Ministry of Transportation & Infrastructure

Geotechnical, Materials & Pavement Engineering
P.O. Box 9850 Stn. Prov. Govt
Victoria, B.C., V8W 9T5

MEMORANDUM

Date: 4 April 2023

Michael Bateman
Project Manager
BC Ministry of Transportation

Attention: Michael Bateman, Project Manager

RE: 18081 Renfrew Road Shawnigan Shoulder Washout and 18080 Renfrew Road Shawnigan Twin 800 Culverts – Culvert Replacements

The British Columbia Ministry of Transportation and Infrastructure (BC MoTI) Project Management Group has requested geotechnical advisement for the proposed culvert replacements for the Renfrew Road Shawnigan Shoulder Washout and the Renfrew Road Twin 800 Culverts projects. This memorandum provides a summary of the in-situ soils observed during the February 2023 site investigation, recommendations on road structure and organic soil removal, and preliminary foundation soil bearing capacities.

1.0 Background

The Renfrew Road culvert sites are located on Renfrew Road, approximately 850 m west of the intersection with West Shawnigan Lake Road as shown in Figure 1 below.

Figure 1: Site Location

Renfrew Road is a two-lane rural road that runs in an east/west direction located in the Shawnigan Lake Electoral Area for Cowichan Valley Regional District. It is located within MoTI's Service Area 1 – South Island in the South Coast Region. The culverts are in a relatively flat, low-lying area with forested regions to the north of Renfrew Road and forest mixed with marsh areas on the south side of Renfrew Road.

Renfrew Road is crowned and surface water is assumed to drain from the road crown to the northside ditch for the westbound lane and from the road crown to the southside ditch for the eastbound lane. These ditches then drain from north to south via the existing culverts at the 18080 project site and from northwest to southeast at the 18081 project site towards the low-lying marsh area south of Renfrew Road.

1.1 Project 18081 – Renfrew Road Shawnigan Shoulder Washout Site

The 18081 project site is located 70 m south of 2795 Renfrew Road. There was a previous washout and sinkhole at this location during the November 2021 atmospheric river flooding event. As a result, a temporary 600 mm diameter HDPE culvert was installed to provide additional capacity for the existing twin 450 mm corrugated steel pipe (CSP) culverts and a steel plate was placed across the westbound and eastbound lanes to cover the sinkhole. In September 2022 a temporary 750 mm HDPE culvert was installed to replace the existing twin 450 mm CSP culverts and to remove the sinkhole.

For the proposed permanent works, the existing 600 mm culvert is to be removed and the existing 750 mm HDPE culvert is planned to be relocated and to run parallel to a proposed 1800 mm x 1500 mm concrete box culvert (Culvert 18081).

1.2 Project 18080 – Renfrew Road Shawnigan Twin 800 Culverts

The 18080 project site is located approximately 20 m west of 2741 Renfrew Road. During the November 2021 atmospheric river flooding event, the existing twin 900 mm diameter CSP culverts at this site experienced significant flooding and damage. As a result, the twin 900 mm CSP culverts are proposed to be replaced with a 2700 mm x 1500 mm concrete box culvert (Culvert 18080).

2.0 Observations

A field investigation was conducted on 9, 10 and 13 of February 2023. The test hole locations are summarized in Table 1 and the draft drill logs can be found in Attachment 1. Test hole locations were limited to the eastbound lane of Renfrew Road to provide a sufficient setback from the overhead utilities present on the northside of the westbound lane. As a result, the westbound lane stratigraphy may vary from the soil layers determined from the field investigation.

The drill holes have not been surveyed and the eastings and northings provided are approximate (± 1-2 m) based on manually placed pins on Google Earth. A GPS Map Camera application was used on site, but the captured coordinates varied significantly from the test hole locations.

Table 1: Summary of Test Hole Locations

Test Hole ID	Date	Approx. Easting (m)	Approx. Northing (m)	Termination Depth (m)
TH23-01	9 February 2023	449137	5389500	15.2
TH23-02	9 February 2023	449133	5389493	15.2
TH23-03	10 February 2023	449368	5389539	15.2
TH23-04	13 February 2023	449379	5389535	22.9

We observed the soil layers shown in Table 2 below.

Table 2: Summary of Observed Soil Layers

	Thickness (m)					
Test Hole	**AP**	**SAND and GRAVEL, SW (FILL)**	**SAND and GRAVEL/ Silty SAND and GRAVEL, SW-SM (FILL)**	**Organic CLAY and SAND, CL/OL**	**Silty SAND and GRAVEL/ Gravelly Silty SAND, SM**	**Gravelly Silty SAND/ Gravelly SAND and SILT/ Silty SAND and GRAVEL, SM (TILL-LIKE)**
TH23-01 (Culvert 18081)	0.08	0.8	0.9	0.8	3.8	5.2
TH23-02 (Culvert 18081)	0.08	0.5	0.3	1.5 (with 0.3 m woody debris)	4.8	4.0
TH23-03 (Culvert 18080)	0.10	0.2	2.4	0.8	2.3	8.9
TH23-04 (Culvert 18080)	0.13	0.3	1.9	0.8	2.2	9.9*

*Sand and Silt layer with organics present within Till-Like layer with an approximate thickness of 6 m

At TH23-04 there was a sand and silt layer with organics present underlaying the silty gravel till-like material from a depth of approximately 15.2 m to 17.8 m below the ground surface. At 17.8m the previous silty gravel till-like layer resumed. The proposed invert of Culvert 18080 is approximately 12 m above the start of this sand and silt layer. As this depth is much greater than twice the width of the culvert (2.7 m), it is not anticipated that this sand and silt layer will influence settlement for the proposed culvert.

Soil testing has been completed by WSP Canada Inc. The soil laboratory tests carried out by WSP are summarized in Table 3. The sieve analysis testing for the organic clay layer sampled at TH23-01 is being retested as results did not match field observations. The updated results will be included in our final geotechnical report.

Table 3: Summary of Geotechnical Lab Testing

Laboratory Test	No. of Tests	
	Culvert 18081	Culvert 18080
Liquid Limit, Plastic Limit and Plasticity Index (ASTM D4318)	2	4
Particle Size Distribution with Hydrometer (ASTM D6913 and ASTM D422)	12	18
Particle Size Distribution (ASTM C136)	2	-
Moisture Content (ASTM D2216)	11	14
Chloride, Water Soluble in Solid (ASTM C1218-97/17)	4	4
Sulfate, Water Soluble in Solid (CSA A23.2-2B/3B)	4	4
Sulfate Brine in Water (CSA A23.2-2B)	1	1

3.0 Analysis

A preliminary bearing capacity analysis was conducted using soil parameter inputs obtained from SPT correlations.

Based on the 50% Design Drawings provided by R.F. Binnie and Associates (Binnie), the bottom of the proposed Culvert 18081 will be in the organic clay layer and the bottom of Culvert 18080 will be in the silty sand and gravel fill layer, just above the organic clay layer. Both culverts will require the organic clay layer to be removed (see Section 4.1 for details). As a result, the foundation soils for both culverts will consist of imported granular material (Select Granular Sub-base or Bridge End Fill) underlain by the native silty sand and gravel. Input parameters were based on this assumed foundation soil.

The bearing capacity analysis was conducted according to the Canadian Highway Bridge Design Code (CSA S6:19) assuming a consequence level of Typical and a Typical degree of understanding. The results of the analysis are presented in Table 4 that follows.

Table 4: Summary of Bearing Capacity Analysis Results

	Culvert 18081	Culvert 18080
Factored Bearing Capacity (kPa)	629	750

An approximate calculation of the vertical stress applied by the culvert, road structure, and live loads was completed. The weight per linear meter for the box culverts was obtained from Langley Concrete Box Culvert Standard Details. The water weight was based on the culvert running full. A summary of the inputs assumed for approximating the vertical pressure on the foundation soils are shown in Table 5.

Table 5: Summary of Inputs for Vertical Pressure on Foundation Soil Approximation

Input	Culvert 18081	Culvert 18080	Unit
Soil unit weight, γ	20	20	kN/m^3
Soil cover depth above culvert	0.375	0.375	m
Asphalt unit weight, γ	23	23	kN/m^3
Asphalt depth	0.075	0.075	m
Culvert length, L	16.3	18.5	m
Culvert width, B	1.8	2.7	m
Culvert height, H	1.5	1.5	m
Linear mass per meter	4000	5700	kg/m
Live load	16	16	kPa

The vertical pressure from culverts 18081 and 18080 on the foundation soil was estimated as 70 kPa and 71 kPa respectively.

In-situ soil settlement is not a concern for the proposed culverts if the existing organic clay layer is removed as recommended in Section 4.1 below. If this organic clay layer is not removed, settlement could be a concern and would require further analysis to quantify.

A debris structure at the inlet of Culvert 18080 has been proposed by Binnie as discussed on 27 March 2023. Further analysis will be completed for the debris structure once the specifications are known.

4.0 Recommendations

Our recommendations for organic material removal, pavement structure, and the bearing capacity results are presented in the sections that follow.

4.1 Organic Clay Removal

Based on our observations during the site investigation, we recommend that the existing organic clay layer be excavated along the proposed culvert footprint with a 0.5 m to 1 m offset and backfilled with either Select Granular Sub-base (SGSB) or Bridge End Fill (BEF) prior to installation of the box culverts, see MoTI Standard Specification for Construction SS 202 for property requirements of these materials. The anticipated excavation depths required to remove the organic clay layers and the soil layers encountered during our site investigation for culverts 18081 and 18080 are shown in Figures 2 and 3.

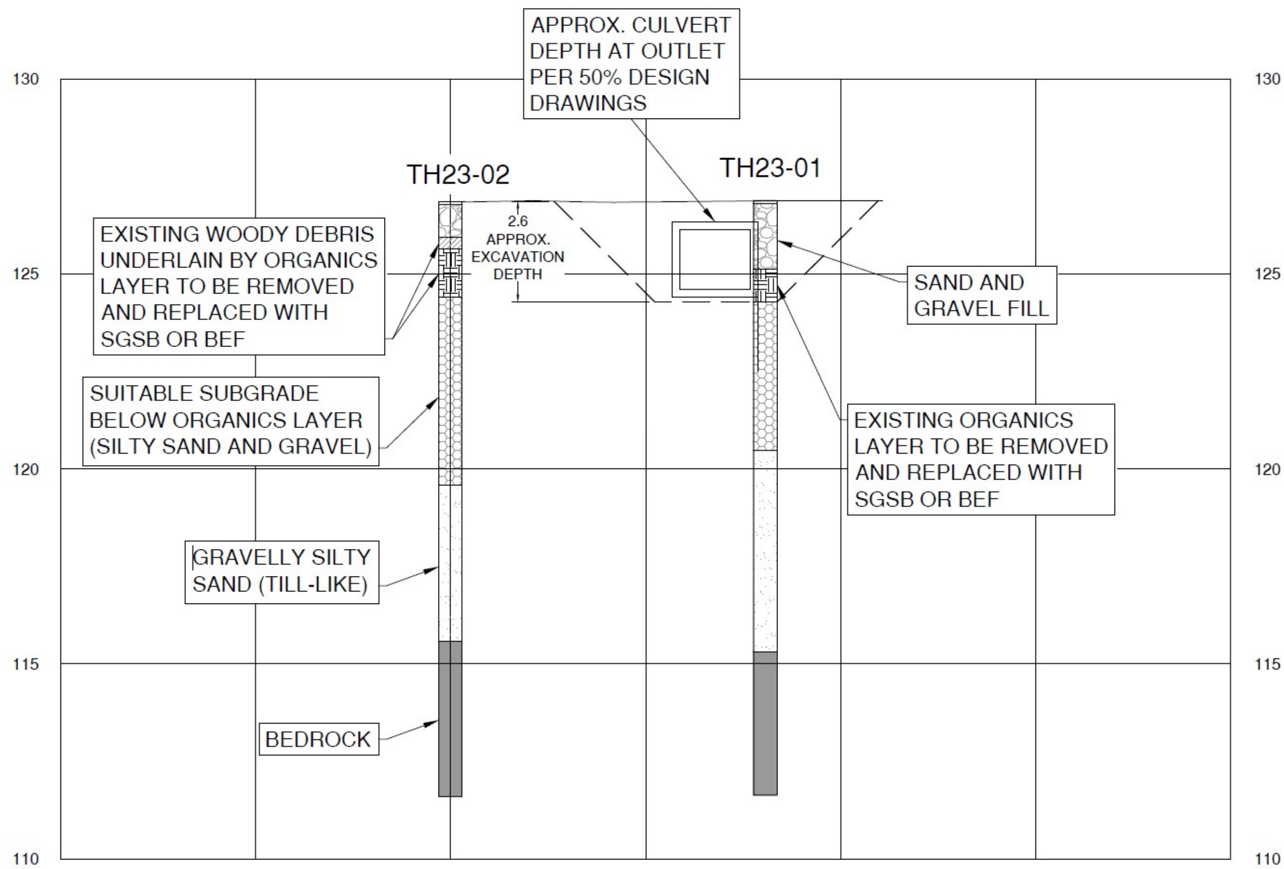

Figure 2: Typical Section of Soil Layers for Culvert 18081

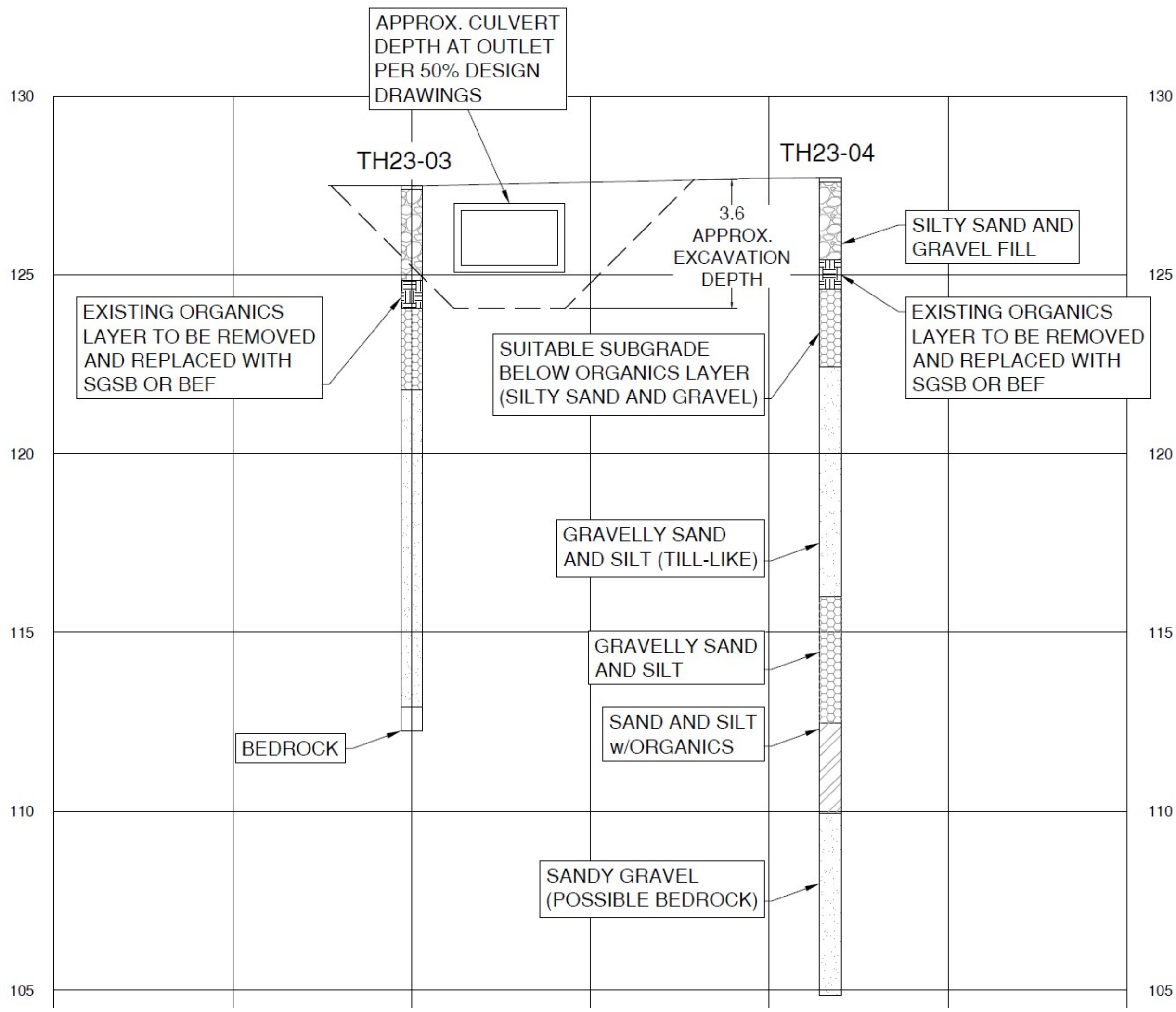

Figure 3: Typical Section of Soil Layers for Culvert 18080

4.1.1 Field Review/Construction

Field review will be required after the organic layer removal and prior to bedding placement and backfill. Culvert bedding and backfill should conform to MoTI's 2020 Standard Specifications for Highway Construction, Section 303.

The trench excavation must follow WorkSafe BC OHS Regulation Part 20, Sections 20.78 to 20.95 for minimum sloping and/or shoring requirements.

4.2 Pavement Structure

For our road structure recommendations, we are assuming Renfrew Road to be a Type C Low to Medium Volume Road (this needs to be confirmed with traffic data). Based on a Type C Road classification, the minimum pavement structure required is shown in Table 4.

Table 6: Recommended Minimum Pavement Structure

Type C Pavement Structure	Thickness (mm)
Asphalt Pavement	75
25 mm Well-Graded Base (WGB)	225
Select Granular Sub-Base (SGSB)	150
Total Depth	450

4.3 Bearing Capacity

The calculated bearing capacity of 629 and 750 kPa for culverts 18081 and 18080 should be sufficient to support the proposed culverts without additional foundation work. The bearing capacity calculated assumes that the organic soils beneath the proposed culverts are removed and replaced with granular material as discussed in Section 4.1.

5.0 Closure

If you have any further questions or require additional information, please contact our office at the above address and telephone number.

Prepared by:

V. Lindstrom, E.I.T.
Geotechnical Engineer

Reviewed by:

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
C. D. BLEACKLEY
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04-04-2023

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Senior Geotechnical Engineer

PERMIT TO PRACTICE
BC Ministry of Transportation and Infrastructure
PERMIT NUMBER: 1003429
Engineers and Geoscientists of BC

Attachments: Attachment 1: Draft Borehole Logs

Ministry of Transportation and Infrastructure — BRITISH COLUMBIA

SUMMARY LOG

Drill Hole #: **TH23-01**

Project: **Renfrew Road Shawnigan Shoulder Washout**
Location: 2795 Renfrew Road, Cowichan Valley

Date(s) Drilled: Feb 9, 2023
Company: Drillwell Enterprises Ltd.
Driller: Cody Aumen
Drill Make/Model: Boart LS250
Drilling Method: Sonic

Prepared by: Ministry of Transportation & Infrastructure
Logged by: VL Reviewed by:

Datum:
Alignment:
Northing/Easting: 5389500 , 449137
Station/Offset:
Elevation:
Coordinates taken with GPS 2023-02-09

Column headings: DEPTH (m) | DRILLING DETAILS / SPT | ✕ Pocket Penetrometer ✕ Shear Strength (kPa) 100 200 300 400; ▲ SPT "N" (BLOWS/300 mm) ▲; W_P% W% W_L% 20 40 60 80 | SAMPLE TYPE | SAMPLE NO | RECOVERY (%) | SOIL SYMBOL | SOIL DESCRIPTION | CLASSIFICATION | COMMENTS TESTING (Drillers Estimate *{G % S % F %}*) | DEPTH (m)

Depth (m)	Soil Description	Classification	Comments / Testing
0 – 0.08m	ASPHALT	AP	*{G:80 S:15 F:5}*
0.08 – 0.89m	Sandy GRAVEL, fine to coarse gravel, well graded, sub-angular, fine to coarse sand, brown, moist, compact, (FILL).	GW	
0.89 – 1.75m	SAND and GRAVEL, some silt, fine to coarse gravel, well-graded, sub-angular, brown-grey, moist, loose (FILL).	SW	**Sieve** (Sa#G1) G:36% S:56% F:8%; *{G:80 S:5 F:15}*
1.75 – 2.59m	ORGANIC CLAY and SAND, medium plastic, dark brown, moist, very soft, slow dilatancy.	OL	**Atterberg** (Sa#G2): PL:16% LL:27%; **Sieve** (Sa#G2) G:0% S:84% F:16%
2.59 – 6.4m	Gravelly Silty SAND, fine to coarse gravel, well-graded, sub-angular to sub-rounded, brown, contains cobbles, moist, very dense.	SM1	*{G:80 S:5 F:15}*; **Sieve** (Sa#G3) G:19% S:62% F:19%; *{G:70 S:15 F:15}*
6.4m –	Gravelly Silty SAND, fine to coarse gravel, well graded, sub-angular to sub-rounded, grey, contains cobbles and boulders, dry, very dense based on drill response (TILL-LIKE). -Transitions from grey to brown color at 8.1m	SM2	*{G:70 S:15 F:15}*; **Sieve** (Sa#G5) G:24% S:52% F:24%; **Sieve** (Sa#G6) G:33% S:44% F:23%

Sample No	Sample Type	Recovery (%)	SPT blows	Water content W%
G1	Grab			7.6
S1	Split Spoon	33	0 / 1 / 1 / 1	
G2	Grab			224.2
S2	Split Spoon	21	11 / 22 / 30 / 46	
G3	Grab			
S3	Split Spoon	0	0	
G4	Grab			7.7
S4	Split Spoon	25	31 / 35 / 58 (>>)	
G5	Grab			7.2
G6	Grab			
G7	Grab			

Legend Sample Type: A-Auger; B-Becker; C-Core; G-Grab; V-Vane; L#-Lab Sample; S-Split Spoon; O-Odex (air rotary); W-Wash (mud return); T-Shelby Tube

Final Depth of Hole: 15.2 m
Depth to Top of Rock:

SUMMARY LOG

Ministry of Transportation and Infrastructure — BRITISH COLUMBIA

Drill Hole #: TH23-01

Project: **Renfrew Road Shawnigan Shoulder Washout**
Location: 2795 Renfrew Road, Cowichan Valley

Date(s) Drilled: Feb 9, 2023
Company: Drillwell Enterprises Ltd.
Driller: Cody Aumen
Drill Make/Model: Boart LS250
Drilling Method: Sonic

Prepared by: Ministry of Transportation & Infrastructure
Logged by: VL Reviewed by:

Datum:
Alignment:
Northing/Easting: 5389500 , 449137
Station/Offset:
Elevation:
Coordinates taken with GPS 2023-02-09

Columns: DEPTH (m) | DRILLING DETAILS (SPT) | ✕ Pocket Penetrometer ✕ Shear Strength (kPa) 100 200 300 400 / ▲ SPT "N" (BLOWS/300 mm) ▲ / W_P% W% W_L% 20 40 60 80 | SAMPLE TYPE | SAMPLE NO | RECOVERY (%) | SOIL SYMBOL | SOIL DESCRIPTION | CLASSIFICATION | COMMENTS TESTING / Drillers Estimate *{G % S % F %}* | DEPTH (m)

Depth (m)	Sample No	Soil Description	Classification	Comments / Testing
10 – 11.58	G8 (≈11.0–11.3)	Gravelly Silty SAND, fine to coarse gravel, well graded, sub-angular to sub-rounded, grey, contains cobbles and boulders, dry, very dense based on drill response (TILL-LIKE). *(continued)*		**Sieve** (Sa#G7) G:19% S:53% F:28%; *{G:60 S:10 F:30}*
11.58m – 15.24m	G9 (≈12.8–13.1), G10 (≈14.3–14.6)	BEDROCK, weathered	BR	**Sieve** (Sa#G10) G:11% S:77% F:12%
15.24m		End of Hole at 15.24m. Water not encountered in hole. Hole backfilled upon completion.		

Depth scale: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Final Depth of Hole: 15.2 m
Depth to Top of Rock:

SUMMARY LOG

Drill Hole #: TH23-02

BRITISH COLUMBIA — Ministry of Transportation and Infrastructure

Project: **Renfrew Road Shawnigan Shoulder Washout**
Location: 2795 Renfrew Road, Cowichan Valley
Datum:
Alignment:
Northing/Easting: 5389493 , 449133
Station/Offset:
Elevation:
Coordinates taken with GPS 2023-02-09

Prepared by: Ministry of Transportation & Infrastructure
Logged by: VL Reviewed by:

Date(s) Drilled: Feb 9, 2023
Company: Drillwell Enterprises Ltd.
Driller: Cody Aumen
Drill Make/Model: Boart LS250
Drilling Method: Sonic

Pocket Penetrometer / Shear Strength (kPa): 100, 200, 300, 400
SPT "N" (BLOWS/300 mm)
W_P% — W% — W_L%: 20, 40, 60, 80

Depth (m)	Soil Description	Classification
0 – 0.08m	ASPHALT	AP
0.08 – 0.61m	Sandy GRAVEL, fine to coarse gravel, well-graded, sub-angular, fine to coarse sand, brown, moist.	GW
0.61 – 0.91m	SAND and GRAVEL, trace silt, fine to coarse gravel, well-graded, sub-angular, brown-grey, moist, loose (FILL).	SW
0.91 – 2.24m	Organic CLAY and SAND, medium plastic, dark brown, moist, very sift, slow dilatancy. -Woody debris present from 0.91m to 1.22m	OL
2.24 – 2.44m	SILTY CLAY, some sand, low plastic, grey and brown, w~PL, soft.	CL-ML
2.44 – 7.26m	Silty SAND and GRAVEL, fine to coarse gravel, well-graded, sub-angular to sub-rounded, brown to brown-grey, contains cobbles, moist, very dense.	SM1
7.26m –	Gravelly Silty SAND, fine to coarse gravel, poorly-graded, sub-angular to sub-rounded, grey, contains cobbles and boulders, dry, very dense based on drill response (TILL-LIKE).	SM2 SM3

Sample No	Sample Type	SPT (blows)	Recovery (%)	W%	Comments / Testing
					{G:80 S:15 F:5}
G1	Grab			19	**Sieve** (Sa#G1) G:46% S:50% F:4%
S2	Split Spoon	0, 1, 0, 1	21		{G:0 S:0 F:100}
G2	Grab			17.6	**Atterberg** (Sa#G2): PL:18% LL:23%; **Sieve** (Sa#G2) G:0% S:13% F:87%
G3	Grab			14.3	**Sieve** (Sa#G3) G:16% S:65% F:19%
S2	Split Spoon	10, 10, 11, 13	25		{G:75 S:10 F:15}
G4	Grab				**Sieve** (Sa#G4) G:48% S:41% F:11%
S3	Split Spoon	11, 11, 25, 44	31		
G5	Grab			14.7	{G:60 S:25 F:15}
S4	Split Spoon	30, 26, 33, 40	92	15.2	
G6	Grab				**Sieve** (Sa#G6) G:23% S:70% F:7%
S6	Split Spoon	11, 26, 50 (>>)	58		{G:60 S:20 F:20}
G7	Grab			12.6	**Sieve** (Sa#G7) G:9% S:55% F:36%
S7	Split Spoon	9			{G:60 S:25 F:15}

Legend Sample Type: A-Auger; B-Becker; C-Core; G-Grab; V-Vane; L#-Lab Sample; S-Split Spoon; O-Odex (air rotary); W-Wash (mud return); T-Shelby Tube

Final Depth of Hole: 15.2 m
Depth to Top of Rock:

SUMMARY LOG

British Columbia — Ministry of Transportation and Infrastructure

Drill Hole #: TH23-02

Project: **Renfrew Road Shawnigan Shoulder Washout**
Location: 2795 Renfrew Road, Cowichan Valley

Date(s) Drilled: Feb 9, 2023
Company: Drillwell Enterprises Ltd.
Driller: Cody Aumen
Drill Make/Model: Boart LS250
Drilling Method: Sonic

Prepared by: Ministry of Transportation & Infrastructure
Logged by: VL   Reviewed by:

Datum:
Alignment:
Northing/Easting: 5389493 , 449133
Station/Offset:
Elevation:
Coordinates taken with GPS 2023-02-09

Column headings: DEPTH (m) | DRILLING DETAILS (SPT) | Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); W_P% W% W_L% 20 40 60 80 | SAMPLE TYPE | SAMPLE NO | RECOVERY (%) | SOIL SYMBOL | SOIL DESCRIPTION | CLASSIFICATION | COMMENTS TESTING (Drillers Estimate *{G % S % F %}*) | DEPTH (m)

Depth (m)	W%	Sample No	Soil Description	Classification	Comments / Testing
10.0–11.28	4.6	G8	Gravelly Silty SAND, fine to coarse gravel, poorly-graded, sub-angular to sub-rounded, grey, contains cobbles and boulders, dry, very dense based on drill response (TILL-LIKE). *(continued)*		**Sieve** (Sa#G8) G:25% S:48% F:26%
11.28–15.24		G9, G10	BEDROCK, weathered	BR	
15.24			End of Hole at 15.24m. Water not encountered in hole. Hole backfilled upon completion.		

Depth scale: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Final Depth of Hole: 15.2 m
Depth to Top of Rock:

SUMMARY LOG

Drill Hole #: TH23-03

BRITISH COLUMBIA — Ministry of Transportation and Infrastructure

Prepared by: Ministry of Transportation & Infrastructure
Logged by: VL Reviewed by:

Project: **Renfrew Road Shawnigan Shoulder Washout**
Location: 2795 Renfrew Road, Cowichan Valley
Datum: Alignment:
Northing/Easting: 5389539 , 449368 Station/Offset:
Elevation: *Coordinates taken with GPS 2023-02-10*

Date(s) Drilled: Feb 10, 2023
Company: Drillwell Enterprises Ltd.
Driller: Cody Aumen
Drill Make/Model: Boart LS250
Drilling Method: Sonic

Columns: DEPTH (m) | DRILLING DETAILS | SPT | ✕ Pocket Penetrometer ✕ Shear Strength (kPa) 100 200 300 400 | ▲ SPT "N" (BLOWS/300 mm) ▲ | W_P% W% W_L% 20 40 60 80 | SAMPLE TYPE | SAMPLE NO | RECOVERY (%) | SOIL SYMBOL | SOIL DESCRIPTION | CLASSIFICATION | COMMENTS TESTING Drillers Estimate *{G % S % F %}* | DEPTH (m)

Depth to base	Soil Description	Classification
0.1m	ASPHALT	AP
0.28m	Sandy GRAVEL, fine to coarse gravel, well-graded, sub-angular, fine to coarse sand, brown, moist.	GW
2.64m	SAND and GRAVEL, some silt, fine to coarse gravel, well-graded, angular, dark brown, moist, very loose (FILL).	SW
3.43m	ORGANIC CLAY and SAND, some gravel, medium plastic, dark brown, moist, very soft, slow dilatancy.	OL
5.69m	SILTY Sand and Gravel, fine to coarse gravel, well-graded, sub-angular to sub-rounded, brown, contains cobbles, moist, very dense.	SM1
9.14m	Gravelly SAND and SILT, fine to coarse gravel, poorly-graded, sub-angular to sub-rounded, grey, contains cobbles and boulders, dry, very dense based on drill response (TILL-LIKE).	SM3 SM4

Sample No	Recovery (%)	SPT	W%	Comments / Testing
G1			10.5	**Sieve** (Sa#G1) G:45% S:43% F:12%
S1	42	5, 3, 1, 4		**Sieve** (Sa#S1) G:26% S:59% F:15%
G2			27.4	**Atterberg** (Sa#G2): PL:24% LL:31%; **Sieve** (Sa#G2) G:26% S:55% F:19%
S2	19	0, 0, 0, 1		*{G:0 S:0 F:100}*
G3				**Sieve** (Sa#G3) G:43% S:42% F:15%
S3	44	15, 26, 18, 19		*{G:80 S:10 F:10}*
G4			7.3	
S4	33	11, 15, 14, 25	8.4	**Sieve** (Sa#S4) G:27% S:11% F:62%
G5				**Sieve** (Sa#G5) G:18% S:42% F:40%
G6			16.6	**Sieve** (Sa#G6) G:0% S:15% F:85%
S6	29	0		*{G:65 S:5 F:30}*

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

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Final Depth of Hole: 15.2 m
Depth to Top of Rock:

SUMMARY LOG

British Columbia Ministry of Transportation and Infrastructure

Drill Hole #: TH23-03

Project: **Renfrew Road Shawnigan Shoulder Washout**
Location: 2795 Renfrew Road, Cowichan Valley

Date(s) Drilled: Feb 10, 2023
Company: Drillwell Enterprises Ltd.
Driller: Cody Aumen
Drill Make/Model: Boart LS250
Drilling Method: Sonic

Prepared by: Ministry of Transportation & Infrastructure
Logged by: VL Reviewed by:

Datum:
Alignment:
Northing/Easting: 5389539 , 449368
Station/Offset:
Elevation:
Coordinates taken with GPS 2023-02-10

Column headings: DEPTH (m) | DRILLING DETAILS | SPT | Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); W_P% W% W_L% 20 40 60 80 | SAMPLE TYPE | SAMPLE NO | RECOVERY (%) | SOIL SYMBOL | SOIL DESCRIPTION | CLASSIFICATION | COMMENTS TESTING Drillers Estimate *{G % S % F %}* | DEPTH (m)

Depth (m)	Sample No	Soil Description	Classification	Comments / Testing
10.0 – 14.58		Silty SAND and GRAVEL, fine to coarse gravel, poorly-graded, sub-angular to sub-rounded, grey, contains cobbles and boulders, dry, very dense based on drill response (TILL-LIKE). -Boulder present from 10.4m to 11.0m *(continued)*	SM1	
~10.5	G7			*{G:65 S:5 F:30}*
~11.7	G8			*{G:65 S:10 F:25}*
~13.0	G9 (W% 3.6)			**Sieve** (Sa#G9) G:43% S:42% F:15%
~13.9	G10			*{G:65 S:5 F:30}*
14.58m – 15.24m		BEDROCK, weathered	BR	
15.24m		End of Hole at 15.24m. Water not encountered in hole. Hole backfilled upon completion.		

Depth scale: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

Draft

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Final Depth of Hole: 15.2 m
Depth to Top of Rock:

SUMMARY LOG

Drill Hole #: TH23-04

Ministry of Transportation and Infrastructure, British Columbia

Prepared by: Ministry of Transportation & Infrastructure

Logged by: VL Reviewed by:

Project: **Renfrew Road Shawnigan Shoulder Washout**

Location: 2795 Renfrew Road, Cowichan Valley

Datum:

Alignment:

Northing/Easting: 5389535 , 449379

Station/Offset:

Elevation:

Coordinates taken with GPS 2023-02-13

Date(s) Drilled: Feb 13, 2023

Company: Drillwell Enterprises Ltd.

Driller: Cody Aumen

Drill Make/Model: Boart LS250

Drilling Method: Sonic

✕ Pocket Penetrometer ✕ Shear Strength (kPa) 100 200 300 400

▲ SPT "N" (BLOWS/300 mm) ▲

W_P% W% W_L% 20 40 60 80

DEPTH (m)	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING / Drillers Estimate *{G % S % F %}*
0 – 0.13m	ASPHALT	AP	
0.13m – 0.41m	Sandy GRAVEL, fine to coarse gravel, well-graded, sub-angular, fine to coarse sand, brown, moist	GW	*{G:75 S:15 F:10}*
0.41m – 2.29m	Silty SAND and GRAVEL, fine to coarse gravel, well-graded, angular, fine to coarse sand, dark brown, moist, compact (FILL).	SM1	**Atterberg** (Sa#G1): PL:22% LL:35% **Sieve** (Sa#G1) G:33% S:42% F:25% *{G:70 S:10 F:20}* **Sieve** (Sa#G2) G:39% S:52% F:9%
2.29m – 3.12m	ORGANIC CLAY and SAND, some gravel, medium plastic, dark brown, moist, very soft, slow dilatancy.	OL	
3.12m – 5.28m	SILTY SAND and GRAVEL, fine to coarse gravel, well-graded, sub-angular to sub-rounded, brown, contains cobbles, moist, very dense.	SM1	**Sieve** (Sa#S2) G:25% S:47% F:28% **Atterberg** (Sa#G3): PL:14% LL:20% **Sieve** (Sa#G3) G:41% S:44% F:15% *{G:60 S:25 F:15}*
5.28m –	Gravelly SAND and SILT, fine to coarse gravel, poorly-graded, sub-angular to sub-rounded, grey, contains cobbles and boulders, dry, very dense based on drill response (TILL-LIKE) -Transitions from grey to blue-grey at 8.7m with increased fine sand content.	SM2	*{G:60 S:25 F:15}* **Sieve** (Sa#S4) G:22% S:52% F:26% **Sieve** (Sa#G5) G:26% S:47% F:27% *{G:60 S:15 F:25}* **Sieve** (Sa#G6) G:10% S:61% F:29% *{G:60 S:25 F:15}*

SAMPLE NO	SPT	RECOVERY (%)	W%
G1			15.6
S1	7, 7, 12, 13	27	
G2			
S2	1, 2, 19, 11	50	14.1
G3			9.1
S3	19, 20, 32, 50	54	9.7
G4			
S4	0	25	8.2
G5			
S5	0	8	
G6			8.2
S6	0	21	
G7			

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Final Depth of Hole: 22.9 m

Depth to Top of Rock:

MOTI-SOIL-REV3 RENFREWCULVERTS_2023TH_2023-03-01.GPJ MOTI_DATATEMPLATE_REV3.GDT 23-3-30

SUMMARY LOG

Drill Hole #: TH23-04

Ministry of Transportation and Infrastructure — British Columbia

Project: **Renfrew Road Shawnigan Shoulder Washout**
Location: 2795 Renfrew Road, Cowichan Valley

Date(s) Drilled: Feb 13, 2023
Company: Drillwell Enterprises Ltd.
Driller: Cody Aumen
Drill Make/Model: Boart LS250
Drilling Method: Sonic

Prepared by: Ministry of Transportation & Infrastructure
Logged by: VL Reviewed by:

Datum:
Northing/Easting: 5389535 , 449379
Elevation:
Alignment:
Station/Offset:
Coordinates taken with GPS 2023-02-13

DEPTH (m)	SAMPLE NO	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING (Drillers Estimate {G % S % F %})
10		Gravelly SAND and SILT, fine to coarse gravel, poorly-graded, sub-angular to sub-rounded, grey, contains cobbles and boulders, dry, very dense based on drill response (TILL-LIKE) -Transitions from grey to blue-grey at 8.7m with increased fine sand content. *(continued)*		*{G:60 S:15 F:25}*
11.73m	G8 (12.0)	Gravelly SAND and SILT, fine to coarse gravel, poorly-graded, angular, fine to coarse sand, dark brown, moist.	SM2	*{G:65 S:20 F:15}*
	G9 (13.2; W% 15)			**Sieve** (Sa#G9) G:10% S:67% F:23%
15.24m	G10 (16.9; W% 51.8)	SAND and SILT, low plastic, coarse to fine sand, angular, some gravel, red brown	ML	**Sieve** (Sa#G10) G:0% S:45% F:55%
17.78m	G11 (19.9)	Sandy GRAVEL, fine to coarse gravel, poorly-graded, sub-angular to sub-rounded, grey, contains cobbles and boulders, dry, very dense based on drill response (TILL-LIKE/possible weathered bedrock per driller) -Drill unable to continue past 22.86m		**Sieve** (Sa#G11) G:59% S:29% F:12%

Chart headings: Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); W_P% W% W_L% 20 40 60 80. Columns: DRILLING DETAILS, SPT, SAMPLE TYPE, RECOVERY (%), SOIL SYMBOL. Depth scale 10–20 m.

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Final Depth of Hole: 22.9 m
Depth to Top of Rock:

SUMMARY LOG

Drill Hole #: **TH23-04**

Ministry of Transportation and Infrastructure, British Columbia

Prepared by: Ministry of Transportation & Infrastructure
Logged by: VL Reviewed by:

Project: **Renfrew Road Shawnigan Shoulder Washout**
Location: 2795 Renfrew Road, Cowichan Valley
Datum: Alignment:
Northing/Easting: 5389535 , 449379 Station/Offset:
Elevation: *Coordinates taken with GPS 2023-02-13*

Date(s) Drilled: Feb 13, 2023
Company: Drillwell Enterprises Ltd.
Driller: Cody Aumen
Drill Make/Model: Boart LS250
Drilling Method: Sonic

DEPTH (m)	DRILLING DETAILS / SPT	Pocket Penetrometer / Shear Strength (kPa) 100 200 300 400; SPT "N" (BLOWS/300 mm); W_P% W% W_L% 20 40 60 80	SAMPLE TYPE	SAMPLE NO	RECOVERY (%)	SOIL SYMBOL	SOIL DESCRIPTION	CLASSIFICATION	COMMENTS TESTING Drillers Estimate *{G % S % F %}*	DEPTH (m)
20							Sandy GRAVEL, fine to coarse gravel, poorly-graded, sub-angular to sub-rounded, grey, contains cobbles and boulders, dry, very dense based on drill response (TILL-LIKE/possible weathered bedrock per driller) -Drill unable to continue past 22.86m *(continued)*	GW		
22			G	G12					*{G:65 S:10 F:25}*	22
22.86m							End of Hole at 22.86m. Water not encountered in hole. Hole backfilled upon completion.			

Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

Legend Sample Type: A-Auger, B-Becker, C-Core, G-Grab, V-Vane, L#-Lab Sample, S-Split Spoon, O-Odex (air rotary), W-Wash (mud return), T-Shelby Tube

Final Depth of Hole: 22.9 m
Depth to Top of Rock: