APPENDIX ‘A’

GEOTECHNICAL REPORT

Morrison Hershfield

Replacement of Existing Culvert at Sherwin Road Over Omand's Creek and Associated Regional Street Improvements

Roadway Information Package

Prepared for:

Morrison Hershfield
1-59 Scurfield Boulevard
Winnipeg, MB R3Y 1V2
Attention: Mr. Bill Ebenspanger, P. Eng

Project Number:
0035 079 00

Date:
October 24, 2019
Final Report

TREK
GEOTECHNICAL
Quality Engineering | Valued Relationships

October 24, 2019 Our File No. 0035 079 00

Mr. Bill Ebenspanger, P.Eng.
Morrison Hershfield
1-59 Scurfield Boulevard
Winnipeg, Manitoba, R3Y 1V2

RE: Sub-Surface Investigation Report for Replacement of Existing Culvert at Sherwin Road Over Omand's Creek and Associated Regional Street Improvements

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TREK Geotechnical Inc. is pleased to submit our information package for the roadway sub-surface investigations for the Replacement of Existing Culvert at Sherwin Road over Omand's Creek and Associated Regional Street Improvements.

Please contact the undersigned if you have any questions. Thank you for the opportunity to serve you on this assignment.

Sincerely,

TREK Geotechnical Inc.
Per:

Michael Van Helden, Ph.D., P. Eng.
Geotechnical Engineer,
Tel: 204.975.9433

cc: Jashandeep Singh Bhullar, EIT (TREK Geotechnical)

Revision History

Revision No.	Author	Issue Date	Description
0	JSB	October 24, 2019	Draft Report

Authorization Signatures

Prepared By:

for Jashandeep Singh Bhullar, EIT

2019/10/24
M.J.
VAN HELDEN
Member
24729

ENGINEERS
GEOSCIENTISTS
MANITOBA
Certificate of Authorization
TREK GEOTECHNICAL INC.
No. 4877 Date: Oct, 24, 2019

Reviewed By:

Michael Van Helden, Ph.D., P.Eng.
Geotechnical Engineer

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1.0 Introduction

This report summarizes the results of the road investigation completed for the Replacement of Existing Culvert at Sherwin Road over Omand's Creek and Associated Regional Street Improvements project. The information collected describes the pavement structure of the existing road as well as the soil stratigraphy beneath the pavement structure at select locations.

2.0 Road Investigation and Laboratory Program

The subsurface investigation included of pavement coring and drilling of 13 shallow road test holes and 2 deep test holes at the existing culvert (which contain supplemental information on pavements and subgrade). The test hole locations are shown on Figure 01 to Figure 05 (attached).

Road test holes (THs) 19-01 to 19-13 were drilled between September 3, 2019 and September 5, 2019. Two additional deep test holes (THs 19-14 and 19-15) were drilled on September 5 and 6, 2019 for the structure replacement. The pavement structure (asphalt and/or concrete) was cored by Jashandeep Singh Bhullar of TREK Geotechnical Inc. (TREK) using a portable coring press equipped with a hollow 150 mm diameter diamond core drill bit. All shallow test holes were drilled to a depth of 3.0 m below road surface by Maple Leaf Drilling Ltd. using a truck mounted drill rig equipped with 125 mm diameter solid stem augers except for TH19-04 which was drilled to 3.4 m below ground. Deep test holes were drilled to depths greater than 20 m. The sub-surface conditions were observed during drilling and other pertinent information such as groundwater and drilling conditions were also recorded. investigation. Disturbed (auger cuttings) samples retrieved during the sub-surface investigation were visually classified and transported to TREK's material testing laboratory for further testing. Core samples were also retrieved and logged at TREK's material testing laboratory.

Core and test hole locations noted on the summary tables and test hole logs are based on their location determined using a hand held GPS and location relative to the nearest address, and measured distances from the edge of pavement or other permanent features.

The laboratory testing program for the roadway program consisted of moisture content determination on all samples, as well as Atterberg limits, and grain size analysis (mechanical sieve and hydrometer methods) on select samples between 0.5 and 1.0 m below pavement. Laboratory testing results are included on the test hole logs in Appendix A, while the individual test results are included in Appendix B with a summary table. Photos of the asphalt and concrete pavement cores are included in Appendix C.

3.0 Closure

The information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information provided (field investigation, laboratory testing, geometries). Soil conditions are natural deposits that can be highly variable across a site. If sub-surface conditions are different than the conditions previously encountered on-site or those presented here, we should be notified to adjust our findings if necessary.

All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work, or a mutually executed standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

This report has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of Morrison Hershfield (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this report are not to be used or relied upon by any third parties, except as agreed to in writing by the Client and Consultant prior to use.

Figures

0035 079 00
Morrison Hershfield
Sherwin Road Bridge over Omands Creek

0 50 100 150 m
SCALE = 1 : 3 500 (279 mm x 432 mm)

NOTES:
1. AERIAL PHOTO FROM CITY OF WINNIPEG 2016

Figure 01

TEST HOLE LOCATION PLAN

ANSI full bleed B (11.00 x 17.00 Inches)
Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\FIG 02_2019-10-09_SHERWIN RD TH_0_A_DW_0035-079-00.dwg, 10/10/2019 2:39:44 PM

0035 079 00
Morrison Hershfield
Sherwin Road Bridge over Omands Creek

ANSI full bleed B (11.00 x 17.00 Inches)
Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\FIG 02_2019-10-02_SHERWIN RD TH_0_A_DW_0035-079-00.dwg, 10/9/2019 9:26:27 AM

0 10 20 30 40 50 m
SCALE = 1 : 1 250 (279 mm x 432 mm)

LEGEND: ⌖ TEST HOLE (TREK, 2019)

NOTES:
1. AERIAL PHOTO FROM CITY OF WINNIPEG 2016
2. GPS COORDINATES OBTAINED FROM HANDHELD GPS DEVICE.

Figure 02
TEST HOLE LOCATION PLAN

0035 079 00
Morrison Hershfield
Sherwin Road Bridge over Omands Creek

0 10 20 30 40 50 m
SCALE = 1 : 1 000 (279 mm x 432 mm)

LEGEND: ⌖ TEST HOLE (TREK, 2019)

NOTES:
1. AERIAL PHOTO FROM CITY OF WINNIPEG 2016
2. GPS COORDINATES OBTAINED FROM HANDHELD GPS DEVICE.

Figure 03
TEST HOLE LOCATION PLAN

Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\FIG 02_2019-10-02_SHERWIN RD TH_0_A_DW_0035-079-00.dwg, 10/2/2019 9:04:24 AM
ANSI full bleed B (11.00 x 17.00 Inches)

0035 079 00
Morrison Hershfield
Sherwin Road Bridge over Omands Creek

0 10 20 30 40 50 m
SCALE = 1 : 1 250 (279 mm x 432 mm)

LEGEND: ⊕ TEST HOLE (TREK, 2019)

NOTES:
1. AERIAL PHOTO FROM CITY OF WINNIPEG 2016
2. GPS COORDINATES OBTAINED FROM HANDHELD GPS DEVICE.

Figure 04

TEST HOLE LOCATION PLAN

ANSI full bleed B (11.00 x 17.00 Inches)
Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\FIG 02_2019-10-02_SHERWIN RD TH_0_A_DW_0035-079-00.dwg, 10/2/2019 9:05:58 AM

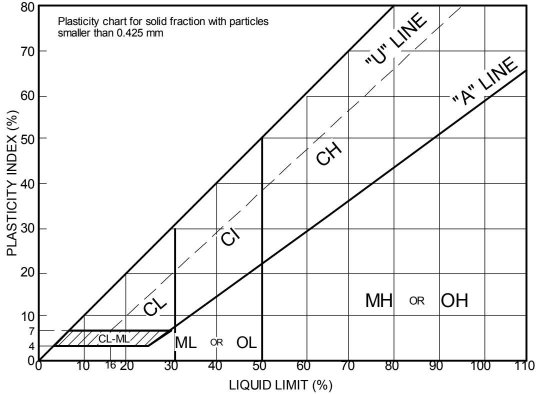
Appendix A

Test Hole Logs

EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.
2. Descriptions on these test hole logs apply only at the specific test hole locations and at the time the test holes were drilled. Variability of soil and groundwater conditions may exist between test hole locations.
3. When the following classification terms are used in this report or test hole logs, the primary and secondary soil fractions may be visually estimated.

Major Divisions			USCS Classification	Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW	▚	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent...... GW, GP, SW, SP More than 12 percent...... GM, GC, SM, SC 6 to 12 percent...... Borderline case4s requiring dual symbols*	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	◌	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	◍	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC	▩	Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW	⁘	Well-graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	░	Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	▦	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC	▧	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML	▥	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart 		
			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 distomaceous fine sandy or silty soils, organic silts			
			CH	▞	Inorganic clays of high plasticity, fat clays			
			OH	≋	Organic clays of medium to high plasticity, organic silts			
	Highly Organic Soils		Pt	⁂	Peat and other highly organic soils	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	

Material		Particle Size mm	ASTM Sieve sizes
Sand	Coarse	2.00 to 4.75	#10 to #4
	Medium	0.425 to 2.00	#40 to #10
	Fine	0.075 to 0.425	#200 to #40
Silt or Clay		< 0.075	< #200

Material		Particle Size mm	ASTM Sieve Sizes
Boulders		> 300	> 12 in.
Cobbles		75 to 300	3 in. to 12 in.
Gravel	Coarse	19 to 75	3/4 in. to 3 in.
	Fine	4.75 to 19	#4 to 3/4 in.

* Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

Other Symbol Types

■	Asphalt	▧	Bedrock (undifferentiated)	◌	Cobbles
░	Concrete	⊞	Limestone Bedrock	▚	Boulders and Cobbles
▩	Fill	☰	Cemented Shale	◍	Silt Till
		▱	Non-Cemented Shale	▨	Clay Till

EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)
PL - Plastic Limit (%)
PI - Plasticity Index (%)
MC - Moisture Content (%)
SPT - Standard Penetration Test
RQD - Rock Quality Designation
Qu - Unconfined Compression
Su - Undrained Shear Strength
VW - Vibrating Wire Piezometer
SI - Slope Inclinometer

▽ Water Level at Time of Drilling

▼ Water Level at End of Drilling

⧨ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

TERM	EXAMPLES	PERCENTAGE
and	and CLAY	35 to 50 percent
"y" or "ey"	clayey, silty	20 to 35 percent
some	some silt	10 to 20 percent
trace	trace gravel	1 to 10 percent

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

The Standard Penetration Test blow count (N) of a non-cohesive soil can be related to compactness condition as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

The Standard Penetration Test blow count (N) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very soft	< 2
Soft	2 to 4
Firm	4 to 8
Stiff	8 to 15
Very stiff	15 to 30
Hard	> 30

The undrained shear strength (Su) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	Undrained Shear Strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

TREK GEOTECHNICAL

Sub-Surface Log

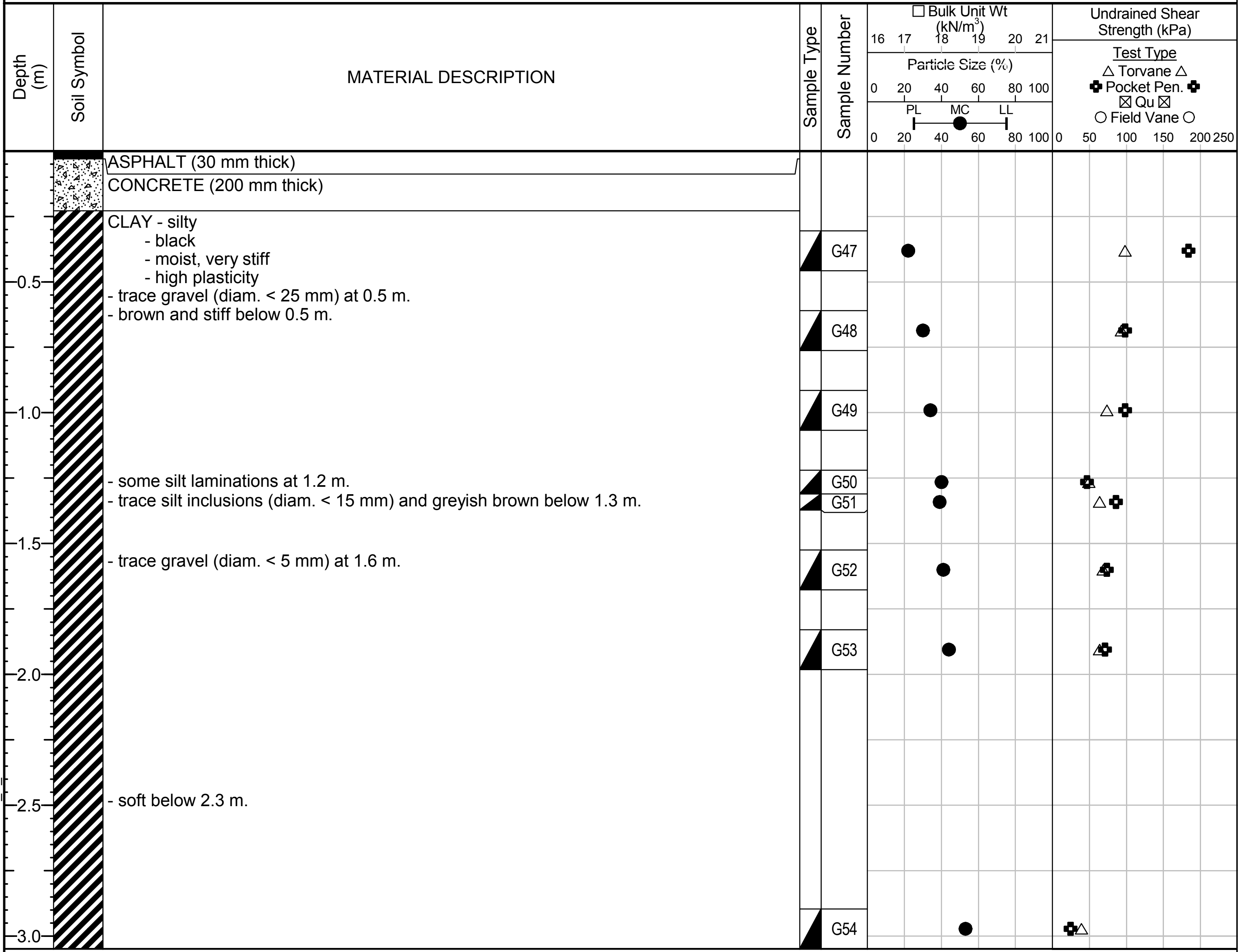
Test Hole TH19-01

1 of 1

Client: Morrison Hershfield
Project Number: 0035-079-00
Project Name: Sherwin Road Bridge Over Omands Creek
Location: UTM-14U, 5530838N, 628422E
Contractor: TREK Geotechnical Inc.
Ground Elevation: Top of Pavement
Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount
Date Drilled: September 5, 2019

Sample Type: ◢ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⛆ Sand ● Gravel ◌ Cobbles ■ Boulders



ASPHALT (30 mm thick)

CONCRETE (200 mm thick)

CLAY - silty
- black
- moist, very stiff
- high plasticity
- trace gravel (diam. < 25 mm) at 0.5 m.
- brown and stiff below 0.5 m.
- some silt laminations at 1.2 m.
- trace silt inclusions (diam. < 15 mm) and greyish brown below 1.3 m.
- trace gravel (diam. < 5 mm) at 1.6 m.
- soft below 2.3 m.

END OF TEST HOLE AT 3.0 m IN CLAY
Notes:
1) No seepage observed.
2) No sloughing observed.
3) Test hole dry and open to 3.0 m below ground surface immediately after drilling.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar
Reviewed By: Nelson Ferreira
Project Engineer: Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH19-02

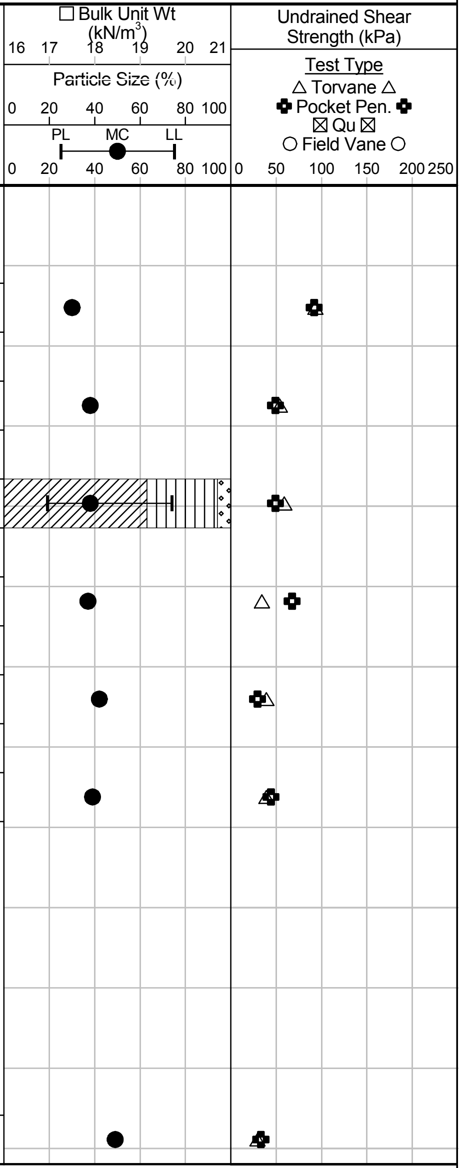
1 of 1

Client: Morrison Hershfield
Project Number: 0035-079-00
Project Name: Sherwin Road Bridge Over Omands Creek
Location: UTM-14U, 5530754N, 628417E
Contractor: TREK Geotechnical Inc.
Ground Elevation: Top of Pavement
Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount
Date Drilled: September 5, 2019

Sample Type: ◩ Grab (G) ◨ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ◫ Core (C)

Particle Size Legend: ▥ Fines ▨ Clay ▥ Silt ▒ Sand ● Gravel ◌ Cobbles ■ Boulders

Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number
0.0		ASPHALT (50 mm thick)		
		CONCRETE (225 mm thick)		
		CLAY (FILL) - silty, trace silt inclusions (diam. <20 mm), trace gravel (diam. <20 mm) - brownish grey - moist, very stiff - high plasticity	◩	G55
0.5		- firm below 0.6 m.	◩	G56
1.0			◩	G57
			◩	G58
1.5		- trace organics below 1.3 m. - soft below 1.5 m.	◩	G59
			◩	G60
2.0				
2.5				
3.0		CLAY - trace silt inclusions (diam. <20 mm), brown, moist, soft, high plasticity	◩	G61



END OF TEST HOLE AT 3.0 m IN CLAY.
Notes:
1) No seepage observed.
2) No sloughing observed.
3) Test hole dry and open to 3.0 m below ground surface immediately after drilling.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH19-03

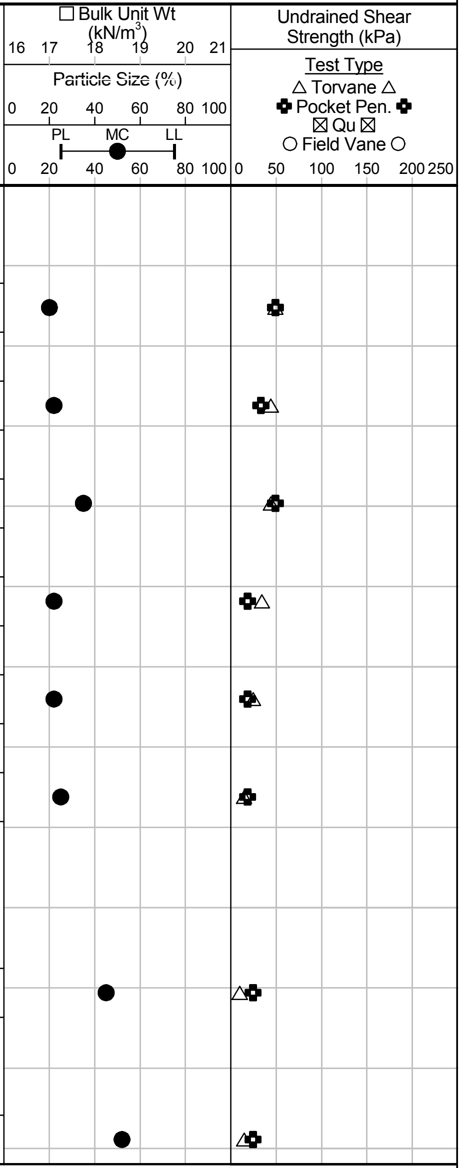
1 of 1

Client:	Morrison Hershfield	**Project Number:**	0035-079-00
Project Name:	Sherwin Road Bridge Over Omands Creek	**Location:**	UTM-14U, 5530652N, 628418E
Contractor:	TREK Geotechnical Inc.	**Ground Elevation:**	Top of Pavement
Method:	125mm Solid Stem Auger, Acker MP8 Truck Mount	**Date Drilled:**	September 5, 2019

Sample Type: ◩ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⠿ Sand ● Gravel ◌ Cobbles ■ Boulders

Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number
	ASPHALT (35 mm thick)		
	CONCRETE (200 mm thick)		
	CLAY (FILL) - silty, trace silt inclusions (diam. < 20 mm), trace gravel - greyish light brown - moist, firm - intermediate plasticity	G	G39
0.5	- no trace gravel and soft below 0.9 m.	G	G40
1.0		G	G41
	- high plasticity below 1.0 m.		
	- light brown and intermediate plasticity below 1.2 m.	G	G42
1.5		G	G43
	- greyish brown below 1.8 m.	G	G44
2.0			
2.5	CLAY - trace silt - greyish brown - moist, soft - high plasticity	G	G45
3.0		G	G46



END OF TEST HOLE AT 3.0 m IN CLAY

Notes:

1) No seepage observed.
2) No sloughing observed.
3) Test hole dry and open to 3.0 m below ground surface immediately after drilling.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

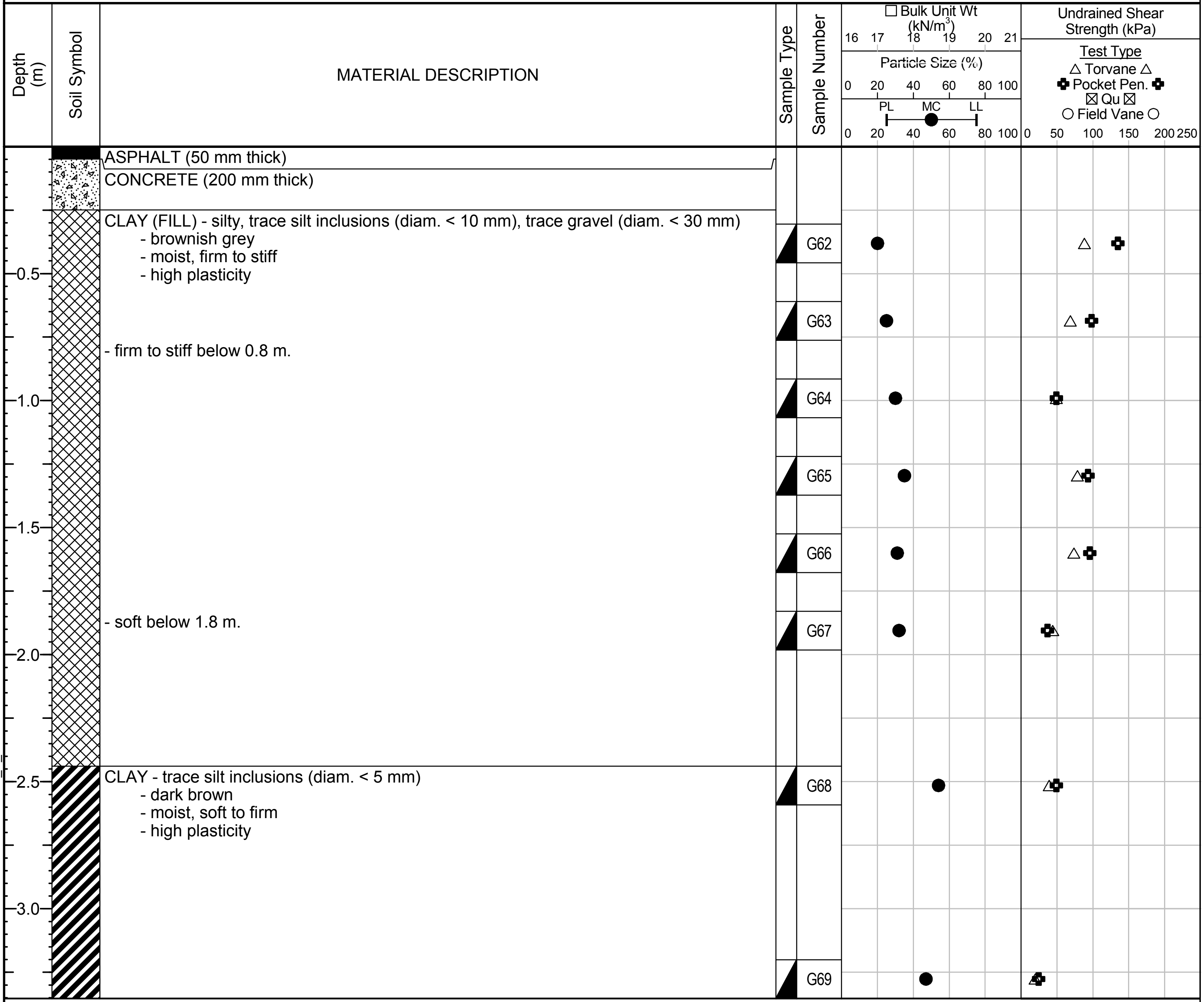
Test Hole TH19-04

1 of 1

Client: Morrison Hershfield
Project Number: 0035-079-00
Project Name: Sherwin Road Bridge Over Omands Creek
Location: UTM-14U, 5530546N, 628411E
Contractor: TREK Geotechnical Inc.
Ground Elevation: Top of Pavement
Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount
Date Drilled: September 5, 2019

Sample Type: ◩ Grab (G) ◫ Shelby Tube (T) ☒ Split Spoon (SS) ⧗ Split Barrel (SB) ◫ Core (C)

Particle Size Legend: ▥ Fines ▨ Clay ▥ Silt ▒ Sand ▓ Gravel ▒ Cobbles ■ Boulders



ASPHALT (50 mm thick)

CONCRETE (200 mm thick)

CLAY (FILL) - silty, trace silt inclusions (diam. < 10 mm), trace gravel (diam. < 30 mm)
- brownish grey
- moist, firm to stiff
- high plasticity

- firm to stiff below 0.8 m.

- soft below 1.8 m.

CLAY - trace silt inclusions (diam. < 5 mm)
- dark brown
- moist, soft to firm
- high plasticity

END OF TEST HOLE AT 3.3 m IN CLAY
Notes:
1) No seepage observed.
2) No sloughing observed.
3) Test hole dry and open to 3.3 m below ground surface immediately after drilling.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

Test Hole TH19-05

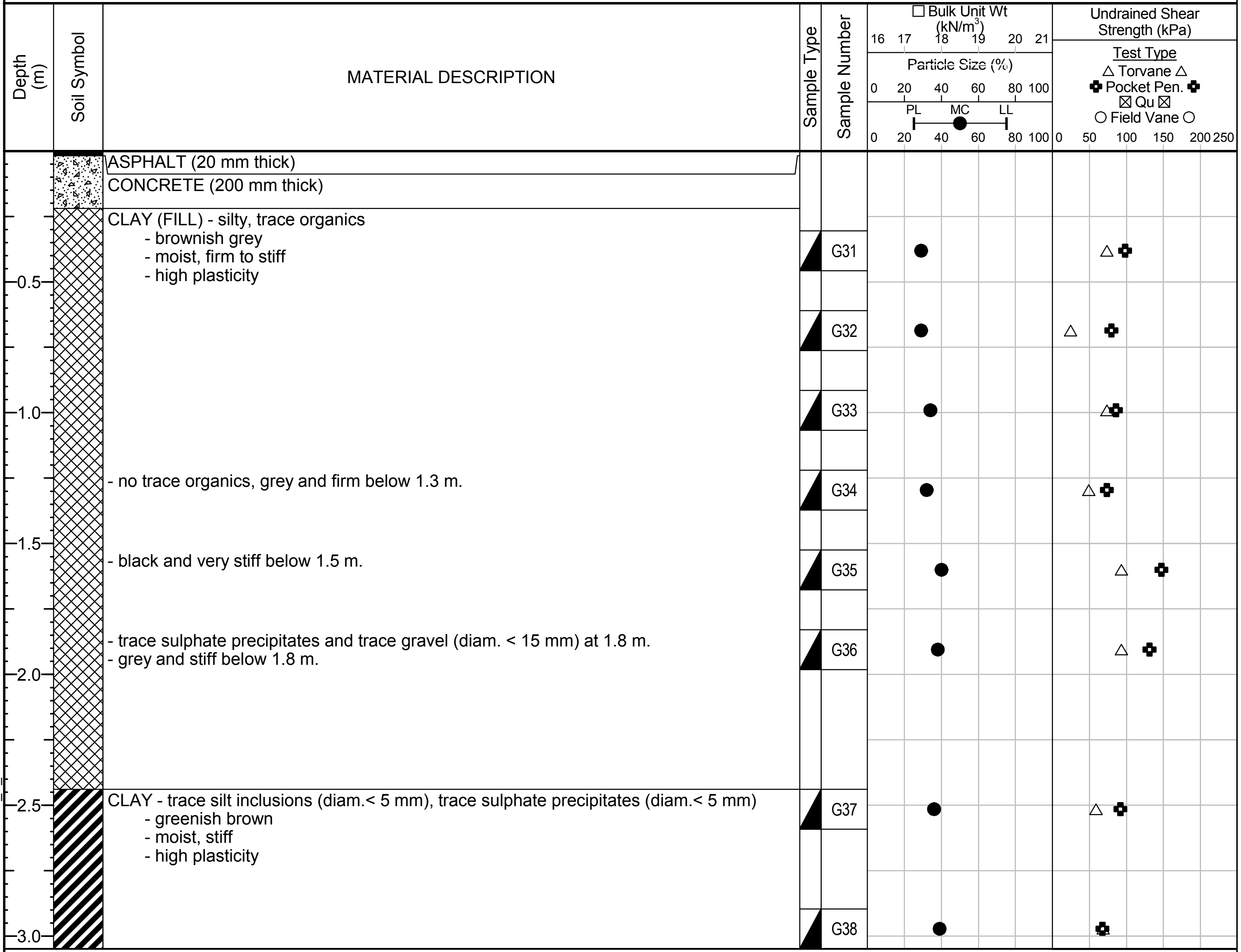
1 of 1

Sub-Surface Log

Client: Morrison Hershfield
Project Number: 0035-079-00
Project Name: Sherwin Road Bridge Over Omands Creek
Location: UTM-14U, 5530448N, 628414E
Contractor: TREK Geotechnical Inc.
Ground Elevation: Top of Pavement
Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount
Date Drilled: September 5, 2019

Sample Type: ◩ Grab (G) ◨ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ◫ Core (C)

Particle Size Legend: ▥ Fines ▨ Clay ▥ Silt ⁘ Sand ● Gravel ◌ Cobbles ■ Boulders



ASPHALT (20 mm thick)

CONCRETE (200 mm thick)

CLAY (FILL) - silty, trace organics
- brownish grey
- moist, firm to stiff
- high plasticity

- no trace organics, grey and firm below 1.3 m.

- black and very stiff below 1.5 m.

- trace sulphate precipitates and trace gravel (diam. < 15 mm) at 1.8 m.
- grey and stiff below 1.8 m.

CLAY - trace silt inclusions (diam.< 5 mm), trace sulphate precipitates (diam.< 5 mm)
- greenish brown
- moist, stiff
- high plasticity

END OF TEST HOLE AT 3.0 m IN CLAY

Notes:
1) No seepage observed.
2) No sloughing observed.
3) Test hole dry and open to 3.0 m below ground surface immediately after drilling.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar
Reviewed By: Nelson Ferreira
Project Engineer: Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

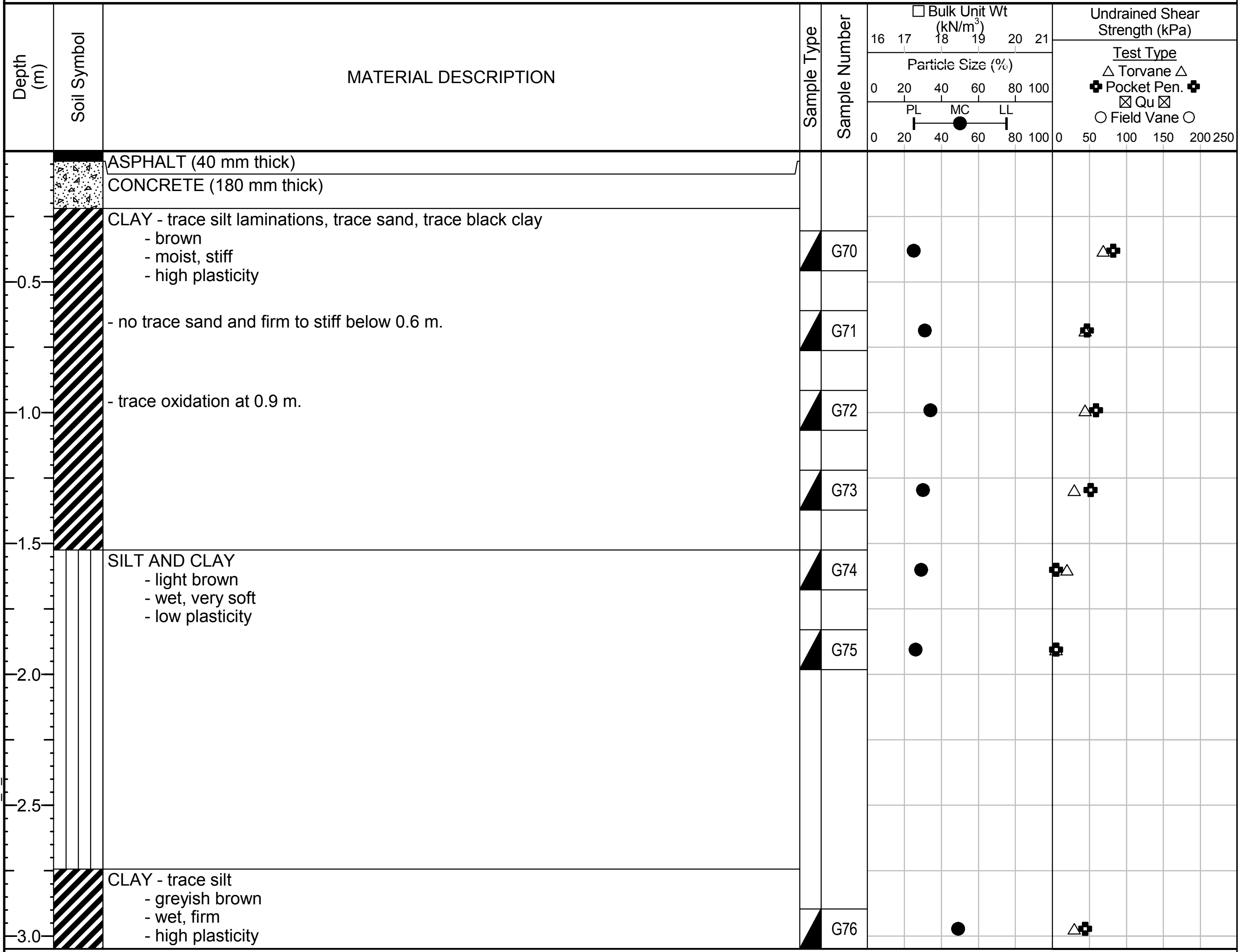
Test Hole TH19-06

1 of 1

Client:	Morrison Hershfield	**Project Number:**	0035-079-00
Project Name:	Sherwin Road Bridge Over Omands Creek	**Location:**	UTM-14U, 5530328N, 628407E
Contractor:	TREK Geotechnical Inc.	**Ground Elevation:**	Top of Pavement
Method:	125mm Solid Stem Auger, Acker MP8 Truck Mount	**Date Drilled:**	September 5, 2019

Sample Type: ◩ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) ⧗ Split Barrel (SB) ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand ● Gravel ◌ Cobbles ■ Boulders



ASPHALT (40 mm thick)

CONCRETE (180 mm thick)

CLAY - trace silt laminations, trace sand, trace black clay
- brown
- moist, stiff
- high plasticity

- no trace sand and firm to stiff below 0.6 m.

- trace oxidation at 0.9 m.

SILT AND CLAY
- light brown
- wet, very soft
- low plasticity

CLAY - trace silt
- greyish brown
- wet, firm
- high plasticity

END OF TEST HOLE AT 3.0 m IN CLAY

Notes:

1) Seepage observed at 1.5 m.
2) No sloughing oobserved.
2) Test hole backfilled with bentonite chips and auger cuttings.
3) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH19-07

1 of 1

Client: Morrison Hershfield

Project Name: Sherwin Road Bridge Over Omands Creek

Contractor: TREK Geotechnical Inc.

Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount

Project Number: 0035-079-00

Location: UTM-14U, 5530242N, 628410E

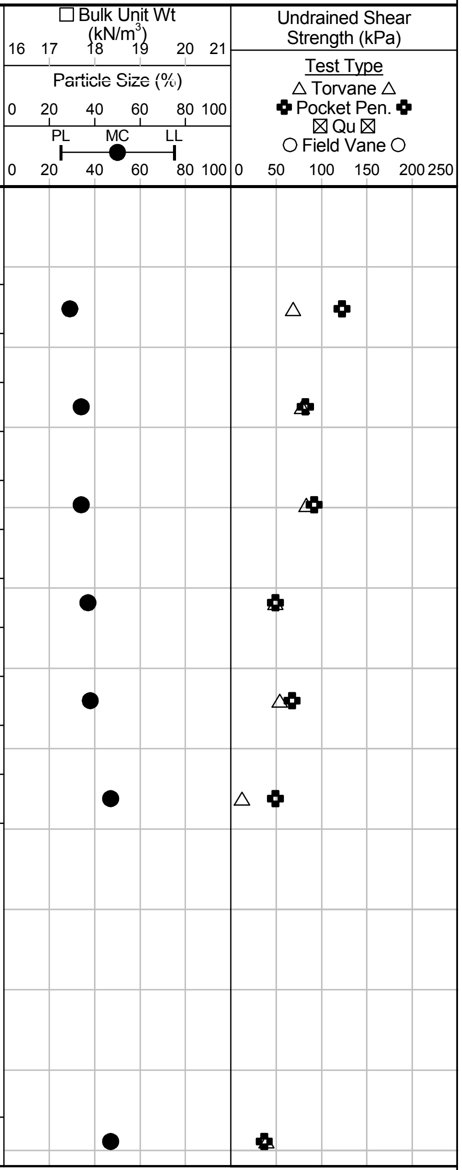
Ground Elevation: Top of Pavement

Date Drilled: September 5, 2019

Sample Type: ◢ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⠿ Sand ● Gravel ◌ Cobbles ■ Boulders

Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number
	ASPHALT (40 mm thick)		
	CONCRETE (205 mm thick)		
	CLAY - trace silt inclusions (diam. < 5 mm), trace organics - blackish grey - moist, stiff to very stiff - high plasticity	◢	G24
0.5	- no trace organics and stiff below 0.6 m.	◢	G25
1.0		◢	G26
	- brownish grey and firm to stiff below 1.2 m.	◢	G27
1.5	- trace sulphate precipitates (diam. < 10 mm) at 1.6 m.	◢	G28
		◢	G29
2.0			
2.5	- greyish brown and firm below 2.4 m.		
3.0		◢	G30



END OF TEST HOLE AT 3.0 m IN CLAY

Notes:

1) No seepage observed.
2) No sloughing observed.
3) Test hole dry and open to 3.0 m below ground surface immediately after drilling.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH19-08

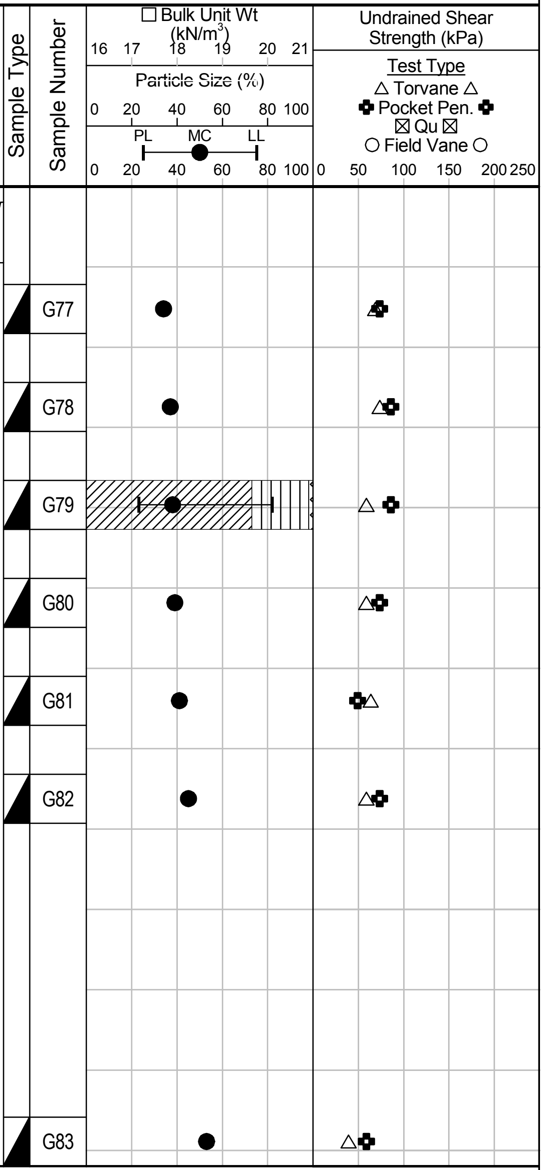
1 of 1

Client: Morrison Hershfield
Project Name: Sherwin Road Bridge Over Omands Creek
Contractor: TREK Geotechnical Inc.
Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount
Project Number: 0035-079-00
Location: UTM-14U, 5530143N, 628402E
Ground Elevation: Top of Pavement
Date Drilled: September 5, 2019

Sample Type: ◩ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) ⧗ Split Barrel (SB) ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand ● Gravel ◌ Cobbles ■ Boulders

Depth (m)	MATERIAL DESCRIPTION
	ASPHALT (50 mm thick)
	CONCRETE (190 mm thick)
	CLAY - trace silt inclusions (diam. < 20 mm), trace orgnaics - blackish grey - moist, firm to stiff - high plasticity - trace gravel (diam. < 30 mm) at 0.5 m. - trace sand at 0.6 m. - no trace organics, brown and stiff below 1.2 m. - trace gravel (diam. < 5 mm) at 1.6 m . - greyish brown and firm to stiff below 1.9 m. - dark brown below 2.7 m.



END OF TEST HOLE AT 3.0 m IN CLAY
Notes:
1) No seepage observed.
2) No sloughing observed.
3) Test hole dry and open to 3.0 m below ground surface immediately after drilling.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar
Reviewed By: Nelson Ferreira
Project Engineer: Michael Van Helden

Test Hole TH19-09

1 of 1

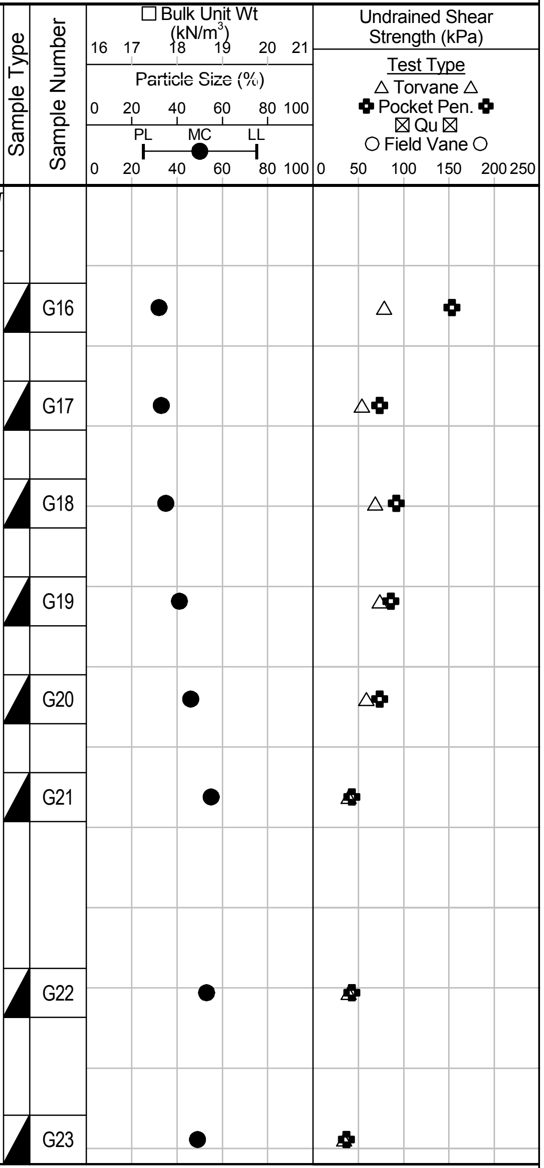
Sub-Surface Log

Client: Morrison Hershfield
Project Number: 0035-079-00
Project Name: Sherwin Road Bridge Over Omands Creek
Location: UTM-14U, 5530044N, 628405E
Contractor: TREK Geotechnical Inc.
Ground Elevation: Top of Pavement
Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount
Date Drilled: September 5, 2019

Sample Type: ◩ Grab (G) ◨ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ◫ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand ● Gravel ◌ Cobbles ■ Boulders

Depth (m)	MATERIAL DESCRIPTION
	ASPHALT (25 mm thick)
	CONCRETE (205 mm thick)
	CLAY - trace silt inclusions (diam. < 5 mm), trace organics - blackish grey - moist, stiff to very stiff - high plasticity
0.5	- no trace organics, light brown and stiff below 0.6 m.
1.0	- trace gravel (diam. < 10 mm) at 0.9 m.
1.5	
2.0	- firm below 1.8 m.
2.5	
3.0	- greyish brown below 2.4 m.



END OF TEST HOLE AT 3.0 m IN CLAY
Notes:
1) No seepage observed.
2) No sloughing observed.
3) Test hole dry and open to 3.0 m below ground surface immediately after drilling.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

SUB-SURFACE LOG LOGS 2019-09-16 SHERWIN ROAD TEST HOLES 0_A_JSB 0035-079-00.GPJ TREK GEOTECHNICAL.GDT 10/24/19

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

Sub-Surface Log

Test Hole TH19-10

1 of 1

Client: Morrison Hershfield
Project Number: 0035-079-00
Project Name: Sherwin Road Bridge Over Omands Creek
Location: UTM-14U, 5529933N, 628398E
Contractor: TREK Geotechnical Inc.
Ground Elevation: Top of Pavement
Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount
Date Drilled: September 5, 2019

Sample Type: ◩ Grab (G) ◫ Shelby Tube (T) ☒ Split Spoon (SS) ☒ Split Barrel (SB) ◫ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ▩ Sand ▩ Gravel ▩ Cobbles ■ Boulders

Depth (m) | Soil Symbol | MATERIAL DESCRIPTION | Sample Type | Sample Number

ASPHALT (50 mm thick)

CONCRETE (190 mm thick)

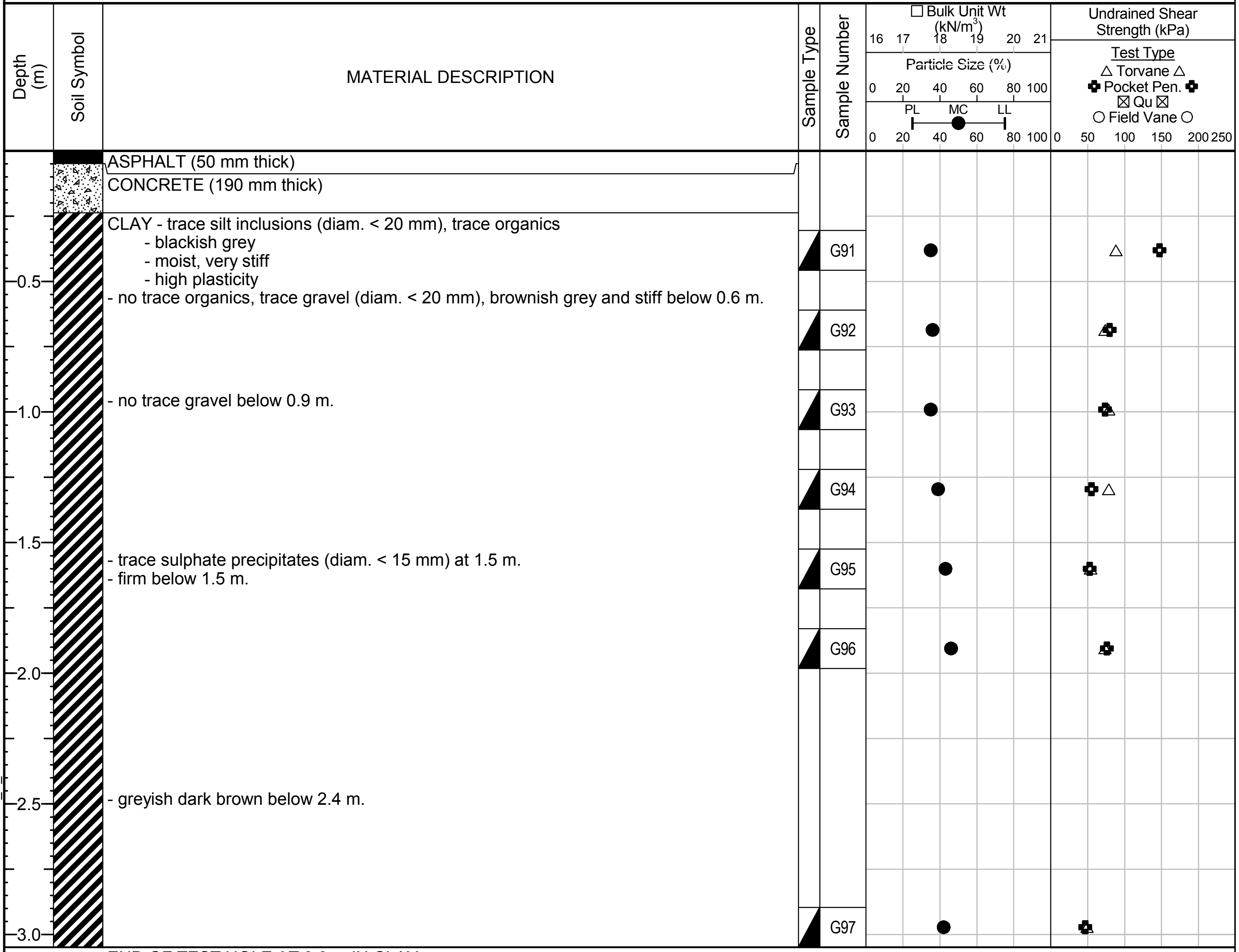
CLAY - trace silt inclusions (diam. < 20 mm), trace organics
- blackish grey
- moist, very stiff
- high plasticity

- no trace organics, trace gravel (diam. < 20 mm), brownish grey and stiff below 0.6 m.

- no trace gravel below 0.9 m.

- trace sulphate precipitates (diam. < 15 mm) at 1.5 m.
- firm below 1.5 m.

- greyish dark brown below 2.4 m.



END OF TEST HOLE AT 3.0 m IN CLAY
Notes:
1) No seepage observed.
2) No sloughing observed.
3) Test hole dry and open to 3.0 m below ground surface immediately after drilling.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar
Reviewed By: Nelson Ferreira
Project Engineer: Michael Van Helden

Sub-Surface Log

Test Hole TH19-11

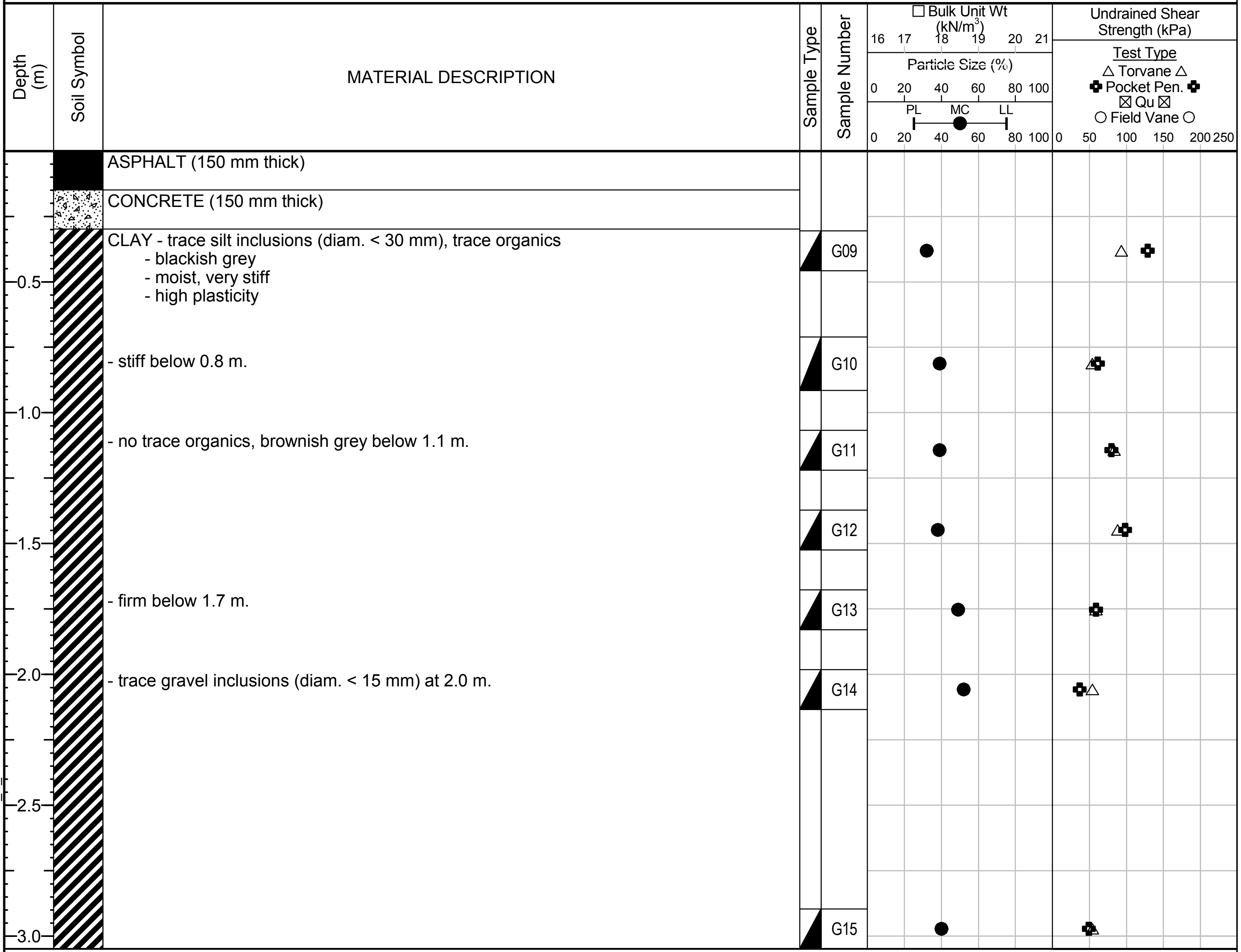
1 of 1

Client: Morrison Hershfield
Project Name: Sherwin Road Bridge Over Omands Creek
Contractor: TREK Geotechnical Inc.
Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount

Project Number: 0035-079-00
Location: UTM-14U, 5529843N, 628402E
Ground Elevation: Top of Pavement
Date Drilled: September 5, 2019

Sample Type: ◩ Grab (G) ◨ Shelby Tube (T) ☒ Split Spoon (SS) ⧗ Split Barrel (SB) ◫ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand ● Gravel ▢ Cobbles ■ Boulders



ASPHALT (150 mm thick)

CONCRETE (150 mm thick)

CLAY - trace silt inclusions (diam. < 30 mm), trace organics
- blackish grey
- moist, very stiff
- high plasticity

- stiff below 0.8 m.

- no trace organics, brownish grey below 1.1 m.

- firm below 1.7 m.

- trace gravel inclusions (diam. < 15 mm) at 2.0 m.

Sample Type	Sample Number
◩	G09
◩	G10
◩	G11
◩	G12
◩	G13
◩	G14
◩	G15

END OF TEST HOLE AT 3.0 m IN CLAY
Notes:
1) No seepage observed.
2) No sloughing observed.
3) Test hole dry and open to 3.0 m below ground surface immediately after drilling.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

Test Hole TH19-12

1 of 1

Sub-Surface Log

Client: Morrison Hershfield

Project Name: Sherwin Road Bridge Over Omands Creek

Contractor: TREK Geotechnical Inc.

Method: 125mm Solid Stem Auger, Acker MP8 Truck Mount

Project Number: 0035-079-00

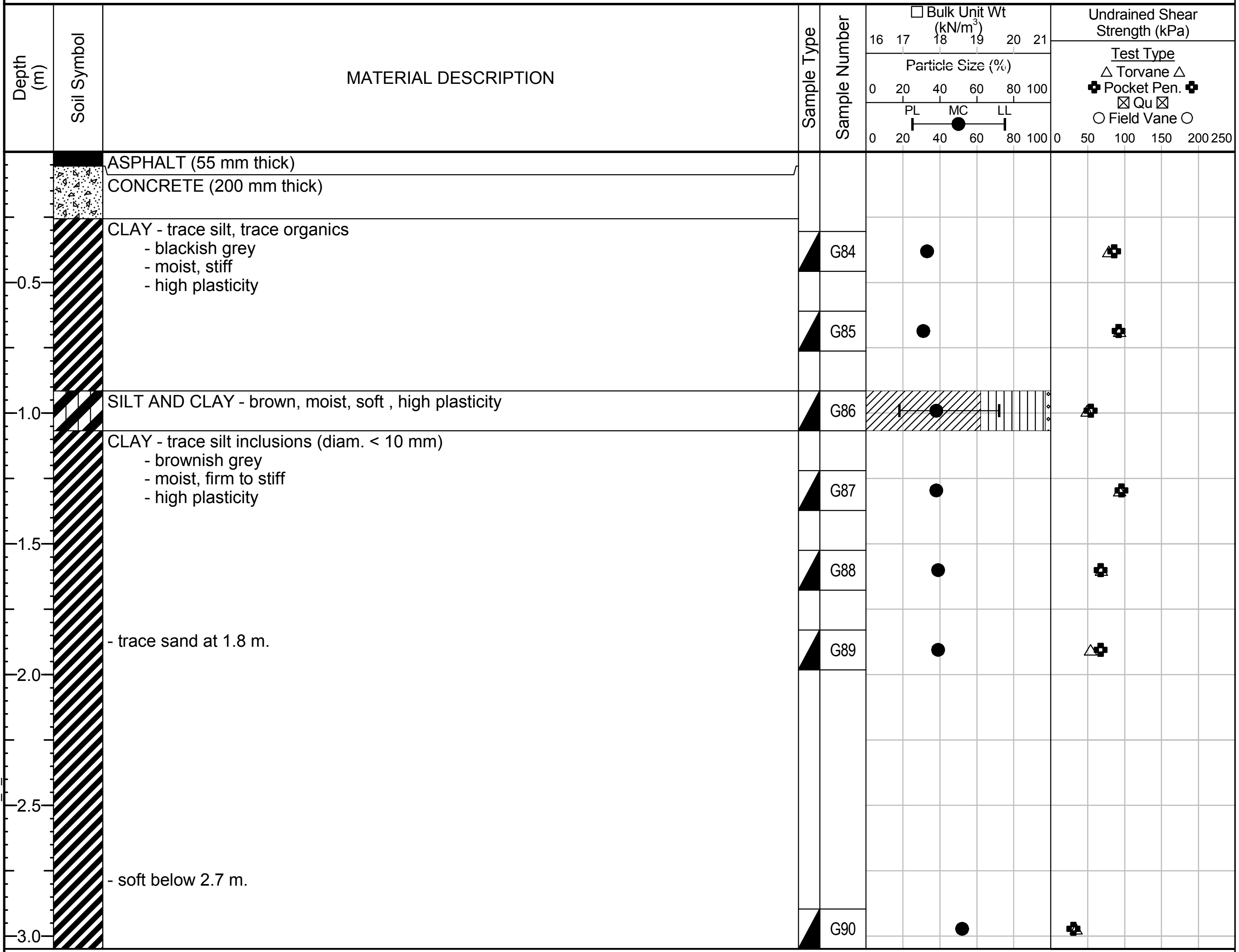
Location: UTM-14U, 5529739N, 628394E

Ground Elevation: Top of Pavement

Date Drilled: September 5, 2019

Sample Type: ◪ Grab (G) ◨ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ◫ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ░ Sand Gravel Cobbles Boulders



ASPHALT (55 mm thick)

CONCRETE (200 mm thick)

CLAY - trace silt, trace organics
- blackish grey
- moist, stiff
- high plasticity

SILT AND CLAY - brown, moist, soft , high plasticity

CLAY - trace silt inclusions (diam. < 10 mm)
- brownish grey
- moist, firm to stiff
- high plasticity

- trace sand at 1.8 m.

- soft below 2.7 m.

END OF TEST HOLE AT 3.0 m IN CLAY

Notes:
1) No seepage observed.
2) No sloughing observed.
3) Test hole dry and open to 3.0 m below ground surface immediately after drilling.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

TREK GEOTECHNICAL

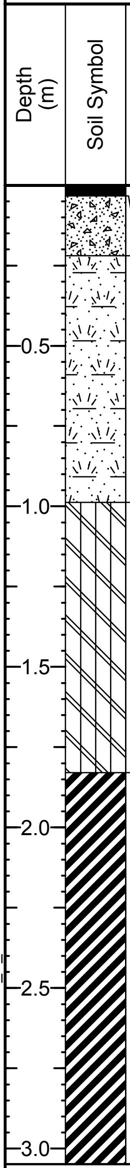
Sub-Surface Log

Test Hole TH19-13
1 of 1

Client: Morrison Hershfield
Project Number: 0035-079-00
Project Name: Sherwin Road Bridge Over Omands Creek
Location: UTM-14U, 5529675N, 628398E
Contractor: TREK Geotechnical Inc.
Ground Elevation: Top of Pavement
Method: 125 mm Solid Stem Auger
Date Drilled: September 5, 2019

Sample Type: ◣ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand Gravel Cobbles Boulders



MATERIAL DESCRIPTION

ASPHALT (35 mm thick)

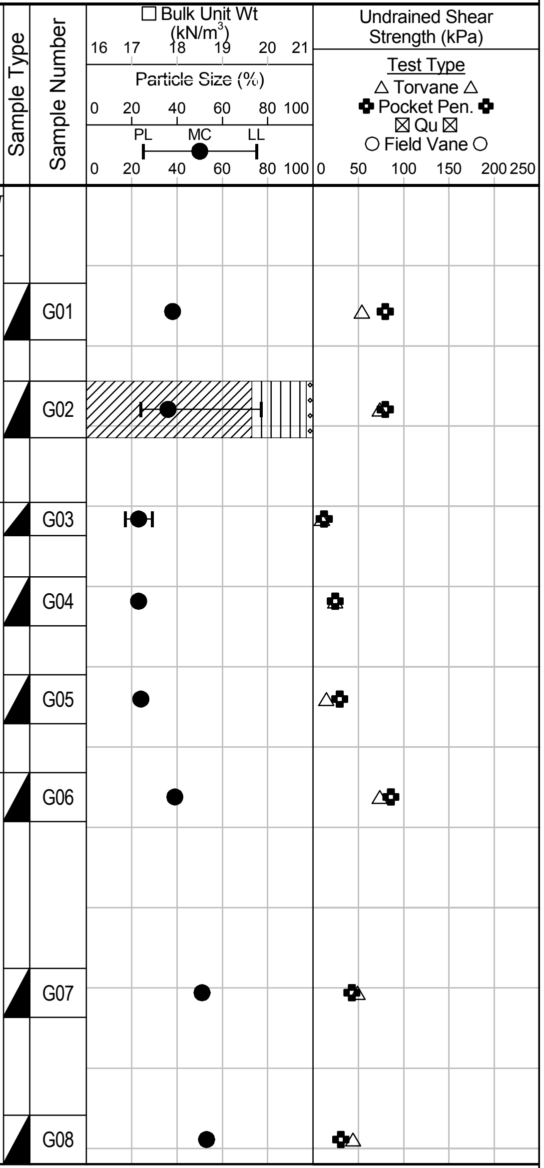
CONCRETE (185 mm thick)

ORGANIC CLAY - trace silt
- blackish grey
- moist, stiff
- high plasticity

SILT AND CLAY- trace sand
- brown
- moist, soft
- low to intermediate plasticity

CLAY - trace silt inclusions (diam. < 15 mm), trace gravel (diam. < 15 mm)
- grey
- moist, stiff
- high plasticity

- trace sulphate precipitates at 2.4 m.
- firm below 2.4 m.



END OF TEST HOLE AT 3.0 m IN CLAY
Notes:
1) No seepage observed.
2) No sloughing observed.
3) Test hole dry and open to 3.0 m below ground surface immediately after drilling.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with the asphalt cold patch.

Logged By: Jashan Bhullar
Reviewed By: Nelson Ferreira
Project Engineer: Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

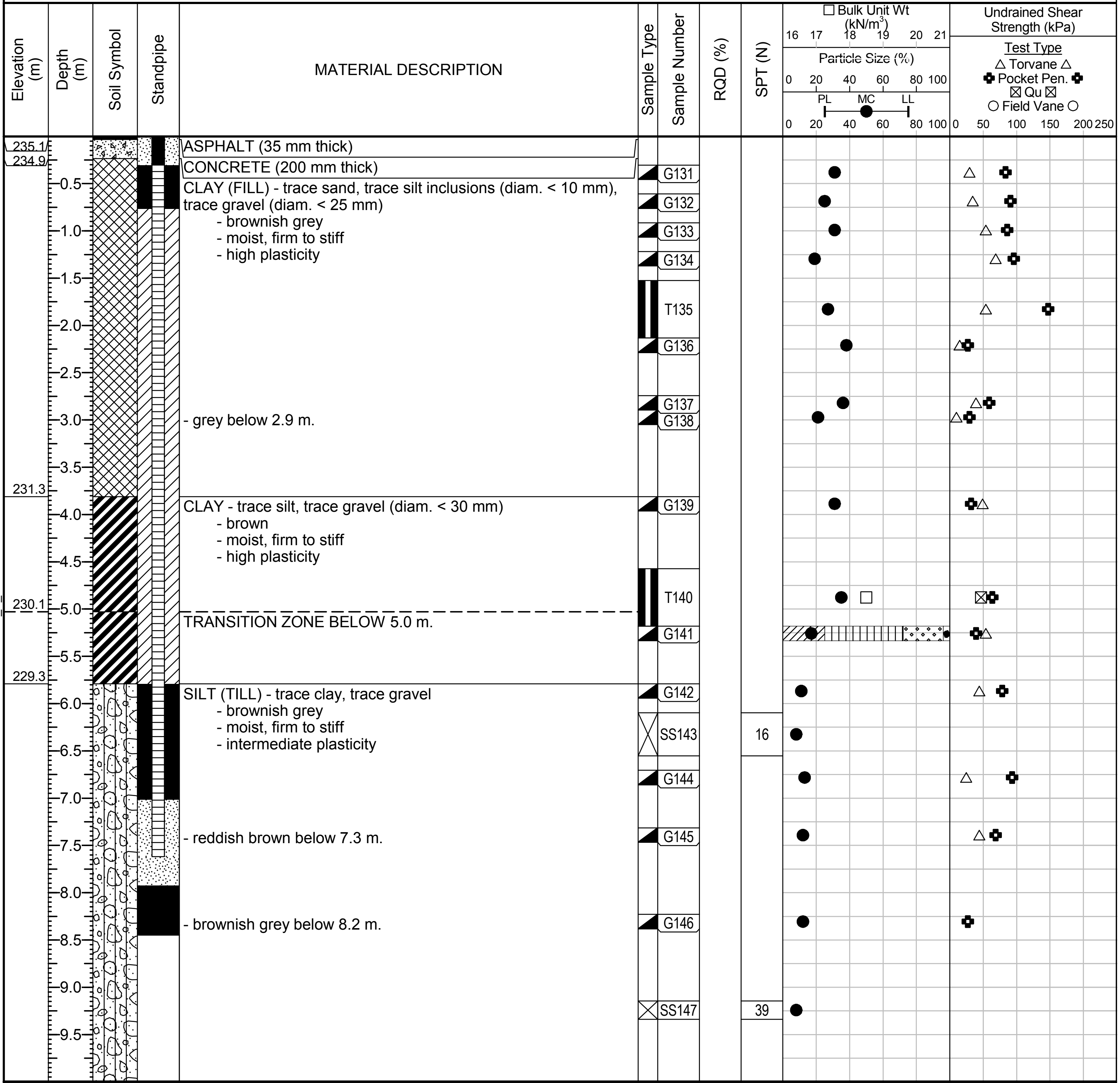
Test Hole TH19-14
1 of 3

Client: Morrison Hershfield
Project Number: 0035-079-00
Project Name: Sherwin Road Bridge Over Omands Creek
Location: UTM N-5530379, E-628408
Contractor: TREK Geotechnical
Ground Elevation: 235.10 m
Method: 125 mm Dia. SSA, HQ Coring, ACKER SS
Date Drilled: September 11, 2019

Sample Type: Grab (G) Shelby Tube (T) Split Spoon (SS) Split Barrel (SB) Core (C)

Particle Size Legend: Fines Clay Silt Sand Gravel Cobbles Boulders

Backfill Legend: Bentonite Cement Drill Cuttings Filter Pack Sand Grout Slough



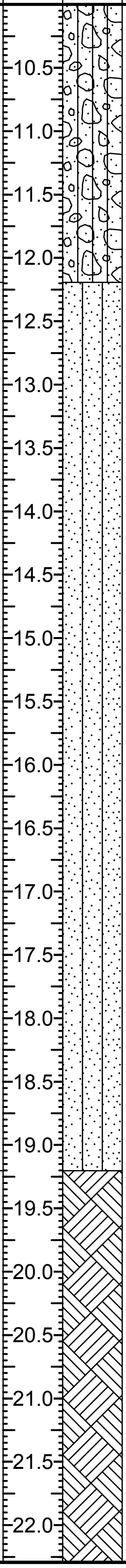
Elevation (m)	Material Description
235.1	ASPHALT (35 mm thick)
234.9	CONCRETE (200 mm thick)
	CLAY (FILL) - trace sand, trace silt inclusions (diam. < 10 mm), trace gravel (diam. < 25 mm) - brownish grey - moist, firm to stiff - high plasticity - grey below 2.9 m.
231.3	CLAY - trace silt, trace gravel (diam. < 30 mm) - brown - moist, firm to stiff - high plasticity
230.1	TRANSITION ZONE BELOW 5.0 m.
229.3	SILT (TILL) - trace clay, trace gravel - brownish grey - moist, firm to stiff - intermediate plasticity - reddish brown below 7.3 m. - brownish grey below 8.2 m.

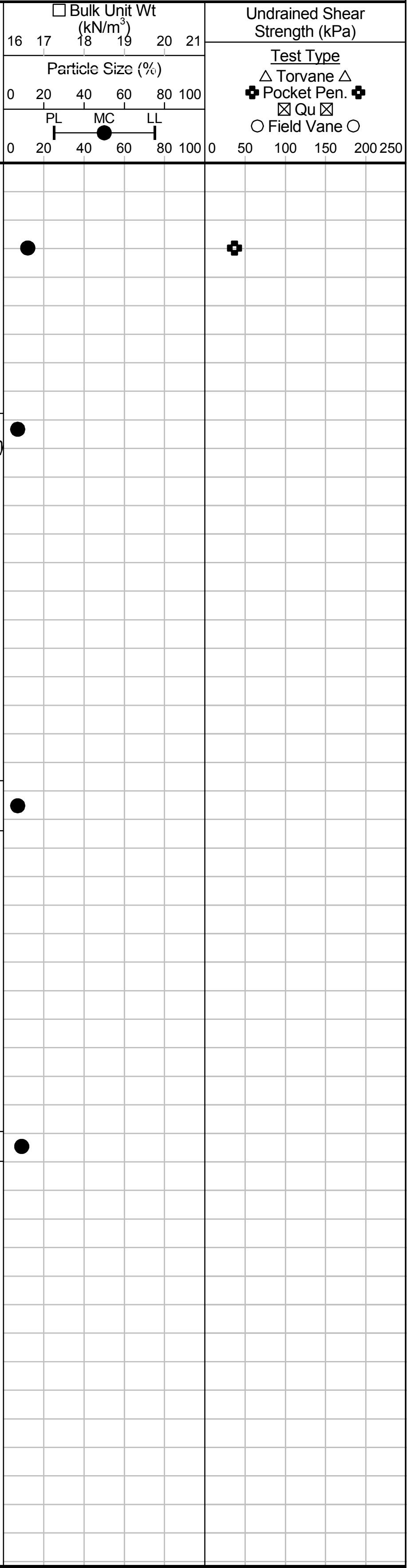
Sample Number	SPT (N)
G131	
G132	
G133	
G134	
T135	
G136	
G137	
G138	
G139	
T140	
G141	
G142	
SS143	16
G144	
G145	
G146	
SS147	39

Logged By: Jashan Bhullar
Reviewed By: Nelson Ferreira
Project Engineer: Michael Van Helden

Sub-Surface Log

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Number	RQD (%)	SPT (N)
			G148		
222.9		SAND (TILL) - trace silt - brown - moist, very dense becoming dense with depth - no to low plasticity - granite and limestone coubles and boulders below 12.5 m.	SS149		50 / 128mm
			C150		
			SS151		68
			SS152		41
215.9		DOLOMITE (Red River formation, Upper Fort Garry) - chert nodules, calcareous - cream to light grey, hard, R3-R4 - brecciated, vuggy	C153		
			C154	23	
			C155	30	
		- vuggy layers, horizontal fractures and fractures at 60 degrees to			

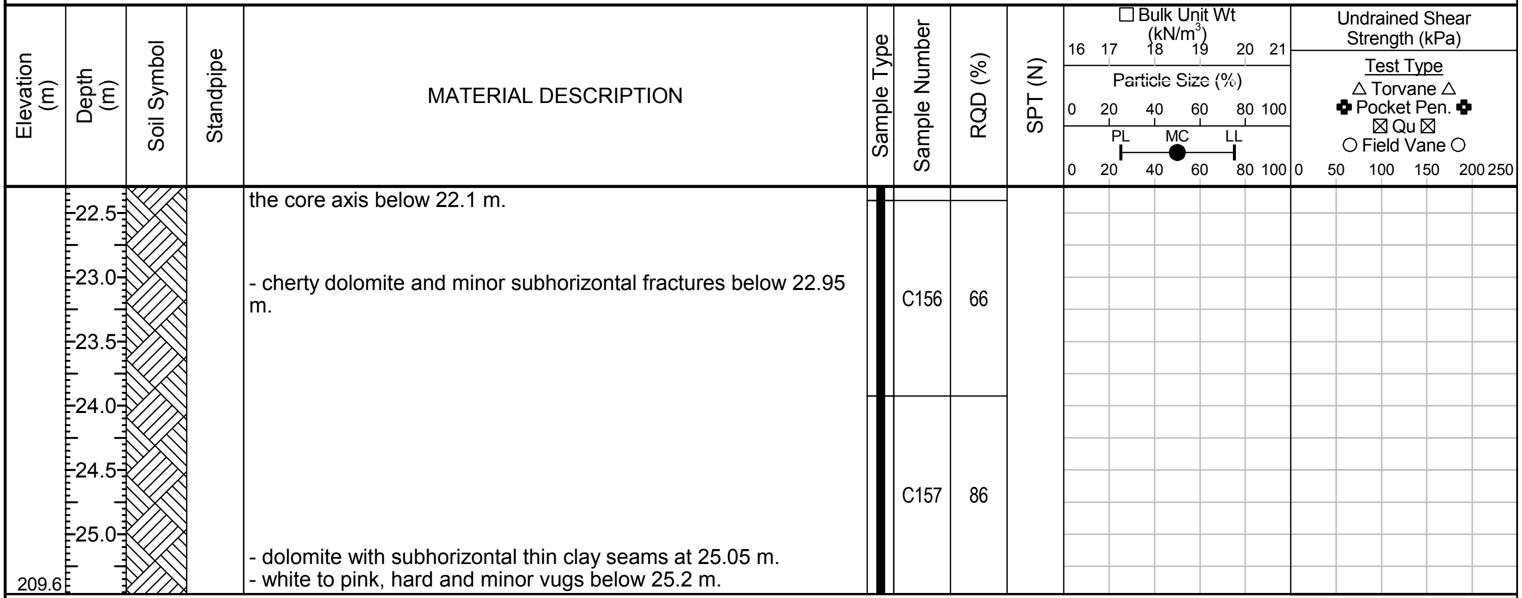




Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

Sub-Surface Log

Test Hole TH19-14



the core axis below 22.1 m.

- cherty dolomite and minor subhorizontal fractures below 22.95 m.

- dolomite with subhorizontal thin clay seams at 25.05 m.
- white to pink, hard and minor vugs below 25.2 m.

Sample Number	RQD (%)
C156	66
C157	86

END OF TEST HOLE AT 25.4 m IN DOLOMITE BEDROCK.
Notes:
1) No seepage observed.
2) No sloughing observed.
3) Switched to HWT casing and HQ coring below 12.6 m.
4) SP19-14 installed in TH19-14A located approx. 1 m South-west of the test hole.
5) Test hole backfilled with bentonite chips and auger cuttings.
6) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

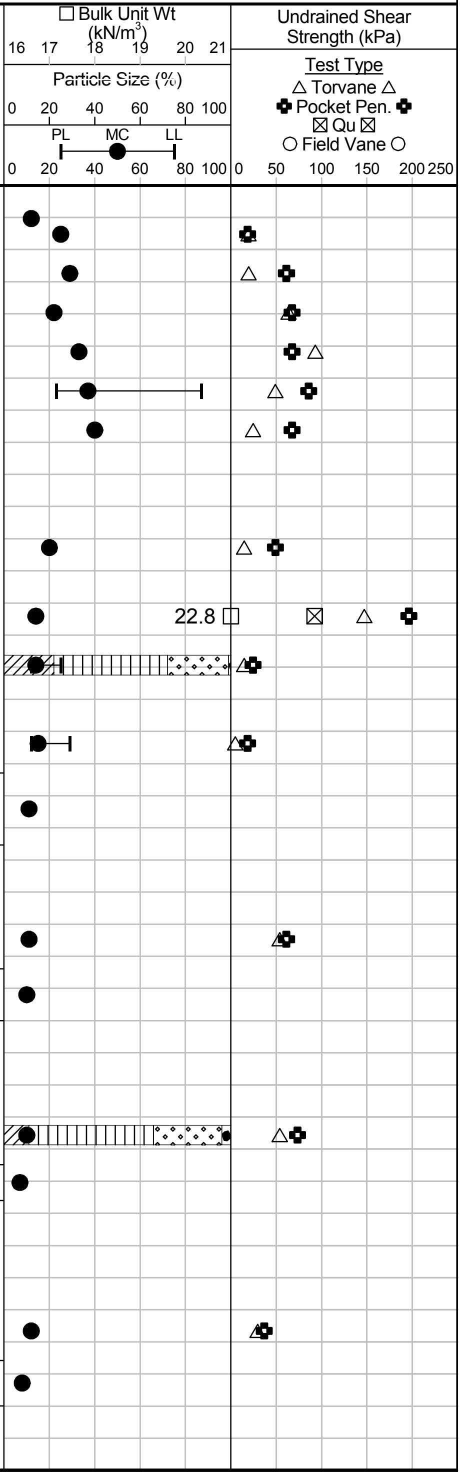
Test Hole TH19-15

Client: Morrison Hershfield
Project Number: 0035-079-00
Project Name: Sherwin Road Bridge Over Omands Creek
Location: UTM N-5530379, E-628408
Contractor: TREK Geotechnical Inc.
Ground Elevation: 235.05 m
Method: Acker Track Mount, 125 mm SSA
Date Drilled: September 6, 2019

Sample Type: ◢ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⛆ Sand ● Gravel ⬭ Cobbles ■ Boulders

Elevation (m)	Depth (m)	Soil Symbol	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)
235.0			ASPHALT (30 mm thick)				
234.8			CONCRETE (210 mm thick)		G98		
	0.5		CLAY (FILL) - silty, trace sand, trace gravel (diam. < 25 mm) - dark brown to grey - moist, stiff - high plasticity		G99		
					G100		
	1.0				G101		
					G102		
233.5	1.5		CLAY - trace silt inclusions (diam. < 5 mm), trace sand, trace gravel (diam. < 20 mm) - dark brown - moist, stiff - high plasticity		G103		
	2.0				G104		
	2.5						
232.3			- TRANSITION ZONE BELOW 2.7 m.		G105		
	3.0						
	3.5				T106		
231.4			SILT (TILL) - trace to some clay, trace sand, trace gravel (diam. < 30 mm) - light brown - moist, compact - low plasticity		G107		
	4.0						
	4.5		- trace clay below 4.6 m.		G108		
	5.0				SS109		11
	5.5						
	6.0		- compact to dense below 6.0 m.		G110		
					SS111		12
	6.5						
	7.0						
	7.5				G112		
					SS113		16
	8.0						
	8.5						
	9.0				G114		
	9.5				SS115		15

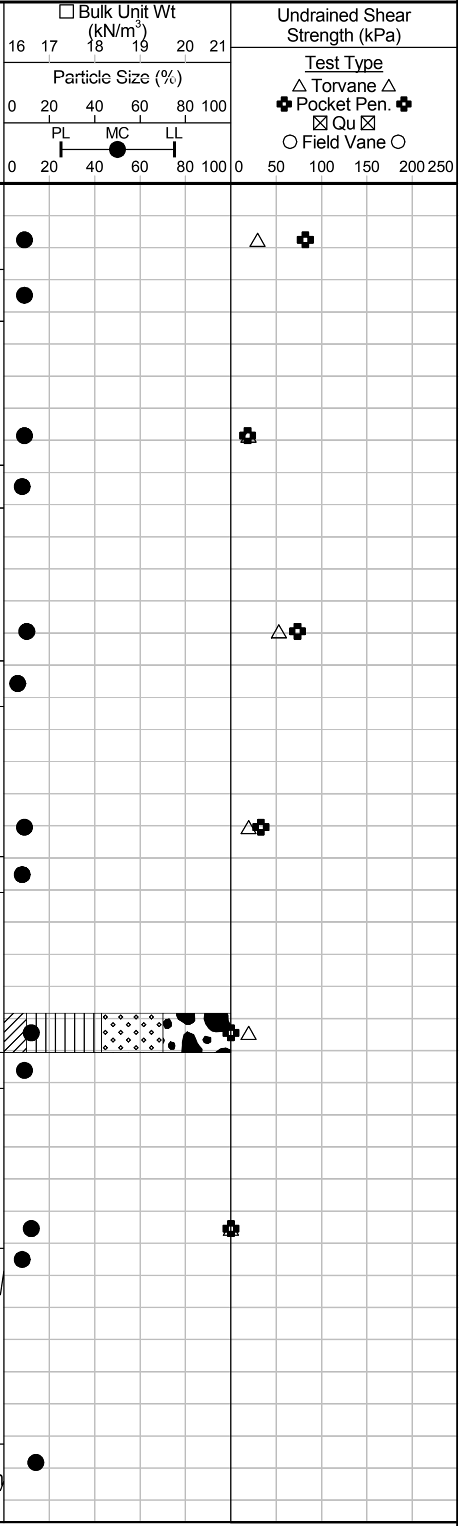


Logged By: Jashan Bhullar
Reviewed By: Nelson Ferreira
Project Engineer: Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)
	10.5		◢	G116		
	10.7	- compact below 10.7 m.	☒	SS117		17
	12.0		◢	G118		
	12.4		☒	SS119		15
	13.5		◢	G120		
	13.7	- no clay, no plasticity and very dense below 13.7 m. - trace limestone gravel at 13.7 m.	☒	SS121		53
	15.0		◢	G122		
219.8	15.2	SANDY SILT (TILL) - brown - damp, very dense - no to low plasticity	☒	SS123		68
218.6	16.4	SANDY SILT - trace gravel - light brown - wet, very dense - no plasticity	◢	G124		
			☒	SS125		105
			◢	G126		
216.8	18.2	SAND (TILL) - silty, trace gravel - brown - moist, very dense - no plasticity	☒	SS127		142 / 24mm
			▮	C128		
215.2	19.8	SAND - poorly graded, fine grained, trace to some gravel, brown, wet, very loose, no plasticity - limestone cobble at 20.3 m.	☒	SS129		51 / 137mm
			▮	C130		
214.6	20.5					



END OF TEST HOLE AT 20.5 m IN SAND.
Notes:
1) Power auger refusal at 18.4 m in SAND (TILL).
2) Switched to HWT casing and HQ coring below 18.4 m.
3) Seepage observed at 15.0 m in SILT (TILL) and below 16.5 m in SANDY SILT.
3) No sloughing observed.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

Appendix B

Soil Sample laboratory Results and Summary Table

Replacement of Existing Culvert at Sherwin Road Over Omand's Creek and Associated Regional Street Improvements

Sub-Surface Investigation

Sherwin Road

Test Hole No.	Test Hole Location	Pavement Surface		Pavement Structure Material		Subgrade Description	Sample Depth (m)		Moisture Content (%)	Grain Size Analysis				Atterberg Limits		
		Type	Thickness (mm)	Type	Thickness (mm)		Top (m)	Bottom (m)		Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Plastic	Liquid	Plasticity Index
TH19-01	UTM : 5530838 N, 628422 E Located in Northbound lane, 1.6 m West of East Curb and opposite of 2070 Notre Dame Avenue on Sherwin Road	Asphalt	30	Concrete	200	Clay	0.3	0.5	22							
						Clay	0.6	0.8	30							
						Clay	0.9	1.1	34							
						Clay	1.2	1.3	40							
						Clay	1.3	1.4	39							
						Clay	1.5	1.7	41							
						Clay	1.8	2.0	44							
						Clay	2.9	3.0	55							
TH19-02	UTM : 5530754 N, 628417 E Located in Southbound lane, 0.9 m East of West curb and opposite to 1240 Sherwin Road	Asphalt	50	Concrete	225	Clay (Fill)	0.3	0.5	30							
						Clay (Fill)	0.6	0.8	38							
						Clay (Fill)	0.9	1.1	38	64	31	6	0	19	74	55
						Clay (Fill)	1.2	1.4	37							
						Clay (Fill)	1.5	1.7	42							
						Clay (Fill)	1.8	2.0	39							
						Clay	2.9	3.0	49							
TH19-03	UTM : 5530652 N, 628418 E Located in Northbound lane, 1.5 m West of East curb and opposite to 1221 Sherwin Road	Asphalt	35	Concrete	200	Clay (Fill)	0.3	0.5	20							
						Clay (Fill)	0.6	0.8	22							
						Clay (Fill)	0.9	1.1	35							
						Clay (Fill)	1.2	1.4	22							
						Clay (Fill)	1.5	1.7	22							
						Clay (Fill)	1.8	2.0	25							
						Clay	2.4	2.6	45							
						Clay	2.9	3.0	52							
TH19-04	UTM : 5530546 N, 628411 E Located in Southbound lane, 1 m East of West curb and opposite to 1200 Sherwin Road	Asphalt	50	Concrete	200	Clay (Fill)	0.3	0.5	20							
						Clay (Fill)	0.6	0.8	25							
						Clay (Fill)	0.9	1.1	29							
						Clay (Fill)	1.2	1.4	35							
						Clay (Fill)	1.5	1.7	31							
						Clay (Fill)	1.8	2.0	32							
						Clay	2.4	2.6	54							
						Clay	3.2	3.4	47							

Replacement of Existing Culvert at Sherwin Road Over Omand's Creek and Associated Regional Street Improvements
Sub-Surface Investigation
Sherwin Road

Test Hole No.	Test Hole Location	Pavement Surface		Pavement Structure Material		Subgrade Description	Sample Depth (m)		Moisture Content (%)	Grain Size Analysis				Atterberg Limits		
		Type	Thickness (mm)	Type	Thickness (mm)		Top (m)	Bottom (m)		Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Plastic	Liquid	Plasticity Index
TH19-05	UTM : 5530448 N, 628414 E Located in Northbound lane, 1 m West of East Curb and opposite to 1155 Sherwin Road	Asphalt	20	Concrete	200	Clay (Fill)	0.3	0.5	29							
						Clay (Fill)	0.6	0.8	29							
						Clay (Fill)	0.9	1.1	34							
						Clay (Fill)	1.2	1.4	32							
						Clay (Fill)	1.5	1.7	40							
						Clay (Fill)	1.8	2.0	38							
						Clay	2.4	2.6	36							
						Clay	2.9	3.0	39							
TH19-06	UTM : 5530328 N, 628407 E Located in Southbound lane, 0.9 m East of West curb and opposite to 1830 Dublin Avenue on Sherwin Road	Asphalt	40	Concrete	180	Clay	0.3	0.5	25							
						Clay	0.6	0.8	31							
						Clay	0.9	1.1	34							
						Clay	1.2	1.4	30							
						Silt and Clay	1.5	1.7	29							
						Silt and Clay	1.8	2.0	26							
						Clay	2.9	3.0	49							
TH19-07	UTM : 5530242 N, 628410 E Located in Northbound lane, 2.2 m West of East curb and opposite to 1093 Sherwin Road	Asphalt	40	Concrete	205	Clay	0.3	0.5	29							
						Clay	0.6	0.8	34							
						Clay	0.9	1.1	34							
						Clay	1.2	1.4	37							
						Clay	1.5	1.7	38							
						Clay	1.8	2.0	47							
						Clay	2.9	3.0	47							
TH19-08	UTM : 5530143 N, 628402 E Located in Southbound lane, 1 m East of West curb and opposite to 1093 Sherwin Road	Asphalt	50	Concrete	190	Clay	0.3	0.5	34							
						Clay	0.6	0.8	37							
						Clay	0.9	1.1	38	25	73	2	0	23	82	59
						Clay	1.2	1.4	39							
						Clay	1.5	1.7	41							
						Clay	1.8	2.0	45							
						Clay	2.9	3.0	53							

TREK GEOTECHNICAL

Replacement of Existing Culvert at Sherwin Road Over Omand's Creek and Associated Regional Street Improvements
Sub-Surface Investigation
Sherwin Road

Test Hole No.	Test Hole Location	Pavement Surface		Pavement Structure Material		Subgrade Description	Sample Depth (m)		Moisture Content (%)	Grain Size Analysis				Atterberg Limits		
		Type	Thickness (mm)	Type	Thickness (mm)		Top (m)	Bottom (m)		Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Plastic	Liquid	Plasticity Index
TH19-09	UTM : 5530044 N, 628405 E Located in Northbound lane, 2.3 m West of East Curb and opposite to 1063 Sherwin Road	Asphalt	25	Concrete	180	Clay	0.3	0.5	32							
						Clay	0.6	0.8	33							
						Clay	0.9	1.1	35							
						Clay	1.2	1.4	41							
						Clay	1.5	1.7	46							
						Clay	1.8	2.0	55							
						Clay	2.4	2.6	53							
						Clay	2.9	3.0	49							
TH19-10	UTM : 5529933 N, 628398 E Located in Southbound lane, 1.3 m East of West curb and opposite to 1051 Sherwin Road	Asphalt	50	Concrete	190	Clay	0.3	0.5	35							
						Clay	0.6	0.8	36							
						Clay	0.9	1.1	35							
						Clay	1.2	1.4	39							
						Clay	1.5	1.7	43							
						Clay	1.8	2.0	46							
						Clay	2.9	3.0	42							
TH19-11	UTM : 5529843 N, 628402 E Located in Northbound lane, 1.5 m West of East curb and opposite to 1001 Sherwin Road	Asphalt	150	Concrete	150	Clay	0.3	0.5	32							
						Clay	0.7	0.9	39							
						Clay	1.1	1.2	39							
						Clay	1.4	1.5	38							
						Clay	1.7	1.8	49							
						Clay	2.0	2.1	52							
						Clay	2.9	3.0	40							
TH19-12	UTM : 5529739 N, 628394 E Located in Southbound lane, 0.95 m East of West curb and opposite to 975 Sherwin Road	Asphalt	55	Concrete	200	Clay	0.3	0.5	33							
						Clay	0.6	0.8	31							
						Silt and Clay	0.9	1.1	38	62	35	3	0	18	72	54
						Clay	1.2	1.4	38							
						Clay	1.5	1.7	39							
						Clay	1.8	2.0	39							
						Clay	2.9	3.0	52							

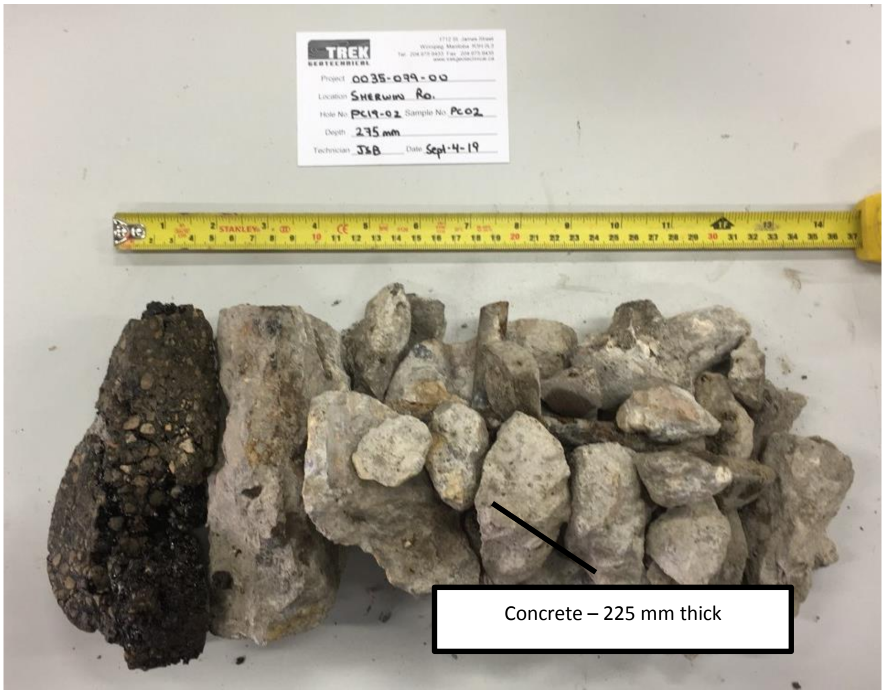
Replacement of Existing Culvert at Sherwin Road Over Omand’s Creek and Associated Regional Street Improvements
Sub-Surface Investigation
Sherwin Road

Test Hole No.	Test Hole Location	Pavement Surface		Pavement Structure Material		Subgrade Description	Sample Depth (m)		Moisture Content (%)	Grain Size Analysis				Atterberg Limits		
		Type	Thickness (mm)	Type	Thickness (mm)		Top (m)	Bottom (m)		Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Plastic	Liquid	Plasticity Index
TH19-13	UTM : 5529739 N, 628398 E Located in Northbound lane, 1.5 m West of East Curb and opposite to 975 Sherwin Road	Asphalt	35	Concrete	185	Clay (Organic)	0.3	0.5	38							
						Clay (Organic)	0.6	0.8	36	73	24	3	0	77	24	53
						Silt and Clay	0.9	1.1	23					17	29	12
						Silt and Clay	1.2	1.4	23							
						Silt and Clay	1.5	1.7	24							
						Clay	1.8	2.0	39							
						Clay	2.4	2.6	51							
						Clay	2.9	3.0	53							
TH19-14	UTM : 5530420 N, 628409 E Located in Southbound lane, 1 m East of West Curb and opposite to 1151 Sherwin Road	Asphalt	35	Concrete	200	Clay (Fill)	0.3	0.5	31							
						Clay (Fill)	0.6	0.8	25							
						Clay (Fill)	0.9	1.1	31							
						Clay (Fill)	1.2	1.4	19							
						Clay (Fill)	1.5	2.1	29							
						Clay (Fill)	2.1	2.3	38							
						Clay (Fill)	2.7	2.9	36							
						Clay (Fill)	2.9	3.0	21							
TH19-15	UTM : 5530379 N, 628408 E Located in at the intersection of Dublin Ave and Sherwin Road, 0.45 m East of West Curb	Asphalt	30	Concrete	210	Clay (Fill)	0.2	0.3	12							
						Clay (Fill)	0.3	0.5	25							
						Clay (Fill)	0.6	0.8	29							
						Clay (Fill)	0.9	1.1	22							
						Clay (Fill)	1.2	1.4	33							
						Clay	1.5	1.7	37							
						Clay	1.8	2.0	40							
						Clay	2.7	2.9	20							

Appendix C

Photographs of Pavement Core Samples

Photo 1: Pavement Core Sample at Test Hole TH19-01



Concrete – 225 mm thick

Photo 2: Pavement Core Sample at Test Hole TH19-02

1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 0035-079-00
Location SHERWIN RD.
Hole No. PC19-03 Sample No. PC03
Depth 235 mm
Technician JSB Date Sept-3-19

Photo 3: Pavement Core Sample at Test Hole TH19-03

1712 St. James Street
Winnipeg, Manitoba R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435
www.trekgeotechnical.ca

Project 0035-079-00
Location SHERWIN RD
Hole No. PC19-04 Sample No. PC04
Depth 250 mm
Technician JSB Date Sept-3-19

Photo 4: Pavement Core Sample at Test Hole TH19-04

Photo 5: Pavement Core Sample at Test Hole TH19-05

Photo 6: Pavement Core Sample at Test Hole TH19-06

Photo 7: Pavement Core Sample at Test Hole TH19-07

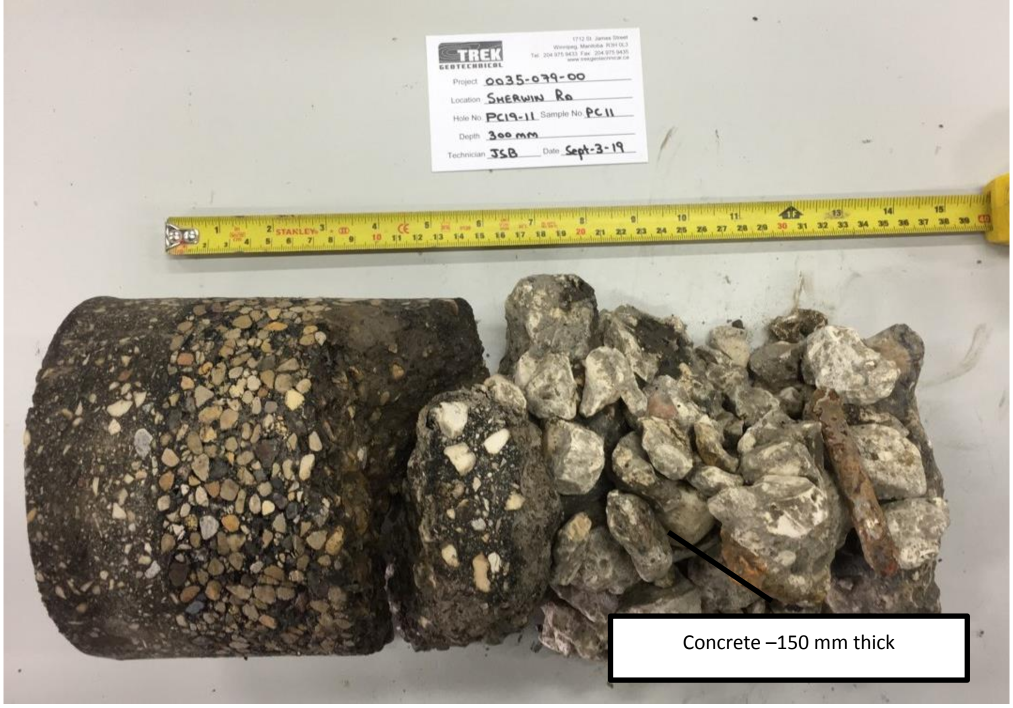
Photo 8: Pavement Core Sample at Test Hole TH19-08

Project 0035-079-00
Location SHERWIN RD
Hole No. PC19-09 Sample No. PC09
Depth 205 mm
Technician JSB Date Sept-3-19

Photo 9: Pavement Core Sample at Test Hole TH19-09

Project 0035-079-00
Location SHERWIN RD
Hole No. PC19-10 Sample No. PC10
Depth 240 mm
Technician JSB Date Sept-4-19

Photo 10: Pavement Core Sample at Test Hole TH19-10



Project 0035-079-00
Location SHERWIN RD
Hole No PC19-11 Sample No PC11
Depth 300 mm
Technician JSB Date Sept-3-19

Photo 11: Pavement Core Sample at Test Hole TH19-11

Project 0035-079-00
Location SHERWIN RD
Hole No PC19-12 Sample No PC12
Depth 255mm
Technician JSB Date Sept-4-19

Photo 12: Pavement Core Sample at Test Hole TH19-12

Project 0035-079-00
Location SHERWIN RD
Hole No PC19-13 Sample No PC13
Depth 220 mm
Technician JSB Date Sept-4-19

Photo 13: Pavement Core Sample at Test Hole TH19-13

Project 0035-079-00
Location SHERWIN RD.
Hole No. PC19-14 Sample No. PC14
Depth 235 mm
Technician JSB Date Sept-6-19

Photo 14: Pavement Core Sample at Test Hole TH19-14

Photo 15: Pavement Core Sample at Test Hole TH19-15

Photo 16: Pavement Core Sample at Test Hole SP19-14

TREK GEOTECHNICAL Quality Engineering | Valued Relationships

MEMORANDUM

Date	November 18, 2019
To	Jashan Bhullar, TREK Geotechnical
From	Angela Fidler-Kliewer, TREK Geotechnical
Project No.	0035-079-00
Project	Sherwin Road Bridge Over Omands Creek
Subject	Laboratory Testing Results – Lab Req. R19-247
Distribution	Michael Van Helden

Attached are the laboratory testing results for the above noted project. This report contains Standard proctor and California Bearing Ration (CBR) test results on a mixture of various samples from between the depths of 0.3 m and 1.1 m .

Regards,

Angela Fidler-Kliewer, C.Tech.

Attach.

Review Control:

Prepared By: AFK	*Reviewed By:* AFK	*Checked By:* NJF

TREK GEOTECHNICAL

Lab Requisition

TREK GEOTECHNICAL
1712 St. James Street
Winnipeg, Manitoba R3H 0L3
T 204.975.9433 F 204.975.9435

PROJECT: Sherwin Rd.
PROJECT NO:
CLIENT: Morrison Hershfield
FIELD TECHNICIAN: Joshan Bhullar.

TEST HOLE NUMBER	SAMPLE NUMBER	Sample Start Depth (ft)	Sample End Depth (ft)	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS				Soil Description/ Comments
TH19-01	447	1'	1'6"												CBR
	448	2'	2'6"												
	449	3'	3'6"												(Mix all the highlighted samples together)
TH19-06	470	1'	1'6"												
	471	2'	2'6"												
	472	3'	3'6"												
TH19-07	424	1'	1'6"												
	425	2'	2'6"												
	426	3'	3'6"												
TH19-08	477	1'	1'6"												
	478	2'	2'6"												
	479	3'	3'6"												
TH19-09	416	1'	1'6"												
	417	2'	2'6"												
	418	3'	3'6"												
TH19-10	491	1'	1'6"												
	492	2'	2'6"												
	493	3'	3'6"												
TH19-11	409	1'	1'6"												
	410	2'4"	3'												
	411	3'6"	4'												
TH19-12	484	1'	1'6"												
	485	2'	2'6"												

Total wet Sample → 17393.7 gms

REQUESTED BY: MVH
REPORT TO: MVH
REQUISTION DATE: Nov 4, 19
DATE REQUIRED:
COMMENTS: One CBR Only.

REQUISITION NO.
R19-247

SHEET ____ OF ____

Sept 30, 2015 DW

TREK GEOTECHNICAL

Replacement of Existing Culvert at Sherwin Road Over Omand's Creek and Associated Regional Street Improvements
Sub-Surface Investigation
Sherwin Road

Test Hole No.	Test Hole Location	Pavement Surface		Pavement Structure Material		Subgrade Description	Sample Depth (m)		Moisture Content (%)	Grain Size Analysis				Atterberg Limits		
		Type	Thickness (mm)	Type	Thickness (mm)		Top (m)	Bottom (m)		Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Plastic	Liquid	Plasticity Index
TH19-01	UTM : 5530838 N, 628422 E Located in Northbound lane, 1.6 m West of East Curb and opposite of 2070 Notre Dame Avenue on Sherwin Road	Asphalt	30	Concrete	200	Clay	0.3	0.5	22							
						Clay	0.6	0.8	30							
						Clay	0.9	1.1	34							
						Clay	1.2	1.3	40							
						Clay	1.3	1.4	39							
						Clay	1.5	1.7	41							
						Clay	1.8	2.0	44							
						Clay	2.9	3.0	55							
TH19-02	UTM : 5530754 N, 628417 E Located in Southbound lane, 0.9 m East of West curb and opposite to 1240 Sherwin Road	Asphalt	50	Concrete	225	Clay (Fill)	0.3	0.5	30							
						Clay (Fill)	0.6	0.8	38							
						Clay (Fill)	0.9	1.1	38	64	31	6	0	19	74	55
						Clay (Fill)	1.2	1.4	37							
						Clay (Fill)	1.5	1.7	42							
						Clay (Fill)	1.8	2.0	39							
						Clay	2.9	3.0	49							
TH19-03	UTM : 5530652 N, 628418 E Located in Northbound lane, 1.5 m West of East curb and opposite to 1221 Sherwin Road	Asphalt	35	Concrete	200	Clay (Fill)	0.3	0.5	20							
						Clay (Fill)	0.6	0.8	22							
						Clay (Fill)	0.9	1.1	35							
						Clay (Fill)	1.2	1.4	22							
						Clay (Fill)	1.5	1.7	22							
						Clay (Fill)	1.8	2.0	25							
						Clay	2.4	2.6	45							
						Clay	2.9	3.0	52							
TH19-04	UTM : 5530546 N, 628411 E Located in Southbound lane, 1 m East of West curb and opposite to 1200 Sherwin Road	Asphalt	50	Concrete	200	Clay (Fill)	0.3	0.5	20							
						Clay (Fill)	0.6	0.8	25							
						Clay (Fill)	0.9	1.1	29							
						Clay (Fill)	1.2	1.4	35							
						Clay (Fill)	1.5	1.7	31							
						Clay (Fill)	1.8	2.0	32							
						Clay	2.4	2.6	54							
						Clay	3.2	3.4	47							

TREK GEOTECHNICAL

Replacement of Existing Culvert at Sherwin Road Over Omand's Creek and Associated Regional Street Improvements

Sub-Surface Investigation

Sherwin Road

Test Hole No.	Test Hole Location	Pavement Surface		Pavement Structure Material		Subgrade Description	Sample Depth (m)		Moisture Content (%)	Grain Size Analysis				Atterberg Limits		
		Type	Thickness (mm)	Type	Thickness (mm)		Top (m)	Bottom (m)		Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Plastic	Liquid	Plasticity Index
TH19-05	UTM : 5530448 N, 628414 E Located in Northbound lane, 1 m West of East Curb and opposite to 1155 Sherwin Road	Asphalt	20	Concrete	200	Clay (Fill)	0.3	0.5	29							
						Clay (Fill)	0.6	0.8	29							
						Clay (Fill)	0.9	1.1	34							
						Clay (Fill)	1.2	1.4	32							
						Clay (Fill)	1.5	1.7	40							
						Clay (Fill)	1.8	2.0	38							
						Clay	2.4	2.6	36							
						Clay	2.9	3.0	39							
TH19-06	UTM : 5530328 N, 628407 E Located in Southbound lane, 0.9 m East of West curb and opposite to 1830 Dublin Avenue on Sherwin Road	Asphalt	40	Concrete	180	Clay	0.3	0.5	25							
						Clay	0.6	0.8	31							
						Clay	0.9	1.1	34							
						Clay	1.2	1.4	30							
						Silt and Clay	1.5	1.7	29							
						Silt and Clay	1.8	2.0	26							
						Clay	2.9	3.0	49							
TH19-07	UTM : 5530242 N, 628410 E Located in Northbound lane, 2.2 m West of East curb and opposite to 1093 Sherwin Road	Asphalt	40	Concrete	205	Clay	0.3	0.5	29							
						Clay	0.6	0.8	34							
						Clay	0.9	1.1	34							
						Clay	1.2	1.4	37							
						Clay	1.5	1.7	38							
						Clay	1.8	2.0	47							
						Clay	2.9	3.0	47							
TH19-08	UTM : 5530143 N, 628402 E Located in Southbound lane, 1 m East of West curb and opposite to 1093 Sherwin Road	Asphalt	50	Concrete	190	Clay	0.3	0.5	34							
						Clay	0.6	0.8	37							
						Clay	0.9	1.1	38	25	73	2	0	23	82	59
						Clay	1.2	1.4	39							
						Clay	1.5	1.7	41							
						Clay	1.8	2.0	45							
						Clay	2.9	3.0	53							

Replacement of Existing Culvert at Sherwin Road Over Omand's Creek and Associated Regional Street Improvements
Sub-Surface Investigation
Sherwin Road

Test Hole No.	Test Hole Location	Pavement Surface		Pavement Structure Material		Subgrade Description	Sample Depth (m)		Moisture Content (%)	Grain Size Analysis				Atterberg Limits		
		Type	Thickness (mm)	Type	Thickness (mm)		Top (m)	Bottom (m)		Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Plastic	Liquid	Plasticity Index
TH19-09	UTM : 5530044 N, 628405 E Located in Northbound lane, 2.3 m West of East Curb and opposite to 1063 Sherwin Road	Asphalt	25	Concrete	180	Clay	0.3	0.5	32							
						Clay	0.6	0.8	33							
						Clay	0.9	1.1	35							
						Clay	1.2	1.4	41							
						Clay	1.5	1.7	46							
						Clay	1.8	2.0	55							
						Clay	2.4	2.6	53							
						Clay	2.9	3.0	49							
TH19-10	UTM : 5529933 N, 628398 E Located in Southbound lane, 1.3 m East of West curb and opposite to 1051 Sherwin Road	Asphalt	50	Concrete	190	Clay	0.3	0.5	35							
						Clay	0.6	0.8	36							
						Clay	0.9	1.1	35							
						Clay	1.2	1.4	39							
						Clay	1.5	1.7	43							
						Clay	1.8	2.0	46							
						Clay	2.9	3.0	42							
TH19-11	UTM : 5529843 N, 628402 E Located in Northbound lane, 1.5 m West of East curb and opposite to 1001 Sherwin Road	Asphalt	150	Concrete	150	Clay	0.3	0.5	32							
						Clay	0.7	0.9	39							
						Clay	1.1	1.2	39							
						Clay	1.4	1.5	38							
						Clay	1.7	1.8	49							
						Clay	2.0	2.1	52							
						Clay	2.9	3.0	40							
TH19-12	UTM : 5529739 N, 628394 E Located in Southbound lane, 0.95 m East of West curb and opposite to 975 Sherwin Road	Asphalt	55	Concrete	200	Clay	0.3	0.5	33							
						Clay	0.6	0.8	31							
						Silt and Clay	0.9	1.1	38	62	35	3	0	18	72	54
						Clay	1.2	1.4	38							
						Clay	1.5	1.7	39							
						Clay	1.8	2.0	39							
						Clay	2.9	3.0	52							

TREK GEOTECHNICAL

Replacement of Existing Culvert at Sherwin Road Over Omand's Creek and Associated Regional Street Improvements

Sub-Surface Investigation

Sherwin Road

Test Hole No.	Test Hole Location	Pavement Surface		Pavement Structure Material		Subgrade Description	Sample Depth (m)		Moisture Content (%)	Grain Size Analysis				Atterberg Limits		
		Type	Thickness (mm)	Type	Thickness (mm)		Top (m)	Bottom (m)		Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Plastic	Liquid	Plasticity Index
TH19-13	UTM : 5529739 N, 628398 E Located in Northbound lane, 1.5 m West of East Curb and opposite to 975 Sherwin Road	Asphalt	35	Concrete	185	Clay (Organic)	0.3	0.5	38							
						Clay (Organic)	0.6	0.8	36	73	24	3	0	77	24	53
						Silt and Clay	0.9	1.1	23					17	29	12
						Silt and Clay	1.2	1.4	23							
						Silt and Clay	1.5	1.7	24							
						Clay	1.8	2.0	39							
						Clay	2.4	2.6	51							
						Clay	2.9	3.0	53							
TH19-14	UTM : 5530420 N, 628409 E Located in Southbound lane, 1 m East of West Curb and opposite to 1151 Sherwin Road	Asphalt	35	Concrete	200	Clay (Fill)	0.3	0.5	31							
						Clay (Fill)	0.6	0.8	25							
						Clay (Fill)	0.9	1.1	31							
						Clay (Fill)	1.2	1.4	19							
						Clay (Fill)	1.5	2.1	29							
						Clay (Fill)	2.1	2.3	38							
						Clay (Fill)	2.7	2.9	36							
						Clay (Fill)	2.9	3.0	21							
TH19-15	UTM : 5530379 N, 628408 E Located in at the intersection of Dublin Ave and Sherwin Road, 0.45 m East of West Curb	Asphalt	30	Concrete	210	Clay (Fill)	0.2	0.3	12							
						Clay (Fill)	0.3	0.5	25							
						Clay (Fill)	0.6	0.8	29							
						Clay (Fill)	0.9	1.1	22							
						Clay (Fill)	1.2	1.4	33							
						Clay	1.5	1.7	37							
						Clay	1.8	2.0	40							
						Clay	2.7	2.9	20							

www.trekgeotechnical.ca
1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

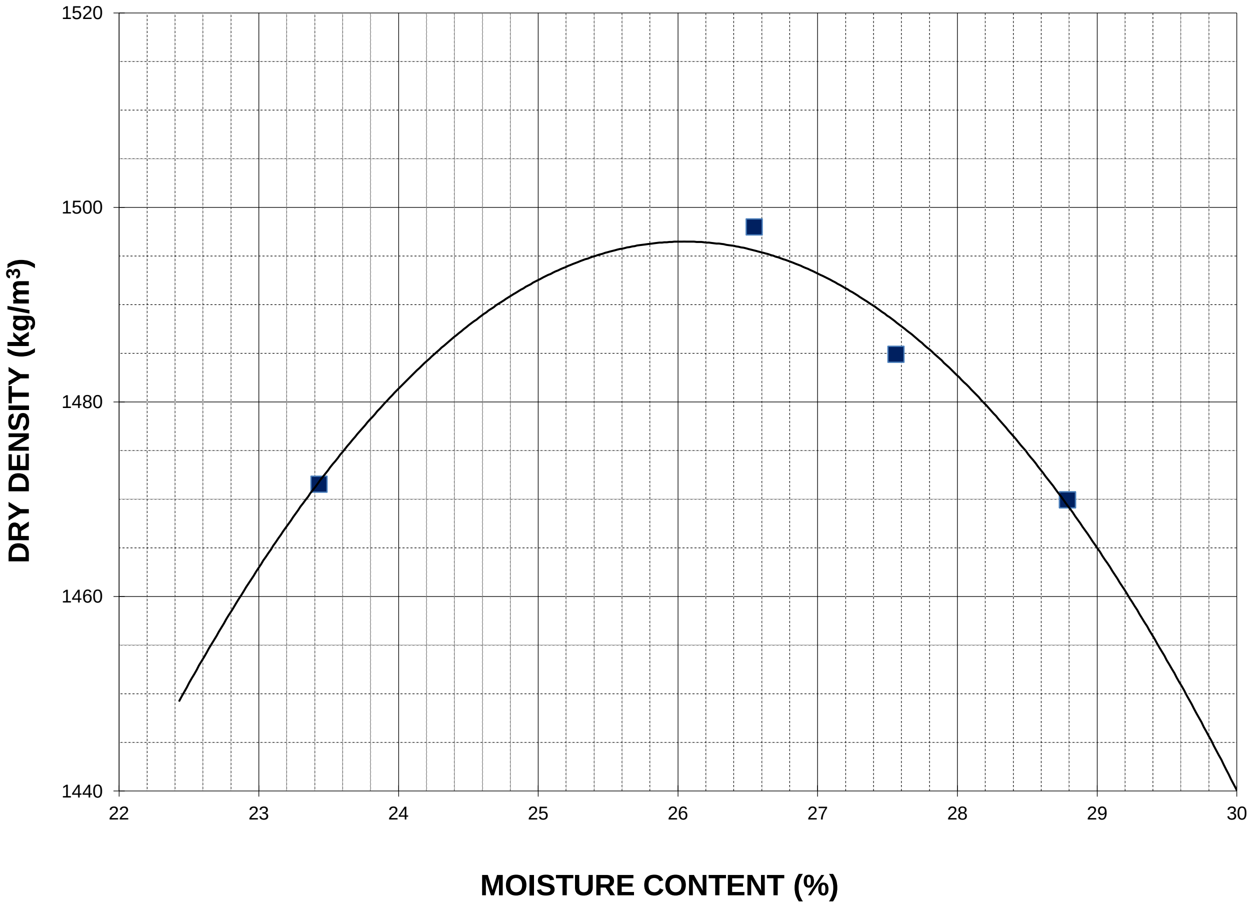
Standard Proctor Compaction Test

ASTM D698-12e2

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road
Sample #	R19-247
Source	Road Test Holes
Material	Clay
Sample Date	05-Sep-19
Test Date	06-Nov-19
Technician	JSB

Maximum Dry Density (kg/m3)	1496
Optimum Moisture (%)	26.0

Trial Number	1	2	3	4	
Wet Density (kg/m^3)	1816	1896	1894	1893	
Dry Density (kg/m^3)	1472	1498	1485	1470	
Moisture Content (%)	23.4	26.5	27.6	28.8	



TREK GEOTECHNICAL
www.trekgeotechnical.ca
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Tel: 204.975.9433 Fax: 204.975.9435

California Bearing Ratio Test Data Sheet

ASTM D1883-16

Project No.	0035-079-00	**Source**	Road Test Holes
Client	Morrison Hershfield	**Material**	Clay
Project	Sherwin Road	**Sample Date**	05/09/2019
Sample #	Clay	**Test Date**	08/11/2019
		Technician	JSB

Proctor Results (ASTM D698)

Maximum Dry Density	1496	kg/m3
Optimum Moisture Content	26.0	%
Material Retained on 19 mm Sieve	0.0	%

CBR Sample Compaction

Dry Density	1433	kg/m3
Initial Moisture Content	29.0	%
Relative Density	95.8	% SPMDD

Soaking Results

Surcharge	4.54	kg
Swell	1.1	%
Moisture Content in top 25 mm	38.1	%
Immersion Period	96	h

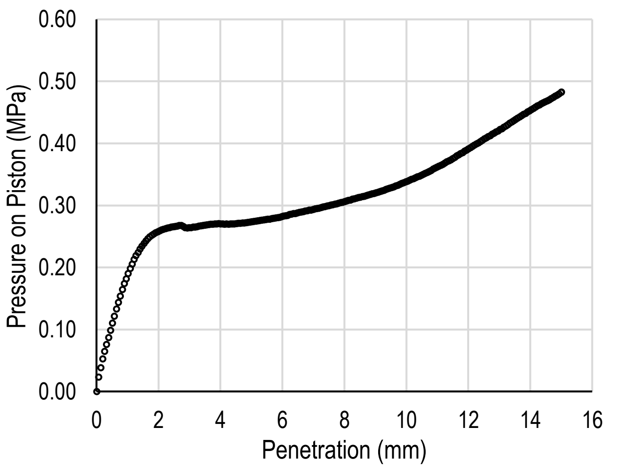
CBR Results

CBR at 2.54 mm	3.9	%
CBR at 5.08 mm	2.7	%
Zero Correction	0	mm

Test Data

Penetration (mm)	Measured Pressure (MPa)	Corrected Pressure (MPa)
0.64	0.13	0.13
1.27	0.22	0.22
1.91	0.26	0.26
2.54	0.27	0.27
3.18	0.27	0.27
3.81	0.27	0.27
4.45	0.27	0.27
5.08	0.27	0.27
7.62	0.30	0.30
10.16	0.34	0.34
12.70	0.41	0.41

Load/Penetration Curve



Comments:

Quality Engineering | Valued Relationships

Morrison Hershfield Ltd.

Culvert Replacement at Sherwin Road over Omand's Creek - Winnipeg, MB

Geotechnical Investigation Report

Prepared for:
Mr. Bill Ebenspanger, P.Eng.
Morrison Hershfield Ltd.
Suite 1, 59 Scurfield Blvd.
Winnipeg, MB R3Y 1V2

Project Number: 0035 079 00

Date: November 14, 2019

TREK GEOTECHNICAL Quality Engineering | Valued Relationships

November 14, 2019 Our File No. 0035 079 00

Mr. Bill Ebenspanger, P.Eng.
Morrison Hershfield Ltd.
Suite 1, 59 Scurfield Blvd.
Winnipeg, MB R3Y 1V2

**RE: Culvert Replacement at Sherwin Road over Omand's Creek - Winnipeg, MB
Geotechnical Investigation Report**

TREK Geotechnical Inc. is pleased to submit our final geotechnical investigation report for the above noted project.

Please contact the undersigned should you have any questions or require additional information.

Sincerely,

TREK Geotechnical Inc.
Per:

Michael Van Helden, Ph.D., P.Eng.
Senior Geotechnical Engineer

Encl.

Revision History

Revision No.	Author	Issue Date	Description
0	NM	November 14, 2019	Final Report

Authorization Signatures

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No. 4877 Date: Nov 14, 2019

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Senior Geotechnical Engineer

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1.0 Introduction

This report summarizes the results of the geotechnical investigation completed by TREK Geotechnical Inc. (TREK) for the proposed culvert replacement on Sherwin Road over Omand's Creek located in Winnipeg, Manitoba. The terms of reference for the investigation are included in our proposal addressed to Beth Phillips, P.Eng., dated June 10, 2019. The scope of work includes a sub-surface investigation, laboratory testing, and provision of preliminary and detailed design recommendations for foundations, slope stability assessment and stabilization measures. The current report forms our primary deliverable for the geotechnical assessment and preliminary design component of the project.

2.0 Background Information

2.1 Project Description

The Sherwin Road bridge culvert over Omand's Creek presently consists of a twin barrel steel plate culvert of 12.46 m in length with concrete headwalls. The base of the culvert is showing signs of rust and deterioration, while the concrete works are also aging. The existing structure accommodates two travel lanes and a multi-use path on the west side which are to be maintained following the structure replacement.

Preferred replacement structure options are a single span bridge culvert or a cast-in-place concrete box culvert. A concrete precast arch culvert may also be considered. The width of the structures at the base of the channel will vary from 6 to 9 m with side slopes of 3H:1V armored with 0.6 m thick rip rap.

3.0 Field Program

3.1 Site Conditions

A visual inspection of site was conducted by TREK personnel during site survey and sub-surface investigation tasks. The creek banks surrounding the bridge culvert are grass-covered sloping towards the creek bottom at angles ranging from 3H:1V to 5.5H:1V. Several trees are present near the existing bridge culvert, which are slightly tilted towards the stream indicating potential bank movements. The site is fenced to west of the existing structure and there are noticeable signs of movement in the fence line likely due to erosion induced movements of the west ditch of Sherwin Road as it enters the creek.

There is also evidence of creek bank erosion near the crossing and slope instabilities (tension cracks) were observed east of the existing culvert (Figure 01). It is likely that these instabilities are influenced by creek bank erosion and rapid-drawdown events following sudden release of blockages (typically ice) downstream of the site. TREK has observed similar instabilities at various sites on Omand's Creek downstream of the project site. No instabilities were observed west of the structure.

3.2 Site Survey

A site survey was completed by TREK on August 8th and 10th and October 1st, 2019 to gather topographic and cross-sectional data for hydrotechnical and geotechnical assessments. The survey data was used to supplement available LiDAR information and to determine the existing creek geometries surrounding the bridge culvert and test hole locations. Existing tension cracks east of the culvert were surveyed and are shown on Figure 01.

3.3 Sub-surface Investigation

A sub-surface investigation was completed on September 6 and 11, 2019 under the supervision of TREK personnel to determine the soil stratigraphy and groundwater conditions at the site. Test holes TH19-14 and 15 were drilled with the Acker MP8 truck mounted rig and Acker Renegade track mounted rigs, both equipped with 125 mm solid stem augers and HQ coring. Test holes TH19-14 and 19-15 were drilled to 25.5 and 20.5 m depths, respectively. One standpipe piezometer was installed in a separate test hole immediately adjacent to TH19-14. All test holes were backfilled with bentonite chips and auger cuttings to surface.

Sub-surface soils observed during drilling were visually classified based on the Unified Soil Classification System (USCS). Samples retrieved during drilling included disturbed (grab samples, split spoon samples), undisturbed (Shelby tube) samples and rock core samples. All samples retrieved during the investigation were transported to TREK's soils laboratory in Winnipeg, Manitoba for further testing and classification.

Laboratory testing consisted of water content determination on all samples as well as Atterberg limits, grain size analysis, bulk unit weight measurements and undrained shear strength testing (unconfined compression, pocket penetrometer and hand-held Torvane) on select samples. Soils laboratory testing results are included in Appendix B.

The sub-surface logs include a description of the soil units encountered and other pertinent information such as groundwater and sloughing conditions, and a summary of the laboratory testing results.

3.4 Stratigraphy

Brief descriptions of the soil units encountered at the test hole locations during drilling are provided below. All interpretations of soil stratigraphy for the purposes of design should refer to the detailed information provided on the attached sub-surface logs.

The soil stratigraphy encountered in the test holes consists of 1.3 to 3.6 m of clay (fill) overlaying silty clay which extended to depths of 5.6 and 3.6 m in TH19-14 and 19-15, respectively, followed by silt (till) and sand (till) layers below. Dolomite (bedrock) was encountered in TH19-14 below a depth of 19.2 m below ground surface.

The clay (fill) contains trace sand, trace silt inclusions, trace gravel, is brownish grey becoming grey with depth, moist, firm to stiff and is of high plasticity. The silty clay contains trace gravel, is brown, moist, firm to stiff and is of high plasticity. The silt (till) layer extended to 12.2 and 18.3 m depths in

TH19-14 and 19-15, respectively. The silt (till) contains trace clay, trace gravel, is brownish grey, moist, compact and of low to intermediate plasticity. The sand (till) extended to a depth of 19.2 m in TH19-14 and to the maximum explored depth of 20.5 m in TH19-15. The sand (till) contains trace silt to silty, trace clay, trace cobbles, trace boulders, is brown, moist, dense to very dense and is of no to low plasticity. The dolomite (bedrock) is from the Upper Fort Garry member formation, contains chert nodules, is calcareous, cream to light grey, hard, is R3 to R4, brecciated and vuggy.

3.5 Power Auger / Excavator Refusal

Power auger refusal (PAR) occurred in TH19-15 at 18.4 m below ground surface (elevation of 216.7 m) within the sand (till), but was not encountered in TH19-14 where drilling switched to HQ coring below a depth of 12.6 m.

3.6 Groundwater Conditions

Groundwater seepage was observed in TH19-15 at 15.0 m within the silt (till) layer and below 16.5 m in the sand (till) layer. Sloughing was not observed in either test hole. A standpipe piezometer was installed within the silt (till) in TH19-14. Two monitoring events were performed and the groundwater level readings are summarized in table 1 below:

Table 1. Groundwater Monitoring Summary

Piezometer	Soil Stratum	Tip Depth (Elevation)	Date	Creek Water Elevation	Standpipe Water Elevation
SP19-14	Silt Till	8.4 m (EL. 226.7 m)	2019-09-04	Not measured	232.67 m
			2019-10-28	233.0 m	232.65 m

These observations are short-term and should not be considered reflective of (static) groundwater levels at the site which would require monitoring over an extended period of time to determine. It is important to recognize that groundwater conditions may vary seasonally, annually, or as a result of construction activities.

4.0 Slope Stability Analysis

Slope stability analysis was conducted to evaluate the existing stability of the creek banks at the location of the culvert replacement and to assess the effects of the proposed works. The analysis cases included a back-analysis of the observed instabilities east of the culvert, the proposed channel reconfiguration(s) and potential slope stabilization works required to achieve design targets. Schematics provided by MHL include two general alternatives for the channel geometry dependent upon whether a box-culvert or a rigid-frame bridge structure is used, which was used to determine the channel geometry for analysis (Figures 02 and 03).

Cross-section A (Figures 02 and 03) is located approximately 42 m east of the existing culvert centreline, within the existing observed instabilities, which was considered a representative section of stability conditions east of the proposed structure and wing-walls. Stability conditions west of the structure are not expected to be of concern to the structure, given that the Sherwin Road ditch (located between the proposed structure and the creek banks to the west) would serve to isolate the structure from any potential instabilities that may occur on that side of the crossing.

4.1 Design Criteria and Groundwater Conditions

A minimum factor of safety (FS) of 1.3 was targeted for areas immediately adjacent to critical infrastructure such as the replacement structure under short term extreme (rapid draw-down) groundwater conditions, representing a 30% improvement over back-analysed conditions.

Critical groundwater conditions assumed in the analysis are considered representative of a rapid-drawdown condition (high bank groundwater level and low creek level) and were established based on observed groundwater monitoring data and historical creek levels. Along Omand's Creek, a low creek level at the channel base (estimated summer water level of 232.6 m) was assumed along with a fully saturated bank (groundwater level considered to be at ground surface).

4.2 Numerical Model Description

The numerical analysis was conducted using a limit-equilibrium slope stability model (Slope/W) from the GeoStudio 2016 software package (Geo-Slope International Inc.). Static piezometric lines were used to represent the groundwater conditions discussed previously. The Morgenstern-Price method of slices with a half-sine interslice force function was used to calculate factors of safety. Critical slip surfaces were identified using a grid and radius slip surface method.

Table 2 lists the soil parameters assumed for the slope stability analysis. The strain softened shear strengths assigned to the intact high plastic silty clay are based on local experience, are considered representative of a slope that has undergone some limited straining over time, and are therefore considered conservative given that no signs of upper bank movements have been observed. The residual shear strengths assigned to the silty clay within the observed area of instability (downslope of tension cracks) are typical of slopes in Winnipeg clays that have undergone considerable movements.

Table 2. Soil Parameters Used in Slope Stability Analysis

Soil Description	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (degrees)
Silty Clay (Intact)	17.5	5	17
Silty Clay (Residual)	17.5	2	12
Silty Clay (Fill)	17.5	2	20
Rip Rap	19	0	45
Shear Key (Rockfill)	20	0	50
Till	Impenetrable		

4.3 Analysis Results

Table 3 summarizes the results of the slope stability analysis, while model results figures are included in Appendix A, as referenced in the table.

4.3.1 Back Analysis

The intent of the back analysis performed is to determine a combination of groundwater and strength assumptions required to achieve a FS of 1.0 for a slip surface that coincides with the observed movements. As shown in Figures A-1 and A-2, the respective back-analysed factors of safety for the north and south slopes are 1.0 and 0.97.

4.3.2 Proposed Channel Geometry and Stabilization Works

The channel geometries proposed by MHL for the two structure replacements involve either a 6 m wide (box-culvert) or 9 m wide (rigid-frame bridge) channel base at Elev. 232.2 m with channel slopes at 3H:1V up to surrounding grades lined with riprap. For simplicity, the top of bank elevation included in the model for both banks was assumed to be consistent with the proposed Sherwin Road profile for each structure option (considered a worst case).

For the single-span bridge case, the FS for the north and south slopes without stabilization works are 0.82 and 0.91, respectively, representing a deterioration in stability over existing conditions (Figures A-3 and A-4). Stabilization works are therefore required. A 1.2 m wide rockfill shear key excavated into till was analysed, which improved the FS for the north and south slopes to 1.31 and 1.44, respectively, and satisfies the design criteria (Figures A-5 and A-6).

For the box-culvert case, the FS for the north and south slopes without stabilization works are 0.91 and 1.02, respectively, representing a deterioration or slight improvement in stability over existing conditions (Figures A-7 and A-8). Stabilization works are therefore required. A 1.2 m wide shear key into till was analysed, which improved the FS for both the north and south slopes to 1.50 and satisfies the design criteria (Figures A-9 and A-10).

Other stabilization alternatives such as thickened riprap or rockfill ribs were analyzed but are not considered to be feasible or cost effective in comparison to a shear key.

Table 3. Slope Stability Analysis Summary table

Back Analysis/Stabilization Works	Groundwater Case (Note 1)	Creek Level (Note 2)	Slip Surface	Factor of Safety	Bank (North/ South)	Change in FS (%Change) over Baseline	Fig No
Back Analysis	SAT	SWL	Critical/ Global (see note 3)	1.0	North	Baseline	A-1
			Critical (localized)	0.97	South		A-2
			Global(see note 3)	1.05	South		
Single Span Bridge with Rip Rap	SAT	SWL	Critical/ Global	0.82	North	-0.18 (-18%)	A-3
			Critical/ Global	0.91	South	-0.06 (-6.2%)	A-4
Single Span Bridge with Shear Key (Rockfill)	SAT	SWL	Critical/ Global	1.31	North	+0.31 (+31%)	A-5
			Critical/ Global	1.44	South	+0.47 (+48%)	A-6
Box culvert with Rip Rap	SAT	SWL	Critical/ Global	0.91	North	-0.09 (-9%)	A-7
			Critical/ Global	1.02	South	-0.05 (+5%)	A-8
Box culvert with Shear Key (Rockfill)	SAT	SWL	Critical/ Global	1.50	North	+0.50 (+50%)	A-9
			Critical/ Global	1.50	South	+0.53 (+55%)	A-10

Notes: 1) Fully saturated bank (GWL at ground surface along the bank).
2) Estimated creek summer water level is 232.6 m.
3) Slip surface closely matches observed tension crack locations

4.3.3 Summary and Recommendations

A 1.2 m wide rockfill shear key will provide adequate stabilization to satisfy slope stability design criteria (FS>1.30) for the channel geometries provided by MHL. The proposed shear key width is considered the minimum practical width for construction. Rockfill for shear keys should consist of well-graded, durable, crushed rock and should be placed in lifts not exceeding 150 mm and compacted to the maximum achievable density based on field conditions. It should be noted that the location of shear keys has been selected for optimal slope stability improvement and also to avoid work within the existing waterway. However, it is advisable that the creek within the area of stabilization should be dewatered during construction of the stabilization works to minimize risks associated with seepage and caving into the shear key excavation. The stabilization works should be confirmed during detailed design, however a preliminary layout is shown on Figures 01 and 02.

5.0 Foundation Recommendations

Based on the sub-surface conditions encountered during the investigation, a raft foundation, strip footings, cast-in-place concrete (CIPC) end-bearing piles and driven steel H piles are feasible foundation alternatives for the new structure. Limit States Design and construction recommendations in accordance with Canadian Highway Bridge Design Code (CHBDC, CAN/CSA-S6S1-14, 2014) are provided in the following sections.

5.1 Limit States Design (CHBDC, CAN/CSA-S6S1-14, 2014).

Limit states design requires consideration of distinct loading scenarios comparing the structural loads to the foundation bearing capacity using resistance and load factors that are based on probabilistic reliability criteria. Two general design scenarios are evaluated corresponding to the serviceability and ultimate capacity requirements.

The **Ultimate Limit State (ULS)** is concerned with ensuring that the maximum structural loads do not exceed the nominal (ultimate) capacity of the foundation units. The ULS foundation bearing capacity is obtained by multiplying the nominal (ultimate) bearing capacity by a resistance factor (reduction factor), which is then compared to the factored (increased) structural loads. The ULS bearing capacity must be greater or equal to the maximum factored load. Table 4summarizes the resistance factors that can be used for the design of foundations as per the CHBDC depending upon the method of analysis and verification testing completed during construction. The CHBDC also requires that the degree of understanding of soil conditions (which can be classified as either low, typical or high) be assessed in the selection of the resistance factors. We consider the current level of understanding at the site to be high. CHBDC also requires that the resistance factor be modified by a consequence factor which ranges from 0.9 for high consequence structures to 1.15 for low consequence structures. The structures for this project are interpreted to be of typical consequence based on the CHBDC guidelines and as such the consequence factor is 1.0.

The **Service Limit State (SLS)** is concerned with limiting deformation or settlement of the foundation under service loading conditions such that the integrity of the structure will not be impacted. The SLS should generally be analysed by calculating the settlement resulting from applied service loads and comparing this to the settlement tolerance of the structure. However, the settlement tolerance of the structure is typically not defined at the preliminary design stage. As such, SLS bearing capacities (or unit resistances) provided are developed on the basis of limiting settlement to approximately 25 mm or less. A more detailed settlement analysis should be conducted to refine the estimated settlement and/or adjust the SLS vertical bearing resistance if a more stringent settlement tolerance is required.

Table 4 ULS Resistance Factors for Foundations (CHBDC, 2014)

Description	Resistance Factor for Typical Degree of Understanding of Soil Conditions	Resistance Factor for High Degree of Understanding of Soil Conditions
Shallow foundations with a typical degree of understanding of soil conditions and using empirical analysis	0.50	0.60
Deep foundations in compression based on static analysis	0.40	0.45
Deep foundations in compression based on dynamic testing	0.50	0.55
Deep foundations in tension based on static analysis	0.30	0.40

5.2 Foundation Alternatives

5.2.1 *Shallow Foundations*

Raft Slabs

Based on the anticipated underside elevation of proposed box culverts, raft foundations may be founded on either clay or the underlying till layer. The depth of excavation to bear on till may be excessive, therefore raft foundations should be designed assuming they bear on firm to stiff silty clay using ULS and SLS bearing resistances of 150 kPa and 85 kPa, respectively. The ULS bearing resistances incorporate a resistance factor of 0.60, while the SLS bearing resistances are based on limiting settlement to less than 25 mm. The net weight of soil removed above the underside of concrete can be added to the ULS and SLS values provided (note any riprap placed within the culvert should be deducted from the net weight of soil removed).

Additional design and construction considerations for raft foundations are provided below:

1. Excavation should be completed by an excavator equipped with a smooth bladed bucket to minimize disturbance to the exposed subgrade. The contractor should be equipped to manage cobbles and boulders during the excavation, if encountered.
2. Till groundwater levels in the area may be close to prairie ground surface. As such, heave and blowout of excavation bases may occur and may require passive or active depressurization measures to achieve a stable excavation base. Due to unusually high fall creek levels, the measured groundwater levels in the till are likely not representative of typical conditions when the creek level is low. Additional monitoring is required in detailed design to evaluate groundwater levels under more typical low flow conditions.
3. The bearing surface should be protected from freezing, drying, inundation with water and mechanical disturbance at all times. If any of these conditions occur, the disturbed material should be removed in its entirety such that only undisturbed silty clay is present.
4. The final bearing surface should be inspected and documented by TREK prior to concrete placement to verify the adequacy of the bearing surface and proper installation of the foundation.

5. If a levelling course is required or the ground surface must be built up, granular "Class A" base course should in accordance with MI Standard Construction Specification No. 900 (Granular Base Course) should be placed in lifts no greater than 150 mm and compacted to a minimum of 100% of the Standard Proctor Maximum Dry Density (SPMDD). It should be noted that even at this level of compaction that long-term settlement of approximately 0.5% of the fill thickness should be expected. Alternatively, a concrete mud-slab with a minimum compressive strength of 2 MPa may be used and may perhaps be more advantageous due to potential groundwater seepage and dewatering issues.
6. The raft should be designed by a qualified structural engineer to resist all applied loads from the proposed structures.

Strip Footings

The depth of excavation required for shallow footings to bear on till may be excessive, therefore shallow foundations (strip footings) should be designed assuming they bear on firm to stiff silty clay using ULS and SLS bearing resistances of 140 kPa and 80 kPa, respectively. The ULS bearing resistance incorporates a resistance factor of 0.6 while the SLS bearing resistance is based on limiting settlement to less than 25 mm.

Additional recommendations regarding shallow foundations are provided below:

1. Footings should be a minimum 0.6 m in width.
2. Fill placed on top of footings above the natural ground surface should be considered as a dead load for the SLS loading case. In this regard, a unit weight of 20 kN/m³ for fill materials can be used.
3. Organics, fill soils, silts, and any other deleterious materials should be stripped away such that the sub-grade consists of native, undisturbed, firm to stiff clay. Excavation should be completed by an excavator equipped with a smooth bladed bucket to minimize disturbance to the exposed subgrade. The contractor should be equipped to manage cobbles and boulders during the excavation if encountered.
7. Till groundwater levels in the area may be close to prairie ground surface. As such, heave and blowout of excavation bases may occur and may require passive or active depressurization measures to achieve a stable excavation base. Due to unusually high fall creek levels, the measured groundwater levels in the till are likely not representative of typical conditions when the creek level is low. Additional monitoring is required in detailed design to evaluate groundwater levels under more typical low flow conditions.
8. The bearing surface should be protected from freezing, drying, inundation with water and disturbance at all times. If any of these conditions occur, the disturbed material should be removed in its entirety such that only undisturbed silty clay is present.

4. If a levelling course is required or the ground surface must be built up, a well graded, 20 mm down sand and gravel or crushed rock may be placed in lifts no greater than 150 mm and compacted to a minimum of 100% of the SPMDD. Alternatively, a concrete mud-slab with a minimum compressive strength of 2 MPa may be used. Granular fill thicknesses should be kept to a minimum as some long-term consolidation of the fill soils will occur (about 0.5% of the fill thickness).

5. The final bearing surface should be inspected and documented by TREK prior to concrete placement to verify the adequacy of the bearing surface and proper installation of the footing.
6. The foundation should be designed by a qualified structural engineer to resist all applied loads from the proposed structures.

Modulus of Subgrade Reaction for Shallow Foundations

The soil response (subgrade reaction) to vertical loads can be modeled assuming the soil beneath a grade-supported slab can be simulated by a series of vertical springs. The soil response can be estimated using an equivalent spring constant referred to as the vertical modulus of subgrade reaction (k_v), which is often defined as the contact bearing pressure of a foundation against the soil that will produce a unit of deflection of the foundation. The modulus of subgrade reaction is not a fundamental soil property and therefore should be applied appropriately by the structural designer, but a function of following combined soil and structural components:

- elastic soil properties
- soil layer thickness and compressibility
- foundation size and depth
- foundation stiffness (moment of inertia and modulus of elasticity)

Recommended values for k_v are provided in Table 5 based on the anticipated size of the strip and and raft footings, as well as the anticipated loading conditions (i.e. linear loading). The values of k_v provided are only to serve as a boundary condition for analyses of structural stresses and should not be used to determine or predict settlements beneath the foundation unit.

Table 5. Values of Modulus of Subgrade Reaction (k_v)

Footing Size	Modulus of Subgrade Reaction, k_v (MPa/m)
Raft Slab (4 m line load spacing)	3.8 to 7.5
Strip Footing (1 to 2 m wide)	7.5 to 30

The values provided in Table 5 assume the foundation is bearing on silty clay. If foundations bear on granular fill over silt till, or directly on silt till, the modulus values may be an approximately an order of magnitude higher. This possibility should be considered in design of the footings, as the till elevations at the site may be variable.

Resistance to Overturning, Uplift and Sliding

If the structure is subjected to lateral and/or eccentric loads, the foundations must be designed to resist overturning and uplift forces. Lateral and eccentric loading will result in the development of overturning and uplift forces and consequently a non-uniform applied pressure distribution under footings. In this regard, the maximum applied pressure should not exceed the ULS unit bearing resistance and the minimum applied pressure should not be less than 0 kPa. Sliding is not expected to be a concern for design; however, the interface sliding resistance of concrete footings on clay can be based on a factored ULS friction angle of 15 degrees.

5.2.2 *Cast-in-Place Concrete End Bearing Caissons (straight shaft or belled)*

Cast-in-place concrete (CIPC) end bearing caissons (straight shaft or belled) installed in very dense sand till (anticipated to be encountered below Elev. 223 m to 218.5 m) are a suitable foundation alternative to support the proposed structure. However, we anticipate that belling may not be possible due to the presence of boulders and seepage. If belled caissons are required, a test bell should be performed at the site to confirm feasibility. The caissons will derive a majority of their axial-compressive resistance in end bearing with a relatively small contribution from shaft friction. Caissons subjected to frost jacking and tension loads will derive a majority of their axial-uplift resistance in shaft friction (straight-shaft), uplift bearing resistance of the bell will provide added uplift resistance. Tables 6 and 7 provide the recommended ULS and SLS end bearing and shaft friction (adhesion) resistance values for axial-compressive and axial-tensile (uplift) loading conditions for mechanically-cleaned caissons bearing on very dense sand till. The uplift bearing resistance for belled caissons is based on the assumption that the bell uplift resistance is provided by the compact to dense silt till above the very dense sand till unit. The SLS capacity of the caissons is settlement-dependent and is based on a maximum settlement of 25 mm. Differential settlements are expected to be less than 13 mm.

Table 6. Recommended ULS and SLS End Bearing Resistances for CIPC Caissons

Soil Unit	Elevation (m) (Note 1)	Factored ULS Axial Resistance (kPa)		SLS Axial Resistance (kPa)
		Compression $\phi = 0.45$	Uplift $\phi = 0.4$	Compression
Sand Till	Below 218.5 to 223.0 m (varies)	900	400	750

Notes:
1. Piles should be designed assuming a minimum pile tip elevation of 218.5 m, however shorter piles may be acceptable depending on the depth to dense sand till encountered in each pile.

Table 7. ULS Shaft Adhesion Resistances for CIPC caissons

Soil Unit	Elevation Range (m)	Factored ULS Resistance (kPa) (Note 1)	
		Compression $\phi = 0.45$	Uplift $\phi = 0.4$
Clay	Above 229.3	0	0
Till	229.3 m to 217.5 m	1.5 (top) to 12.0 (bottom)	1.0 (top) to 9.0 (bottom)

Notes:
1. Shaft resistance varies linearly over the elevation range provided.
2. Shaft adhesion is not applicable for the Service Limit State.

Caisson Design Recommendations

The following recommendations apply to the design of CIPC end bearing caissons (straight shaft or belled):

1. The weight of the embedded portion of the pile should be included in the calculation of pile dead loads.
2. Shaft adhesion should be neglected within the upper 2.4 m below final grade and within the upper 1.5 m of the pile shaft (whichever is greater). Shaft adhesion should also be neglected for belled piles below one pile shaft diameter above the top of the bell.
3. Caisson bases must be founded in very dense sand till. The base of the caisson must be free from debris, and in a clean dry state prior to concrete placement. Disturbed or softened till soils should be entirely removed prior to concrete placement.
4. Caissons should have a minimum spacing of 2.5 caisson diameters measured centre to centre. If a closer spacing is required, TREK should be contacted to provide an efficiency (reduction) factor to account for potential group effects.
5. All caissons require steel reinforcement design by a qualified structural engineer for the anticipated axial (compression and uplift), lateral, and bending loads from the structure.

Caisson Installation Recommendations

The following recommendations apply to the installation of CIPC end bearing caissons (straight shaft or belled):

1. Temporary steel casings (*i.e.* sleeves) should be on site and used if sloughing of the caisson hole occurs, to control groundwater seepage if encountered. Care should be taken in removing sleeves to prevent sloughing (necking) of the shaft walls and a reduction in the cross-sectional area of the pile.

2. The foundation contractor should expect to encounter boulders during installation of the caissons. Chopping and removal of boulders may be necessary to advance the caisson shaft to the very dense sand till.

3. Caisson bases must be free of loose and/or disturbed soil.

4. Concrete should be placed immediately after the completion of drilling the caisson hole and under dry conditions to avoid softening of the soil at the base of the pile and construction problems such as sloughing or caving of the caisson hole and groundwater seepage.

5. Concrete placed by free-fall methods should be directed through the middle of the caisson shaft and steel reinforcing cage to prevent striking of the caisson walls to protect against soil contamination of the concrete.

6. Concrete should be placed in one continuous operation.

7. The drilling of all caisson shafts should be observed and documented by TREK Geotechnical to verify the soil conditions and proper installation of the caissons.

5.2.3 *Driven Steel H-Piles*

Driven steel H-piles may reach refusal on very dense till or bedrock and are considered suitable to support the proposed structure. However, the depth and strength characteristics of the bearing stratum where pile driving refusal will be reached is uncertain due to variability of the soil stratigraphy at site. Pile capacities are therefore based on practical refusal occurring in dense till and are lower than if piles were to reach refusal on bedrock. The depth of refusal is also uncertain; and bedrock was encountered only in one of the test holes at 19.4 m. Power auger refusal was encountered only in one of TREK's test holes at 18.4 m below ground surface.

This pile type will derive a majority of its resistance in end bearing with a significant contribution from shaft adhesion. Piles driven to practical refusal based on the hammer energy and criteria described below are expected to develop a nominal pile capacity of 2,400 kN, resulting in a factored ULS pile capacity of 1,320 kN.

A wave-equation analysis (WEAP) is recommended during detailed design to determine a termination criteria and driving energy such that the desired capacity can be reached without damage being done to the piles, and to aid in confirming the anticipated depth of refusal.

The pile head settlement under unfactored service loads can be calculated based on 5 mm or less of pile tip displacement plus elastic shortening of the pile.

Steel H-piles driven to practical refusal will derive their uplift resistance in skin friction within overburden deposits. For the purposes of uplift resistance calculations, an average ULS skin friction of 18 kPa should be used for soils above bedrock.

Additional Design and Construction Recommendations

The following design and construction recommendations apply to driven steel H-piles:

1. The weight of the embedded portion of the pile should be neglected in design.
2. Pile spacing should be a minimum of 2.5 pile diameters measured centre to centre. No reduction in pile capacity is required for the group effects provided the piles are driven to refusal on very dense till or bedrock.
3. The piles must be structurally designed to withstand the design loads, handling stresses, and driving stresses.
4. All piles should be fitted with hard-bite driving tips to help protect the pile tip during installation and to prevent sliding of pile tips during driving on sloping bedrock. The driving tip must be designed to withstand driving stresses and long-term design load cases.

Additional installation recommendations apply to driven steel H-piles

1. Piles should be driven to refusal on very dense till or bedrock. Pile installation should be completed carefully near refusal to avoid overdriving of the piles, which could lead to pile damage or misalignment. Refusal can generally be considered to be three consecutive sets of 25 mm or less of permanent set (pile displacement) with 12 blows of the hammer, provided that a driving system capable of producing the required delivered energy to the pile per blow is used. Pile damage may result from driving to three consecutive sets if sudden pile refusal is observed (i.e. on bedrock). In this case, the driving criteria may be modified as directed by TREK's geotechnical engineer.
2. A pile driving system (i.e. pile-driving hammer) capable of delivering 30 kJ of energy to the pile head should be specified for driving steel piles. Commonly used piling hammers such as the Pileco D19-42, ICE 19v2 or Junttan HHK 5A would be capable of delivering sufficient energy, if they are properly maintained. It should be noted that delivered energy is a function of the rated energy and the efficiency of the driving system and can be considered to be the net energy transferred to the pile head. The delivered energy should not be taken directly as the rated energy.
3. The pile-driving hammer should have the capability of adjusting the fuel setting or stroke to deliver higher energy to the pile during driving if the energy is not sufficient to drive the pile to bedrock. The driving system should also have the capability of adjusting the fuel setting or stroke to deliver lower energy to prevent pile damage upon sudden refusal.
4. The Contractor should be required to submit a proposed driving system for approval a minimum of 7 days prior to the start of pile driving. The pile driving system should be capable of installing the piles to the required capacity within specified allowable driving stresses.
5. A driveability analysis (i.e. wave equation analysis) should be performed by TREK during detailed design, as well as prior to construction on the proposed driving system to:
   a. establish a preliminary driving criteria (i.e. practical refusal criteria),
   b. determine the required developed energy to drive the piles to required capacity, and
   c. Assess the driving stresses and their potential impact on the structural integrity of the pile.
6. Driving stresses in the pile should not exceed 90% of the yield stress of the pile material.
7. All piles driven within 5 pile diameters of one another should be monitored for pile heave and where heave is observed, all piles should be checked and piles exhibiting heave should be re-driven to one set of the specified refusal criteria.
8. Pile verticality (plumbness) should be measured on all piles after practical refusal has been achieved to check if verticality is within the limits of the structural design. It is common local practice to specify a maximum acceptable percentage that the pile can be out of vertical plumbness (e.g. 2% out of plumb) or out of the specified batter.
9. Existing structures within close proximity of the proposed construction area should be monitored for heave, vibrations, and damage during pile driving. Pre-boring adjacent to sensitive structures can be considered to minimize the stresses and vibrations in the structures due to pile driving. TREK should be contacted to review and approve the pre-boring procedure, as it may affect other aspects of the foundation design.

10. Inspection of all driven H-piles should be performed by TREK geotechnical personnel to confirm that the refusal criteria have been met and to record that pile installation has been completed according to the design.
11. Any piles damaged, out of plumb an excessive amount or reaching premature refusal may need to be replaced. The structural designer will have to assess non-conforming piles to determine if they are acceptable. PDA testing with CAPWAP analysis is recommended to confirm the pile capacity achieved, in particular for any piles that are suspected to not meet the design capacity or to be damaged if a structural solution is not possible.

5.3 Lateral Loads

The soil response (subgrade reaction) to lateral loads can be modeled in a simplified manner that assumes the soil around a pile can be simulated by a series of horizontal springs for the preliminary design of pile foundations. The soil behaviour can be estimated using an equivalent spring constant referred to as the lateral subgrade reaction modulus (k_s). Table 8 provides the recommended subgrade reaction modulus for the lateral load analysis. The majority of lateral resistance will typically be offered by the upper 5 to 10 m of soil, depending on the relative stiffness of the pile and soil units. If pre-boring is required to aid in alignment of the piles or to reduce driving effects on adjacent structures, pre-bore holes should have a diameter at least 50 mm smaller than the pile to ensure compliance with the surrounding soil. If pre-bore holes are larger than the pile, the void space between the pile and the soil should be in-filled with sand. If in-filling is not completed, the depth of the pre-bore should be neglected from lateral pile resistance calculations.

Table 8. Recommended Values for Lateral Sub-grade Reaction Modulus (Ks)

Soil	Approximate Elevation (m)	K_s (kN/m^3)
Clay (Fill)	Above 233.5	4020 / d
Silty Clay	230.5 to 233.5	3080 / d
Silt Till	232 to 219	4400 z / d
Sand Till	219 to 215	11000 z / d

Notes: d = pile diameter, z = depth below ground surface

As part of detailed design, a more rigorous lateral pile analysis that incorporates the material and section properties of the pile, applied loads, final lateral deflection criteria and a more realistic elastic-plastic model of the soil response to loading should be carried out by TREK to confirm the lateral load capacity of the piles.

5.4 Foundation Concrete

All foundation concrete should be designed by a qualified structural engineer for the anticipated axial (compression and uplift), lateral, and bending loads from the structure. Based on local experience gathered through previous work in Winnipeg, the degree of exposure for concrete subjected to sulphate attack is classified as severe according to Table 3, CSA A23.1-09 (Concrete Materials and Methods of Concrete Construction). Accordingly, all concrete in contact with the native soil should be made with high sulphate-resistant cement (HS or HSb). Furthermore, the concrete should have a minimum specified 56-day compressive strength of 32 MPa and have a maximum water to cement ratio of 0.45 in accordance with Table 2, CSA A23.1-09 for concrete with severe sulphate exposure (S2). Concrete that may be exposed to freezing and thawing should be adequately air entrained to improve freeze-thaw durability in accordance with Table 4, CSA A23.1-09.

5.5 Foundation Inspection Requirements

In accordance with Section *4.2.2.3 Field Review* of the NBCC (2015), the designer or other suitably qualified person shall carry out a field review on:

a) continuous basis during:
   i. the construction of all deep foundation units with all pertinent information recorded for each *foundation unit*,
   ii. during the installation and removal of retaining structures and related backfilling operations,
   iii. during the placement of engineered fills that are to be used to support the *foundation units*, and

b) as-required, unless otherwise directed by the *authority having jurisdiction*,
   i. in the construction of all *shallow foundation units,* and
   ii. in excavating, dewatering and other related works

In accordance with Engineers and Geoscientists of Manitoba, a Professional Engineer or delegated staff responsible to them must perform site reviews for the work presented in the documents they've sealed.

For conformance with the NBCC and EGM requirements, TREK should be retained on a full-time basis to observe and document the installation of all pile foundations, shoring or engineered fills supporting the structure, and on an as-required basis for other components such as subgrade inspections and compaction testing. TREK is familiar with the geotechnical conditions present and the underlying design assumptions of our foundation recommendations. TREK is therefore solely qualified to evaluate any design modifications deemed to be necessary should altered subsurface conditions be encountered.

6.0 Lateral Earth Pressure

The magnitude of lateral earth pressures from retained soil against buried structures will depend on the backfill material type, method of placing and compacting the backfill and the magnitude of horizontal deflection of the retaining wall after the backfill is placed. Cohesive soils should not be used as backfill against buried walls as these soils could generate excessive lateral earth pressures from swelling.

An active pressure coefficient (K_a) of 0.3 should be used to calculate lateral loads from free draining granular soils against retaining structures which are free to translate horizontally by at least 0.2 percent of the retaining wall height. For retaining structures which are not free to translate, an at-rest earth pressure coefficient (K_o) of 0.5 should be used. Surcharge loading should also be included in the earth pressure distribution to account for surface loads, based on the appropriate earth pressure coefficient.

Over-compaction of the backfill soils adjacent to buried walls may result in earth pressures that are considerably higher than those predicted in design. Compaction of the granular fills within about 1 m of the vertical walls should be conducted with a light hand operated vibrating plate compactor and the number of compaction passes should be limited to achieve a maximum of 92% of Standard Proctor Maximum Dry Density (SPMDD). Compensation for any settlement can be made in the final grading by placing additional fill adjacent to the structure and to provide positive drainage away from the structure. Backfill compacted in this manner (lightly) will ultimately settle by a maximum of about 2 to 4% of the fill depth. Beyond the 1 m offset, the granular fill should be compacted to at least 98% SPMDD in an unfrozen state in lifts not exceeding 200 mm loose thickness.

Lateral earth pressures from surcharge loads (if applicable), or for heavy compaction equipment (if used) should be accounted for in design. If drainage is not provided at the base of the reservoir, the buoyant soil unit weight should be used and the water (hydrostatic) pressure added assuming a water level coincident with the ground surface. Backfill materials and compaction methods should be reviewed during final design.

7.0 Temporary Excavations

Excavations must be carried out in compliance with the appropriate regulations under the Manitoba Workplace Safety and Health Act. Any open-cut excavation greater than 3 m deep must be designed and sealed by a professional engineer and reviewed by the geotechnical engineer of record (TREK). If space is limited or the stability of adjacent structures may be endangered by an excavation, a shoring system may be required to prevent damage to, or movement of, any part of adjacent structures, and the creation of a hazard to workers and the public.

Excavation stability is the responsibility of the Contractor for the duration of construction. Excavations should be monitored regularly and flattened as necessary to maintain stability recognizing that excavation stability is time and weather dependent. Excavated slopes should be covered with polyethylene sheets to prevent wetting and drying.

Stockpiles of excavated material and heavy equipment should be kept away from the edge of any excavation by a distance equal to or greater than the depth of excavation. Dewatering measures should be completed as necessary to maintain a dry excavation and permit proper completion of the work. If seepage is encountered, it should be collected and pumped out of the excavation. If saturated silts or sands are encountered, shoring or slope flattening may be required. To prevent wet silts and sands from entering the excavation, gravel buttressing could be used in conjunction with sump pits for dewatering. Surface water should be diverted away from the excavation and the excavation should be backfilled as soon as possible following construction.

TREK recommends that inspections of any open excavations be carried out once a day for the length of time the excavation remains open. Daily inspections may be performed by qualified on-site personnel.

8.0 Design Reviews

TREK should be involved in the following as part of detailed design:

1. Plans for the structure arrangement, roadway elevations, foundations, channel slope geometry, retaining walls and general grading should be reviewed to confirm conformance with the assumptions noted herein. If significant deviations are noted, updated slope stability analysis or design recommendations may be required.
2. Anticipated temporary excavations for the structure construction should be reviewed to confirm feasibility and/or whether shoring will be required.
3. Impacts of the works on existing underground utilities (e.g. surcharge loading and deformation) should be assessed once foundation loads and structure geometries are established.
4. Specifications for foundations, site development (incl. temporary access of creek bank slopes), slope stabilization works and riprap should be prepared or reviewed by TREK.

9.0 Closure

The geotechnical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information provided (field investigation and laboratory testing). Soil conditions are natural deposits that can be highly variable across a site. If sub-surface conditions are different than the conditions previously encountered on-site or those presented here, we should be notified to adjust our findings if necessary.

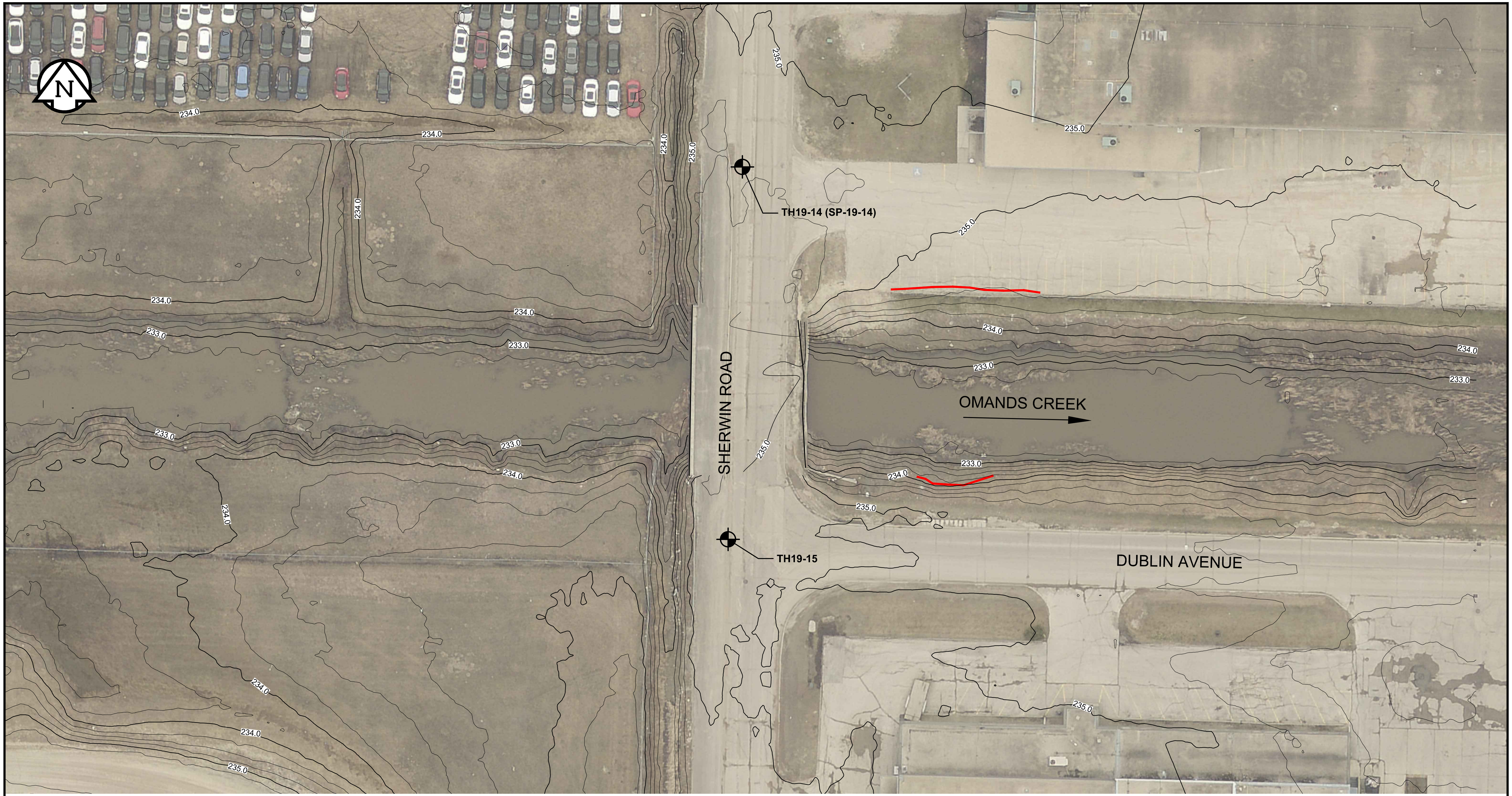
All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work, or a mutually executed standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

This report has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of Morrison Hershfield Ltd. (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this report are not to be relied upon by any third parties, except as agreed to in writing by the Client and Consultant prior to use.

Figures

TREK GEOTECHNICAL

0035 079 00
Morrison Hershfield
Sherwin Road over Omands Creek Culvert Replacement



1
-
SITE AND TEST HOLE LOCATION PLAN
SCALE: 1:500

0 5 10 15 20 25 m
SCALE = 1 : 500 (279mm x 432mm)

LEGEND:
- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- TEST HOLES (TREK, 2019)
- EXISTING TENSION CRACK

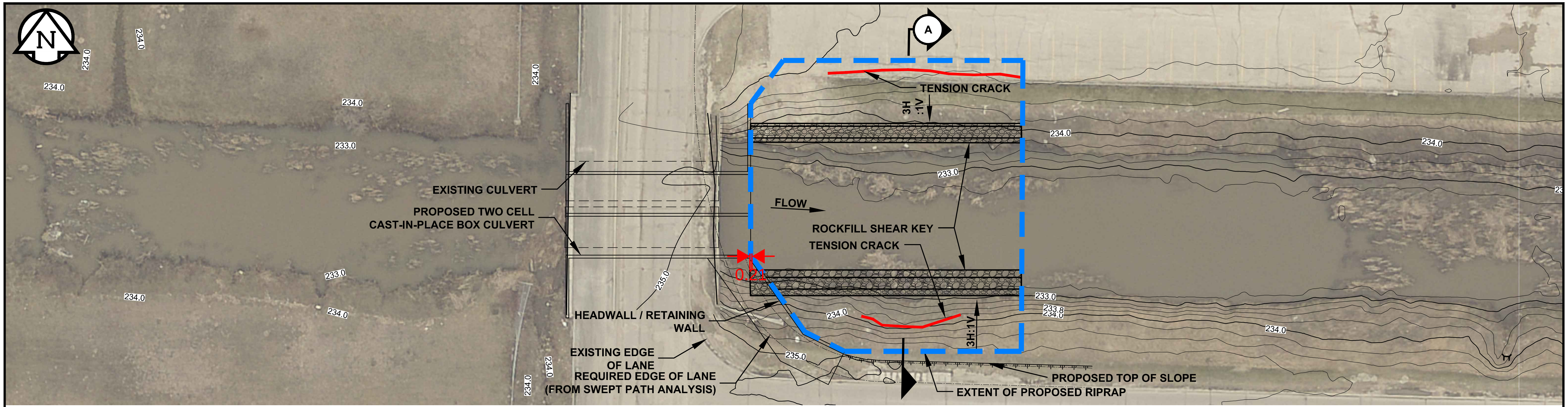
NOTES:
1. EXISTING GROUND SURFACE FROM AUGUST 2015 LIDAR
2. CONTOUR INTERVAL 0.25m to 1.00m

FIGURE 01
SITE AND TEST HOLE
LOCATION PLAN

0035 079 00
Morrison Hershfield
Sherwin Road over Omands Creek Culvert Replacement

ANSI full bleed B (11.00 x 17.00 Inches)

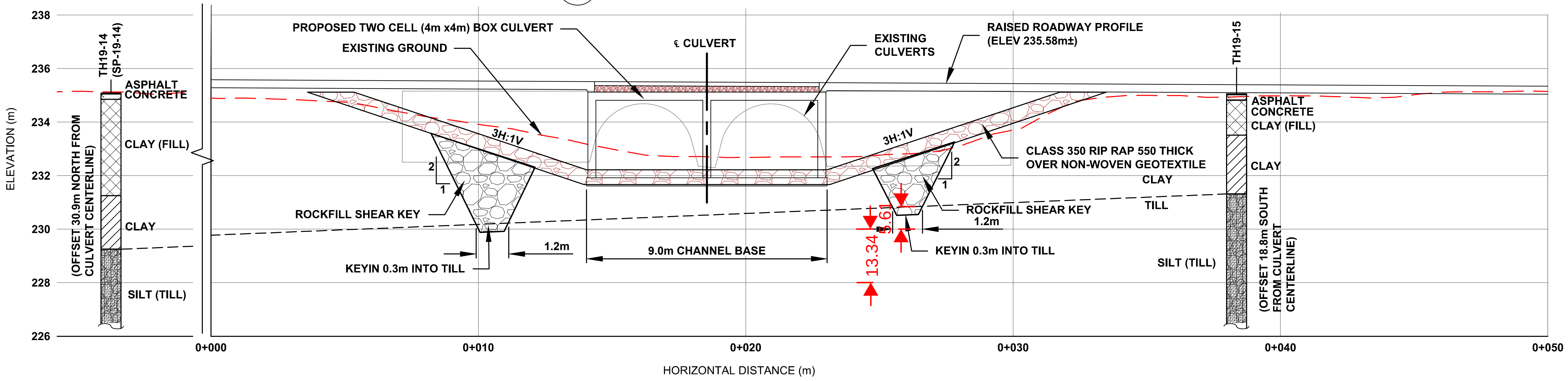
Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\3.4.2.3 CULVERT OPENING\FIG 02_2019-11-14_BOX_0_F_DW_0035-079-00.dwg, 11/14/2019 4:54:11 PM



1 / -

PROPOSED BOX CULVERT PLAN

SCALE: 1:400



2 / -

PROPOSED BOX CULVERT SECTION

SCALE: 1:150

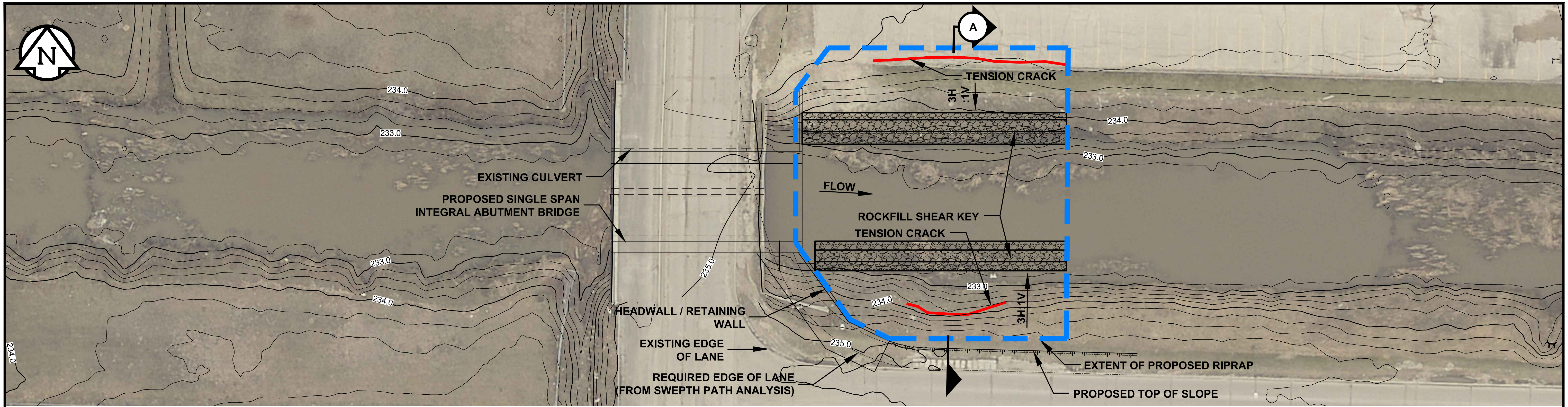
0 5 10 15 20 m
SCALE = 1 : 400 (279mm x 432mm)
0 4.5 9.0m
SCALE = 1 : 150 (279mm x 432mm)

NOTES: 1. EXISTING GROUND SURFACE FROM AUGUST 2015 LIDAR COMBINED WITH TOPOGRAPHIC SURVEY (TREK, 2019)

FIGURE 02

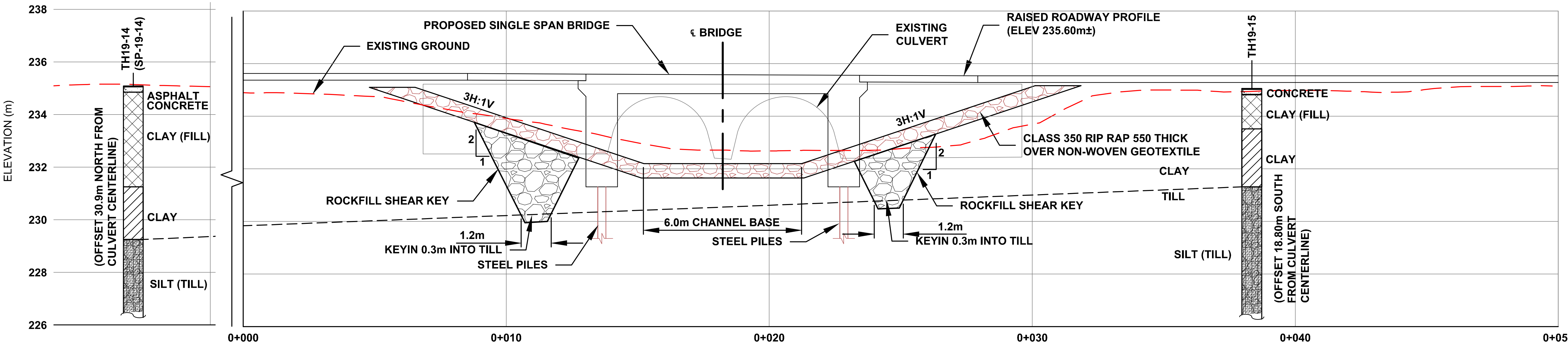
PROPOSED BOX CULVERT
PLAN AND SECTION

ANSI full bleed B (11.00 x 17.00 Inches)
Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder\3.4.2.3 CULVERT OPENING\FIG 03_2019-11-14_BRIDGE_0_G_DW_0035-079-00.dwg, 11/14/2019 4:47:28 PM



1 - PROPOSED SINGLE SPAN INTEGRAL ABUTMENT BRIDGE PLAN

SCALE: 1:400



2 - PROPOSED SINGLE SPAN INTEGRAL ABUTMENT BRIDGE SECTION

SCALE: 1:150

0 5 10 15 20 m
SCALE = 1 : 400 (279mm x 432mm)

0 4.5 9.0m
SCALE = 1 : 150 (279mm x 432mm)

NOTES:
1. EXISTING GROUND SURFACE FROM AUGUST 2015 LIDAR COMBINED WITH TOPOGRAPHIC SURVEY (TREK, 2019)

FIGURE 03

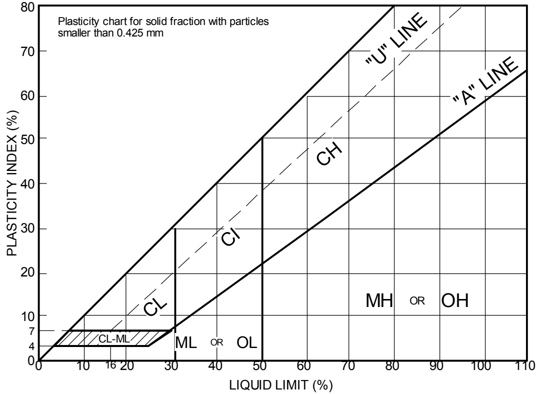
PROPOSED SINGLE SPAN INTEGRAL ABUTMENT BRIDGE
PLAN AND SECTION

Test Hole Logs

EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.
2. Descriptions on these test hole logs apply only at the specific test hole locations and at the time the test holes were drilled. Variability of soil and groundwater conditions may exist between test hole locations.
3. When the following classification terms are used in this report or test hole logs, the primary and secondary soil fractions may be visually estimated.

Major Divisions			USCS Classi- fication	Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW	■	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent...... GW, GP, SW, SP More than 12 percent...... GM, GC, SM, SC 6 to 12 percent...... Borderline case4s requiring dual symbols*	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	◌	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	▥	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC	▨	Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW	⁘	Well-graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	░	Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	▥	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC	▨	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML	▥	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart 		
			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 distomaceous fine sandy or silty soils, organic silts			
			CH	▨	Inorganic clays of high plasticity, fat clays			
			OH	≈	Organic clays of medium to high plasticity, organic silts			
	Highly Organic Soils		Pt	※	Peat and other highly organic soils	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	

Material		Particle Size mm	Particle Size ASTM Sieve sizes
Sand	Coarse	2.00 to 4.75	#10 to #4
	Medium	0.425 to 2.00	#40 to #10
	Fine	0.075 to 0.425	#200 to #40
Silt or Clay		< 0.075	< #200

Material		Particle Size mm	Particle Size ASTM Sieve Sizes
Boulders		> 300	> 12 in.
Cobbles		75 to 300	3 in. to 12 in.
Gravel	Coarse	19 to 75	3/4 in. to 3 in.
	Fine	4.75 to 19	#4 to 3/4 in.

* Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

Other Symbol Types

■	Asphalt	▧	Bedrock (undifferentiated)	◌	Cobbles
░	Concrete	⊞	Limestone Bedrock	■	Boulders and Cobbles
▩	Fill	▤	Cemented Shale	▥	Silt Till
		▨	Non-Cemented Shale	▨	Clay Till

EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)
PL - Plastic Limit (%)
PI - Plasticity Index (%)
MC - Moisture Content (%)
SPT - Standard Penetration Test
RQD - Rock Quality Designation
Qu - Unconfined Compression
Su - Undrained Shear Strength
VW - Vibrating Wire Piezometer
SI - Slope Inclinometer

▽ Water Level at Time of Drilling

▼ Water Level at End of Drilling

⧨ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

TERM	EXAMPLES	PERCENTAGE
and	and CLAY	35 to 50 percent
"y" or "ey"	clayey, silty	20 to 35 percent
some	some silt	10 to 20 percent
trace	trace gravel	1 to 10 percent

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

The Standard Penetration Test blow count (N) of a non-cohesive soil can be related to compactness condition as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

The Standard Penetration Test blow count (N) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very soft	< 2
Soft	2 to 4
Firm	4 to 8
Stiff	8 to 15
Very stiff	15 to 30
Hard	> 30

The undrained shear strength (Su) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	Undrained Shear Strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

EXPLANATION OF ROCK CLASSIFICATION

(Canadian Foundation Engineering Manual, 4th Edition, 2006)

Grade*	Term	Uniaxial Comp. Strength (MPa)	Point Load Index (MPa)	Field Estimate of Strength	Examples
R6	Extremely strong	>250	>10	Specimen can only be chipped with a geological hammer	Fresh basalt, chert, diabase, gneiss, granite, quartzite
R5	Very strong	100-250	4-10	Specimen requires many blows of a geological hammer to fracture it	Amphibolite, sandstone, basalt, gabbro, gneiss, granodiorite, peridotite, rhyolite, tuff
R4	Strong	50-100	2-4	Specimen requires more than one blow of a geological hammer to fracture it	Limestone, marble, sandstone, schist
R3	Medium Strong	25-50	1-2	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single blow from a geological hammer	Concrete, phyllite, schist, siltstone
R2	Weak	5-25	***	Can be peeled with a pocket knife with difficulty, shallow indentation made by a firm blow with the point of a geological hammer	Chalk, claystone, potash, marl, siltstone, shale, rocksalt
R1	Very weak	1-5	***	Crumbles under firm blows with point of a geological hammer, can be peeled with a pocket knife	Highly weathered or altered rock, shale
R0	Extremely weak	0.25-1	***	Indented by thumbnail	Stiff fault gouge

* Grade according to ISRM (1981).

** All rock types exhibit a broad range of uniaxial comprehensive strengths reflecting heterogeneity in composition and anisotropy in structure. Strong rocks are characterized by well-interlocked crystal fabric and few voids.

*** Rocks with a uniaxial compressive strength below 25 MPa are likely to yield highly ambiguous results under point load testing.

Sub-Surface Log

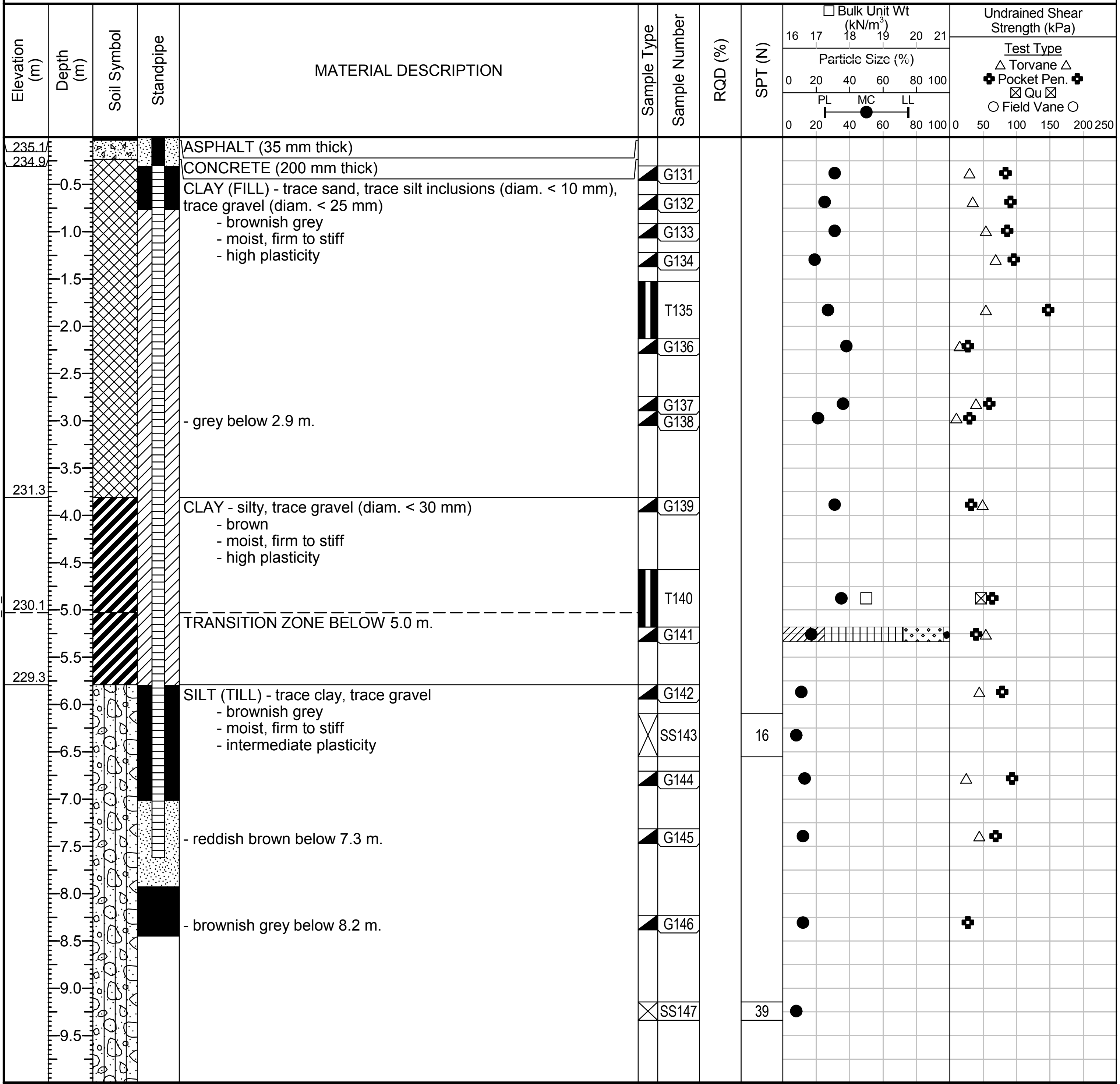
Test Hole TH19-14

Client: Morrison Hershfield
Project Number: 0035-079-00
Project Name: Sherwin Road Bridge Over Omands Creek
Location: UTM N-5530379, E-628408
Contractor: TREK Geotechnical
Ground Elevation: 235.10 m
Method: 125mm Solid Stem Auger / HQ Coring, Acker MP8 Truck Mount
Date Drilled: September 11, 2019

Sample Type: ◢ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand ● Gravel ◇ Cobbles ■ Boulders

Backfill Legend: ■ Bentonite ▩ Cement ▨ Drill Cuttings ⁘ Filter Pack Sand ⁘ Grout ▩ Slough



ASPHALT (35 mm thick)

CONCRETE (200 mm thick)

CLAY (FILL) - trace sand, trace silt inclusions (diam. < 10 mm), trace gravel (diam. < 25 mm)
- brownish grey
- moist, firm to stiff
- high plasticity

- grey below 2.9 m.

CLAY - silty, trace gravel (diam. < 30 mm)
- brown
- moist, firm to stiff
- high plasticity

TRANSITION ZONE BELOW 5.0 m.

SILT (TILL) - trace clay, trace gravel
- brownish grey
- moist, firm to stiff
- intermediate plasticity

- reddish brown below 7.3 m.

- brownish grey below 8.2 m.

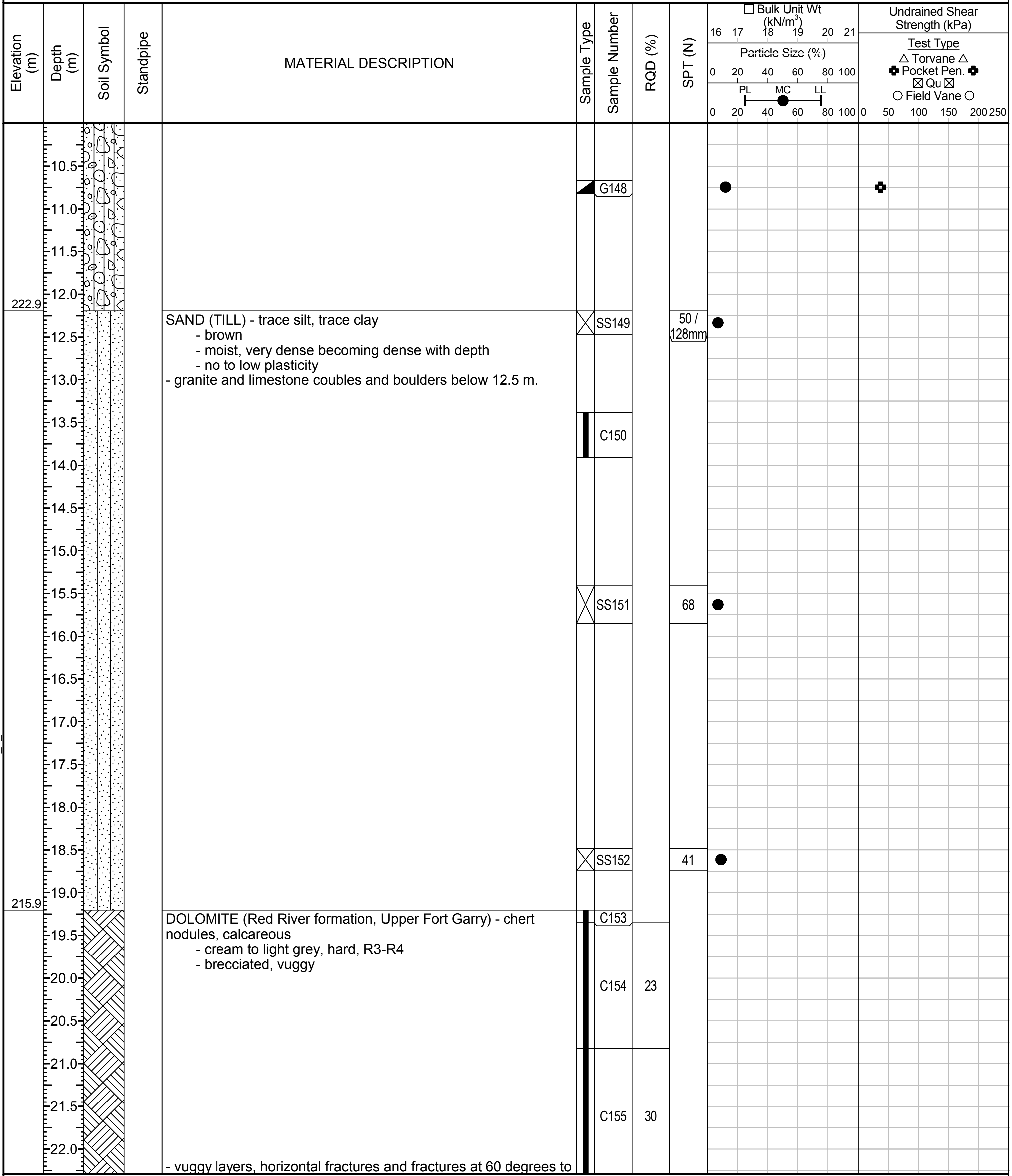
Sample Type	Sample Number	SPT (N)
◢	G131	
◢	G132	
◢	G133	
◢	G134	
▮	T135	
◢	G136	
◢	G137	
◢	G138	
◢	G139	
▮	T140	
◢	G141	
◢	G142	
☒	SS143	16
◢	G144	
◢	G145	
◢	G146	
☒	SS147	39

Logged By: Jashan Bhullar
Reviewed By: Nelson Ferreira
Project Engineer: Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH19-14



Elevation (m)	MATERIAL DESCRIPTION	Sample Number	RQD (%)	SPT (N)
		G148		
222.9	SAND (TILL) - trace silt, trace clay - brown - moist, very dense becoming dense with depth - no to low plasticity - granite and limestone coubles and boulders below 12.5 m.	SS149		50 / 128mm
		C150		
		SS151		68
		SS152		41
215.9	DOLOMITE (Red River formation, Upper Fort Garry) - chert nodules, calcareous - cream to light grey, hard, R3-R4 - brecciated, vuggy	C153		
		C154	23	
	- vuggy layers, horizontal fractures and fractures at 60 degrees to	C155	30	

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

Sub-Surface Log

Test Hole TH19-14

Elevation (m)	Depth (m)	Soil Symbol	Standpipe	MATERIAL DESCRIPTION	Sample Type	Sample Number	RQD (%)	SPT (N)	☐ Bulk Unit Wt (kN/m^3) 16 17 18 19 20 21 Particle Size (%) 0 20 40 60 80 100 PL ● MC LL 0 20 40 60 80 100	Undrained Shear Strength (kPa) Test Type △ Torvane △ ✚ Pocket Pen. ✚ ☒ Qu ☒ ○ Field Vane ○ 0 50 100 150 200 250
	22.5			the core axis below 22.1 m.						
	23.0			- cherty dolomite and minor subhorizontal fractures below 22.95 m.		C156	66			
	23.5									
	24.0									
	24.5					C157	86			
	25.0			- dolomite with subhorizontal thin clay seams at 25.05 m. - white to pink, hard and minor vugs below 25.2 m.						
209.6										

END OF TEST HOLE AT 25.4 m IN DOLOMITE BEDROCK.
Notes:
1) No seepage observed.
2) No sloughing observed.
3) Switched to HWT casing and HQ coring below 12.6 m.
4) SP19-14 installed in TH19-14A located approx. 1 m South-west of the test hole.
5) Test hole backfilled with bentonite chips and auger cuttings.
6) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

TREK GEOTECHNICAL

Sub-Surface Log

Test Hole TH19-15

1 of 2

Client: Morrison Hershfield

Project Name: Sherwin Road Bridge Over Omands Creek

Contractor: TREK Geotechnical Inc.

Method: 125 mm Solid Stem Augers / HQ Coring, Acker Renegade Track Mount

Project Number: 0035-079-00

Location: UTM N-5530379, E-628408

Ground Elevation: 235.05 m

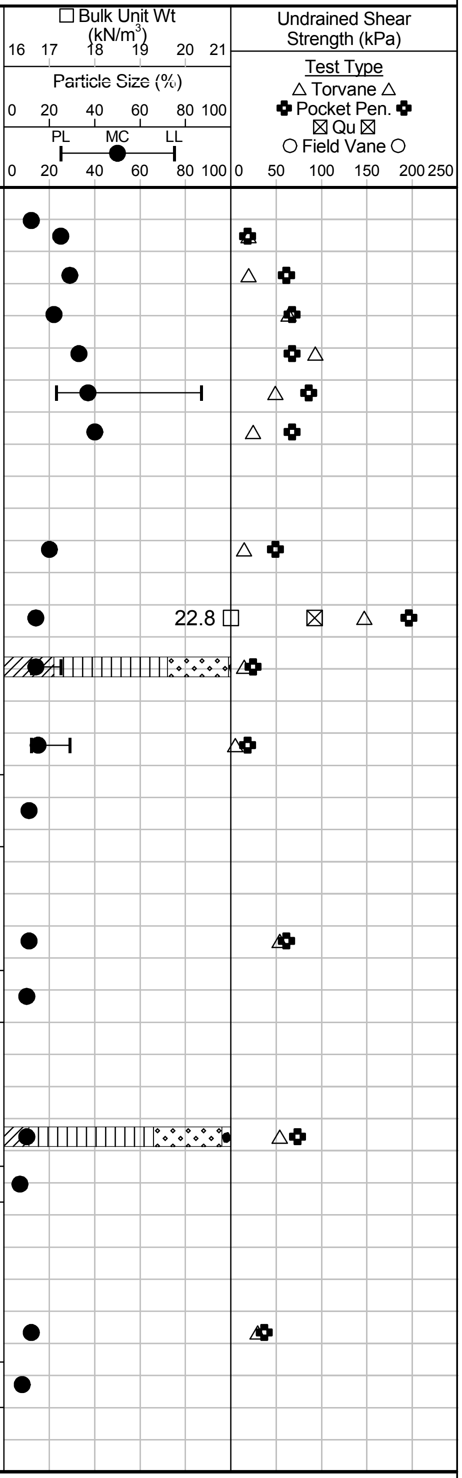
Date Drilled: September 6, 2019

Sample Type: ◣ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) ⧓ Split Barrel (SB) ▯ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand Gravel Cobbles Boulders

Elevation (m)	Depth (m)	MATERIAL DESCRIPTION
235.0		ASPHALT (30 mm thick)
234.8		CONCRETE (210 mm thick)
		CLAY (FILL) - silty, trace sand, trace gravel (diam. < 25 mm) - dark brown to grey - moist, stiff - high plasticity
233.5	1.5	CLAY - silty, trace silt inclusions (diam. < 5 mm), trace sand, trace gravel (diam. < 20 mm) - dark brown - moist, stiff - high plasticity
232.3		- TRANSITION ZONE BELOW 2.7 m.
231.4		SILT (TILL) - trace to some clay, trace sand, trace gravel (diam. < 30 mm) - light brown - moist, compact - low plasticity - trace clay below 4.6 m. - compact to dense below 6.0 m.

Sample Type	Sample Number	RQD (%)	SPT (N)
◣	G98		
◣	G99		
◣	G100		
◣	G101		
◣	G102		
◣	G103		
◣	G104		
◣	G105		
▮	T106		
◣	G107		
◣	G108		
☒	SS109		11
◣	G110		
☒	SS111		12
◣	G112		
☒	SS113		16
◣	G114		
☒	SS115		15



Logged By: Jashan Bhullar

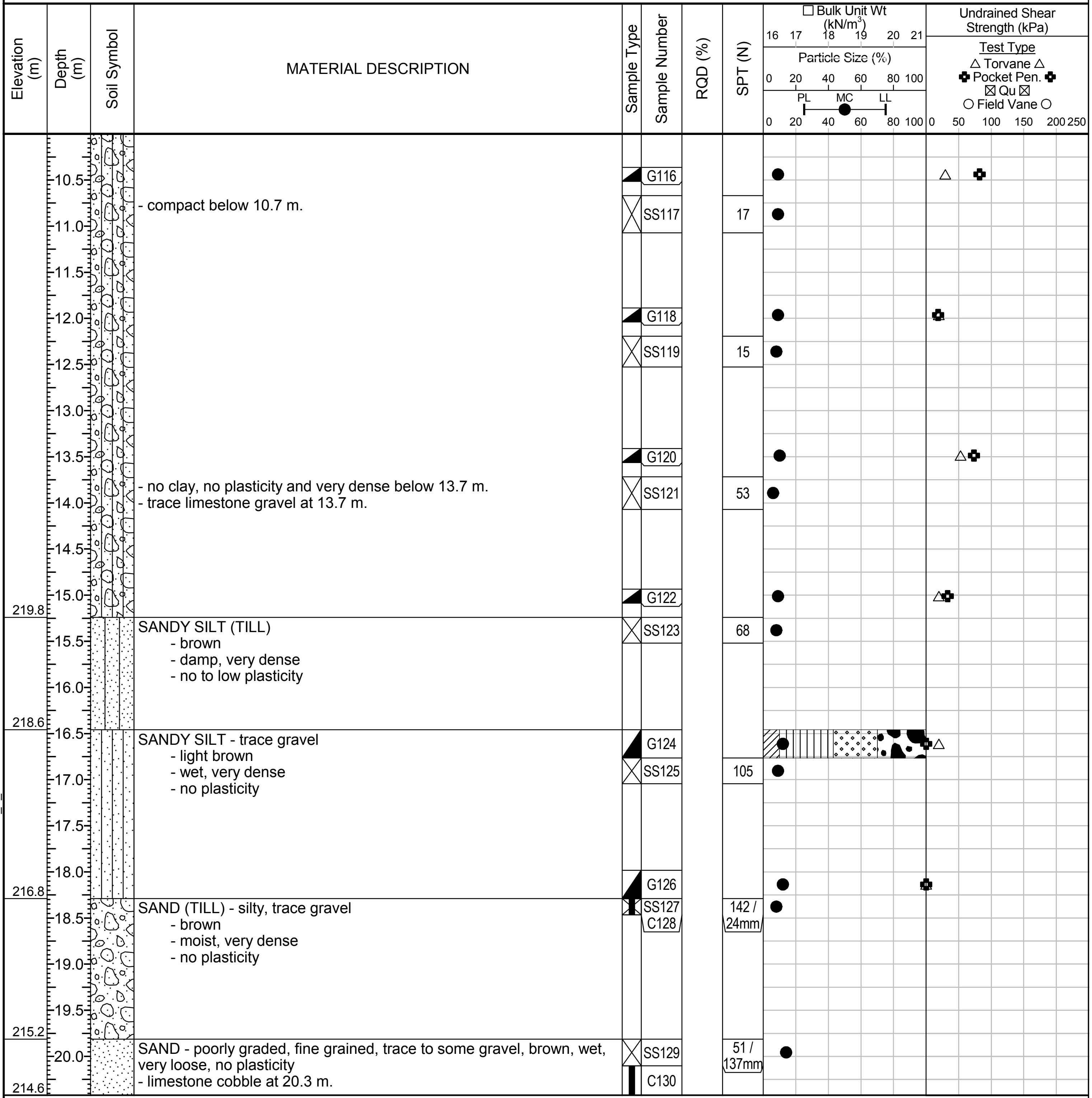
Reviewed By: Nelson Ferreira

Project Engineer: Michael Van Helden

Sub-Surface Log

Test Hole TH19-15

2 of 2



- compact below 10.7 m.

- no clay, no plasticity and very dense below 13.7 m.
- trace limestone gravel at 13.7 m.

SANDY SILT (TILL)
- brown
- damp, very dense
- no to low plasticity

SANDY SILT - trace gravel
- light brown
- wet, very dense
- no plasticity

SAND (TILL) - silty, trace gravel
- brown
- moist, very dense
- no plasticity

SAND - poorly graded, fine grained, trace to some gravel, brown, wet, very loose, no plasticity
- limestone cobble at 20.3 m.

Sample Number	SPT (N)
G116	
SS117	17
G118	
SS119	15
G120	
SS121	53
G122	
SS123	68
G124	
SS125	105
G126	
SS127	142 / 24mm
C128	
SS129	51 / 137mm
C130	

END OF TEST HOLE AT 20.5 m IN SAND.
Notes:
1) Power auger refusal at 18.4 m in SAND (TILL).
2) Switched to HWT casing and HQ coring below 18.4 m.
3) Seepage observed at 15.0 m in SILT (TILL) and below 16.5 m in SANDY SILT.
3) No sloughing observed.
4) Test hole backfilled with bentonite chips and auger cuttings.
5) Test hole top sealed with asphalt cold patch.

Logged By: Jashan Bhullar **Reviewed By:** Nelson Ferreira **Project Engineer:** Michael Van Helden

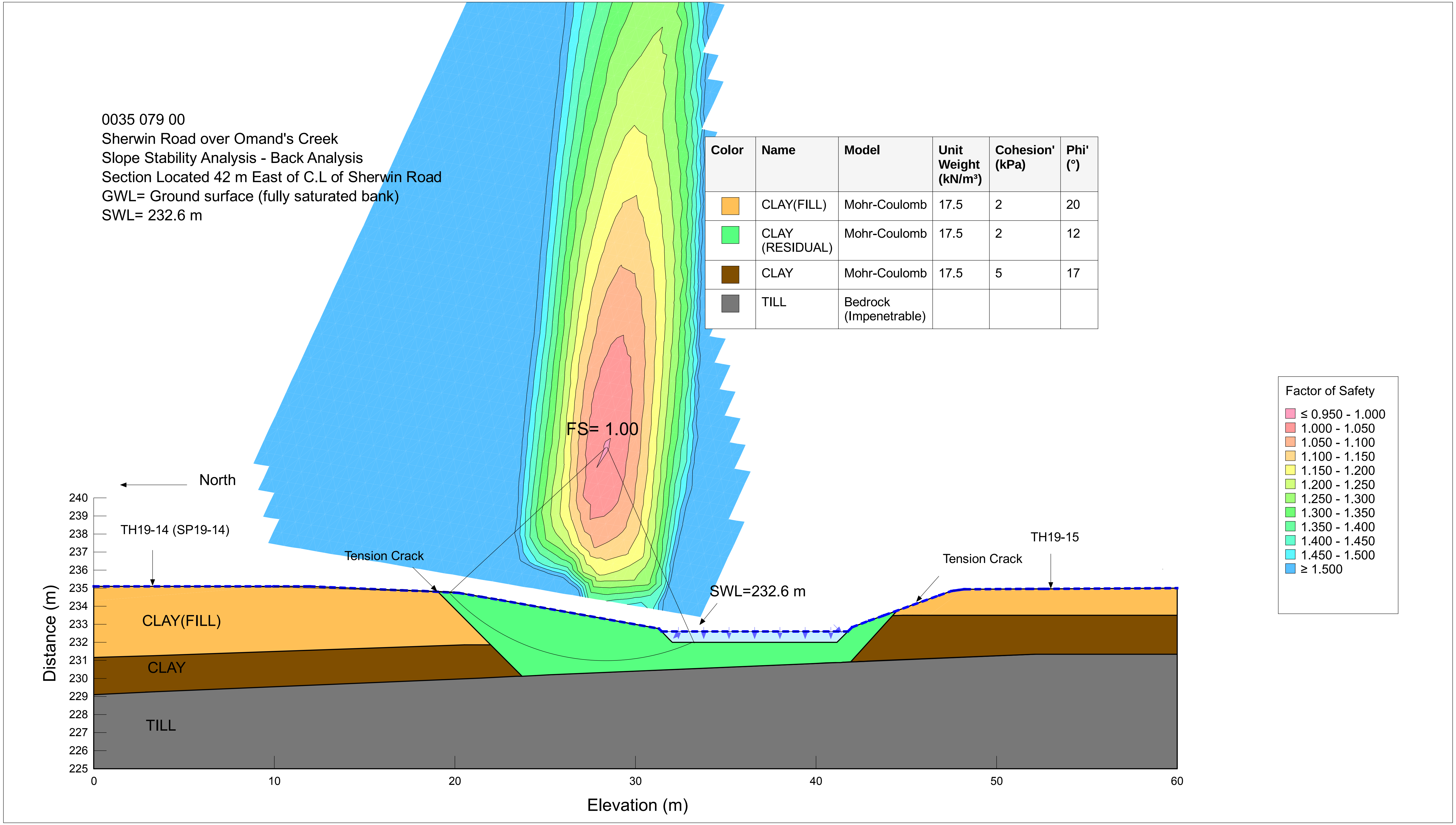
Appendix A

Slope Stability Modelling Results

Tabloid (279mm x 432mm)

SAVED: 06/11/2019 8:56:59 AM

SCALE: 1:200 (279mm x 432mm)



0035 079 00
Sherwin Road over Omand's Creek
Slope Stability Analysis - Back Analysis
Section Located 42 m East of C.L of Sherwin Road
GWL= Ground surface (fully saturated bank)
SWL= 232.6 m

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟧	CLAY(FILL)	Mohr-Coulomb	17.5	2	20
🟩	CLAY (RESIDUAL)	Mohr-Coulomb	17.5	2	12
🟫	CLAY	Mohr-Coulomb	17.5	5	17
⬛	TILL	Bedrock (Impenetrable)			

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\2 Design\2.7 Modelling\Geostudio Model\M002B- Back Analysis(42 m East of centerline of existing culvert).gsz

Figure A-1

Back analysis (North Bank)

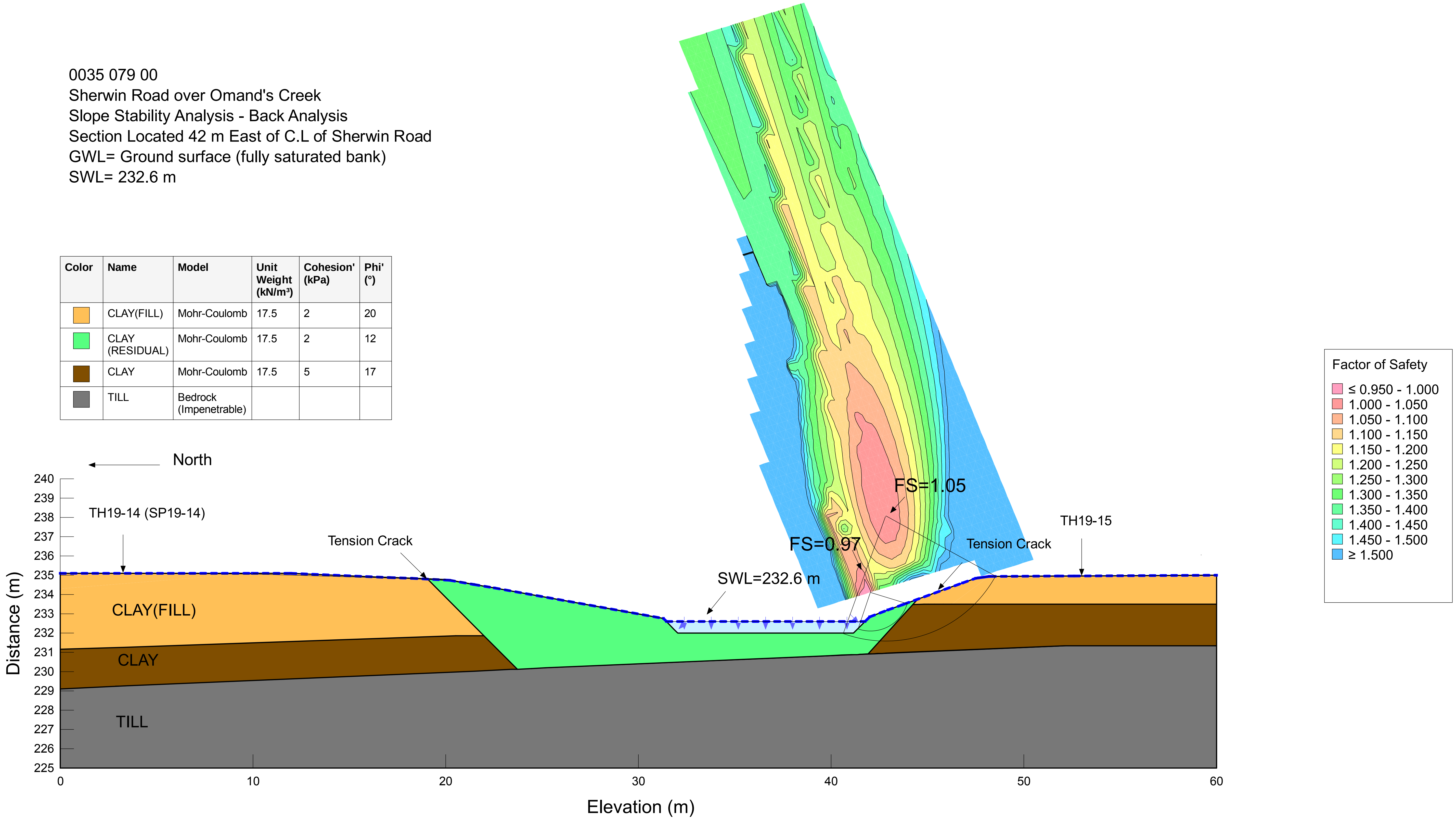
Tabloid (279mm x 432mm)

SAVED: 06/11/2019 8:56:59 AM

SCALE: 1:200 (279mm x 432mm)

0035 079 00
Sherwin Road over Omand's Creek
Slope Stability Analysis - Back Analysis
Section Located 42 m East of C.L of Sherwin Road
GWL= Ground surface (fully saturated bank)
SWL= 232.6 m

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟧	CLAY(FILL)	Mohr-Coulomb	17.5	2	20
🟩	CLAY (RESIDUAL)	Mohr-Coulomb	17.5	2	12
🟫	CLAY	Mohr-Coulomb	17.5	5	17
⬛	TILL	Bedrock (Impenetrable)			



FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\2 Design\2.7 Modelling\Geostudio Model\M002B- Back Analysis(42 m East of centerline of existing culvert).gsz

Figure A-2

Back analysis (South Bank)

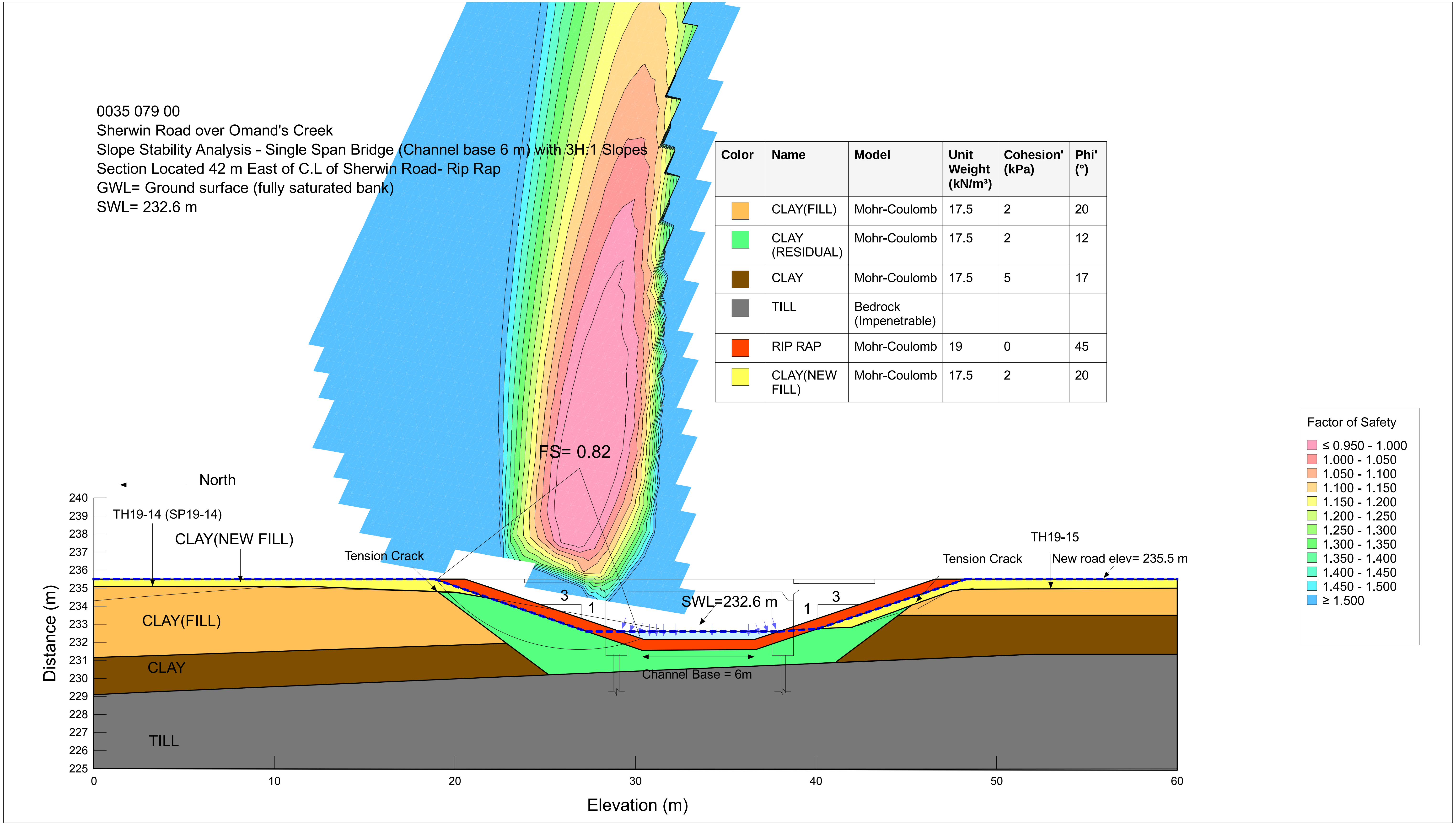
0035 079 00

Morrison Hershfield
Sherwin Road over Omand's Creek

Tabloid (279mm x 432mm)

SAVED: 06/11/2019 10:01:59 AM

SCALE: 1:200 (279mm x 432mm)



0035 079 00
Sherwin Road over Omand's Creek
Slope Stability Analysis - Single Span Bridge (Channel base 6 m) with 3H:1 Slopes
Section Located 42 m East of C.L of Sherwin Road- Rip Rap
GWL= Ground surface (fully saturated bank)
SWL= 232.6 m

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟧	CLAY(FILL)	Mohr-Coulomb	17.5	2	20
🟩	CLAY (RESIDUAL)	Mohr-Coulomb	17.5	2	12
🟫	CLAY	Mohr-Coulomb	17.5	5	17
▨	TILL	Bedrock (Impenetrable)			
🟥	RIP RAP	Mohr-Coulomb	19	0	45
🟨	CLAY(NEW FILL)	Mohr-Coulomb	17.5	2	20

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\2 Design\2.7 Modelling\Geostudio Model\M003B- Single Span (channel base 6m).gsz

Figure A-3

Single Span Bridge with Rip Rap (North Bank)

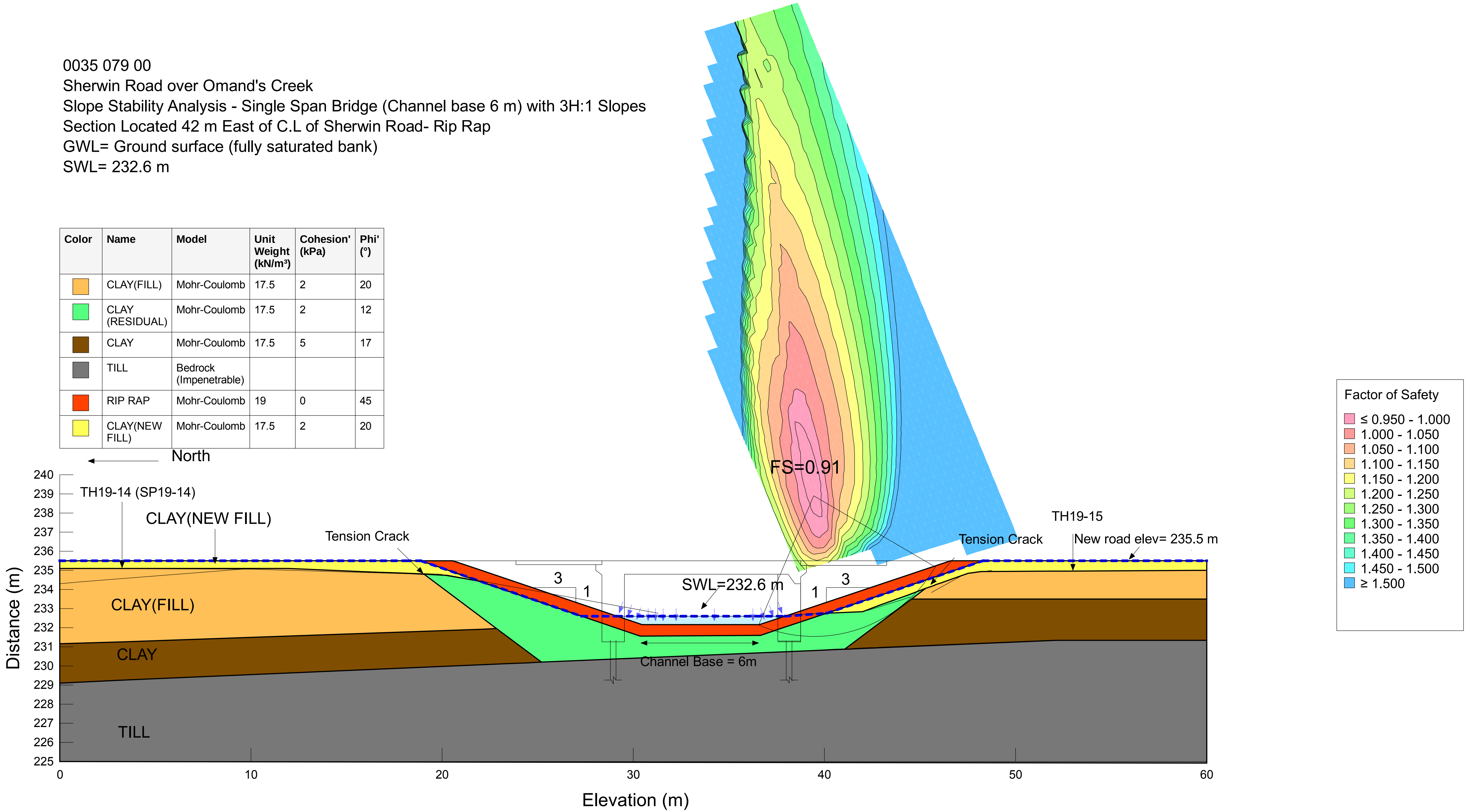
Tabloid (279mm x 432mm)

SAVED: 06/11/2019 10:01:59 AM

SCALE: 1:200 (279mm x 432mm)

0035 079 00
Sherwin Road over Omand's Creek
Slope Stability Analysis - Single Span Bridge (Channel base 6 m) with 3H:1 Slopes
Section Located 42 m East of C.L of Sherwin Road- Rip Rap
GWL= Ground surface (fully saturated bank)
SWL= 232.6 m

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟧	CLAY(FILL)	Mohr-Coulomb	17.5	2	20
🟩	CLAY (RESIDUAL)	Mohr-Coulomb	17.5	2	12
🟫	CLAY	Mohr-Coulomb	17.5	5	17
⬛	TILL	Bedrock (Impenetrable)			
🟥	RIP RAP	Mohr-Coulomb	19	0	45
🟨	CLAY(NEW FILL)	Mohr-Coulomb	17.5	2	20



FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\2 Design\2.7 Modelling\Geostudio Model\M003B- Single Span (channel base 6m).gsz

Figure A-4

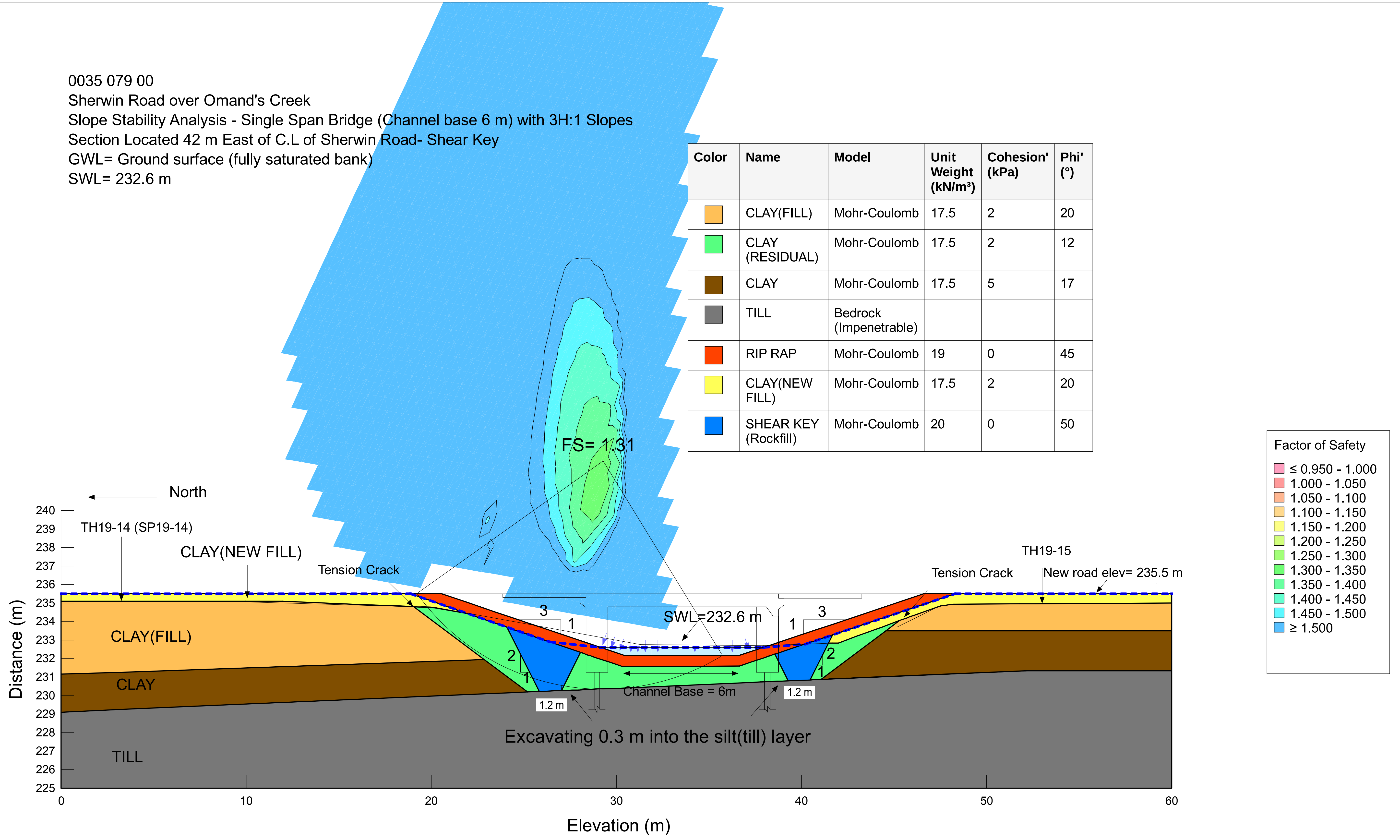
Single Span Bridge with Rip Rap (South Bank)

Tabloid (279mm x 432mm)

SAVED: 06/11/2019 9:11:51 AM

SCALE: 1:200 (279mm x 432mm)

0035 079 00
Sherwin Road over Omand's Creek
Slope Stability Analysis - Single Span Bridge (Channel base 6 m) with 3H:1 Slopes
Section Located 42 m East of C.L of Sherwin Road- Shear Key
GWL= Ground surface (fully saturated bank)
SWL= 232.6 m



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟧	CLAY(FILL)	Mohr-Coulomb	17.5	2	20
🟩	CLAY (RESIDUAL)	Mohr-Coulomb	17.5	2	12
🟫	CLAY	Mohr-Coulomb	17.5	5	17
⬛	TILL	Bedrock (Impenetrable)			
🟥	RIP RAP	Mohr-Coulomb	19	0	45
🟨	CLAY(NEW FILL)	Mohr-Coulomb	17.5	2	20
🟦	SHEAR KEY (Rockfill)	Mohr-Coulomb	20	0	50

Factor of Safety
- ≤ 0.950 - 1.000
- 1.000 - 1.050
- 1.050 - 1.100
- 1.100 - 1.150
- 1.150 - 1.200
- 1.200 - 1.250
- 1.250 - 1.300
- 1.300 - 1.350
- 1.350 - 1.400
- 1.400 - 1.450
- 1.450 - 1.500
- ≥ 1.500

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\2 Design\2.7 Modelling\Geostudio Model\M006D- Single Span (channel base 6m- Shear Key).gsz

Figure A-5

Single Span Bridge with shear key at channel (North Bank)

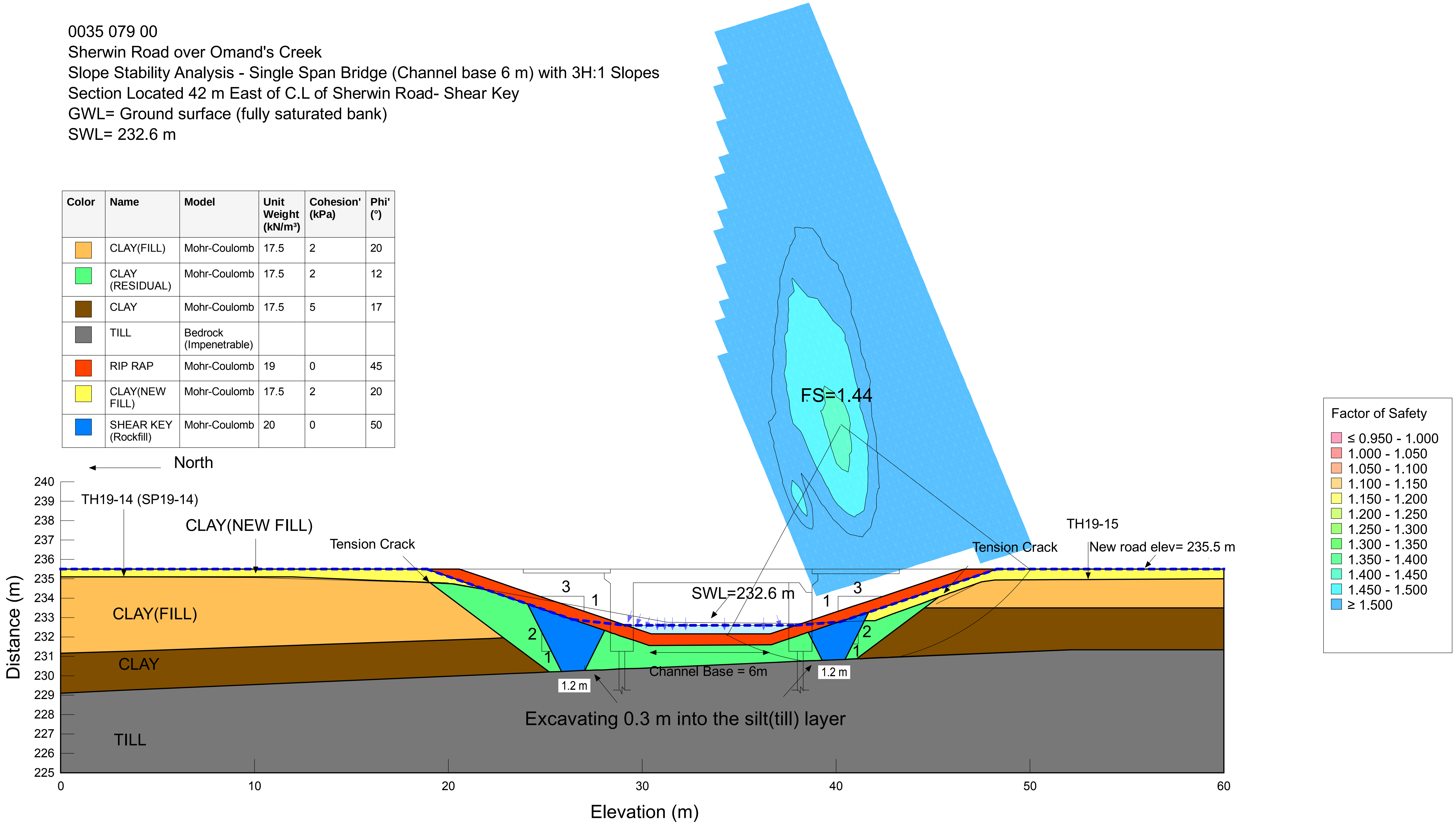
Tabloid (279mm x 432mm)

SAVED: 06/11/2019 9:11:51 AM

SCALE: 1:200 (279mm x 432mm)

0035 079 00
Sherwin Road over Omand's Creek
Slope Stability Analysis - Single Span Bridge (Channel base 6 m) with 3H:1 Slopes
Section Located 42 m East of C.L of Sherwin Road- Shear Key
GWL= Ground surface (fully saturated bank)
SWL= 232.6 m

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟧	CLAY(FILL)	Mohr-Coulomb	17.5	2	20
🟩	CLAY (RESIDUAL)	Mohr-Coulomb	17.5	2	12
🟫	CLAY	Mohr-Coulomb	17.5	5	17
⬛	TILL	Bedrock (Impenetrable)			
🟥	RIP RAP	Mohr-Coulomb	19	0	45
🟨	CLAY(NEW FILL)	Mohr-Coulomb	17.5	2	20
🟦	SHEAR KEY (Rockfill)	Mohr-Coulomb	20	0	50



FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\2 Design\2.7 Modelling\Geostudio Model\M006D- Single Span (channel base 6m- Shear Key).gsz

Figure A-6

Single Span Bridge with shear key at channel (South Bank)

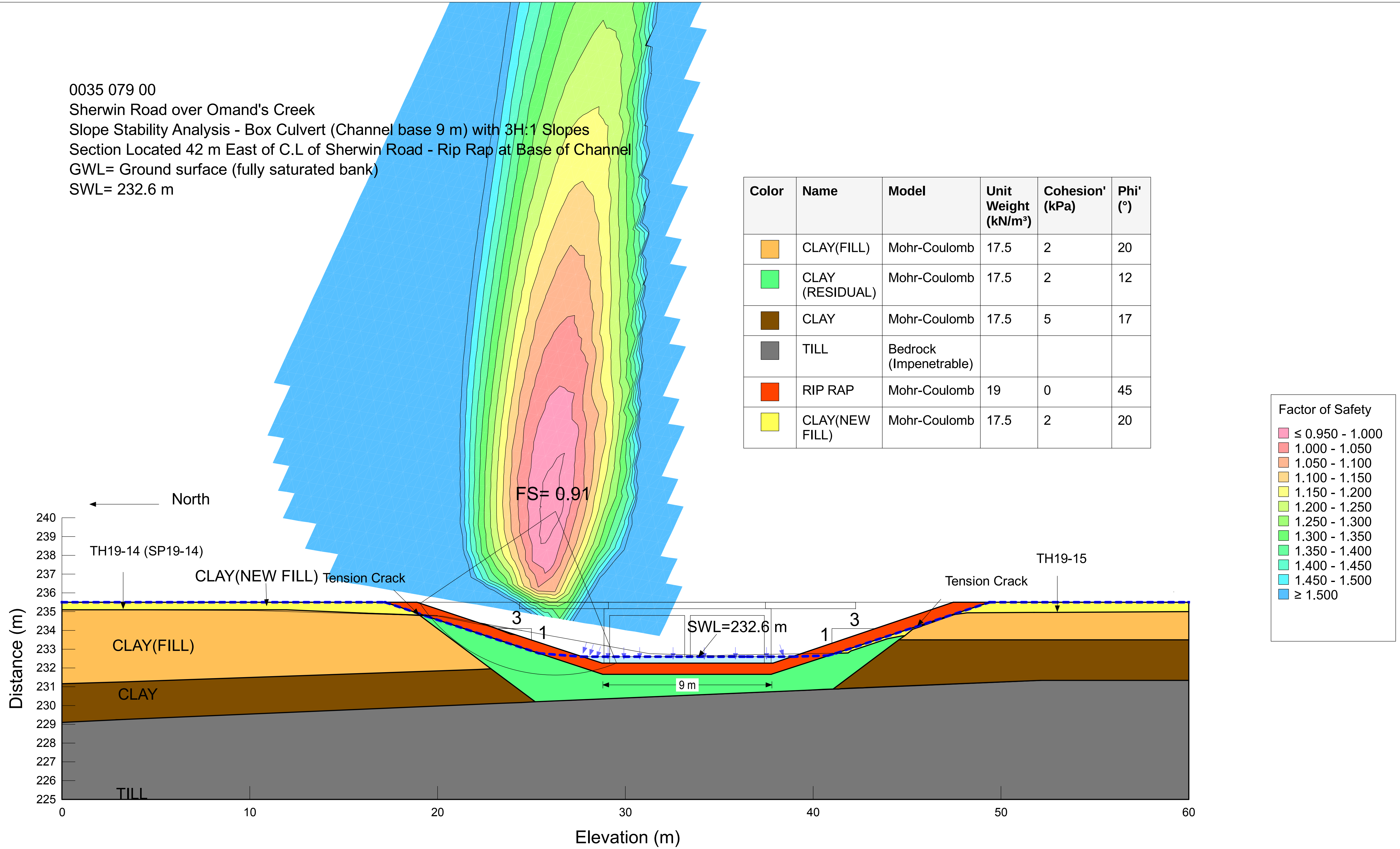
TREK GEOTECHNICAL

0035 079 00
Morrison Hershfield
Sherwin Road over Omand's Creek

Tabloid (279mm x 432mm)

SAVED: 06/11/2019 10:14:04 AM

SCALE: 1:200 (279mm x 432mm)



0035 079 00
Sherwin Road over Omand's Creek
Slope Stability Analysis - Box Culvert (Channel base 9 m) with 3H:1 Slopes
Section Located 42 m East of C.L of Sherwin Road - Rip Rap at Base of Channel
GWL= Ground surface (fully saturated bank)
SWL= 232.6 m

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟧	CLAY(FILL)	Mohr-Coulomb	17.5	2	20
🟩	CLAY (RESIDUAL)	Mohr-Coulomb	17.5	2	12
🟫	CLAY	Mohr-Coulomb	17.5	5	17
⬛	TILL	Bedrock (Impenetrable)			
🟥	RIP RAP	Mohr-Coulomb	19	0	45
🟨	CLAY(NEW FILL)	Mohr-Coulomb	17.5	2	20

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\2 Design\2.7 Modelling\Geostudio Model\M007D- Box culvert with rip Rap (Channel Base 9 m).gsz

Figure A-7

Box culvert with rip rap at channel (North Bank)

TREK GEOTECHNICAL

0035 079 00
Morrison Hershfield
Sherwin Road over Omand's Creek

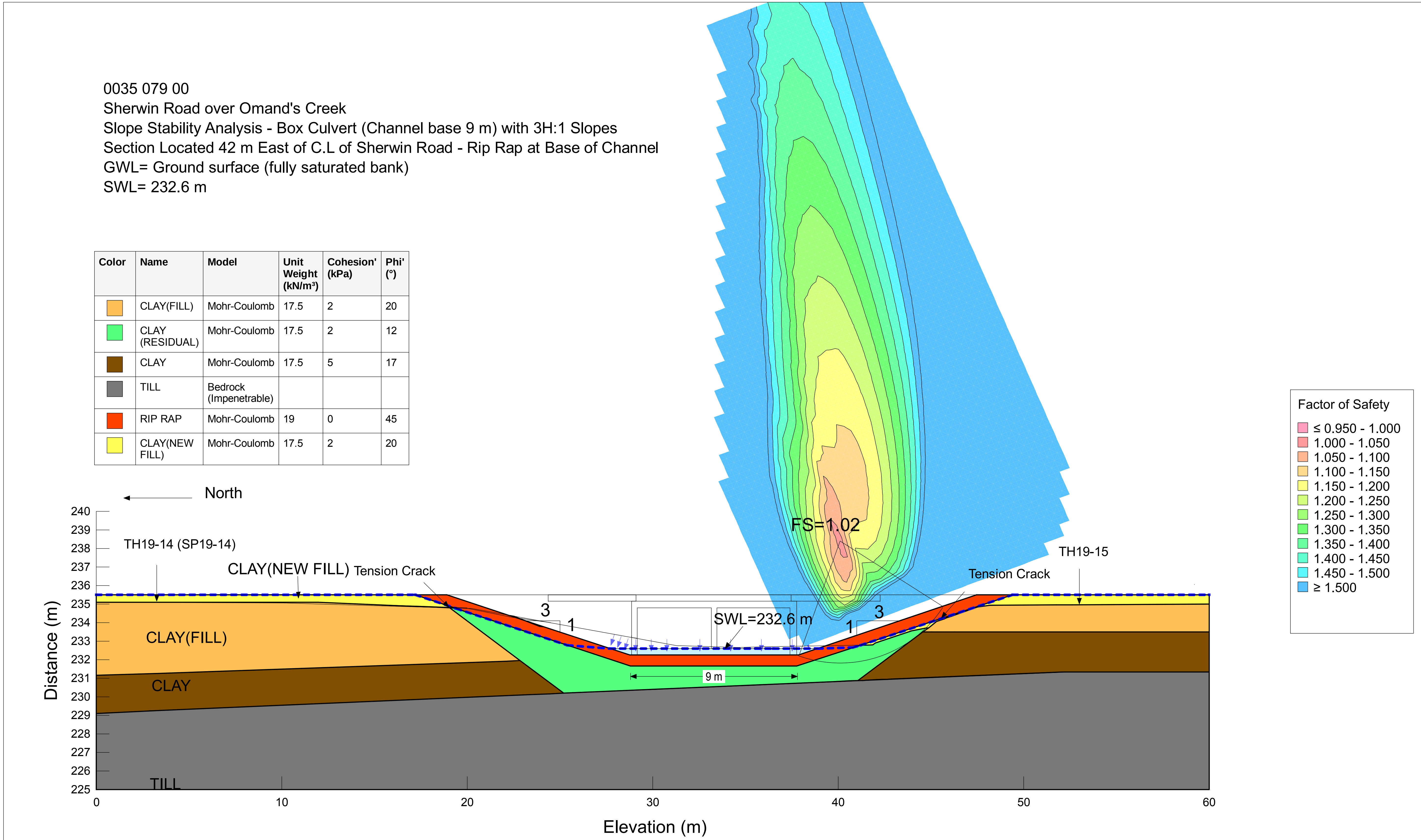
Tabloid (279mm x 432mm)

SAVED: 06/11/2019 10:14:04 AM

SCALE: 1:200 (279mm x 432mm)

0035 079 00
Sherwin Road over Omand's Creek
Slope Stability Analysis - Box Culvert (Channel base 9 m) with 3H:1 Slopes
Section Located 42 m East of C.L of Sherwin Road - Rip Rap at Base of Channel
GWL= Ground surface (fully saturated bank)
SWL= 232.6 m

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟧	CLAY(FILL)	Mohr-Coulomb	17.5	2	20
🟩	CLAY (RESIDUAL)	Mohr-Coulomb	17.5	2	12
🟫	CLAY	Mohr-Coulomb	17.5	5	17
⬛	TILL	Bedrock (Impenetrable)			
🟥	RIP RAP	Mohr-Coulomb	19	0	45
🟨	CLAY(NEW FILL)	Mohr-Coulomb	17.5	2	20



FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\2 Design\2.7 Modelling\Geostudio Model\M007D- Box culvert with rip Rap (Channel Base 9 m).gsz

Figure A-8

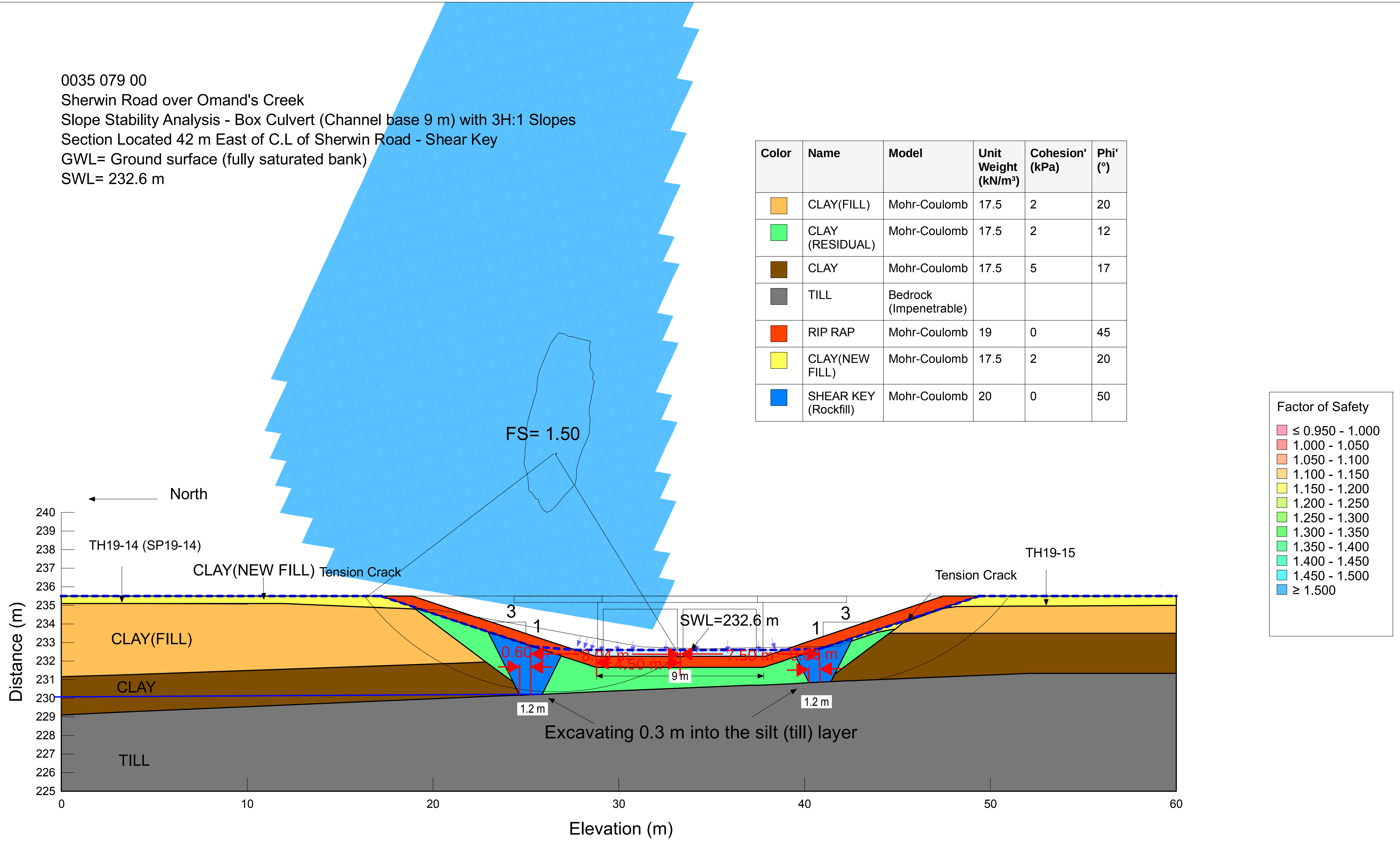
Box culvert with rip rap at channel (South Bank)

Tabloid (279mm x 432mm)

SAVED: 06/11/2019 9:50:39 AM

SCALE: 1:200 (279mm x 432mm)

0035 079 00
Sherwin Road over Omand's Creek
Slope Stability Analysis - Box Culvert (Channel base 9 m) with 3H:1 Slopes
Section Located 42 m East of C.L of Sherwin Road - Shear Key
GWL= Ground surface (fully saturated bank)
SWL= 232.6 m



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟧	CLAY(FILL)	Mohr-Coulomb	17.5	2	20
🟩	CLAY (RESIDUAL)	Mohr-Coulomb	17.5	2	12
🟫	CLAY	Mohr-Coulomb	17.5	5	17
⬛	TILL	Bedrock (Impenetrable)			
🟥	RIP RAP	Mohr-Coulomb	19	0	45
🟨	CLAY(NEW FILL)	Mohr-Coulomb	17.5	2	20
🟦	SHEAR KEY (Rockfill)	Mohr-Coulomb	20	0	50

FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\2 Design\2.7 Modelling\Geostudio Model\M010D- Box culvert (Channel Base 9 m- Shear Key).gsz

Figure A-9

Box culvert with shear key (North Bank)

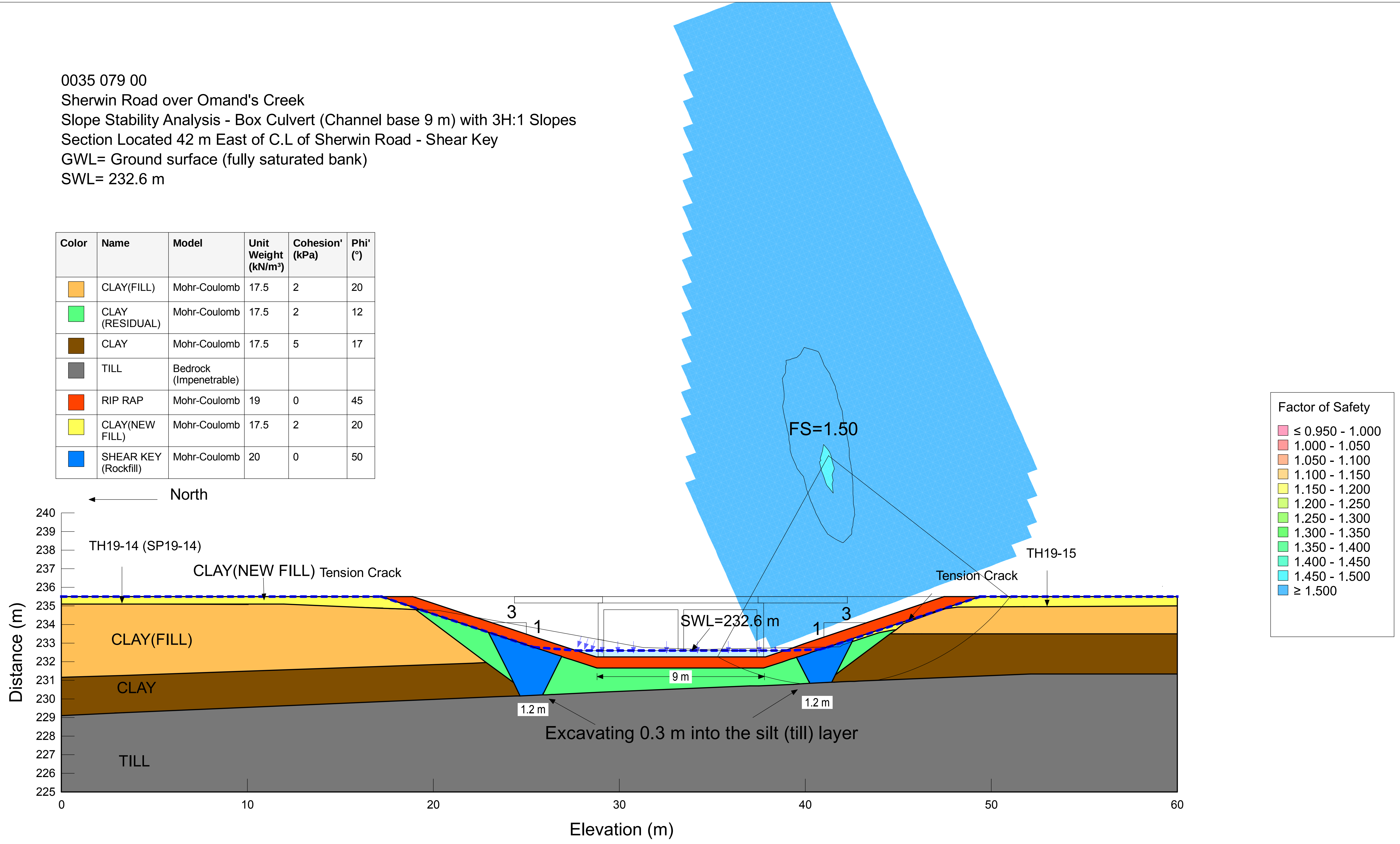
Tabloid (279mm x 432mm)

SAVED: 06/11/2019 9:50:39 AM

SCALE: 1:200 (279mm x 432mm)

0035 079 00
Sherwin Road over Omand's Creek
Slope Stability Analysis - Box Culvert (Channel base 9 m) with 3H:1 Slopes
Section Located 42 m East of C.L of Sherwin Road - Shear Key
GWL= Ground surface (fully saturated bank)
SWL= 232.6 m

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟧	CLAY(FILL)	Mohr-Coulomb	17.5	2	20
🟩	CLAY (RESIDUAL)	Mohr-Coulomb	17.5	2	12
🟫	CLAY	Mohr-Coulomb	17.5	5	17
⬛	TILL	Bedrock (Impenetrable)			
🟥	RIP RAP	Mohr-Coulomb	19	0	45
🟨	CLAY(NEW FILL)	Mohr-Coulomb	17.5	2	20
🟦	SHEAR KEY (Rockfill)	Mohr-Coulomb	20	0	50



FILE PATH: Z:\Projects\0035 Morrison Hershfield\0035 079 00 Sherwin Road Bridge over Omands Creek\2 Design\2.7 Modelling\Geostudio Model\M010D- Box culvert (Channel Base 9 m- Shear Key).gsz

Figure A-10

Box culvert with shear key (South Bank)

Appendix B

Laboratory Testing Results

TREK GEOTECHNICAL Quality Engineering | Valued Relationships

MEMORANDUM

Date	October 4, 2019
To	Jashan Bhullar, TREK Geotechnical
From	Angela Fidler-Kliewer, TREK Geotechnical
Project No.	0035-079-00
Project	Sherwin Road Bridge Over Omands Creek
Subject	Laboratory Testing Results – Lab Req. R19-210
Distribution	Michael Van Helden

Attached are the laboratory testing results for the above noted project. The testing included moisture content determinations, particle size distribution (hydrometer method) tests, Atterberg limits and unconfined compression tests with related testing on Shelby tube samples.

Regards,

Angela Fidler-Kliewer, C.Tech.

Attach.

Review Control:

Prepared By: SA	*Reviewed By:* AFK	*Checked By:* NJF

TREK GEOTECHNICAL

LABORATORY REQUISITION

CLIENT Morrison Hershfield

PROJECT NO: 0035-079-00

PROJECT NAME Sherwin Road Bridge Over Omands Creek

FIELD TECHNICIAN: Jashan Bhullar

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE (ft)	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS				Soil Description/Comments
TH19-01	G47	1.0 - 1.5		X										Pp, Tv
TH19-01	G48	2.0 - 2.5		X										
TH19-01	G49	3.0 - 3.5		X										
TH19-01	G50	4.0 - 4.3		X										Tv,
TH19-01	G51	4.3 - 4.5		X										Tv,
TH19-01	G52	5.0 - 5.5		X										
TH19-01	G53	6.0 - 6.5		X										
TH19-01	G54	9.5 - 10.0		X										
TH19-02	G55	1.0 - 1.5		X										
TH19-02	G56	2.0 - 2.5		X										
TH19-02	G57	3.0 - 3.5		X		X	X							Clay Backfill Tv
TH19-02	G58	4.0 - 4.5		X										Tv
TH19-02	G59	5.0 - 5.5		X										Tv
TH19-02	G60	6.0 - 6.5		X										Tv
TH19-02	G61	9.5 - 10.0		X										Tv
TH19-03	G39	1.0 - 1.5		X										Tv
TH19-03	G40	2.0 - 2.5		X										Tv
TH19-03	G41	3.0 - 3.5		X										Tv
TH19-03	G42	4.0 - 4.5		X										Tv
TH19-03	G43	5.0 - 5.5		X										
TH19-03	G44	6.0 - 6.5		X										
TH19-03	G45	8.0 - 8.5		X										
TH19-03	G46	9.5 - 10.0		X										
TH19-04	G62	1.0 - 1.5		X										Tv
TH19-04	G63	2.0 - 2.5		X										Tv
TH19-04	G64	3.0 - 3.5		X										Tv
TH19-04	G65	4.0 - 4.5		X										Tv
TH19-04	G66	5.0 - 5.5		X										Tv
TH19-04	G67	6.0 - 6.5		X										Tv
TH19-04	G68	8.0 - 8.5		X										Tv
TH19-04	G69	10.5 - 11.0		X										
TH19-05	G31	1.0 - 1.5		X										
TH19-05	G32	2.0 - 2.5		X										
TH19-05	G33	3.0 - 3.5		X										Tv
TH19-05	G34	4.0 - 4.5		X										

REQUESTED BY: Jashan Bhullar

REPORT TO: MVH

REQUISITION DATE: Sept-12-2019

DATE REQUIRED:

COMMENTS:

REQUISITION NO. R19-199

PAGE 1 OF 5

TREK GEOTECHNICAL

LABORATORY REQUISITION

CLIENT Morrison Hershfield

PROJECT NAME Sherwin Road Bridge Over Omands Creek

PROJECT NO: 0035-079-00

FIELD TECHNICIAN: Jashan Bhullar

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE (ft)	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS					Soil Description/Comments
TH19-05	G35	5.0 - 5.5		X											Tv
TH19-05	G36	6.0 - 6.5		X											Tv
TH19-05	G37	8.0 - 8.5		X											Tv
TH19-05	G38	9.5 - 10.0		X											Tv
TH19-06	G70	1.0 - 1.5		X											Tv
TH19-06	G71	2.0 - 2.5		X											Tv
TH19-06	G72	3.0 - 3.5		X											Tv
TH19-06	G73	4.0 - 4.5		X											Tv
TH19-06	G74	5.0 - 5.5		X											Pp, Tv
TH19-06	G75	6.0 - 6.5		X											Pp, Tv
TH19-06	G76	9.5 - 10.0		X											Pp, Tv
TH19-07	G24	1.0 - 1.5		X											Pp, Tv
TH19-07	G25	2.0 - 2.5		X											Pp, Tv
TH19-07	G26	3.0 - 3.5		X											Tv
TH19-07	G27	4.0 - 4.5		X											Tv
TH19-07	G28	5.0 - 5.5		X											
TH19-07	G29	6.0 - 6.5		X											
TH19-07	G30	9.5 - 10.0		X											Tv
TH19-08	G77	1.0 - 1.5		X											Tv
TH19-08	G78	2.0 - 2.5		X											
TH19-08	G79	3.0 - 3.5		X											
TH19-08	G80	4.0 - 4.5		X											
TH19-08	G81	5.0 - 5.5		X											
TH19-08	G82	6.0 - 6.5		X											Tv
TH19-08	G83	9.5 - 10.0		X											
TH19-09	G16	1.0 - 1.5		X											Tv
TH19-09	G17	2.0 - 2.5		X											Tv
TH19-09	G18	3.0 - 3.5		X											Tv
TH19-09	G19	4.0 - 4.5		X											Tv
TH19-09	G20	5.0 - 5.5		X											Tv
TH19-09	G21	6.0 - 6.5		X											Tv
TH19-09	G22	8.0 - 8.5		X											Tv
TH19-09	G23	9.5 - 10.0		X											Tv
TH19-10	G91	1.0 - 1.5		X											Tv
TH19-10	G92	2.0 - 2.5		X											

REQUESTED BY: Jashan Bhullar

REQUISITION DATE: Sept-12-2019

COMMENTS:

REPORT TO:

DATE REQUIRED:

REQUISITION NO.

TREK GEOTECHNICAL

LABORATORY REQUISITION

CLIENT Morrison Hershfield
PROJECT NO: 0035-079-00
PROJECT NAME Sherwin Road Bridge Over Omands Creek
FIELD TECHNICIAN: Jashan Bhullar

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE (ft)	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS					Soil Description/Comments
TH19-10	G93	3.0 - 3.5		X											
TH19-10	G94	4.0 - 4.5		X											Tv
TH19-10	G95	5.0 - 5.5		X											Tv
TH19-10	G96	6.0 - 6.5		X											
TH19-10	G97	9.5 - 10.0		X											Tv
TH19-11	G09	1.0 - 1.5		X											Tv
TH19-11	G10	2.3 - 3.0		X											
TH19-11	G11	3.5 - 4.0		X											Tv
TH19-11	G12	4.5 - 5.0		X											Tv
TH19-11	G13	5.5 - 6.0		X											Tv
TH19-11	G14	6.5 - 7.0		X											
TH19-11	G15	9.5 - 10.0		X											
TH19-12	G84	1.0 - 1.5		X											Tv
TH19-12	G85	2.0 - 2.5		X											
TH19-12	G86	3.0 - 3.5		X		X	X								Tv/Silt [redacted]
TH19-12	G87	4.0 - 4.5		X											Tv
TH19-12	G88	5.0 - 5.5		X											
TH19-12	G89	6.0 - 6.5		X											
TH19-12	G90	9.5 - 10.0		X											Tv
TH19-13	G01	1.0 - 1.6		X											
TH19-13	G02	2.0 - 2.6		X		X	X								Organic Clay.
TH19-13	G03	3.0 - 3.6		X											Tv . Pp }
TH19-13	G04	4.0 - 4.5		X											Tv , Pp } [redacted] Too Sgt.
TH19-13	G05	5.0 - 5.5		X											Tv }
TH19-13	G06	6.0 - 6.5		X											
TH19-13	G07	8.0 - 8.5		X											[redacted]
TH19-13	G08	9.5 - 10.0		X											
TH19-14 B	G131	1.0 - 1.5		X											
TH19-14 B	G132	2.0 - 2.5		X											
TH19-14 B	G133	3.0 - 3.5		X											
TH19-14 B	G134	4.0 - 4.5		X											
TH19-14 B	T135	5.0 - 7.0		\						X					
TH19-14 B	G136	7.0 - 7.5		X											
TH19-14 B	G137	9.0 - 9.5		X											
TH19-14 B	G138	9.5 - 10.0		X											

REQUESTED BY: Jashan Bhullar
REPORT TO:
REQUISITION DATE: Sept-12-19
DATE REQUIRED:
COMMENTS:

REQUISITION NO.

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* TH19-14 A done only for Standpipe installation.
No Samples grabed.

TREK LABORATORY REQUISITION LOGS 2019-09-09 SHERWIN ROAD BRIDGE OVER OMANDS CREEK 0_A_JSB 0035-079-00.GPJ TREK GEOTECHNICAL.GDT 12/9/19

TREK GEOTECHNICAL

LABORATORY REQUISITION

CLIENT Morrison Hershfield
PROJECT NO: 0035-079-00
PROJECT NAME Sherwin Road Bridge Over Omands Creek
FIELD TECHNICIAN: Jashan Bhullar

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE (ft)	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILLARY TESTS					Soil Description/Comments
TH19-14 B	G139	12.5 - 13.0		X											
TH19-14 B	T140	15.0 - 17.0		\						X					
TH19-14 B	G141	17.0 - 17.5		X			X								
TH19-14 B	G142	19.0 - 19.5		X											
TH19-14 B	SS143	20.0 - 21.5		X											
TH19-14 B	G144	22.0 - 22.5		X											
TH19-14 B	G145	24.0 - 24.5		X											
TH19-14 B	G146	27.0 - 27.5		X											
TH19-14 B	SS147	30.0 - 30.6		X											
TH19-14 B	G148	35.0 - 35.5		X											
TH19-14 B	SS149	40.0 - 40.9		X											
TH19-14 B	C150	43.9 - 45.6													
TH19-14 B	SS151	50.6 - 52.0		X											
TH19-14 B	SS152	60.6 - 61.5		X											
TH19-14 B	C153	63.0 - 63.5													
TH19-14 B	C154	63.5 - 68.3													
TH19-14 B	C155	68.3 - 73.5													
TH19-14 B	C156	73.5 - 78.5													
TH19-14 B	C157	78.5 - 83.6													
TH19-15	G98	0.7 - 1.0		X											
TH19-15	G99	1.0 - 1.5		X											
TH19-15	G100	2.0 - 2.5		X											
TH19-15	G101	3.0 - 3.5		X											Tv
TH19-15	G102	4.0 - 4.5		X											Tv
TH19-15	G103	5.0 - 5.5		X		X									
TH19-15	G104	6.0 - 6.5		X											
TH19-15	G105	9.0 - 9.5		X											
TH19-15	T106	10.0 - 12.0		\						X					
TH19-15	G107	12.0 - 12.5		X		X	X								
TH19-15	G108	14.0 - 14.5		X		X									
TH19-15	SS109	15.0 - 16.8		X											
TH19-15	G110	19.0 - 19.5		X											Tv
TH19-15	SS111	20.0 - 21.3		X											
TH19-15	G112	24.0 - 24.5		X			X								Tv/PP
TH19-15	SS113	25.0 - 25.9		X											

REQUESTED BY: Jashan Bhullar
REPORT TO:
REQUISITION DATE: Sept-12-19
DATE REQUIRED:
COMMENTS:

REQUISITION NO.

TREK GEOTECHNICAL

LABORATORY REQUISITION

CLIENT Morrison Hershfield
PROJECT NO: 0035-079-00
PROJECT NAME Sherwin Road Bridge Over Omands Creek
FIELD TECHNICIAN: Jashan Bhullar

TEST HOLE NUMBER	SAMPLE NUMBER	DEPTH OF SAMPLE (ft)	TARE NUMBER (LAB USE ONLY)	MOISTURE	VISUAL CLASS.	ATTERBERG LIMITS	HYDROMETER	GRADATION	STD. PROCTOR	UNCONFINED AND AUXILARY TESTS					Soil Description/Comments
TH19-15	G114	29.0 - 29.5		X											Tv
TH19-15	SS115	30.0 - 31.2		X											
TH19-15	G116	34.0 - 34.5		X											
TH19-15	SS117	35.0 - 36.3		X											
TH19-15	G118	39.0 - 39.5		X											
TH19-15	SS119	40.0 - 41.1		X											
TH19-15	G120	44.0 - 44.5		X											Tv
TH19-15	SS121	45.0 - 46.2		X											
TH19-15	G122	49.0 - 49.5		X											Tv
TH19-15	SS123	50.0 - 50.9		X											
TH19-15	G124	54.0 - 55.0		X			X								Tv
TH19-15	SS125	55.0 - 55.9		X											
TH19-15	G126	59.0 - 60.0		X											
TH19-15	SS127	60.0 - 60.6		X											
TH19-15	C128	60.0 - 60.6													
TH19-15	SS129	65.0 - 66.0		X											
TH19-15	C130	66.0 - 67.0													

REQUESTED BY: Jashan Bhullar
REPORT TO:
REQUISITION DATE: Sept 12, 19
DATE REQUIRED:
COMMENTS:

REQUISITION NO.

PAGE 5 OF 5

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1712 St. James Street
Winnipeg, MB R3H 0L3
Tel: 204.975.9433 Fax: 204.975.9435

Moisture Content Report
ASTM D2216-10

Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Sample Date 05-Sep-19
Test Date 13-Sep-19
Technician AD

Test Hole	TH19-01	TH19-01	TH19-01	TH19-01	TH19-01	TH19-01
Depth (m)	0.3 - 0.5	0.6 - 0.8	0.9 - 1.1	1.2 - 1.3	1.3 - 1.4	1.5 - 1.7
Sample #	G47	G48	G49	G50	G51	G52
Tare ID	H38	F131	H61	N74	Z80	AB35
Mass of tare	8.4	8.4	8.4	8.6	8.6	6.9
Mass wet + tare	265.2	189.6	228.2	214.2	202.4	176.2
Mass dry + tare	219.6	148.2	172.8	155.8	147.6	127.2
Mass water	45.6	41.4	55.4	58.4	54.8	49.0
Mass dry soil	211.2	139.8	164.4	147.2	139.0	120.3
Moisture %	21.6%	29.6%	33.7%	39.7%	39.4%	40.7%

Test Hole	TH19-01	TH19-01	TH19-02	TH19-02	TH19-02	TH19-02
Depth (m)	1.8 - 2.0	2.9 - 3.0	0.3 - 0.5	0.6 - 0.8	0.9 - 1.1	1.2 - 1.4
Sample #	G53	G54	G55	G56	G57	G58
Tare ID	F103	E110	Z57	F150	A30	D56
Mass of tare	8.8	8.6	8.6	8.2	8.2	8.8
Mass wet + tare	207.8	193.4	191.2	179.8	452.2	182.8
Mass dry + tare	146.8	128.0	149.2	132.8	330.2	136.2
Mass water	61.0	65.4	42.0	47.0	122.0	46.6
Mass dry soil	138.0	119.4	140.6	124.6	322.0	127.4
Moisture %	44.2%	54.8%	29.9%	37.7%	37.9%	36.6%

Test Hole	TH19-02	TH19-02	TH19-02	TH19-03	TH19-03	TH19-03
Depth (m)	1.5 - 1.7	1.8 - 2.0	2.9 - 3.0	0.3 - 0.5	0.6 - 0.8	0.9 - 1.1
Sample #	G59	G60	G61	G39	G40	G41
Tare ID	P30	W02	F63	Z90	K19	E133
Mass of tare	8.6	8.4	8.6	8.4	8.4	8.4
Mass wet + tare	214.0	177.0	182.4	205.8	217.6	271.6
Mass dry + tare	153.0	129.4	125.4	173.0	180.0	202.8
Mass water	61.0	47.6	57.0	32.8	37.6	68.8
Mass dry soil	144.4	121.0	116.8	164.6	171.6	194.4
Moisture %	42.2%	39.3%	48.8%	19.9%	21.9%	35.4%

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Moisture Content Report
ASTM D2216-10

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Sample Date	05-Sep-19
Test Date	13-Sep-19
Technician	AD

Test Hole	TH19-03	TH19-03	TH19-03	TH19-03	TH19-03	TH19-04
Depth (m)	1.2 - 1.4	1.5 - 1.7	1.8 - 2.0	2.4 - 2.6	2.9 - 3.0	0.3 - 0.5
Sample #	G42	G43	G44	G45	G46	G62
Tare ID	F73	D9	E36	C27	AB32	H31
Mass of tare	8.6	8.6	8.4	8.4	6.8	8.6
Mass wet + tare	233.2	166.0	222.6	165.0	123.0	247.4
Mass dry + tare	193.4	137.2	180.0	116.2	83.4	207.8
Mass water	39.8	28.8	42.6	48.8	39.6	39.6
Mass dry soil	184.8	128.6	171.6	107.8	76.6	199.2
Moisture %	21.5%	22.4%	24.8%	45.3%	51.7%	19.9%

Test Hole	TH19-04	TH19-04	TH19-04	TH19-04	TH19-04	TH19-04
Depth (m)	0.6 - 0.8	0.9 - 1.1	1.2 - 1.4	1.5 - 1.7	1.8 - 2.0	2.4 - 2.6
Sample #	G63	G64	G65	G66	G67	G68
Tare ID	W28	AA07	N45	W65	P33	AA20
Mass of tare	8.6	6.6	8.6	8.4	8.6	6.6
Mass wet + tare	279.4	228.2	166.6	216.8	185.0	166.4
Mass dry + tare	225.0	177.0	125.8	167.2	142.4	110.6
Mass water	54.4	51.2	40.8	49.6	42.6	55.8
Mass dry soil	216.4	170.4	117.2	158.8	133.8	104.0
Moisture %	25.1%	30.0%	34.8%	31.2%	31.8%	53.7%

Test Hole	TH19-04	TH19-05	TH19-05	TH19-05	TH19-05	TH19-05
Depth (m)	3.2 - 3.4	0.3 - 0.5	0.6 - 0.8	0.9 - 1.1	1.2 - 1.4	1.5 - 1.7
Sample #	G69	G31	G32	G33	G34	G35
Tare ID	AB06	F41	N12	W23	E109	AB03
Mass of tare	7.0	8.4	8.6	8.6	8.4	6.8
Mass wet + tare	163.6	212.8	248.4	212.4	157.0	174.0
Mass dry + tare	113.8	167.2	194.2	160.2	121.4	126.4
Mass water	49.8	45.6	54.2	52.2	35.6	47.6
Mass dry soil	106.8	158.8	185.6	151.6	113.0	119.6
Moisture %	46.6%	28.7%	29.2%	34.4%	31.5%	39.8%

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Moisture Content Report
ASTM D2216-10

Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Sample Date 05-Sep-19
Test Date 13-Sep-19
Technician AD

Test Hole	TH19-05	TH19-05	TH19-05	TH19-06	TH19-06	TH19-06
Depth (m)	1.8 - 2.0	2.4 - 2.6	2.9 - 3.0	0.3 - 0.5	0.6 - 0.8	0.9 - 1.1
Sample #	G36	G37	G38	G70	G71	G72
Tare ID	H70	E85	N48	N79	F154	E25
Mass of tare	8.8	8.4	8.6	8.6	8.6	8.8
Mass wet + tare	209.0	204.4	152.2	162.4	188.6	182.6
Mass dry + tare	154.0	152.8	111.8	131.6	146.4	138.4
Mass water	55.0	51.6	40.4	30.8	42.2	44.2
Mass dry soil	145.2	144.4	103.2	123.0	137.8	129.6
Moisture %	37.9%	35.7%	39.1%	25.0%	30.6%	34.1%

Test Hole	TH19-06	TH19-06	TH19-06	TH19-06	TH19-07	TH19-07
Depth (m)	1.2 - 1.4	1.5 - 1.7	1.8 - 2.0	2.9 - 3.0	0.3 - 0.5	0.6 - 0.8
Sample #	G73	G74	G75	G76	G24	G25
Tare ID	F148	W07	D18	F109	AB20	W25
Mass of tare	8.4	8.6	8.6	8.8	7.0	8.4
Mass wet + tare	168.8	228.0	235.2	187.4	163.8	201.6
Mass dry + tare	131.8	178.4	188.8	128.8	128.8	152.8
Mass water	37.0	49.6	46.4	58.6	35.0	48.8
Mass dry soil	123.4	169.8	180.2	120.0	121.8	144.4
Moisture %	30.0%	29.2%	25.7%	48.8%	28.7%	33.8%

Test Hole	TH19-07	TH19-07	TH19-07	TH19-07	TH19-07	TH19-08
Depth (m)	0.9 - 1.1	1.2 - 1.4	1.5 - 1.7	1.8 - 2.0	2.9 - 3.0	0.3 - 0.5
Sample #	G26	G27	G28	G29	G30	G77
Tare ID	AC02	AB30	E61	K9	H65	Z12
Mass of tare	6.6	6.8	8.6	8.6	8.6	8.6
Mass wet + tare	196.0	235.0	198.6	175.4	178.2	195.0
Mass dry + tare	148.2	173.0	146.8	122.0	123.8	147.8
Mass water	47.8	62.0	51.8	53.4	54.4	47.2
Mass dry soil	141.6	166.2	138.2	113.4	115.2	139.2
Moisture %	33.8%	37.3%	37.5%	47.1%	47.2%	33.9%

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Moisture Content Report
ASTM D2216-10

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Sample Date	05-Sep-19
Test Date	13-Sep-19
Technician	AD

Test Hole	TH19-08	TH19-08	TH19-08	TH19-08	TH19-08	TH19-08
Depth (m)	0.6 - 0.8	0.9 - 1.1	1.2 - 1.4	1.5 - 1.7	1.8 - 2.0	2.9 - 3.0
Sample #	G78	G79	G80	G81	G82	G83
Tare ID	K28	K2	AC04	F77	F112	H44
Mass of tare	8.6	8.4	7	8.6	8.2	8.4
Mass wet + tare	158.6	182.2	190.2	158.6	188.2	162.6
Mass dry + tare	118.2	134.8	139.0	115.0	132.6	109.4
Mass water	40.4	47.4	51.2	43.6	55.6	53.2
Mass dry soil	109.6	126.4	132.0	106.4	124.4	101.0
Moisture %	36.9%	37.5%	38.8%	41.0%	44.7%	52.7%

Test Hole	TH19-09	TH19-09	TH19-09	TH19-09	TH19-09	TH19-09
Depth (m)	0.3 - 0.5	0.6 - 0.8	0.9 - 1.1	1.2 - 1.4	1.5 - 1.7	1.8 - 2.0
Sample #	G16	G17	G18	G19	G20	G21
Tare ID	H34	D17	K35	W32	AB27	GH57
Mass of tare	8.8	8.6	8.4	8.4	6.6	8.6
Mass wet + tare	231.6	161.0	222.4	139.6	167.6	189.8
Mass dry + tare	178.0	123.6	166.8	101.2	116.6	125.6
Mass water	53.6	37.4	55.6	38.4	51.0	64.2
Mass dry soil	169.2	115.0	158.4	92.8	110.0	117.0
Moisture %	31.7%	32.5%	35.1%	41.4%	46.4%	54.9%

Test Hole	TH19-09	TH19-09	TH19-10	TH19-10	TH19-10	TH19-10
Depth (m)	2.4 - 2.6	2.9 - 3.0	0.3 - 0.5	0.6 - 0.8	0.9 - 1.1	1.2 - 1.4
Sample #	G22	G23	G91	G92	G93	G94
Tare ID	H46	N07	D30	N53	F99	A100
Mass of tare	8.6	8.6	8.2	8.2	8.4	8.4
Mass wet + tare	196.8	177.0	188.6	155.2	164.8	158.6
Mass dry + tare	132.0	121.6	141.4	116.4	124.2	116.8
Mass water	64.8	55.4	47.2	38.8	40.6	41.8
Mass dry soil	123.4	113.0	133.2	108.2	115.8	108.4
Moisture %	52.5%	49.0%	35.4%	35.9%	35.1%	38.6%

Moisture Content Report
ASTM D2216-10

Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

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Technician AD

Test Hole	TH19-10	TH19-10	TH19-10	TH19-11	TH19-11	TH19-11
Depth (m)	1.5 - 1.7	1.8 - 2.0	2.9 - 3.0	0.3 - 0.5	0.7 - 0.9	1.1 - 1.2
Sample #	G95	G96	G97	G09	G10	G11
Tare ID	E80	Z114	H50	F13	F127	Z78
Mass of tare	8.4	8.6	8.6	8.8	8.4	9
Mass wet + tare	215.6	163.6	170.8	209.6	185.8	182.4
Mass dry + tare	153.8	114.6	122.6	160.8	135.8	134.0
Mass water	61.8	49.0	48.2	48.8	50.0	48.4
Mass dry soil	145.4	106.0	114.0	152.0	127.4	125.0
Moisture %	42.5%	46.2%	42.3%	32.1%	39.2%	38.7%

Test Hole	TH19-11	TH19-11	TH19-11	TH19-11	TH19-12	TH19-12
Depth (m)	1.4 - 1.5	1.7 - 1.8	2.0 - 2.1	2.9 - 3.0	0.3 - 0.5	0.6 - 0.8
Sample #	G12	G13	G14	G15	G84	G85
Tare ID	H17	Z61	D48	Z91	W87	AB98
Mass of tare	8.4	10	8.8	8.6	9	7
Mass wet + tare	200.6	194.4	200.6	207.2	205.6	199.6
Mass dry + tare	147.4	134.0	135.2	151.0	157.4	153.8
Mass water	53.2	60.4	65.4	56.2	48.2	45.8
Mass dry soil	139.0	124.0	126.4	142.4	148.4	146.8
Moisture %	38.3%	48.7%	51.7%	39.5%	32.5%	31.2%

Test Hole	TH19-12	TH19-12	TH19-12	TH19-12	TH19-12	TH19-13
Depth (m)	0.9 - 1.1	1.2 - 1.4	1.5 - 1.7	1.8 - 2.0	2.9 - 3.0	0.3 - 0.5
Sample #	G86	G87	G88	G89	G90	G01
Tare ID	E40	Z31	AA18	E34	Z33	E24
Mass of tare	8.6	8.4	6.8	8.4	8.6	8.6
Mass wet + tare	478.8	196.6	167.0	155.0	146.6	159.8
Mass dry + tare	349.4	144.4	122.2	114.0	99.6	118.6
Mass water	129.4	52.2	44.8	41.0	47.0	41.2
Mass dry soil	340.8	136.0	115.4	105.6	91.0	110.0
Moisture %	38.0%	38.4%	38.8%	38.8%	51.6%	37.5%

Moisture Content Report
ASTM D2216-10

Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Sample Date 05-Sep-19
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Technician AD

Test Hole	TH19-13	TH19-13	TH19-13	TH19-13	TH19-13	TH19-13
Depth (m)	0.6 - 0.8	0.9 - 1.1	1.2 - 1.4	1.5 - 1.7	1.8 - 2.0	2.4 - 2.6
Sample #	G02	G03	G04	G05	G06	G07
Tare ID	W57	AB74	AB67	AB56	W39	D1
Mass of tare	8.8	6.8	7.2	6.8	8.4	8.4
Mass wet + tare	456.6	251.6	234.2	232.4	215.2	194.6
Mass dry + tare	337.0	206.6	191.6	188.6	157.6	131.4
Mass water	119.6	45.0	42.6	43.8	57.6	63.2
Mass dry soil	328.2	199.8	184.4	181.8	149.2	123.0
Moisture %	36.4%	22.5%	23.1%	24.1%	38.6%	51.4%

Test Hole	TH19-13	TH19-14	TH19-14	TH19-14	TH19-14	TH19-14
Depth (m)	2.9 - 3.0	0.3 - 0.5	0.6 - 0.8	0.9 - 1.1	1.2 - 1.4	2.1 - 2.3
Sample #	G08	G131	G132	G133	G134	G136
Tare ID	AB42	A20	A615	Z89	W98	F87
Mass of tare	8.4	6.8	8.8	7	8.4	8.6
Mass wet + tare	164.8	177.4	248.9	220.6	217.6	178.6
Mass dry + tare	110.8	136.6	200.6	170.6	183.8	131.4
Mass water	54.0	40.8	48.3	50.0	33.8	47.2
Mass dry soil	102.4	129.8	191.8	163.6	175.4	122.8
Moisture %	52.7%	31.4%	25.2%	30.6%	19.3%	38.4%

Test Hole	TH19-14	TH19-14	TH19-14	TH19-14	TH19-14	TH19-14
Depth (m)	2.7 - 2.9	2.9 - 3.0	3.8 - 4.0	5.2 - 5.3	5.8 - 5.9	6.1 - 6.6
Sample #	G137	G138	G139	G141	G142	SS143
Tare ID	W88	H66	P36	AB68	D2	D5
Mass of tare	8.6	8.4	8.4	8.4	6.6	8.4
Mass wet + tare	226.6	286	197.4	487.6	280.2	247.6
Mass dry + tare	168.9	238.4	153	418.2	253	229.2
Mass water	57.7	47.6	44.4	69.4	27.2	18.4
Mass dry soil	160.3	230.0	144.6	409.8	246.4	220.8
Moisture %	36.0%	20.7%	30.7%	16.9%	11.0%	8.3%

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Moisture Content Report
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Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Sample Date 05-Sep-19
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Technician AD

Test Hole	TH19-14	TH19-14	TH19-14	TH19-14	TH19-14	TH19-14
Depth (m)	6.7 - 6.9	7.3 - 7.5	8.2 - 8.4	9.1 - 9.3	10.7 - 10.8	12.2 - 12.5
Sample #	G144	G145	G146	SS147	G148	SS149
Tare ID	D5	H47	N68	F69	H55	W48
Mass of tare	8.2	8.3	8.5	8.5	8.4	8
Mass wet + tare	233.7	211.4	198.9	174.5	187.7	171
Mass dry + tare	207.0	189.6	178.8	162.2	168.0	160.6
Mass water	26.7	21.8	20.1	12.3	19.7	10.4
Mass dry soil	198.8	181.3	170.3	153.7	159.6	152.6
Moisture %	13.4%	12.0%	11.8%	8.0%	12.3%	6.8%

Test Hole	TH19-14	TH19-14	TH19-15	TH19-15	TH19-15	TH19-15
Depth (m)	15.4 - 15.8	18.5 - 18.7	0.2 - 0.3	0.3 - 0.5	0.6 - 0.8	0.9 - 1.1
Sample #	SS151	SS152	G98	G99	G100	G101
Tare ID	AA17	W77	P09	Z63	W105	E79
Mass of tare	6.6	8.4	8.4	8.5	8.4	8.4
Mass wet + tare	196.6	165.7	175.9	198.8	182.8	259.2
Mass dry + tare	184.2	153.4	158.2	160.6	143.6	214.8
Mass water	12.4	12.3	17.7	38.2	39.2	44.4
Mass dry soil	177.6	145.0	149.8	152.1	135.2	206.4
Moisture %	7.0%	8.5%	11.8%	25.1%	29.0%	21.5%

Test Hole	TH19-15	TH19-15	TH19-15	TH19-15	TH19-15	TH19-15
Depth (m)	1.2 - 1.4	1.5 - 1.7	1.8 - 2.0	2.7 - 2.9	3.7 - 3.8	4.3 - 4.4
Sample #	G102	G103	G104	G105	G107	G108
Tare ID	Z140	AA21	F451	E59	AA22	E44
Mass of tare	8.8	6.7	8.2	8.5	7.2	8.7
Mass wet + tare	180.3	359.4	188.9	207.4	479.6	330.8
Mass dry + tare	137.6	265	137.4	175	421	288
Mass water	42.7	94.4	51.5	32.4	58.6	42.8
Mass dry soil	128.8	258.3	129.2	166.5	413.8	279.3
Moisture %	33.2%	36.5%	39.9%	19.5%	14.2%	15.3%

Moisture Content Report
ASTM D2216-10

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek

Sample Date	05-Sep-19
Test Date	13-Sep-19
Technician	AD

Test Hole	TH19-15	TH19-15	TH19-15	TH19-15	TH19-15	TH19-15
Depth (m)	4.6 - 5.1	5.8 - 5.9	6.1 - 6.5	7.3 - 7.5	7.6 - 7.9	8.8 - 9.0
Sample #	SS109	G110	SS111	G112	SS113	G114
Tare ID	E1	P22	K37	Z09	D38	AB78
Mass of tare	8.4	8.6	8.6	8.3	8.5	6.7
Mass wet + tare	187.4	252.4	189.3	194.8	175	254.6
Mass dry + tare	170.4	228.6	173.4	177.8	164.2	229
Mass water	17.0	23.8	15.9	17.0	10.8	25.6
Mass dry soil	162.0	220.0	164.8	169.5	155.7	222.3
Moisture %	10.5%	10.8%	9.6%	10.0%	6.9%	11.5%

Test Hole	TH19-15	TH19-15	TH19-15	TH19-15	TH19-15	TH19-15
Depth (m)	9.1 - 9.5	10.4 - 10.5	10.7 - 11.1	11.9 - 12.0	12.2 - 12.5	13.4 - 13.6
Sample #	SS115	G116	G117	G118	SS119	G120
Tare ID	B31	N112	AC38	Z101	F7	Z36
Mass of tare	8.6	8.4	6.8	8.8	8.5	8.6
Mass wet + tare	226	333.5	322.4	278.3	253.8	282.8
Mass dry + tare	209.4	306.8	296.2	255.4	236.2	258.4
Mass water	16.6	26.7	26.2	22.9	17.6	24.4
Mass dry soil	200.8	298.4	289.4	246.6	227.7	249.8
Moisture %	8.3%	8.9%	9.1%	9.3%	7.7%	9.8%

Test Hole	TH19-15	TH19-15	TH19-15	TH19-15	TH19-15	TH19-15
Depth (m)	0.5 - 14.1	14.9 - 15.1	15.2 - 15.5	16.5 - 16.8	16.8 - 17.0	18.0 - 18.3
Sample #	SS121	G122	G123	G124	SS125	G126
Tare ID	K20	P36	W67	W102	N111	Z01
Mass of tare	8.6	8.6	8.1	8.2	8.7	8.5
Mass wet + tare	200.2	214.2	228.5	638.7	364.8	428.4
Mass dry + tare	189	198	211.9	570.6	335.8	383.8
Mass water	11.2	16.2	16.6	68.1	29.0	44.6
Mass dry soil	180.4	189.4	203.8	562.4	327.1	375.3
Moisture %	6.2%	8.6%	8.1%	12.1%	8.9%	11.9%

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Moisture Content Report
ASTM D2216-10

Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Sample Date 05-Sep-19
Test Date 13-Sep-19
Technician AD

Test Hole	TH19-15	TH19-15				
Depth (m)	18.3 - 18.5	19.8 - 20.1				
Sample #	SS127	SS129				
Tare ID	AB17	D28				
Mass of tare	6.7	8.5				
Mass wet + tare	293.6	212.4				
Mass dry + tare	271.6	187				
Mass water	22.0	25.4				
Mass dry soil	264.9	178.5				
Moisture %	8.3%	14.2%				

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Grain Size Analysis (Hydrometer Method)
ASTM D422

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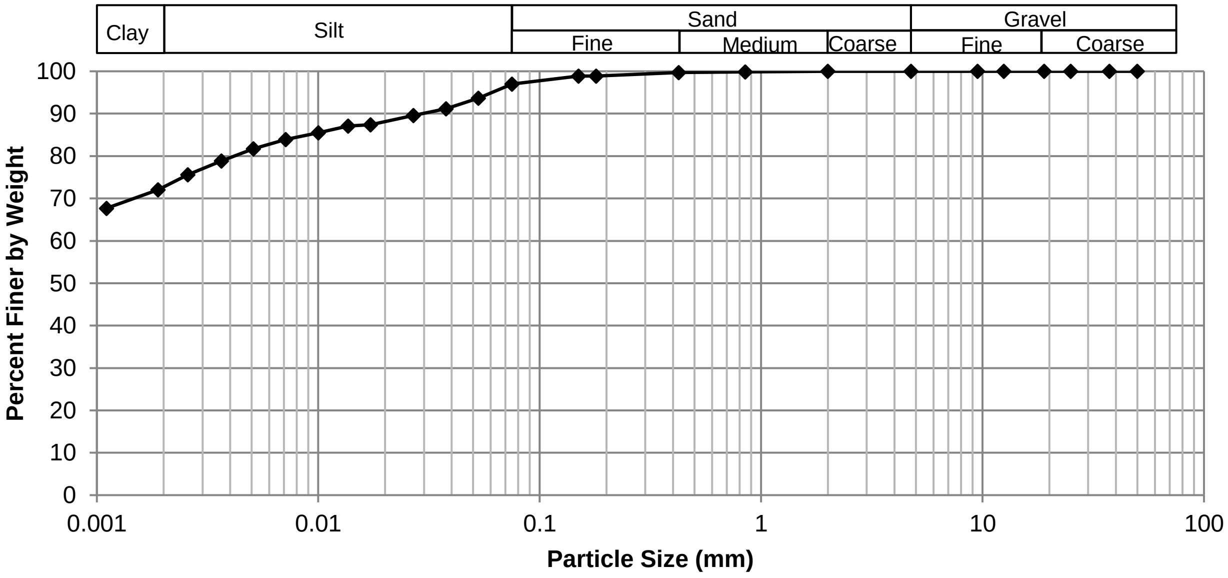
For specific tests as listed on www.ccil.com

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-13
Sample #	G02
Depth (m)	0.6 - 0.8
Sample Date	5-Sep-19
Test Date	17-Sep-19
Technician	NM

Gravel	0.0%
Sand	3.0%
Silt	24.3%
Clay	72.7%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	100.00	0.0750	97.02
37.5	100.00	2.00	100.00	0.0528	93.64
25.0	100.00	0.850	99.86	0.0378	91.14
19.0	100.00	0.425	99.72	0.0270	89.58
12.5	100.00	0.180	98.87	0.0172	87.39
9.50	100.00	0.150	98.84	0.0136	87.07
4.75	100.00	0.075	97.02	0.0100	85.51
				0.0071	83.95
				0.0051	81.76
				0.0037	78.88
				0.0026	75.62
				0.0019	72.05
				0.0011	67.69

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Grain Size Analysis (Hydrometer Method)
ASTM D422

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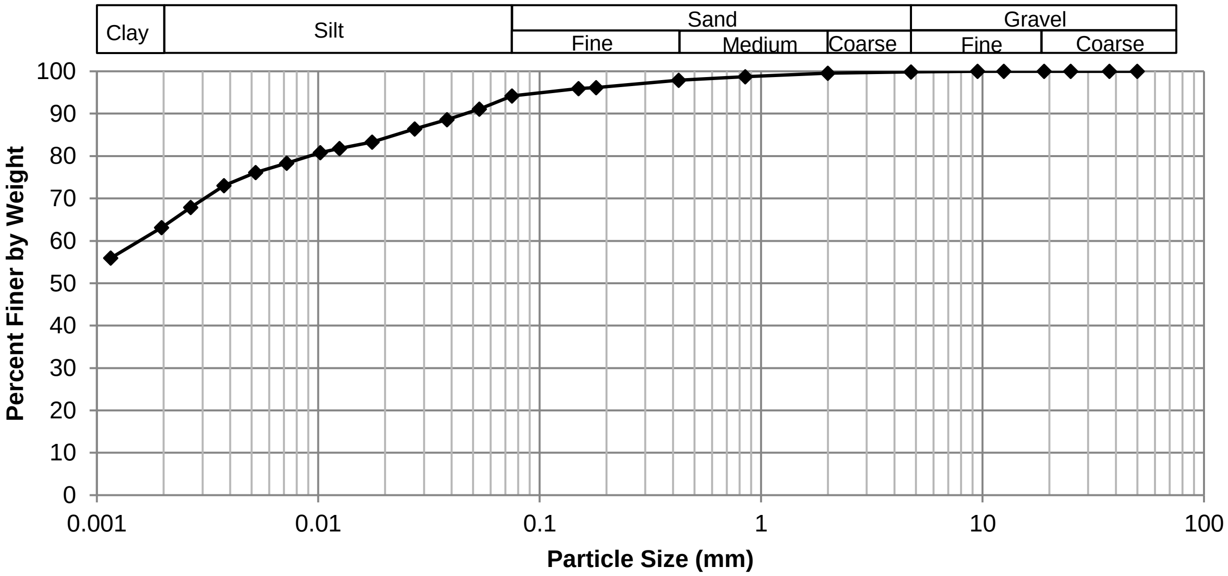
Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Test Hole TH19-02
Sample # G57
Depth (m) 0.9 - 1.1
Sample Date 5-Sep-19
Test Date 17-Sep-19
Technician NM

Gravel	0.1%
Sand	5.7%
Silt	30.7%
Clay	63.5%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	99.85	0.0750	94.19
37.5	100.00	2.00	99.55	0.0534	91.11
25.0	100.00	0.850	98.73	0.0382	88.62
19.0	100.00	0.425	97.91	0.0273	86.44
12.5	100.00	0.180	96.18	0.0175	83.33
9.50	100.00	0.150	95.96	0.0125	81.77
4.75	99.85	0.075	94.19	0.0102	80.84
				0.0072	78.35
				0.0052	76.17
				0.0037	73.00
				0.0027	67.91
				0.0020	63.14
				0.0012	55.94

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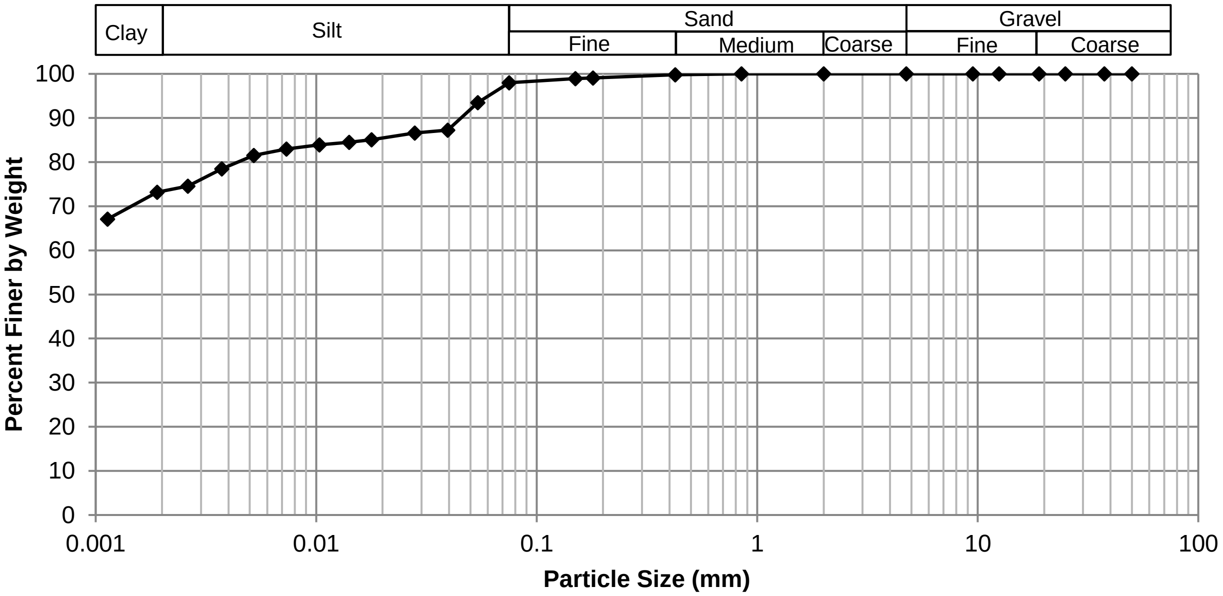
Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-08
Sample #	G79
Depth (m)	0.9 - 1.1
Sample Date	30-Sep-19
Test Date	2-Oct-19
Technician	KG

Gravel	0.0%
Sand	2.0%
Silt	24.7%
Clay	73.3%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	100.00	0.0750	98.00
37.5	100.00	2.00	100.00	0.0541	93.50
25.0	100.00	0.850	100.00	0.0394	87.25
19.0	100.00	0.425	99.78	0.0280	86.62
12.5	100.00	0.180	99.06	0.0178	85.06
9.50	100.00	0.150	98.96	0.0141	84.51
4.75	100.00	0.075	98.00	0.0103	83.88
				0.0073	82.95
				0.0052	81.53
				0.0037	78.48
				0.0026	74.56
				0.0019	73.15
				0.0011	67.08

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

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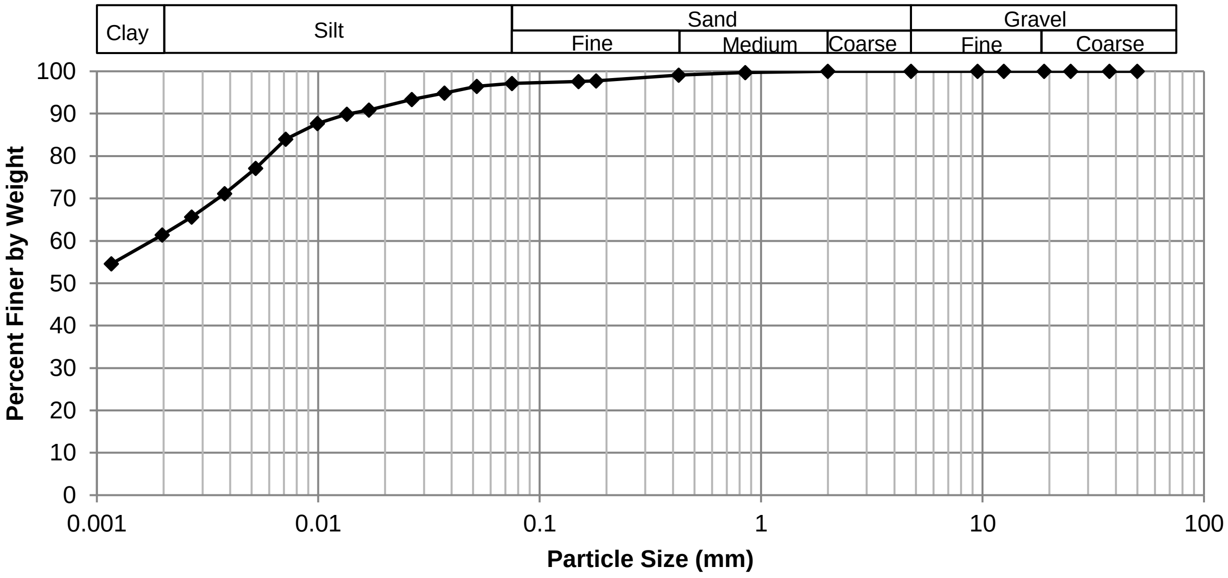
Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-12
Sample #	G86
Depth (m)	0.9 - 1.1
Sample Date	5-Sep-19
Test Date	17-Sep-19
Technician	NM

Gravel	0.0%
Sand	2.9%
Silt	35.5%
Clay	61.6%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	100.00	0.0750	97.11
37.5	100.00	2.00	100.00	0.0521	96.46
25.0	100.00	0.850	99.71	0.0371	94.90
19.0	100.00	0.425	99.10	0.0265	93.34
12.5	100.00	0.180	97.74	0.0169	90.84
9.50	100.00	0.150	97.62	0.0135	89.90
4.75	100.00	0.075	97.11	0.0099	87.71
				0.0071	83.96
				0.0052	77.08
				0.0038	71.14
				0.0027	65.63
				0.0020	61.43
				0.0012	54.57

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

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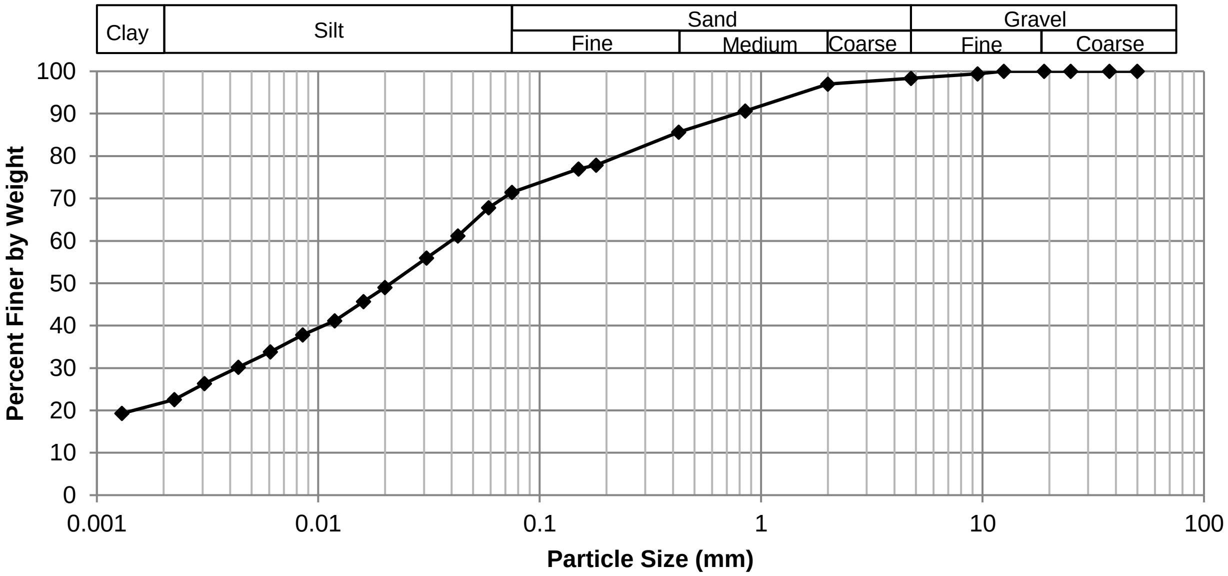
Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-15
Sample #	G107
Depth (m)	3.7 - 3.8
Sample Date	5-Sep-19
Test Date	17-Sep-19
Technician	AD

Gravel	1.6%
Sand	26.9%
Silt	49.7%
Clay	21.7%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	98.37	0.0750	71.44
37.5	100.00	2.00	97.02	0.0588	67.82
25.0	100.00	0.850	90.61	0.0428	61.15
19.0	100.00	0.425	85.65	0.0308	55.99
12.5	100.00	0.180	77.88	0.0200	49.01
9.50	99.43	0.150	76.95	0.0160	45.68
4.75	98.37	0.075	71.44	0.0119	41.13
				0.0085	37.79
				0.0061	33.85
				0.0044	30.21
				0.0031	26.35
				0.0022	22.57
				0.0013	19.28

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

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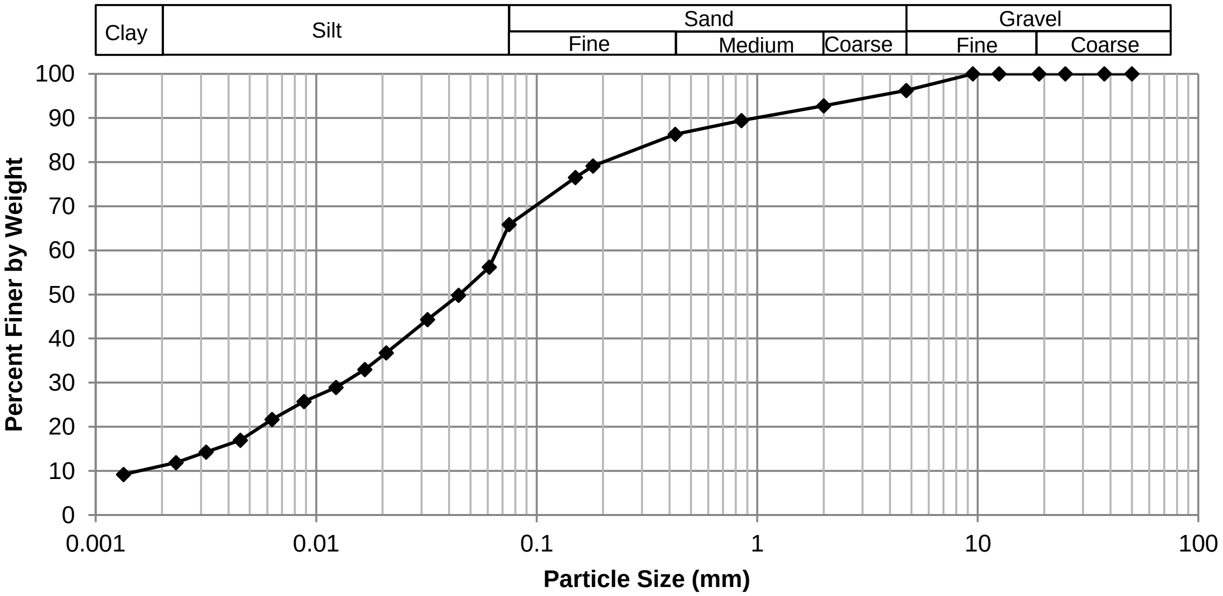
Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-15
Sample #	G112
Depth (m)	7.3 - 7.5
Sample Date	5-Sep-19
Test Date	17-Sep-19
Technician	AD

Gravel	3.8%
Sand	30.4%
Silt	54.9%
Clay	11.0%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	96.22	0.0750	65.86
37.5	100.00	2.00	92.76	0.0610	56.19
25.0	100.00	0.850	89.41	0.0443	49.81
19.0	100.00	0.425	86.29	0.0320	44.30
12.5	100.00	0.180	79.12	0.0208	36.76
9.50	100.00	0.150	76.49	0.0166	32.99
4.75	96.22	0.075	65.86	0.0123	28.93
				0.0088	25.74
				0.0063	21.68
				0.0045	16.99
				0.0032	14.27
				0.0023	11.85
				0.0013	9.21

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Grain Size Analysis (Hydrometer Method)
ASTM D422

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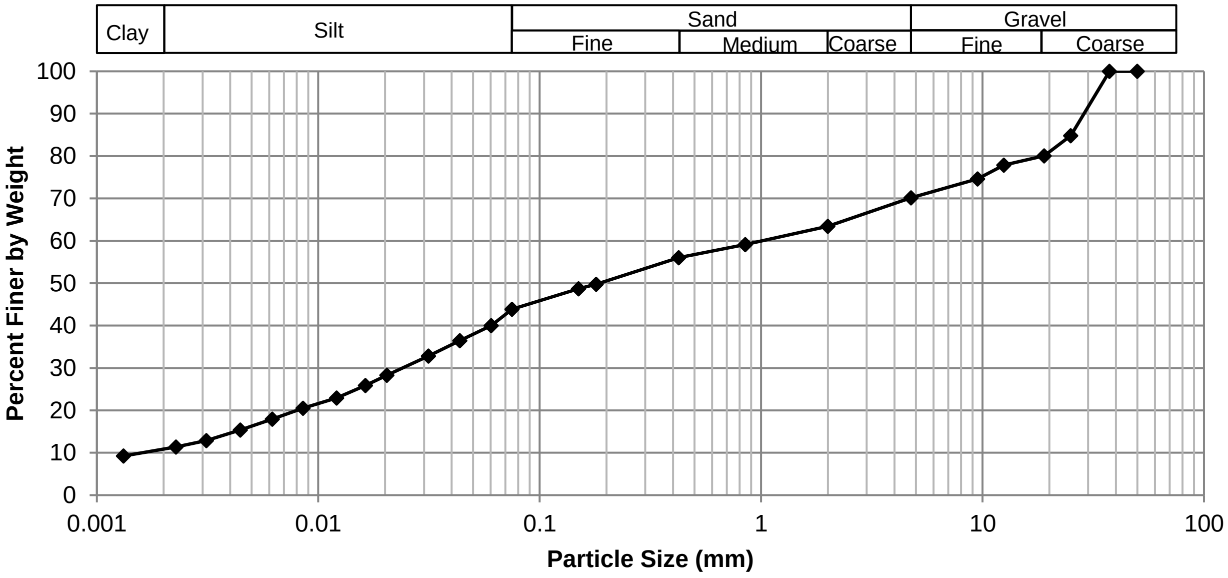
Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Test Hole TH19-15
Sample # G124
Depth (m) 16.5 - 16.8
Sample Date 5-Sep-19
Test Date 17-Sep-19
Technician HS

Gravel	29.8%
Sand	26.4%
Silt	33.0%
Clay	10.9%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	70.20	0.0750	43.83
37.5	100.00	2.00	63.47	0.0605	40.00
25.0	84.81	0.850	59.15	0.0437	36.43
19.0	80.06	0.425	56.07	0.0315	32.86
12.5	77.89	0.180	49.76	0.0204	28.29
9.50	74.61	0.150	48.73	0.0164	25.91
4.75	70.20	0.075	43.83	0.0121	22.94
				0.0085	20.55
				0.0062	17.97
				0.0045	15.35
				0.0031	12.87
				0.0023	11.39
				0.0013	9.24

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Grain Size Analysis (Hydrometer Method)
AASHTO T 88

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-14
Sample #	G141
Depth (m)	5.2 - 5.3
Sample Date	5-Sep-19
Test Date	17-Sep-19
Technician	AD

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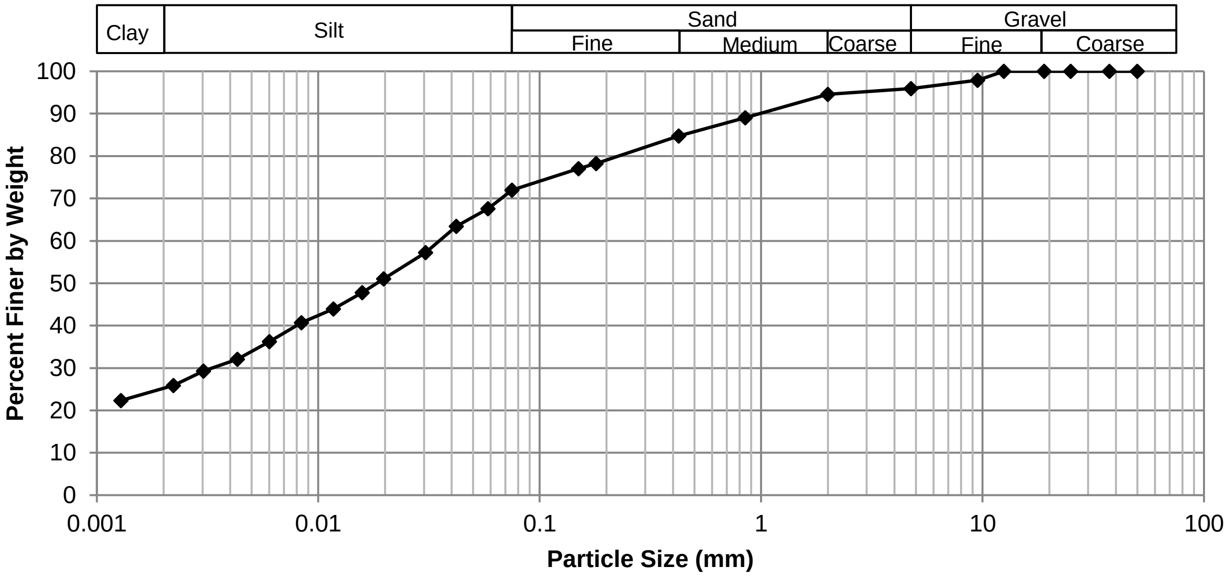
Gravel	4.1%
Sand	23.9%
Silt	46.9%
Clay	25.1%

Particle Size Distribution Curve



Gravel		Sand		Silt and Clay	
Particle Size (mm)	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**	**Particle Size (mm)**	**Percent Passing**
50.0	100.00	4.75	95.91	0.0750	71.97
37.5	100.00	2.00	94.60	0.0585	67.60
25.0	100.00	0.850	89.05	0.0421	63.45
19.0	100.00	0.425	84.78	0.0305	57.24
12.5	100.00	0.180	78.21	0.0198	51.03
9.50	97.91	0.150	77.06	0.0158	47.78
4.75	95.91	0.075	71.97	0.0117	43.93
				0.0084	40.68
				0.0060	36.24
				0.0043	32.10
				0.0030	29.25
				0.0022	25.88
				0.0013	22.34

Atterberg Limits
ASTM D4318-10e1

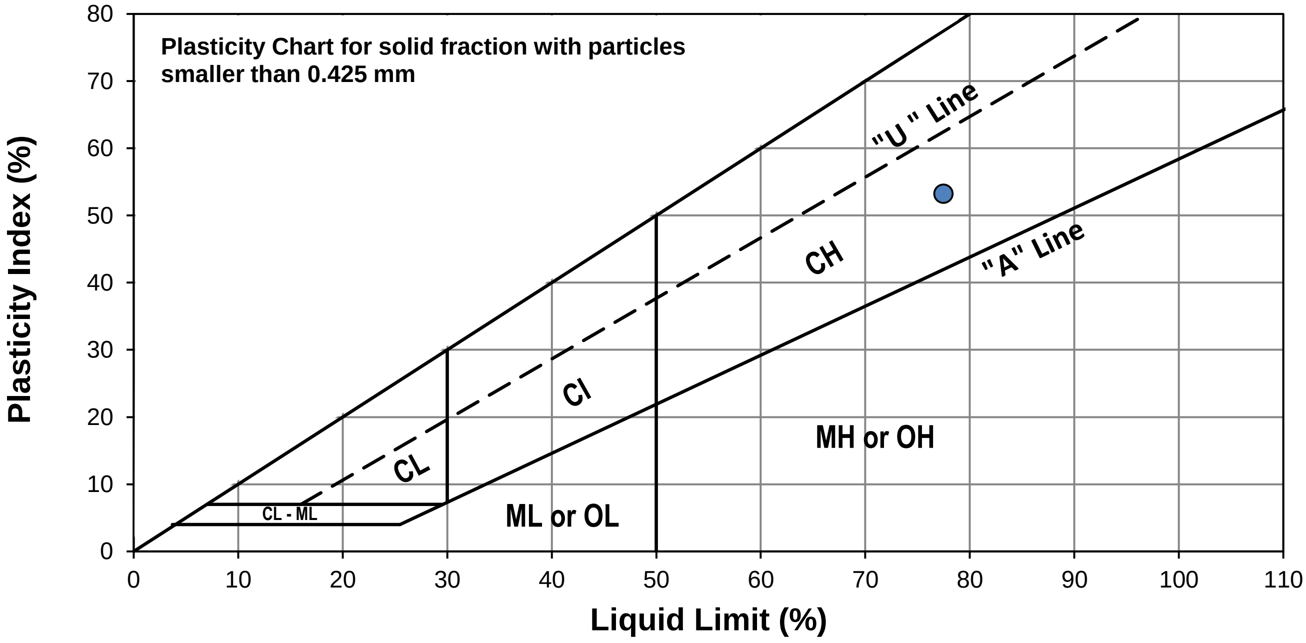
Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Test Hole TH19-13
Sample # G02
Depth (m) 0.6 - 0.8
Sample Date 5-Sep-19
Test Date 17-Sep-19
Technician HS

Liquid Limit	77
Plastic Limit	24
Plasticity Index	53

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	15	28	31		
Mass Wet Soil + Tare (g)	32.388	35.481	33.896		
Mass Dry Soil + Tare (g)	24.189	26.167	25.460		
Mass Tare (g)	14.075	14.109	14.282		
Mass Water (g)	8.199	9.314	8.436		
Mass Dry Soil (g)	10.114	12.058	11.178		
Moisture Content (%)	81.066	77.243	75.470		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.117	14.134			
Mass Wet Soil + Tare (g)	20.393	22.867			
Mass Dry Soil + Tare (g)	19.173	21.156			
Mass Water (g)	1.220	1.711			
Mass Dry Soil (g)	5.056	7.022			
Moisture Content (%)	24.130	24.366			

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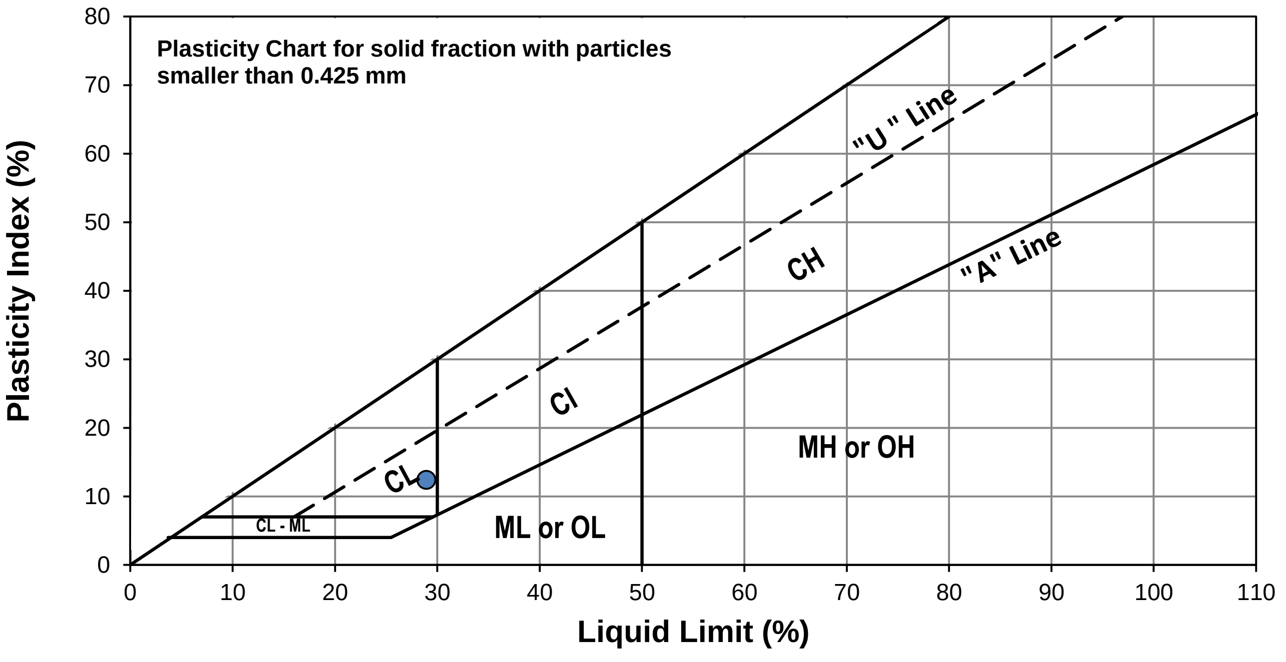
Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-13
Sample #	G03
Depth (m)	0.9 - 1.1
Sample Date	30-Sep-19
Test Date	02-Oct-19
Technician	KG

Liquid Limit	29
Plastic Limit	17
Plasticity Index	12

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	15	27	34		
Mass Wet Soil + Tare (g)	24.586	22.779	22.161		
Mass Dry Soil + Tare (g)	22.079	20.866	20.468		
Mass Tare (g)	14.107	14.141	14.313		
Mass Water (g)	2.507	1.913	1.693		
Mass Dry Soil (g)	7.972	6.725	6.155		
Moisture Content (%)	31.448	28.446	27.506		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.229	14.092			
Mass Wet Soil + Tare (g)	20.191	20.674			
Mass Dry Soil + Tare (g)	19.338	19.746			
Mass Water (g)	0.853	0.928			
Mass Dry Soil (g)	5.109	5.654			
Moisture Content (%)	16.696	16.413			

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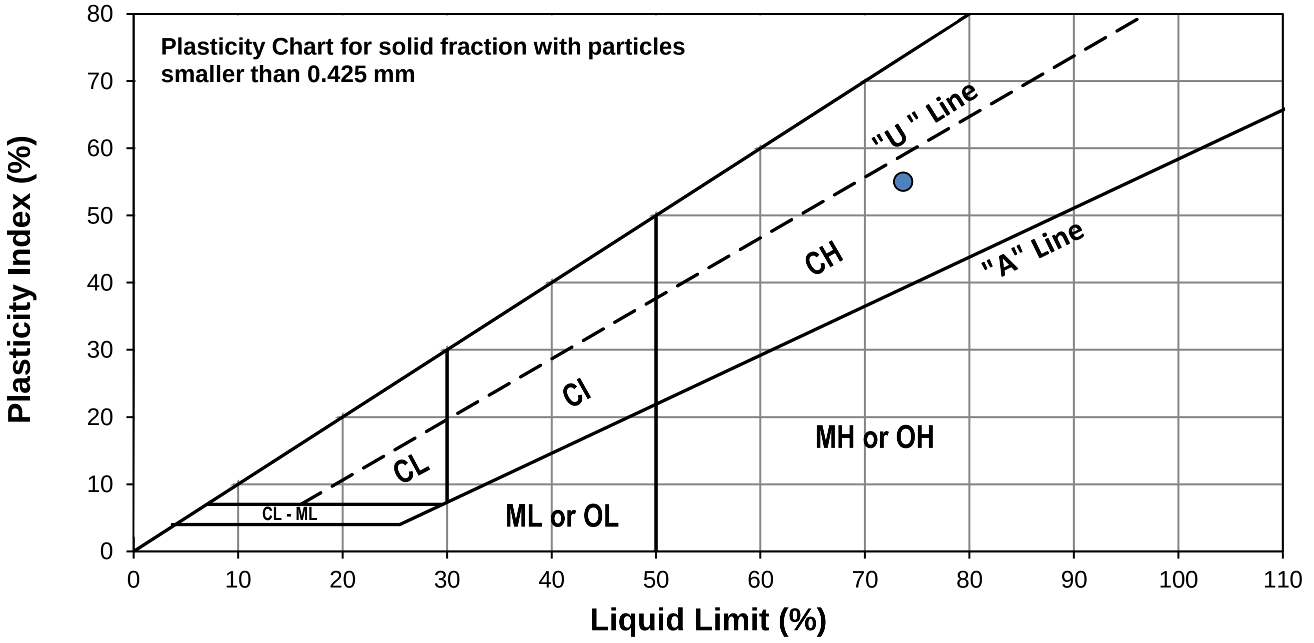
Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-02
Sample #	G57
Depth (m)	0.9 - 1.1
Sample Date	5-Sep-19
Test Date	17-Sep-19
Technician	DS

Liquid Limit	74
Plastic Limit	19
Plasticity Index	55

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	15	23	35		
Mass Wet Soil + Tare (g)	23.209	23.352	22.608		
Mass Dry Soil + Tare (g)	19.202	19.468	19.120		
Mass Tare (g)	14.024	14.263	14.203		
Mass Water (g)	4.007	3.884	3.488		
Mass Dry Soil (g)	5.178	5.205	4.917		
Moisture Content (%)	77.385	74.621	70.938		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.212	14.126			
Mass Wet Soil + Tare (g)	23.852	23.503			
Mass Dry Soil + Tare (g)	22.347	22.019			
Mass Water (g)	1.505	1.484			
Mass Dry Soil (g)	8.135	7.893			
Moisture Content (%)	18.500	18.801			

Atterberg Limits
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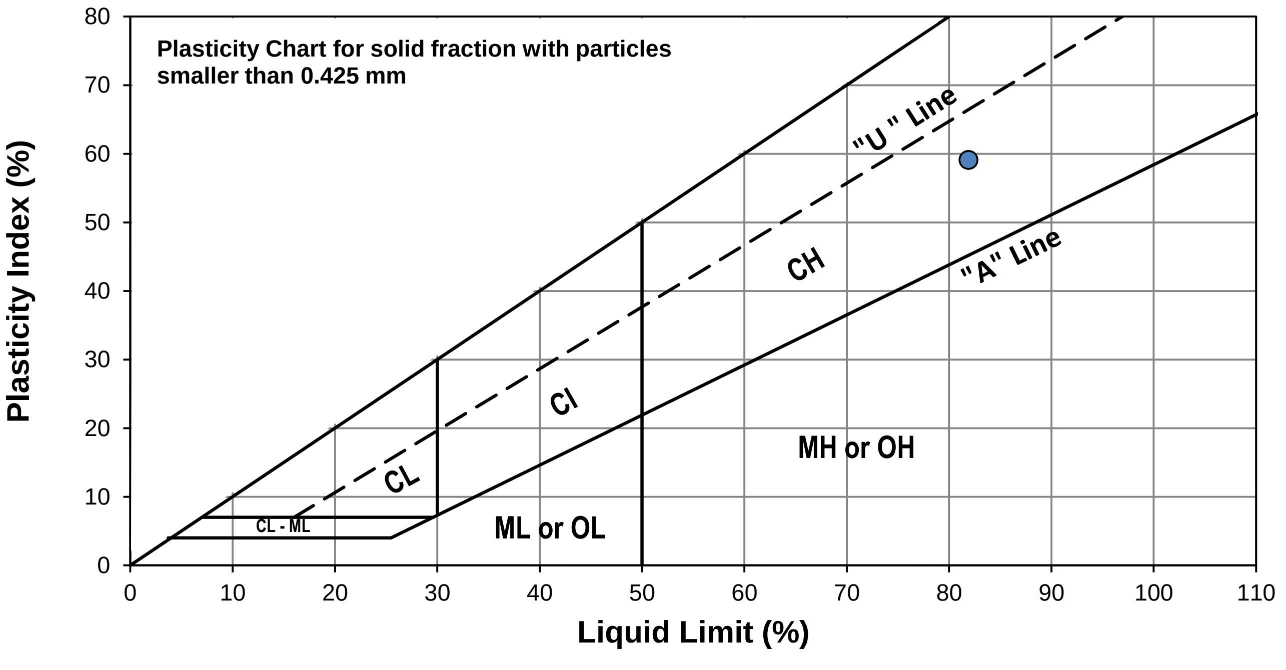
Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-08
Sample #	G79
Depth (m)	0.9 - 1.1
Sample Date	30-Sep-19
Test Date	03-Oct-19
Technician	NM

Liquid Limit	82
Plastic Limit	23
Plasticity Index	59

Liquid Limit

Trial #	1	2	3		
Number of Blows (N)	17	25	34		
Mass Wet Soil + Tare (g)	24.996	24.591	24.446		
Mass Dry Soil + Tare (g)	20.038	19.762	19.961		
Mass Tare (g)	14.205	13.865	14.315		
Mass Water (g)	4.958	4.829	4.485		
Mass Dry Soil (g)	5.833	5.897	5.646		
Moisture Content (%)	84.999	81.889	79.437		



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	14.084	14.117			
Mass Wet Soil + Tare (g)	20.378	19.916			
Mass Dry Soil + Tare (g)	19.215	18.834			
Mass Water (g)	1.163	1.082			
Mass Dry Soil (g)	5.131	4.717			
Moisture Content (%)	22.666	22.938			

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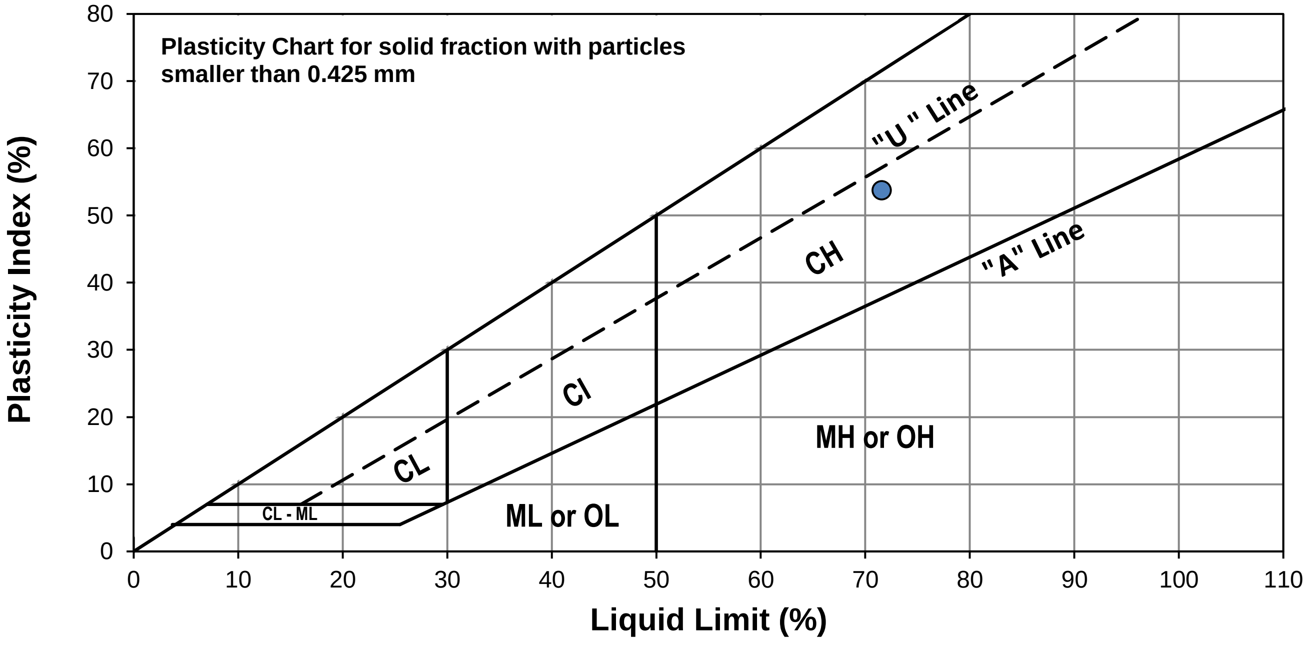
Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Test Hole TH19-12
Sample # G86
Depth (m) 0.9 - 1.1
Sample Date 5-Sep-19
Test Date 17-Sep-19
Technician DS

Liquid Limit	72
Plastic Limit	18
Plasticity Index	54

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	17	26	34		
Mass Wet Soil + Tare (g)	23.670	23.155	22.767		
Mass Dry Soil + Tare (g)	19.579	19.392	19.116		
Mass Tare (g)	14.041	14.108	13.890		
Mass Water (g)	4.091	3.763	3.651		
Mass Dry Soil (g)	5.538	5.284	5.226		
Moisture Content (%)	73.871	71.215	69.862		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.119	14.217			
Mass Wet Soil + Tare (g)	20.035	19.312			
Mass Dry Soil + Tare (g)	19.139	18.540			
Mass Water (g)	0.896	0.772			
Mass Dry Soil (g)	5.020	4.323			
Moisture Content (%)	17.849	17.858			

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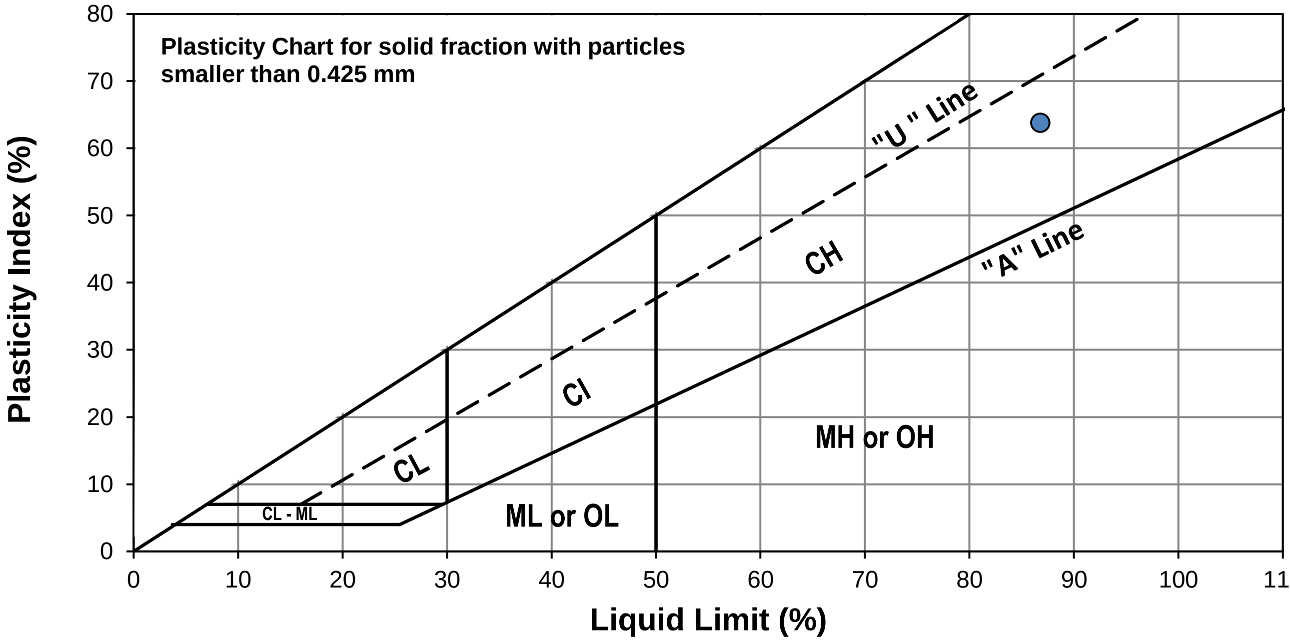
Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-15
Sample #	G103
Depth (m)	1.5 - 1.7
Sample Date	5-Sep-19
Test Date	17-Sep-19
Technician	DS

Liquid Limit	87
Plastic Limit	23
Plasticity Index	64

Liquid Limit

Trial #	1	2	3		
Number of Blows (N)	16	24	35		
Mass Wet Soil + Tare (g)	21.576	21.554	20.860		
Mass Dry Soil + Tare (g)	17.958	18.108	17.798		
Mass Tare (g)	13.979	14.159	14.133		
Mass Water (g)	3.618	3.446	3.062		
Mass Dry Soil (g)	3.979	3.949	3.665		
Moisture Content (%)	90.927	87.263	83.547		



Plastic Limit

Trial #	1	2	3	4	5
Mass Tare (g)	13.996	13.990			
Mass Wet Soil + Tare (g)	19.882	21.385			
Mass Dry Soil + Tare (g)	18.777	20.008			
Mass Water (g)	1.105	1.377			
Mass Dry Soil (g)	4.781	6.018			
Moisture Content (%)	23.112	22.881			

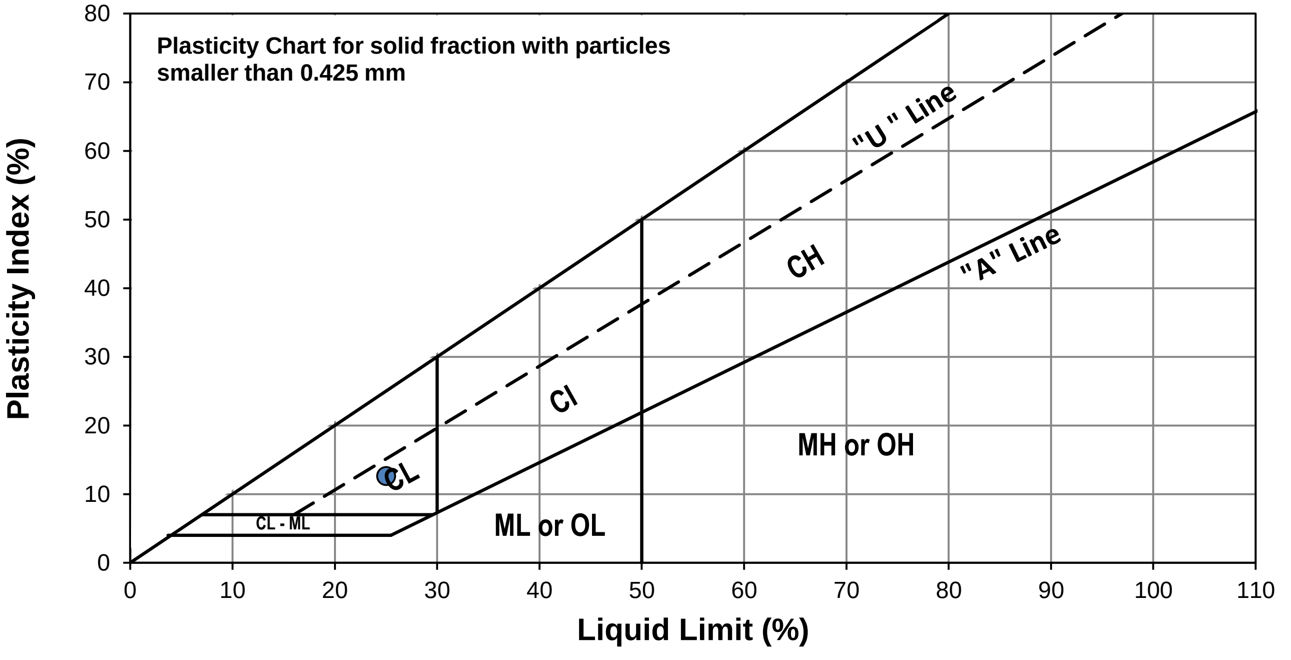
Atterberg Limits
ASTM D4318-10e1

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-15
Sample #	G107
Depth (m)	3.7 - 3.8
Sample Date	05-Sep-19
Test Date	17-Sep-19
Technician	KG

Liquid Limit	25
Plastic Limit	12
Plasticity Index	13

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	15	20	31		
Mass Wet Soil + Tare (g)	23.524	23.011	25.130		
Mass Dry Soil + Tare (g)	21.629	21.227	22.989		
Mass Tare (g)	14.290	14.216	14.300		
Mass Water (g)	1.895	1.784	2.141		
Mass Dry Soil (g)	7.339	7.011	8.689		
Moisture Content (%)	25.821	25.446	24.640		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.112	14.228			
Mass Wet Soil + Tare (g)	22.504	21.996			
Mass Dry Soil + Tare (g)	21.575	21.139			
Mass Water (g)	0.929	0.857			
Mass Dry Soil (g)	7.463	6.911			
Moisture Content (%)	12.448	12.401			

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Atterberg Limits
ASTM D4318-10e1

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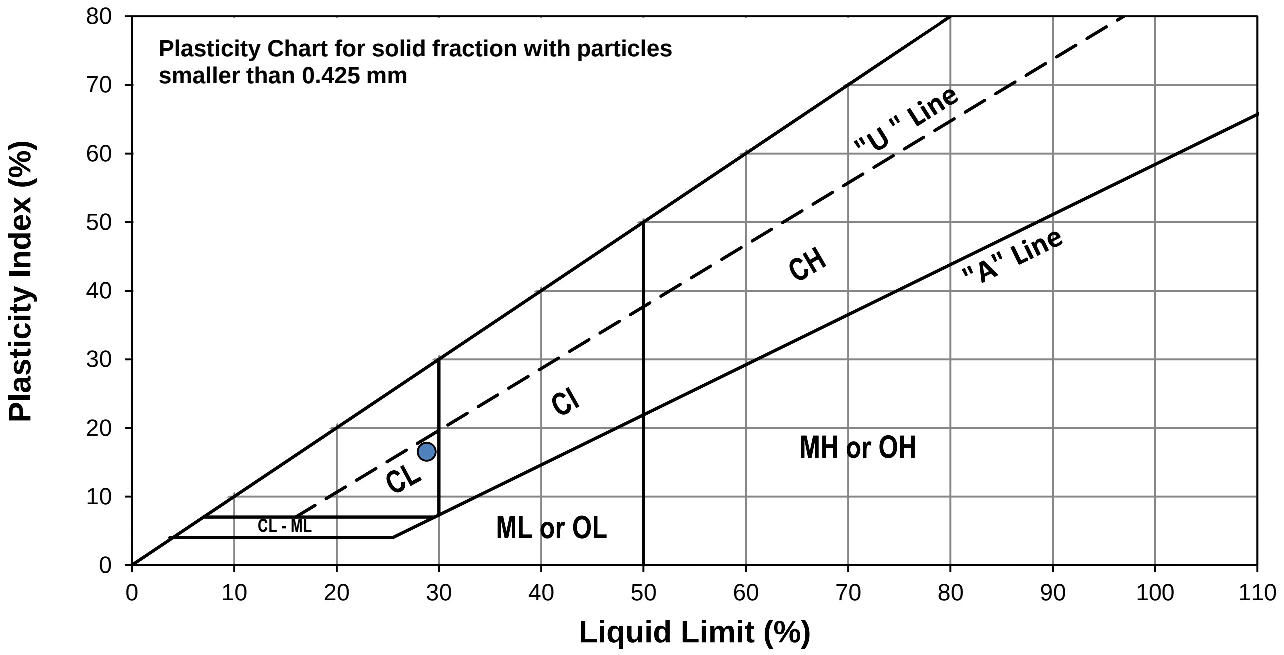
Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Test Hole TH19-15
Sample # G108
Depth (m) 4.3 - 4.4
Sample Date 05-Sep-19
Test Date 17-Sep-19
Technician KG

Liquid Limit	29
Plastic Limit	12
Plasticity Index	17

Liquid Limit

Trial #	**1**	**2**	**3**		
Number of Blows (N)	16	20	29		
Mass Wet Soil + Tare (g)	23.463	25.589	25.670		
Mass Dry Soil + Tare (g)	21.329	22.958	23.133		
Mass Tare (g)	14.187	14.037	14.198		
Mass Water (g)	2.134	2.631	2.537		
Mass Dry Soil (g)	7.142	8.921	8.935		
Moisture Content (%)	29.880	29.492	28.394		



Plastic Limit

Trial #	**1**	**2**	**3**	**4**	**5**
Mass Tare (g)	14.113	14.090			
Mass Wet Soil + Tare (g)	25.127	24.305			
Mass Dry Soil + Tare (g)	23.916	23.191			
Mass Water (g)	1.211	1.114			
Mass Dry Soil (g)	9.803	9.101			
Moisture Content (%)	12.353	12.240			

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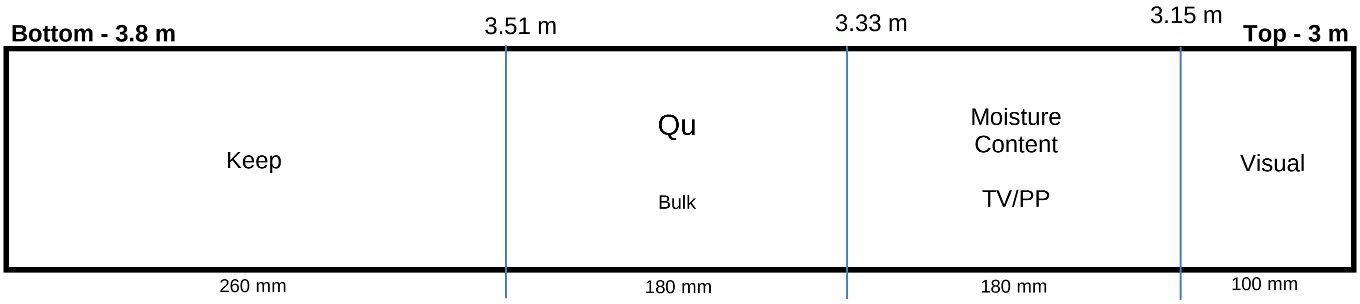
Shelby Tube Visual

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-15
Sample #	T106
Depth (m)	3.0 - 3.7
Sample Date	11-Sep-19
Test Date	16-Sep-19
Technician	HS

Tube Extraction

Recovery (mm) 720



Visual Classification

Material	CLAY (TILL)
Composition	silty
trace gravel (<10 mm diam.)	
trace sand	
trace silt inclusions (<10 mm diam.)	
Color	grey
Moisture	moist
Consistency	very stiff
Plasticity	intermediate plasticity
Structure	-
Gradation	-

Torvane

Reading	0.60
Vane Size (s,m,l)	s
Undrained Shear Strength (kPa)	147.1

Pocket Penetrometer

Reading	**1**	2.20
	2	2.40
	3	2.80
	Average	2.47
Undrained Shear Strength (kPa)		121.0

Moisture Content

Tare ID	AB61
Mass tare (g)	6.8
Mass wet + tare (g)	378.3
Mass dry + tare (g)	332.8
Moisture %	14.0%

Unit Weight

Bulk Weight (g)		1314.0
Length (mm)	**1**	140.50
	2	140.07
	3	140.10
	4	140.08
Average Length (m)		0.140
Diam. (mm)	**1**	71.17
	2	71.87
	3	72.05
	4	71.37
Average Diameter (m)		0.072
Volume (m^3)		5.65E-04
Bulk Unit Weight (kN/m^3)		22.8
Bulk Unit Weight (pcf)		145.3
Dry Unit Weight (kN/m^3)		20.0
Dry Unit Weight (pcf)		127.5

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Unconfined Compressive Strength
ASTM D2166

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek

Test Hole	TH19-15
Sample #	T106
Depth (m)	3.0 - 3.7
Sample Date	11-Sep-19
Test Date	16-Sep-19
Technician	HS

Unconfined Strength

	kPa	**ksf**
Max q_u	184.9	3.9
Max S_u	92.4	1.9

Specimen Data

Description CLAY (TILL) - silty, trace gravel (<10 mm diam.), trace sand, trace silt inclusions (<10 mm diam.), grey, moist, very stiff, intermediate plasticity

Length	140.2	(mm)	**Moisture %**	14%	
Diameter	71.6	(mm)	**Bulk Unit Wt.**	22.8	(kN/m^3)
L/D Ratio	2.0		**Dry Unit Wt.**	20.0	(kN/m^3)
Initial Area	0.00403	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

Reading	**Undrained Shear Strength**	
tsf	**kPa**	**ksf**
0.60	147.1	3.07
Vane Size		
s		

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	2.20	107.9	2.25
	2.40	117.7	2.46
	2.80	137.3	2.87
Average	**2.47**	**121.0**	**2.53**

Failure Geometry

Sketch:

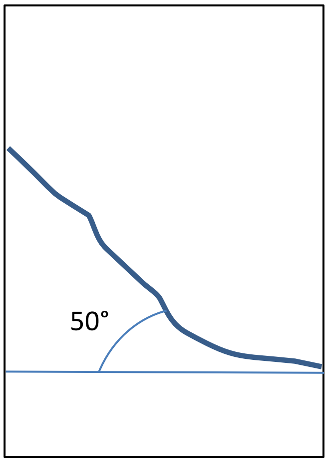


Photo:

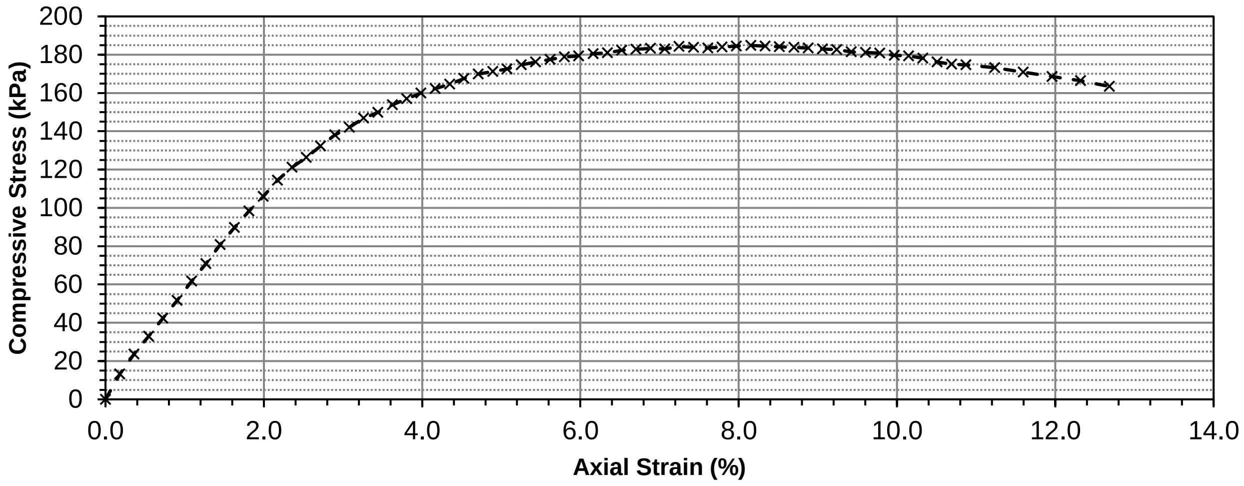
Project 0035-079-00
Location SHERWIN ROAD
Hole No. TH19-15 Sample No. T106
Depth 10'-12'
Technician HS Date SEP13/19

Unconfined Compressive Strength

ASTM D2166

Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004028	0.0	0.00	0.00
10	14	0.2540	0.18	0.004035	53.2	13.18	6.59
20	25	0.5080	0.36	0.004043	95.3	23.57	11.79
30	35	0.7620	0.54	0.004050	133.6	32.98	16.49
40	45	1.0160	0.72	0.004057	171.9	42.36	21.18
50	55	1.2700	0.91	0.004065	209.9	51.63	25.82
60	66	1.5240	1.09	0.004072	251.4	61.74	30.87
70	76	1.7780	1.27	0.004080	289.1	70.87	35.44
80	87	2.0320	1.45	0.004087	330.3	80.81	40.40
90	97	2.2860	1.63	0.004095	367.7	89.79	44.90
100	107	2.5400	1.81	0.004102	403.6	98.39	49.19
110	116	2.7940	1.99	0.004110	435.4	105.94	52.97
120	126	3.0480	2.17	0.004118	470.9	114.35	57.18
130	134	3.3020	2.36	0.004125	500.2	121.26	60.63
140	140	3.5560	2.54	0.004133	522.2	126.36	63.18
150	147	3.8100	2.72	0.004141	547.9	132.32	66.16
160	154	4.0640	2.90	0.004148	572.9	138.10	69.05
170	159	4.3180	3.08	0.004156	590.4	142.05	71.02
180	165	4.5720	3.26	0.004164	611.3	146.82	73.41
190	169	4.8260	3.44	0.004172	625.3	149.90	74.95
200	174	5.0800	3.62	0.004180	642.8	153.80	76.90
210	178	5.3340	3.80	0.004187	657.1	156.91	78.46
220	182	5.5880	3.99	0.004195	671.4	160.03	80.02
230	185	5.8420	4.17	0.004203	682.1	162.29	81.14

Unconfined Compressive Strength

ASTM D2166

Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Unconfined Compression Test Data (cont'd)

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
240	188	6.0960	4.35	0.004211	692.9	164.54	82.27
250	192	6.3500	4.53	0.004219	707.2	167.62	83.81
260	195	6.6040	4.71	0.004227	718.0	169.85	84.92
270	197	6.8580	4.89	0.004235	725.1	171.22	85.61
280	199	7.1120	5.07	0.004243	732.3	172.58	86.29
290	202	7.3660	5.25	0.004251	743.0	174.77	87.38
300	204	7.6200	5.44	0.004260	750.2	176.11	88.05
310	206	7.8740	5.62	0.004268	757.3	177.44	88.72
320	208	8.1280	5.80	0.004276	764.4	178.77	89.38
330	209	8.3820	5.98	0.004284	768.0	179.26	89.63
340	211	8.6360	6.16	0.004293	775.1	180.57	90.29
350	212	8.8900	6.34	0.004301	778.7	181.05	90.53
360	214	9.1440	6.52	0.004309	785.8	182.36	91.18
370	215	9.3980	6.70	0.004318	789.4	182.83	91.41
380	216	9.6520	6.89	0.004326	792.9	183.30	91.65
390	216	9.9060	7.07	0.004334	792.9	182.94	91.47
400	218	10.1600	7.25	0.004343	800.1	184.22	92.11
410	218	10.4140	7.43	0.004351	800.1	183.86	91.93
420	218	10.6680	7.61	0.004360	800.1	183.50	91.75
430	219	10.9220	7.79	0.004368	803.6	183.96	91.98
440	220	11.1760	7.97	0.004377	807.2	184.41	92.21
450	221	11.4300	8.15	0.004386	810.7	184.86	92.43
460	221	11.6840	8.33	0.004394	810.7	184.50	92.25
470	221	11.9380	8.52	0.004403	810.7	184.13	92.07
480	221	12.1920	8.70	0.004412	810.7	183.77	91.88
490	221	12.4460	8.88	0.004421	810.7	183.40	91.70
500	221	12.7000	9.06	0.004429	810.7	183.04	91.52
510	221	12.9540	9.24	0.004438	810.7	182.67	91.34
520	220	13.2080	9.42	0.004447	807.2	181.51	90.75
530	220	13.4620	9.60	0.004456	807.2	181.15	90.57
540	220	13.7160	9.78	0.004465	807.2	180.78	90.39
550	219	13.9700	9.97	0.004474	803.6	179.62	89.81
560	219	14.2240	10.15	0.004483	803.6	179.26	89.63
570	218	14.4780	10.33	0.004492	800.1	178.11	89.05
580	216	14.7320	10.51	0.004501	792.9	176.16	88.08
590	215	14.9860	10.69	0.004510	789.4	175.02	87.51
600	215	15.2400	10.87	0.004519	789.4	174.66	87.33
620	214	15.7480	11.23	0.004538	785.8	173.17	86.58
640	212	16.2560	11.60	0.004556	778.7	170.89	85.45
660	210	16.7640	11.96	0.004575	771.5	168.64	84.32
680	208	17.2720	12.32	0.004594	764.4	166.39	83.19
700	205	17.7800	12.68	0.004613	753.7	163.38	81.69

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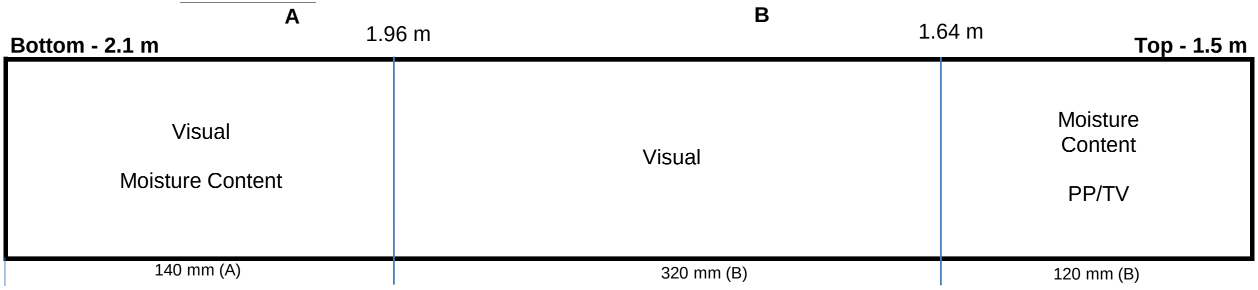
Shelby Tube Visual

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omand Creek
Test Hole	TH19-14B
Sample #	T135
Depth (m)	1.5 - 2.1
Sample Date	11-Sep-19
Test Date	13-Sep-19
Technician	HS

Tube Extraction

Recovery (mm) 580



Visual Classification

	B	A
Material	CLAY (FILL)	SILT (TILL)
Composition	silty	clayey
	trace gravel (< 50mm diam.), trace silt inclusions (< 15 mm diam.)	trace gravel (< 15 mm diam.)
	trace sand, trace organics, trace oxidation	trace sand
Color	grey	brown
Moisture	moist	moist
Consistency	stiff	firm
Plasticity	intermediate plasticity	intermediate plasticity
Structure	-	-
Gradation	-	-

Moisture Content

	B	A
Tare ID	AB81	A16
Mass tare (g)	6.8	8.4
Mass wet + tare (g)	301.9	286.4
Mass dry + tare (g)	217.6	246
Moisture %	40.0%	17.0%

Unit Weight

Bulk Weight (g)		-	-
			-
Length (mm)	**1**	-	-
	2	-	-
	3	-	-
	4	-	
Average Length (m)		-	-
Diam. (mm)	**1**	-	-
	2	-	-
	3	-	-
	4	-	-
Average Diameter (m)		-	-
Volume (m^3)		-	-
Bulk Unit Weight (kN/m^3)		-	-
Bulk Unit Weight (pcf)		-	-
Dry Unit Weight (kN/m^3)		-	-
Dry Unit Weight (pcf)		-	-

Torvane

	B	A	
Reading	0.8	-	
Vane Size (s,m,l)	m	-	
Undrained Shear Strength	78.5		(kPa)

Pocket Penetrometer

		A	B	
Reading	**1**	1.500	-	
	2	1.400	-	
	3	1.700	-	
	Average	1.533	-	
Undrained Shear Strength		75.2	-	(kPa)

Shelby Tube Visual

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek
Test Hole	TH19-14
Sample #	T140
Depth (m)	4.6 - 5.2
Sample Date	11-Sep-19
Test Date	16-Sep-19
Technician	HS

Tube Extraction

Recovery (mm) 590

Bottom - 5.2 m	4.87 m	4.70 m	4.62 m	**Top - 4.6 m**
Keep	Qu Bulk	TV/PP Visual	Moisture Content	
295 mm	165 mm	80 mm	50 mm	

Visual Classification

Material	CLAY (TILL)
Composition	silty
trace sand (<5 mm diam.)	
trace silt inclusion (<5 mm diam.)	
Color	grey
Moisture	moist
Consistency	firm to stiff
Plasticity	high plasticity
Structure	-
Gradation	-

Torvane

Reading	0.40
Vane Size (s,m,l)	m
Undrained Shear Strength (kPa)	39.2

Pocket Penetrometer

Reading	**1**	0.70
	2	0.80
	3	0.70
	Average	0.73
Undrained Shear Strength (kPa)		36.0

Moisture Content

Tare ID	A28
Mass tare (g)	6.5
Mass wet + tare (g)	300.5
Mass dry + tare (g)	225.1
Moisture %	34.5%

Unit Weight

Bulk Weight (g)		1159.7
Length (mm)	**1**	147.89
	2	147.82
	3	148.05
	4	147.55
Average Length (m)		0.148
Diam. (mm)	**1**	72.85
	2	72.86
	3	72.95
	4	72.77
Average Diameter (m)		0.073
Volume (m^3)		6.16E-04
Bulk Unit Weight (kN/m^3)		18.5
Bulk Unit Weight (pcf)		117.5
Dry Unit Weight (kN/m^3)		13.7
Dry Unit Weight (pcf)		87.3

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Unconfined Compressive Strength

ASTM D2166

Project No.	0035-079-00
Client	Morrison Hershfield
Project	Sherwin Road Bridge Over Omands Creek

Test Hole	TH19-14
Sample #	T140
Depth (m)	4.6 - 5.2
Sample Date	11-Sep-19
Test Date	16-Sep-19
Technician	HS

Unconfined Strength

	kPa	**ksf**
Max q_u	93.7	2.0
Max S_u	46.8	1.0

Specimen Data

Description CLAY (TILL) - silty, trace sand (<5 mm diam.), trace silt inclusion (<5 mm diam.), grey, moist, firm to stiff, high plasticity

Length	147.8	(mm)	**Moisture %**	34%	
Diameter	72.9	(mm)	**Bulk Unit Wt.**	18.5	(kN/m^3)
L/D Ratio	2.0		**Dry Unit Wt.**	13.7	(kN/m^3)
Initial Area	0.00417	(m^2)	**Liquid Limit**	-	
Load Rate	1.00	(%/min)	**Plastic Limit**	-	
			Plasticity Index	-	

Undrained Shear Strength Tests

Torvane

trace coarse s	**Undrained Shear Strength**	
trace silt inclu	**kPa**	**ksf**
0.40	39.2	0.82
Vane Size		
m		

Pocket Penetrometer

	Reading	**Undrained Shear Strength**	
	tsf	**kPa**	**ksf**
	0.70	34.3	0.72
	0.80	39.2	0.82
	0.70	34.3	0.72
Average	**0.73**	**36.0**	**0.75**

Failure Geometry

Sketch:

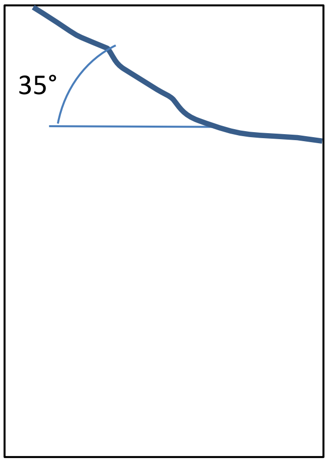

Photo:

Project 0035-079-00
Location SHERWIN ROAD
Hole No. TH19-14B Sample No. T140
Depth 15'-17'
Technician HS Date SEP 16/19

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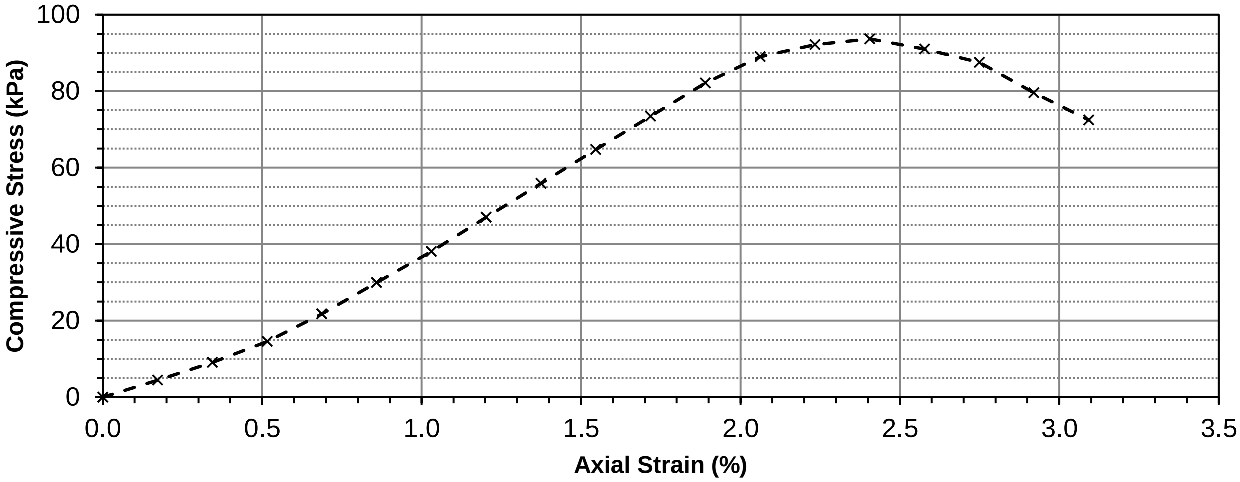
Unconfined Compressive Strength

ASTM D2166

Project No. 0035-079-00
Client Morrison Hershfield
Project Sherwin Road Bridge Over Omands Creek

Unconfined Compression Test Graph



Unconfined Compression Test Data

Deformation Dial Reading	Load Ring Dial Reading	Deflection (mm)	Axial Strain (%)	Corrected Area (m^2)	Axial Load (N)	Compressive Stress, q_u (kPa)	Shear Stress, S_u (kPa)
0	0	0.0000	0.00	0.004169	0.0	0.00	0.00
10	5	0.2540	0.17	0.004176	18.7	4.49	2.24
20	10	0.5080	0.34	0.004183	37.9	9.05	4.53
30	16	0.7620	0.52	0.004191	60.8	14.52	7.26
40	24	1.0160	0.69	0.004198	91.5	21.79	10.89
50	33	1.2700	0.86	0.004205	125.9	29.94	14.97
60	42	1.5240	1.03	0.004212	160.4	38.07	19.04
70	52	1.7780	1.20	0.004220	198.6	47.05	23.53
80	62	2.0320	1.37	0.004227	236.3	55.90	27.95
90	72	2.2860	1.55	0.004235	274.1	64.72	32.36
100	82	2.5400	1.72	0.004242	311.6	73.45	36.73
110	92	2.7940	1.89	0.004249	349.0	82.12	41.06
120	100	3.0480	2.06	0.004257	378.9	89.01	44.50
130	104	3.3020	2.23	0.004264	393.0	92.17	46.08
140	106	3.5560	2.41	0.004272	400.1	93.66	46.83
150	103	3.8100	2.58	0.004279	389.5	91.02	45.51
160	99	4.0640	2.75	0.004287	375.2	87.51	43.76
170	90	4.3180	2.92	0.004295	341.5	79.52	39.76
180	82	4.5720	3.09	0.004302	311.6	72.42	36.21