

**TITLE: GEOTECHNICAL INVESTIGATION  
PROPOSED RESIDENTIAL SUBDIVISION  
N1/2 OF 35-26-30-W1  
LAKE OF THE PRAIRIES, SASKATCHEWAN**

**CLIENT: SUN HILLS RESORT LTD.**

**FILE NO: GE-0923                      DATE: DECEMBER 15, 2009**

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**APPENDIX A:** Slope Stability Cross Sections



# GROUND ENGINEERING LTD.

CIVIL & GEOENVIRONMENTAL ENGINEERS

415 - 7th AVENUE • REGINA • SASKATCHEWAN • CANADA • S4N 1P1  
TELEPHONE: (306) 569-9075 FAX: (306) 565-3677 EMAIL: geground@accesscomm.ca

FILE: GE-0923

December 15, 2009

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Y

Sun Hills Resort Ltd.  
c/o Konrad & Claudia Zangl  
P.O. Box 194  
TOGO, Saskatchewan  
S0A 4E0

Dear Konrad & Claudia:

**SUBJECT: GEOTECHNICAL INVESTIGATION  
PROPOSED RESIDENTIAL SUBDIVISION  
N1/2 OF 35-26-30-W1  
LAKE OF THE PRAIRIES, SASKATCHEWAN**

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## 1.0 INTRODUCTION

This report presents the results of a site specific subsurface soils investigation and geotechnical analysis carried out for the above captioned project located approximately 11 km south of the Town of Togo, Saskatchewan. It is understood that the proposed development consists of 48 residential lots overlooking the north valley wall adjacent to Lake of the Prairies. The objectives of this investigation were to provide the following information:

- .1 To define the subsurface soil stratigraphy, groundwater regime and engineering properties of the foundation soils at the proposed subdivision site.



A MEMBER ORGANIZATION OF THE ASSOCIATION OF CONSULTING ENGINEERS OF CANADA

AFFILIE A LA FIDIC MEMBER



SOIL MECHANICS AND FOUNDATION CONSULTANTS     SITE INVESTIGATIONS     FOUNDATION DESIGN  
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- .2 To provide design and installation recommendations for the most suitable and economical foundation system to support the proposed residential buildings;
- .3 To comment on possible excavation and construction problems related to foundation construction with particular reference to groundwater conditions;
- .4 To provide recommendations for floor slab design and construction;
- .5 To determine the slope stability, comment on possible slope stability problems and provide recommendations for site development, including suitable building sites and set-back distances for residential development;
- .6 To provide recommendations on pertinent geotechnical issues identified during the subsurface investigation.

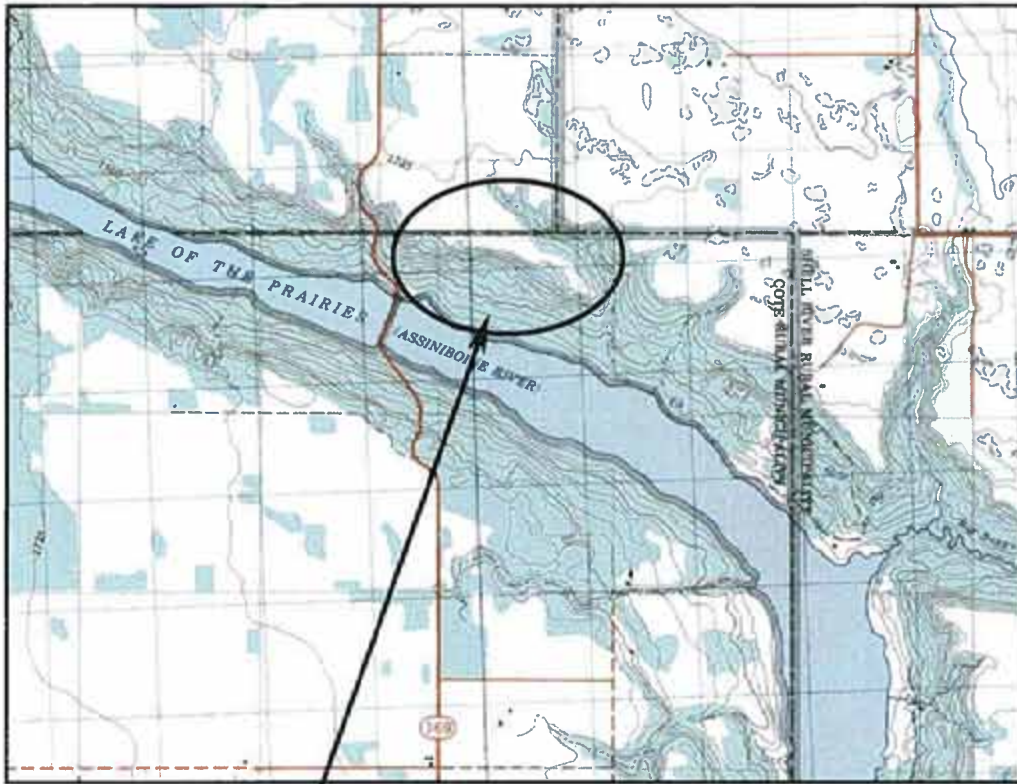
Authorization to proceed with this work was received verbally on April 15, 2009.

## **2.0 DESCRIPTION OF SITE**

The study area shown in Figure 1 is located in the N1/2 of 35-26-30-W1, approximately 11 kilometers south of the Town of Togo, Saskatchewan. The property includes a relatively flat till plain overlooking the Assiniboine River Valley and Lake of the Prairies. Lake of the Prairies is a man-made lake which was formed following construction of the Shellmouth Dam. The valley wall (south of the proposed residential lots) shows signs of landslide activity in the past. There is an elevation difference of approximately 90 metres between Lake of The Prairies and the top of the valley wall.

## **3.0 FIELD AND LABORATORY INVESTIGATION**

The subsurface conditions were investigated by drilling eight (8) test borings at the locations shown on Drawing No. GE-0923-1. The test holes were drilled on May 12 and 13, 2009, using a truck-mounted, Brat 22 digger equipped with a 150 mm diameter continuous flight auger and were drilled to depths ranging from 13.7 to 15.2 metres below existing ground surface.



**STUDY AREA**



**FIGURE 1**  
**LOCATION OF STUDY AREA**

Representative disturbed auger samples and undisturbed Shelby tube soil samples were recovered from the test borings at selected intervals and were taken to our laboratory for analysis. Standard Penetration tests were conducted in Test Holes 102, 103, 104 and 105. Each soil sample was visually examined to determine its textural classification and a natural moisture content test was performed on each soil sample. In addition, Atterberg Limits, gradation analysis, dry density, unconfined compressive strength and sulphate content tests were performed on selected soil samples. Estimates of the undrained shear strength were made using both a pocket penetrometer and a laboratory vane shear apparatus. Details of the soil profile, samples taken, laboratory test results and stratigraphic interpretations of the subsoils are presented on Drawing Nos. GE-0923-5 to -18, inclusive.

Standpipe piezometers were installed in Test Holes 101, 103, 105, 106 and 108 to monitor groundwater levels. Details of the piezometer installations are shown on the corresponding test hole logs. The water levels were measured after the test drilling was completed and again on June 8 and August 25, 2009.

## **4.0 GEOTECHNICAL ANALYSIS**

### **4.1 Geology**

The study area is located in the physiographic division known as the Assiniboine River Plain. The prominent landform adjacent to the valley wall is a till plain. The glacial sediments which form the surficial geology in the study area consist predominantly of sand, glacial till and lacustrine clay. The adjacent valley was carved out of the till plain by glacial meltwater during the last deglaciation period. The valley has since been partially filled with alluvium. The underlying bedrock consists of Upper Cretaceous shale of the Pierre Shale Formation.

### **4.2 Stratigraphy**

The drilling information indicates that along the top of the valley wall, the surficial topsoil is underlain by a sand stratigraphic unit which extends to depths ranging from 1.2 to 2.4 metres below existing grade. The sand is medium to coarse grained with trace amounts of gravel and occasional cobbles. The sand is loose to medium dense with Standard Penetration 'N'

values ranging from a low of 8 blows per foot to a high of 29 blows per foot. Typical gradations of the sand are shown on Drawing Nos. GE-0923-15 to 17, inclusive.

The surficial sand unit is underlain by a thin veneer of glacial till which extends to depths ranging from 3.6 to 4.7 metres below existing grade in Test Holes 101 through 105, inclusive. The till is a heterogeneous mixture of clay, silt, sand and gravel with numerous sand lenses and occasional cobblestones and boulders. The till is medium plastic with an average Liquid Limit of 41 percent and an average Plasticity Index of 27 percent. The till is clayey and stiff to hard in consistency with undrained shear strengths ranging from 120 to 290 kPa based on unconfined compression tests and has a dry density ranging from 1.64 to 1.80 tonnes per cubic metre. The term till on the borehole logs indicates that the material originates from geological processes associated with glaciation. These processes produce a material that is heterogeneous in composition and as such, may contain pockets and/or seams of material such as sand, gravel, silt or clay. Thin lenses of fine grained sand and clay were encountered at various depths within the till unit. The sand and till units were not encountered in the test holes drilled on the lower portion of the valley wall (Test Holes 106, 107 and 108).

The surficial topsoil and/or sand and till units are generally underlain by a silty clay stratigraphic unit which extends to the maximum depth penetrated in Test Holes 101 through 105 (15.2 metres) and to depths ranging from 3.4 to 6.5 metres below grade in the remaining test holes. The clay is moist and stiff to hard in consistency with undrained shear strengths ranging from 75 to 230 kPa based on vane shear and unconfined compression tests and has a dry density ranging from 1.46 to 1.88 tonnes per cubic metre. The clay is a medium to highly plastic material with a Liquid Limit ranging from 38 to 65 percent and a Plasticity Index ranging from 25 to 47 percent. The clay unit was not encountered in Test Hole 107.

A surficial stratified drift unit was encountered in Test Hole 107 which extends to a depth of 2.4 metres below grade. The drift consists of interbedded layers of silt and sand. The drift sediments are normally consolidated, moist and oxidized. A typical gradation of the sand encountered in Test Hole 107 is shown on Drawing No. GE-0923-18.

The bedrock surface was encountered beneath the surficial drift unit in Test Holes 106 through 108, inclusive. The bedrock in this area is known as the Pierre Shale Formation. The shale extends to the maximum depth penetrated in the test holes (13.7 to 15.2 metres). The shale consists on non-calcareous, highly plastic clay of marine origin which contains interbedded silt and bentonitic layers. The shale is moist and stiff to hard in consistency with undrained shear strengths ranging from 120 to 230 kPa based on vane shear and unconfined compression tests and has a dry density ranging from 1.49 to 1.60 tonnes per cubic metre.. Atterberg Limits test results indicate that the shale has a Liquid Limit in the order of 65 percent and a Plasticity Index in the order of 50 percent.

### 4.3 Groundwater

The soils encountered at this site are generally moist, however, saturated sand lenses were encountered in Test Holes 102, 103, 104, 105 and 106 at varying depths below the existing ground surface. Water levels in the piezometers were measured by our technologists as shown in Table 1, below:

**TABLE 1**  
**PIEZOMETRIC SURFACE MEASUREMENTS**

STANDPIPE PIEZOMETER NO.	DATE MEASURED	DEPTH OF WELL FROM GROUND SURFACE (m)	GROUNDWATER LEVEL FROM TOP OF PIPE (m)	GEODETTIC PIEZOMETRIC SURFACE ELEVATION (m)
TH 101	May 12, 2009	15.2	Dry	-
	June 8, 2009		14.4	505.1
	August 25, 2009		14.6	504.9
TH 103	May 12, 2009	6.3	Dry	-
	June 8, 2009		2.9	516.9
	August 25, 2009		3.9	515.9
TH 105	May 12, 2009	4.9	Dry	-
	June 8, 2009		5.0	515.4
	August 25, 2009		*	*
TH 106	May 12, 2009	15.2	Dry	-
	June 8, 2009		5.6	433.5
	August 25, 2009		5.8	433.3
TH 108	May 12, 2009	15.2	Dry	-
	June 8, 2009		15.5	426.9
	August 25, 2009		15.5	426.9

\* TH 105 was destroyed prior to August 25, 2009 monitoring.

### 5.0 SLOPE STABILITY

The following information provides an assessment of the slope stability of the subject property based on interpretation of the subsurface data.



## **5.1 History of Slope Movement**

The valley in which Lake of the Prairies (Assiniboine River Valley) is situated is the remnant of an early post glacial drainage system. During deglaciation, rushing meltwater cut a large, steep-walled valley through the surficial glacial deposits and into the underlying shale bedrock. Undercutting of the bedrock foundation materials undermined the slopes and produced the slumping activity which is still evident in some areas along the valley wall. The slumped areas form the ridges and localized discontinuities in surface drainage now present on the valley walls. The slumping activity has now subsided due to the deposition of post-glacial alluvium in the valley which has produced a buttressing effect, helping to stabilize the valley walls. However, active landsliding is still occurring along the shoreline where wave erosion is undermining the slope. The lot locations for this proposed development are located on the till plain above the valley wall.

## **5.2 Stratigraphy**

The surficial sand and glacial till encountered at the top of the valley is relatively competent. One of the main factors controlling slope stability is the position of the drift/bedrock contact with respect to the lake level. Where the drift/bedrock contact is at or near the lake level, slopes are flatter and the slump blocks are more frequent. These slopes are actually less stable than the steeper sloped areas where the drift/bedrock contact is below the lake level. According to SRC Surficial Geology maps of the area, the drift/bedrock contact in the study area is above the lake level at an elevation of approximately 472 metres, Geodetic.

## **5.3 Topography**

The valley wall along Lake of the Prairies exhibits the distinctive topographic features of a slope which has been subjected to landsliding. The identifying features are a steep headscarp and a hummocky broken slope. On air photographs, a series of arcuate, interconnected rear headscarps and a pattern of subparallel ridges down the slope are evident. Luxuriant vegetation growth is evident in the numerous undrained closed depressions which have formed behind many of the slump blocks.

#### **5.4 Groundwater**

One of the major factors controlling slope stability is the position of the water table. It is generally accepted that a slope that is fully drained will stand at an angle approximately twice that of a slope that has the groundwater table at surface. A high water table induces a higher water pressure at the slide surface which tends to hold the soil particles apart, thereby reducing the effective stress. The total weight of overlying soil is taken by the sum of the pore pressure and the effective stress between soil particles. Therefore, a rise in the water table causes a reduction in the factor of safety against sliding, conversely, lowering the water table would tend to stabilize the slide.

#### **5.5 Discussion**

Once landsliding has occurred on a valley slope, the factor of safety with respect to slope stability would be close to unity under natural conditions before any new developments constructed by man. The factor of safety is defined as the resisting forces divided by the driving forces. A safety factor close to 1.0 means that small changes in the stress environment may initiate additional downslope movement in the landslide slump blocks. Usually these movements are gradual creep type movements that range from a few millimetres to possibly several centimetres per year. Large, sudden drops in the order of 300 to 600 mm may also occur, however, these types of movements are less common than gradual creep type movements.

#### **6.0 SLOPE STABILITY ANALYSIS**

The purpose of a slope stability analysis is to determine the factor of safety of a potential failure surface. The analysis involves passing an assumed slip surface (generally circular) through the slope and dividing the inscribed portion into slices. The factor of safety is defined as a ratio between the resisting force and the driving force both applied along the potential failure surface. When the driving force due to the weight of the soil is equal to the resisting force due to shear strength, the factor of safety is equal to 1 and failure is imminent. The slope stability analysis was performed using the *Slide Version 5.0* computer software developed by Rocscience Inc. An effective stress slope stability analysis using the Morgenstern-Price method and half sine interslice force function was used.

Soil strength parameters were determined from the laboratory testing and information available in our company files as shown in Table 2, below.

**TABLE 2**  
**SOIL PARAMETERS**

SOIL TYPE	PEAK STRENGTH		UNIT WEIGHT
	Friction Angle	Cohesion	
Sand	35°	0.0 kPa	19.0 kN/m <sup>3</sup>
Till	28°	10.0 kPa	20.0 kN/m <sup>3</sup>
Clay	20°	8.0 kPa	18.5 kN/m <sup>3</sup>
Shale Bedrock	14°	8.0 kPa	18.5 kN/m <sup>3</sup>

The factor of safety was calculated at the locations of Cross Sections 1-1, 2-2, and 3-3 (shown on Drawing No. GE-0923-1) for the existing conditions at the top of the valley wall. Using the soil strength parameters shown above, the long term factor of safety against sliding at each cross section location is shown in Table 3, below.

**TABLE 3**  
**CALCULATED SAFETY FACTORS**

CROSS SECTION LOCATION	EXISTING FACTOR OF SAFETY
1-1	1.11
2-2	1.22
3-3	1.12

Our test results and slope stability analysis indicates that the top of the existing valley wall has a factor of safety ranging from 1.11 to 1.22. The stability analysis is shown on the drawings included in Appendix A.

## **7.0 SITE DEVELOPMENT GUIDELINES**

Development in an area of previous landslide activity involves some risk. The risk is associated with the possible reactivation of old landslides or the creation of entirely new landslides. At the present time, the top of the valley wall is relatively stable and the probability of major slope movements taking place in the future is considered to be low. Our analysis indicates that the factor of safety against retrogressive sliding at the top of the valley wall is in the order of 1.11 to 1.22 using a minimum set-back distance of 6 metres

from the edge of the valley wall. Residential lots are considered to be feasible from a geotechnical engineering standpoint provided development controls are implemented to minimize the risk of future landslides. To minimize the potential problems associated with slope stability, the following guidelines are provided for development at this time.

- .1 The majority of each lot is located above the edge of the valley wall where no previous landslide activity has occurred. A minimum set back distance of 6.0 metres from the edge of the valley wall is recommended. Walk-out type basements are not recommended for Lots in Block B but may be suitable for Lots 1 to 5, Block A.
- .2 Water should be encouraged to drain off the properties. The natural drainage courses down the valley wall should be maintained as best as possible.
- .3 The valley walls are highly susceptible to erosion. Removal of existing vegetation should be kept to a minimum. Areas where the vegetation is disturbed should be re-vegetated as soon as possible. Any erosion which does occur should be repaired immediately.
- .4 Excessive lawn and garden watering should not be permitted near the edge of the valley wall. Excessive lawn and garden watering will increase the water table and will therefore reduce the factor of safety of the slope.
- .5 Swimming pools usually leak and contribute substantial quantities of water into the soil. For this reason, swimming pools should not be permitted without a liner system designed or reviewed by a geotechnical engineer.

## **8.0 FOUNDATION CONSIDERATIONS**

It is anticipated that the foundation loads for the proposed residential buildings will be relatively light. The soil conditions at this site are suitable for shallow footing type foundation systems. Our specific design recommendations for footing type foundation systems are presented below:

## **8.1 Spread Footing and/or Post and Pad Type Foundation System**

- .1 Properly constructed shallow spread footings bearing on the undisturbed soil may be designed for a safe net bearing pressure of 120 kPa (2,500 psf). Maximum toe pressure under wind loading may exceed the average pressure by no more than one-third (1/3). Regardless of footing pressure considerations, the minimum width of footings should be 450 mm.
- .2 The footings should be placed at a minimum depth of 1.8 metres below finished grade elevation for frost protection. If the footings are placed above this depth, insulation should be placed to prevent frost penetration into the soils beneath the footings. All footings should be adequately reinforced to resist localized stresses.
- .3 Dewatering should not be required at this site, however, every effort should be made to pour the footings as soon as possible after excavation is completed. The steel reinforcing mats should be made up in advance to minimize the possibility of soil disturbance during placement.
- .4 All loose or disturbed material at the base of the footing excavations should be compacted prior to placement of forms, reinforcing steel and concrete.
- .5 Landscaping should ensure a minimum of 3% slope away from the perimeter of the buildings.

## **9.0 EXCAVATION CONSIDERATIONS**

Excavations will be in the surficial sand and till units. Conventional excavation procedures should therefore be applicable to the soils at this site. Occupational Health and Safety Regulations require that any trench or excavation in which persons must work must be cut back at least one (1) horizontal to one (1) vertical or a temporary shoring system must be used to support the sides of the excavation.

## **10.0 FLOOR SLAB CONSIDERATIONS**

The soil conditions are suitable for either grade supported floor slabs or structurally supported floors constructed over a crawl space. The following recommendations are provided for both types of floor systems.

### **10.1 Structurally Supported Floor Systems**

A structural floor system would be the most positive way to ensure satisfactory long term performance of the floor. We recommend the following items of work for preparation of the subgrade in the crawl space area beneath the floor slab.

- .1 The crawl space should be covered with a Permalon vapour barrier to reduce the humidity in the crawl space and prevent drying of the subgrade soils.
- .2 Service lines and heating ducts could be installed beneath the floor and this would provide a more comfortable floor for the people occupying the building. Heating ducts should be insulated to prevent heat loss and potential drying of the subgrade soil.
- .3 The ground surface in the crawl space should be graded to slope towards a positive outlet in order to drain any water that may enter the crawl space area.
- .4 Provisions should be made to ventilate the crawl space area.

### **10.2 Grade Supported Floor Slabs**

- .1 The subgrade under a grade supported slab should be as uniform as possible. The exposed subgrade should be proof-rolled with a heavy sheepsfoot or vibratory padfoot roller. Any soft or spongy areas should be excavated and filled with compacted granular material. A well graded pit run sand (Type 8) compacted to 95% Standard Proctor density is suitable for this purpose. The final 200 mm below underside of the floor slab should be radon rock.

- .2 The concrete slab in areas where only light floor loads are to be supported, may have a minimum thickness of 100 mm. The minimum 28 day concrete compressive strength should be specified as 25 MPa.
- .3 A generous amount of reinforcing steel running both ways in the slab is desirable.
- .4 A layer of robust polyethylene sheeting should be placed between the granular base and the concrete slab to deter the migration of moisture through the floor.

## **11.0 OTHER**

- .1 The results of this investigation indicate that additional lots are feasible in the flat areas near the bottom of the slope where TH 106, 107 and 108 were drilled. Site specific development guidelines by a geotechnical engineer will be required for future development in this area based on the proposed lay-out of the lots.
- .2 Adequate drainage away from the buildings should be provided and maintained to minimize infiltration of water into the subgrade. The building sites should be set at as high an elevation as possible in relation to the surrounding area.
- .3 Test results on selected samples indicate that the soluble sulphate contents in the soils are in order of 0.04 to 0.06 percent by dry soils weight. Class 2 Concrete with Type 50 cement as specified in the Guide for Use of Sulphate Resistant Cement on Drawing No. GE-0923-19, may be used for all concrete placed in contact with the native soils.
- .4 In the event that changes are made in the design, location or nature of the project, the conclusions and recommendations included in this report would not be deemed valid unless the changes in the project were reviewed by our firm. Modification to this report would then be made if necessary. Furthermore, it is recommended that this firm be allowed an opportunity for a general review of the final design plans and specifications in order to ensure that the recommendations made in this report are properly interpreted and implemented. If this firm is not allowed the opportunity for this review, we assume no responsibility for the misinterpretation of any of the recommendations.

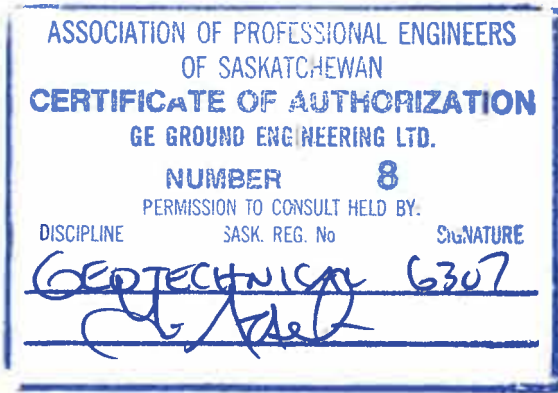
- .5 It is recommended that GE Ground Engineering Ltd. be retained to provide inspection services during construction of this project. This is to observe compliance with the design concepts, specifications and recommendations and to allow design changes in the event that the subsurface conditions differ from what was anticipated.
- .6 This report has been prepared for Sun Hills Resort Ltd. and is intended for the specific application to the design and construction of the proposed residential subdivision located in the N1/2-35-26-30-W1M south of the Town of Togo, Saskatchewan. The analysis and recommendations are based in part on the data obtained from the test hole logs. The boundaries between soil strata have been established at bore hole locations. Between the boreholes, the boundaries are assumed from geological evidence and may be subject to considerable error. Contractors bidding on the project works are particularly advised against reviewing the report without realizing the limitations of the subsurface information. It is recommended that Contractors should make such tests, inspections and other on-site investigations as is considered necessary to satisfy themselves as to the nature of the conditions to be encountered.
- .7 The soil samples from this site will be retained in our laboratory for 90 days following the date of this report. Should no instructions be received to the contrary, these samples will then be discarded.



**12.0 CLOSURE**

We trust that this report is satisfactory for your purposes. If you have any questions or require additional information, please contact this office.

Yours very truly  
GE GROUND ENGINEERING LTD.



*[Signature]*  
Prepared by: PAUL WALSH, P. ENG.



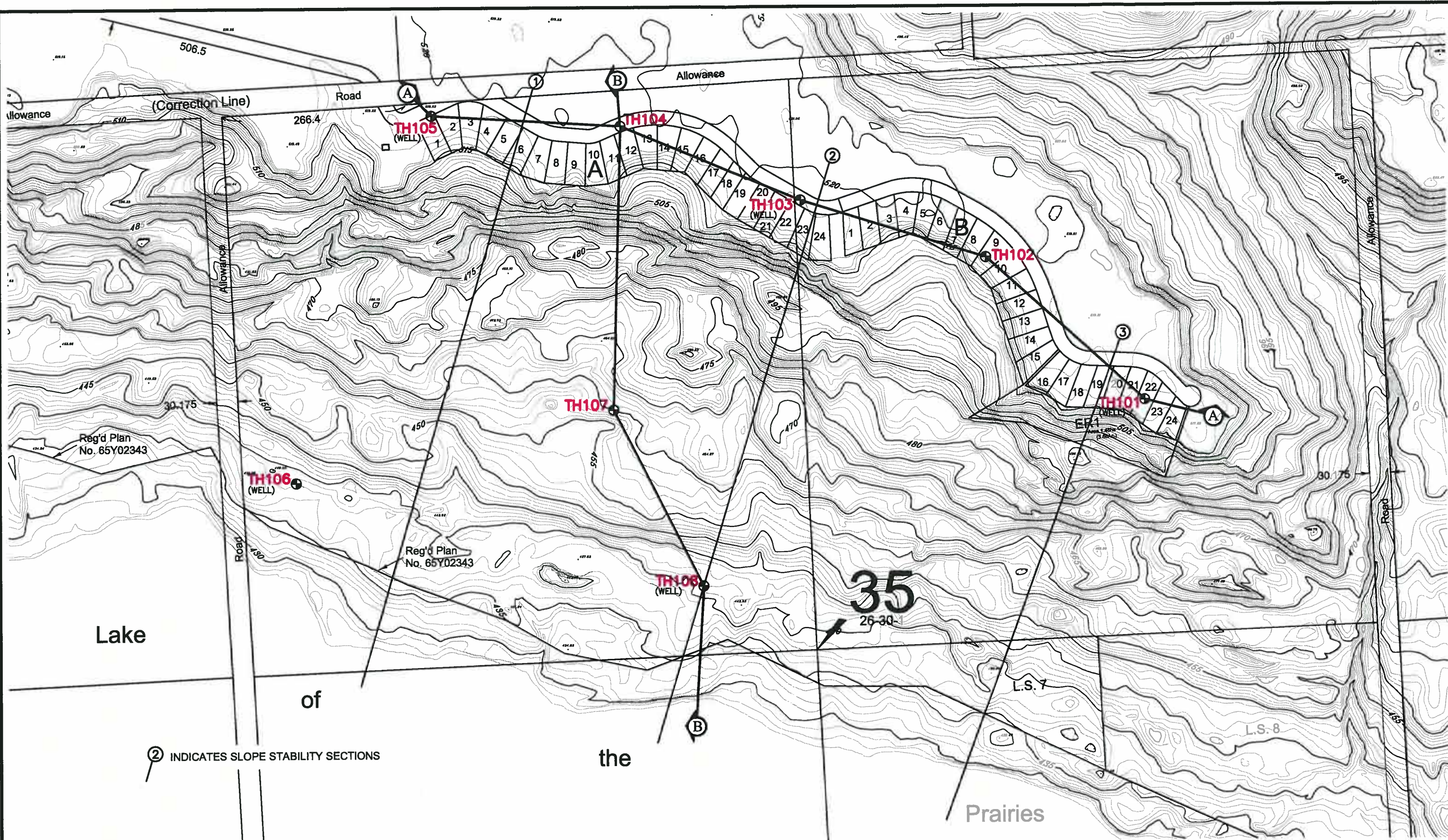
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Reviewed by: TIM ADELMAN , P. ENG., P. GEO.

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## **DRAWINGS**



PLAN PROVIDED BY FOCUS CORPORATION.



SCALE: 1:5000

**GE** **GROUND ENGINEERING LTD.**  
 CONSULTING GEOENVIRONMENTAL ENGINEERS  
 REGINA, SASKATCHEWAN

CLIENT: SUN HILLS RESORT LTD.

SITE PLAN SHOWING LOCATION OF TEST HOLES  
 PROPOSED RESIDENTIAL SUBDIVISION  
 N 1/2 OF 35-26-30-W1M  
 LAKE OF THE PRAIRIES, SASKATCHEWAN

APPROVED:	DATE:	DWG. NO.:
	DECEMBER 15, 2009	GE-0923-1

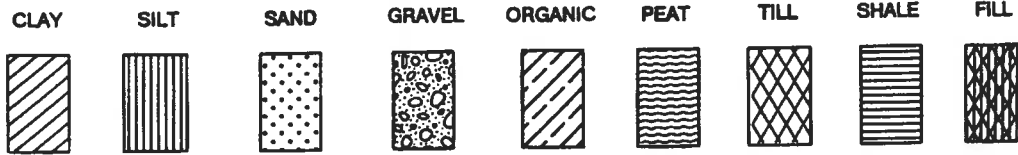
## CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 - 69 AND D 2488 - 69  
(Unified Soil Classification System)

Major Divisions		Group Symbols	Typical Names	Classification Criteria		
<b>Coarse-grained soils</b> More than 50% retained on No. 200 sieve *	<b>Gravels</b> 50% or more of coarse fraction retained on No. 4 sieve	Clean gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	$C_u = \frac{D_{60}}{D_{10}} \text{ greater than 4:}$ $C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}} \text{ between 1 and 3}$	
		Gravels with fines	GP	Poorly graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		
	<b>Sands</b> More than 50% of coarse fraction passes No. 4 sieve	Clean sands	SW	Well-graded sands and gravelly sands, little or no fines	$C_u = \frac{D_{60}}{D_{10}} \text{ greater than 6:}$ $C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}} \text{ between 1 and 3}$	Not meeting both criteria for SW
			SP	Poorly graded sands and gravelly sands, little or no fines		
		Sands with fines	SM	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		
		<b>Fine-grained soils</b> 50% or more passes No. 200 sieve *	Silts and clays Liquid limit 50% or less	ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands	<b>PLASTICITY CHART</b> 
				CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
OL	Organic silts and organic silty clays of low plasticity					
Silts and clays Liquid limit greater than 50%	MH		Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts			
	CH		Inorganic clays of high plasticity, fat clays			
	OH		Organic clays of medium to high plasticity			
Highly organic soils	Pt		Peat, muck and other highly organic soils			

\*Based on the material passing the 75mm (3in) sieve.

## SYMBOLS AND TERMS USED IN THE REPORT



The symbols may be combined to denote various soil combinations, the predominate soil being heavier.

### RELATIVE PROPORTIONS

TERM	RANGE
Trace	0 - 5%
A Little	5 - 15%
Some	15 - 30%
With	30 - 50%

### ASTM CLASSIFICATION BY PARTICLE SIZE

Boulder	> 300 mm
Cobble	300 mm - 75 mm
Gravel	75 mm - 4.75 mm
Sand	
coarse	4.75 mm - 2 mm
medium	2 mm - 425 um
fine	425 um - 75 um
Silt	75 um - 5 um
Clay	< 5 um

### DENSITY OF SANDS AND GRAVELS

DESCRIPTIVE TERM	RELATIVE DENSITY <sup>1</sup>	N VALUE STANDARD <sup>2</sup> PENETRATION TEST
Very loose	0 - 15%	0 - 4 Blows per 300mm
Loose	15 - 35%	4 - 10 Blows per 300mm
Medium Dense	35 - 65%	10 - 30 Blows per 300mm
Dense	65 - 85%	30 - 50 Blows per 300mm
Very Dense	85 - 100%	> 50 Blows per 300mm

### CONSISTENCY OF CLAYS AND SILTS

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa) <small>(CFEM, 2nd Ed., 1985)</small>	N VALUE STANDARD <sup>2</sup> PENETRATION TEST	FIELD IDENTIFICATION <small>(ASTM D 2488-84)</small>
Very Soft	<12	< 2 Blows per 300mm	Thumb will penetrate soil more than 25 mm
Soft	12 - 25	2 - 4 Blows per 300mm	Thumb will penetrate soil about 25 mm
Firm	25 - 50	4 - 8 Blows per 300mm	Thumb will indent soil about 6 mm
Stiff	50 - 100	8 - 15 Blows per 300mm	Thumb will indent, but only with great effort (CFEM)
Very Stiff	100 - 200	15 - 30 Blows per 300mm	Readily indented by thumbnail (CFEM)
Hard	>200	> 30 Blows per 300mm	Thumb will not indent soil but readily indented with thumbnail

- NOTES:** 1. Relative Density determined by standard laboratory tests.  
2. N Value - Blows/300mm of a 620N hammer falling 762mm on a 50mm O.D. Split Spoon.

**SYMBOLS AND TERMS USED IN THE REPORT (continued)**

**GROUNDWATER**

- ▼ Water level measured in the borings at the time and under the conditions indicated. In sand, the indicated levels can be considered reliable groundwater levels. In clay soil, it is not possible to determine the groundwater level within the normal scope of a test boring investigation, except where lenses or layers of more pervious waterbearing soil are present and then a long period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed texture soils may not indicate the true level of the groundwater table. The available water level information is given at the bottom of the log sheet.
- ▽ Water level determined by piezometer installation - In all soils the levels can be considered reliable groundwater levels.

**DESCRIPTIVE SOIL TERMS**

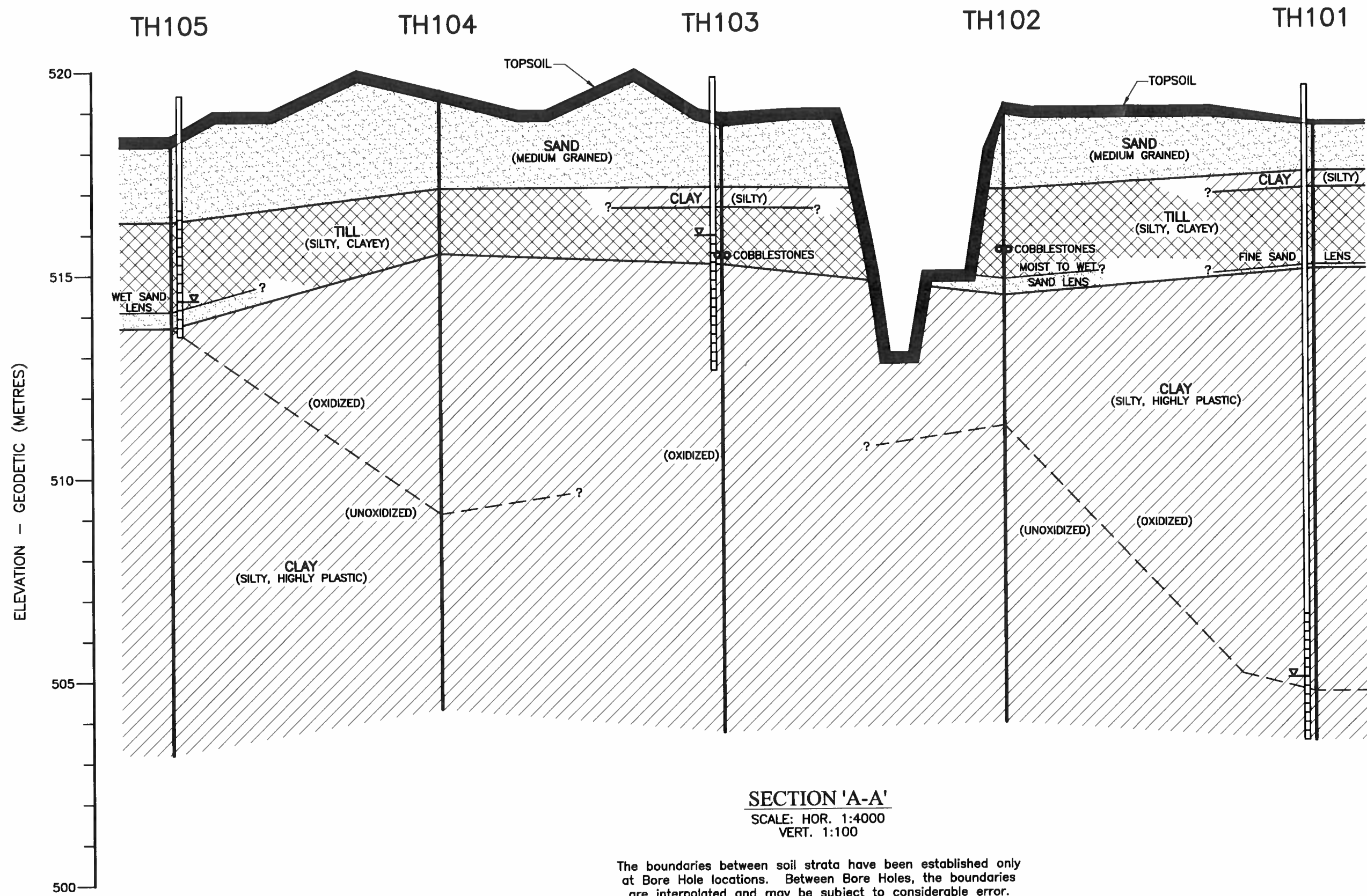
- WELL GRADED** Having wide range of grain sizes and substantial amounts of all intermediate sizes.
- POORLY GRADED** Predominantly of one grain size.
- SLICKENSIDES** Refers to a clay that has planes that are slick and glossy in appearance; slickensides are caused by shear movements.
- SENSITIVE** Exhibiting loss of strength on remolding.
- FISSURED** Containing cracks, usually attributable to shrinkage. Fissured clays are sometimes described as having a nuggetty structure.
- STRATIFIED** Containing layers of different soil types.
- ORGANIC** Containing organic matter; may be decomposed or fibrous.
- PEAT** A fibrous mass of organic matter in various stages of decomposition. Generally dark brown to black in color and of spongy consistency.
- BEDROCK** Preglacial material.
- DRIFT** Material deposited directly by glaciers or glacial melt-water.
- ALLUVIAL** Soils that have been deposited from suspension from moving water.
- LACUSTRINE** Soils that have been deposited from suspension in fresh water lakes.

**DRILLING AND SAMPLING TERMS**

SYMBOL	DEFINITION
C.S.	Continuous Sampling
Sy	75mm Thin Wall Tube Sample
Sy (2)	50mm Thin Wall Tube Sample
SPT (SS)	50mm O.D. Split Spoon Sample
<u>BLOWS</u> 300mm	"N" Value - Standard Penetration Test
Bag	Disturbed Bag Sample
No.	Sample Identification Number
→	Piezometer Tip
S.I.	Slope Indicator
SPG →	Observed Seepage


**LABORATORY TEST SYMBOLS**

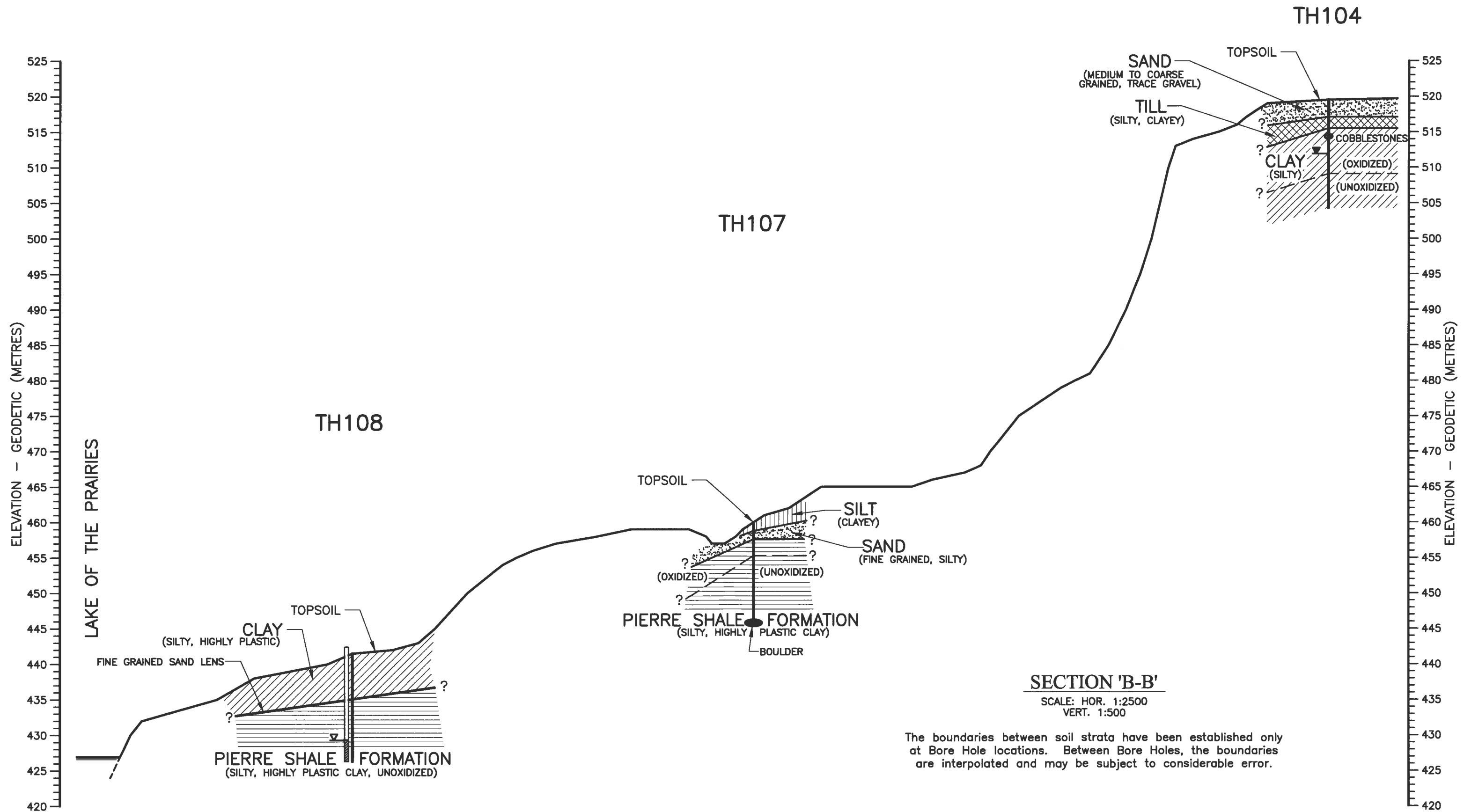
SYMBOL	DEFINITION
●	Moisture Content - Percent of Dry Weight
→	Plastic and Liquid Limit determined in accordance with ASTM D-423 and D-424
◆	Dry Density - $t/m^3$
■	Shear Strength - As determined by Unconfined Compression Test
▲	Shear Strength - As determined by Field Vane
▲	Shear Strength - As determined by Pocket Penetrometer Test
%SO <sub>4</sub>	Water Soluable Sulphates - Percent of Dry Weight
M.A.	Grain Size Analysis




**SECTION 'A-A'**  
 SCALE: HOR. 1:4000  
 VERT. 1:100

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes, the boundaries are interpolated and may be subject to considerable error.

 <b>GROUND ENGINEERING LTD.</b> CONSULTING GEOENVIRONMENTAL ENGINEERS REGINA, SASKATCHEWAN	STRATIGRAPHIC CROSS SECTION 'A-A' PROPOSED RESIDENTIAL SUBDIVISION N 1/2 OF 35-26-30-W1M LAKE OF THE PRAIRIES, SASKATCHEWAN		
	CLIENT: SUN HILLS RESORT LTD.	APPROVED:	DATE: DECEMBER 15, 2009

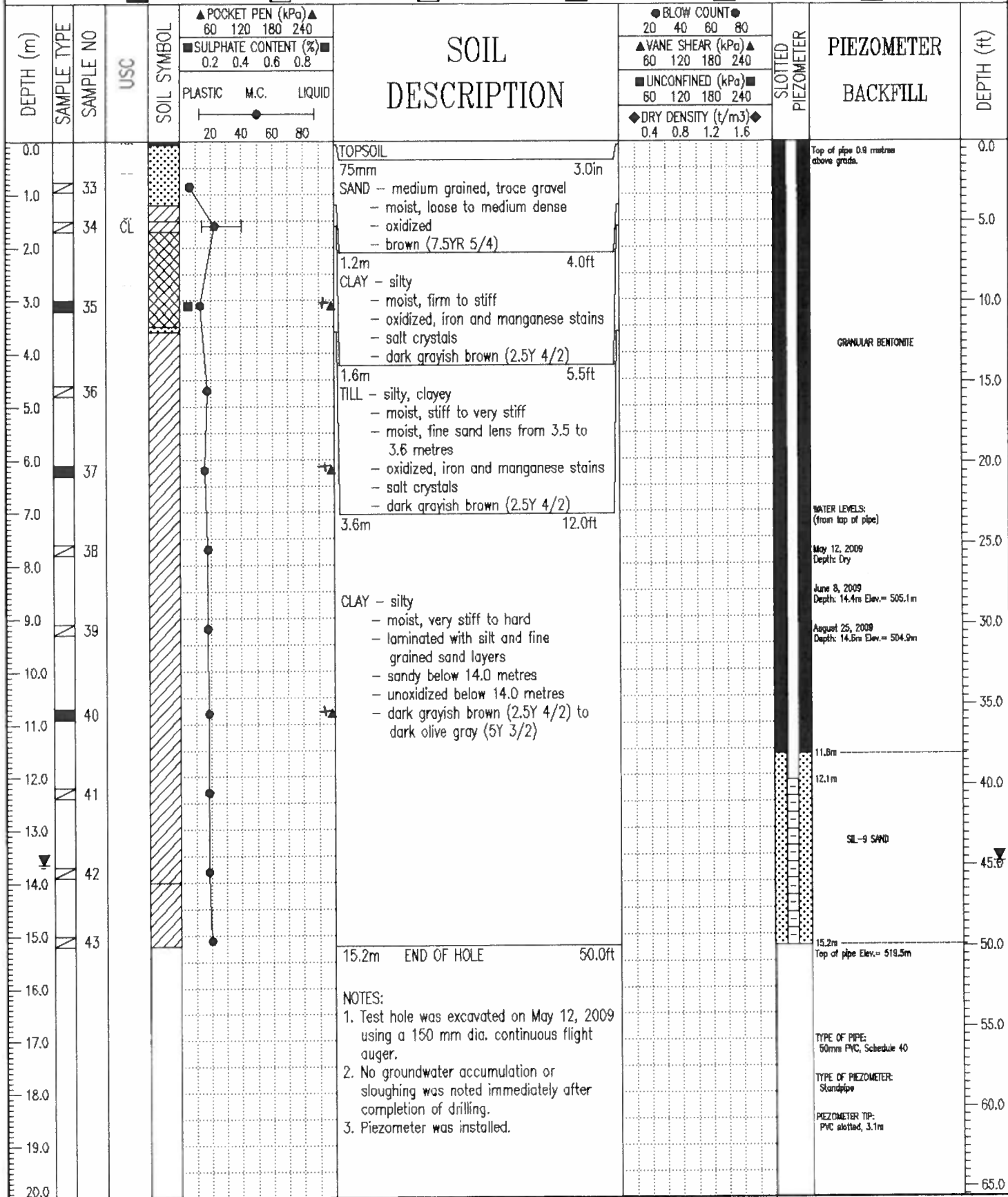


 <b>GROUND ENGINEERING LTD.</b> CONSULTING GEOENVIRONMENTAL ENGINEERS REGINA, SASKATCHEWAN	STRATIGRAPHIC CROSS SECTION 'B-B' PROPOSED RESIDENTIAL SUBDIVISION N 1/2 OF 35-26-30-W1M LAKE OF THE PRAIRIES, SASKATCHEWAN		
	CLIENT: SUN HILLS RESORT LTD.	APPROVED:	DATE: DECEMBER 15, 2009



PROJECT: PROP. RESIDENTIAL SUBDIVISION	LOCATION: 5686015 N; 14321040 E	TEST HOLE NO: 0923-TH101
CLIENT: SUN HILLS RESORT LTD.	LOCATION: N 1/2 35-26-30-W1M	PROJECT NO: GE-0923
DRILL RIG: BRAT 22 DIGGER	ELEVATION: 518.60 metres (GEODETIC)	ELEVATION: 518.60 (m)

SAMPLE TYPE  SHELBY TUBE  DISTURBED  SPT SAMPLE  PAIL SAMPLE  NO RECOVERY  JAR SAMPLE



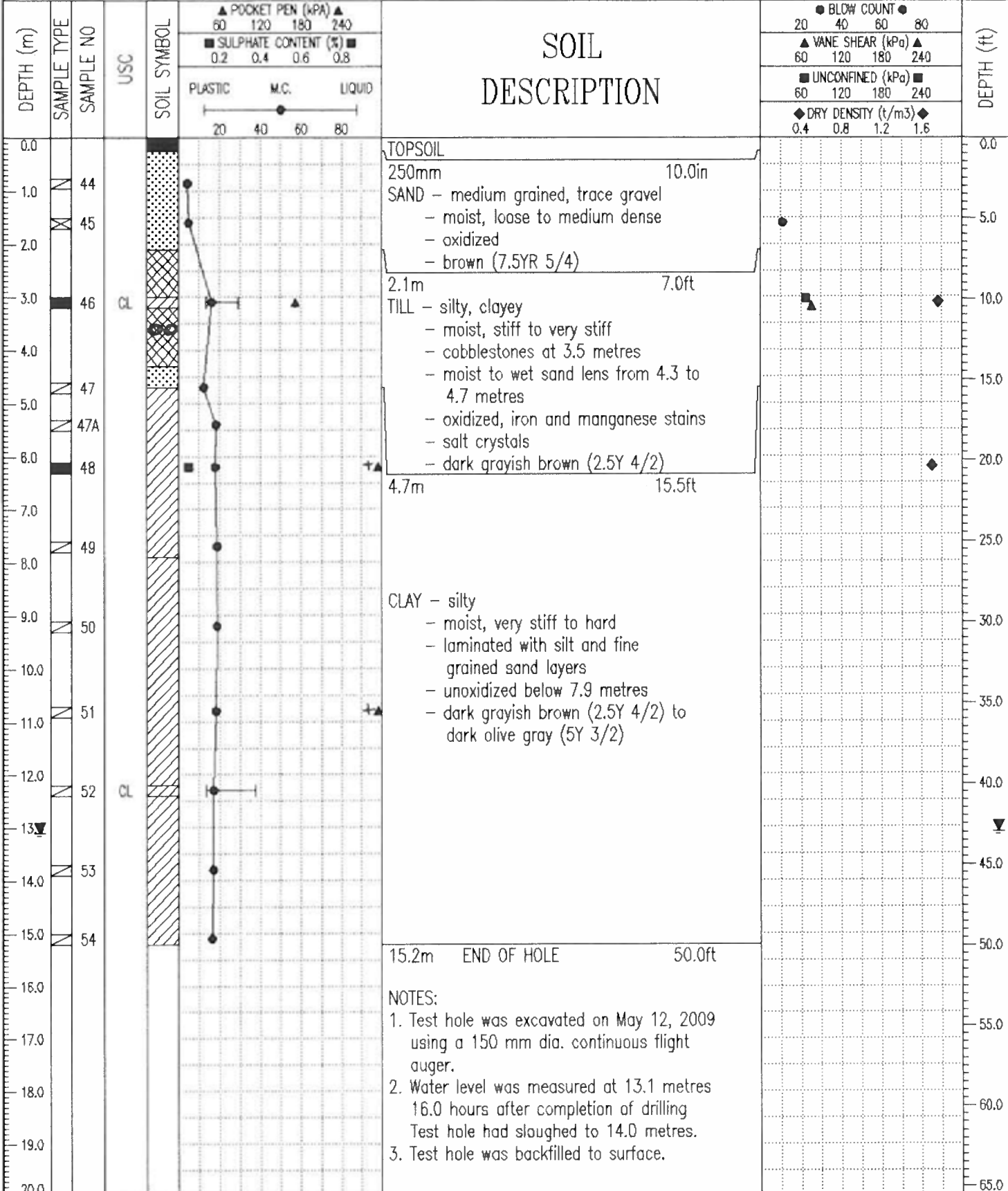
GE GROUND ENGINEERING LTD. Regina, Saskatchewan	LOGGED BY: RY	COMPLETION DEPTH: 15.2 m
	REVIEWED BY: PW	COMPLETE: 09/05/12
	Fig. No: GE-0923-7	Page 1 of 1

PROJECT: PROP. RESIDENTIAL SUBDIVISION      LOCATION: 5686230 N; 14320822 E      TEST HOLE NO: 0923-TH102

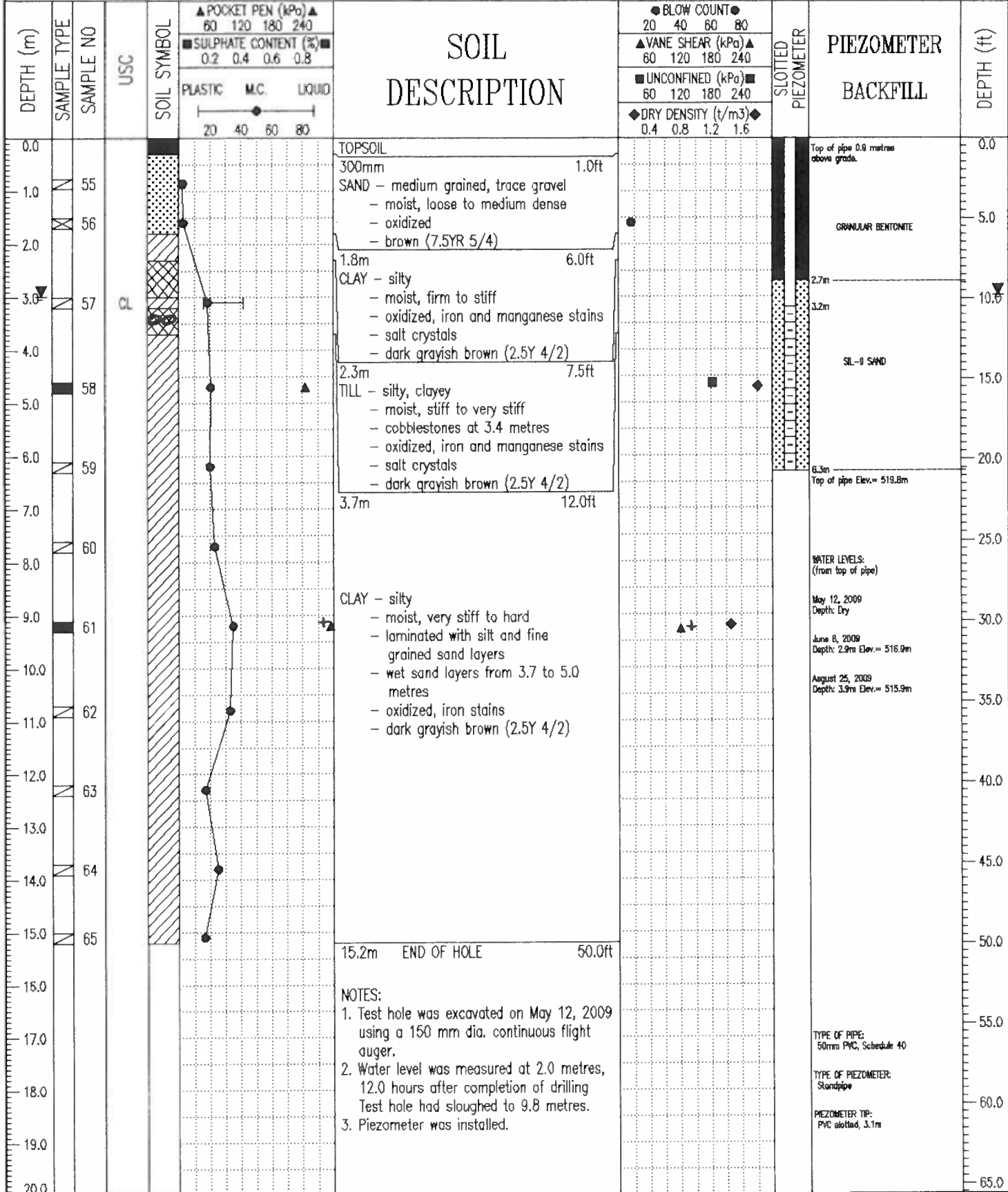
CLIENT: SUN HILLS RESORT LTD.      LOCATION: N 1/2 35-26-30-W1M      PROJECT NO: GE-0923

DRILL RIG: BRAT 22 DIGGER      ELEVATION: 519.10 metres (GEODETTIC)      ELEVATION: 519.10 (m)

SAMPLE TYPE:  SHELBY TUBE     DISTURBED     SPT SAMPLE     PAIL SAMPLE     NO RECOVERY     JAR SAMPLE

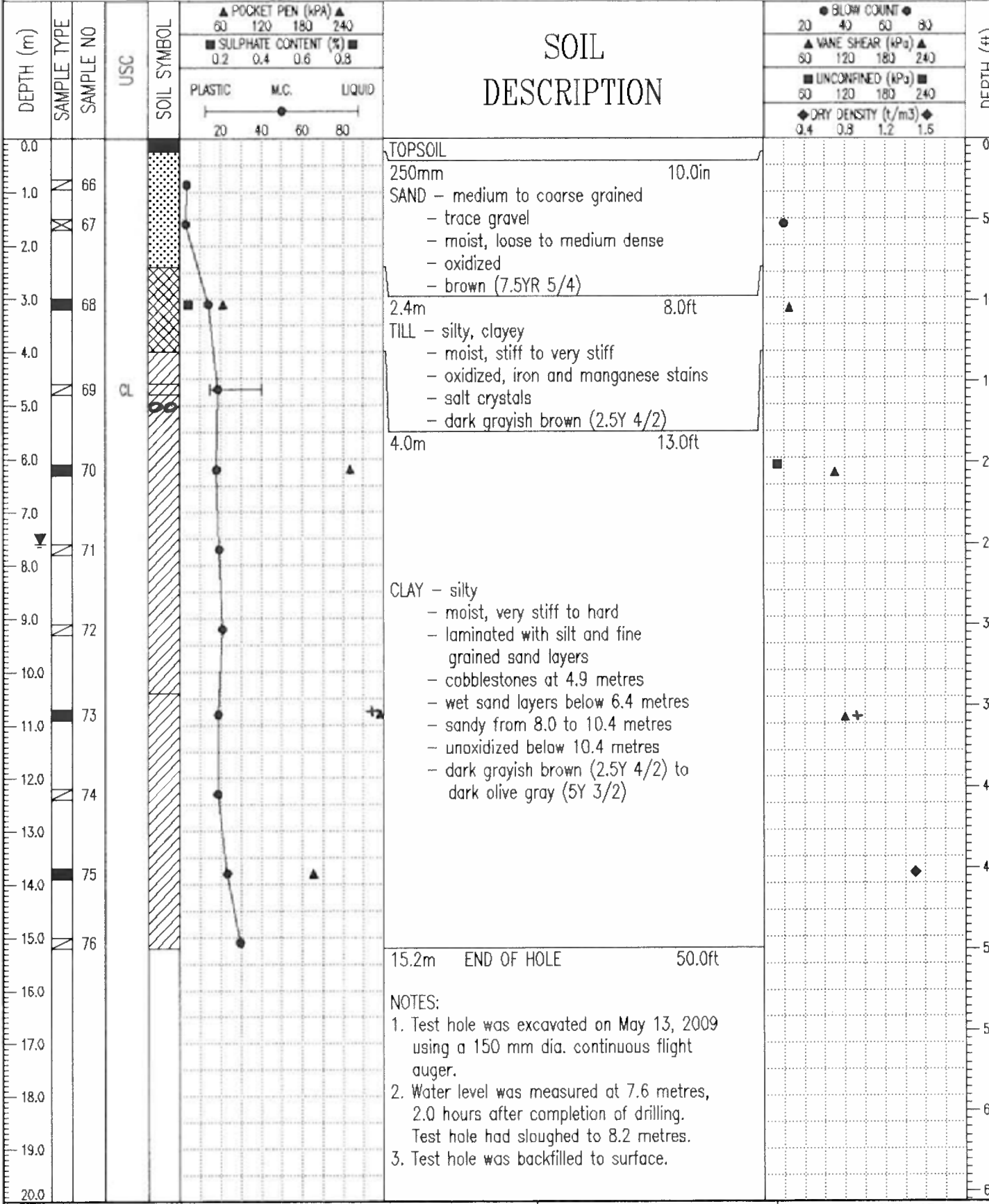


NOTES:  
 1. Test hole was excavated on May 12, 2009 using a 150 mm dia. continuous flight auger.  
 2. Water level was measured at 13.1 metres 16.0 hours after completion of drilling. Test hole had sloughed to 14.0 metres.  
 3. Test hole was backfilled to surface.

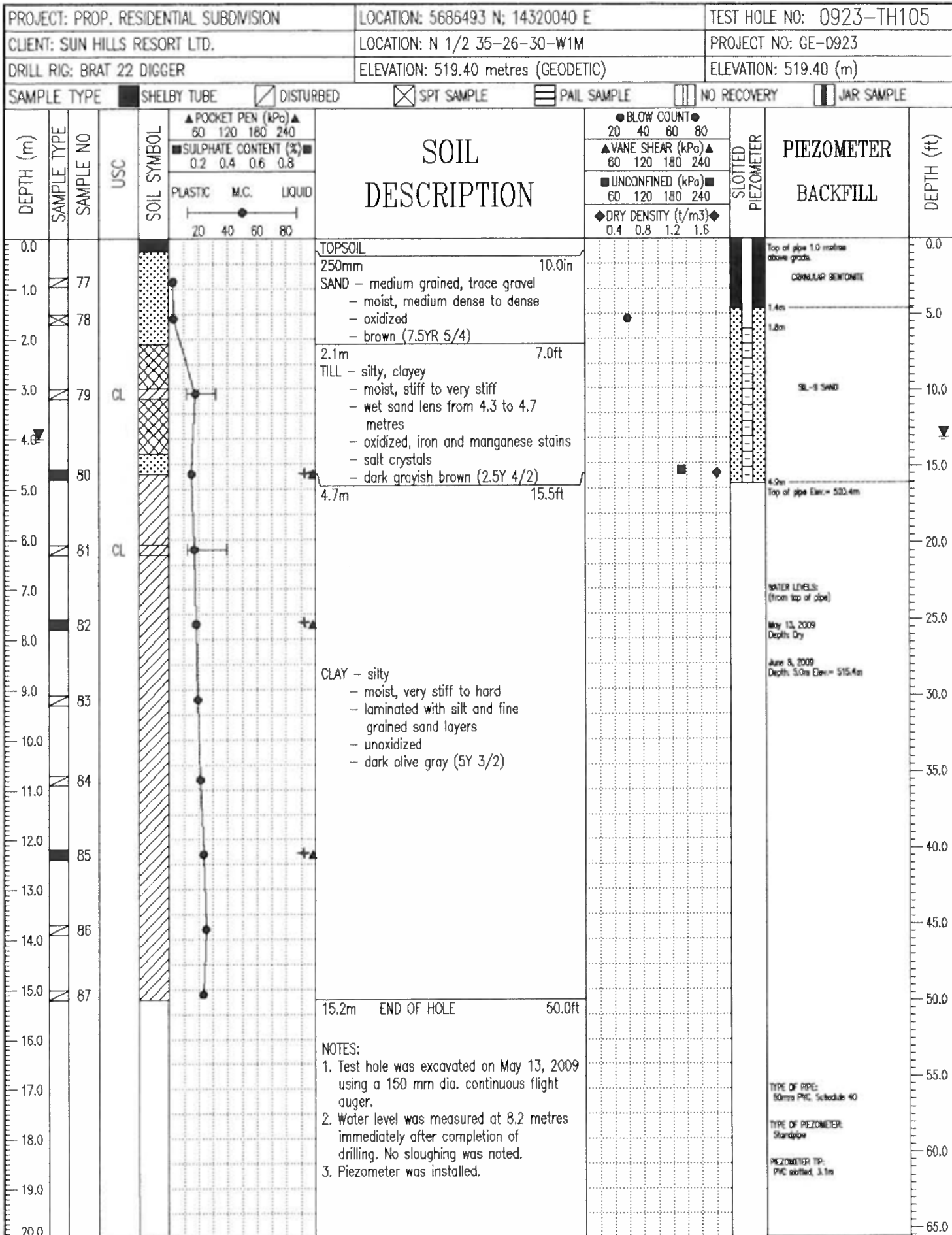


PROJECT: PROP. RESIDENTIAL SUBDIVISION	LOCATION: 5686442 N; 14320291 E	TEST HOLE NO: 0923-TH104
CLIENT: SUN HILLS RESORT LTD.	LOCATION: N 1/2 35-26-30-W1M	PROJECT NO: GE-0923
DRILL RIG: BRAT 22 DIGGER	ELEVATION: 519.50 metres (GEODETTIC)	ELEVATION: 519.50 (m)

SAMPLE TYPE  SHELBY TUBE  DISTURBED  SPT SAMPLE  PAIL SAMPLE  NO RECOVERY  JAR SAMPLE



GE GROUND ENGINEERING LTD. Regina, Saskatchewan	LOGGED BY: RY	COMPLETION DEPTH: 15.2 m
	REVIEWED BY: PW	COMPLETE: 09/05/13
	Fig. No: GE-0923-10	Page 1 of 1



PROJECT: PROP. RESIDENTIAL SUBDIVISION

LOCATION: 5685954 N; 14319822 E

TEST HOLE NO: 0923-TH106

CLIENT: SUN HILLS RESORT LTD.

LOCATION: N 1/2 35-26-30-W1M

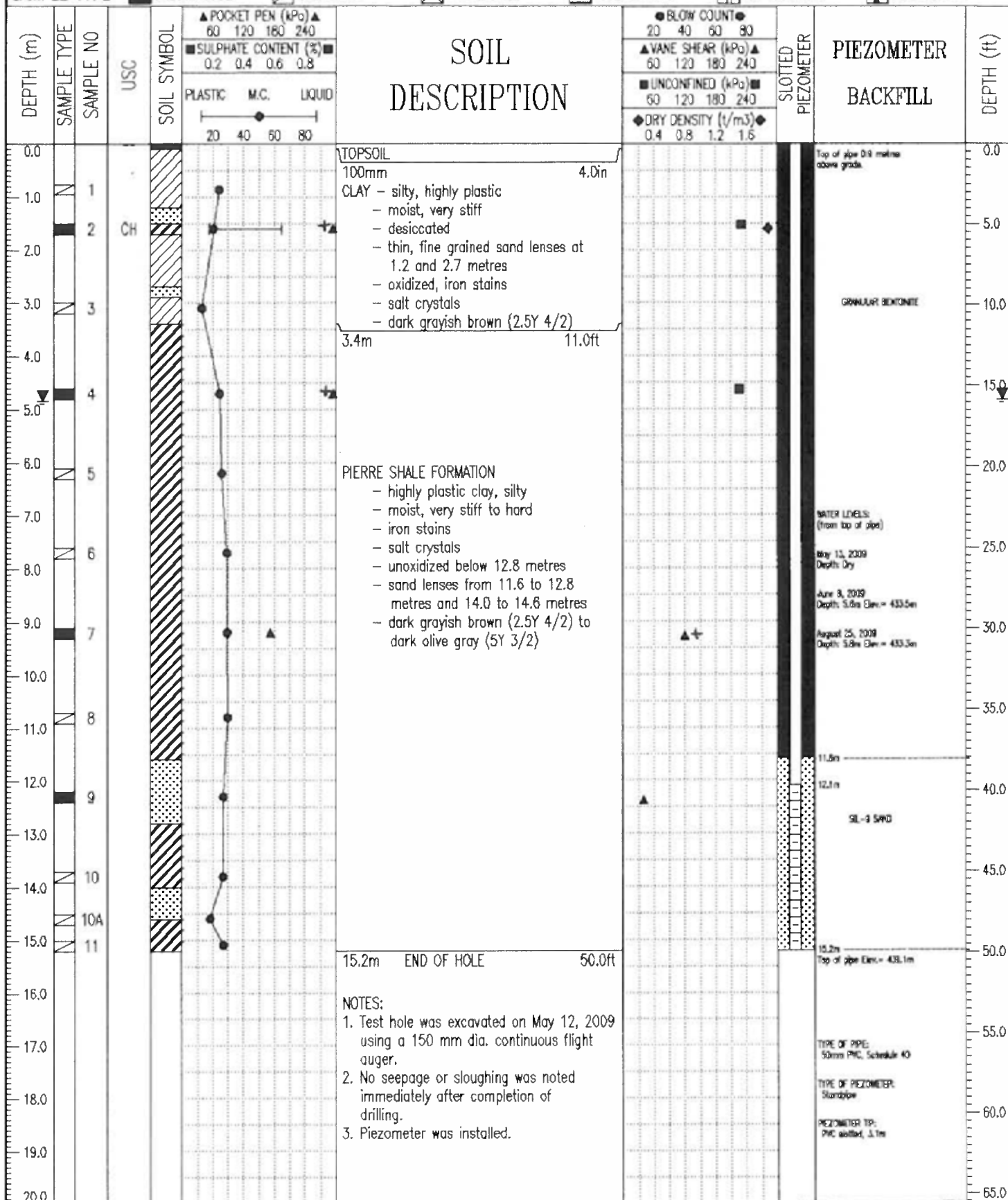
PROJECT NO: GE-0923

DRILL RIG: BRAT 22 DIGGER

ELEVATION: 438.20 metres (GEODETTIC)

ELEVATION: 438.20 (m)

SAMPLE TYPE  SHELBY TUBE  DISTURBED  SPT SAMPLE  PAIL SAMPLE  NO RECOVERY  JAR SAMPLE



GE GROUND ENGINEERING LTD.  
Regina, Saskatchewan

LOGGED BY: RY

REVIEWED BY: PW

Fig. No: GE-0923-12

COMPLETION DEPTH: 15.2 m

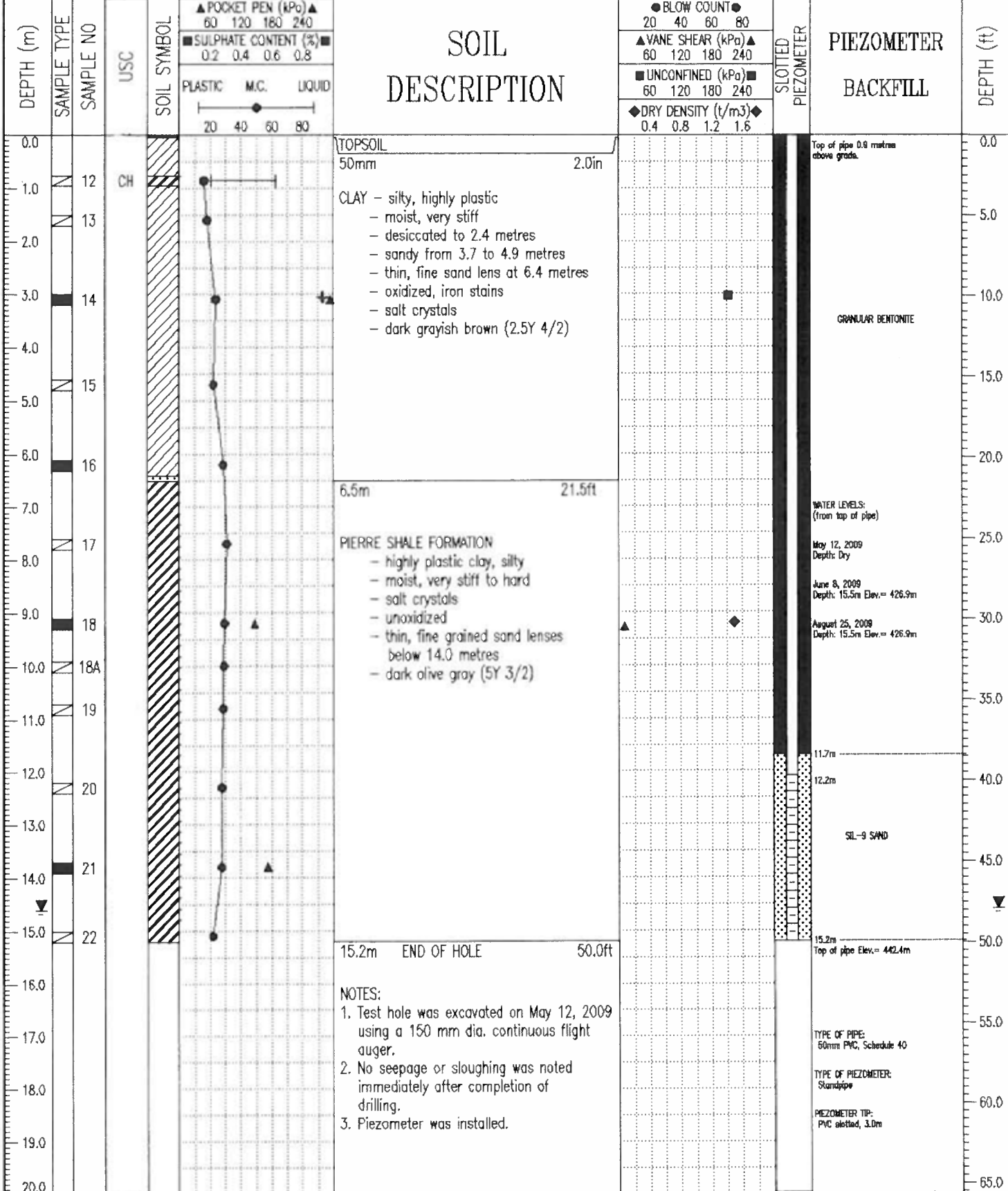
COMPLETE: 09/05/12

Page 1 of 1



PROJECT: PROP. RESIDENTIAL SUBDIVISION	LOCATION: 5685779 N; 14320396 E	TEST HOLE NO: 0923-TH108
CLIENT: SUN HILLS RESORT LTD.	LOCATION: N 1/2 35-26-30-W1M	PROJECT NO: GE-0923
DRILL RIG: BRAT 22 DIGGER	ELEVATION: 441.50 metres (GEODETIC)	ELEVATION: 441.50 (m)

SAMPLE TYPE  SHELBY TUBE  DISTURBED  SPT SAMPLE  PAIL SAMPLE  NO RECOVERY  JAR SAMPLE



<b>GE GROUND ENGINEERING LTD.</b> Regina, Saskatchewan	LOGGED BY: RY	COMPLETION DEPTH: 15.2 m
	REVIEWED BY: PW	COMPLETE: 09/05/12
	Fig. No: GE-0923-14	Page 1 of 1



**GRAIN SIZE CURVE**

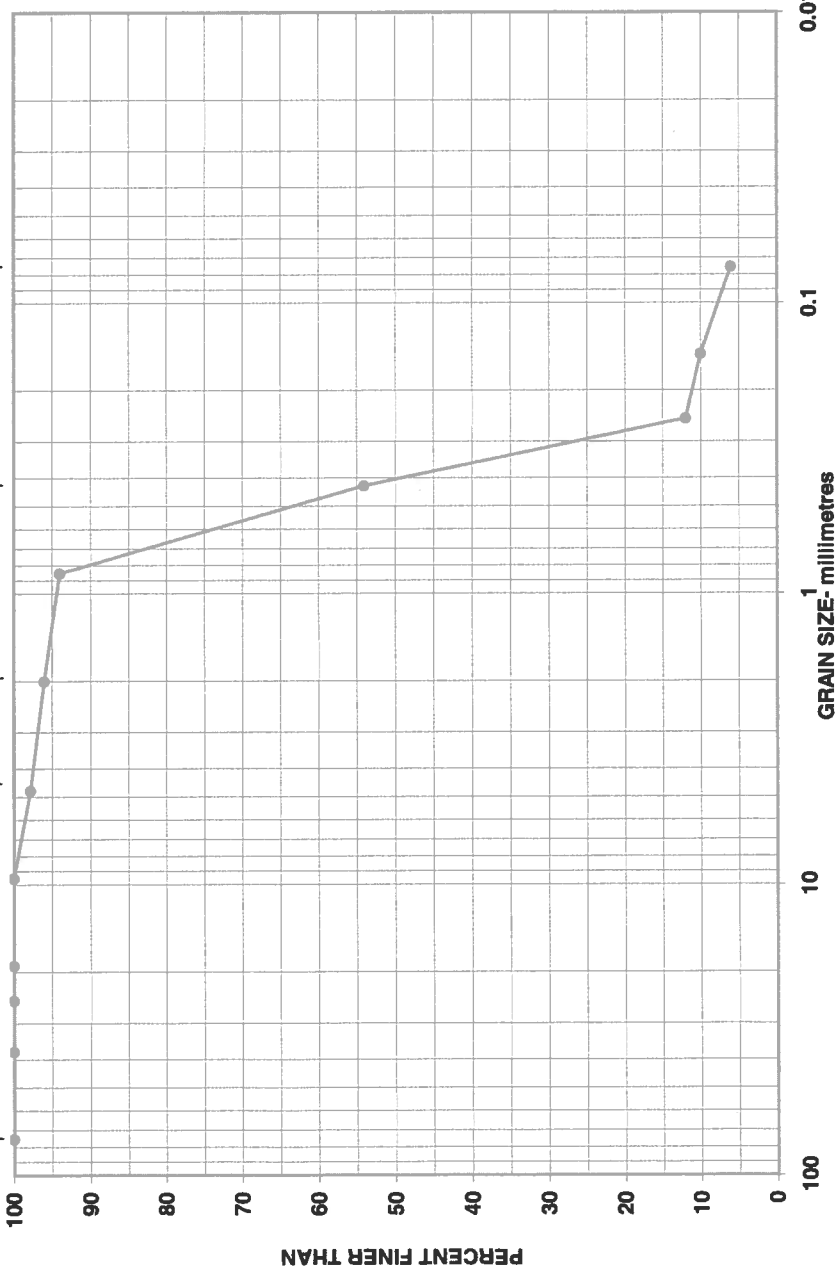
(A.S.T.M. C-136, C.S.A. A23.2-2A & 5A)

**JOB No:** GE-0923    **DATE:** May 19, 2009    **TECH:** K. WOLENSKY  
**CLIENT:** SUN HILLS RESORT LTD.  
**PROJECT:** GEOTECHNICAL INVESTIGATION - PROPOSED SUN HILLS RESORT  
**LOCATION:** LAKE OF THE PRAIRIES, SASKATCHEWAN

**GRAIN SIZE CATEGORIES AS DESIGNATED BY A.S.T.M.**

COBBLES	GRAVEL SIZES		SAND SIZES		SILT AND CLAY SIZES	
	COARSE		MEDIUM		FINE	

SIZE OF OPENING (mm)	SPECIFIED % FINER THAN	PERCENT FINER THAN
75.0		100
37.5		100
25.0		100
19.0		100
9.51		100
4.75		98
2.00		96
0.850		94
0.425		54
0.250		12
0.150		10
0.075		6



GRAIN SIZE CATEGORY	PARTICLE SIZE RANGE (mm)	PERCENT RETAINED
GRAVEL	75 to 4.75	2
COARSE SAND	4.75 to 2.0	2
MEDIUM SAND	2.0 to 0.425	42
FINE SAND	0.425 to 0.075	48
SILT & CLAY	< 0.075	6

**SAMPLE DESCRIPTION:** SAND, A LITTLE SILT AND CLAY, A TRACE OF GRAVEL

**MATERIAL SUPPLIED BY:** TEST HOLE 102    **SAMPLED BY:** R. YAREMKO OF GE GROUND ENGINEERING LTD.

**SAMPLE LOCATION:** 45 AT 5' BELOW GRADE    **DATE SAMPLED:** May 12, 2009

**DISTRIBUTION:**

WE CERTIFY TESTING PROCEDURES IN ACCORDANCE WITH  
 C.S.A. & A.S.T.M. STANDARDS FOR THAT PORTION  
 OF THE TESTING PERFORMED BY THIS COMPANY  
 GE GROUND ENGINEERING LTD.

Per: KELLY MAUNDER, A.Sc.T.

**JOB No:** GE-0923  
**CLIENT:** SUN HILLS RESORT LTD.  
**PROJECT:** GEOTECHNICAL INVESTIGATION - PROPOSED SUN HILLS RESORT  
**LOCATION:** LAKE OF THE PRAIRIES, SASKATCHEWAN

**DATE:** May 19, 2009  
**TECH:** K. WOLENSKY

**GRAIN SIZE CURVE**

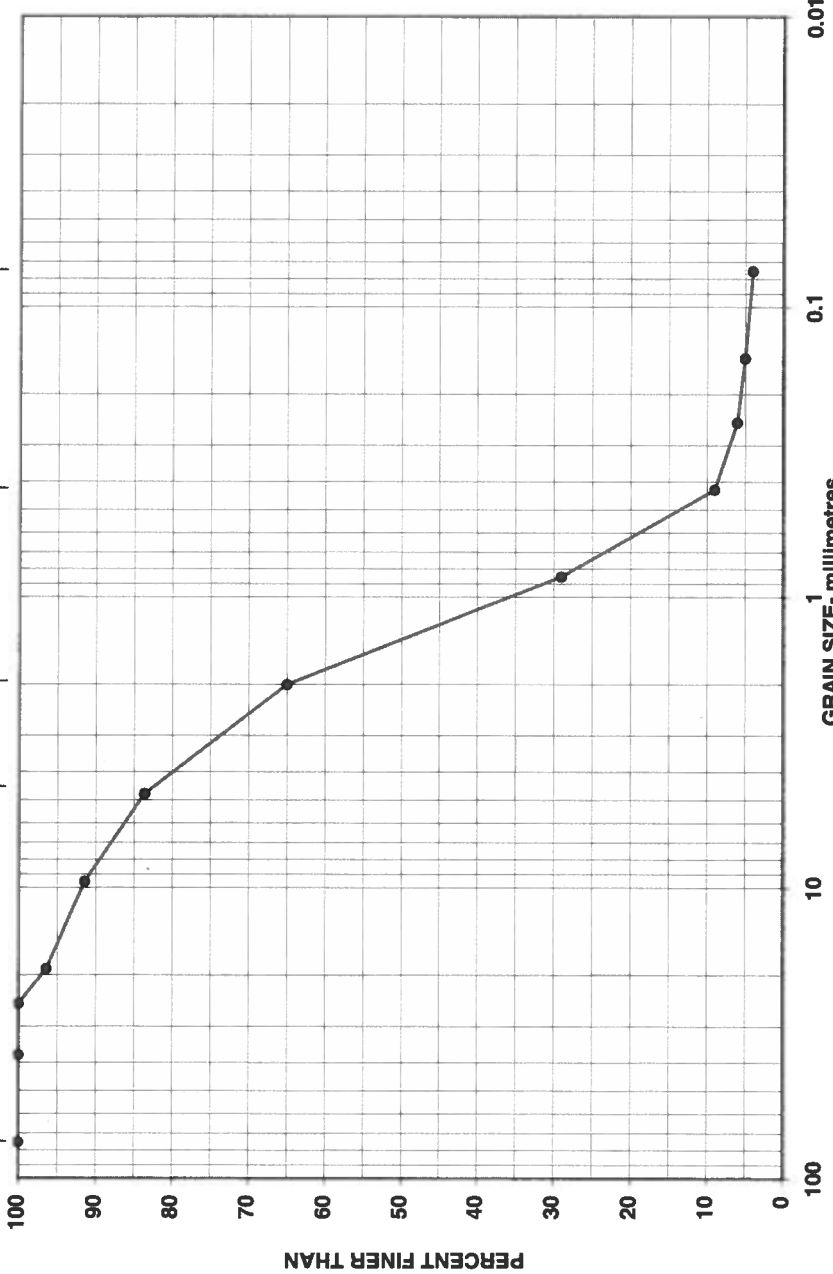
(A.S.T.M. C-136, C.S.A. A23.2.2A & 5A)

GRAIN SIZE CATEGORIES AS DESIGNATED BY A.S.T.M.

COBBLES	GRAVEL SIZES			SAND SIZES			SILT AND CLAY SIZES
	MEDIUM			FINE			

SIZE OF OPENING (mm)	SPECIFIED % FINER THAN	PERCENT FINER THAN
75.0		100
37.5		100
25.0		100
19.0		96
9.51		91
4.75		84
2.00		65
0.850		29
0.425		9
0.250		6
0.150		5
0.075		4

GRAIN SIZE CATEGORY	PARTICLE SIZE RANGE (mm)	PERCENT RETAINED
GRAVEL	75 to 4.75	16
COARSE SAND	4.75 to 2.0	19
MEDIUM SAND	2.0 to 0.425	56
FINE SAND	0.425 to 0.075	5
SILT & CLAY	< 0.075	4



**SAMPLE DESCRIPTION :** SAND, SOME GRAVEL, A TRACE OF SILT AND CLAY.

**MATERIAL SUPPLIED BY:**

**SAMPLE LOCATION:** TEST HOLE 104

**SAMPLE NUMBER:** 66 AT 2.5' BELOW GRADE **DATE SAMPLED :** May 12, 2009

**DISTRIBUTION:**

**SAMPLED BY :** R. YAREMKO OF GE GROUND ENGINEERING LTD.

WE CERTIFY TESTING PROCEDURES IN ACCORDANCE WITH  
 C.S.A. & A.S.T.M. STANDARDS FOR THAT PORTION  
 OF THE TESTING PERFORMED BY THIS COMPANY  
 GE GROUND ENGINEERING LTD.

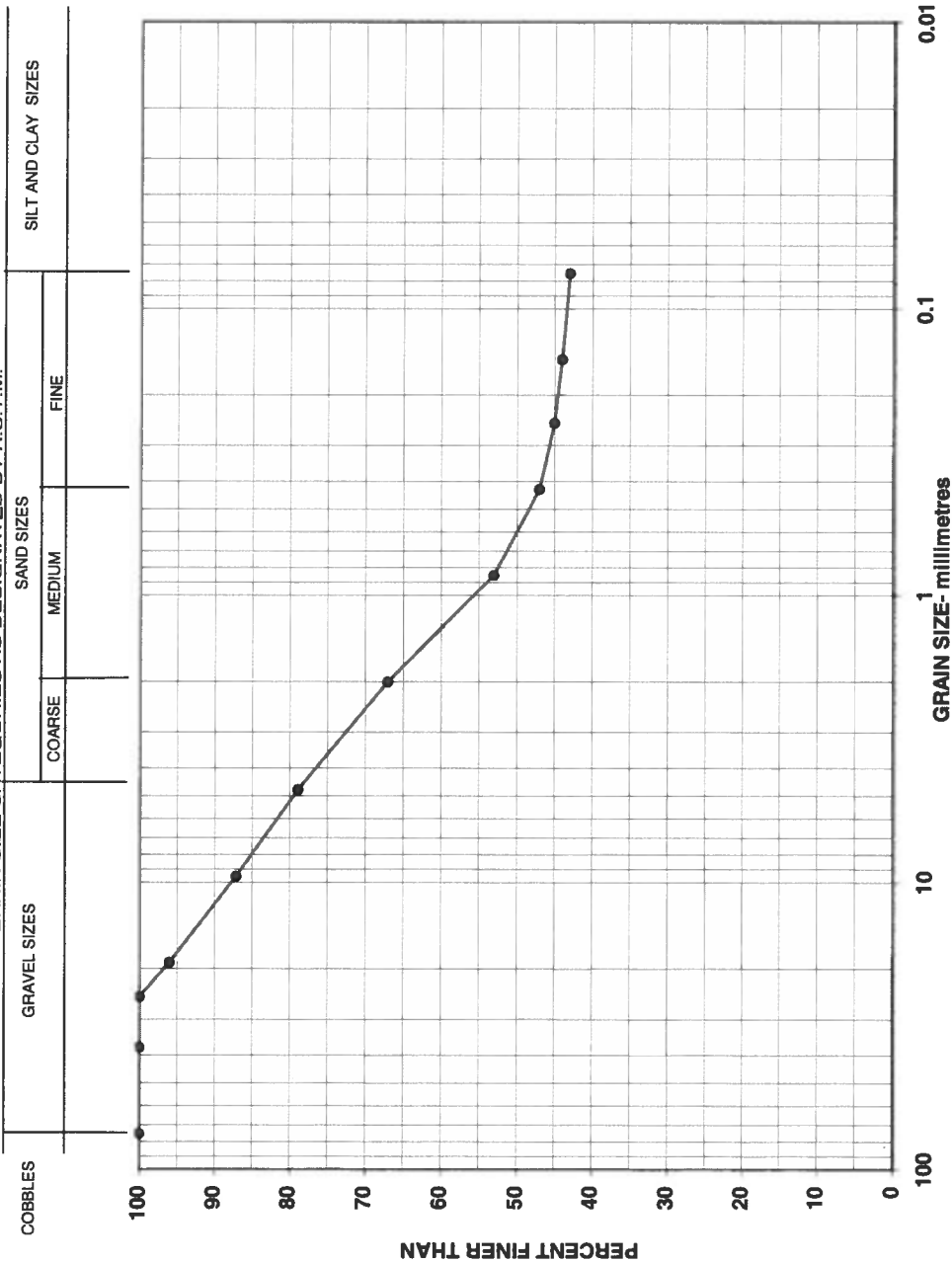
Per: \_\_\_\_\_  
 KELLY MAUNDER, A.Sc.T.

**GRAIN SIZE CURVE**

(A.S.T.M. C-136, C.S.A. A93.2-2A & 5A)

JOB No: GE-0923 DATE: May 19, 2009 TECH: K. WOLENSKY  
 CLIENT: SUN HILLS RESORT LTD.  
 PROJECT: GEOTECHNICAL INVESTIGATION - PROPOSED SUN HILLS RESORT  
 LOCATION: LAKE OF THE PRAIRIES, SASKATCHEWAN

GRAIN SIZE CATEGORIES AS DESIGNATED BY A.S.T.M.



SIZE OF OPENING (mm)	SPECIFIED % FINER THAN	PERCENT FINER THAN
75.0		100
37.5		100
25.0		100
19.0		96
9.51		87
4.75		79
2.00		67
0.850		53
0.425		47
0.250		45
0.150		44
0.075		43

GRAIN SIZE CATEGORY	PARTICLE SIZE RANGE (mm)	PERCENT RETAINED
GRAVEL	75 to 4.75	21
COARSE SAND	4.75 to 2.0	12
MEDIUM SAND	2.0 to 0.425	20
FINE SAND	0.425 to 0.075	4
SILT & CLAY	< 0.075	43

SAMPLE DESCRIPTION : SILT AND CLAY WITH SAND, A LITTLE GRAVEL

MATERIAL SUPPLIED BY :

SAMPLE LOCATION: TEST HOLE 105

SAMPLE NUMBER: 78 AT 5' BELOW GRADE DATE SAMPLED : May 12, 2009

DISTRIBUTION:

SAMPLED BY : R. YAREMKO OF GE GROUND ENGINEERING LTD.

SAMPLED BY : R. YAREMKO OF GE GROUND ENGINEERING LTD.

WE CERTIFY TESTING PROCEDURES IN ACCORDANCE WITH  
 C.S.A. & A.S.T.M. STANDARDS FOR THAT PORTION  
 OF THE TESTING PERFORMED BY THIS COMPANY  
 GE GROUND ENGINEERING LTD.

Per: \_\_\_\_\_  
 KELLY MAUNDER, A.Sc.T.

**JOB No:** GE-0923  
**CLIENT:** SUN HILLS RESORT LTD.  
**PROJECT:** GEOTECHNICAL INVESTIGATION - PROPOSED SUN HILLS RESORT  
**LOCATION:** LAKE OF THE PRAIRIES, SASKATCHEWAN

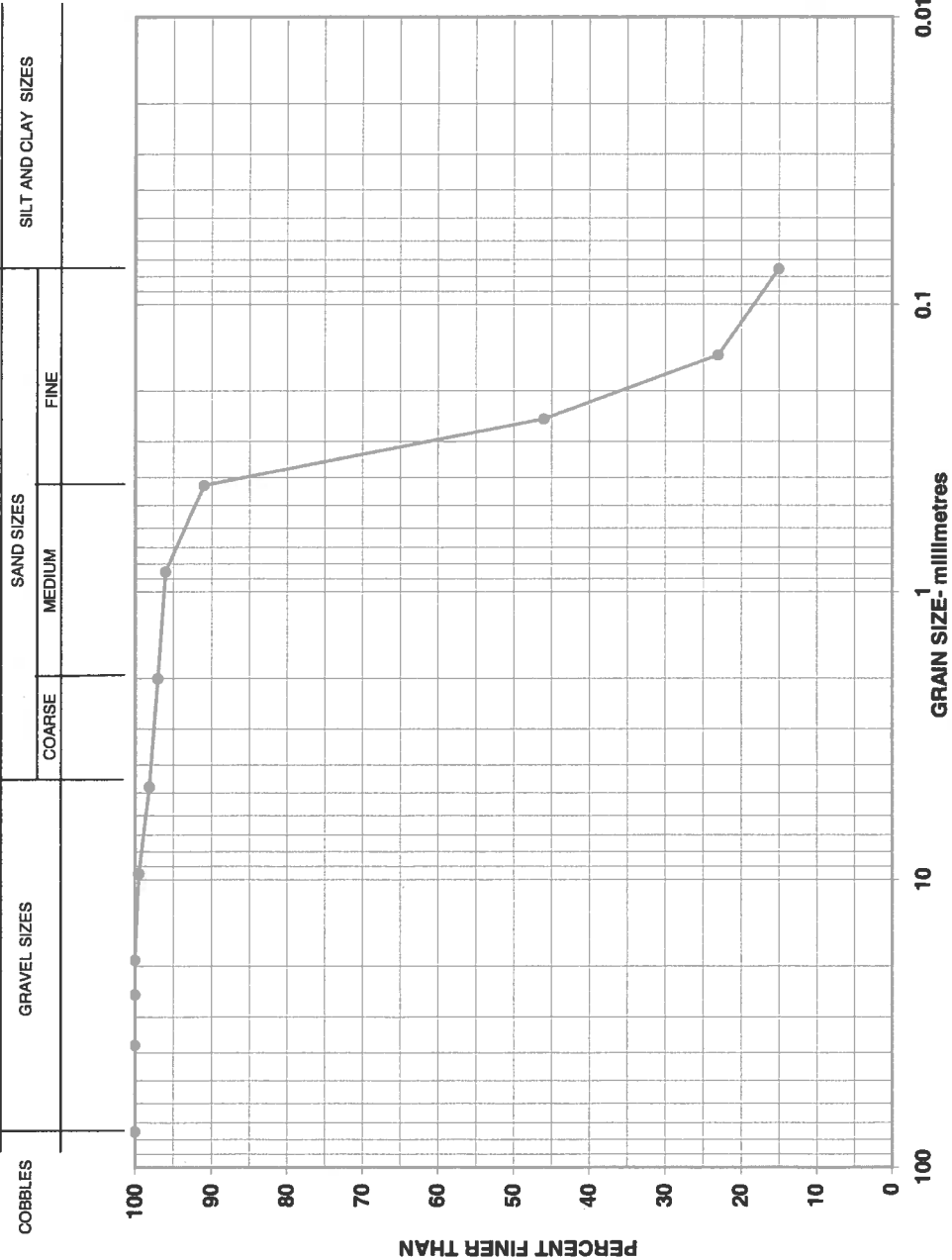
**DATE:** May 20, 2009  
**TECH:** N. EDWARDS

**Per:** \_\_\_\_\_  
 KELLY MAUNDER, A.Sc.T.

**GRAIN SIZE CURVE**

(A.S.T.M. C-136, C.S.A. A23.2-2A & 5A)

GRAIN SIZE CATEGORIES AS DESIGNATED BY A.S.T.M.



SIZE OF OPENING (mm)	SPECIFIED % FINER THAN	PERCENT FINER THAN
75.0		100
37.5		100
25.0		100
19.0		100
9.51		100
4.75		98
2.00		97
0.850		96
0.425		91
0.250		46
0.150		23
0.075		15

GRAIN SIZE CATEGORY	PARTICLE SIZE RANGE (mm)	PERCENT RETAINED
GRAVEL	75 to 4.75	2
COARSE SAND	4.75 to 2.0	1
MEDIUM SAND	2.0 to 0.425	6
FINE SAND	0.425 to 0.075	76
SILT & CLAY	< 0.075	15

**SAMPLE DESCRIPTION:** SAND, SOME SILT AND CLAY, A TRACE OF GRAVEL.

**MATERIAL SUPPLIED BY:** \_\_\_\_\_

**SAMPLED BY:** R. YAREMKO OF GE GROUND ENGINEERING LTD.

**SAMPLE LOCATION:** TEST HOLE 107

WE CERTIFY TESTING PROCEDURES IN ACCORDANCE WITH C.S.A. & A.S.T.M. STANDARDS FOR THAT PORTION OF THE TESTING PERFORMED BY THIS COMPANY GE GROUND ENGINEERING LTD.

**SAMPLE NUMBER:** 24A AT 7.5' BELOW GRADE

**DATE SAMPLED:** May 12, 2009

**DISTRIBUTION:** \_\_\_\_\_

**\* GUIDE FOR USE OF SULPHATE RESISTANT CEMENT (TYPE V)**

**Concentration of Sulphates Expressed as SO<sub>3</sub>**

Class	In Soil		In Ground-Water	Types of cement and limiting mix proportions for dense, fully compacted concrete and special protective measures when necessary (note 2). The cement contents shown apply to 20mm maximum size aggregate which should comply with BS 1047.
	Total SO <sub>3</sub>	SO <sub>3</sub> in 1:1 Water Extract		
1	Less Than 0.2%		Less Than 30 Parts / 100 000	Ordinary Portland cement or Portland blastfurnace cement. For structural reinforced concrete work; minimum cement content 280 kg/m <sup>3</sup> (475 lbs./cu. yd.); maximum free water/cement ratio 0.55 by weight. For plain concrete, these recommendations may be relaxed.
2	0.2% to 0.5%		30-120 parts / 100 000	See Note 1. (a) Ordinary Portland cement or Portland blastfurnace cement. Minimum cement content 330 kg/m <sup>3</sup> (560 lbs./cu. yd.); maximum free water/cement ratio 0.50 by weight. (b) Sulphate-resistant Portland cement. Minimum cement content 280 kg/m <sup>3</sup> (475 lbs./cu. yd.); maximum free water/cement ratio 0.50 by weight. (c) Supersulphated cement. Minimum cement content 310 kg/m <sup>3</sup> (525 lbs./cu. yd.); maximum free water/cement ratio 0.50 by weight.
3	0.5% to 1.0%	2.5-5.0 g/litre	120-250 parts / 100 000	Sulphate-resisting Portland cement, supersulphated cement or high alumina cement. Minimum cement content 330 kg/m <sup>3</sup> (560 lbs./cu. yd.); maximum free water/cement ratio 0.50 by weight.
4	1.0% to 2.0%	5.0-10.0 g/litre	250-500 parts / 100 000	(a) Sulphate-resisting Portland cement or supersulphated cement. Minimum cement content 370 kg/m <sup>3</sup> (625 lbs./cu. yd.) maximum free water/cement ratio 0.45 by weight. (b) High alumina cement. Minimum cement content 340 kg/m <sup>3</sup> (575 lbs./cu. yd.); maximum free water/cement ratio 0.45 by weight.
5	Over 2%	Over 10 g/litre	Over 500 parts / 100 000	Either cements described in 4(a) plus adequate protective coatings of inert material such as asphalt or bituminous emulsions reinforced with fibreglass membranes, or high alumina cement with a minimum cement content of 370kg/m <sup>3</sup> (625 lbs./cu. yd.); maximum free water/cement ratio 0.40 by weight.

**NOTES:**

- The cement contents given in class 2 are the minima recommended by the manufacturers. For SO<sub>3</sub> contents near the upper limit of class 2, cement contents above these minima are advised.
- For severe conditions, e.g. thin sections, sections under hydrostatic pressure on one side only and sections partly immersed, consideration should be given to a further reduction of water/cement ratio and, if necessary, an increase in cement content to ensure the degree of workability needed for full compaction and thus minimum permeability.

\* REFERENCE - Portland Cement Association

## **APPENDIX A**

Safety Factor



- 1.080
- 1.240
- 1.400
- 1.560
- 1.720
- 1.880
- 2.040
- 2.200
- 2.360
- 2.520
- 2.680
- 2.840
- 3.000
- 3.160
- 3.320
- 3.480
- 3.640
- 3.800
- 3.960
- 4.120
- 4.280
- 4.440
- 4.600
- 4.760
- 4.920



GEODETIC ELEVATION (METRES)

550  
500  
450  
400  
350  
300  
250

-150 -100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

DISTANCE (METRES)

GE-0923 - CROSS SECTION '1-1'  
PROPOSED RESIDENTIAL SUBDIVISION  
N 35-26-30-W1M  
LAKE OF THE PRAIRIES, SASKATCHEWAN

-200

-400

-200

0

200

400

600

800

1000

1200

Safety Factor

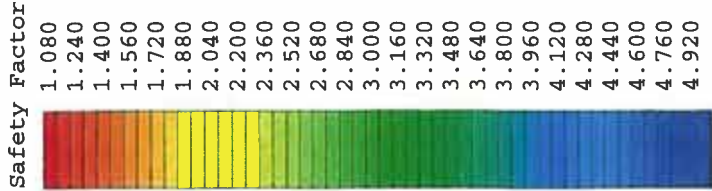


DISTANCE (METRES)  
-150-100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

GE-0923 - CROSS SECTION '2-2'  
PROPOSED RESIDENTIAL SUBDIVISION  
N 35-26-30-W1M  
LAKE OF THE PRAIRIES, SASKATCHEWAN







DISTANCE (METRES)

GE-0923 - CROSS SECTION '3-3'  
 PROPOSED RESIDENTIAL SUBDIVISION  
 N 35-26-30-W1M  
 LAKE OF THE PRAIRIES, SASKATCHEWAN

-150 -100 -50 0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000

550  
500  
450  
400  
350  
300  
250

GEOTECTIC ELEVATION (METRES)

-400 -200 0 200 400 600 800 1000