



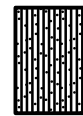
GC



SW



SP



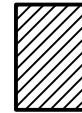
SM



SC



ML



CL



OL



CI



MH



CH



OH



PT



Topsoil

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# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

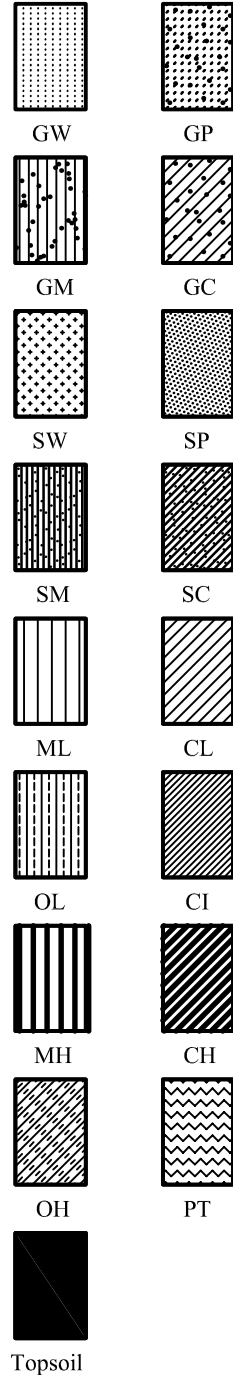
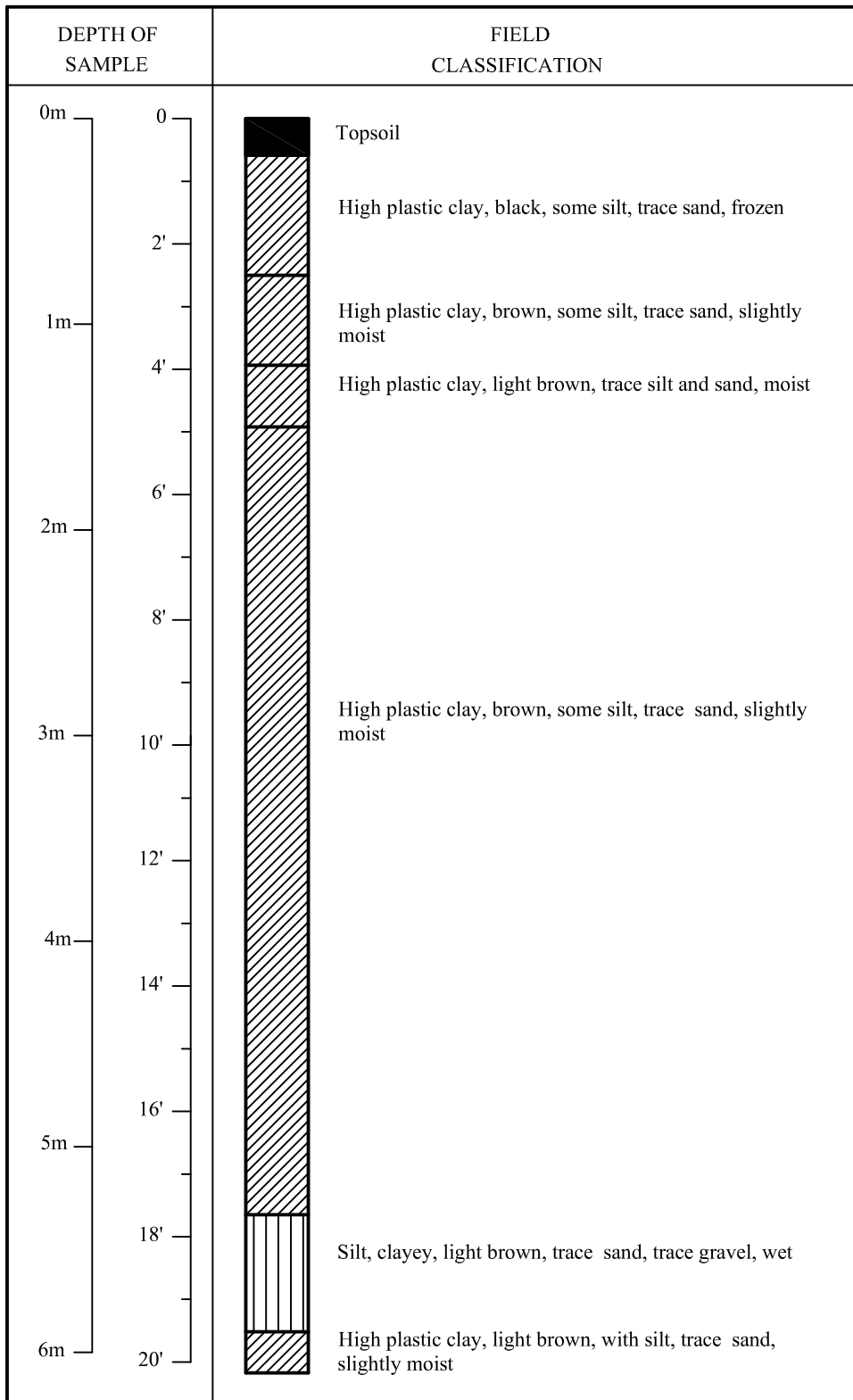
LOCATION : RM of Brokenhead

DATE : January 15, 2002

LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

TEST HOLE # 6



The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.



# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

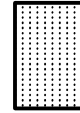
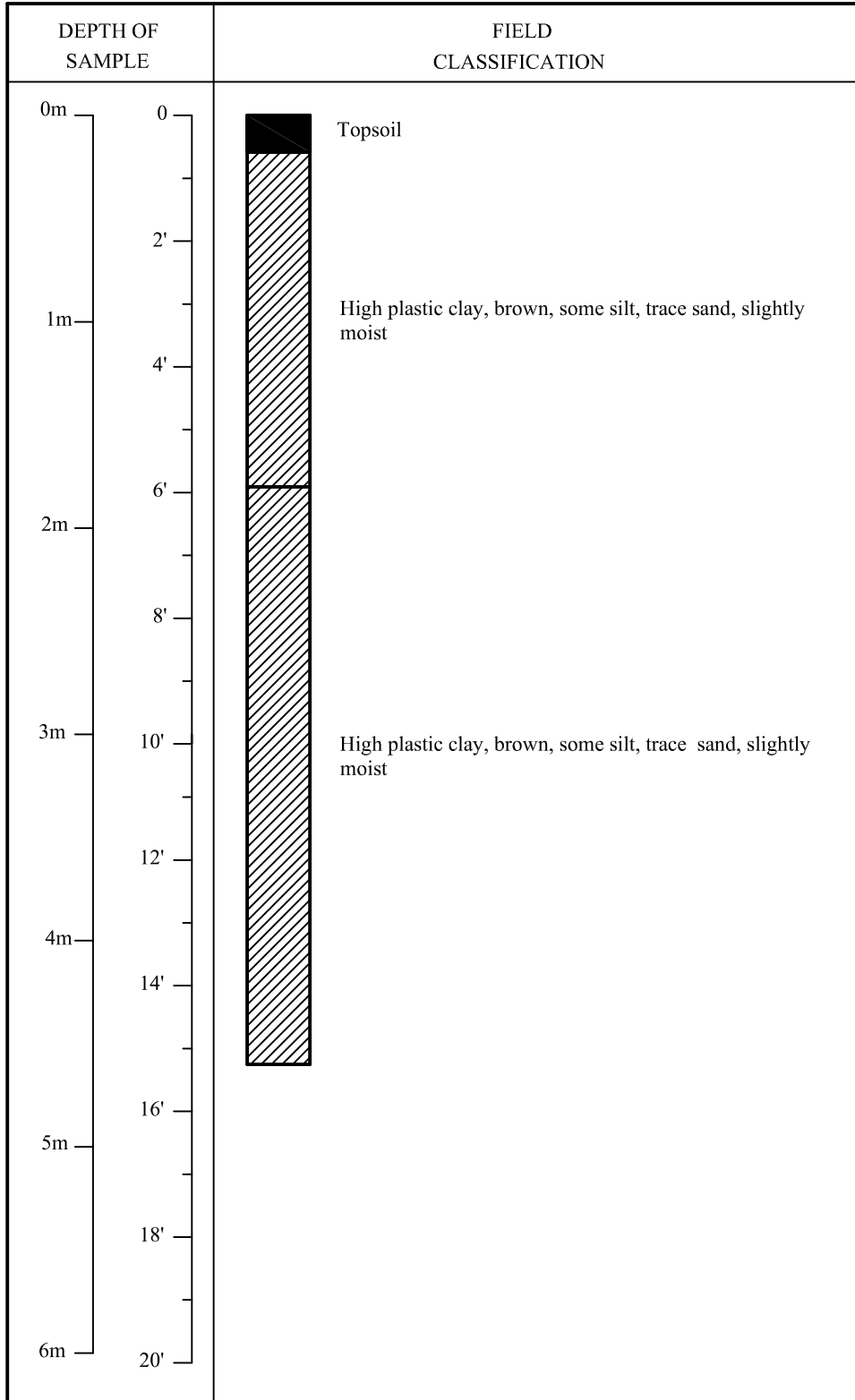
LOCATION : RM of Brokenhead

DATE : January 15, 2002

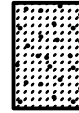
LOCATION OF BORING : NW 15-13-6E

PROJECT : Garson/Tyndall Proposed Wastewater Lagoon G-201.02

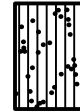
TEST HOLE # 7



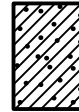
GW



GP



GM



GC



SW



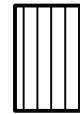
SP



SM



SC



ML



CL



OL



CI



MH



CH



OH



PT



Topsoil

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas do to the limited number of test holes as compared to that of a unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

## 2012 Past Test Hole Logs

J. R. Cousin Consultants Ltd.  
TEST HOLE LOGS

SYMBOL INDEX



GW. : Well graded gravels and gravel sand mixtures, little or no fines



GP. : Poorly graded gravels, gravel - sand mixtures,  
little or no fines



GM. : Silty gravels, gravel-sand-silt mixtures



GC. : Clayey gravels, gravel-sand-clay mixtures



SW. : Well graded sands, gravelly sands, little or no fines



SP. : Poorly graded sands, or gravelly sands, little or no fines



SM. : Silty sands, sand-silt mixtures



SC. : Clayey sands, sand-clay mixtures



ML. : Inorganic silts and very fine sands, rock flour, silty or clayey fine sands,  
or clayey silts with slight plasticity



CL. : Inorganic clays of low plasticity, gravelly clays, sandy or silty  
clays, lean clays



OL. : Organic silts and organic silty clays of low plasticity



CI. : Inorganic clays of medium or intermediate plasticity



MH. : Inorganic silts, fine sandy or silty soils



CH. : Inorganic clays of high plasticity, fat clays



OH. : Organic clays of medium to high plasticity, organic silts



Pt. : Peat, humus, swamp soils with high organic contents



TOPSOIL

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# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

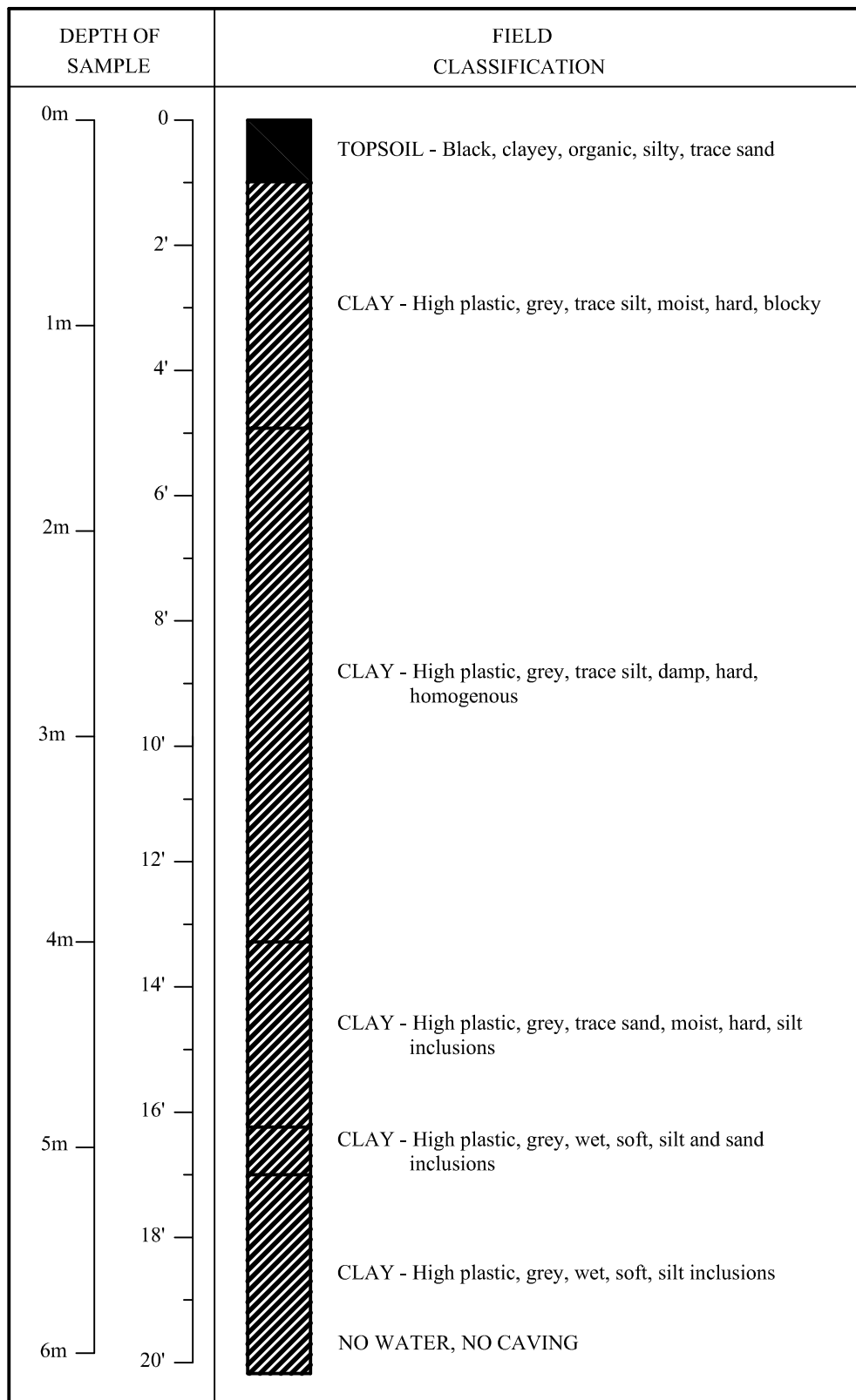
LOCATION : R.M. of Brokenhead

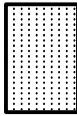
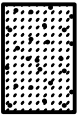
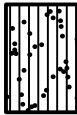
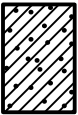

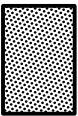

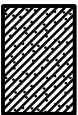

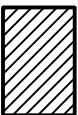
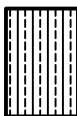
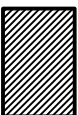
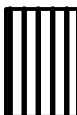
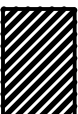
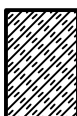


DATE : March 27, 2012

ELEVATION: 236.163

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 1



	
GW	GP
	
GM	GC
	
SW	SP
	
SM	SC
	
ML	CL
	
OL	CI
	
MH	CH
	
OH	PT
	
Topsoil	

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

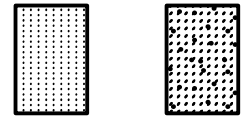
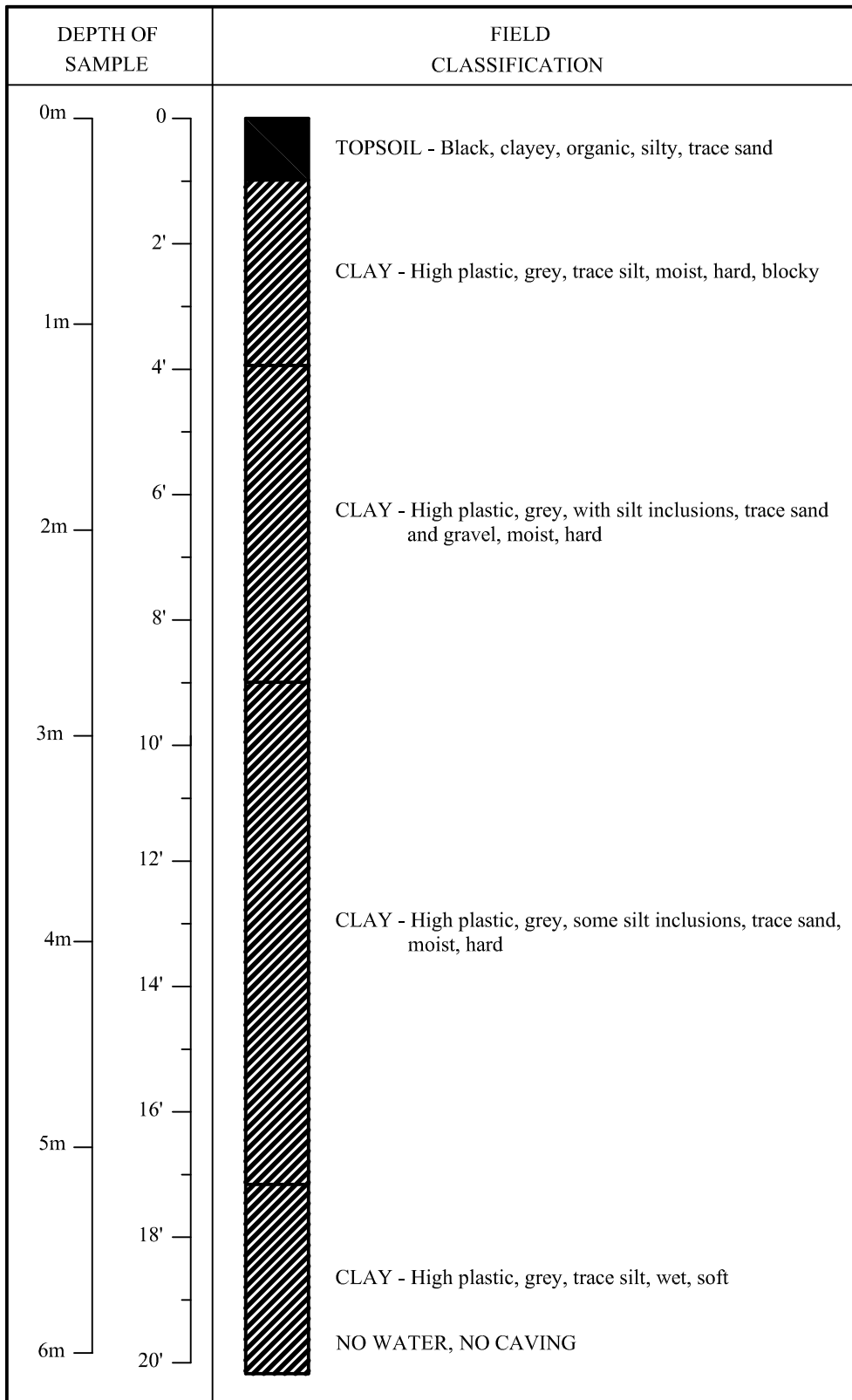
LOCATION : R.M. of Brokenhead

DATE : March 27, 2012

ELEVATION: 236.297

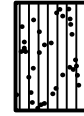
PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 2

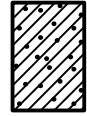


GW

GP



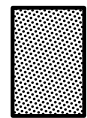
GM



GC



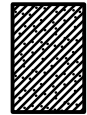
SW



SP



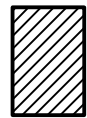
SM



SC



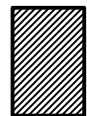
ML



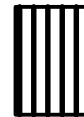
CL



OL



CI



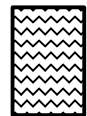
MH



CH



OH



PT



Topsoil

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

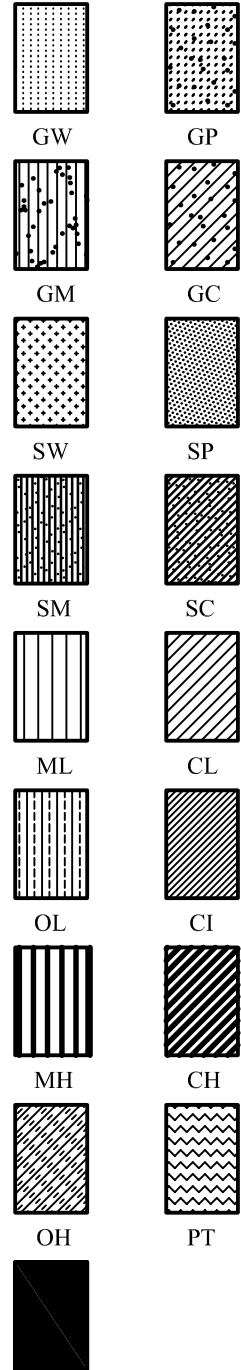
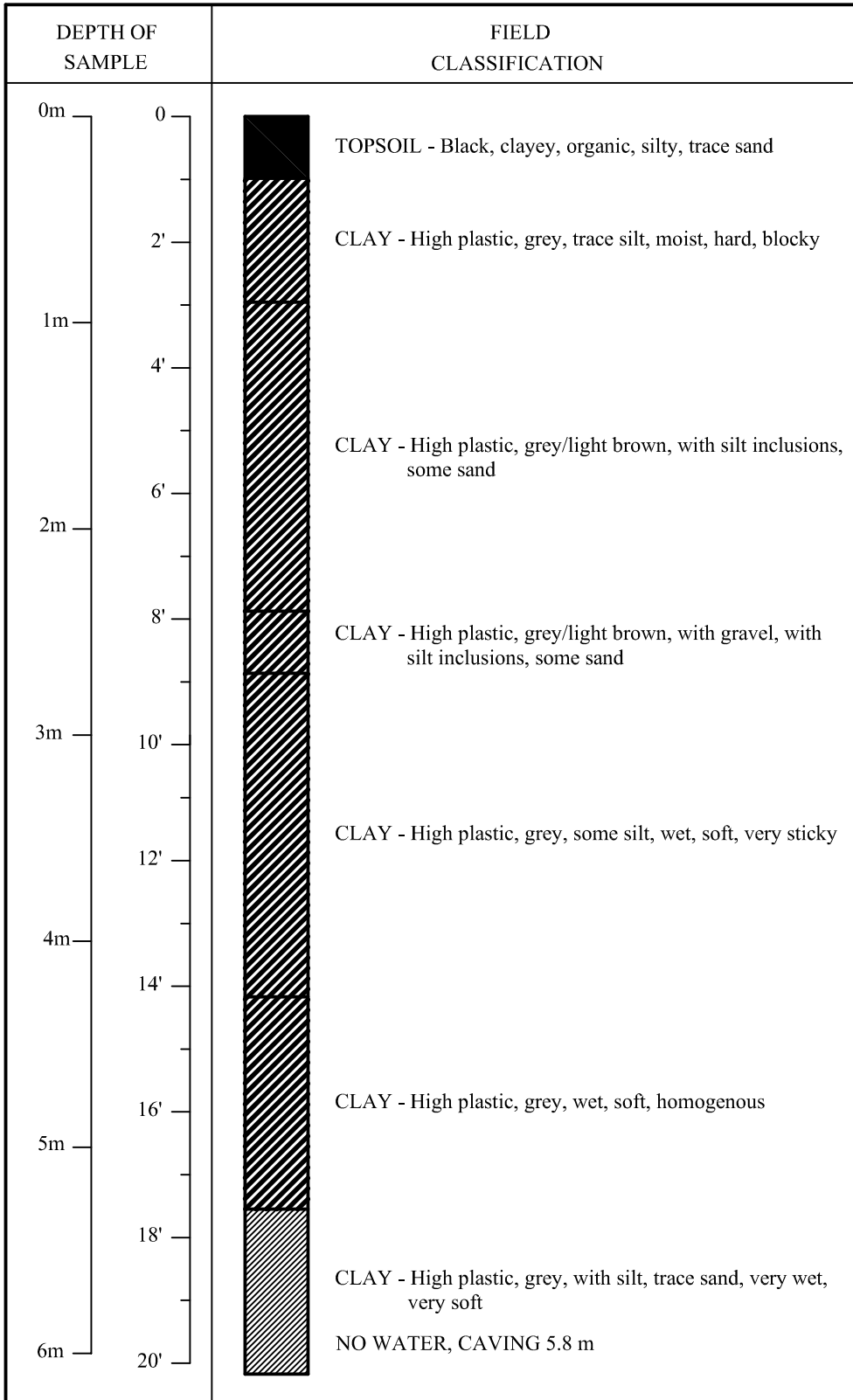
LOCATION : R.M. of Brokenhead

DATE : March 27, 2012

ELEVATION: 236.195

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 3



The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of a unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

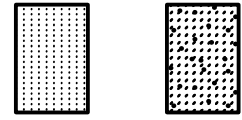
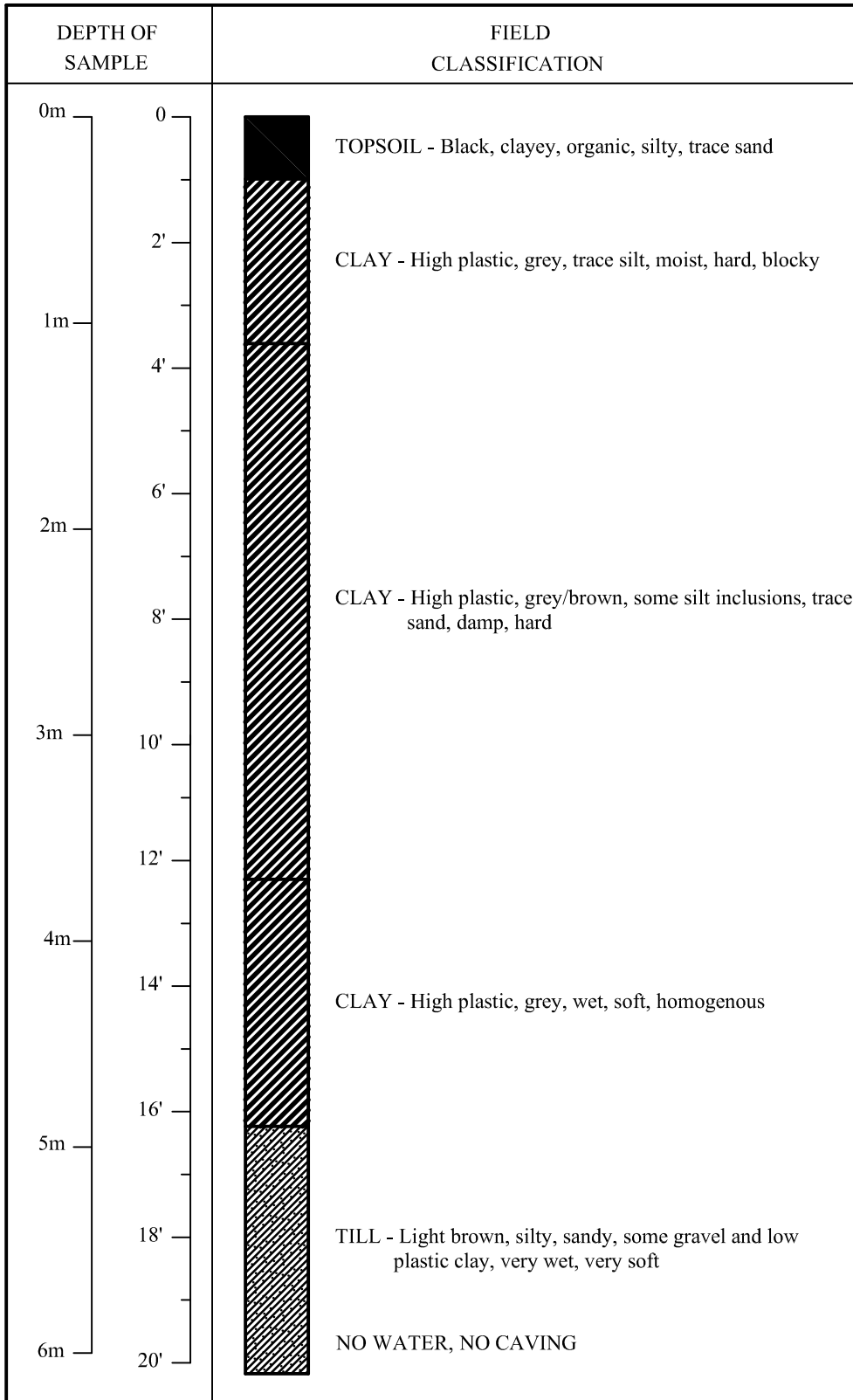
LOCATION : R.M. of Brokenhead

DATE : March 27, 2012

ELEVATION: 236.933

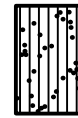
PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 4

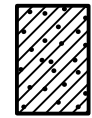


GW

GP



GM



GC



SW



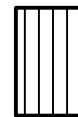
SP



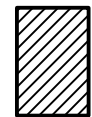
SM



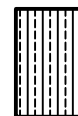
SC



ML



CL



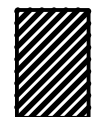
OL



CI



MH



CH



OH



PT



Topsoil

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

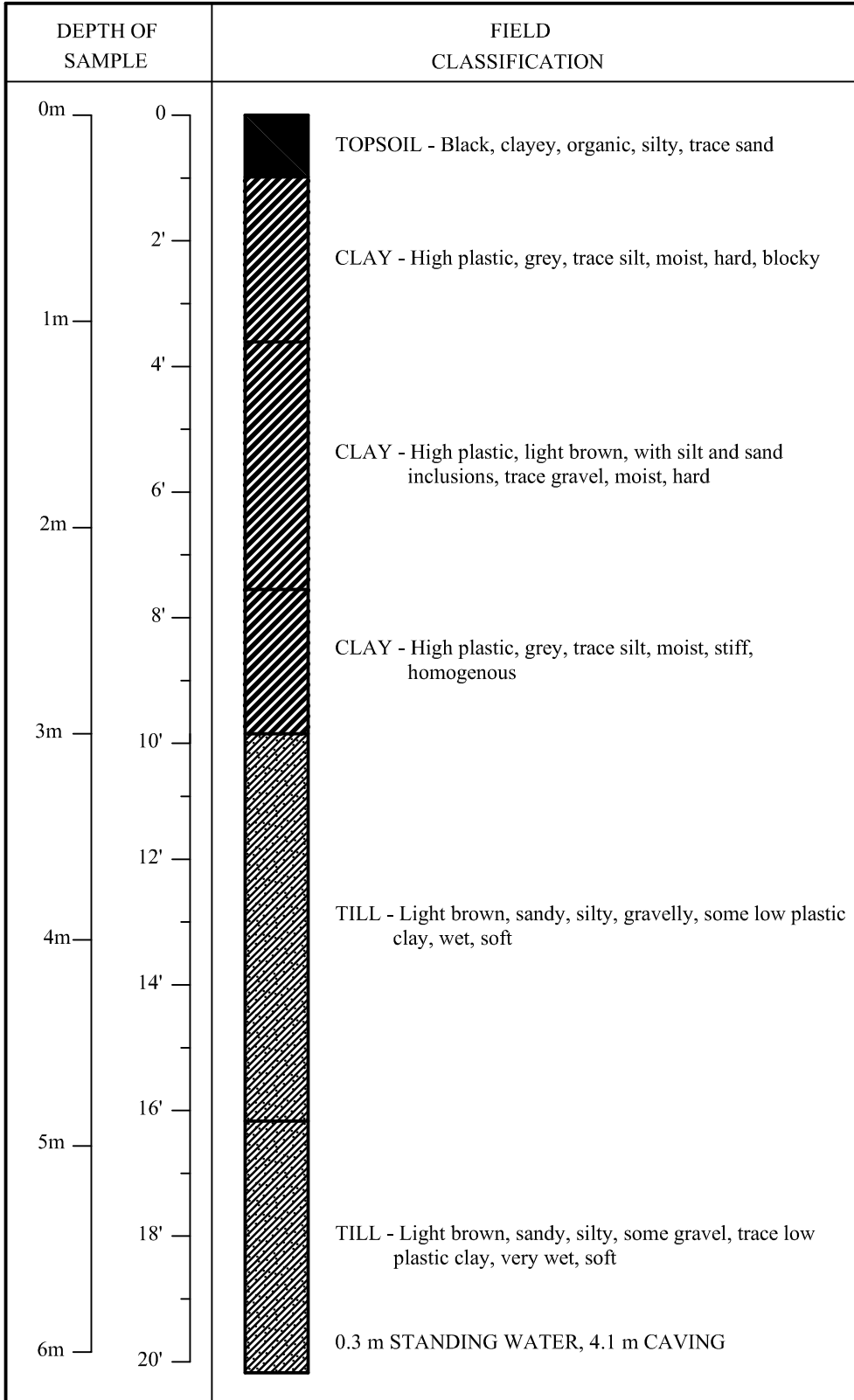
LOCATION : R.M. of Brokenhead

DATE : March 27, 2012

PROJECT : GTH Lagoon Feasibility Study

ELEVATION: 236.823

TEST HOLE # 5



GW	GP
GM	GC
SW	SP
SM	SC
ML	CL
OL	CI
MH	CH
OH	PT
Topsoil	

The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.



# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

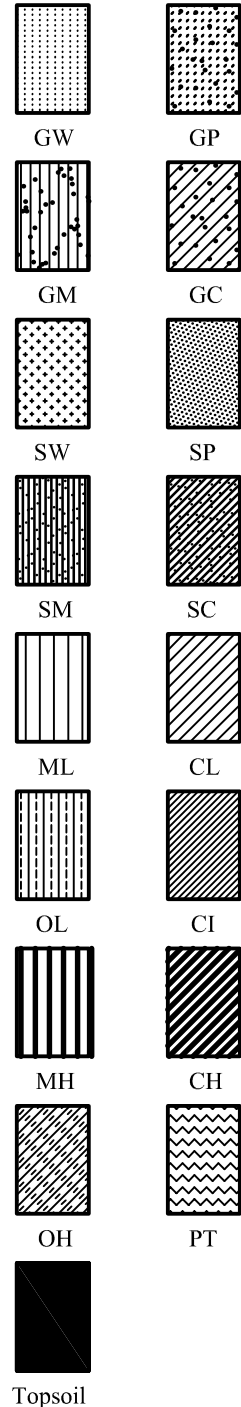
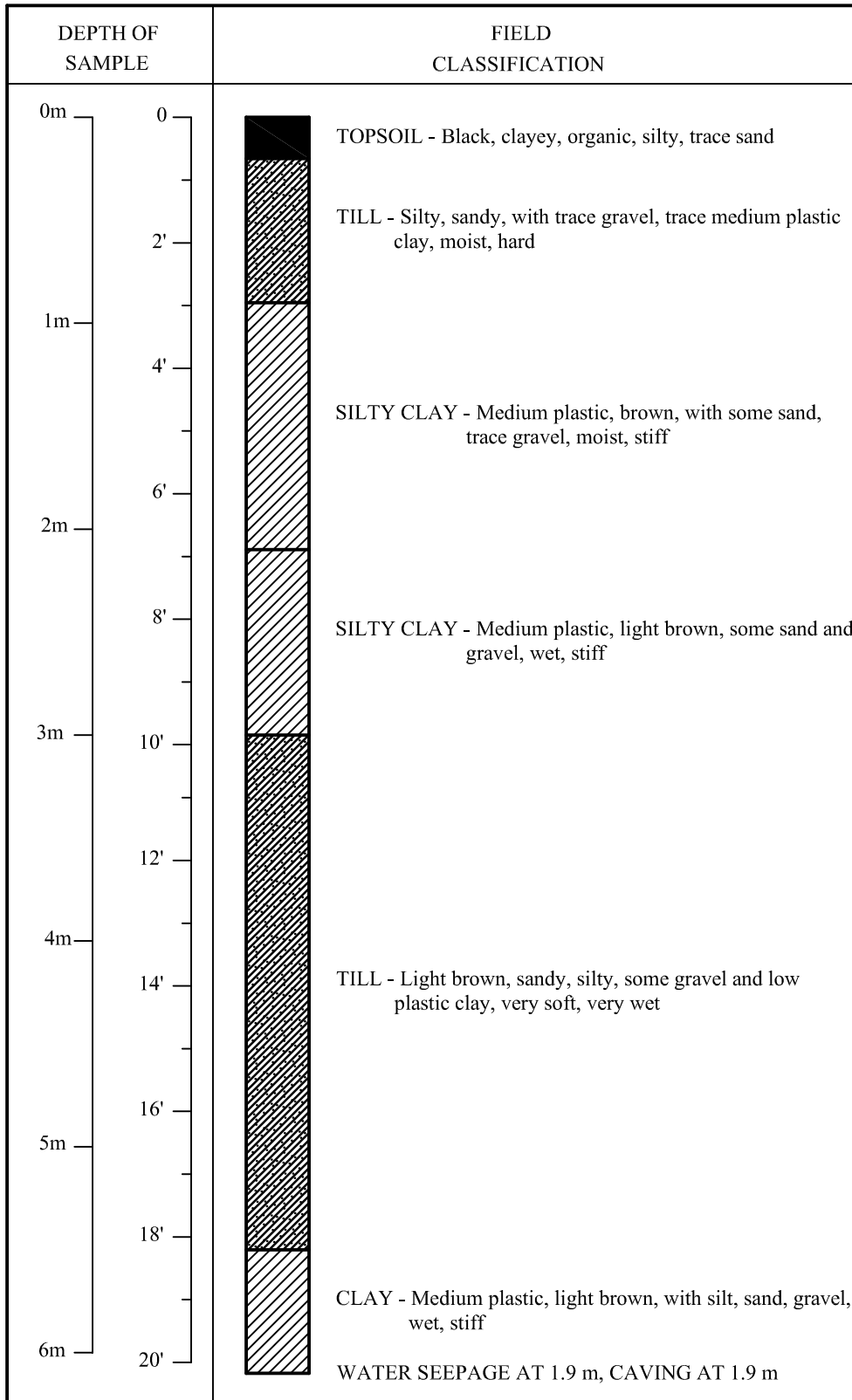
LOCATION : R.M. of Brokenhead

DATE : March 27, 2012

ELEVATION: 236.533

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE # 6



The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

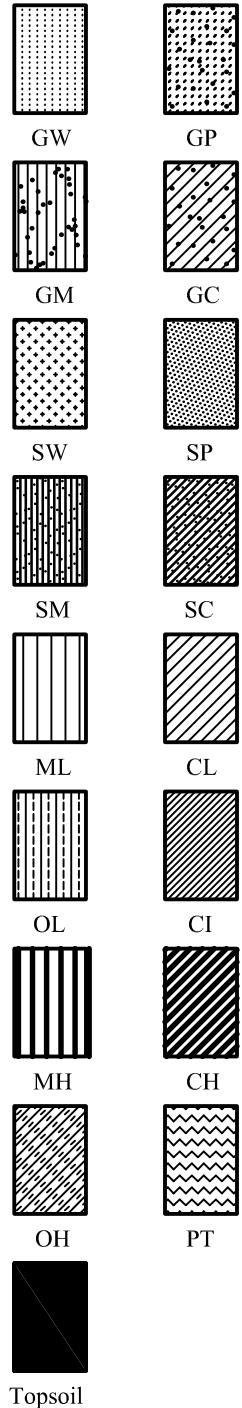
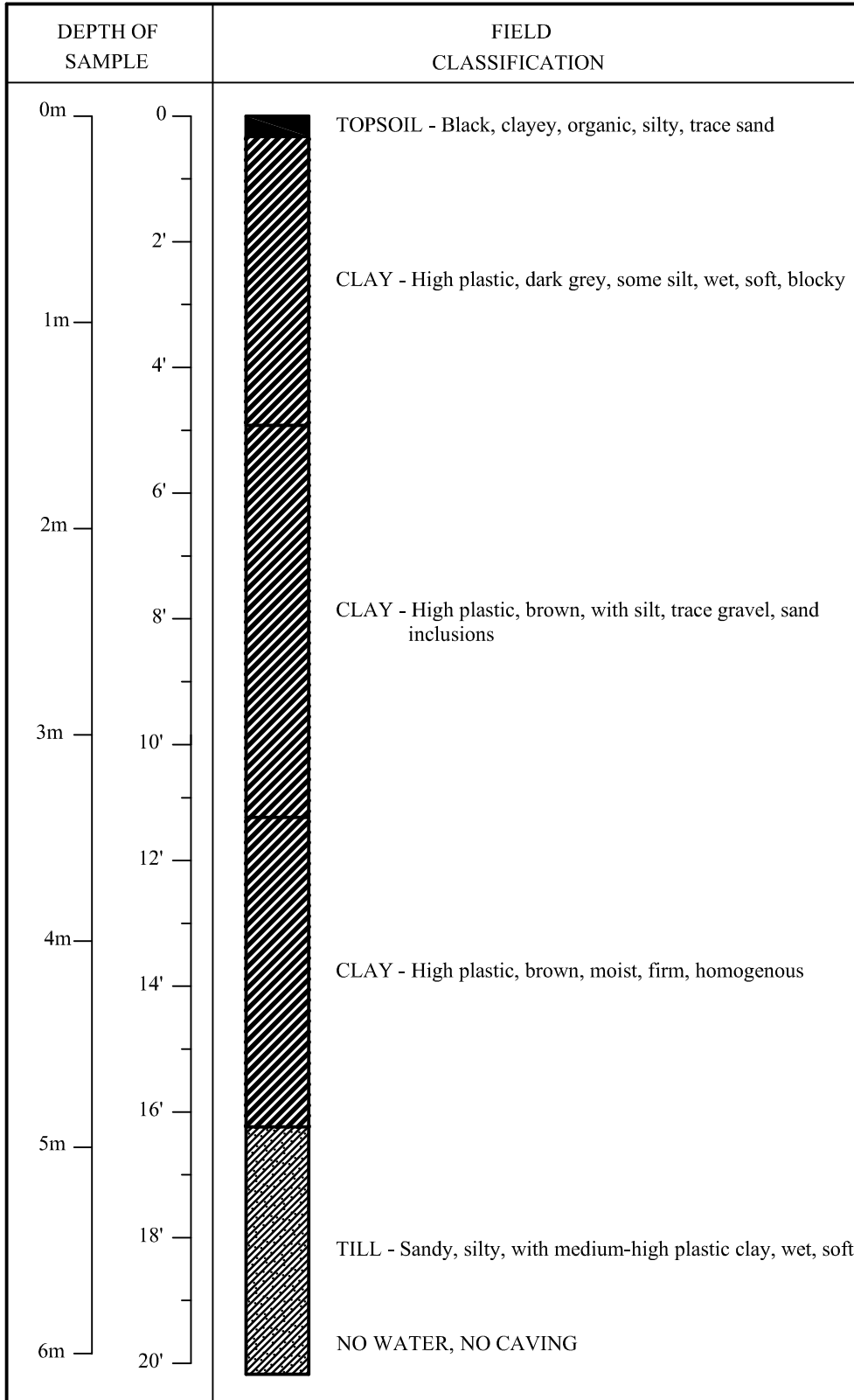
LOCATION : R.M. of Brokenhead

DATE : March 27, 2012

PROJECT : GTH Lagoon Feasibility Study

ELEVATION: 235.971

TEST HOLE # 7



The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

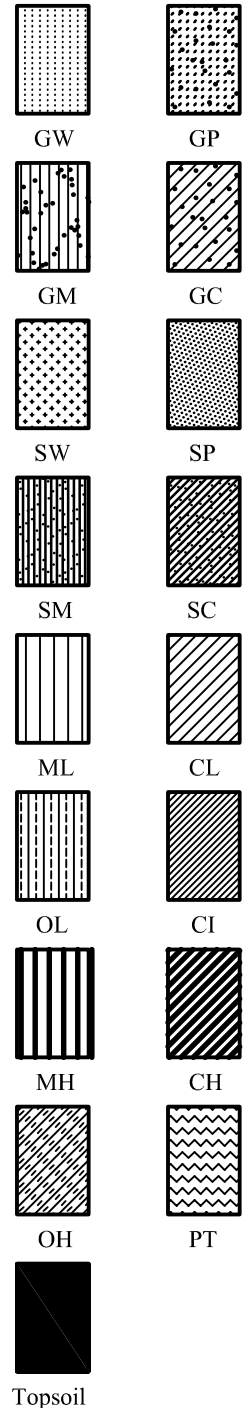
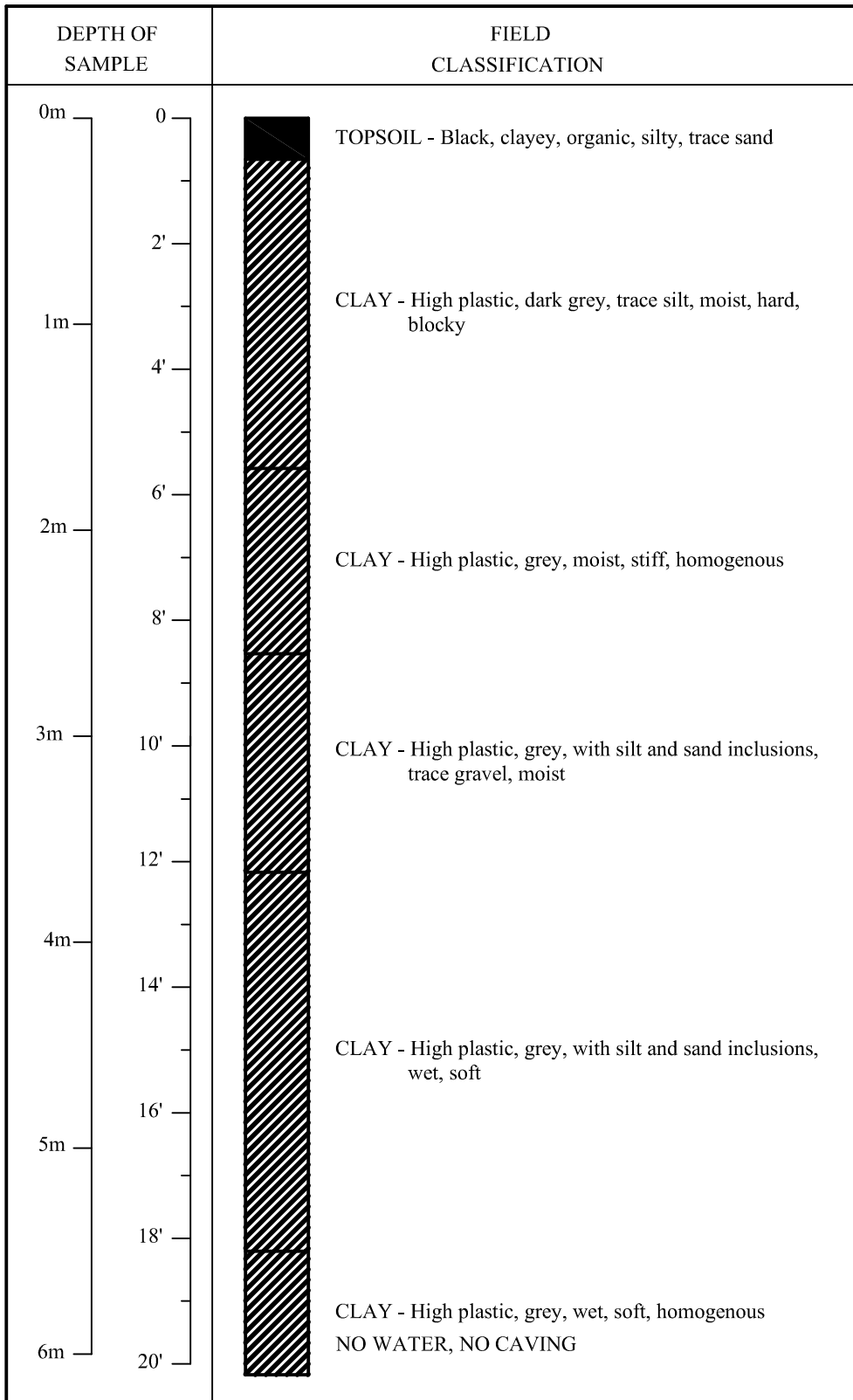
LOCATION : R.M. of Brokenhead

DATE : March 27, 2012

PROJECT : GTH Lagoon Feasibility Study

ELEVATION: 235.802

TEST HOLE # 8



The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

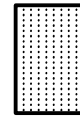
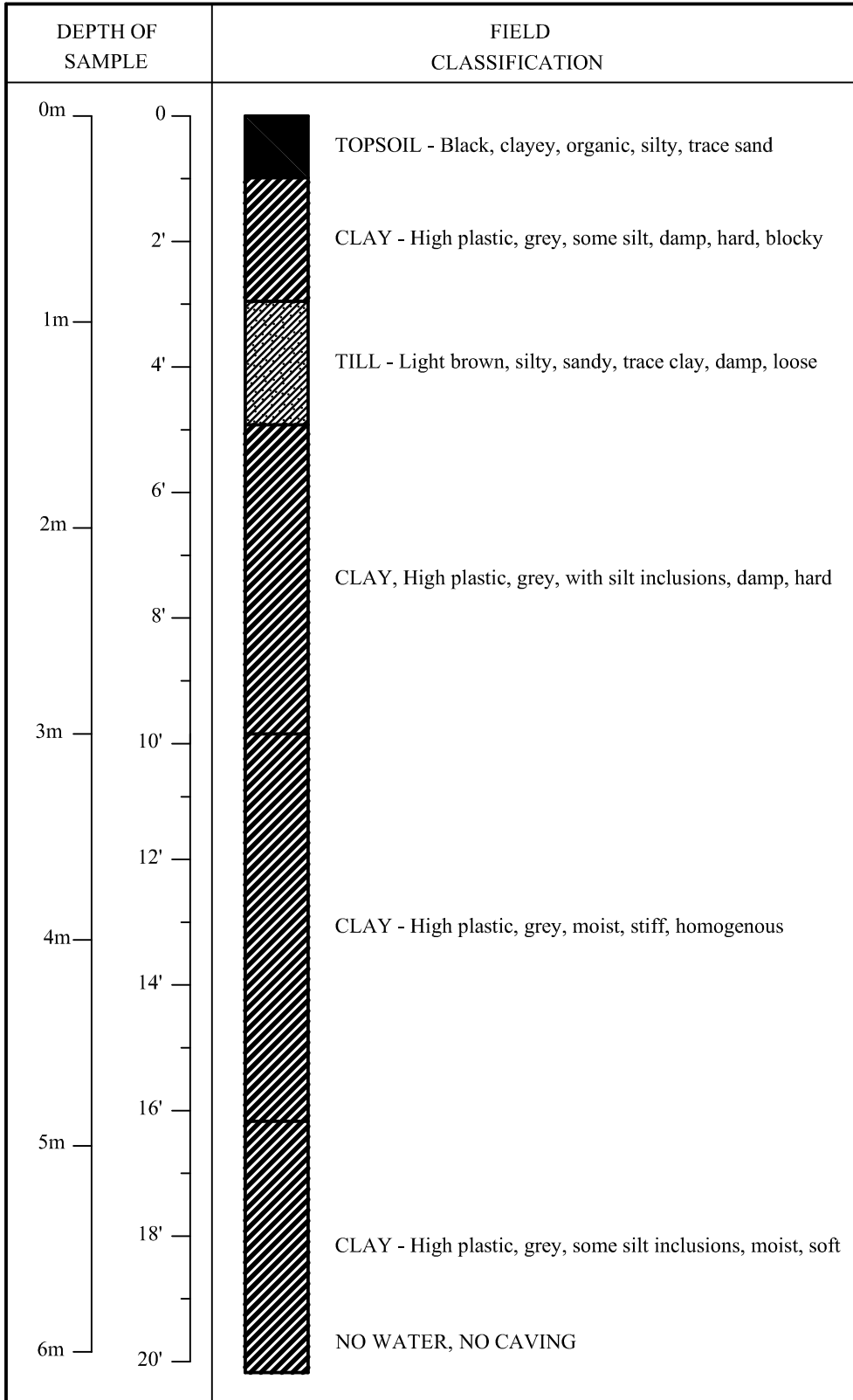
LOCATION : R.M. of Brokenhead

DATE : March 27, 2012

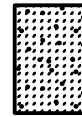
PROJECT : GTH Lagoon Feasibility Study

ELEVATION: 236.180

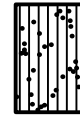
TEST HOLE # 9



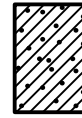
GW



GP



GM



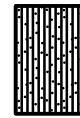
GC



SW



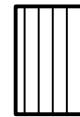
SP



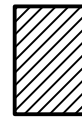
SM



SC



ML



CL



OL



CI



MH



CH



OH



PT



Topsoil

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# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

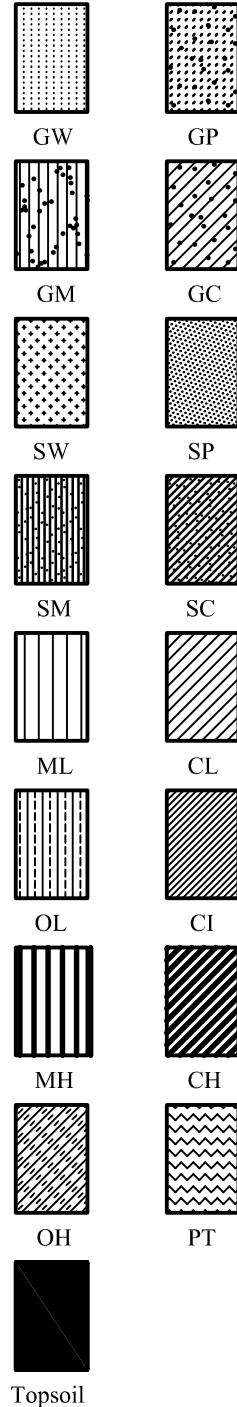
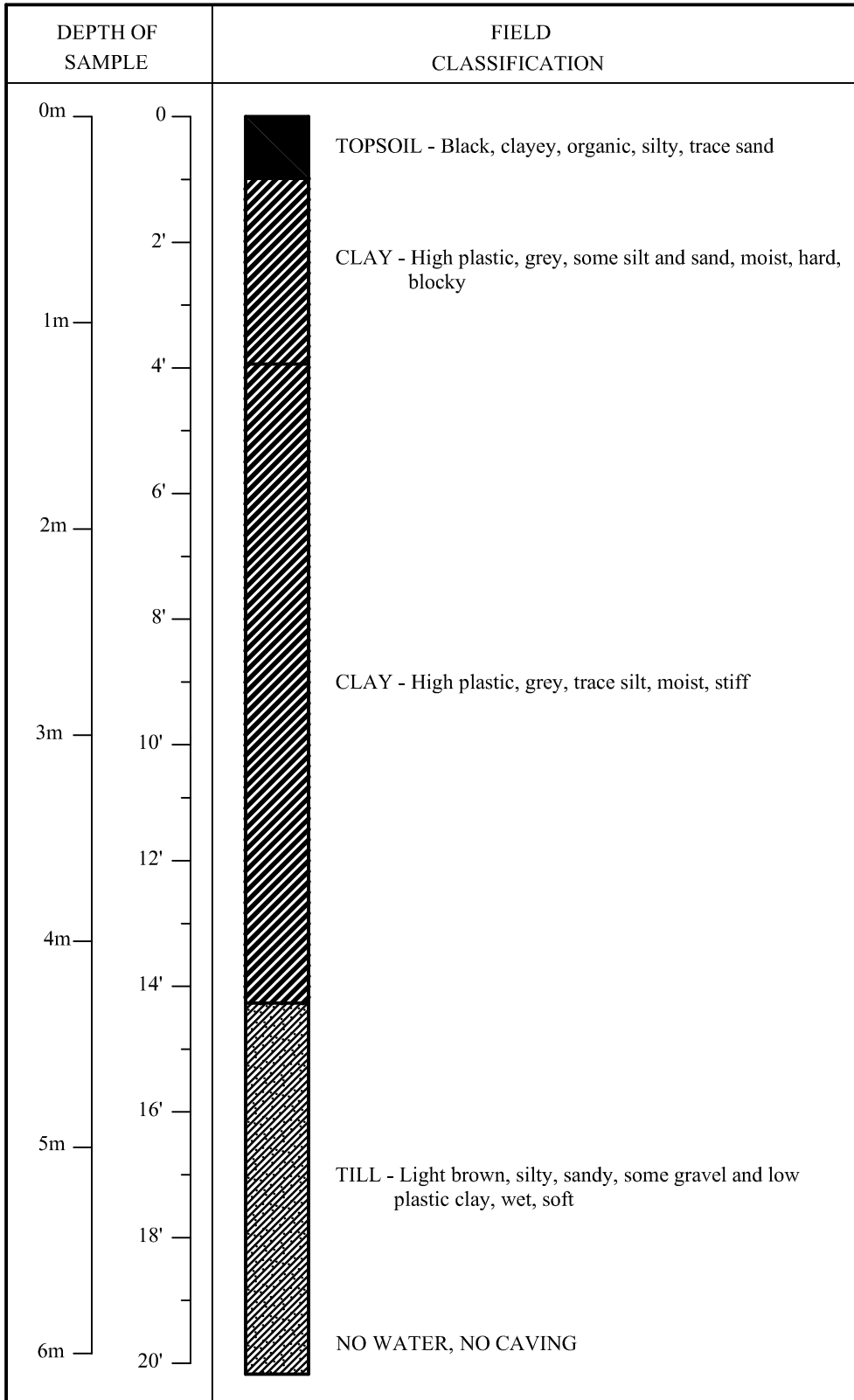
LOCATION : R.M. of Brokenhead

DATE : March 27, 2012

PROJECT : GTH Lagoon Feasibility Study

ELEVATION: 236.089

TEST HOLE # 10



The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of an unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

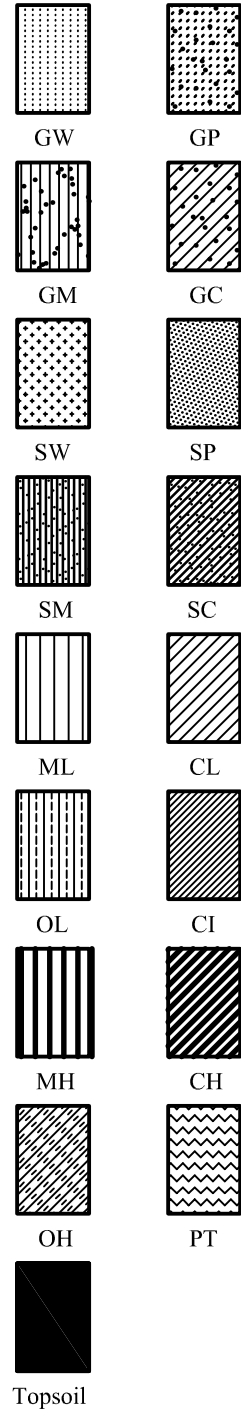
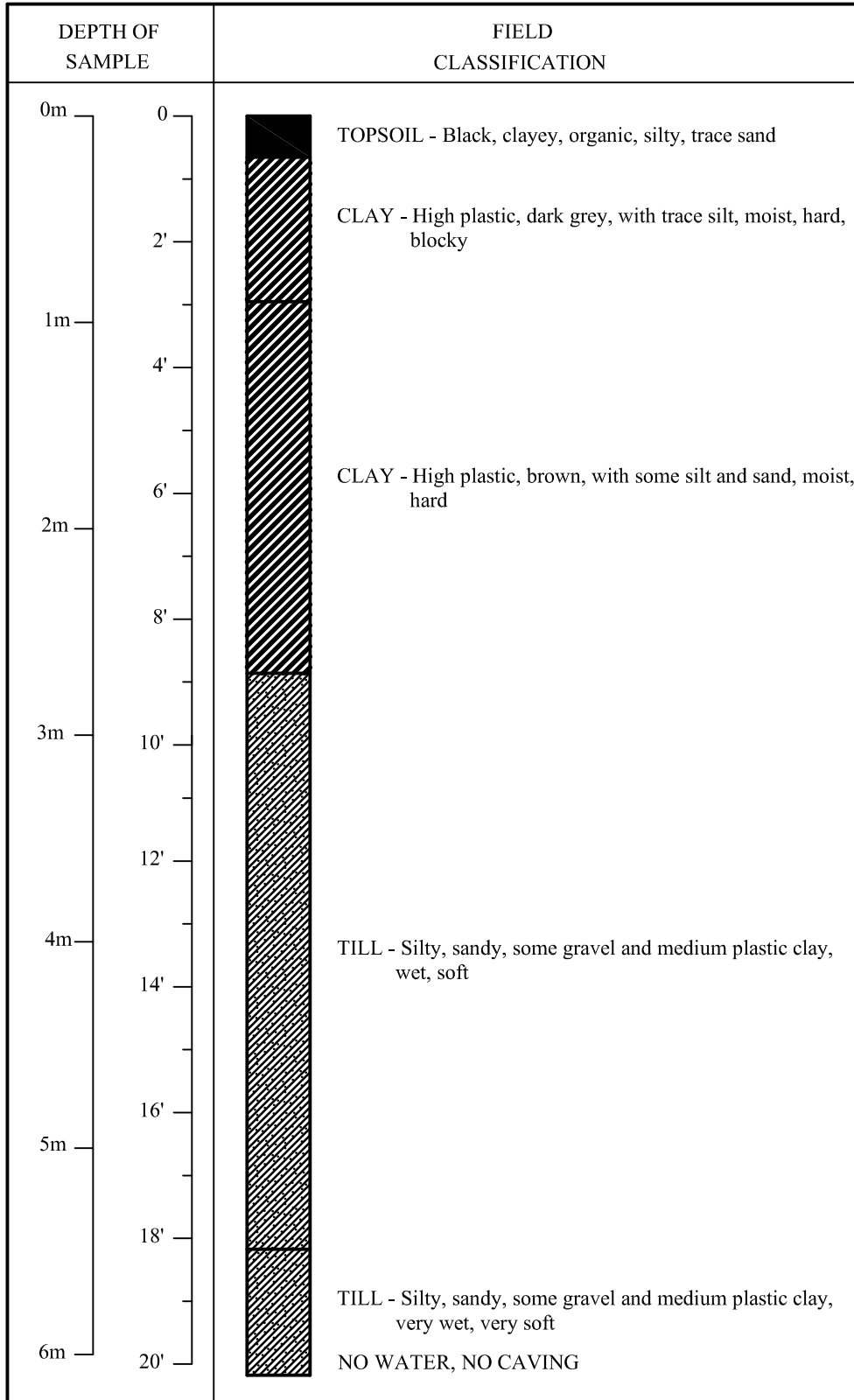
LOCATION : R.M. of Brokenhead

DATE : March 27, 2012

ELEVATION: 236.581

PROJECT : GTH Lagoon Feasibility Study

TEST HOLE #11



The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of a unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

# J. R. Cousin Consultants Ltd.

## TEST HOLE LOG SHEET

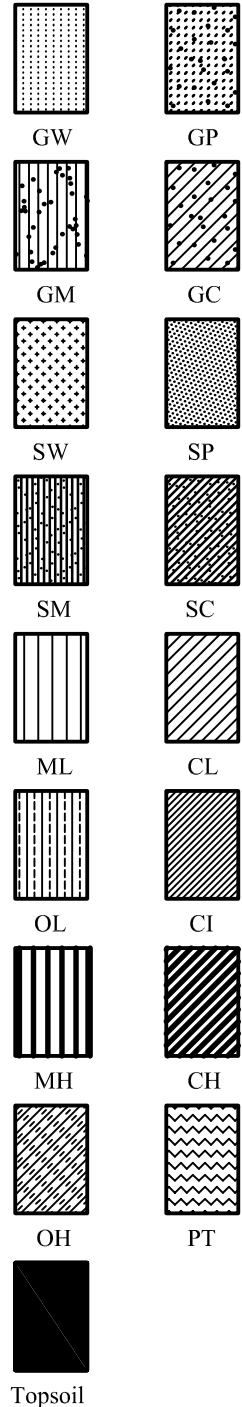
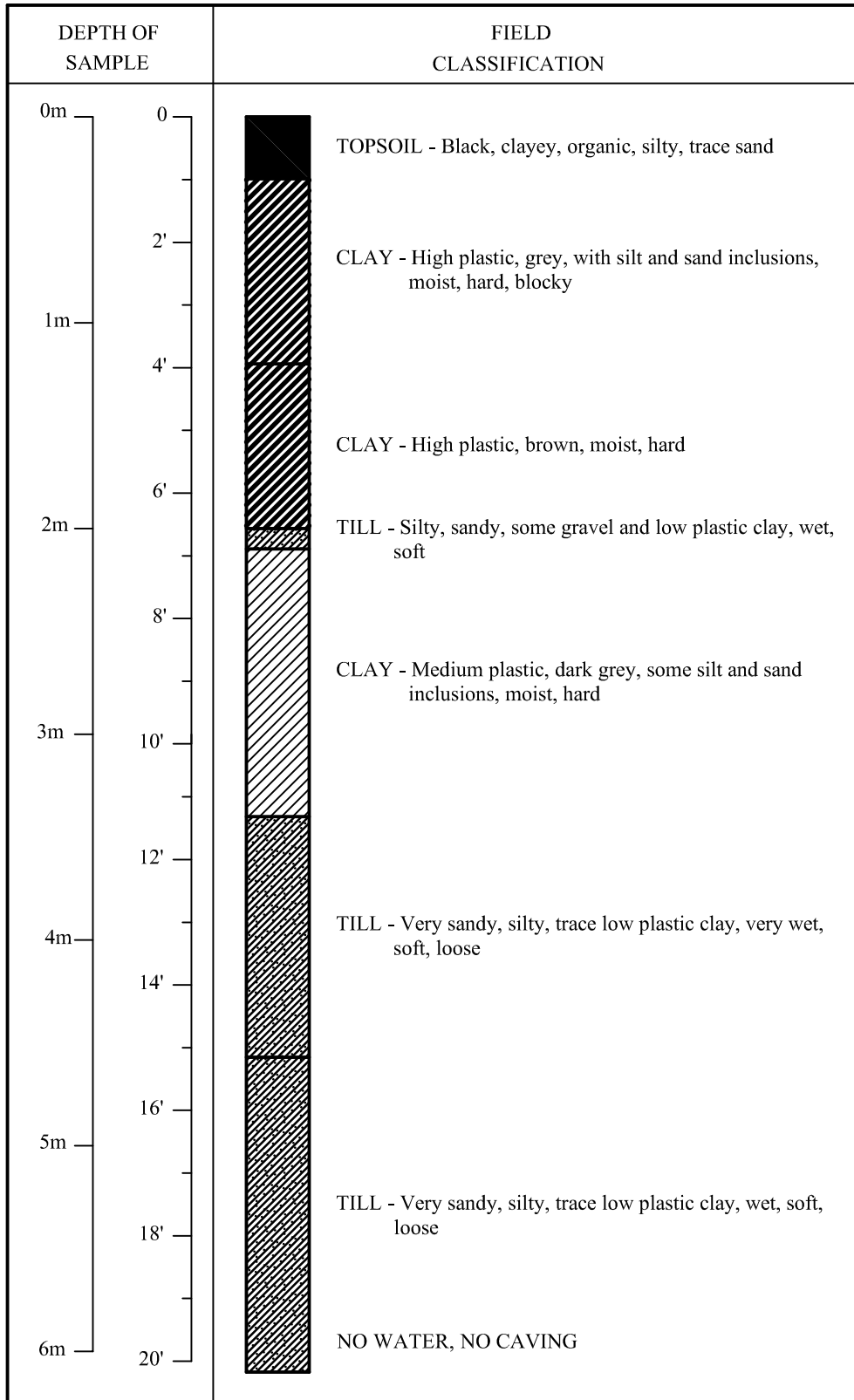
LOCATION : R.M. of Brokenhead

DATE : March 27, 2012

PROJECT : GTH Lagoon Feasibility Study

ELEVATION: 236.615

TEST HOLE # 12



The soil logs are based upon objective data available to us at the time of forming our opinions. The soil logs indicate site specific soil characteristics and must not be generalized over larger areas due to the limited number of test holes as compared to that of a unlimited number of test holes. Every effort is made to evaluate the information by methods generally recognized. The soil represent our opinions. J.R. Cousin Consultants Ltd. cannot be responsible for actual site conditions proved to be materially at variance from our analysis or from the data generalization over untested areas.

Stantec Consulting Ltd. Test Results, dated November 7, 2014





Stantec Consulting Ltd.  
199 Henlow Bay, Winnipeg MB R3Y 1G4

November 7, 2014  
File: 123311627

**Attention: Mr. Brett McCormac**

JR Cousin Consultants Ltd.  
91A Scurfield Blvd.  
Winnipeg, MB R3Y 1G4

Dear Brett,

**Reference: RM of Brokenhead – GTH Lagoon Expansion**

Soil samples were submitted to our laboratory on October 22, 2014. The following tests were conducted on selected soil samples:

- Water content (ASTM D2216)
- Particle-Size Analysis (ASTM D422)
- Liquid Limit (one-point), plastic limit, and plasticity index (ASTM D4318)
- Soil Classification (ASTM D2487)
- Hydraulic Conductivity (ASTM D5084)
- Visual Classification

The test results for the soil samples are summarized in the following table and in the attached particle size analysis, Atterberg limits and hydraulic conductivity reports.

An assessment of the bagged soil samples was conducted to determine whether the soil represented by the bagged samples could be used in-situ as a lagoon liner and would obtain a permeability of less than  $1.0 \times 10^{-7}$  cm/sec without being reworked, and when re-moulded and re-compacted.

Based upon previous testing conducted in our laboratory, homogeneous soil samples with a plasticity index greater than 25 and a clay content greater than 50% will typically have a hydraulic conductivity of  $1.0 \times 10^{-7}$  cm/sec or less. Sample TH2 at 3.4-5.5 m had a plasticity index of 18 and a clay content of 24.9% and sample TH7 at 4.0-6.1 m had a plasticity index of 8 and a clay content of 26.9%, which does not fall within this range and are considered not suitable to be used as a lagoon liner. The remaining bagged samples were considered suitable to be used as a lagoon liner. Our comments regarding the potential use of the material as a liner are based upon the soil being homogeneous with no preferential flow paths. It should be noted that estimating the hydraulic conductivity of a soil based upon classification test results (plasticity index and particle size analysis) alone might be misleading if the soil contains layers of sand, silt, or organic material.



November 6, 2014  
Mr. Brett McCormac  
Page 2 of 4

**Reference: RM of Brokenhead – GTH Lagoon Expansion**

We appreciate the opportunity to assist you in this project. Please call if you have any questions regarding this report.

Regards,

**STANTEC CONSULTING LTD.**

Jason Thompson, CET  
Associate - Manager, Materials Testing Services  
Phone: (204) 928-4004  
Fax: (204) 488-6947  
Jason.Thompson@stantec.com

Attachment: Table 1 – Summary of Water Content, Particle Size, Atterberg Limits, Soil Classification Test Data  
11x Particle Size Analysis Report  
7 x Atterberg Limits Report  
2 x Hydraulic Conductivity Report

**TABLE 1**  
**SUMMARY OF WATER CONTENT, PARTICLE SIZE, ATTERBERG LIMITS, SOIL CLASSIFICATION**  
**TEST DATA**

Testhole	Depth (m)	Visual Classification	Water Content (%)	Gravel (%) 75 to 4.75 mm	Sand (%)			Silt (%) <0.075 to 0.005 mm	Clay (%) <0.005 mm	Liquid Limit	Plastic Limit	Plasticity Index	Soil Classification ASTM D2487	Potential use as a lagoon liner when re-moulded and re-compacted	Potential use as a lagoon liner without being reworked
					Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm								
TH1	0.2-2.1	brown, stiff, moist, high plasticity clay with trace silt, trace sand and trace gravel	32.3	0.4	0.2	0.4	2.0	9.7	87.3	88	24	64	CH(Fat Clay)	Yes	Yes
TH1	2.1-4.3	brown, stiff, moist, high plasticity clay with some silt, trace sand and trace gravel	40.2	0.5	0.4	1.1	3.2	15.2	79.6	80	23	57	CH(Fat Clay)	Yes	Yes
TH2	0.3-2.4	brown, stiff, moist, high plasticity clay with trace silt, trace sand and trace gravel	36.6	0.1	0.2	0.2	3.0	8.5	88.0	85	27	58	CH(Fat Clay)	Yes	Yes
TH2	3.4-5.5	brown, firm, moist, medium plasticity sandy clay, with some silt and trace gravel	12.0	7.2	5.3	12.4	14.5	24.9	35.7	30	12	18	CL(Sandy Lean Clay)	No	No
TH3	2.1-2.7	brown, stiff, moist, high plasticity clay with some silt, trace sand and trace gravel	44.5	2.0	0.8	2.2	4.0	11.9	79.1	82	23	59	CH(Fat Clay)	Yes	Yes
TH6	0.0-0.3	black, stiff, moist, high plasticity silty clay with some sand and trace gravel	40.1	0.8	0.8	4.2	10.5	24.9	58.8	75	31	44	CH(Fat Clay with Sand)	Yes	Yes
TH6	0.3-2.4	brown, stiff, moist, high plasticity clay with some silt, trace sand and trace gravel	29.9	0.6	0.8	0.9	4.7	19.3	73.7	73	19	54	CH(Fat Clay)	Yes	Yes



**Reference: RM of Brokenhead – GTH Lagoon Expansion**

TH6	2.4-3.4	brown, stiff, moist, high plasticity clay with trace silt, trace sand and trace gravel	46.5	0.2	0.3	0.4	2.1	6.1	90.9	101	27	74	CH(Fat Clay)	Yes	Yes
TH7	0.3-2.4	brown, stiff, moist, high plasticity clay with some silt, trace sand and trace gravel	29.7	1.3	1.5	2.1	5.0	17.5	72.6	66	19	47	CH(Fat Clay)	Yes	Yes
TH7	2.4-4.0	brown, stiff, moist, high plasticity clay with trace silt, trace sand and trace gravel	50.0	0.3	0.1	0.4	0.9	6.7	91.6	100	28	72	CH(Fat Clay)	Yes	Yes
TH7	4.0-6.1	tan, soft, moist, low plasticity sandy silt, clayey with some gravel	12.7	10.0	5.5	7.2	15.4	35.0	26.9	19	11	8	CL(Sandy Lean Clay)	No	No

**Notes:**

1. The soil samples were air-dried during sample preparation for Atterberg limits and particle size analysis
2. A high speed stirring device was used for 1 minute to disperse the test samples for particle size analysis
3. Atterberg limits conducted in accordance with ASTM D4318 Method B (one-point liquid limit)



**LABORATORY**  
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**PARTICLE SIZE ANALYSIS  
 ASTM D422**

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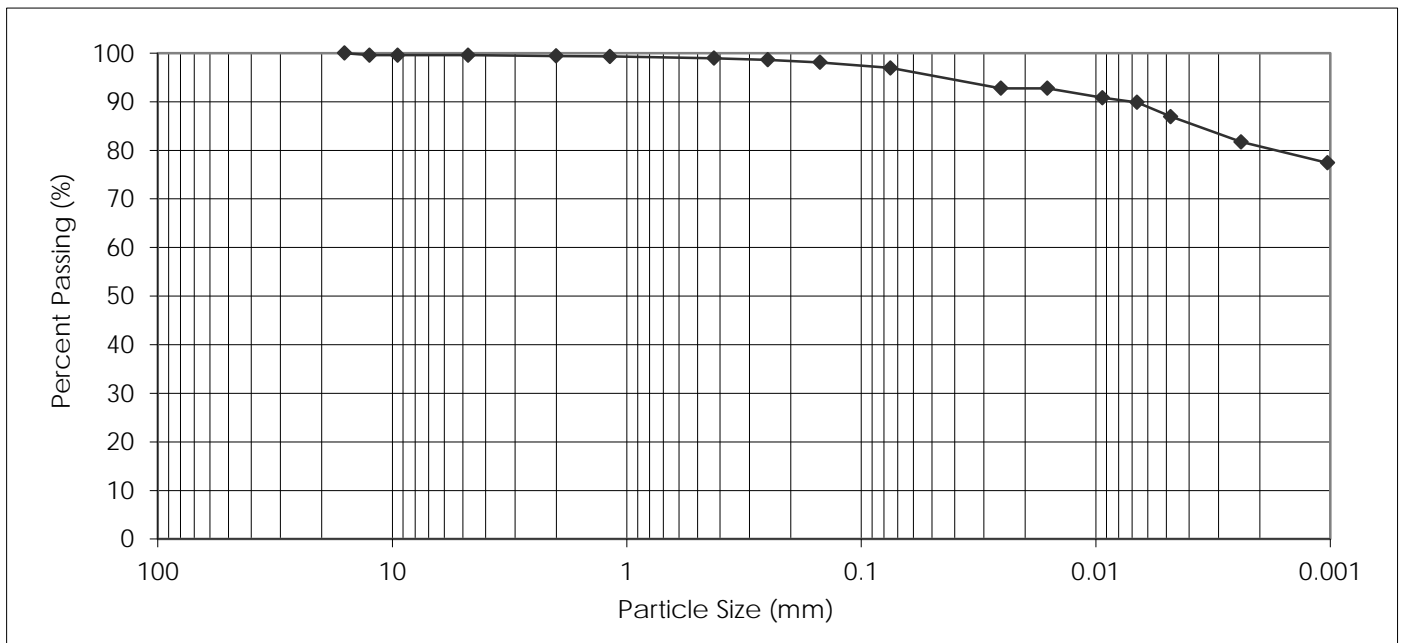
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client  
 SAMPLE ID: TH1 at 0.2m - 2.1m

DATE RECEIVED: October 22, 2014  
 TESTED BY: Sothea Bun




PARTICLE SIZE	PERCENT PASSING	PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0	1.18 mm	99.3
25.00 mm	100.0	0.425 mm	99.0
19.00 mm	100.0	0.250 mm	98.6
16.00 mm	100.0	0.150 mm	98.1
12.50 mm	99.6	0.075 mm	97.0
9.50 mm	99.6	0.005 mm	87.3
4.75 mm	99.6	0.002 mm	80.5
2.00 mm	99.4	0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.4	0.2	0.4	2.0	9.7	87.3	NT*

NT\* Sample not tested for colloids

October 27, 2014

REVIEWED BY:  Jason Thompson, CET



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**PARTICLE SIZE ANALYSIS**  
**ASTM D422**

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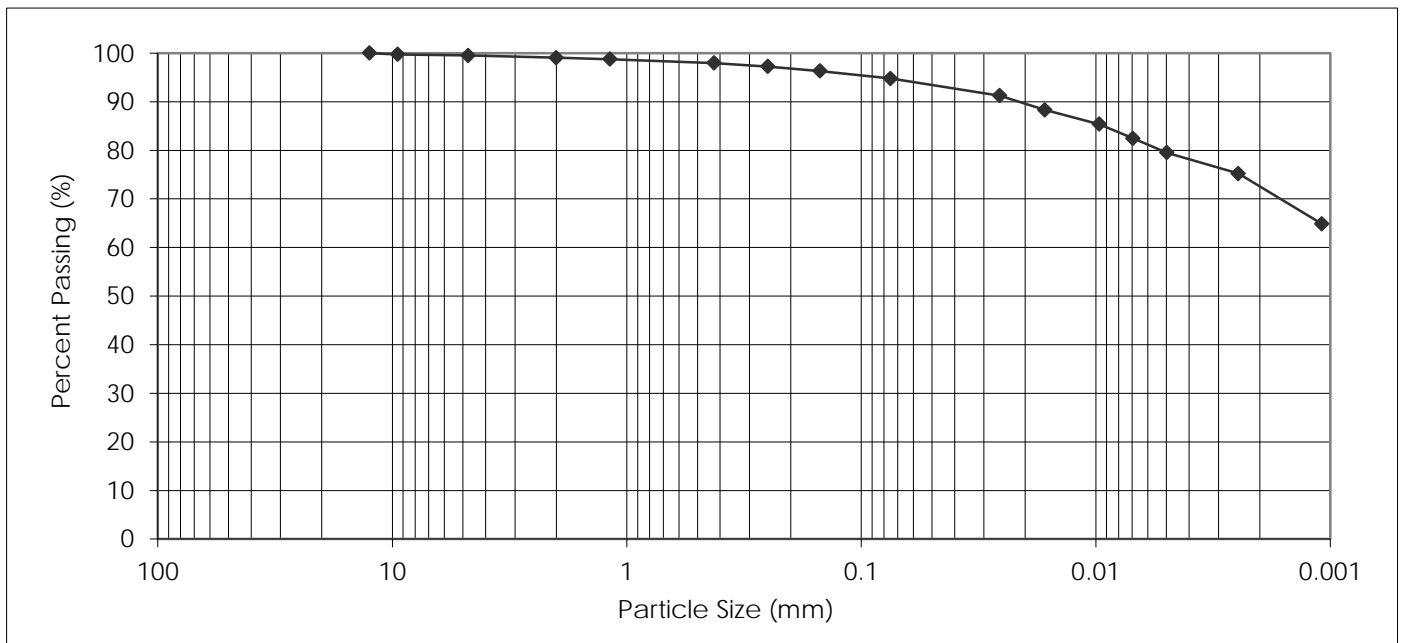
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client  
 SAMPLE ID: TH1 at 2.1m - 4.3m

DATE RECEIVED: October 22, 2014  
 TESTED BY: Sothea Bun




PARTICLE SIZE	PERCENT PASSING	PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0	1.18 mm	98.7
25.00 mm	100.0	0.425 mm	98.0
19.00 mm	100.0	0.250 mm	97.2
16.00 mm	100.0	0.150 mm	96.3
12.50 mm	100.0	0.075 mm	94.8
9.50 mm	99.8	0.005 mm	79.6
4.75 mm	99.5	0.002 mm	71.7
2.00 mm	99.1	0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.5	0.4	1.1	3.2	15.2	79.6	NT*

NT\* Sample not tested for colloids

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**PARTICLE SIZE ANALYSIS  
 ASTM D422**

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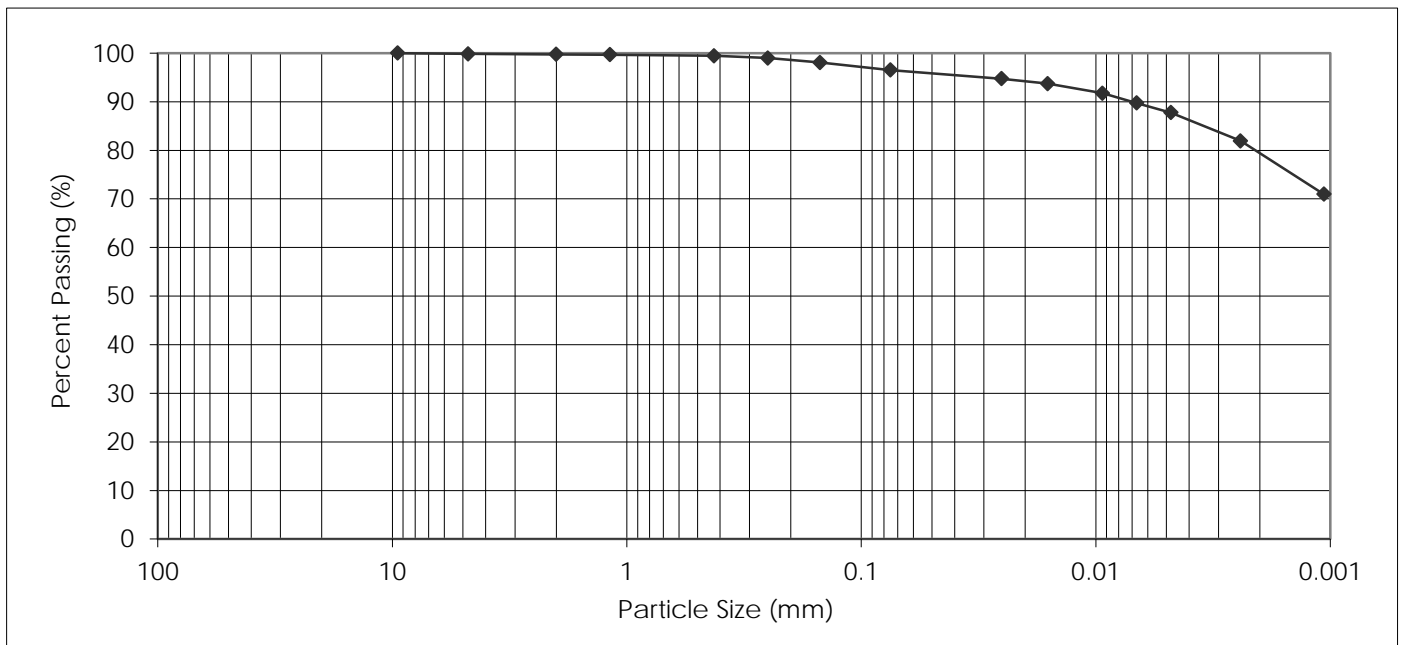
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client  
 SAMPLE ID: TH2 at 0.3m - 2.4m

DATE RECEIVED: October 22, 2014  
 TESTED BY: Larry Presado



PARTICLE SIZE	PERCENT PASSING	PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0	1.18 mm	99.7
25.00 mm	100.0	0.425 mm	99.5
19.00 mm	100.0	0.250 mm	99.0
16.00 mm	100.0	0.150 mm	98.1
12.50 mm	100.0	0.075 mm	96.5
9.50 mm	100.0	0.005 mm	88.0
4.75 mm	99.9	0.002 mm	78.6
2.00 mm	99.7	0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.1	0.2	0.2	3.0	8.5	88.0	NT*

NT\* Sample not tested for colloids

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REVIEWED BY:  Jason Thompson, CET



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**PARTICLE SIZE ANALYSIS  
 ASTM D422**

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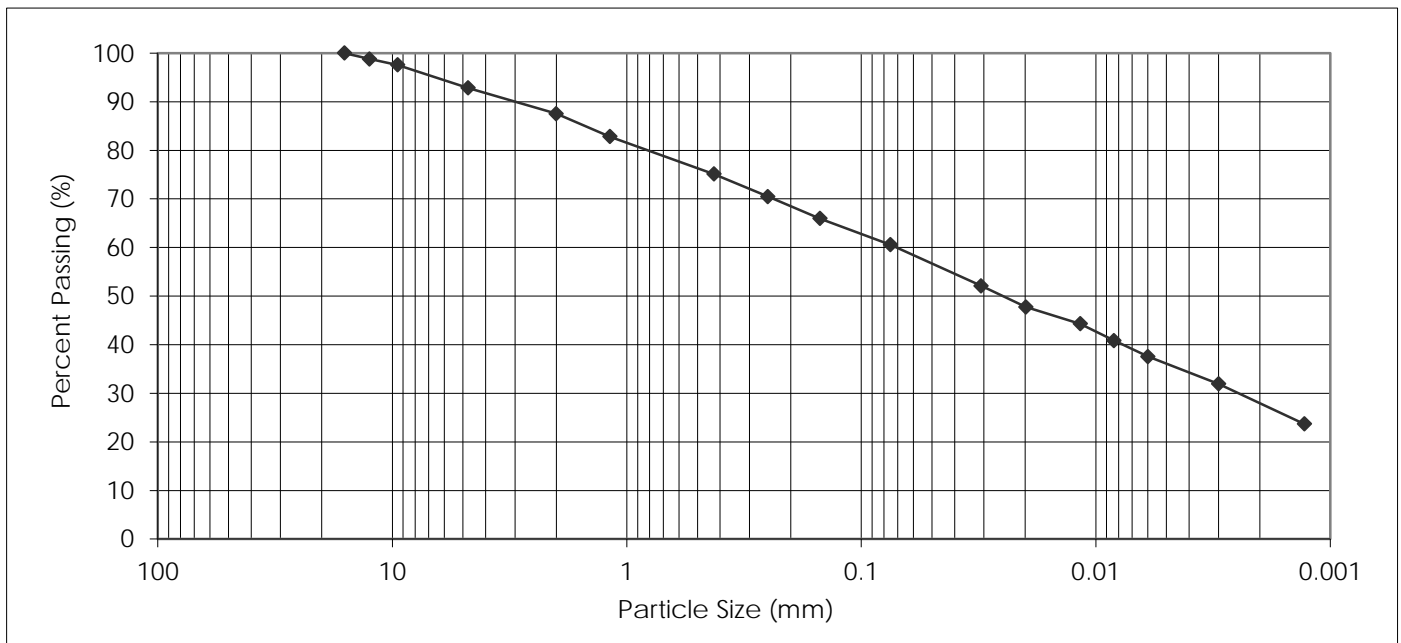
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client  
 SAMPLE ID: TH2 at 3.4m - 5.5m

DATE RECEIVED: October 22, 2014  
 TESTED BY: Sothea Bun




PARTICLE SIZE	PERCENT PASSING	PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0	1.18 mm	82.8
25.00 mm	100.0	0.425 mm	75.1
19.00 mm	100.0	0.250 mm	70.5
16.00 mm	100.0	0.150 mm	66.0
12.50 mm	98.8	0.075 mm	60.6
9.50 mm	97.6	0.005 mm	35.7
4.75 mm	92.8	0.002 mm	27.1
2.00 mm	87.5	0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
7.2	5.3	12.4	14.5	24.9	35.7	NT*

NT\* Sample not tested for colloids

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**PARTICLE SIZE ANALYSIS  
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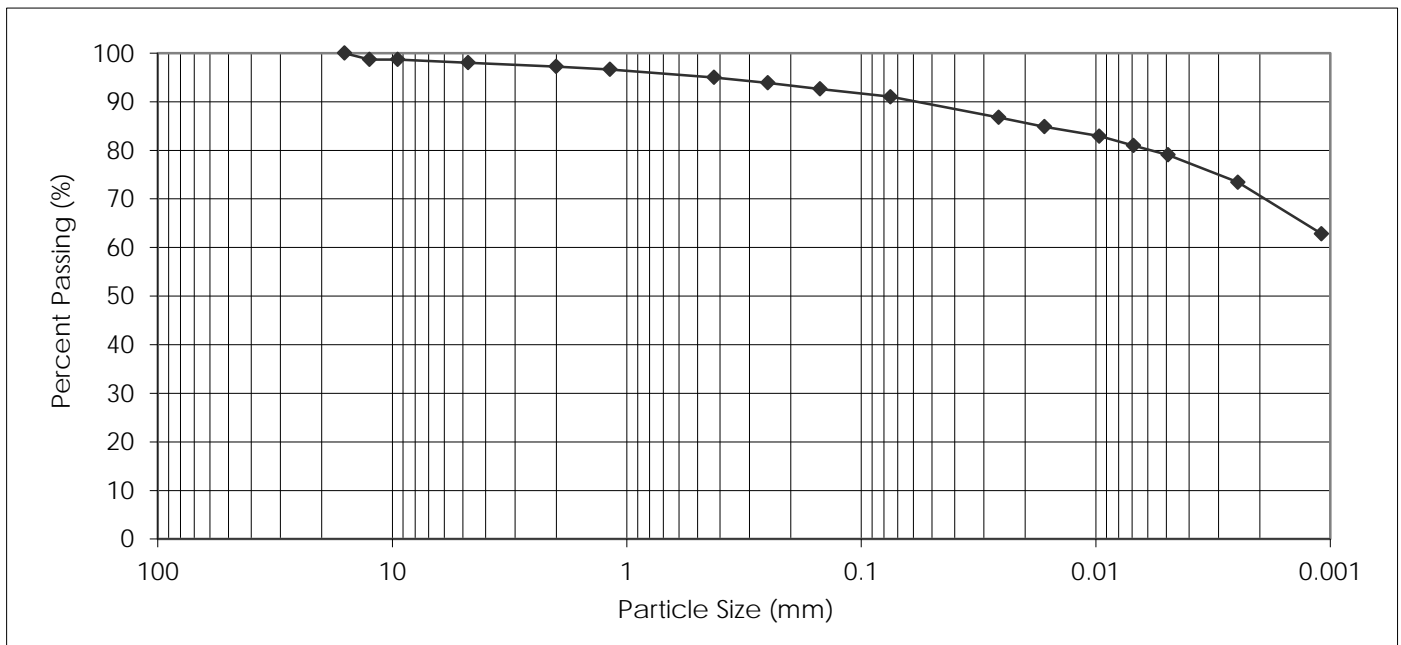
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client  
 SAMPLE ID: TH3 at 2.1m - 2.7m


DATE RECEIVED: October 22, 2014  
 TESTED BY: Larry Presado



PARTICLE SIZE		PERCENT PASSING		PARTICLE SIZE		PERCENT PASSING	
37.50 mm		100.0		1.18 mm		96.6	
25.00 mm		100.0		0.425 mm		95.0	
19.00 mm		100.0		0.250 mm		93.9	
16.00 mm		100.0		0.150 mm		92.7	
12.50 mm		98.7		0.075 mm		91.0	
9.50 mm		98.7		0.005 mm		79.1	
4.75 mm		98.0		0.002 mm		69.8	
2.00 mm		97.2		0.001 mm		NT*	
Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm	
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm				
2.0	0.8	2.2	4.0	11.9	79.1	NT*	

NT\* Sample not tested for colloids

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**PARTICLE SIZE ANALYSIS**  
**ASTM D422**

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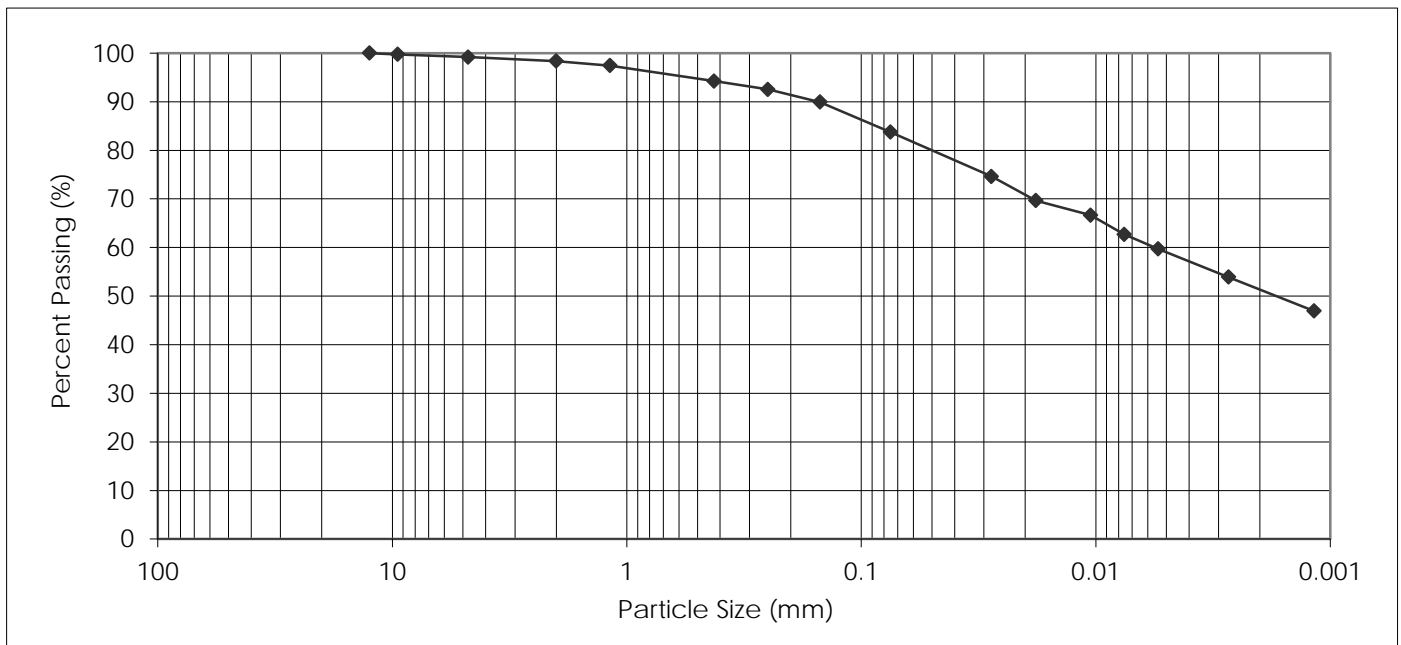
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client  
 SAMPLE ID: TH6 at 0.0m - 0.3m


DATE RECEIVED: October 22, 2014  
 TESTED BY: Larry Presado



PARTICLE SIZE		PERCENT PASSING		PARTICLE SIZE		PERCENT PASSING	
37.50 mm		100.0		1.18 mm		97.4	
25.00 mm		100.0		0.425 mm		94.2	
19.00 mm		100.0		0.250 mm		92.5	
16.00 mm		100.0		0.150 mm		90.0	
12.50 mm		100.0		0.075 mm		83.7	
9.50 mm		99.7		0.005 mm		58.8	
4.75 mm		99.2		0.002 mm		50.7	
2.00 mm		98.4		0.001 mm		NT*	
Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm	
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm				
0.8	0.8	4.2	10.5	24.9	58.8	NT*	

NT\* Sample not tested for colloids

October 27, 2014

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**PARTICLE SIZE ANALYSIS  
 ASTM D422**

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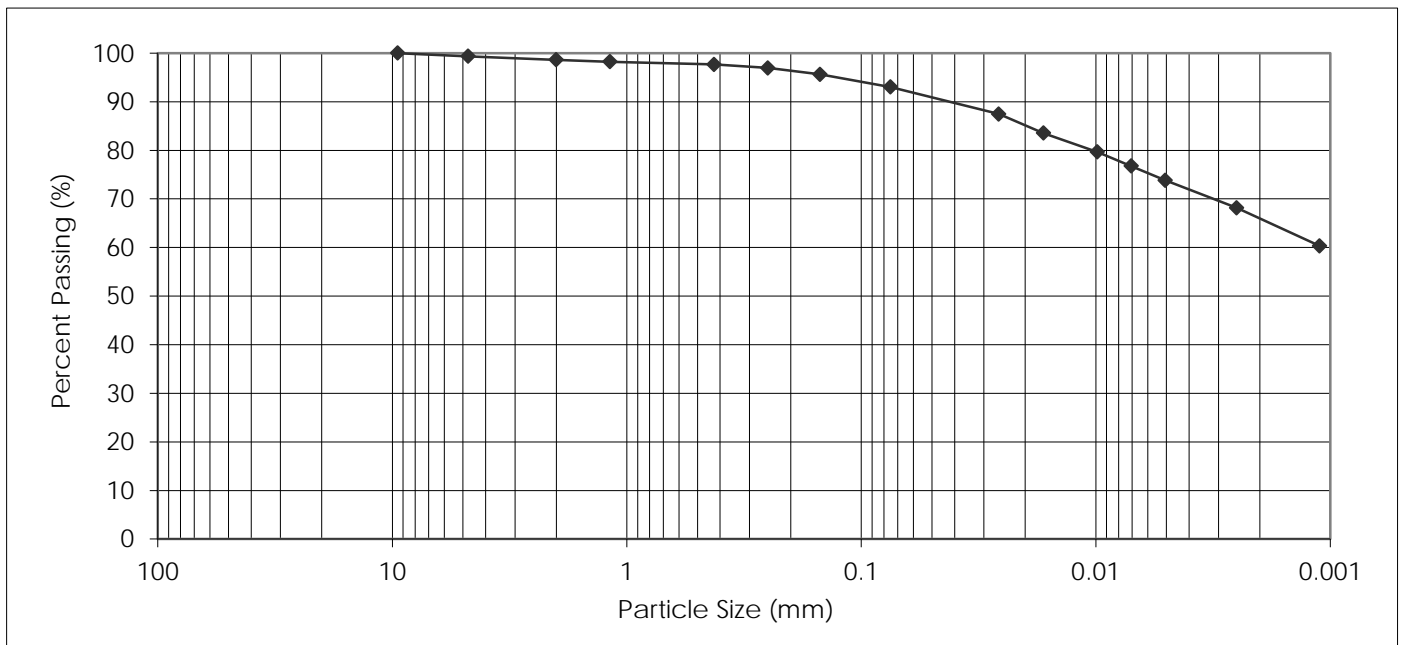
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client  
 SAMPLE ID: TH6 at 0.3m - 2.4m


DATE RECEIVED: October 22, 2014  
 TESTED BY: Larry Presado



PARTICLE SIZE		PERCENT PASSING		PARTICLE SIZE		PERCENT PASSING	
37.50 mm	100.0	1.18 mm	98.2	0.425 mm	97.7	0.250 mm	97.0
25.00 mm	100.0	0.150 mm	95.6	0.075 mm	93.0	0.005 mm	73.7
19.00 mm	100.0	0.002 mm	65.3	0.001 mm	NT*		
16.00 mm	100.0						
12.50 mm	100.0						
9.50 mm	100.0						
4.75 mm	99.4						
2.00 mm	98.6						
Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm	
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm				
0.6	0.8	0.9	4.7	19.3	73.7	NT*	

NT\* Sample not tested for colloids

October 27, 2014

REVIEWED BY:  Jason Thompson, CET



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**PARTICLE SIZE ANALYSIS  
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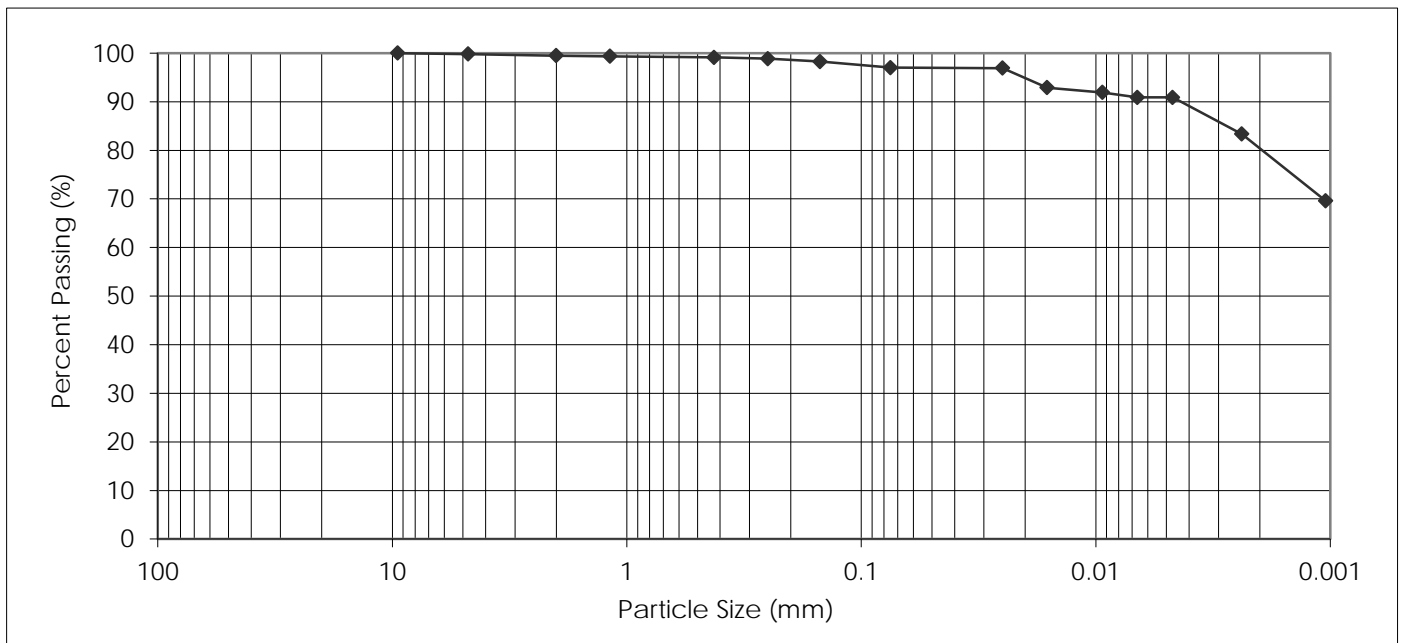
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client  
 SAMPLE ID: TH6 at 2.4 m - 3.4 m

DATE RECEIVED: October 22, 2014  
 TESTED BY: Larry Presado



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	100.0
12.50 mm	100.0
9.50 mm	100.0
4.75 mm	99.8
2.00 mm	99.5

PARTICLE SIZE	PERCENT PASSING
1.18 mm	99.3
0.425 mm	99.1
0.250 mm	98.9
0.150 mm	98.3
0.075 mm	97.0
0.005 mm	90.9
0.002 mm	79.4
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.2	0.3	0.4	2.1	6.1	90.9	NT*

NT\* Sample not tested for colloids

October 27, 2014

REVIEWED BY:  Jason Thompson, CET



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**PARTICLE SIZE ANALYSIS**  
**ASTM D422**

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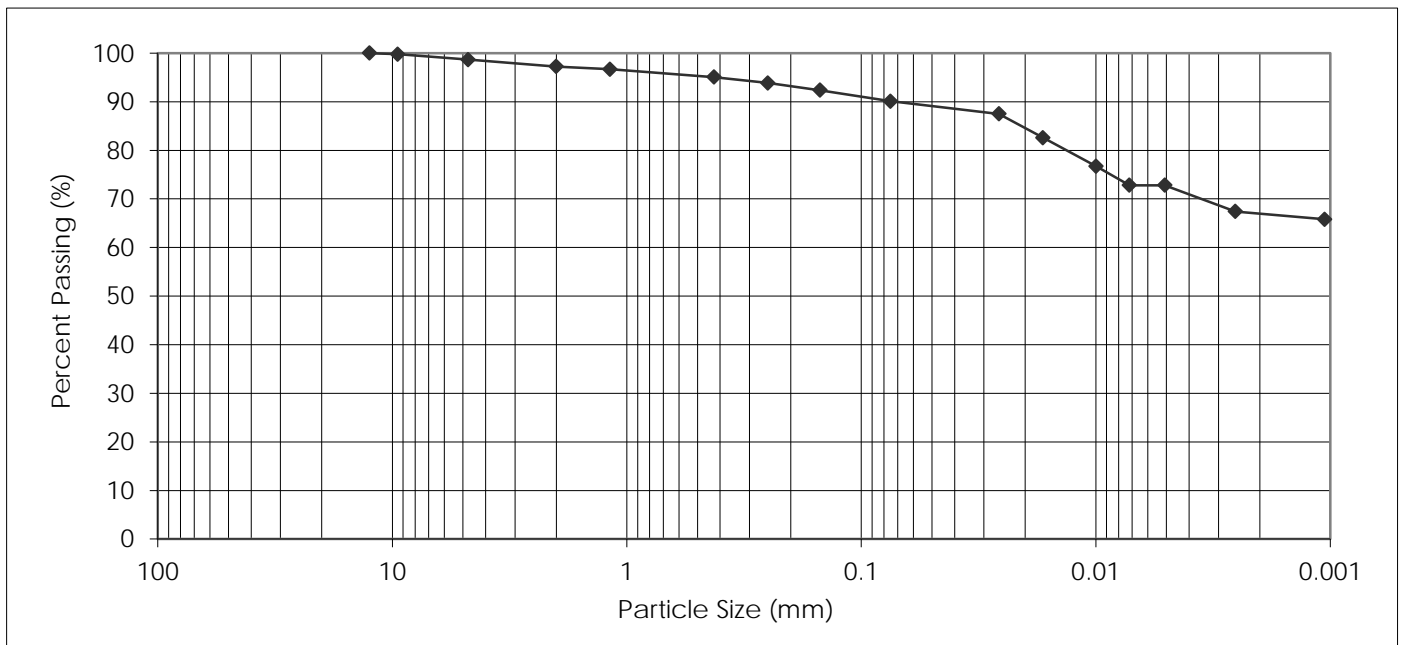
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client  
 SAMPLE ID: TH7 at 0.3 m - 2.4 m

DATE RECEIVED: October 22, 2014  
 TESTED BY: Larry Presado




PARTICLE SIZE	PERCENT PASSING	PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0	1.18 mm	96.7
25.00 mm	100.0	0.425 mm	95.1
19.00 mm	100.0	0.250 mm	93.8
16.00 mm	100.0	0.150 mm	92.4
12.50 mm	100.0	0.075 mm	90.1
9.50 mm	99.8	0.005 mm	72.6
4.75 mm	98.7	0.002 mm	66.8
2.00 mm	97.2	0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
1.3	1.5	2.1	5.0	17.5	72.6	NT*

NT\* Sample not tested for colloids

October 27, 2014

REVIEWED BY:  Jason Thompson, CET



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**PARTICLE SIZE ANALYSIS**  
**ASTM D422**

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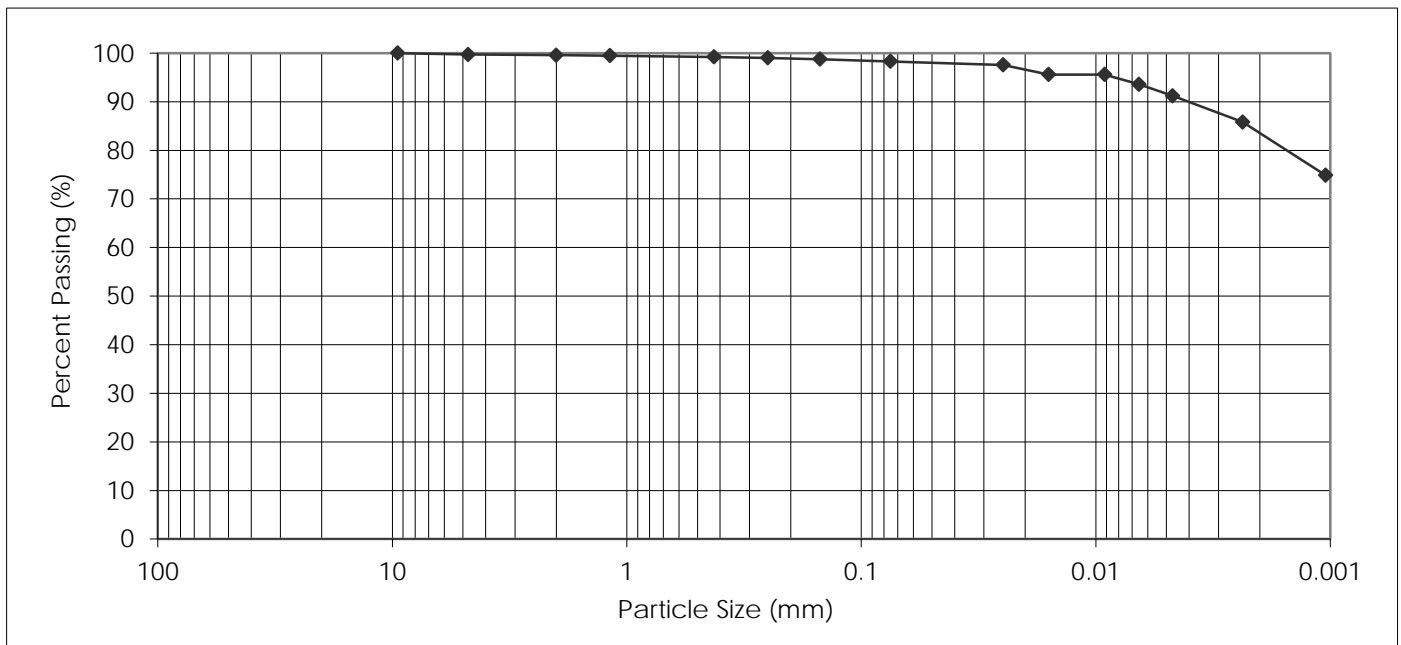
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client  
 SAMPLE ID: TH7 at 2.4m - 4.0m

DATE RECEIVED: October 22, 2014  
 TESTED BY: Larry Presado




PARTICLE SIZE	PERCENT PASSING	PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0	1.18 mm	99.5
25.00 mm	100.0	0.425 mm	99.2
19.00 mm	100.0	0.250 mm	99.0
16.00 mm	100.0	0.150 mm	98.8
12.50 mm	100.0	0.075 mm	98.3
9.50 mm	100.0	0.005 mm	91.6
4.75 mm	99.7	0.002 mm	82.8
2.00 mm	99.6	0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
0.3	0.1	0.4	0.9	6.7	91.6	NT*

NT\* Sample not tested for colloids

October 27, 2014

REVIEWED BY:  Jason Thompson, CET



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**PARTICLE SIZE ANALYSIS  
 ASTM D422**

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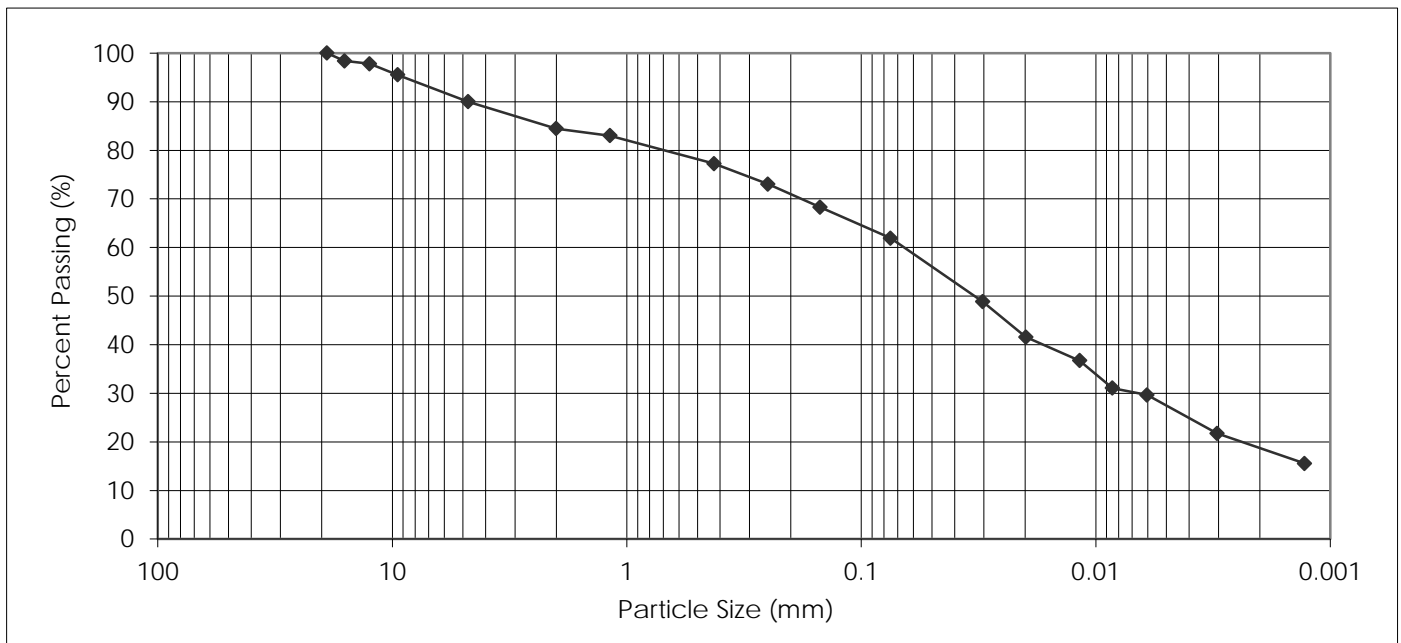
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

SAMPLED BY: Client  
 SAMPLE ID: TH7 at 4.0 m - 6.1 m

DATE RECEIVED: October 22, 2014  
 TESTED BY: Larry Presado



PARTICLE SIZE	PERCENT PASSING
37.50 mm	100.0
25.00 mm	100.0
19.00 mm	100.0
16.00 mm	98.4
12.50 mm	97.8
9.50 mm	95.5
4.75 mm	90.0
2.00 mm	84.5

PARTICLE SIZE	PERCENT PASSING
1.18 mm	83.0
0.425 mm	77.3
0.250 mm	73.1
0.150 mm	68.3
0.075 mm	61.9
0.005 mm	26.9
0.002 mm	18.1
0.001 mm	NT*

Gravel, % 75 to 4.75 mm	Sand, %			Silt, % <0.075 to 0.005 mm	Clay, % <0.005 mm	Colloids, % < 0.001 mm
	Coarse <4.75 to 2.0 mm	Medium <2.0 to 0.425 mm	Fine <0.425 to 0.075 mm			
10.0	5.5	7.2	15.4	35.0	26.9	NT*

NT\* Sample not tested for colloids

October 27, 2014

REVIEWED BY:  Jason Thompson, CET



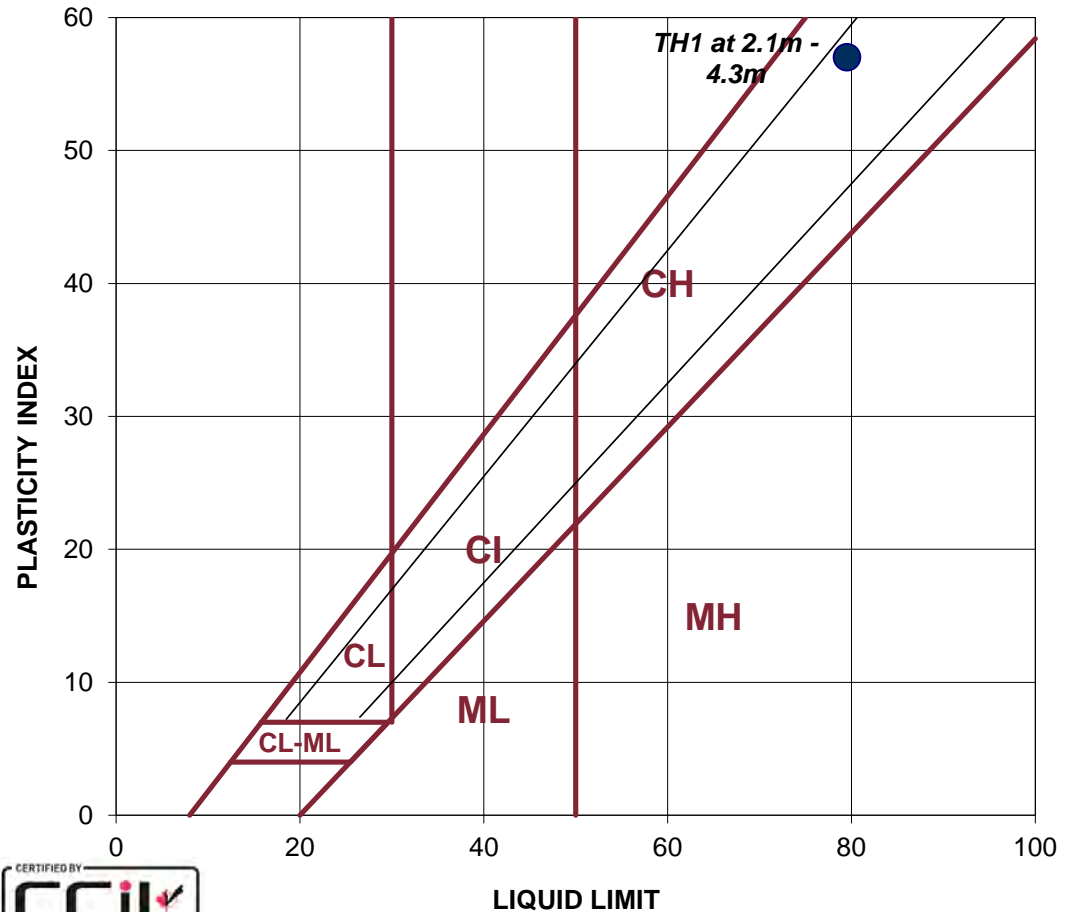
**Atterberg Limits**  
 ASTM D4318  
 Method B- One Point

Client: JR Cousin Consultants Ltd.  
 Project Name: RM of Brokenhead-GTH Lagoon Expansion  
 Project No: 123311627  
 Date Received: October 22, 2014  
 Date Tested: October 29, 2014  
 Tested By: Nestor Abarca

**LABORATORY**  
 199 Henlow Bay  
 Winnipeg, Manitoba  
 Canada R3Y 1G4

Tel: (204) 488-6999

Sample:		Sample:	
TH1 at 2.1m - 4.3m		TH1 at 0.2m - 2.1m	
LIQUID		LIQUID	
1	2	Trial No.	
20	20	Number of Blows	24      24
242	237	Container Number	281      153
38.17	36.71	Wt. Sample (wet+tare)(g)	40.35      37.91
30.19	29.44	Wt. Sample (dry+tare)(g)	31.23      29.40
20.43	20.54	Wt. Tare (g)	20.93      19.74
9.8	8.9	Wt. Dry Soil (g)	10.3      9.7
8.0	7.3	Wt. Water (g)	9.1      8.5
81.8%	81.7%	Water Content (%)	88.5%      88.1%
79.6%	79.5%	Corrected Water Content (%)	88.1%      87.7%
PLASTIC		PLASTIC	
1	2	Trial No.	
304	173	Container Number	136      260
29.39	29.62	Wt. Sample (wet+tare)(g)	28.94      29.07
27.67	27.7	Wt. Sample (dry+tare)(g)	27.15      27.4
20.31	19.47	Wt. Tare (g)	19.69      20.54
7.4	8.2	Wt. Dry Soil (g)	7.5      6.9
1.7	1.9	Wt. Water (g)	1.8      1.7
23.4%	23.3%	Water Content (%)	24.0%      24.3%
AVERAGE VALUES		AVERAGE VALUES	
1	2	1	2
LL	80	LL	88
PL	23	PL	24
PI	57	PI	64
CLASSIFICATION		CLASSIFICATION	
<b>CH</b>		<b>CH</b>	



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Reviewed By: Jason Thompson, CET





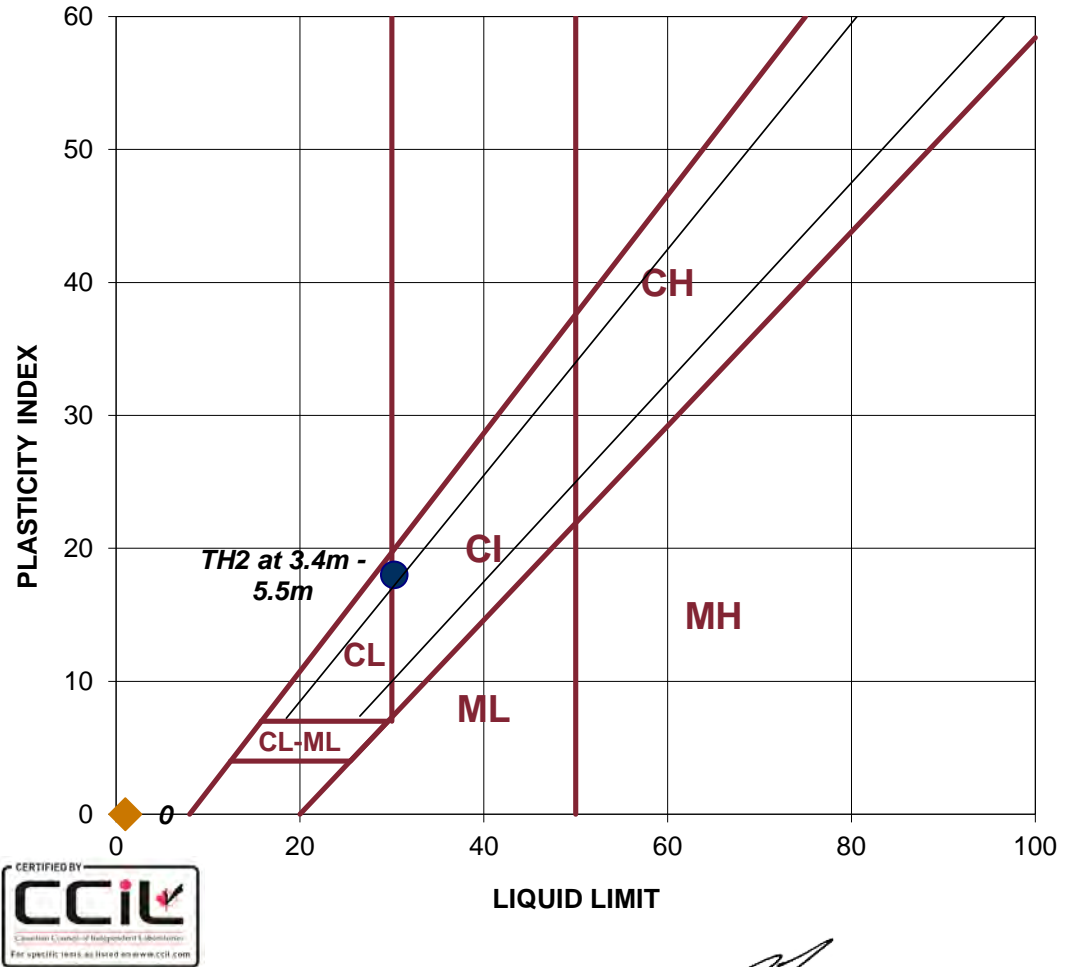
**Atterberg Limits**  
 ASTM D4318  
 Method B- One Point

Client: JR Cousin Consultants Ltd.  
 Project Name: RM of Brokenhead-GTH Lagoon Expansion  
 Project No: 123311627  
 Date Received: October 22, 2014  
 Date Tested: October 29, 2014  
 Tested By: Nestor Abarca

**LABORATORY**  
 199 Henlow Bay  
 Winnipeg, Manitoba  
 Canada R3Y 1G4

Tel: (204) 488-6999

Sample:		Sample:	
TH2 at 3.4m - 5.5m			
LIQUID		LIQUID	
1	2	Trial No.	1 2
21	21	Number of Blows	
282	262	Container Number	
41.94	45.68	Wt. Sample (wet+tare)(g)	
36.95	39.78	Wt. Sample (dry+tare)(g)	
20.81	20.67	Wt. Tare (g)	
16.1	19.1	Wt. Dry Soil (g)	
5.0	5.9	Wt. Water (g)	
30.9%	30.9%	Water Content (%)	
30.3%	30.2%	Corrected Water Content (%)	
PLASTIC		PLASTIC	
1	2	Trial No.	1 2
310	312	Container Number	
32.82	31.93	Wt. Sample (wet+tare)(g)	
31.55	30.72	Wt. Sample (dry+tare)(g)	
20.7	20.47	Wt. Tare (g)	
10.9	10.3	Wt. Dry Soil (g)	
1.3	1.2	Wt. Water (g)	
11.7%	11.8%	Water Content (%)	
AVERAGE VALUES		AVERAGE VALUES	
1	2	1	2
LL	30	LL	
PL	12	PL	
PI	18	PI	
CLASSIFICATION		CLASSIFICATION	
<b>CI-CL</b>		<b>NON-PLASTIC</b>	



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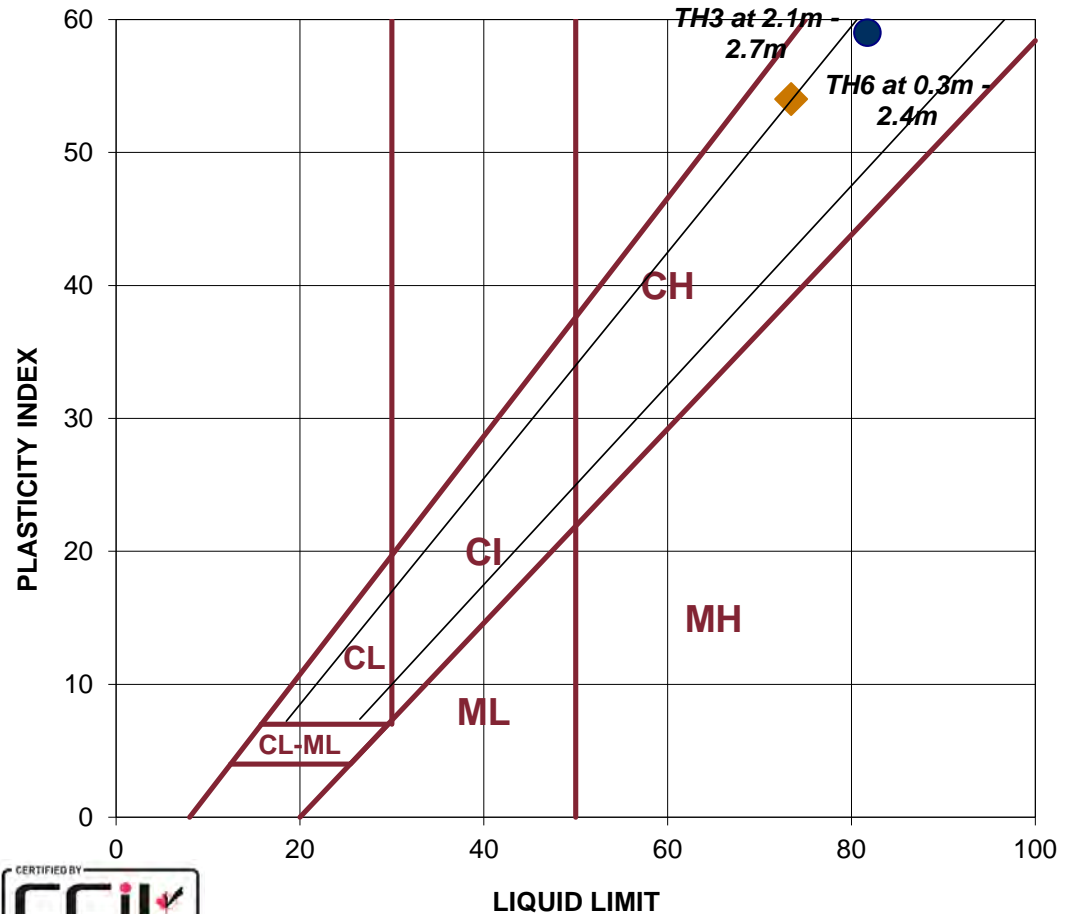


**Atterberg Limits**  
 ASTM D4318  
 Method B- One Point

Client: JR Cousin Consultants Ltd.  
 Project Name: RM of Brokenhead-GTH Lagoon Expansion  
 Project No: 123311627  
 Date Received: October 22, 2014  
 Date Tested: October 28, 2014  
 Tested By: Nestor Abarca

**LABORATORY**  
 199 Henlow Bay  
 Winnipeg, Manitoba  
 Canada R3Y 1G4  
 Tel: (204) 488-6999

Sample:		Sample:	
TH3 at 2.1m - 2.7m		TH6 at 0.3m - 2.4m	
LIQUID		LIQUID	
1	2	Trial No.	
23	22	Number of Blows	22    22
265	232	Container Number	220    259
39.65	39.43	Wt. Sample (wet+tare)(g)	38.04    38.18
31.07	30.67	Wt. Sample (dry+tare)(g)	30.18    30.70
20.68	20.12	Wt. Tare (g)	19.64    20.68
10.4	10.6	Wt. Dry Soil (g)	10.5    10.0
8.6	8.8	Wt. Water (g)	7.9    7.5
82.6%	83.0%	Water Content (%)	74.6%    74.7%
81.8%	81.8%	Corrected Water Content (%)	73.4%    73.5%
PLASTIC		PLASTIC	
1	2	Trial No.	
320	152	Container Number	249    166
32.31	29.75	Wt. Sample (wet+tare)(g)	31.09    31.27
30.14	27.9	Wt. Sample (dry+tare)(g)	29.35    29.37
20.87	20.03	Wt. Tare (g)	20.3    19.76
9.3	7.9	Wt. Dry Soil (g)	9.1    9.6
2.2	1.9	Wt. Water (g)	1.7    1.9
23.4%	23.5%	Water Content (%)	19.2%    19.8%
AVERAGE VALUES		AVERAGE VALUES	
1	2	1	2
LL	82	LL	73
PL	23	PL	19
PI	59	PI	54
CLASSIFICATION		CLASSIFICATION	
<b>CH</b>		<b>CH</b>	



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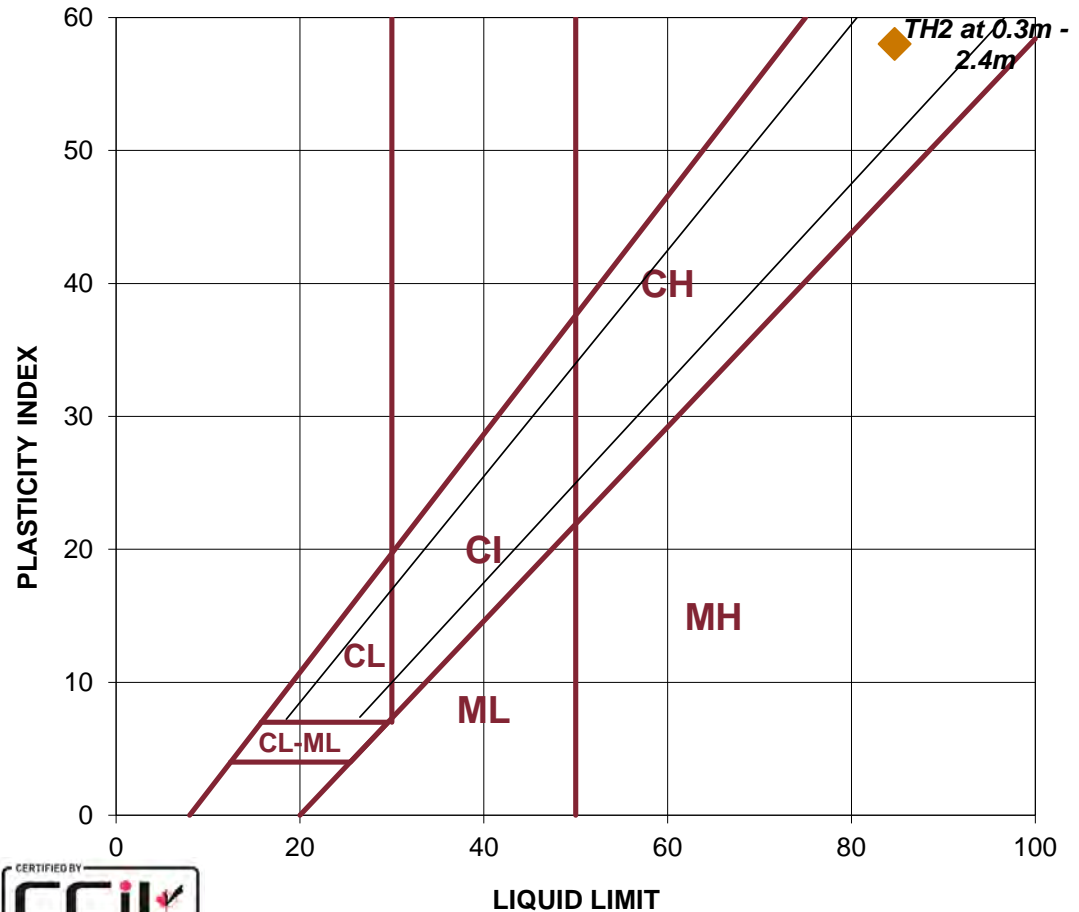
**Atterberg Limits**  
 ASTM D4318  
 Method B- One Point

Client: JR Cousin Consultants Ltd.  
 Project Name: RM of Brokenhead-GTH Lagoon Expansion  
 Project No: 123311627  
 Date Received: October 22, 2014  
 Date Tested: October 28, 2014  
 Tested By: Nestor Abarca

**LABORATORY**  
 199 Henlow Bay  
 Winnipeg, Manitoba  
 Canada R3Y 1G4

Tel: (204) 488-6999

Sample:		Sample:	
TH7 at 2.4m - 4.0m		TH2 at 0.3m - 2.4m	
LIQUID		LIQUID	
1	2	Trial No.	
24	23	Number of Blows	22    23
165	276	Container Number	275    158
36.55	36.92	Wt. Sample (wet+tare)(g)	39.16    39.50
28.03	28.61	Wt. Sample (dry+tare)(g)	30.71    30.57
19.59	20.42	Wt. Tare (g)	20.82    20.21
8.4	8.2	Wt. Dry Soil (g)	9.9    10.4
8.5	8.3	Wt. Water (g)	8.5    8.9
100.9%	101.5%	Water Content (%)	85.4%    86.2%
100.5%	100.4%	Corrected Water Content (%)	84.1%    85.3%
PLASTIC		PLASTIC	
1	2	Trial No.	
255	217	Container Number	298    296
27.71	28.38	Wt. Sample (wet+tare)(g)	31.84    30.86
26.21	26.35	Wt. Sample (dry+tare)(g)	29.42    28.77
20.75	19.17	Wt. Tare (g)	20.25    20.96
5.5	7.2	Wt. Dry Soil (g)	9.2    7.8
1.5	2.0	Wt. Water (g)	2.4    2.1
27.5%	28.3%	Water Content (%)	26.4%    26.8%
AVERAGE VALUES		AVERAGE VALUES	
1	2	1	2
LL	100	LL	85
PL	28	PL	27
PI	72	PI	58
CLASSIFICATION		CLASSIFICATION	
<b>CH</b>		<b>CH</b>	



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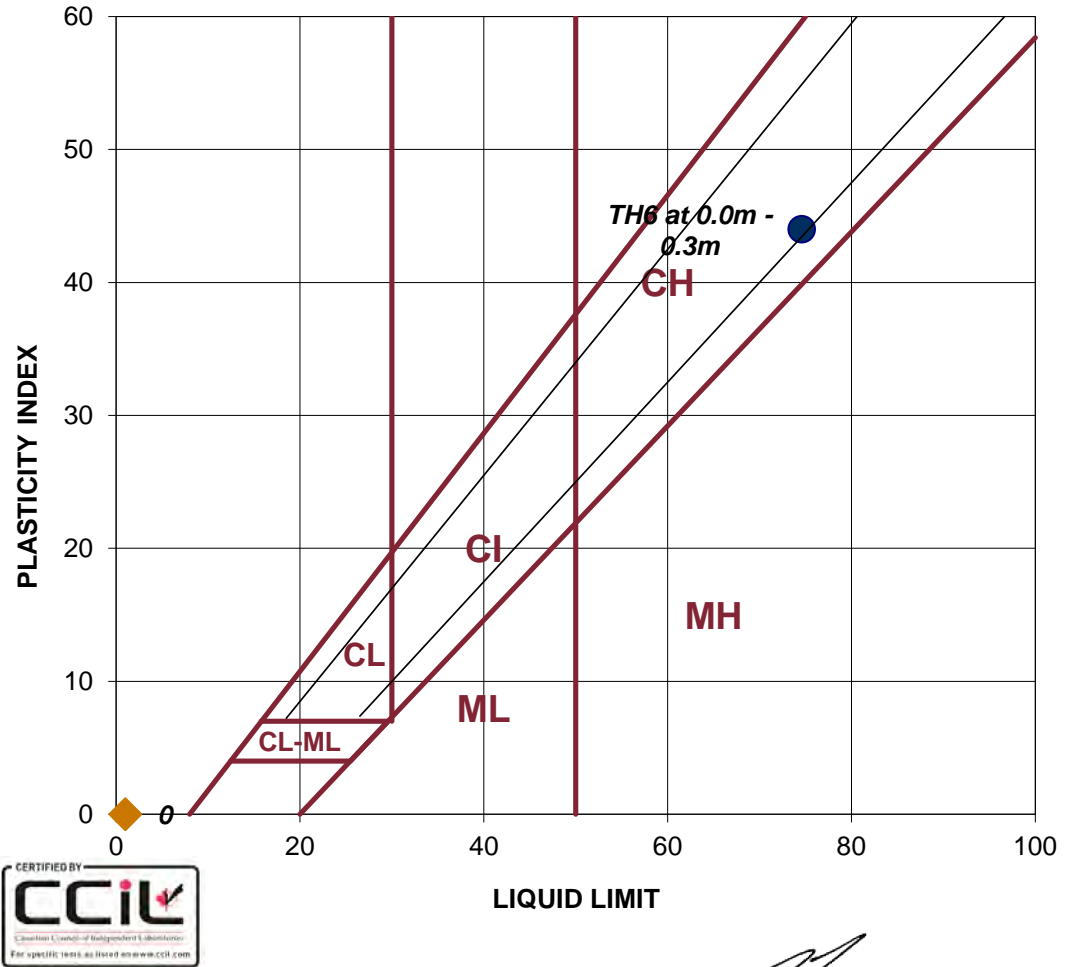
**Atterberg Limits**  
 ASTM D4318  
 Method B- One Point

Client: JR Cousin Consultants Ltd.  
 Project Name: RM of Brokenhead-GTH Lagoon Expansion  
 Project No: 123311627  
 Date Received: October 22, 2014  
 Date Tested: October 28, 2014  
 Tested By: Nestor Abarca

**LABORATORY**  
 199 Henlow Bay  
 Winnipeg, Manitoba  
 Canada R3Y 1G4

Tel: (204) 488-6999

Sample:		Sample:	
TH6 at 0.0m - 0.3m			
LIQUID		LIQUID	
1	2	Trial No.	1 2
25	25	Number of Blows	
215	212	Container Number	
35.98	39.45	Wt. Sample (wet+tare)(g)	
29.06	31.15	Wt. Sample (dry+tare)(g)	
19.76	20.05	Wt. Tare (g)	
9.3	11.1	Wt. Dry Soil (g)	
6.9	8.3	Wt. Water (g)	
74.4%	74.8%	Water Content (%)	
74.4%	74.8%	Corrected Water Content (%)	
PLASTIC		PLASTIC	
1	2	Trial No.	1 2
292	285	Container Number	
33.41	32.75	Wt. Sample (wet+tare)(g)	
30.45	30.02	Wt. Sample (dry+tare)(g)	
20.84	21.26	Wt. Tare (g)	
9.6	8.8	Wt. Dry Soil (g)	
3.0	2.7	Wt. Water (g)	
30.8%	31.2%	Water Content (%)	
AVERAGE VALUES		AVERAGE VALUES	
1	2	1	2
LL	75	LL	
PL	31	PL	
PI	44	PI	
CLASSIFICATION		CLASSIFICATION	
<b>CH</b>		<b>NON-PLASTIC</b>	



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Reviewed By: Jason Thompson, CET

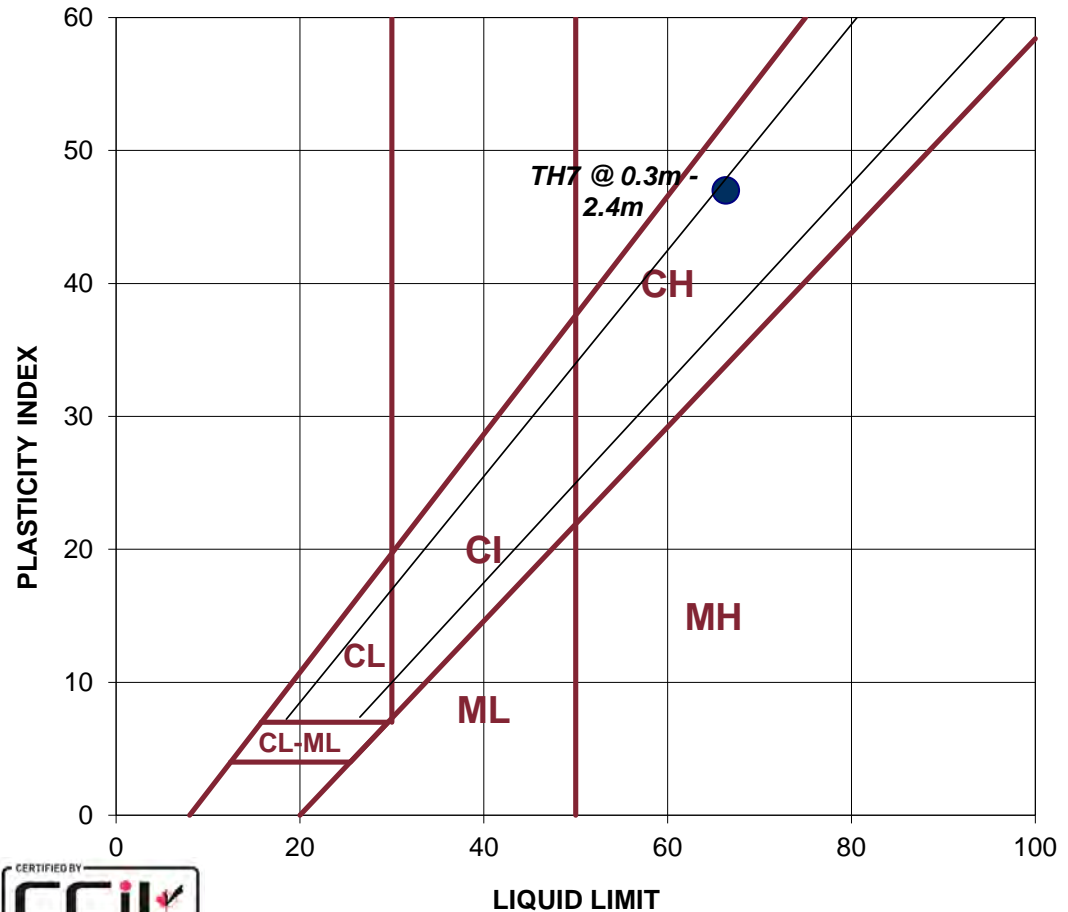


**Atterberg Limits**  
 ASTM D4318  
 Method B- One Point

Client: JR Cousin Consultants Ltd.  
 Project Name: RM of Brokenhead-GTH Lagoon Expansion  
 Project No: 123311627  
 Date Received: October 22, 2014  
 Date Tested: October 27, 2014  
 Tested By: Larry Presado

**LABORATORY**  
 199 Henlow Bay  
 Winnipeg, Manitoba  
 Canada R3Y 1G4  
 Tel: (204) 488-6999

Sample: TH7 @ 0.3m - 2.4m		Sample: TH6 @ 2.4m - 3.4m	
LIQUID		LIQUID	
1	2	Trial No.	
24	24	Number of Blows	24    25
281	242	Container Number	262    282
39.47	39.17	Wt. Sample (wet+tare)(g)	41.65    45.10
32.05	31.67	Wt. Sample (dry+tare)(g)	31.10    32.87
20.92	20.42	Wt. Tare (g)	20.67    20.83
11.1	11.3	Wt. Dry Soil (g)	10.4    12.0
7.4	7.5	Wt. Water (g)	10.6    12.2
66.7%	66.7%	Water Content (%)	101.2%    101.6%
66.3%	66.3%	Corrected Water Content (%)	100.7%    101.6%
PLASTIC		PLASTIC	
1	2	Trial No.	
237	304	Container Number	173    153
31.11	31.36	Wt. Sample (wet+tare)(g)	30.29    31.58
29.39	29.59	Wt. Sample (dry+tare)(g)	27.99    29.06
20.56	20.31	Wt. Tare (g)	19.48    19.76
8.8	9.3	Wt. Dry Soil (g)	8.5    9.3
1.7	1.8	Wt. Water (g)	2.3    2.5
19.5%	19.1%	Water Content (%)	27.0%    27.1%
AVERAGE VALUES		AVERAGE VALUES	
1	2	1	2
LL	66	LL	101
PL	19	PL	27
PI	47	PI	74
CLASSIFICATION		CLASSIFICATION	
<b>CH</b>		<b>CH</b>	



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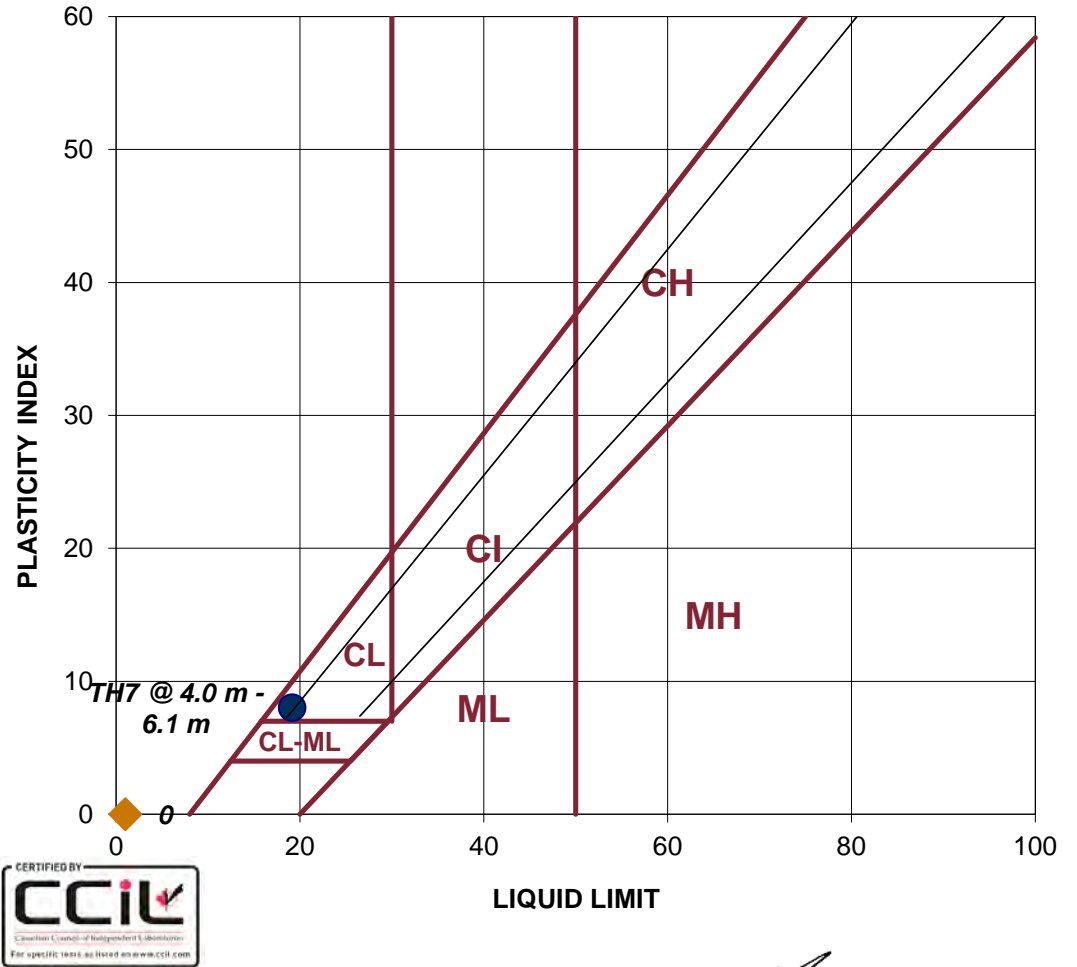
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 ASTM D4318  
 Method B- One Point

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 Project Name: RM of Brokenhead-GTH Lagoon Expansion  
 Project No: 123311627  
 Date Received: October 22, 2014  
 Date Tested: October 27, 2014  
 Tested By: Larry Presado

**LABORATORY**  
 199 Henlow Bay  
 Winnipeg, Manitoba  
 Canada R3Y 1G4

Tel: (204) 488-6999

Sample:		Sample:	
TH7 @ 4.0 m - 6.1 m			
LIQUID		LIQUID	
1	2	Trial No.	1 2
24	23	Number of Blows	
312	310	Container Number	
53.37	54.13	Wt. Sample (wet+tare)(g)	
48.04	48.73	Wt. Sample (dry+tare)(g)	
20.48	20.67	Wt. Tare (g)	
27.6	28.1	Wt. Dry Soil (g)	
5.3	5.4	Wt. Water (g)	
19.3%	19.2%	Water Content (%)	
19.2%	19.1%	Corrected Water Content (%)	
PLASTIC		PLASTIC	
1	2	Trial No.	1 2
136	260	Container Number	
38.03	38.67	Wt. Sample (wet+tare)(g)	
36.18	36.84	Wt. Sample (dry+tare)(g)	
19.69	20.57	Wt. Tare (g)	
16.5	16.3	Wt. Dry Soil (g)	
1.9	1.8	Wt. Water (g)	
11.2%	11.2%	Water Content (%)	
AVERAGE VALUES		AVERAGE VALUES	
1	2	1	2
LL	19	LL	
PL	11	PL	
PI	8	PI	
CLASSIFICATION		CLASSIFICATION	
<b>CL</b>		<b>NON-PLASTIC</b>	



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Reviewed By: Jason Thompson, CET



**LABORATORY**  
 199 Henlow Bay  
 Winnipeg MB R3Y 1G4  
 Tel: (204) 488-6999

**HYDRAULIC CONDUCTIVITY  
 ASTM D5084**

JR Cousin Consultants Ltd.  
 91A Scurfield Blvd.  
 Winnipeg, Manitoba  
 R3Y 1G4

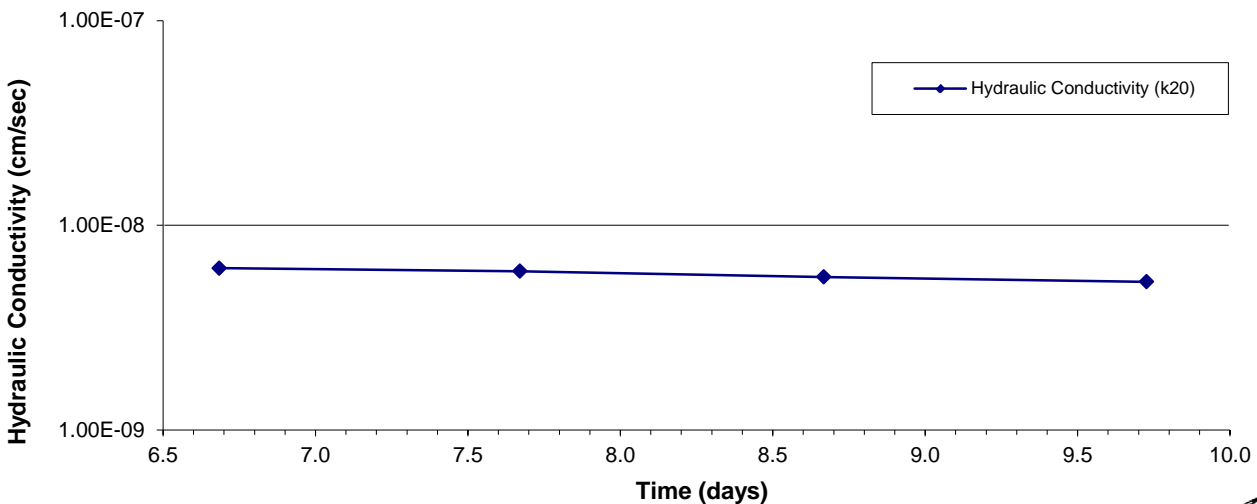
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

**SAMPLE I.D.:** TH3 @ 2.1 m - 2.7 m  
**SOIL DESCRIPTION:** Brown, stiff, moist, high plasticity sand clay  
 some silt and trace gravel  
**DATE TESTED:** October 22 to November 1, 2014  
**CONFINING PRESSURE (kPa):** 137.9  
**EFFECTIVE SATURATION STRESS (kPa):** 34.5  
**ASSUMED SPECIFIC GRAVITY:** 2.72  
**HYDRAULIC GRADIENT:** 20.4  
**TYPE OF PERMEANT LIQUID:** De-aired Water  
**HYDRAULIC CONDUCTIVITY, "k" (cm/s):** 5.8E-09  
**HYDRAULIC CONDUCTIVITY, "k<sub>20</sub>" (cm/s):** 5.8E-09

	Height (mm)	Diameter (mm)	Wet Mass (g)	Dry Density (g/cm <sup>3</sup> )	Water Content (%)	Saturation (%)
<b>Initial Reading</b>	73.1	72.5	531.0	1.297	35.8	88.8
<b>Final Reading</b>	72.3	72.1	535.1	1.242	46.1	105.4



November 6, 2014

REVIEWED BY:  Jason Thompson, CET



**LABORATORY**  
 199 Henlow Bay  
 Winnipeg MB R3Y 1G4  
 Tel: (204) 488-6999

**HYDRAULIC CONDUCTIVITY  
 ASTM D5084**

JR Cousin Consultants Ltd.  
 91A Scurfield Blvd.  
 Winnipeg, Manitoba  
 R3Y 1G4

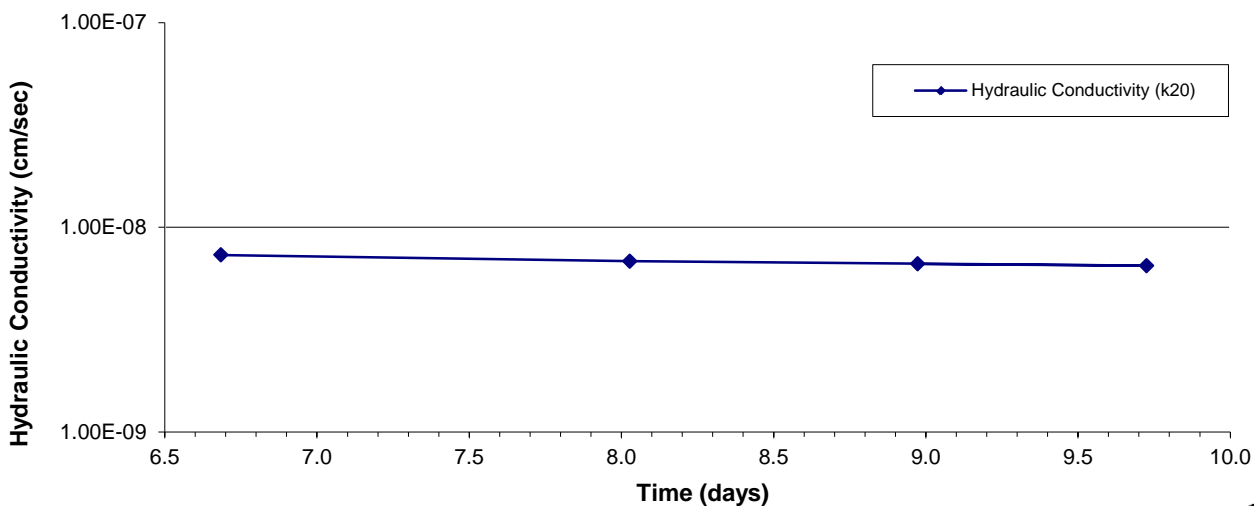
PROJECT: RM of Brokenhead  
 GTH Lagoon Expansion

Attention: Brett McCormac

PROJECT NO.: 123311627

**SAMPLE I.D.:** TH6 @ 0.9 m - 1.5 m  
**SOIL DESCRIPTION:** Brown, stiff, moist, high plasticity clay  
 some silt, trace sand and trace gravel  
**DATE TESTED:** October 22 to November 1, 2014  
**CONFINING PRESSURE (kPa):** 137.9  
**EFFECTIVE SATURATION STRESS (kPa):** 34.5  
**ASSUMED SPECIFIC GRAVITY:** 2.72  
**HYDRAULIC GRADIENT:** 20.3  
**TYPE OF PERMEANT LIQUID:** De-aired Water  
**HYDRAULIC CONDUCTIVITY, "k" (cm/s):** 7.0E-09  
**HYDRAULIC CONDUCTIVITY, "k<sub>20</sub>" (cm/s):** 6.8E-09

	Height (mm)	Diameter (mm)	Wet Mass (g)	Dry Density (g/cm <sup>3</sup> )	Water Content (%)	Saturation (%)
<b>Initial Reading</b>	72.2	72.4	595.5	1.590	26.0	99.3
<b>Final Reading</b>	72.9	72.0	601.1	1.587	27.6	105.0



November 6, 2014

REVIEWED BY:  Jason Thompson, CET



## GW Driller's Well Logs

LOCATION: NW15-13-6E

Well\_PID: 47683  
Owner: J KOROLEWICH  
Driller: Stasiuk & Sons Drilling Inc.  
Well Name:  
Well Use: PRODUCTION  
Water Use: Domestic,Livestock  
UTMX: 664609.113  
UTMY: 5552607.24  
Accuracy XY: UNKNOWN  
UTMZ:  
Accuracy Z:  
Date Completed: 1983 May 09

WELL LOG

From	To	Log
(ft.)	(ft.)	
0	18.0	BROWN CLAY
18.0	64.0	BROWN TILL
64.0	66.0	GRAVEL AND SAND
66.0	82.9	BROWN ROCK

WELL CONSTRUCTION

From	To	Casing	Inside	Outside	Slot	Type	Material
(ft.)	(ft.)	Type	Dia.(in)	Dia.(in)	Size(in)		
0	67.0	casing	4.30				
GALVANIZED							
67.0	82.9	open hole	4.00				

Top of Casing: 1.0 ft. below ground

PUMPING TEST

Date: 1983 May 09  
Pumping Rate: 30.0 Imp. gallons/minute  
Water level before pumping: 2.0 ft. below ground  
Pumping level at end of test: 4.0 ft. below ground  
Test duration: hours, minutes  
Water temperature: ?? degrees F

---

LOCATION: SE15-13-6E

Well\_PID: 36953  
Owner: A PAWLICK  
Driller: Paul Slusarchuk Well Drilling LTD.  
Well Name:  
Well Use: PRODUCTION  
Water Use: Domestic

UTMX: 665432.607  
UTMY: 5551810.46  
Accuracy XY: UNKNOWN  
UTMZ:  
Accuracy Z:  
Date Completed: 1979 Aug 30

WELL LOG

From (ft.)	To (ft.)	Log
0	35.0	CLAY
35.0	68.0	TILL
68.0	75.0	GRAVEL
75.0	124.9	LIMESTONE

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	77.2	casing	4.00			T & C	
GALVANIZED							
77.2	124.9	open hole	3.90				

Top of Casing: 1.0 ft. below ground

PUMPING TEST

Date: 1979 Aug 30  
Pumping Rate: 12.0 Imp. gallons/minute  
Water level before pumping: ft. below ground  
Pumping level at end of test: ?? ft. below ground  
Test duration: 1 hours, minutes  
Water temperature: ?? degrees F

---

LOCATION: SW15-13-6E

Well\_PID: 155399  
Owner: DARYL GROSSER  
Driller: Perimeter Drilling Ltd.  
Well Name:  
Well Use: PRODUCTION  
Water Use: Domestic  
UTMX: 664939  
UTMY: 5551472  
Accuracy XY: 1 EXACT [<5M] [GPS]  
UTMZ: 234  
Accuracy Z: 4 FAIR - Shuttle at Centroid  
Date Completed: 2009 Jul 15

WELL LOG

From (ft.)	To (ft.)	Log
0	2.0	TOP SOIL
2.0	34.0	CLAY
34.0	84.0	TILL
84.0	85.0	BROKEN LIMESTONE
85.0	180.0	LIMESTONE

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	88.0		5.00			INSERT	PVC
88.0	180.0	OPEN HOLE CASING GROUT	4.50				CEMENT

Top of Casing: 2.5 ft. above ground

PUMPING TEST

Date: 2009 Jul 15  
Pumping Rate: ?? Imp. gallons/minute  
Water level before pumping: 60.0 ft. above ground  
Pumping level at end of test: 3.0 ft. above ground  
Test duration: ??? hours, ?? minutes  
Water temperature: ?? degrees F

LOCATION: SW15-13-6E

Well\_PID: 140056  
Owner: TERRY PANISIAK  
Driller: Maple Leaf Enterprises LTd.  
Well Name:  
Well Use: PRODUCTION  
Water Use: Domestic  
UTMX: 664637.297  
UTMY: 5551793.04  
Accuracy XY:  
UTMZ:  
Accuracy Z:  
Date Completed: 2006 Sep 07

WELL LOG

From (ft.)	To (ft.)	Log
0	30.0	CLAY
30.0	35.0	CLAY WITH STONES
35.0	55.0	BROWN TILL
55.0	57.0	GREY TILL

57.0	85.0	GREY SILT WITH BOULDERS
85.0	88.0	LIMESTONE
88.0	91.0	SOFT WHITE LIMESTONE OR SHALE
91.0	160.0	LIMESTONE (SAND LAYERS IN LIMESTONE AFTER 135')

WELL CONSTRUCTION

From (ft.)	To (ft.)	Casing Type	Inside Dia.(in)	Outside Dia.(in)	Slot Size(in)	Type	Material
0	87.0	CASING	5.00			WELDED	PVC
82.0	92.0	CASING	4.00			WELDED	PVC
92.0	160.0	CASING	3.90				
0	70.0						

BENTONITE

Top of Casing: 4.0 ft. above ground

PUMPING TEST

Date: 2006 Sep 07  
Pumping Rate: 20.0 Imp. gallons/minute  
Water level before pumping: 2.0 ft. below ground  
Pumping level at end of test: 40.0 ft. below ground  
Test duration: 1 hours, minutes  
Water temperature: ?? degrees F

REMARKS

GARSON, PUMPED WITH AIR. 4 GPM AT 130', 20 GPM AT 160. GLUED 5" EXTENSION TO 4' ABOVE GRD, WELL MAY FLOW IN WET YEARS.

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