P. MACHIBRODA ENGINEERING LTD.

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GEOTECHNICAL INVESTIGATION JOUSSARD CLIMATE STATION WITHIN NW-1/4-23-73-13-W5M MUNICIPAL DISTRICT OF BIG LAKES, ALBERTA

PMEL FILE NO. A13-2314

FEBRUARY 7, 2014

PREPARED FOR:

STEPHENS KOZAK ACI ARCHITECTS AND PLANNERS
#200, 16814 114 AVENUE
EDMONTON, ALBERTA
T5M 3S2

ATTENTION: MR. ERIC LUMLEY

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1.0 INTRODUCTION

The following report has been prepared on the subsurface soil conditions existing at site of the proposed Joussard Climate Station to be constructed within NW-1/4-23-73-13-W5M, in the Municipal District of Big Lakes, Alberta.

Authorization to conduct this investigation was provided on December 12, 2013 by Mr. Eric Lumley of Stephens Kozak ACI Architects and Planners. The Terms of Reference for this investigation were presented in P. Machibroda Engineering Ltd. (PMEL) Proposal No. 1210-2664, dated December 10, 2013.

The field test drilling and soil sampling were conducted on January 14, 2014.

2.0 FIELD INVESTIGATION

Seven test holes, located as shown on the Site Plan, Drawing No. A13-2314-1, were dry drilled using our limited access, continuous flight, solid stem auger drill rig. The test holes were 150 mm in diameter and were extended to depths of 3 to 4.5 metres below the existing ground surface.

Test hole drill logs were compiled during test drilling to record the soil stratification, the groundwater conditions, the position of unstable sloughing soils and the depths at which cobblestones and/or boulders were encountered.

Both relatively undisturbed and disturbed soil samples were collected during test drilling. Relatively undisturbed soil samples were collected by hydraulically pushing thin walled (Shelby) tubes into the bottom of the test hole as drilling advanced. The Shelby tubes were sealed with polyethylene bags to minimize moisture loss. Disturbed samples of auger cuttings, collected during test drilling, were sealed in plastic bags to minimize moisture loss. The soil samples were taken to our laboratory for analysis.

3.0 FIELD DRILL LOGS

The field drill logs recorded during test drilling have been shown plotted on Drawing Nos. A13-2314-2 to 8, inclusive.

The ground surface elevation at each Test Hole location was reference to a bolt on the existing power pole (approximately 1.8 metres above the existing ground surface), located approximately as shown on the Site Plan, Drawing No. A13-2314-1. A datum elevation of 100.00 metres was assumed for bolt on the powerpole.

3.1 Soil Profile

The general subgrade soil conditions consisted of organic topsoil (100 to 600 mm thick) overlying glacial till, which extended to a depth of at least 4.5 metres below existing ground surface, the maximum depth explored with our test holes at this site. Inter/intra silt and sand seams/layers were encountered within the glacial till stratum.

Clay shale was encountered in Test Hole No. 13-2 at a depth of 2.8 metres below existing ground surface.

3.2 Groundwater Conditions, Sloughing

The test holes remained open and dry during and immediately after test drilling.

3.3 Cobblestones, Boulders and Bedrock

Cobblestones/boulders were encountered in Test Hole No. 13-3 at a depth of approximately 3.4 metres below existing ground surface.

Clay shale (bedrock) was encountered in Test Hole No. 13-2 at a depth of 2.8 metres below ground surface.

The glacial till consisted of a heterogeneous mixture of gravel, sand, silt and clay-sized particles. The glacial till strata also contained sorted deposits of the above particle sizes. In addition to the sorted deposits, a random distribution of larger particle sizes in the cobblestone range (60 to 200 mm) and boulder-sized range (larger than 200 mm) were encountered during test drilling.

It should be recognized that the statistical probability of encountering cobblestones and/or boulders in the small diameter Test Holes drilled at this site was low. Intertill deposits of cobblestones, boulders, boulder pavements and isolated deposits of saturated sand or gravel should be anticipated. The frequency of encountering such deposits will increase proportionately with the number of holes drilled and/or volume excavated.

4.0 LABORATORY ANALYSIS

The soil classification and index tests performed during this investigation consisted of a visual classification of the soil, water contents, unit weights, Atterberg limits, unconfined compressive strengths and grain size distribution analysis.

The results of soil classification and index tests conducted on representative samples of soil recovered from this site have been plotted on the drill logs alongside the corresponding depths at which the samples were recovered as shown on Drawing Nos. A13-2314-2 to 8, inclusive.

The results of the grain size distribution analyses have been shown plotted on Drawing Nos. A13-2314-9 to 11, inclusive.

5.0 DESIGN RECOMMENDATIONS

Based on the foregoing outline of soil test results, the following foundation design considerations and recommendations have been presented.

5.1 Design Considerations

It is understood that the Joussard Climate Station will consists of an access road and a gravel pad area.

The general subgrade soil conditions consisted of organic topsoil overlying glacial till to the maximum depth explored. Clay shale was encountered in Test Hole No. 13-2. The subgrade soils are frost susceptible and the average depth of frost penetration for the Joussard area is approximately 2.5 metres.

Recommendations have been prepared for site preparation; gravel pad area and access road.

5.2 Site Preparation

All organic topsoil and deleterious materials should be removed from the site. Staining and root intrusion from the overlying organic material and roots may be encountered during excavation within the subsurface mineral soils. If these conditions are encountered, a representative of the geotechnical consultant should inspect the site during excavation to verify the depth of organic topsoil which should be removed. In addition to organic topsoil, all loose fill and other deleterious materials should also be removed. See Appendix B for further information in regards to topsoil composition and soil structure.

The surface of the subgrade should be leveled and compacted to the following minimum density requirements.

Roadway/Pad Areas	96 percent of standard Proctor density at optimum moisture content.
Landscape Areas	90 percent of standard Proctor density at optimum moisture content.

Fill, required to bring the subgrade soil to the design subgrade elevation in the roadway area, should preferably consist of granular soil or local soil (glacial till). The fill should be placed in thin lifts (maximum 150 mm loose) and compacted to 98 percent of standard Proctor density at optimum moisture content. All fill materials should be approved by the Geotechnical Consultant prior to use.

5.3 Gravel Pad Area and Access Road

The following minimum recommendations should be incorporated into the design of the gravel pad area and access road.

1. All topsoil, organics and other deleterious materials should be removed from the proposed construction area.

2. Scarify the upper 150 mm of the subgrade soil, moisture condition and compact to 96 percent of standard Proctor density at optimum moisture content. If wet and/or unworkable areas of weak subgrade are encountered, the soft areas should be excavated and replaced with non-expansive fine grained soils and compacted to 96 percent of standard Proctor density.

3. The need for special measures (i.e., overexcavation, geotextile, geogrid, cement stabilization and/or gravel fill) in soft areas must be subject to review by the Geotechnical Consultant during field construction. Based on the actual conditions encountered at the time of construction, the pavement structure may need to be modified to accommodate the construction equipment and the intended use. To minimize disturbance of the subgrade soil, all necessary excavation should be performed with a backhoe or gradall equipment. The excavating/hauling equipment should not be allowed to travel on the prepared subgrade. The use of light equipment will be required for moisture conditioning, levelling and compaction of the uppermost 150 mm of the subgrade at final design elevation. The granular sub-base should be placed by the end-dump method to avoid heavily loaded traffic on the prepared subgrade.

4. As a subgrade support, the California Bearing Ratio (CBR) rating of the compacted subgrade soil should be in the order of 3. Based on the CBR rating, the following pavement structures have been presented in Table I.

TABLE I. THICKNESS DESIGN

Structure	**Gravel Area Pad (mm)**	**Light Truck/Passenger Vehicle Traffic Wheel Loading (1,830 kg) (mm)**
Granular Base (Min CBR = 80)	100	100
Granular Sub-Base (Min CBR =20)	250	250
Prepared Subgrade	(150)	(150)
Geotextile	As Required	As Required
Total Thickness	**350**	**350**

5. Subgrade fill, if required, should consist of imported granular material. Subgrade fill should be placed in thin lifts (150 mm loose, maximum) and compacted to 96 percent of standard Proctor density at optimum moisture content.

6. All granular fill placed above the subgrade elevation should be placed in thin lifts (150 mm loose) and compacted to 98 percent of standard Proctor density. The granular base and sub-base course material should meet the aggregate gradation requirements presented in Table II.

TABLE II. AGGREGATE GRADATION REQUIREMENTS

GRAIN SIZE (mm)	PERCENT PASSING	
	*BASE COURSE	**SUB-BASE COURSE
80.0	--	100
50.0	--	55-100
25.0	100	38-100
20.0	82-97	
16.0	70-94	32-85
10.0	52-79	
5.0	35-64	20-65
1.25	18-43	
0.630	12-34	
0.315	8-26	6-30
0.160	5-18	
0.080	2-10	2-10
Plasticity Index (%)	0 -6	0-8
CBR (min.)	80	25
% Fracture (min.)	60	--

*Alberta Transportation – Designation 2, Class 25
**Alberta Transportation – Designation 6, Class 80

7. Positive surface drainage is recommended to reduce the potential for moisture infiltration through the pad/roadway structure.

8. Surface water should be prevented from seeping back under the outer edges of the roadway structure.

9. Periodic maintenance such gravel regrading will be required.

6.0 LIMITATIONS

The presentation of the summary of the field drill logs and design recommendations has been completed as authorized. Seven, 150 mm diameter test holes were dry drilled using a continuous flight auger drill rig. Field drill logs were compiled for the Test Holes during test drilling which, we believe, were representative of the subsurface conditions at the Test Hole locations at the time of test drilling.

Variations in the subsurface conditions from that shown on the drill logs at locations other than the exact test hole locations should be anticipated. If conditions should differ from those reported here, then we should be notified immediately in order that we may examine the conditions in the field and reassess our recommendations in the light of any new findings.

No detectable evidence of environmentally sensitive materials such as hydrocarbon odour was detected during the actual time of the field test drilling program. If on the basis of any knowledge, other than that formally communicated to us, there is reason to suspect that environmentally sensitive materials may exist, then additional test holes should be drilled and samples recovered for chemical analysis.

The subsurface investigation necessitated the drilling of deep test holes. The test holes were backfilled at the completion of test drilling. Please be advised that some settlement of the backfill materials will occur which may leave a depression or an open hole. It is the responsibility of the client to inspect the site and backfill, as required, to ensure that the ground surface at each Test Hole location is maintained level with the existing grade.

This report has been prepared for the exclusive use of Stephens Kozak ACI Architects and Planners and their agents for specific application to the Joussard Climate Station to be constructed within NW-1/4-23-73-13-W5M, in the Municipal District of Big Lakes, Alberta. It has been prepared in accordance with generally accepted geotechnical engineering practices and no other warranty, express or implied, is made.

Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, is the responsibility of such Third Parties. Governing Agencies such as municipal, provincial or federal agencies having jurisdiction with respect to this development and/or construction of the facilities described herein have full jurisdiction with respect to the described development. Any other unspecified subsequent development would be considered Third Party and would, therefore, require prior review by PMEL. PMEL accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

The acceptance of responsibility for the design/construction recommendations presented in this report is contingent on adequate and/or full time inspection (as required, based on site conditions at the time of construction) by a representative of the Geotechnical Consultant. PMEL will not accept any responsibility on this project for any unsatisfactory performance if adequate and/or full time inspection is not performed by a representative of PMEL.

If this report has been transmitted electronically, it has been digitally signed and secured with personal passwords to lock the document. Due to the possibility of digital modification, only originally signed reports and those reports sent directly by PMEL can be relied upon without fault.

We trust that this report fulfills your requirements for this project. Please contact our office if you should require additional information.

P. MACHIBRODA ENGINEERING LTD.

Matthew LaBrecque, EIT.

PROFESSIONAL ENGINEER ALBERTA
JOEL FORD BLANCO
Feb. 7, 2014

Joel Ford Blanco, P. Eng.

PROFESSIONAL ENGINEER ALBERTA
P. MACHIBRODA
2014-02-07

Paul Machibroda, P. Eng., FCSCE
ML/JB:PM:zz:clb

PERMIT TO PRACTICE
P. Machibroda Engineering Ltd.
Signature P. Machibroda
Date 2014-02-07
PERMIT NUMBER: P-5862
The Association of Professional Engineers and Geoscientists of Alberta

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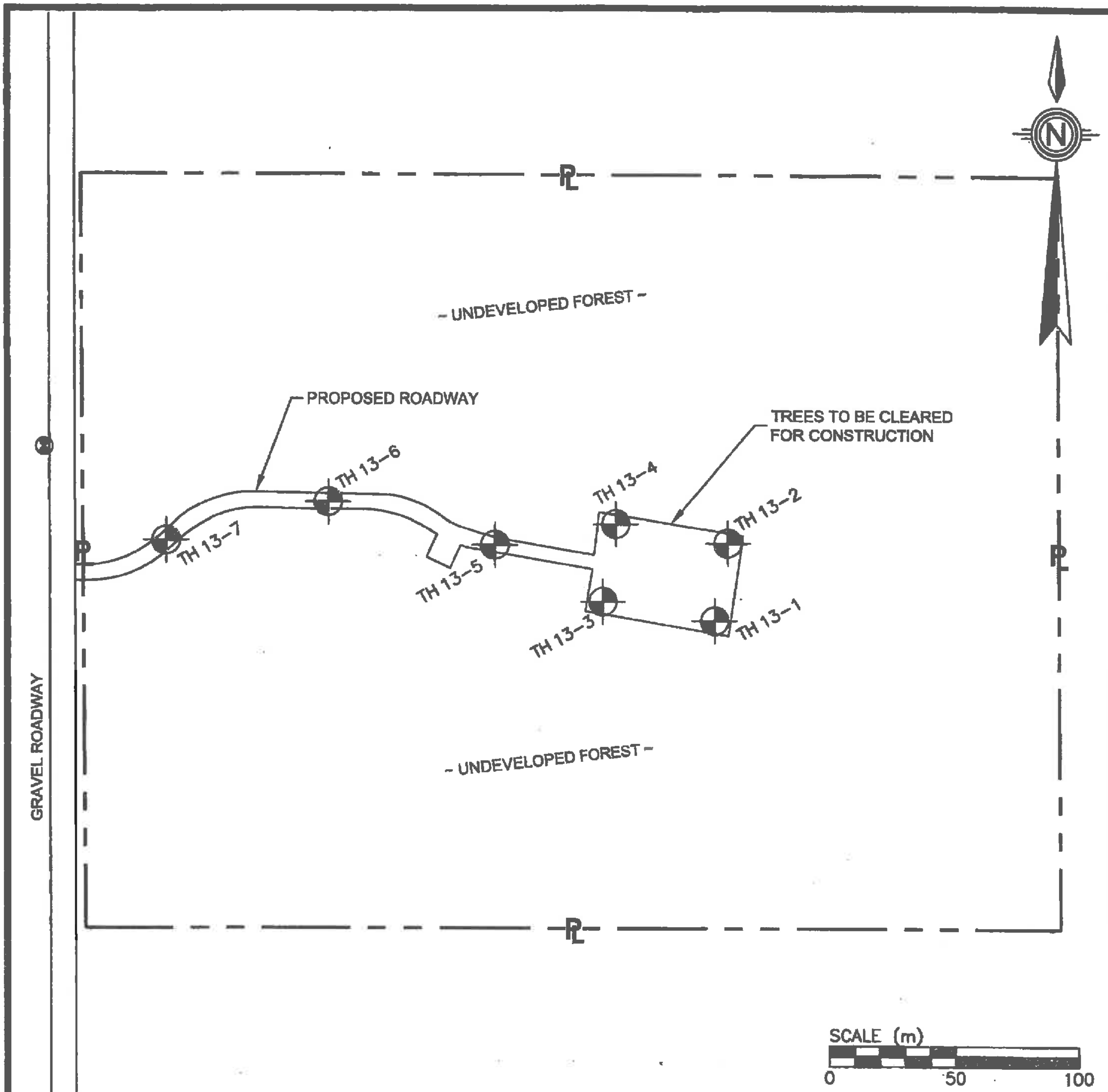
DRAWINGS



NOTE:
1. THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.
2. THIS DRAWING WAS COMPILED FROM A SITE PLAN PROVIDED BY STEPHENS KOZAK ACI ARCHITECTS AND PLANNERS, DRAWING No. W-A01.
3. BENCHMARK: BOLT ON EXISTING POWER POLE, 1.8 m ABOVE EXISTING GRADE, ASSUMED DATUM ELEVATION = 100.00 m.

LEGEND — PMEL TEST HOLE — BENCHMARK — PROPERTY LINE

CONSULTING GEOENVIRONMENTAL GEOTECHNICAL ENGINEERS

P. MACHIBRODA ENGINEERING LTD.

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DRAWING TITLE:

SITE PLAN - TEST HOLE LOCATIONS

PROJECT:

JOUSSARD CLIMATE STATION
WITHIN NW-1/4-23-73-13-W5M, M.D. OF BIG LAKES, AB

APPROVED BY:	DRAWN BY:	DRAWING NUMBER:
JB	BH	A13-2314-1
DATE: JANUARY, 2014	SCALE: 1:2000	

TEST HOLE 13-1

DEPTH (m)

N	U pp	γ_w	Pw	Lw	w	ELEV: 100.6 m
					40.5	**TOPSOIL,** organics, moist, black, rootlets, wood chips.
					22.0	**GLACIAL TILL,** clay, some silt, some sand, trace gravel, medium plastic, moist, brown. –frozen to 1.0 m. –stiff below 1.0 m.
					26.9	
					24.6	
						–grey below 3.5 m.
					18.0	

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

NOTE:
1. Test Hole open to 4.5 m and dry I.A.D.

LEGEND:

TOPSOIL, FILL, CLAY SHALE, SAND, SILT, CLAY, GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

SHELBY TUBE, SPLIT SPOON, CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

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FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT: JOUSSARD CLIMATE STATION

LOCATION: WITHIN NW-1/4-23-73-13-W5M, M.D. OF BIG LAKES, AB

NORTHING: 6133286 **EASTING:** 570078

DATE DRILLED: JAN 14/14

DRAWING NUMBER: A13-2314-2

TEST HOLE 13-2

DEPTH (m) | N | U (pp) | γ_w | Pw | Lw | w | ELEV: 100.0 m

DEPTH (m)	N	U pp	γ_w	Pw	Lw	w
~0.5				14	29	21.2
~1.0						19.6
~2.5			20.4			19.3
~3.0				18	38	19.5
~4.5						17.6

TOPSOIL, organics, moist, black, rootlets, wood chips.

GLACIAL TILL, clay, some silt, some sand, trace gravel, medium plastic, moist, brown.
- –sand pocket to 600 mm.
- –frozen to 1.0 m.
- –stiff below 1.0 m.

CLAY SHALE, silty, very stiff, medium plastic, moist, grey.

NOTE:
1. Test Hole open to 4.5 m and dry I.A.D.

LEGEND:

TOPSOIL, FILL, CLAY SHALE, SAND, SILT, CLAY, GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

SHELBY TUBE | SPLIT SPOON | CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

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FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT: JOUSSARD CLIMATE STATION

LOCATION: WITHIN NW-1/4-23-73-13-W5M, M.D. OF BIG LAKES, AB

NORTHING: 6133299 **EASTING:** 570092

DATE DRILLED: JAN 14/14

DRAWING NUMBER: A13-2314-3

TEST HOLE 13-3

DEPTH (m) | N | U (pp) | γ_w | Pw | Lw | w | ELEV: 99.8 m

Depth (m)	N	U / pp	γ_w	Pw	Lw	w
0.4				18	40	21.6
0.9						19.8
1.9						19.9
3.3			20.7			20.2
4.5						19.3

TOPSOIL, organics, moist, black, rootlets, wood chips.

GLACIAL TILL, clay, some silt, some sand, trace gravel, low plastic, moist, brown, oxide stained.
- laminated to 600 mm.
- gypsum crystals below 600 mm.
- frozen to 1.0 m.
- firm below 1.0 m.
- cobbles at 3.4 m.
- stiff, grey below 3.5 m.

NOTE:
1. Test Hole open to 4.5 m and dry I.A.D.

LEGEND:

TOPSOIL, FILL, CLAY SHALE, SAND, SILT, CLAY, GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

SHELBY TUBE — SPLIT SPOON — CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT: JOUSSARD CLIMATE STATION

LOCATION: WITHIN NW-1/4-23-73-13-W5M, M.D. OF BIG LAKES, AB

NORTHING: 6133288 **EASTING:** 570046

DATE DRILLED: JAN 14/14

DRAWING NUMBER: A13-2314-4

TEST HOLE 13-4

ELEV: 99.5 m

DEPTH (m)	N	U	γ_w	Pw	Lw	w	Description
0		pp					**TOPSOIL,** organics, moist, black, rootlets, wood chips.
				13	25	16.1	**GLACIAL TILL,** clay, some silt, some sand, trace gravel, firm, low plastic, moist, brown.
1						21.6	–sandy, frozen to 600 mm. –silty, laminated 600 mm to 1.5 m. –gypsum crystals below 900 mm. –stiff, medium plastic below 1.5 m.
2						20.5	
3						19.7	
4						21.3	

NOTE:
1. Test Hole open to 4.5 m and dry I.A.D.

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

LEGEND:

TOPSOIL, FILL, CLAY SHALE, SAND, SILT, CLAY, GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m^3)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm^2)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

SHELBY TUBE, SPLIT SPOON, CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

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FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT: JOUSSARD CLIMATE STATION

LOCATION: WITHIN NW-1/4-23-73-13-W5M, M.D. OF BIG LAKES, AB

NORTHING: 6133315 **EASTING:** 570064

DATE DRILLED: JAN 14/14

DRAWING NUMBER: A13-2314-5

TEST HOLE 13-5

ELEV: 99.0 m

DEPTH (m)	N	U (PP)	γ_w	Pw	Lw	w
				16	32	18.9
						20.8
						22.7
						22.9
3				16	32	25.0

DEPTH (m): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

TOPSOIL, organics, moist, black, rootlets, wood chips.

GLACIAL TILL, clay, some silt, some sand, trace gravel, medium plastic, moist, brown.
—sandy, frozen to 1.0 m.
—firm below 1.0 m.

—stiff below 1.5 m.

NOTE:
1. Test Hole open to 3.0 m and dry I.A.D.

LEGEND:

TOPSOIL, FILL, CLAY SHALE, SAND, SILT, CLAY, GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m^3)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm^2)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

SHELBY TUBE — SPLIT SPOON — CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT: JOUSSARD CLIMATE STATION

LOCATION: WITHIN NW-1/4-23-73-13-W5M, M.D. OF BIG LAKES, AB

NORTHING: 6133323 **EASTING:** 570002

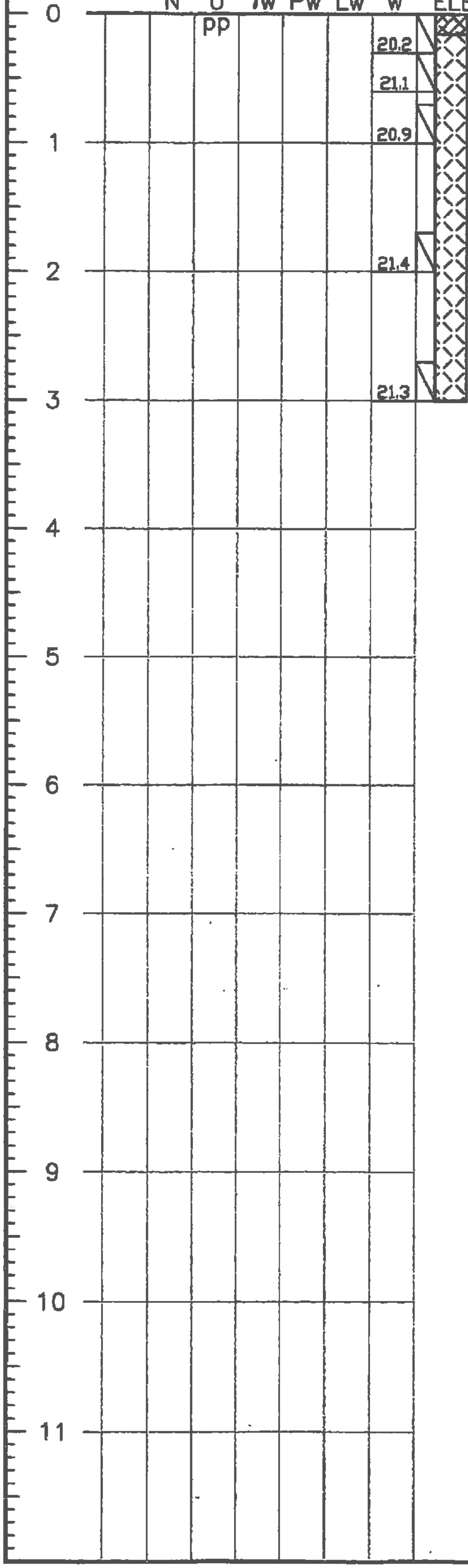
DATE DRILLED: JAN 14/14

DRAWING NUMBER: A13-2314-6

TEST HOLE 13-6

DEPTH (m)

N U γ_w Pw Lw w ELEV: 98.9 m

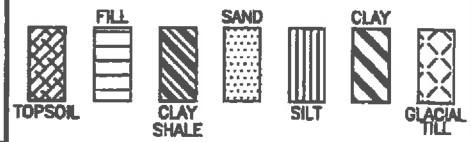


TOPSOIL, organics, moist, black.

GLACIAL TILL, clay, some silt, some sand, trace gravel, medium plastic, moist, brown.
—frozen to 1.0 m.
—stiff below 1.0 m.

NOTE:
1. Test Hole open to 3.0 m and dry I.A.D.

LEGEND:



w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m³)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm²)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4.....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT:
JOUSSARD CLIMATE STATION

LOCATION:
WITHIN NW-1/4-23-73-13-W5M,
M.D. OF BIG LAKES, AB

NORTHING: 6133330 **EASTING:** 569939

DATE DRILLED: JAN 14/14

DRAWING NUMBER: A13-2314-7

TEST HOLE 13-7

DEPTH (m) | N | U pp | γ_w | Pw | Lw | w | ELEV: 98.7 m

Depth (m)	N	U / pp	γ_w	Pw	Lw	w	Description
0				13	25	18.4	**TOPSOIL,** organics, moist, black.
						18.4	**GLACIAL TILL,** clay, some silt, some sand, trace gravel, firm, low plastic, moist, brown. —sandy, frozen to 500 mm. —medium plastic below 600 mm.
1						20.5	
2						20.9	
3						20.9	

NOTE:
1. Test Hole open to 3.0 m and dry I.A.D.

Depth scale: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

LEGEND:

TOPSOIL, FILL, CLAY SHALE, SAND, SILT, CLAY, GLACIAL TILL

w.....WATER CONTENT (PERCENT OF DRY SOIL WEIGHT)

Lw...LIQUID LIMIT

Pw...PLASTIC LIMIT

γ_w...WET UNIT WEIGHT (kN/m^3)

U.....UNCONFINED COMPRESSIVE STRENGTH (kPa)

pp...POCKET PENETROMETER (kg/cm^2)

N.....STANDARD PENETRATION TEST (SAFETY HAMMER w/AUTOMATIC TRIP) (50/125 = BLOWS/SAMPLER PENETRATION [mm])

SO_4 .....SULPHATE CONTENT (PERCENT OF DRY SOIL WEIGHT)

P200...% PASSING No. 200 SIEVE

I.A.D.....IMMEDIATELY AFTER DRILLING

▽...RECORDED WATER LEVEL (TEST HOLE I.A.D.)

▼...RECORDED WATER LEVEL (PIEZO)

SHELBY TUBE SPLIT SPOON CUTTINGS

LIMITATIONS: THE FIELD DRILL LOG IS A SUMMARY OF THE SUBSURFACE CONDITIONS ENCOUNTERED AT THE SPECIFIC TEST HOLE LOCATION AT THE TIME OF TEST DRILLING. SUBSURFACE CONDITIONS MAY VARY AT OTHER LOCATIONS OF THIS SITE AND, IN TIME, MAY CHANGE AT THIS SPECIFIC TEST HOLE LOCATION.

P. MACHIBRODA ENGINEERING LTD.

FIELD DRILL LOG AND SOIL TEST RESULTS

PROJECT: JOUSSARD CLIMATE STATION

LOCATION: WITHIN NW-1/4-23-73-13-W5M, M.D. OF BIG LAKES, AB

NORTHING: 6133313 **EASTING:** 569874

DATE DRILLED:	**DRAWING NUMBER:**
JAN 14/14	A13-2314-8

ASTM D422: GRAIN SIZE ANALYSIS OF SOIL

Project: Joussard Climate Station
Within NW-1/4-23-73-13-W5M, M.D. of Big Lakes, AB

Project No.: A13-2314

Date Tested: January 22, 2014

Test Hole No.: 14-2

Sample No.: 9

Depth (m): 3.0

Sieve Analysis:

Sieve	Diameter mm	% Finer
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.5	100
# 4	4.75	100
# 10	2.00	100
# 20	0.850	99
# 40	0.425	98.4
# 60	0.250	96.7
# 100	0.150	94.4
# 200	0.075	89.6

Hydrometer Analysis:

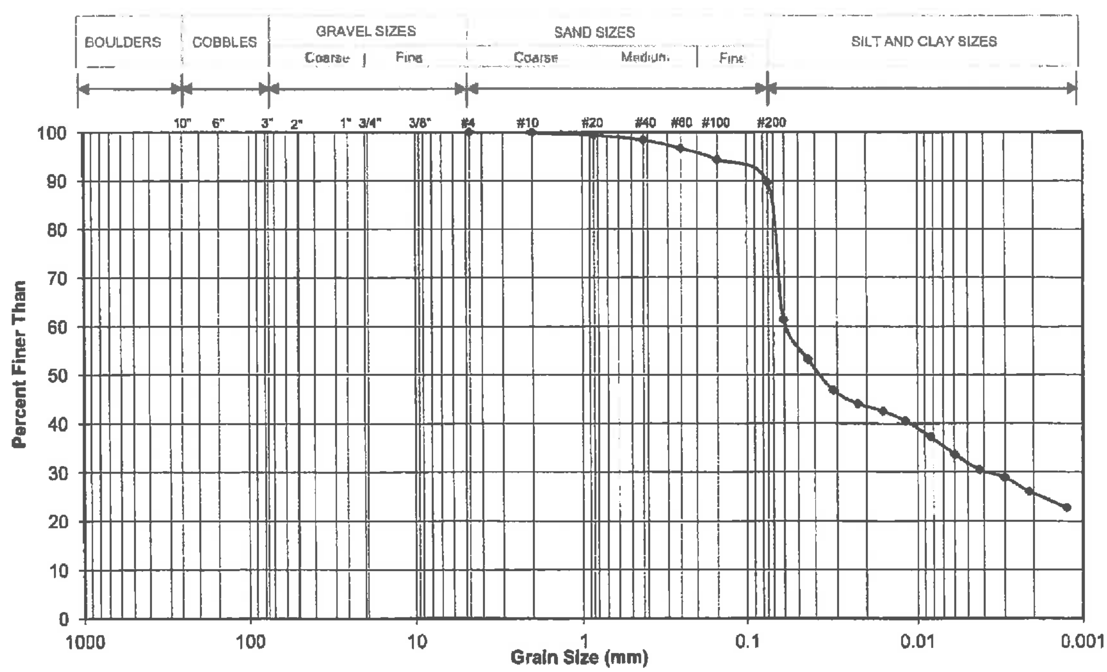
Dispersing Agent:
Sodium Hexametaphosphate

Diameter mm	% Finer
0.0607	61.4
0.0438	53.2
0.0314	46.8
0.0225	44.1
0.0160	42.6
0.0117	40.5
0.0083	37.3
0.0060	33.6
0.0042	30.5
0.0030	28.9
0.0021	26.1
0.0012	22.7

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt Sizes	% Clay Sizes
0	10	64	26

Remarks:



P. MACHIBRODA ENGINEERING LTD.

DRAWING NO.

A13-2314-9

ASTM D422: GRAIN SIZE ANALYSIS OF SOIL

Project: Joussard Climate Station
Within NW-1/4-23-73-13-W5M, M.D. of Big Lakes, AB

Project No.: A13-2314

Date Tested: January 22, 2014

Test Hole No.: 14-3

Sample No.: 11

Depth (m): 0.5

Sieve Analysis:

Sieve	Diameter mm	% Finer
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	96
3/8"	9.5	96
# 4	4.75	96
# 10	2.00	96
# 20	0.850	94
# 40	0.425	91.5
# 60	0.250	85.6
# 100	0.150	77.7
# 200	0.075	63.0

Hydrometer Analysis:

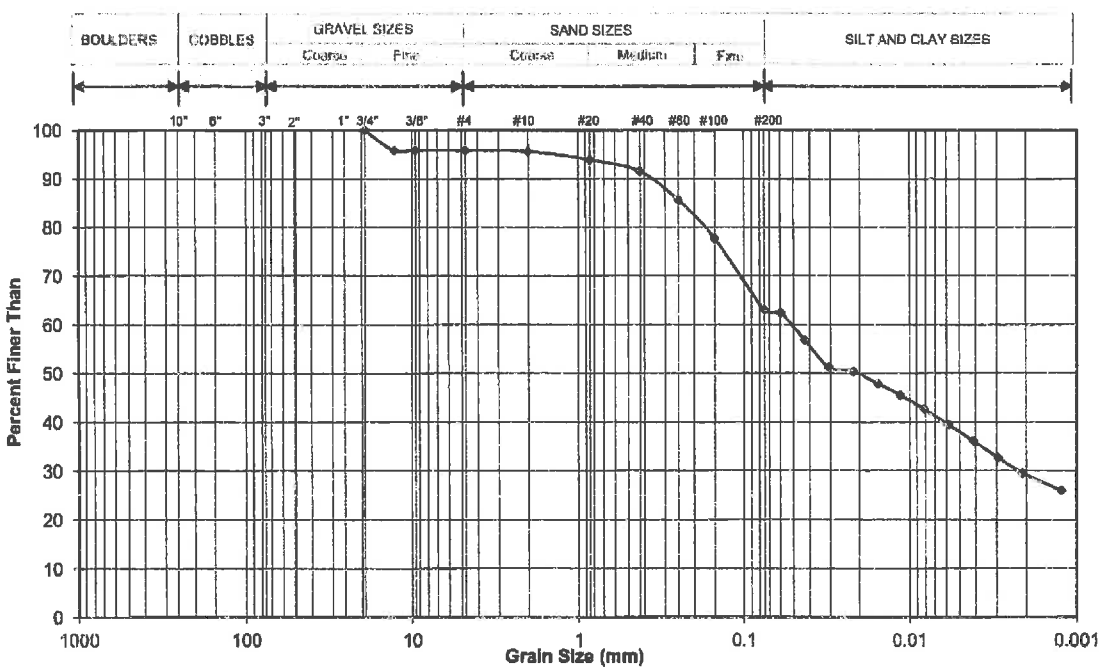
Dispersing Agent:
Sodium Hexametaphosphate

Diameter mm	% Finer
0.0598	62.4
0.0428	56.9
0.0306	51.3
0.0217	50.4
0.0155	47.9
0.0114	45.6
0.0081	42.7
0.0058	39.5
0.0041	36.1
0.0029	32.7
0.0021	29.5
0.0012	26.0

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt Sizes	% Clay Sizes
4	33	33	30

Remarks:



P. MACHIBRODA ENGINEERING LTD.

DRAWING NO.

A13-2314-10

ASTM D422: GRAIN SIZE ANALYSIS OF SOIL

Project: Joussard Climate Station
Within NW-1/4-23-73-13-W5M, M.D. of Big Lakes, AB

Project No.: A13-2314

Date Tested: January 22, 2014

Test Hole No.: 14-5

Sample No.: 25

Depth (m): 3.0

Sieve Analysis:

Sieve	Diameter mm	% Finer
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.5	100
# 4	4.75	100
# 10	2.00	100
# 20	0.850	95
# 40	0.425	88.2
# 60	0.250	79.3
# 100	0.150	74.0
# 200	0.075	66.4

Hydrometer Analysis:

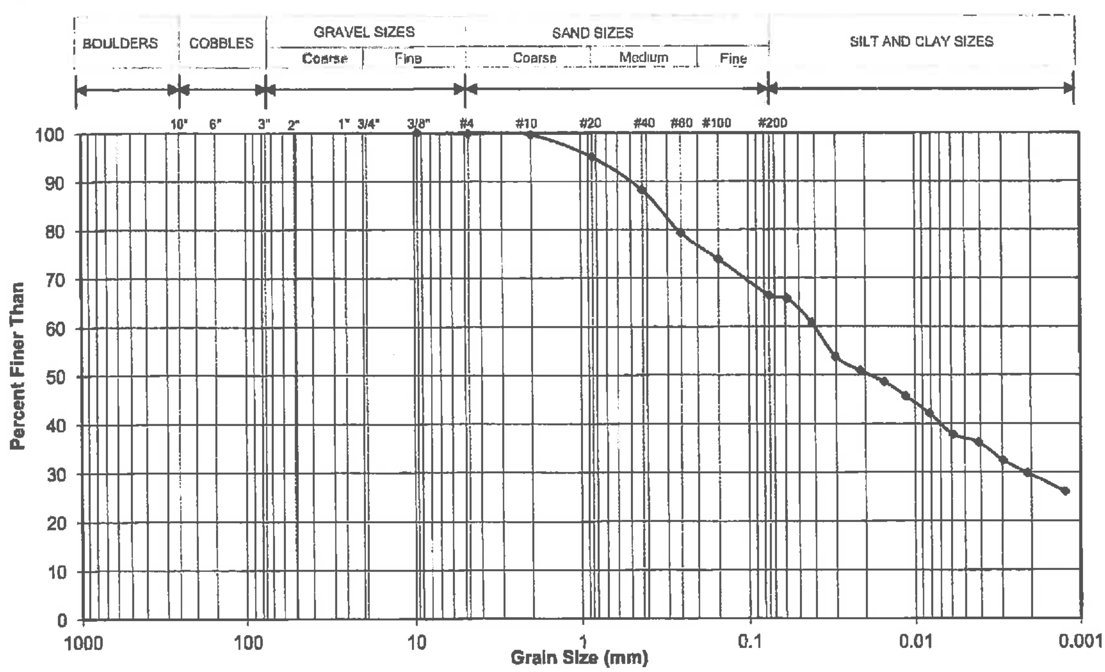
Dispersing Agent:
Sodium Hexametaphosphate

Diameter mm	% Finer
0.0587	65.8
0.0419	60.8
0.0302	53.8
0.0215	51.0
0.0154	48.6
0.0114	45.7
0.0081	42.2
0.0059	37.8
0.0041	36.2
0.0030	32.4
0.0021	29.9
0.0012	26.1

Material Description:

% Gravel Sizes	% Sand Sizes	% Silt Sizes	% Clay Sizes
0	33	37	30

Remarks:



P. MACHIBRODA ENGINEERING LTD.

DRAWING NO.

A13-2314-11

APPENDIX A

EXPLANATION OF TERMS ON TEST HOLE LOGS

CLASSIFICATION OF SOILS

Coarse-Grained Soils: Soils containing particles that are visible to the naked eye. They include gravels and sands and are generally referred to as cohesionless or non-cohesive soils. Coarse-grained soils are soils having more than 50 percent of the dry weight larger than particle size 0.080 mm.

Fine-Grained Soils: Soils containing particles that are not visible to the naked eye. They include silts and clays. Fine-grained soils are soils having more than 50 percent of the dry weight smaller than particle size 0.080 mm.

Organic Soils: Soils containing a high natural organic content.

Soil Classification By Particle Size

Clay – particles of size	< 0.002 mm
Silt – particles of size	0.002 – 0.060 mm
Sand – particles of size	0.06 – 2.0 mm
Gravel – particles of size	2.0 – 60 mm
Cobbles – particles of size	60 – 200 mm
Boulders – particles of size	>200 mm

TERMS DESCRIBING CONSISTENCY OR CONDITION

Coarse-grained soils: Described in terms of compactness condition and are often interpreted from the results of a Standard Penetration Test (SPT). The standard penetration test is described as the number of blows, N, required to drive a 51 mm outside diameter (O.D.) split barrel sampler into the soil a distance of 0.3 m (from 0.15 m to 0.45 m) with a 63.5 kg weight having a free fall of 0.76 m.

Compactness Condition	SPT N-Index (blows per 0.3 m)
Very loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	Over 50

Fine-Grained Soils: Classified in relation to undrained shear strength.

Consistency	Undrained Shear Strength (kPa)	N Value (Approximate)	Field Identification
Very Soft	<12	0-2	Easily penetrated several centimetres by the fist.
Soft	12-25	2-4	Easily penetrated several centimetres by the thumb.
Firm	25-50	4-8	Can be penetrated several centimetres by the thumb with moderate effort.
Stiff	50-100	8-15	Readily indented by the thumb, but penetrated only with great effort.
Very Stiff	100-200	15-30	Readily indented by the thumb nail.
Hard	>200	>30	Indented with difficulty by the thumbnail.

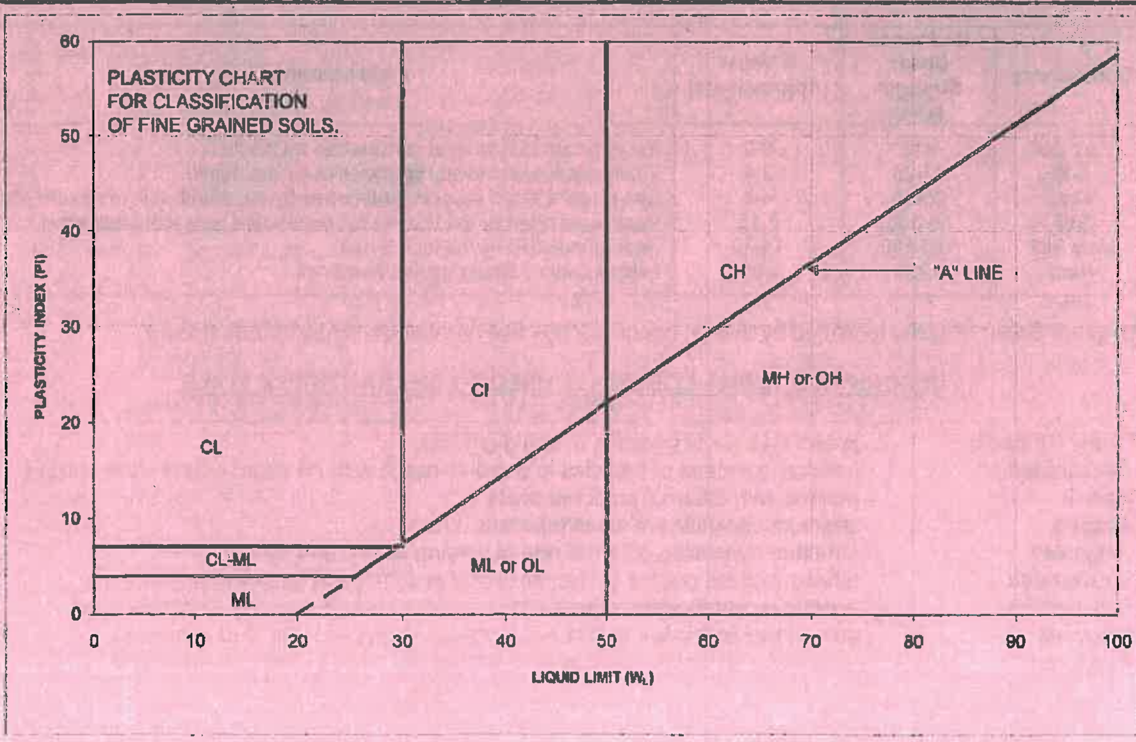
Organic Soils: Readily identified by colour, odour, spongy feel and frequently by fibrous texture.

DESCRIPTIVE TERMS COMMONLY USED TO CHARACTERIZE SOILS

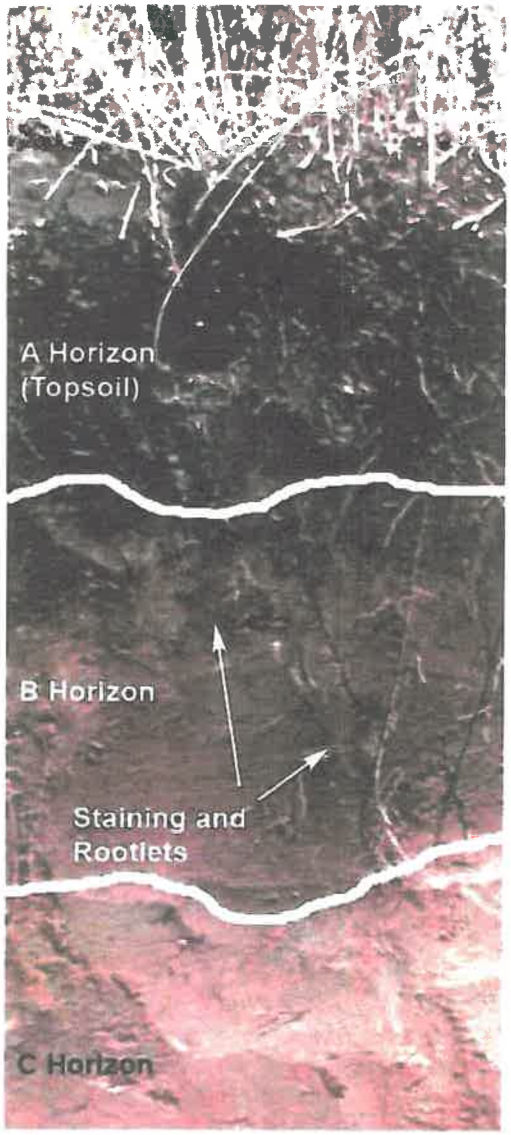
Poorly Graded	- predominance of particles of one grain size.
Well Graded	- having no excess of particles in any size range with no intermediate sizes lacking.
Mottled	- marked with different coloured spots.
Nuggety	- structure consisting of small prismatic cubes.
Laminated	- structure consisting of thin layers of varying colour and texture.
Slickensided	- having inclined planes of weakness that are slick and glossy in appearance.
Fissured	- containing shrinkage cracks.
Fractured	- broken by randomly oriented interconnecting cracks in all 3 dimensions.

SOIL CLASSIFICATION SYSTEM (MODIFIED U.S.C.)

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR AND OFTEN FIBROUS TEXTURE
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN NO. 200 SIEVE SIZE)	GRAVELS More than half coarse fraction larger than No. 4 sieve size	CLEAN GRAVELS	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES <5% FINES	$C_u = \frac{D_{60}}{D_{10}} > 4$ $C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}} = 1$ to 3
			GP	POORLY-GRADED GRAVELS AND GRAVEL-SAND MIXTURES <5% FINES	NOT MEETING ALL ABOVE REQUIREMENTS FOR GW
		DIRTY GRAVELS	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES >12% FINES	ATTERBERG LIMITS BELOW "A" LINE OR PI < 4
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES >12% FINES	ATTERBERG LIMITS ABOVE "A" LINE WITH PI > 7
	SANDS More than half coarse fraction smaller than No. 4 sieve size	CLEAN SANDS	SW	WELL-GRADED SANDS, GRAVELLY SANDS MIXTURES <5% FINES	$C_u = \frac{D_{60}}{D_{10}} > 6$ $C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}} = 1$ to 3
			SP	POORLY-GRADED SANDS OR GRAVELLY SANDS <5% FINES	NOT MEETING ALL GRADATION REQUIREMENTS FOR SW
		DIRTY SANDS	SM	SILTY SANDS, SAND-SILT MIXTURES >12% FINES	ATTERBERG LIMITS BELOW "A" LINE OR PI < 4
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES >12% FINES	ATTERBERG LIMITS ABOVE "A" LINE WITH PI >7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSING NO. 200 SIEVE SIZE)	SILTS Below "A" line on plasticity chart; negligible organic content		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	$W_L < 50$
			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	$W_L > 50$
	CLAYS Above "A" line on plasticity chart; negligible organic content		CL	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS	$W_L < 30$
			CI	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS	$W_L > 30 < 50$
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	$W_L > 50$
	ORGANIC SILTS & ORGANIC CLAYS Below "A" line on plasticity chart		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	$W_L < 50$
			OH	ORGANIC CLAYS OF HIGH PLASTICITY	$W_L > 50$



APPENDIX B
TOPSOIL, ORGANIC MATTER, ORGANICS



A Horizon

The A horizon is the topsoil layer of the soil strata. It is characterized by a build up of organic matter, and a lower unit weight than subsequent layers. The organic matter content of this layer is typically 4-10% by mass.

The colour of this horizon varies from dark black to brown, depending on surface vegetation and climatic conditions.

B Horizon

Typically reddish brown in colour and contains accumulations of matter that have been washed down from the A Horizon. The B horizon is generally composed of clay that has been washed out of the A Horizon, but can also contain iron, calcium and sodium deposits as well.

C Horizon

Unweathered parent soil.

Topsoil is a mixture of mineral soil and organic matter. The organic matter is developed from decaying biological material (leaves, grass, trees, animals, etc.) and contributes to the brown to black colour of the soil. Following the topsoil is the B horizon which is a transition layer, where staining from the overlying topsoil is common. This results in a darker colour of the soil immediately below the organic topsoil layer. Depending on the surface vegetation, rootlets may be present below the depth of topsoil. However it should be recognized that these rootlets are not the same as organic matter in topsoil.

Physically speaking in comparison to mineral soil, topsoil has a significantly lower bulk density and a lower unit weight as compared to the underlying parent soil. This is due to larger pore spaces and non mineral materials in the soil matrix. Along with lower density, topsoil is often spongy and colloidal/fibrous. The following figure is of a typical prairie soil. Each horizon is labelled accordingly to demonstrate a typical soil profile.

Reference

Henry L. 2003. Henry's Handbook of Soil and Water, Henry Perspectives, Saskatoon, SK.