THURBER ENGINEERING LTD.

GEOTECHNICAL INVESTIGATION
PROTECTION MOUNTAIN CAMPGROUND IMPROVEMENT
BANFF NATIONAL PARK, AB

Report
to
O2 Planning + Design Inc.

Mathew Stenhouse, E.I.T.
Project Engineer

PERMIT TO PRACTICE
THURBER ENGINEERING LTD.
Signature
Date Feb. 25/16
PERMIT NUMBER: P 5186
The Association of Professional Engineers, Geologists and Geophysicists of Alberta

PROFESSIONAL ENGINEER ALBERTA
CORLIN D. SMITH
Feb. 25/16

Date: February 25, 2016
File: 10039

Corlin Smith, P. Eng.
Review Principal

THURBER

TABLE OF CONTENTS

THURBER

1. INTRODUCTION

1.1 General

This report presents the results of a geotechnical investigation completed by Thurber Engineering Ltd. (Thurber) for the Protection Mountain Campground Improvement project in Banff National Park, Alberta.

The investigation was carried out in general accordance with our proposal letter to Mr. Michael Magnan, MArch, BSc. of O2 Planning + Design Inc. on November 25, 2015.

1.2 Proposed Development

The location of the Protection Mountain Campground Improvement project is shown on Figures 1 and 2 in Appendix A.

The project primarily involves re-designing the current campground layout. The conceptual design includes upgrading the existing ring road, replacing the existing camping loops with RV camping pads and construction of new camping loops. The campground is currently not in use and construction is scheduled for summer/fall 2016.

1.3 Scope of Work

Thurber's scope of work was as follows:

- Review of existing geological information available for the project area,
- Assessment of subgrade soil conditions for design of the new pavement structure using a test pitting program,
- Assessment of the subsurface conditions for possible relocation of existing buried utilities,
- Provision of a geotechnical report summarizing the findings and providing geotechnical design recommendations for the proposed development including site preparation, sub-grade construction, cut/fill and utility installation backfill, road structure designs, etc.

Assessment of environmental issues or provision of any site survey was not within Thurber's scope of services.

2. METHOD OF INVESTIGATION

2.1 Field Program

Prior to the field investigation, Thurber coordinated with Alberta-One-Call and a private utility locator to confirm that there were no utility conflicts at the proposed test pit locations. Thurber also obtained the necessary permits to work within the National Park.

Six test pits were selected for the investigation as shown on Figure 2. The test pits were excavated on January 6, 2016, under the supervision of Mr. Mathew Stenhouse, E.I.T of Thurber, using a CAT 318E excavator owned and operated by Prairie Pride Construction of Canmore, AB.

Each test pit was visually logged, noting material type and soil layer thicknesses, as well as any zones of seepage or sloughing ground conditions. Representative soil samples were obtained for further laboratory testing.

John Gibbons of Parks Canada requested that any frozen soils excavated at the surface be placed at the bottom of the excavation for test pits that were located directly on the cross country ski track that was built on the existing ring road. All other excavated soils were kept separated by material type and were placed back in the excavation in the same order that they were removed. The soil was placed in 0.5 m thick lifts and bucket compacted. All test pit locations were surfaced with topsoil that was removed during the excavation and covered with snow as per John's request.

Test pit logs describing the observed soil stratigraphy at each test pit location and an explanation of the symbols and terms used on the test pit logs are provided in Appendix B.

2.2 Laboratory Testing

Laboratory testing included visual classification and determination of the natural moisture content of all soil samples. Atterberg Limits, gradation analysis, water soluble soil sulphate, Standard Proctor and CBR tests were performed on selected soil samples. Laboratory test results are presented on the test pit logs in Appendix B. Detailed laboratory test results are also provided in Appendix C.

THURBER

3. SITE CONDITIONS

3.1 Surface Conditions

The topography of the project site is relatively flat and is sparsely vegetated with shrubs and trees. Most of the native trees have been clear-cut and their stumps remain protruding up from the ground throughout the site. The existing roads and camp pads are surfaced with gravel. The site was covered with snow at the time of investigation.

During utility locates no underground utilities were noted within the areas swept near the test pit locations.

3.2 Sub-Surface and Groundwater Conditions

TP16-1 was located on the existing ring road. At the time of the excavation the upper 600 mm of soil was frozen. The current road structure consisted of approximately 150 mm of gravel underlain by a layer of clay and sand.

The upper most layer of soil encountered for all remaining test pits (TP16-2, 3, 4, 5, and 6) was topsoil with a heavy presence of organics (i.e. wood, grass, roots, etc.) mixed in with clay or sand. This organic layer typically ranged between 0.15 m and 0.4 m in thickness at the test pit locations. It was generally underlain by a layer of clay or sand to the termination depth of each test pit, except at TP16-6 where a layer of cobbles and gravel was encountered between 0.9 m and 2.1 m below surface.

The topsoil thickness shown on the test pit logs should not be used for stripping volume estimates, as there is a high risk that the estimated volume may substantially vary from the actual volume removed during construction.

Further descriptions of soils encountered are provided on the test pit logs in Appendix B.

Groundwater seepage was not observed in any of the test pits during the relatively short duration they were left open.

THURBER

4. GEOTECHNICAL EVALUATION AND RECOMMENDATIONS

4.1 General

The proposed development primarily involves resurfacing the existing gravel ring road, constructing new sections of interior roads, new tent and RV pads/sites. The results of this investigation indicate that the subsurface soils to the termination depths of test pits were comprised of clay, sand, and cobbles. Based on this, the site soil conditions are suitable for the proposed development.

Geotechnical design and construction recommendations for site grading, cut/fills, utility installation and road/pad surfaces are presented in the following sections.

4.2 Site Grading and Subgrade Preparation

All existing topsoil or any other deleterious material should be stripped over the entire footprint of proposed roads and camp sites that are to be surfaced with gravel. The exposed surface should be inspected to confirm that a suitable subgrade has been achieved. This should entail proof-rolling the area using a heavily loaded truck to identify possible soft/loose spots or other areas of concern. Any identified soft or loose material should be sub-excavated and backfilled with better quality fill materials.

The subgrade should be scarified to a minimum depth of 200 mm and re-compacted to a minimum 98% of Standard Proctor Maximum Dry Density (SPMDD), within ±2% of Optimum Moisture Content (OMC). It is recommended that the finished subgrade surface be sloped at a minimum of 1% towards perimeter ditches. The purpose of this is to drain any subsurface water from the subgrade and thereby prevent ponding of water which could result in swelling, softening, and/or possible frost heaving of the subgrade.

If additional fill material is required, it should be free of any organic or other deleterious materials and should be pre-approved by a geotechnical engineer prior to placement. The fill should be placed in 200 mm maximum thick lifts, and compacted to a minimum 98% of SPMDD, within ±2% of OMC.

It is advised that existing graveled roads or pads that will be resurfaced with gravel are proof rolled under the supervision of qualified geotechnical personnel to identify any soft spots prior to the placement of any new gravel structures.

4.3 Cut/Fill Construction

Given the site topography, only shallow cuts or fills are expected during construction. Parts of the existing road structure are expected to be demolished and the soils contained within them may be used as fill elsewhere onsite.

In fill areas, all topsoil or any other deleterious materials should be removed from within the footprint of the proposed fills prior to fill placement. Fill should be placed and compacted as described above. It is expected that fill material will typically consist of clay and sand obtained from on-site cuts and possibly from unidentified off-site borrow sources. If borrow materials are used, all borrow material should be unfrozen and free of organics, snow and ice. The borrow material should also be at a suitable moisture content for compaction.

4.4 Gravel Structure Design

The recommended gravel structure for the roads and camping pads/parking areas throughout the campground is provided in Table 1.

Table 1. Granular Structures

Material	New Roads Design Thickness (mm)		Preliminary Existing Ring Road Overlay Design Thickness (mm)		Camping Pads Design Thickness (mm)
	Conventional Design	With Geogrid	Conventional Design	With Geogrid	Conventional Design
Granular Surfacing	100	50	50	50	100
Granular Base	275	200[1]	175	150[2]	175
Total Thickness	**375**	**250**	**225**	**200**	**275**

Notes: 1 - Tensar BX1100 or equivalent. Geogrid placed at the middle of Granular Base layer.
2 - Tensar BX1100 or equivalent. Geogrid placed on top of the existing road structure.

An assessment of the gravel ring road could not be completed as the gravel was frozen and covered with snow at the time of the investigation. Additional recommendations on reusing existing gravel can be provided upon inspection in spring/summer once the road thaws and the snow cover melts.

A proof roll test should be completed by qualified geotechnical personnel to assess the existing road conditions to determine if there are any soft areas prior to the addition of any gravel overlays. It should also be noted that some areas within the road may have organic growth or material (i.e. pine needles, grass, roots, etc.) that will have to be removed prior to placing additional gravel.

The Surfacing Course and Base Course should consist of well graded granular materials and be compacted to a minimum of 98% of the SPMDD within ±2% of OMC. Typical gradation for Surfacing and Base Courses are provided in Table 2 and Table 3, respectively. Other granular materials can also be considered but should be pre-approved by a geotechnical engineer before use.

Table 2. Surfacing Gravel Gradation

Sieve Size (mm)	% Passing
25	100
10	30-77
5	15-55
1.25	0-30
0.08	0-12

In addition, Surfacing gravel should meet the following criteria:

- LA Abrasion Loss: Max. 45%
- % Fracture by weight: Min. 40%
- Plasticity Index: Max. 8

Table 3. Base Course Gradation

Sieve Size (mm)	% Passing
80	100
50	55-100
25	38-100
16	32-85
5	20-65
0.315	6-30
0.08	2-10

In addition, Base Course gravel should meet the following criteria:

- LA Abrasion Loss: Max. 45%
- % Fracture by weight: Min. 20%
- Plasticity Index: Max. 8

4.5 Utility Installations

It is understood that the target depth of excavation for the installation of utilities is between 1.2 m and 2.5 m. Groundwater is generally not expected to be a significant concern above 3 m and if present, could be handled by a sump and pump system during installation.

All excavations should be made in compliance with the Alberta Occupational Health and Safety regulations.

Shallow excavations should be excavated no steeper than 1H:1V, though flatter slopes may be required in areas where sand and gravel was encountered. In areas of clay it may be possible to excavate the lower 1.5 m of the excavation vertically, though this should be confirmed at the time of construction. Any stockpiled material should be kept back from the top of the slope by a distance greater than the depth of the excavation.

If steeper slopes are excavated, a portable trench shield should be used to protect workmen when working in the trenches and the trenches should be backfilled as soon as possible to avoid trench collapse.

It is understood that new water services are to be installed. For pipe installation, the pipe bedding and backfilling should be performed in accordance with the requirements of the pipe supplier. The bedding and backfill material should be placed in 150 mm layers and compacted to a minimum of 95% of SPMDD within the pipe zone. Backfill material placed above the pipe zone should be compacted to a minimum of 98% of SPMDD within ±2% of OMC.

4.6 Cement Type

The water-soluble sulphate tests performed on the soil samples indicated a negligible potential for sulphate attack on the subsurface concrete. On this basis, Type GU or equivalent hydraulic cement can be used in concrete placed in contact with native soils. Air entrainment should also be included in concrete exposed to freeze-thaw cycles to enhance its durability as specified in CSA A23.1-14. Any imported fill that will be in contact with concrete should also be tested for water-soluble sulphate content.

5. GEOTECHNICAL REVIEW AND CONSTRUCTION INSPECTION

It is recommended that details of the design drawings be reviewed by a geotechnical engineer before they are finalized and issued for tender. It is recommended that inspections be provided by qualified geotechnical/materials personnel during construction. Compaction testing and materials qualification testing should be carried out as required to ensure compliance with the contract specifications.

6. LIMITATIONS AND THE USE OF THE REPORT

Designers and contractors undertaking or bidding the work should examine the factual results of this investigation, satisfy themselves as to the adequacy of the information for design and construction, and make their own interpretation of the data as it may affect their proposed scope of work, cost, schedule, safety, and equipment capabilities. There is a possibility that this report may form part of the design and construction documents for information purposes. This report was issued before any final design or construction details have been prepared or issued. Therefore differences may exist between the report recommendations and the final design, in the contract documents or during construction. In such instances, Thurber Engineering Ltd. should be contacted immediately to address these differences.

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

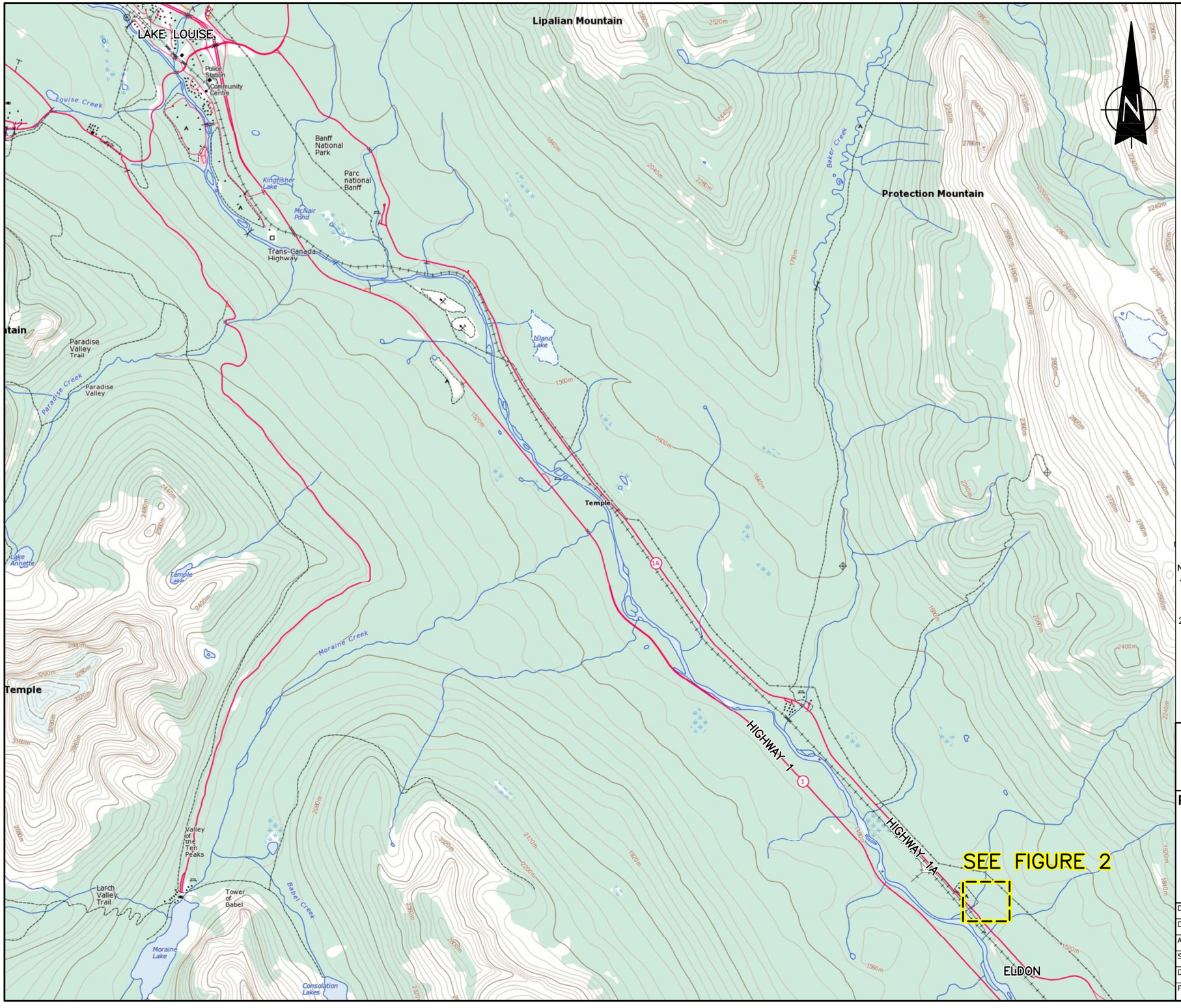
7. INDEPENDENT JUDGEMENTS OF CLIENT

The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

THURBER

APPENDIX A

Figures



NOTES:

1 DRAWING MUST BE USED IN CONJUNCTION WITH THE ATTACHED REPORT REFERENCE 10039 DATED FEBRUARY 2016 AND IS SUBJECT TO THE STATEMENT OF LIMITATIONS AND CONDITIONS INCLUDED IN THE REPORT.

2 BASE MAP FROM NATURAL RESOURCES CANADA TOPORAMA FILE "toporama_082o05_1_0_utm.map" AND "toporama_082n08_1_0_utm.map" DATED 2008-10-01 EDITION 1.0.

0 0.5 1.0 1.5 2.0 2.5 km

O2 PLANNING + DESIGN

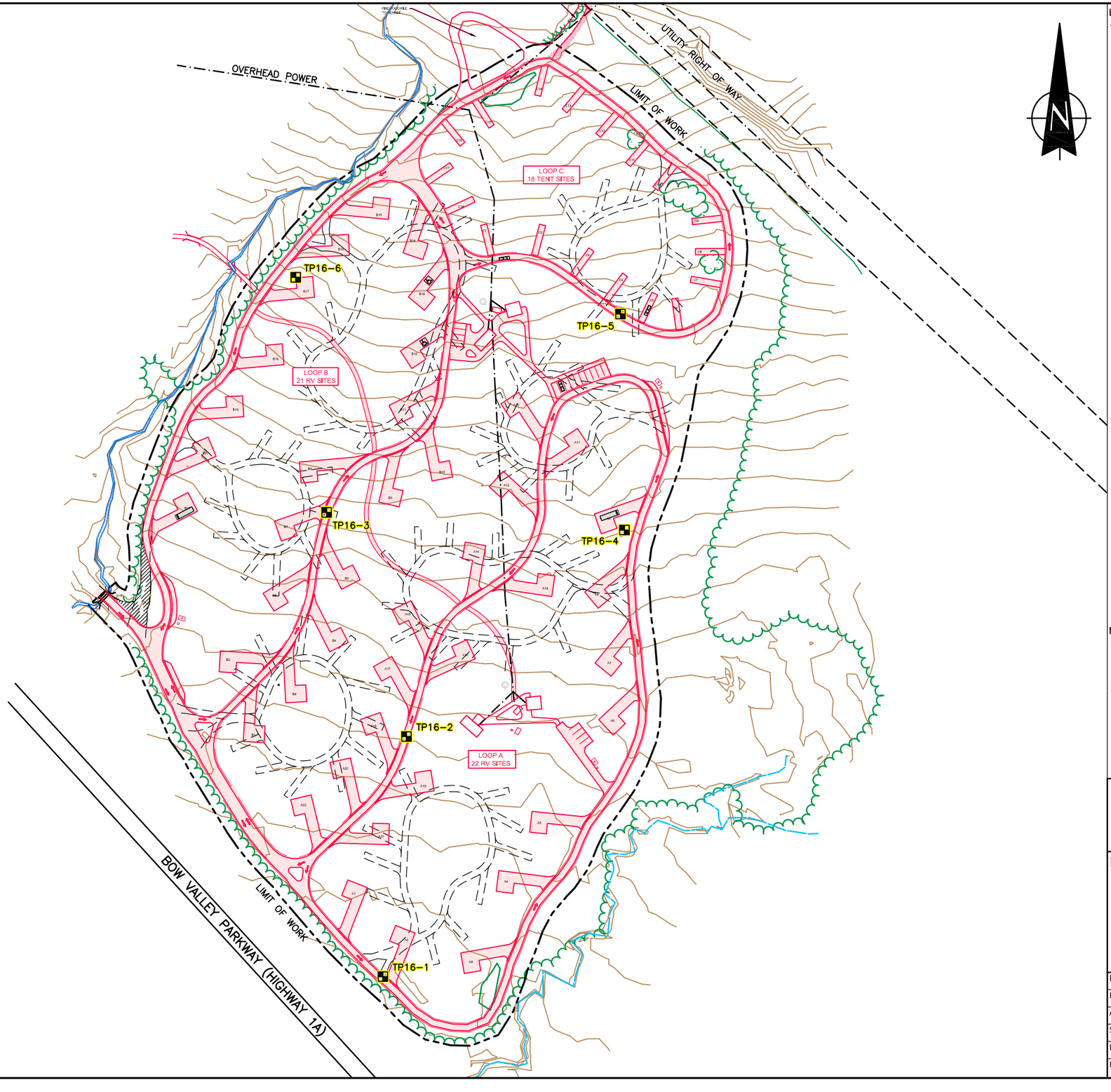
PROTECTION MOUNTAIN CAMPGROUND IMPROVEMENTS

LOCATION PLAN

FIGURE 1

DRAWN BY	ICB
DESIGNED BY	MDS
APPROVED BY	CDS
SCALE	1:50 000
DATE	JANUARY 21, 2016
FILE No.	10039-A2B

THURBER ENGINEERING LTD.



LEGEND:

TEST PIT LOCATION (APPROXIMATE)

NOTES:

1 DRAWING MUST BE USED IN CONJUNCTION WITH THE ATTACHED REPORT REFERENCE 10039 DATED FEBRUARY 2016 AND IS SUBJECT TO THE STATEMENT OF LIMITATIONS AND CONDITIONS INCLUDED IN THE REPORT.

2 BASE PLAN SUPPLIED BY CLIENT.

0 25 50 100 150 m

O2 PLANNING + DESIGN

PROTECTION MOUNTAIN CAMPGROUND IMPROVEMENTS

TEST PIT LOCATION PLAN

FIGURE 2

DRAWN BY	ICB
DESIGNED BY	MDS
APPROVED BY	CDS
SCALE	1:2 000
DATE	JANUARY 14, 2016
FILE No.	10039-A1A

THURBER ENGINEERING LTD.

THURBER

APPENDIX B

Modified Unified Soils Classification

Symbols and Terms used on the Test Pit Logs

Test Pit Logs

SYMBOLS AND TERMS USED ON TEST HOLE LOGS

1. VISUAL TEXTURAL CLASSIFICATION OF MINERAL SOILS

CLASSIFICATION	APPARENT PARTICLE SIZE
Boulders	Greater than 200 mm
Cobbles	75 mm to 200 mm
Gravel	5 mm to 75 mm
Sand	Not Visible to 5 mm
Silt	Non-Plastic particles, not visible to the naked eye
Clay	Plastic particles, not visible to the naked eye

2. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	APPROXIMATE UNDRAINED SHEAR STRENGTH	
Very Soft	Less than 10 kPa	
Soft	10 - 25 kPa	
Firm	25 - 50 kPa	
Stiff	50 - 100 kPa	
Very Stiff	100 - 200 kPa	Modified from
Hard	200 - 300 kPa	National Building
Very Hard	Greater than 300 kPa	Code

3. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	STANDARD PENETRATION TEST (SPT) (Number of Blows per 300 mm)	
Very Loose	0 - 4	
Loose	4 - 10	
Compact	10 - 30	
Dense	30 - 50	Modified from
Very Dense	Over 50	National Building Code

4. LEGEND FOR TEST HOLE LOGS

SYMBOL FOR SAMPLE TYPE


Shelby Tube


A- Casing


SPT


Grab


No Recovery


Core


MC - Moisture Content (% by weight) as determined by sample


Water Level

CPen - Shear Strength determined by pocket penetrometer

Cvane - Shear Strength determined by pocket vane

Cu - Undrained Shear Strength determined by unconfined compression test

MAJOR DIVISION			SYMBOL	THURBER LOG SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75 µm)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN 4.75 mm	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		WELL GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	Determine percentages of gravel and sand from grain size curve. Depending on percentages of fines (fraction smaller than 75 µm) coarse grained soils are classified as follows: Less than 5% GW, GP, SW, SP; More than 12% GM, GC, SM, SC; 5% to 12% Borderline cases requiring use of dual symbols
			GP		POORLY GRADED GRAVELS, GRAVEL-SAND MISTURES, LITTLE OR NO FINES	
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM		SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	
			GC		CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES	
	SANDS MORE THAN HALF COARSE GRAINS SMALLER THAN 4.75 mm	CLEAN SANDS (LITTLE OR NO FINES)	SW		WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	
			SP		POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	
		SAND WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM		SILTY SANDS, SAND-SILT MIXTURES	
			SC		CLAYEY SANDS, SAND-CLAY MIXTURES	
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75 µm)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$w_L < 50\%$	ML		INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (see below)
		$w_L > 50\%$	MH		INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS	
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	$w_L < 30\%$	CL		INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS	
		$30\% < w_L < 50\%$	CI		INORGANIC CLAYS OF MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS	
		$w_L > 50\%$	CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$w_L < 50\%$	OL		ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW AND MEDIUM PLASTICITY	
		$w_L > 50\%$	OH		ORGANIC CLAYS OF HIGH PLASTICITY, ORGANIC SILTS	
HIGHLY ORGANIC SOILS			PT		PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBROUS TEXTURE

$C_u = \frac{D_{60}}{D_{10}} > 4$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3

NOT MEETING ALL GRADATION REQUIREMENTS FOR GW

ATTERBERG LIMITS BELOW "A" LINE I_p LESS THAN 4

ATTERBERG LIMITS ABOVE "A" LINE I_p MORE THAN 7

Above "A" line with I_p between 4 and 7 are borderline cases requiring use of dual symbols

$C_u = \frac{D_{60}}{D_{10}} > 6$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3

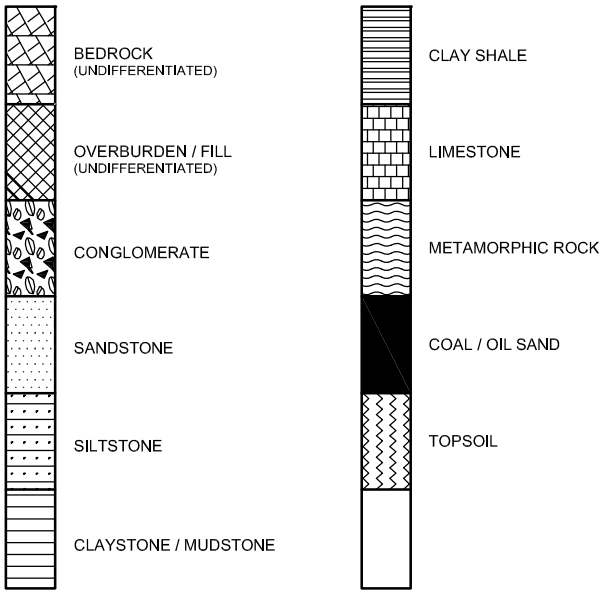
NOT MEETING ALL GRADATION REQUIREMENTS FOR SW

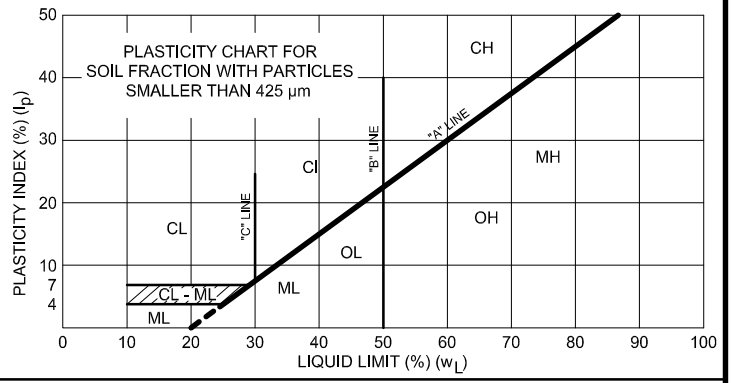
ATTERBERG LIMITS BELOW "A" LINE I_p LESS THAN 4

ATTERBERG LIMITS ABOVE "A" LINE I_p MORE THAN 7

Above "A" line with I_p between 4 and 7 are borderline cases requiring use of dual symbols

SPECIAL SYMBOLS





MODIFIED UNIFIED SOIL CLASSIFICATION SYSTEM

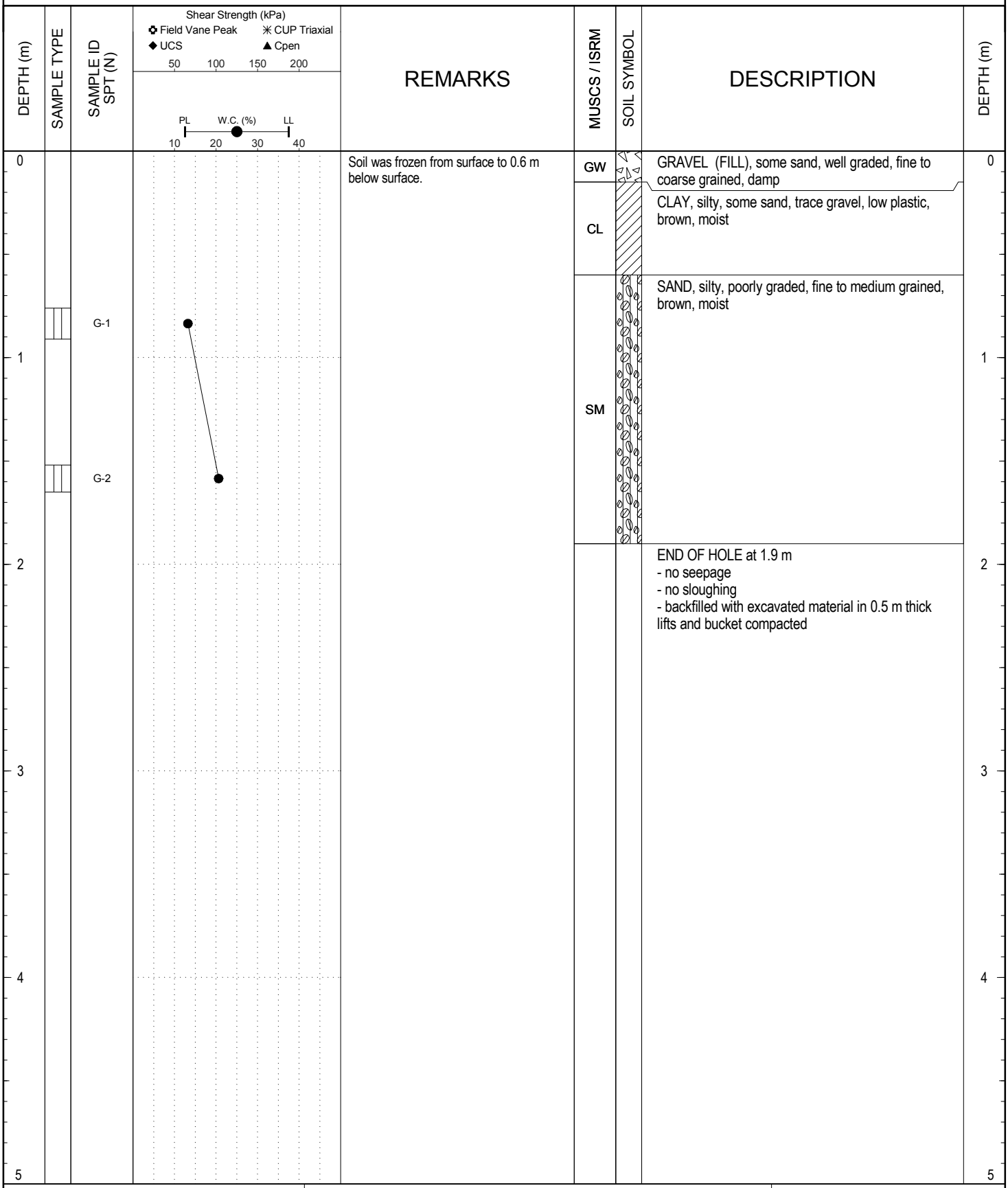
(MODIFIED BY PFRA, 1985)

THURBER ENGINEERING LTD.

CLIENT: O2 Planning + Design Inc.	PROJECT: Protection Mountain Campground Improvment	TEST PIT NO: **TP16-1**
PROJECT NO: 10039	UTM 11 NAD 83, Northing: 5686317 m, Easting: 567338 m	ELEVATION:

SAMPLE TYPE: Grab Sample

BACKFILL TYPE:

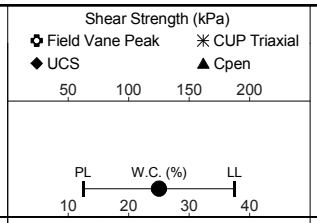


THURBER ENGINEERING LTD.	EXCAVATION CO.: Prairie Pride Construction		
	EXCAVATOR TYPE: CAT 318E	COMPILED BY: MDS	COMPLETION DEPTH: 1.9 m
	EXCAVATION METHOD: Tooth Bucket	REVIEWED BY: CDS	COMPLETION DATE: 06/01/2016
	INSPECTOR: MDS		Page 1 of 1

CLIENT: O2 Planning + Design Inc.	PROJECT: Protection Mountain Campground Improvment	TEST PIT NO: **TP16-2**
PROJECT NO: 10039	UTM 11 NAD 83, Northing: 5686431 m, Easting: 567350 m	ELEVATION:

SAMPLE TYPE: Grab Sample

BACKFILL TYPE:



DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)
0				TPS		TOPSOIL AND CLAY, brown, moist, roots and organics	0
						CLAY, silty, some sand, trace gravel, low plastic, brown, moist	
1		G-1	SO_4 = 0.0% Hydrometer Analysis Gravel = 0.1% Sand = 20.2% Silt = 63.9% Clay = 15.8%	CL			1
2		G-2					2
		G-3					
3						END OF HOLE at 2.5 m - no seepage - no sloughing - backfilled with excavated material in 0.5 m thick lifts and bucket compacted	3
4							4
5							5

THURBER ENGINEERING LTD.

EXCAVATION CO.: Prairie Pride Construction		
EXCAVATOR TYPE: CAT 318E	COMPILED BY: MDS	COMPLETION DEPTH: 2.5 m
EXCAVATION METHOD: Tooth Bucket	REVIEWED BY: CDS	COMPLETION DATE: 06/01/2016
INSPECTOR: MDS		Page 1 of 1

CLIENT: O2 Planning + Design Inc.	PROJECT: Protection Mountain Campground Improvment	TEST PIT NO: **TP16-3**
PROJECT NO: 10039	UTM 11 NAD 83, Northing: 5686539 m, Easting: 567312 m	ELEVATION:

SAMPLE TYPE: Grab Sample

BACKFILL TYPE:

DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)
0				TPS		TOPSOIL AND CLAY, silty, some sand, low plastic, brown, moist, roots and organics	0
				CI		CLAY, silty, some sand, medium plastic, brown, moist	
1		G-1	Bulk Sample taken from 0.3 m to 1.3 m Maximum Dry Density = 1730 kg/m3 Optimum Moisture = 18.0%				1
		G-2					
2						END OF HOLE at 2.2 m - no seepage - no sloughing - backfilled with excavated material in 0.5 m thick lifts and bucket compacted	2
3							3
4							4
5							5

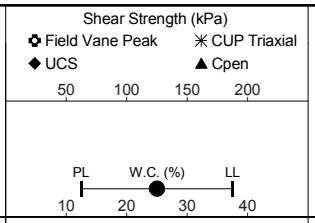
THURBER ENGINEERING LTD.

EXCAVATION CO.: Prairie Pride Construction		
EXCAVATOR TYPE: CAT 318E	COMPILED BY: MDS	COMPLETION DEPTH: 2.2 m
EXCAVATION METHOD: Tooth Bucket	REVIEWED BY: CDS	COMPLETION DATE: 06/01/2016
INSPECTOR: MDS		Page 1 of 1

CLIENT: O2 Planning + Design Inc.	PROJECT: Protection Mountain Campground Improvment	TEST PIT NO: **TP16-4**
PROJECT NO: 10039	UTM 11 NAD 83, Northing: 5686530 m, Easting: 567454 m	ELEVATION:

SAMPLE TYPE: Grab Sample

BACKFILL TYPE:



DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)
0				TPS		TOPSOIL AND CLAY, some silt, medium plastic, brown, moist, roots and organics	0
				CI		CLAY, some silt, medium plastic, very stiff, brown, moist	
1		G-1					1
		G-2	SO_4 = 0.0%				
2						END OF HOLE at 2.0 m - no seepage - no sloughing - backfilled with excavated material in 0.5 m thick lifts and bucket compacted	2
3							3
4							4
5							5

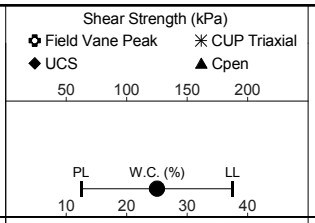
THURBER ENGINEERING LTD.

EXCAVATION CO.: Prairie Pride Construction		
EXCAVATOR TYPE: CAT 318E	COMPILED BY: MDS	COMPLETION DEPTH: 2.0 m
EXCAVATION METHOD: Tooth Bucket	REVIEWED BY: CDS	COMPLETION DATE: 06/01/2016
INSPECTOR: MDS		Page 1 of 1

CLIENT: O2 Planning + Design Inc.	PROJECT: Protection Mountain Campground Improvment	TEST PIT NO: **TP16-5**
PROJECT NO: 10039	UTM 11 NAD 83, Northing: 5686633 m, Easting: 567452 m	ELEVATION:

SAMPLE TYPE: Grab Sample

BACKFILL TYPE:



DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)
0				TPS		TOPSOIL AND CLAY, silty, some sand, low plastic, brown, moist, roots and organics	0
				SW		SAND, trace gravel, trace clay, well graded, fine to coarse grained, brown, damp	
		G-1					
		G-2		SC		SAND, clayey, some gravel, trace cobbles, well graded, fine to coarse grained, brown, damp	
1							1
		G-3					
2						END OF HOLE at 2.2 m - no seepage - minor sloughing at 0.8 m - backfilled with excavated material in 0.5 m thick lifts and bucket compacted	2
3							3
4							4
5							5

THURBER ENGINEERING LTD.

EXCAVATION CO.: Prairie Pride Construction		
EXCAVATOR TYPE: CAT 318E	COMPILED BY: MDS	COMPLETION DEPTH: 2.2 m
EXCAVATION METHOD: Tooth Bucket	REVIEWED BY: CDS	COMPLETION DATE: 06/01/2016
INSPECTOR: MDS		Page 1 of 1

CLIENT: O2 Planning + Design Inc.	PROJECT: Protection Mountain Campground Improvment	TEST PIT NO: **TP16-6**
PROJECT NO: 10039	UTM 11 NAD 83, Northing: 5686651 m, Easting: 567297 m	ELEVATION:

SAMPLE TYPE: Grab Sample

BACKFILL TYPE:

DEPTH (m)	SAMPLE TYPE	SAMPLE ID SPT (N)	Shear Strength (kPa) / PL W.C. (%) LL	REMARKS	MUSCS / ISRM	SOIL SYMBOL	DESCRIPTION	DEPTH (m)
0					TPS		TOPSOIL AND CLAY, some silt, trace sand, medium plastic, brown, moist, roots and organics	0
		G-1		SO_4 = 0.0%	CI		CLAY, some silt, trace sand, medium plastic, brown, moist	
1					CB		COBBLES AND GRAVEL, trace sand, well graded, brown, damp	1
2							END OF HOLE at 2.1 m - no seepage - no sloughing - backfilled with excavated material in 0.5 m thick lifts and bucket compacted	2
3								3
4								4
5								5

Shear Strength (kPa): Field Vane Peak, CUP Triaxial, UCS, Cpen; 50 100 150 200

PL W.C. (%) LL; 10 20 30 40

THURBER ENGINEERING LTD.

EXCAVATION CO.: Prairie Pride Construction		
EXCAVATOR TYPE: CAT 318E	COMPILED BY: MDS	COMPLETION DEPTH: 2.1 m
EXCAVATION METHOD: Tooth Bucket	REVIEWED BY: CDS	COMPLETION DATE: 06/01/2016
INSPECTOR: MDS		Page 1 of 1

THURBER

APPENDIX C

Detailed Laboratory Test Results

ATTERBERG LIMITS REPORT

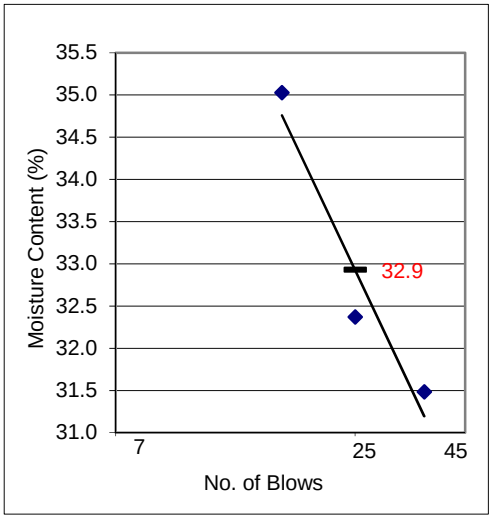
THURBER ENGINEERING LTD.
Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8 T. (403) 253-9217 F. (403) 252-8159 www.thurber.ca

Client:	O2 Planning & Design Inc.	Date Tested:	13-Jan-16
Project:	Protection Mountain Campground Improvements	Date Sampled:	06-Jan-16
Project No.:	10039	Tested By:	RL

Sample Source: Sample No.:
Sample Location: TH 16-3 Depth: 0.75m

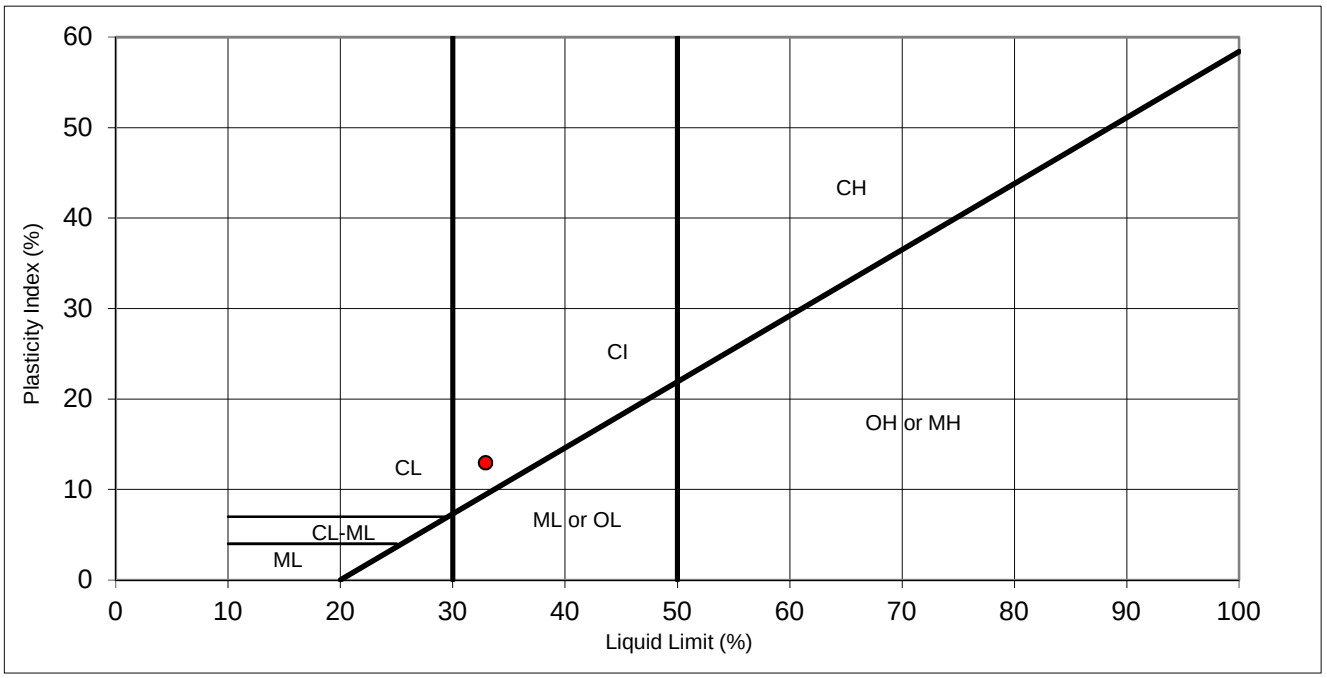
LIQUID LIMIT

Trial No.	1	2	3	4
No of Blows	36	25	17	
Container No.				
Wt. of Container - g	1.02	1.06	1.10	
Wet Soil + Container - g	24.70	23.96	23.92	
Dry Soil + Container - g	19.03	18.36	18.00	
Moisture Content (%)	31.5	32.4	35.0	



PLASTIC LIMIT

	1	2		AVERAGE
Container No.				
Wt. of Container - g	1.07	1.16		
Wet Soil + Container - g	7.66	5.99		
Dry Soil + Container - g	6.53	5.21		
Moisture Content (%)	20.7	19.3		**20.0**



Remarks:

Liquid Limit - %:	**33**
Plastic Limit - %:	**20**
Plasticity Index -%:	**13**
USC Classification:	**CI**

Checked By: MDS

Tes+A1:K58ted in accordance with ASTM Designation D4318 unless otherwise noted

THURBER ENGINEERING LTD.

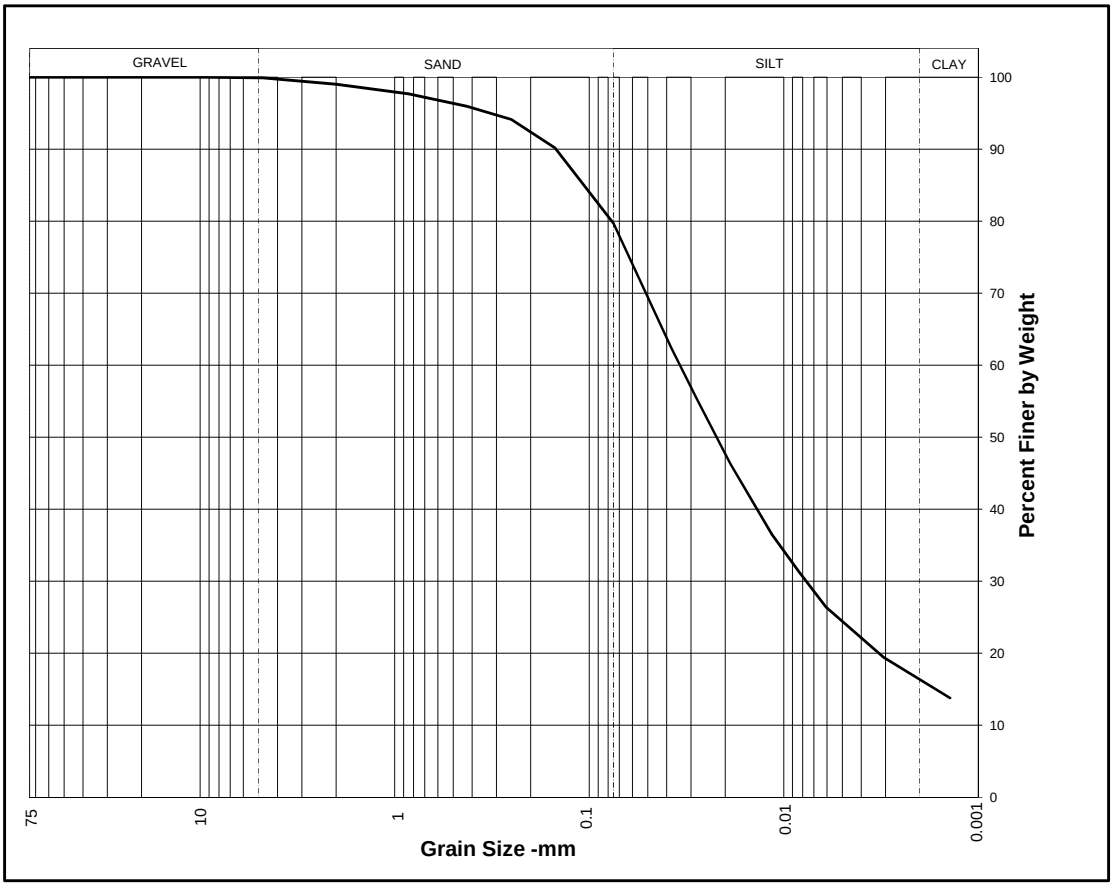
Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8 T. (403) 253-9217 F. (403) 252-8159 www.thurber.ca

GRAIN SIZE DISTRIBUTION REPORT

Client:	O2 Planning & Design Inc.			Date Tested:	09-Jan-16
Project:	Protection Mountain Campground Improvements			Date Sampled:	06-Jan-16
Project No.:	10039	Sampled By:	MS	Tested By:	AMM

Sample Source:		Sample No.:	
Sample Location:	TH 16-2	Depth:	0.75m
Sample Description:	CLAY, silty, some sand, trace gravel		

Sieve Size -mm	Percent Finer
100.0	100.0
75.0	100.0
62.5	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	100.0
12.5	100.0
9.5	100.0
4.75	99.9
2.00	99.0
0.850	97.7
0.425	96.0
0.250	94.1
0.150	90.2
0.075	79.7
0.038	62.5
0.028	55.4
0.019	46.3
0.011	36.5
0.008	31.3
0.006	26.4
0.003	19.4
0.001	13.8



Distribution	
Cobbles	0.0%
Gravel	0.1%
Sand	20.2%
Silt	63.9%
Clay	15.8%

Coefficients
D10
D30
D60
Cu
Cc

Atterberg Limits	
LL	%
PL	%
PI	%

UCS

Remarks: Visual Classification: CL

Checked By: MDS

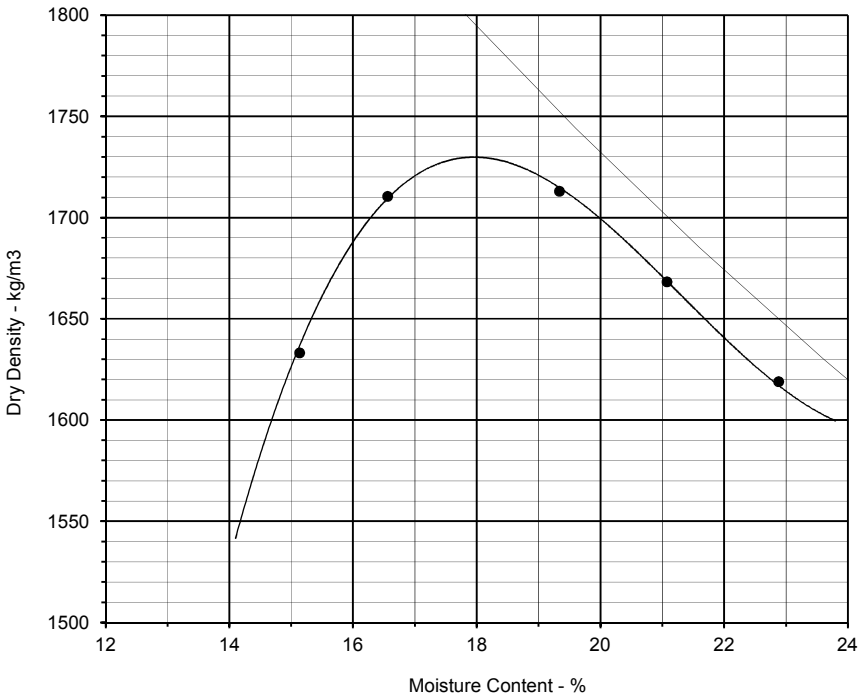
THURBER ENGINEERING LTD.
Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8 T. (403) 253-9217 F. (403) 252-8159 www.thurber.ca

MOISTURE - DENSITY RELATIONSHIP (PROCTOR) REPORT

Client:	O2 Planning & Design Inc.			Date Tested:	11-Jan-16
Project:	Protection Mountain Campground Improve.			Date Sampled:	06-Jan-16
Project No.:	10039	Sampled By:	MS	Tested By:	MM

Sample Source:	N/A	Sample No.:	bulk
Sample Location:	TH 16-3 @ 0.3-1.3m	Depth:	0.3-1.3m
Sample Description:	CLAY, silty, some sand, low plastic, brown		
Oversized Material:	0.0% retained on the 4.75 mm sieve	As-Rec'd Moisture:	24.0%

Wet Density - kg/m3	1880	1994	2044	2020	1989		
Dry Density - kg/m3	1633	1710	1713	1668	1619		
Moisture - %	15.1	16.6	19.3	21.1	22.9		
Pocket Pen. (kg/cm²)	4.5+	4.5+	4.5+	2.25	1.00		



Maximum Dry Density: 1730 kg/m³
Optimum Moisture: 18.0%

Corrected Maximum Dry Density: **1730 kg/m³**
Corrected Optimum Moisture: **18.0%**

Preparation: Dry
Compaction Std.: ASTM D698
Test Method: A
Rammer Type: Manual

Sampled By: MS
Project Eng.: MS

Zero Air Voids Curve plotted for a Specific Gravity of 2.65

Remarks:

Rock Corrections:

5 %	R.C.	1761	kg/m³ at	17.1%
10 %	R.C.	1792	kg/m³ at	16.2%
20 %	R.C.	1859	kg/m³ at	14.4%
30 %	R.C.	1931	kg/m³ at	12.6%

Report Checked By: _____

Tested in accordance with ASTM Designation D698 or D1557 unless otherwise noted

THURBER ENGINEERING LTD.
Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8 T. (403) 253-9217 F. (403) 252-8159 www.thurber.ca

CALIFORNIA BEARING RATIO TEST REPORT

Client:	O2 Planning & Design Inc.	Project Number:	10039
Project:	Protection Mountain Campground Improve.	Date Tested:	14-Jan-16
Attention:		Date Sampled:	6-Jan-16

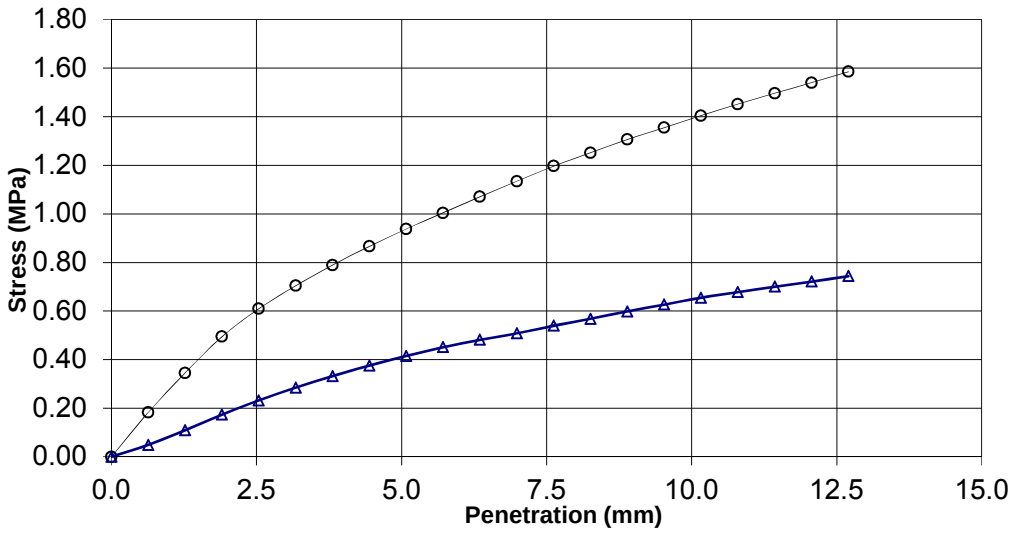
Sample Location: TH 16-3 @ 0.3-1.3m

Sample Description: CLAY, silty, some sand, low plastic, brown

USC Classification: CL

Maximum Dry Density: 1730 kg/m^3 Optimum Moisture: 18.0 %

Sample	Surcharge Weight (kg):	Density (kg/m^3)	% of Max. Dry Density	Moisture Content, %	CBR %:		Max. Swell, %
					2.5 mm	5 mm	
O - Unsoaked	4.5	1678	97	18.1	8.8	9.1	-
Δ - Soaked	4.5	1653	96	22.9	3.4	4.0	0.70



Sampled By:	MS	Sample Preparation Method:	ASTM D 698
Tested By:	KNL	Test Method:	Soaked & Unsoaked
Project Eng.:	MS	Soak Period (hrs):	96 hrs.

Tested in accordance with ASTM Designation D1883-07 unless otherwise noted

THURBER ENGINEERING LTD.

SULPHATE TEST REPORT

Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8 T. (403) 253-9217 F. (403) 252-8159 www.thurber.ca

Client:	O2 Planning & Design Inc.	Date Tested:	26-Jan-16
Project:	Protection Mountain Campground Improvement	Date Sampled:	
Project No.:	10039	Tested By:	JAM

Sample Source:		Depth:	0.75m
Sample Location:	TP 2	Sample No.:	

TEST PROCEDURE - using PFRA METHOD

1. Add 100 g of oven-dried soil, passing No.40 sieve.
2. Add 500 ml of distilled water or ratio of 20 g soil/100 g water. Beaker No. 14
3. Add 3 drops of concentrated HCL acid.
4. Place mixture in oven for 1 hour at 110°C, (or allow to sit over night).
   Time In: 11:10 AM Time Out: 12:10 PM
5. Draw off by filtering 100 ml clear liquid from mixture into 250 ml beaker. Beaker No. 27
6. Add 100 ml distilled water and 5ml concentrated HCL acid.
7. Heat in oven for 1 hour at 110°C. Time In: 1:20 PM Time Out: 2:20 PM
8. Add 10 ml of 10% $BaCl_2$ solution, mix thoroughly, observe reaction.

■ CLEAR SOLUTION No Reaction	☐ SLIGHTLY MILKY No Precipitate	☐ MILKY SOLUTION With Precipitate

9. If clear solution, end test. If slightly or milky solution, filter mixture through crucible on vacuum setup, dry crucible thoroughly in oven.

Dry Weight of Crucible + $BaSO_4$ (ppt)	A		g
Dry Weight of Empty Crucible	B		g
Weight of $BaSO_4$ (ppt)	A-B	0.00	g
Weight of Soil Used (passing No. 40 sieve)		100.0	g

Crucible No. _____

CALCULATIONS

Gravimetric Factor = 2.60

$$\text{Weight of Sulphate} = \frac{\text{Weight of } BaSO_4 \text{ (ppt)}}{\text{Gravimetric Factor}} = \frac{0.00}{2.60} = 0.00000 \text{ g}$$

$$\text{\% Sulphate} = \frac{\text{Weight of } SO_4 \times 100\%}{\text{Weight of Soil}} = \frac{0.00000 \times 100\%}{20.0} = \mathbf{0.00}\ \%$$

RESULT **CSA DEGREE OF EXPOSURE**

■	0-0.09% SO_4	Clear solution, no reaction.	Non
☐	0.1-0.19% SO_4	Slightly milky, no precipitate. Dangerous if water table is too high.	Moderate
☐	0.2-2.0% SO_4	Milky, with precipitate. Dangerous, Use high sulphate-resistant cement.	Severe
☐	Over 2.0% SO_4	Milky, with precipitate. Dangerous, Use high sulphate-resistant cement.	Very Severe

THURBER ENGINEERING LTD.

SULPHATE TEST REPORT

Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8 T. (403) 253-9217 F. (403) 252-8159 www.thurber.ca

Client:	O2 Planning & Design Inc.	Date Tested:	26-Jan-16
Project:	Protection Mountain Campground Improvement	Date Sampled:	
Project No.:	10039	Tested By:	JAM

Sample Source:		Depth:	1.5m
Sample Location:	TP 4	Sample No.:	

TEST PROCEDURE - using PFRA METHOD

1. Add 100 g of oven-dried soil, passing No.40 sieve.
2. Add 500 ml of distilled water or ratio of 20 g soil/100 g water. Beaker No. 5
3. Add 3 drops of concentrated HCL acid.
4. Place mixture in oven for 1 hour at 110°C, (or allow to sit over night).
   Time In: 11:10 AM Time Out: 12:10 PM
5. Draw off by filtering 100 ml clear liquid from mixture into 250 ml beaker. Beaker No. 35
6. Add 100 ml distilled water and 5ml concentrated HCL acid.
7. Heat in oven for 1 hour at 110°C. Time In: 1:20 PM Time Out: 2:20 PM
8. Add 10 ml of 10% $BaCl_2$ solution, mix thoroughly, observe reaction.

■ CLEAR SOLUTION No Reaction	☐ SLIGHTLY MILKY No Precipitate	☐ MILKY SOLUTION With Precipitate

9. If clear solution, end test. If slightly or milky solution, filter mixture through crucible on vacuum setup, dry crucible thoroughly in oven.

Dry Weight of Crucible + $BaSO_4$ (ppt)	A		g
Dry Weight of Empty Crucible	B		g
Weight of $BaSO_4$ (ppt)	A-B	0.00	g
Weight of Soil Used (passing No. 40 sieve)		100.0	g

Crucible No. _____

CALCULATIONS

Gravimetric Factor = 2.60

$$\text{Weight of Sulphate} = \frac{\text{Weight of } BaSO_4 \text{ (ppt)}}{\text{Gravimetric Factor}} = \frac{0.00}{2.60} = 0.00000 \text{ g}$$

$$\%\ \text{Sulphate} = \frac{\text{Weight of } SO_4 \times 100\%}{\text{Weight of Soil}} = \frac{0.00000 \times 100\%}{20.0} = \mathbf{0.00}\ \%$$

RESULT **CSA DEGREE OF EXPOSURE**

■	0-0.09% SO_4	Clear solution, no reaction.	Non
☐	0.1-0.19% SO_4	Slightly milky, no precipitate. Dangerous if water table is too high.	Moderate
☐	0.2-2.0% SO_4	Milky, with precipitate. Dangerous, Use high sulphate-resistant cement.	Severe
☐	Over 2.0% SO_4	Milky, with precipitate. Dangerous, Use high sulphate-resistant cement.	Very Severe

THURBER ENGINEERING LTD.

SULPHATE TEST REPORT

Suite 180, 7330 Fisher Street S.E., CALGARY, AB T2H 2H8 T. (403) 253-9217 F. (403) 252-8159 www.thurber.ca

Client:	O2 Planning & Design Inc.	Date Tested:	26-Jan-16
Project:	Protection Mountain Campground Improvement	Date Sampled:	
Project No.:	10039	Tested By:	JAM

Sample Source:		Depth:	0.5m
Sample Location:	TP 6	Sample No.:	

TEST PROCEDURE - using PFRA METHOD

1. Add 100 g of oven-dried soil, passing No.40 sieve.
2. Add 500 ml of distilled water or ratio of 20 g soil/100 g water. Beaker No. 15
3. Add 3 drops of concentrated HCL acid.
4. Place mixture in oven for 1 hour at 110°C, (or allow to sit over night).
   Time In: 11:10 AM Time Out: 12:10 PM
5. Draw off by filtering 100 ml clear liquid from mixture into 250 ml beaker. Beaker No. 21
6. Add 100 ml distilled water and 5ml concentrated HCL acid.
7. Heat in oven for 1 hour at 110°C. Time In: 1:20 PM Time Out: 2:20 PM
8. Add 10 ml of 10% $BaCl_2$ solution, mix thoroughly, observe reaction.

■ CLEAR SOLUTION No Reaction	☐ SLIGHTLY MILKY No Precipitate	☐ MILKY SOLUTION With Precipitate

9. If clear solution, end test. If slightly or milky solution, filter mixture through crucible on vacuum setup, dry crucible thoroughly in oven.

Dry Weight of Crucible + $BaSO_4$ (ppt)	A		g
Dry Weight of Empty Crucible	B		g
Weight of $BaSO_4$ (ppt)	A-B	0.00	g
Weight of Soil Used (passing No. 40 sieve)		100.0	g

Crucible No. _____

CALCULATIONS

Gravimetric Factor = 2.60

$$\text{Weight of Sulphate} = \frac{\text{Weight of } BaSO_4 \text{ (ppt)}}{\text{Gravimetric Factor}} = \frac{0.00}{2.60} = 0.00000 \text{ g}$$

$$\%\ \text{Sulphate} = \frac{\text{Weight of } SO_4 \times 100\%}{\text{Weight of Soil}} = \frac{0.00000 \times 100\%}{20.0} = \mathbf{0.00}\ \%$$

RESULT **CSA DEGREE OF EXPOSURE**

■	0-0.09% SO_4	Clear solution, no reaction.	Non
☐	0.1-0.19% SO_4	Slightly milky, no precipitate. Dangerous if water table is too high.	Moderate
☐	0.2-2.0% SO_4	Milky, with precipitate. Dangerous, Use high sulphate-resistant cement.	Severe
☐	Over 2.0% SO_4	Milky, with precipitate. Dangerous, Use high sulphate-resistant cement.	Very Severe