



**Geotechnical Investigation
Tenas Haul Road
Tenas Project Feasibility Study
Telkwa, BC**

Prepared for:

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1 Introduction and Scope

Westrek Geotechnical Services Ltd. (Westrek) conducted a geotechnical investigation of the proposed Tenas Haul Road. The investigation was conducted as part of Telkwa Coal Ltd.'s (Telkwa) feasibility study, to provide geotechnical parameters for the preliminary road design and capital cost estimate.

The general configuration of the road was detailed in the preliminary design for the prefeasibility study completed in April 2017¹ by DWB Consulting Services Ltd. (DWB). This original layout only covered that portion of the Tenas Haul Road that follows the existing Goathorn Creek Road. DWB subsequently revised the road alignment and extended it 11 km farther to the rail loadout facilities in April 2019². Although the total road alignment is more than 14 km long, this investigation covers approximately Sta. 9+000 to 14+220, and focuses on specific aspects of the road design.

The specific objectives of the geotechnical investigation included the following:

- i. Assess the general stability of the slopes from approximately Sta. 11+400 to Sta. 12+000, to recommend suitable cut and fill slope angles.
- ii. Assess the recent fillslope failure near Sta. 11+400.
- iii. Assess the recent cutslope failure near Sta. 11+800 and prepare a conceptual design of stabilization measures.
- iv. Assess fillslope stability near Sta. 13+040 and prepare a conceptual design of stabilization measures.
- v. Assess the foundation conditions for the large fill planned across the draw near Sta. 13+700.
- vi. Assess slope stability from about Sta. 13+840 to 14+220 where extensive tension cracking was noted in the existing road.
- vii. Assess road subgrade conditions from Sta. 9+000 to 12+500 and preliminary design of the structural thicknesses for the gravel-surfaced haul road.
- viii. Assess the foundation bearing conditions at the proposed bridge site.

The road stationing was developed after the field investigation was completed; therefore, all stations throughout this report are approximate only.

The services provided by Westrek are subject to the terms and conditions set out in the *Interpretation and Use of Study and Report and Limitations*, which is attached in Appendix A and incorporated herein by reference.

¹ DWB Drawings 17364-018-P40 to P42, Rev A, "Telkwa Coal Limited, Prefeasibility Study Goathorn Creek Road (Small Mine Option)", dated 2017-04-24.

² DWB Drawings 18364-204-00 to -16 "Telkwa Coal Limited, Tenas Haul Road", dated 2019-04-12; and Cross-sections Drawings 18364-204-X1 to -X94, dated 2019-04-09.

2 Background Research

The geology of the area, development history, and landslide history were reviewed using the following background information.

2.1 Historical Airphotos

The historical airphotos used for this project are listed below:

Year	Flightline	Number
1949	BC 1020	38 to 40
1959	BC 2670 BC 2671	72 to 74 37 to 39
1968	BC 5301	231 to 233
1972	BC 5481	162 to 163
1975	BC 7746 BC 7747	174 to 176 23 to 25
1987	BCC 700	109 to 111 & 156 to 158
1993	BCC 93064	100 to 101 & 134 to 136
2001	BCC 01004	136 to 137
2006	BCC 06043	52 to 54 & 118 to 120

2.2 Historical Mine Workings

A plan showing the historic mine workings in the general vicinity of Goathorn Creek Road was included as Figure 1-1 of a memo by ERM Consultants Canada Ltd. dated August 24, 2018. A more detailed plan and cross-sections of BVC No. 2 Mine, which is the closest mine and has the greatest impact on the current project, were provided by Telkwa Coal Ltd.

2.3 Terrain Mapping

Preliminary mapping of the surficial geology and terrain stability along the road corridor was provided by Weiland Terrain Sciences. The mapping is fairly high-level and initially only covered the road corridor from Sta. 0+000 to 12+000 and, as such, did not include the main elements of this geotechnical investigation. The map coverage was subsequently expanded to include the remainder of the road alignment in August 2019.

3 Investigation

3.1 Phase I

Phase I of the geotechnical investigation included drilling three boreholes between September 24 and 29, 2018. The sonic boreholes were completed by Boart Longyear to depths ranging from 12.2 m to 30.5 m below ground surface. A rubber-tracked Minisonic LS250 drill rig was used with 150 mm diameter casing to retrieve 100 mm diameter core samples. Sonic drilling methods were used with and without water, depending on the soil recovery. Representative samples were obtained from the sonic core for laboratory testing (Section 3.6).

Dynamic Cone Penetration Tests (DCPTs) were conducted to assess the relative soil densities until encountering near-refusal. Standard Penetration Tests (SPTs) were also conducted at select depths to confirm the DCPT results.

3.2 Phase II

A total of 11 test pits were excavated along the proposed haul road, in Phase II of the investigation, to evaluate subgrade conditions. TP18-29 to TP18-33 were excavated along the proposed new alignment from Sta. 9+000 to Sta. 11+400. TP18-34 to TP18-37 were excavated along the existing Goathorn Creek Road from Sta. 11+400 to 12+450. TP18-38 and TP18-39 were excavated in a gravel pit located off of Caribou FSR01. No test pits were excavated along the first 9 km of new alignment, nor were any test pits excavated along the existing road beyond Sta. 12+450.

The subgrade at most of the test pit sites was also evaluated in-situ using a Zorn Instruments ZFG 3000 GPS Lightweight Deflectometer (LWD). The LWD fall weight is 10 kg and the fall height is 535 cm, delivering a maximum pulse force of 7.07 kN to the 20 cm diameter load plate. The deflection of the subgrade was measured after each of three pulses and a dynamic deflection modulus (E_{vd}) was calculated.

The subgrade strength was also assessed in-situ by Dynamic Cone Penetration Tests (DCPTs) using a portable hammer and cone. Westrek's portable DCPT equipment uses a 6.8 kg hammer and a drop height of 50.8 cm to deliver approximately 30 kN-m/m² of energy per blow. DCPTs were performed, according to the manufacture's (AMS Inc.) specifications, adjacent to TP18-29 to TP18-33, and TP18-35, to depths ranging from 0.5 to 1.5 m, depending on where heavy resistance occurred. Calibration charts were used to estimate Standard Penetration Testing (SPT) "N" values based on the penetration resistance.

The test pits were relatively shallow because the subgrade analyses relied more on the LWD and DCPTs, which penetrated beyond the bottom of the test pits.

3.3 Phase III

Phase III of the investigation included drilling 7 boreholes using the same sonic drill as Phase I.

- Boreholes T19-28S to T19-31S were drilled between Sta. 13+840 and 14+200, where tension cracks and apparent ground movement were noted in the road;
- Borehole T19-32S was drilled near Sta. 13+600, where a high fill will be constructed across a draw; and
- Borehole T19-33S was drilled near the west abutment of the revised bridge location.

3.4 Summaries

The locations of the boreholes and test pits are shown on Drawings 1 to 3 (Appendix B). The Phase I and III borehole locations were surveyed by HBH Land Surveying Inc. (HBH). The Phase II test pits were not surveyed; therefore, the locations and elevations are approximate only based on measurements by Westrek using a handheld GPS (estimated accuracy ± 3 to 10 m).

Borehole logs are provided in Appendix C, while Table 1 summarizes the borehole locations and depths.

Table 1 Summary of Boreholes & Test Pits

Phase	Borehole/ Test Pit	Location	Approximate Station Tenas Haul Road	Total Depth (below surface)
Phase 1	T18-14S	Goathorn Creek Road	Near 11+400	30.5 m
	T18-15S	Caribou FSR01	150 m left of 12+100	30.5 m
	T18-16S	Goathorn Creek Road original bridge crossing.	120 m south of Bridge	12.2 m
Phase 2	TP18-29	Proposed New Alignment	8+975	1.6 m
	TP18-30	Proposed New Alignment	9+350	1.1 m
	TP18-31	Proposed New Alignment	9+860	1.4 m
	TP18-32	Proposed New Alignment	70 m left of 10+340	1.5 m
	TP18-33	Proposed New Alignment	11+200	1.7 m
	TP18-34	Goathorn Creek Road	11+390	0.8 m
	TP18-35	Goathorn Creek Road	11+790	1.6 m
	TP18-36	Goathorn Creek Road	12+450	1.0 m
	TP18-37	Goathorn Creek Road	12+100	1.6 m
	TP18-38	Gravel Pit off Caribou FSR01	n/a	2.2 m
	TP18-39	Gravel Pit off Caribou FSR01	n/a	1.5 m

Phase	Borehole/ Test Pit	Location	Approximate Station Tenas Haul Road	Total Depth (below surface)
Phase 3	T19-28S	Goathorn Creek Road	10 m left of 14+145	16.8 m
	T19-28S-1	Goathorn Creek Road	14+145	10.7 m
	T19-29S	Goathorn Creek Road	14+000	10.7 m
	T19-29S-1	Goathorn Creek Road	13+980	3.0 m
	T19-30S	Goathorn Creek Road	14+010	18.3 m
	T19-31S	Goathorn Creek Road	13+915	24.4 m
	T19-32S	Goathorn Creek Road	13+630	17.4 m
	T19-33S	West abutment of revised bridge location.	13+260	6.1 m

3.5 Instrumentation

3.5.1 Installations

Standpipe piezometers were installed in Boreholes T18-14S and T18-15S, and consist of 50 mm diameter PVC. The slotted sections are located near the contact between the till and overlying sand and gravel sequences at both locations. Vibrating wire (VW) piezometers were installed in Boreholes T19-28S, T19-29S, T19-30S, and T19-31S. The VW piezometers were grouted in place using a bentonite/cement grout mix.

Slope inclinometers were installed in Boreholes T19-28S, T19-29S, T19-30S, and T19-31S and were also grouted in place using a bentonite/cement mix.

Table 2 summarizes the piezometer and inclinometer installations.

Table 2: Summary of Installations

Borehole	Piezometer Depth [Elevation]	Groundwater Measurements		Slope Inclinometer Depth / Elevation
		High Water Depth [Elevation]	Low Water Depth [Elevation]	
T18-14S	6.7 – 8.2 m [674.8 – 676.3 m]	5.4 m [677.6 m]	5.9 m [677.1 m]	-
T18-15S	11.3 – 14.3 m [702.4 – 705.4 m]	12.4 m [704.3 m]	12.7 m [704.0 m]	-
T19-28S	9.1 m [701.3 m]	6.5 m [703.9 m]	7.5 m [702.9 m]	16.8 m / 693.6 m
T19-29S	-	-	-	10.7 m / 696.2 m
T19-30S	14.9 m [691.8 m]	11.4 m [695.3 m]	13.6 m [693.1 m]	18.3 m / 688.4 m
T19-31S	7.6 m [697.3 m]	(no water) [<697.3 m]		24.4 m / 680.5 m

3.5.2 Monitoring

The two standpipe piezometers were initially measured on November 13, 2018, shortly after installation, and then again on December 12. Telkwa subsequently assumed responsibility of monitoring and measured them monthly up until May 2019 and then every two to three months. The latest readings included in this report were from November 19, 2019. The range of groundwater levels are provided on Table 2.

The VW piezometers were fitted with automatic data loggers and programmed to read groundwater pressures every 4 hours. The data must be manually downloaded, which was done periodically up until November 26, 2019. The range of groundwater pressures are included on Table 2.

The SIs were initially measured by Westrek on February 24, 2019 and again on April 3. Subsequent readings were made by Telkwa on April 19, May 27, September 2, and November 26. Telkwa is expected to continue monitoring the SIs and piezometers. The results are discussed for the relevant sections of the road in Sections 12, 13 and 14.

The use of three different inclinometer probes seems to have affected the readings, creating a higher than normal variability in the measurements. This variability is not serious but affects the instrument accuracy and the ability to interpret the results. Future readings, using only Telkwa's SI probe should not encounter the same variability, thereby improving the overall accuracy and reliability in the long term.

3.6 Laboratory Testing

A laboratory testing program was carried out to assist in characterizing the soil's engineering properties. Selected samples from the Phase I drilling program were submitted for testing to Wood Environment & Infrastructure's laboratory in Kamloops. Selected samples from Phase II test pitting and Phase III drilling were tested by Golder Associates.

The analyses carried out included:

- 45 moisture contents,
- 9 hydrometer,
- 6 standard Proctor density tests,
- 1 LA Abrasion Test
- 26 wash sieves (grain size analyses),
- 10 Atterberg limits,
- 6 California Bearing Ratio (CBR) Tests
- 2 Micro-Deval Tests

The borehole samples tested are summarized on Table 3A, while the test pit samples tested are summarized on Table 3B.

The laboratory test results are provided in Appendix D and summarized on the borehole logs. The laboratory results pertaining to the road structure are discussed in Section 16.1.

Table 3A.
Summary of Laboratory Tests on Bore Hole Samples

Borehole	Sample	Depth (m)	Moisture Content	Wash Sieve	Hydrometer	Atterberg Limits
T18-14S	SA-03	4.9 – 5.2	X			
T18-14S	SA-06	7.0 – 7.3	X			
T18-14S	SS-02	10.7 – 11.3	X			
T18-14S	SA-08	12.8 – 13.1	X			X
T18-14S	SA-10	17.1 – 17.4	X	X	X	
T18-14S	SA-12	21.9 – 22.3	X			
T18-14S	SA-15	28.3 – 28.7	X			
T18-15S	SA-03	5.2 – 5.5	X	X		
T18-15S	SA-05	11.0 – 11.3	X			
T18-15S	SA-06	13.7 – 14.0	X			
T18-15S	SA-08	20.7 – 21.0	X			X
T18-15S	SA-11	26.5 – 27.1	X			
T19-28S	SA-01	1.2 - 1.5	X	X		
T19-28S	SA-02	2.7 – 3.0	X			
T19-28S	SA-03	5.8 – 6.1	X	X	X	
T19-28S	SA-05	8.5 – 8.8	X			
T19-28S-1	SA-01	1.2 – 1.5	X			
T19-28S-1	SA-03	4.0 – 4.3	X	X	X	
T19-28S-1	SA-05	8.5 – 8.8	X			
T19-30S	SA-01	1.2 – 1.5	X			
T19-30S	SA-03	4.3 – 4.6	X	X	X	X
T19-30S	SA-04	8.8 – 9.1	X			
T19-30S	SA-06	11.9 – 12.2	X	X	X	
T19-30S	SA-09	13.7 – 14.0	X	X	X	
T19-31S	SA-01	1.2 - 1.5	X	X		
T19-31S	SA-02	4.3 – 4.6	X			
T19-31S	SA-03	8.2 – 8.5	X	X		
T19-31S	SA-04	13.1 – 13.4	X	X	X	
T19-31S	SA-05	17.4 – 17.7	X			
T19-32S	SA-02	4.9 – 5.2	X	X	X	X
T19-32S	SA-03	8.2 – 8.5	X			
T19-32S	SA-04	10.4 – 10.7	X	X	X	X
T19-33S	SA-01	1.2 – 1.5	X	X		

Table 3B.
Summary of Laboratory Tests on Test Pit Samples

Borehole	Sample	Depth (m)	Moisture Content	Wash Sieve	Hydrometer	Atterberg Limits	Standard Proctor	CBR	LA Abrasion	Micro-Deval
TP18-29	SA-01	0.7 to 1.2	X	X		X	X	X		
TP18-30	SA-01	0.6 to 1.0	X	X		X				
TP18-31	SA-01	0.75 to 1.25	X	X		X	X	X		
TP18-32	SA-01	0.5 to 1.0	X	X		X				
TP18-32	SA-02	1.3 to 1.5	X	X		X				
TP18-33	SA-01	0.5 to 1.0	X	X						
TP18-35	SA-01	0.2 to 0.4	X	X			X	X		
TP18-35	SA-02	0.75 to 1.25	X	X						
TP18-36	SA-01	0.3 to 0.7	X	X			X	X		
TP18-37	SA-01	0.1 to 0.5	X	X						
TP18-38	SA-01	1.9 to 2.2	X	X			X	X	X	X
TP18-39	SA-01	1.2 to 1.5	X	X			X	X		X

4 Development History

The Goathorn Creek area has an extensive mining history, based on maps of historical workings provided by Telkwa.

- Bulkley Valley Collieries (BVC) No. 1 Mine was an underground mine that operated between 1930 and 1943 beneath the east bank of Goathorn Creek, adjacent to the original bridge site along Goathorn Creek Road.
- BVC No. 2 Mine was an underground mine that operated from 1943 to 1951 within the west bank of the valley, adjacent to the Telkwa Haul Road between approximately Sta. 13+900 and 14+100. A structure, probably the tipple, is visible in the 1959 airphotos near Sta. 14+050.
- BVC No. 3 Mine was an underground mine that operated from 1950 to 1951 beneath the east bank of Goathorn Creek, approximately 500 to 750 m southeast of BVC No. 1 Mine.
- BVC No. 4 Mine was an underground mine within the west valley wall opposite approximately Sta. 11+600 to 12+000 of the Telkwa Haul Road (Goathorn Creek Road).
- Luscar Open Pit Mine operated on the west side of the valley, opposite approximately Sta. 11+400.

The extensive mining history has altered the valley in many ways, including the creek channel, waste rock deposits, and an array of access roads. The current Goathorn Creek Road appears to have been constructed during the early years of operation of BVC No. 2 Mine. The original road was located upslope of the current road, descending the valley slope at a gentler grade and reaching the valley bottom near Sta. 12+800. This original road appears to have been used to access BVC No. 1 Mine.

A third road, referred to as Caribou FSR01, branches off Goathorn Creek Road at Sta. 11+425 and follows the crest of the valley slope southward. Borehole T18-15S was drilled alongside this active resource road, which generally follows the edge of the plateau directly above the steep valley slope.

The main impact of past mining activities on the proposed Tenas Haul Road, identified during this investigation, are the thick deposits of waste rock fill from BVC No. 2 Mine dumped between Sta. 13+840 and 14+220 (discussed in Sections 12 to 14).

5 Subsurface Conditions

5.1 Grain Size Test Results

The grain size test results are summarized on Table 4, representing all tests on a variety of soil types. The gradations are discussed in more detail for each soil unit in the following subsections.

Table 4
Summary of Grain Size Analyses

Test Pit/ Borehole	Sample	Gradation					Classification
		% Cobbles	% Gravel	% Sand	% Silt	% Clay	
T18-14S	10	0	3	13	73	11	ML
T18-15S	3	0	44	47	9		SW-SM
T19-28S	1	0	29	35	36		SM-SC
T19-28S	3	0	0	6	59	35	ML-CL
T19-28S-1	3	0	4	9	57	30	ML-CL
T19-30S	3	0	15	29	35	21	ML-CL
T19-30S	6	0	37	8	45	10	ML
T19-30S	9	0	22	10	48	20	ML
T19-31S	1	0	21	28	51		ML-SM
T19-31S	3	0	40	11	49		GM-GC
T19-31S	4	0	14	5	57	24	ML-CL
T19-32S	2	0	4	15	50	31	ML-CL
T19-32S	4	0	0	2	65	33	ML-CL
T19-33S	1	0	47	44	9		GW-GM
TP18-29	1	15	15	26	44		CL
TP18-30	1	0	18	30	52		CL
TP18-31	1	0	18	30	52		CL
TP18-32	1	0	8	30	62		ML-CL
TP18-32	2	0	17	28	55		CL
TP18-33	1	0	2	21	77		CL
TP18-35	1	0	32	47	21		SM-SC
TP18-35	2	0	22	59	19		SM-SC
TP18-36	1	0	62	34	4		GW
TP18-37	1	0	10	73	17		SM-SC
TP18-38	1	3	45	50	2		SP
TP18-39	1	0	52	45	3		GP

Refer to ASTM D2487 for full description of Soil Classification descriptions, procedures and nomenclature.

ML = low plastic silt

CL = low plastic clay

SC = clayey sand

SM = silty sand

SP = poorly graded sand

SW = well-graded sand

GC = clayey gravel

GM = silty gravel

GP = poorly graded gravel

GW = well-graded gravel

G could also signify sandy gravel mixtures

5.2 Road Alignment East of Goathorn Creek Valley

The terrain along the road alignment east of the Goathorn Creek valley is gentle to rolling, and mapped as mostly till. The test pits only sampled the upper 1 to 2 m but typically encountered weathered till immediately below the topsoil. The till is mostly silt, with a fines content ranging from 52% to 62%. The sand content is typically 30% and the gravel content is less than 20%. Trace cobbles and boulders were identified in the field logs but excluded from sampling.

The geology changes close to the Goathorn Creek valley where TP18-33 and Borehole T18-14S both identified sandy silt near the original ground surface.

5.3 East Side of Valley

The geology on the east side of the Goathorn Creek valley consists of a glaciofluvial terrace, comprising glaciofluvial sand and gravel near the crest, underlain by sequences of glaciolacustrine silt and till. The Tenas Haul Road descends across this slope from the north and does not seem to encounter much of the glaciofluvial deposit. Most of the road seems to cut across various deposits of glaciolacustrine silt and till.

Boreholes T18-14S and T18-15S provide a general indication of the surficial geology on the east side of Goathorn Creek, both upslope and downslope of the existing road. Borehole T18-15S was drilled at a higher elevation along Caribou FSR01; therefore, the geologic sequence begins with this borehole.

Borehole T18-15S encountered a thick deposit of compact to dense sand and gravel from the ground surface at 716.7 m elevation down to a depth of 12.8 m (703.9 m elevation). A grain size test on the sample near 5 m depth contains 9% fines, 47% sand and 44% gravel. The deposit contains at least a trace of cobbles; however, drill samples often under-represent the cobble content. DCPT and SPT results indicate that the deposit is compact to dense but the blowcounts could be skewed by the coarse gravel and cobbles. This deposit is interpreted to be of glaciofluvial origin.

The glaciofluvial deposit overlies till at 12.8 m depth in Borehole T18-15S. The till is hard, medium to dark grey, and mostly silt with trace sand, gravel and cobbles. It transitions into hard, maroon brown silt to silty clay, interpreted to be a glaciolacustrine deposit, at 19.2 m (697.5 m elevation). The borehole was drilled to 30.5 m depth (686.2 m elevation) without penetrating beneath the glaciolacustrine deposit.

Borehole T18-14S was drilled to the north near Sta. 11+400, at 683.0 m elevation or 3 m below the bottom of Borehole T18-15S. Therefore, this borehole did not encounter the upper glaciofluvial deposit but, instead, found dark brown, loose to compact sand fill containing chunks of rusty brown, dense silt. This area appears to have been used as a spoil site during construction of the road.

The fill in Borehole T18-14S directly overlies dense sandy silt from about 4.0 m to 6.4 m depth (679.0 m to 676.5 m elevation), interpreted to be glaciolacustrine in origin. This silt deposit is

underlain by a 0.75 m thick seam of dense to very dense, silty sand and gravel that was wet and water bearing. The groundwater discharge is related to the road failure, as discussed in Section 7.

This silty sand and gravel seam is underlain by till at around 7.5 m depth (675.5 m elevation), described as hard, medium to dark grey, silt with trace sand and gravel and containing cobbles. The till transitions into hard, maroon brown silt to silty clay, interpreted to be a glaciolacustrine deposit, at 14.9 m depth (668.9 m elevation). Another till deposit was found to underlie the glaciolacustrine unit at 23.2 m depth (659.8 m elevation).

The till and glaciolacustrine deposits on the valley slope are both overlain by a veneer to blanket of colluvium. Since the colluvium is derived from the same deposits, its composition is similar but more weathered and less competent.

The valley bottom is mostly comprised of contemporary fluvial sand and gravel, with some cobbles and boulders. Bedrock was found to be quite shallow at both the original and revised bridge sites discussed in Section 15.

5.4 West Side of Valley

Bedrock is more dominant on the west side of the Goathorn Creek valley, particularly the ridge west of the road. The gentler terrain between the road and the creek is comprised of glaciolacustrine silt and till overlying shallow bedrock. Contemporary fluvial sediments overlie shallow bedrock in the boreholes at both the original and revised bridge locations, and some bedrock is exposed along the toe of the creek bank downstream of the revised bridge crossing.

The boreholes drilled on the west side of the valley (T19-28S through T19-32S) encountered mostly fill, assumed to be waste rock from BVC No. 2 Mine. Most of the fill is highly weathered and predominantly silt, often gap-graded with some gravel. The fill was found to be underlain by either the glaciolacustrine silt deposit or bedrock.

6 Road Stability – Sta. 11+400 to 11+920

Most of the initial field work on the east side of Goathorn Creek was completed using the original road layout based on stations flagged in the field. The road layout and stationing were both subsequently changed. Based on a comparison of the two alignments, Westrek applied the following chainage equation up to the bridge crossing, but this equation is approximate only (estimated accuracy is ± 5 to 10 m):

Sta. 0+000 of Goathorn Creek Road = Sta. 11+420 of the Tenas Haul Road.

6.1 Road Conditions

6.1.1 Sta. 11+400 to 11+440

A fillslope failure occurred in 2013 at the crossing of gully headwall near the junction of Goathorn Creek Road and Caribou FSR01. Goathorn Creek Road was subsequently realigned on the approach to and across the failure. The outside shoulder of the pre-2013 road appears to have been at least 3 m farther out over the slope.

This failure is described in more detail in Section 7.

6.1.2 Sta. 11+440 to 11+510

The cutslope gradually increases in height from 3 m high to 6 m, sloping at 70 to 80% (1.25H:1V to 1.4H:1V), and is generally stable and partially forested with immature conifer trees.

The fillslope is 90% (1.1H:1V) for the upper 4 to 5 m, then flattens to 80% (1.25H:1V) for approximately 20 m. The slope is forested with immature conifers and mature deciduous trees.

6.1.3 Sta. 11+510 to 11+590

The cutslope is 6 m or higher and slopes from 90% (1.1H:1V) to more than 100% (1:1). Although over-steepened, this cutslope appears to have experienced only small scale slumping and ravelling, particularly from Sta. 11+560 to 11+590.

The fillslope is generally 90% (1.1H:1V) but steepens to 100% (1:1) for 5 to 7 m near Sta. 11+560. The fillslope does not show signs of movement, such as tension cracks along the shoulder, but the fillslope angle is over-steepened and supported against the standing trees.

6.1.4 Sta. 11+590 to 11+640

The cutslope flattens and pulls away from the road.

The fillslope is 100% (1:1) for 5 to 7 m and supported by tree trunks and roots (Photo 1). No tension cracks are visible in the road; however, this fillslope is over-steepened and marginally stable.



Photo 1: Over-steepened fillslope supported by tree roots and trunks near Sta. 11+600.



Photo 2: Cutslope at the bend in the road between Sta. 11+640 and 11+700.

6.1.5 Sta. 11+640 to 11+700

The road bends to the left (south) and reaches the toe of the cutslope again. The cutslope is approximately 13 m long and slopes at 80% (1.25H:1V) with signs of active ravelling. Potential cutslope failures should be relatively small but could still deposit on the road. The ditch is quite small and could be easily filled by ravelled material (Photo 2).

The fillslope gradually flattens and is only 60 to 65% (1.5H:1V to 1.67H:1V) from Sta. 11+650 onward, but merges into the natural slope and continues for more than 60 m below the road. A bare patch 10 to 20 m downslope of the road raises some stability concerns because it is devoid of trees. Groundwater discharge was not noted, but the assessment occurred in September and seepage may be limited to spring snow-melt. The slope steepens to 70% about 20 m farther downslope but no signs of slope movement were observed. Still, this localized area raises some concern for potential slope failures below the road.

6.1.6 Sta. 11+700 to 11+778

The cutslope increases to 20 m or higher and slopes at 70% (1.4H:1V) or more. No signs of groundwater discharge or large-scale slope failures were noted, but the cutslope is close to the angle of repose, creating the potential for small-scale ravelling failures.

The fillslope up to Sta. 11+740 is 90% (1.1H:1V) for 5 to 10 m and then flattens to between 60% and 65% (1.5H:1V to 1.67H:1V). Beyond Sta. 11+740, the fillslope is 90% for more than 20 m. The road shoulder shows no signs of movement and the slope is forested, but the steep angle creates a potential for fillslope failures.

6.1.7 Sta. 11+778 to 11+845

A 30 m wide cutslope failure occurred 1 to 2 years ago between Sta. 11+800 and 11+830, blocking the road. This section of cutslope warrants particular attention and is addressed in Section 8.

The fillslope near Sta. 11+778 is 90% to 100% (1.1H:1V to 1:1) for 5 to 10 m and then flattens onto the natural slope at 50 to 60% (1.67H:1V to 2H:1V) for 15 to 20m before reaching the valley bottom. By Sta. 11+800, the fillslope is 100% (1:1) and visibly over-steepened with fill supported by tree trunks. No tension cracks or other signs of movement were noted, and the toe of the slope is about 20 m below the road grade.

6.1.8 Sta. 11+845 to 11+940

The cutslope pulls away from the road but the terrain upslope ranges from 60 to 65% (1.5H:1V to 1.67H:1V), and is composed of the same glaciolacustrine silt as in the adjacent cutslope failure. No signs of tension cracks or movement were noted beyond Sta. 11+845 and the adjacent failure does not appear to extend to the south. However, the terrain upslope of the road is not distinctly different than in the landslide, thus the potential for another similar failure is a concern.

The fillslope is 90% (1.1H:1V) and leads onto the 60% natural slope, but the toe of the slope is 15 m or less downslope, and continues to reduce as the road grade approaches the valley bottom.

6.2 Road Recommendations

6.2.1 Fillslopes

DWB used a standard fillslope angle of 67% (1.5H:1V) for this section of road, which is reasonable for feasibility design. Actual fillslope angles will depend on the slope height and type of fill material. Where materials excavated during road construction are to be used as fill, such materials are expected to be comprised of glaciolacustrine clayey silt, till, or colluvium derived from till. The till ranges from silty sand to clayey silt with some sand and trace to some gravel and cobbles. Such materials contain a significant fines content and will be difficult to compact when wet, particularly the clayey silt. The moisture content must be controlled, which can be challenging during the wet seasons. Some excavated materials will not be suitable for use as fill. The objective should be to place all fill in maximum 0.3 m lifts and to compact each lift to 95% standard Proctor maximum dry density.

Most of the existing road from Sta. 11+420 to 11+940 was constructed across terrain steeper than 65% (1.5H:1V) and often steeper than 70% (1.4H:1V). Most of the fillslopes are already steeper than 70% and composed of fine-grained soil derived from the adjacent excavations. Most of the existing fillslopes are marginally stable and partially supported by the roots of trees that have grown since construction. Some of the fill is also supported by the trunks of older trees, particularly near the slope crest where the road has been widened by grading. The absence of tension cracks along the outside shoulder indicates that the current fillslopes can remain as is without the need for flattening, provided the existing trees can be maintained. However, in general, the road should not be widened by sidecasting additional fill.

DWB's design cross-sections show sliver fills from Sta. 11+550 to 11+620 and from Sta. 11+760 to 11+815. The existing fillslope is over-steepened and adding sliver fill is not recommended. The narrow benches shown on the cross-sections are not continuous enough to adequately support the toe of the fillslope and some of the sliver fills will not be adequately supported. If additional fill is to be placed, the existing fillslope should be benched to create level benches about every 4 m elevation to support the fillslope. The fill should then be constructed in lifts beginning along the bottom bench. Alternatively, the road can be realigned 1 to 2 m into the cutslope to avoid filling, as discussed in Section 6.2.2.

DWB's design cross-sections also show a sliver fill from Sta. 11+840 to 11+940. Realigning 1 to 2 m into the cutslope could eliminate the need for this sliver fill as well; however, a sliver fill is more viable at this location. This road segment is approaching the valley bottom and the existing fillslope is 12 m high or less. Here, the toe of the existing fillslope is more readily accessible from the south, allowing the toe of the proposed fill to be properly supported. The total height of the fillslope is

more reasonable and the fillslope can be properly constructed in lifts from the bottom upwards. Trees and vegetation would have to be cleared and grubbed from the slope, and the existing fillslope should be benched to allow the additional fill to be well keyed-in. The construction trail should be at least 4 m wide to allow for equipment and truck access. The slope should be over-built and then trimmed by pulling back the outer slope in order to allow better compaction out to the edge of the final fillslope.

6.2.2 Cutslopes

In general, widening of the road could be achieved by excavating farther into the cutslope. The proposed cutslope angles in these cohesive soils should be designed based on the performance of the existing cutslopes. The existing cutslope angles are typically 70 to 90% (1.1H:1V to 1.4H:1V) and have performed adequately with only minor failures, such as ravelling, except for the large failure between Sta. 11+800 and 11+830. Any trimming of the cutslope to widen the road should attempt to recreate the existing cutslope angles. For feasibility design, an average cutslope angle of 1.25H:1V or 80% should be assumed.

DWB's cross-sections do not show any widening of the road into the cutslope, preferring to widen the road onto the fillslope. The segments from Sta. 11+550 to 11+620 and from Sta. 11+760 to 11+815 are recommended to be realigned 1 to 2 m into the cutslope to eliminate the proposed sliver fills. Additional trimming of the cutslope will also be needed along much of the road to deepen the ditch. Most of these cutslopes can be suitably trimmed to 1.25H:1V within the reach-height of a large excavator. Where the crest of the cutslope is beyond the excavator's reach, the cutslope could be steepened to 1.1H:1V.

Still, some sections of the cutslope are already beyond the excavator's reach and the upper part of the cutslope will ultimately be partially undercut. These sections of the cutslope could be more prone to small-scale failures that plug the ditch or even deposit some debris onto the road. Such sections of road often require additional ditch maintenance and grading. If particular sections prove to be problematic, other options can be explored to stabilize the cutslope or contain the debris. In general, such small-scale cutslope hazards are more easily mitigated than an over-steepened or unstable fillslope.

7 Slope Failure at Sta. 11+420

7.1 Site Conditions

This failure near the culvert outlet near Sta. 11+420 reportedly occurred in 2013. Borehole T18-14S was drilled on the east side of the failure and noted 4 m of loose to compact sand fill overlying dense, sandy silt and then till. These conditions match the soil exposures in the headscarp.

The slope below the road forms two small bowls with steep headwalls at 70% to 90%, exposing loose sand (Photo 3). The terrain flattens to 40% roughly 6 m below the road grade where the sandy fill overlies till. The culvert outlet in the west headwall was not flowing at the time of the site assessment, yet significant seepage was discharging below the culvert, increasing farther downslope, and forming a small stream incised through hard clay till. The east headwall does not have a culvert, but groundwater discharges from the base of the sandy fill, forming a second channel (Photo 4). These two channels merge into one incised channel about 70 m downslope of the road, and then drains onto the floodplain below.

Surface water in this area drains from a large, low-lying area 100 to 200 m south along Caribou FSR01, beginning just north of the gravel pit. A trench or ditch was dug along Caribou FSR01 to partially drain this ponded area. The ditch drains into a culvert, across Goathorn Creek Road and directly into the failure headscarp. Water was reportedly ponded in the ditch prior to the failure.



Photo 1: Overview of fillslope failure with the culvert in the middle of the photo and the other bowl to the left. Note the junction with Caribou FSR01. Goathorn Creek Road continues to the right.



Photo 2: View looking up the slide with seepage zone at the base of the fill.

7.2 Causes of Failure

The cause of this slope failure is difficult to determine based on observations 5 years after the event occurred. However, the fillslope failure appears to have been caused by saturated, loose sandy fill dumped over the natural slope at too steep of an angle. The wet conditions were likely caused by ponded water seeping through the sand fill. The sand is predominantly fine grained, relatively loose, and highly erodible. Discharge from the culvert may have caused some erosion, also contributing to the failure.

7.3 Recommendations

The existing Goathorn Creek Road was realigned by at least 3 m across the failure headscarp. However, the slope below the road is still over-steepened and should be flattened by pulling it back to a more uniform 1.5H:1V (67%) or less. DWB's alignment allows for adequate pullback and flattening up to the culvert at Sta. 11+421, but 1 to 2 m more realignment is recommended to improve the slope setback from Sta. 11+425 to 11+440.

The flattened slope should be seeded or vegetated to reduce erosion. Rockfill or cobble armouring should be placed below the culvert outlet, and across the seepage zone 5 to 6 m below the road grade.

Drainage improvements near the culvert inlet should ensure that the culvert does not plug again.

8 Landslide at Sta. 11+778 to 11+845

8.1 Site Conditions

A 30 m wide cutslope failure occurred 1 to 2 years ago, between approximately Sta. 11+800 and 11+830. The landslide deposit blocked the road but was recently cleared (Photo 5).



Photo 3: The road near Sta. 11+820 after slide debris had been cleared.

The failure headscarp is about 15 m upslope of the road; however, a much larger landslide is developing with the headscarp located 40 m upslope, along the former access road to BVC No. 1 Mine. Tension cracks in the shoulder of the abandoned road measure up to 1.2 m of vertical movement and 1 m of horizontal movement (Photo 6).

The upper road seems to follow the geologic contact with glaciofluvial sand and gravel upslope, and exposures of both clay till and glaciolacustrine silt downslope within the landslide. The landslide area is wet; however, no distinct seepage zones were traceable. By comparison, the terrain upslope of the abandoned road is well drained, without any drainage diversions or other obvious cause of the wet conditions below. Groundwater likely follows the base of the sand and gravel deposit, discharging onto the slope below the abandoned road. Groundwater probably also discharges from sandy seams within the underlying glaciolacustrine silt deposit. The resulting wet surficial conditions are probably the main cause of the landslide.

The landslide appears to still be active. The initial landslide probably ceased moving when the landslide mass reached Goathorn Creek Road, but began moving again when the landslide debris was cleared. The lack of toe support creates a high likelihood of a retrogressive landslide 70 m wide by 50 m long, capable of completely blocking the Tenas Haul Road.



Photo 4: Vertical displacement in the former access road to BVC No 1 Mine.

8.2 Recommendations

The toe of the cutslope should be supported by a toe buttress from Sta. 11+778 to 11+845 (note that the original survey was based on the former road stationing and the applied chainage equation is approximate only). The existing information is inadequate to properly analyze slope stability; however, a toe buttress 4 to 5 m high is expected to be adequate to prevent future slope movement. The face of the toe buttress should be constructed of Geosynthetic Reinforced Soil (GRS), as shown on Figure 1.

Design details for this structure include the following:

- The width of the reinforced soil zone should be $0.8 \times$ the wall height.
- The geotextile should be AIL100 (Atlantic Industries Ltd.) or HP370 (Nilex or Armtec).
- The geotextile layers should be spaced at 25 to 28 cm with a minimum 1 m pullback to create the wrap, and 0.5 m overlap along all seams.
- The welded-wire forms should be 4 gauge galvanized steel supplied by Nilex, Armtec or AIL.
- Support struts should also be 4 gauge galvanized steel, placed 0.5 to 0.6 m on-centre.
- The reinforced backfill should be free-draining pitrun, crushed gravel, or blasted rockfill with less than 5% fines, for drainage. Maximum particle size should be 15 cm.
- If free-draining material is not available, an alternative design will be required, incorporating internal drainage within the buttress.

The final grade along the top of the GRS wall should be graded for drainage.

9 Sta. 13+040 – Erosion of Fillslope

9.1 Site Conditions

Approximately 40 m of the existing road fillslope is over-steepened due to toe erosion by a flood channel to Goathorn Creek. The fillslope is 4 to 5 m high, steeper than 100% and exposes loose, fine-grained sand. Most of the slope is vegetated with salmonberry and other shrubs but the toe of the slope shows signs of erosion (Photo 7).



Photo 7: Over-steepened slope below road.

The adjacent back channel has a low gradient, contains deadfall, and is vegetated with sedges, indicating a low water velocity (Photo 8). The channel forms a meander that naturally erodes the toe of the slope below the road, but probably only during peak flow periods in Goathorn Creek.



Photo 8: Flood channel below the road that has caused the erosion.

The road surface does not show signs of movement, but the fillslope is over-steepened and the road width is narrow. Additional fill placed to widen the road would further reduce stability unless the toe of the fill was well supported at the base of the slope, within the flood channel.

9.2 Recommendations

DWB's cross-sections show a realignment of the road up to 3 m into the cutslope, which is quite viable. However, the horizontal alignment already forms a small curve around this feature, which would be further accented by the realignment. Another option would be to stabilize the fillslope.

The erosion could be readily remediated by removing the vegetation from the slope, draping a layer geotextile over the bank, and armouring the bank with boulder riprap. Since the riprap would indirectly support the road as well as resist erosion, the slope should be flattened to 1.5H:1V. The riprap should be 2 m wide at the bottom and reduce in thickness towards the road shoulder. The riprap should be 0.5 to 1 m diameter at the bottom and gradually reduce in size with height. The riprapped fillslope is shown as Option 1 on Figure 2. Environmental regulations may require a permit to place fill within the flood channel.

An alternative to riprap armouring would be to reconstruct the road, supporting the fillslope with a GRS wall. The fillslope could be steepened without losing any road width, allowing room outside of the flood channel to place riprap armour across the toe of the slope, as shown in Option 2 on Figure 2.

Design details include the following:

- The width of the reinforced soil zone should be 0.7 x the wall height.
- The geotextile should be AIL100 or HP370.
- The geotextile layers should be spaced at 25 to 28 cm with a minimum 1 m pullback to create the wrap, and 0.5 m overlap along all seams.
- The welded-wire forms should be 4 gauge galvanized steel supplied by Nilex, Armtec or AIL.
- Support struts should also be 4 gauge galvanized steel, placed 0.5 m on-centre.
- The reinforced backfill should be free-draining pitrun, crushed gravel, or blasted rockfill with less than 5% fines. Maximum particle size should be 15 cm.
- If free-draining material is not available, an alternative design will be required, incorporating internal drainage within the buttress.
- The top of the GRS wall should be set at least 0.2 m below the road grade to prevent the grader and snow-clearing equipment from damaging the welded-wire facing.
- The road grade could be widened up to 1 m using Option 2.

Option 2 would involve more work and costs, but would not directly impinge on the flood channel. The GRS wall also allows the fillslope to be steepened so that the road can be widened slightly.

10 Landslide at East Abutment of Prefeasibility Design Bridge Location

10.1 Site Conditions

A large landslide is situated upslope of the east abutment of the prefeasibility design bridge site. The map of historical mine workings shows BVC No.1 Mine directly beneath this slope but the location of the adit portal is not shown on the map and was not found in the field. The mine operated up to 1943 and the landslide is visible in the oldest set of historical airphotos from 1949. All subsequent airphotos show the landslide scar in various stages of vegetation but without clear indications of any distinct events.

The headscarp is located approximately 125 m upslope of the creek and is more than 80 m wide. The headscarp is quite short, indicating that the past landslide was very shallow. The upper surface slopes at 75% and exposes clayey silt (Photo 9). The occasional patch of vegetation indicates that the slide is prone to frequent surface erosion and shallow slope movement.



Photo 9: Clayey/silty soils in the landslide initiation zone.

Several generations of landslide activity are apparent by smaller flows and slumps within the larger landslide scar. Debris from recent events deposited within the trees on the lower slope. Larger events likely reached the valley bottom but the debris would have been cleared off the road surface. Any debris that reached the river would have been transported downstream.

Several wide tension cracks were exposed in the silt/clay in the upper slip surface (Photo 10). They may be partly caused by desiccation but could also indicate continuing shallow slope movement. These tension cracks are of particular concern.

The headscarp follows the slope break with 75% terrain downslope within the landslide, flattening to 25% immediately upslope. More tension cracks are visible in the undisturbed ground 5 to 10 m upslope of the headscarp. These tension cracks are open 10 to 20 cm (Photo 11), indicating a potential for retrogressive failures.



Photo 10: Open cracks in the landslide surface.



Photo 11: Tension cracks upslope of the landslide.

The gentle terrain upslope of the landslide forms a wide bowl that collects surface water and shallow groundwater. The surficial soils are wet or imperfectly drained and the bowl is forested with mostly birch or aspen trees without any conifers. The gently sloping part of the bowl is about 50 m wide and then the terrain steepens to between 50 and 70% and is forested with some conifers.

The slope climbs up to the plateau where Caribou FSR01 is located. The road was assessed for surface water diversions as a possible cause of the landslide but no culverts were noted. Nor does the road have much of a ditch or any signs of concentrated drainage. Much of the outside shoulder has a windrow of graded material that prevents runoff from discharging below the road surface.

While the landslide scar exposes silt and clay, the upper slope from the bowl up to the plateau consists of glaciofluvial sand and gravel. The geologic contact appears to be at the base of the bowl where the impermeable till causes groundwater within the sand and gravel to discharge above the landslide.

Similar conditions were found southeast of the landslide, on the same steep slope overlooking the creek. The south edge of the landslide borders a strip of coniferous trees along a shallow ridge, but the slope forms another concave bowl to the south, similar to the landslide area. Another landslide was observed 150 m to the southeast and several more landslides are visible even farther upstream, indicating that the east valley wall is prone to such landslides.

The terrain to the northwest of the landslide, directly upslope of the revised bridge location, is mostly 55 to 65% and is continuous or uniform across the slope. The slope does not form concavities or bowls where groundwater discharges and surface water is concentrated. The slope is also forested with a mixture of conifers and deciduous trees but does not have a wide patch of deciduous trees that often indicate ground disturbance, such as past landslides. The forest does not indicate any large scale landslides immediately north of the existing active landslide.

10.2 Assessment

10.2.1 Possible Causes of the Landslide

The natural terrain, geology and groundwater conditions are significant factors in the occurrence of this landslide and probably also those landslides noted farther upstream. Groundwater discharge along the base of the glaciofluvial deposit creates wet ground conditions beginning near the slope break. The wet conditions coupled with steep terrain and silt/clayey soils with a low frictional resistance, create a high potential for landslides.

The creek channel historically meandered towards the valley slope and eroded into the toe directly below this landslide. As a result, the valley slope is steeper at the specific location of the landslide. Each of the natural landslides immediately south are also directly above meanders in the creek channel, indicating that fluvial erosion may also have contributed to their initiation.

The relationship between the landslide and mining activity cannot be assessed without further information regarding the location and operation of BVC Mine No. 1; however, timing of the landslide suggests a possible relationship. The mine operated from 1930 to 1943; the landslide existed at the time of the oldest airphotos in 1949. The landslide could have been triggered by underground blasting or waste material from the mine could have been spoiled over this slope.

10.2.2 Future Landslide Hazard

The likelihood of more landslide activity within the existing landslide scar is high. The potential landslide runout area includes the prefeasibility design bridge abutment, which would have been at risk of damage and blockage of the road. The area to the southeast has the potential of another similar landslide. The terrain to the northwest is not as steep, better drained, and appears to have a lower likelihood of a large landslide. A landslide could occur on the slope above the detailed design bridge site, but the likelihood of a landslide is much less than at the prefeasibility design bridge site.

Downstream bridge locations could still be exposed to indirect damage from a future landslide at this location. The large-scale landslide would deposit sediment and woody debris into Goathorn Creek, which would be transported downstream by the creek. However, the risks to the detailed design bridge site are much less than at the prefeasibility design bridge location.

11 Sta. 13+620 to 13+740

11.1 Site Conditions

The current road bends around this deep draw to maintain the vertical alignment. DWB's 2017 road design realigned the road directly across the draw, creating a filled embankment up to 6 m high at centreline. The base of the draw slopes at approximately 20%, resulting in a total fillslope height up to 10 m. However, DWB's 2019 road design eliminated this realignment and maintains the existing curve through the draw.

11.2 Subsurface Conditions

Borehole T19-32S was drilled on the pullout near Sta. 13+630 and encountered 7.8 m of fill overlying 1 m of compact silty sand and then very stiff to hard glaciolacustrine silt. The silt deposit was found to be 6.7 m thick, overlying siltstone bedrock at 15.5 m depth (all depths are relative to the existing road surface).

The fill varies from silty sand to clayey silt with some sand, but does not appear to have been placed and compacted in a controlled manner. Soil conditions at the base of the draw are expected to consist of less fill.

The Atterberg limits classify the glaciolacustrine deposit as clay with intermediate plasticity. It is heavily overconsolidated with undrained shear strengths from 150 kPa to more than 200 kPa.

11.3 Embankment Stability

The existing fill is loose and the fillslope is over-steepened across the middle of the draw.

With respect to the realignment option, the glaciolacustrine clayey silt should not be prone to excessive settlement under the proposed 6 m high embankment. The deposit could create a weak layer beneath the embankment; however, slope stability analysis suggests that the embankment should have a minimum factor of safety of 1.5 if the fillslope is constructed of well-drained granular fill and slopes at 2H:1V or flatter.

11.4 Road Recommendations

If maintaining the existing alignment, this fillslope should be flattened to no more than 1.75H:1V, preferably using coarse rockfill supported at the base of the draw.

If realigning across the draw, the fillslope should be constructed of free draining, granular fill with less than 5% fines. The fillslope should be constructed in 0.3 m thick lifts with each lift compacted to a minimum 95% standard Proctor maximum dry density (SPMDD). The final fillslope should be over-built and then trimmed to 2H:1V or flatter in order to compact to the final edge of slope. Further details for this embankment fill should be determined during detailed design.

12 Sta. 13+840 to 13+930

12.1 Surface Conditions

The road climbs gently towards the base of a bedrock bluff and talus slope. The terrain immediately upslope of the road is gently sloping and benchy, but steepens rapidly at the base of the steep colluvial slope near Sta. 13+920. The terrain downslope of the road forms a wide bench and then steps down onto the next bench about 14 m below. The road configuration seems stable, yet tension cracks cross the road between approximately Sta. 13+920 and 13+930. One set of tension cracks cross the road orthogonal to the alignment while the other crosses the road obliquely (Photo 12). Both tension cracks cross the entire road surface and are not limited to the outside shoulder. Ponded water also delineates an area of settlement across the entire road.



Photo 12: Settlement and tension cracks near Sta. 13+920 to 13+930.

12.2 Subsurface Conditions

Borehole T19-31S drilled within the road near Sta. 13+915 found 10.4 m of fill overlying glaciolacustrine silt. Bedrock was encountered at 18.3 m depth.

The upper 4 m of fill is loose to very loose and comprised of silt, sand and gravel with traces of coal fragments. The fill from 4 to 10.4 m depth is loose to compact, gap-graded gravel and silt with some sand. The fill appears to be waste material from the mine that has weathered over the past 60 to 70 years since placement. The material does not appear to have been placed and compacted in a controlled manner and is highly prone to settlement.

The glaciolacustrine silt is very stiff, contains 24% clay and has low plasticity but also contains 14% gravel, which is unusual. The deposit is over-consolidated and not highly prone to settlement.

The extent of the fill cannot be determined from a single borehole. The northern limit of the fill is likely defined by the tension cracks but the southern extent is unknown. Nor is it apparent how far downslope the waste material extends.

12.3 Assessment

The fill is loose, highly prone to settlement and, after apparently 70 years in place, it is still settling. The extent of the fill is not known but based on the local topography, it could be a wedge that increases in thickness from Sta. 13+890 to 13+930, where the fill abuts a steep bedrock slope. The fillslope below the road is less than 50% and leads down onto a bench, which may also comprise fill. Longitudinal tension cracks in the road surface were not visible and the fillslope appears to be stable.

The SI in Borehole T19-31S measured up to 9 mm of movement within the upper 2 m of fill. This movement is in the uphill direction and likely due to frost penetration. This same SI also shows up to 2.5 mm of reverse (i.e. uphill) movement occurred between February 24 and April 19, although the April 19 reading seems to be an anomaly. The main zone of movement was between 18 and 24 m depth, entirely within the bedrock, which is unlikely. The movement reversed direction in May, returning almost to its baseline position. Subsequent measurements showed virtually no movement between May and November 2019 and less than 1 mm of total movement since February 2019.

Some movement in the SI could be due to settlement of the fill and variations in moisture conditions. However, most of the movement reflected in the SI plots in Appendix E is likely the result of the three different SI probes used to date. The measurements since May, using the same probe consistently, indicate that the road fill is stable at this location.

The main geotechnical issue that could affect the haul road is ongoing settlement and soft subgrade conditions. The rapid change in subgrade conditions, from soft/loose fill to bedrock, near Sta. 13+930 could magnify the issue. Ongoing settlement could increase under the dynamic loading of the heavy trucks, but can be mitigated with routine road maintenance and grading. The soft subgrade conditions will warrant a thicker road structure.

12.4 Recommendations

The loose fill should be subexcavated an additional 1 to 2 m on the approach to Sta. 13+930 and backfilled with well-compacted granular material to reduce differential settlement and improve subgrade support. Alternatively, the subbase could be reinforced with geogrid from roughly Sta. 13+900 to 13+930.

Continued monitoring of the SI is recommended every 2 to 3 months. The results should be re-assessed prior to detailed design.

13 Sta. 13+930 to 14+030

13.1 Surface Conditions

The road crosses below a bedrock bluff from approximately Sta. 13+930 to 14+020, with transverse and oblique tension cracks crossing the road at both ends. The crest of the bedrock bluff is 20 to 25 m above the road and the bluff is more than 10 m high, exposing mostly siltstone and mudstone (visible in the background of Photo 12). A talus slope has formed at the base of the bluff, leading down to the edge of the road, 10 to 12 m below. The talus slope comprises scree or fine-grained colluvium derived from weathering of the bluff above.

The terrain above the bedrock bluff climbs at a slope angle of 65% to 70% for another 20 m elevation, then flattens to form a wide, gently sloping plateau. BVC Mine No. 2 is located directly beneath this area and several decommissioned ventilation shafts were found on the slope above the bluff. The mine records indicate that the coal seam dips westward between 10° and 15°. The east end of the mine, close to the exposed bedrock bluff, is between 720 and 730 m elevation while the adjacent road is between 705 and 707 m elevation. The underground mine is located above the road grade and behind the exposed cutslope.

While most of this road segment seems solid, the outside shoulder is often tension cracked and has settled significantly (Photo 13). Some of the settlement also extends into the road subgrade. The terrain below the road slopes at 75% to 80% overall and is 12 to 22 m high, with the higher slopes located towards the north end of this segment. Several sets of tension cracks cross this steep fillslope, each measuring 0.3 to 1.5 m of vertical displacement and exposing silty/clayey colluvium and very weak, highly weathered siltstone and mudstone.



Photo 13: Tension crack in shoulder.

The terrain flattens 20 m to 35 m downslope of the road (measured slope distance), forming a 15% bench more than 40 m wide. The terrain then gradually steepens downslope towards Goathorn Creek. This steep creek bank exposes siltstone/mudstone up to about 2 m above creek level, overlain by colluvium derived from weathered siltstone/mudstone.

13.2 Subsurface Conditions

Boreholes T19-29S and T19-29S-1 were drilled approximately 30 m apart within this road segment, directly below the bedrock bluffs. Both boreholes encountered weathered siltstone directly beneath the road base. The weathered siltstone in Borehole T19-29S overlies clayey siltstone at 7.6 m depth. The extent of weathering implies that the bedrock bench is natural and was not blasted to support the road.

13.3 Assessment

The bedrock bench is assumed to underlie most of the road; however, the condition of the underlying bedrock slope is unknown. This slope could be quite irregular, with some sections where the fill is much thicker.

The SI in Borehole T19-29S measured minor movement in the upper 5 m of the borehole but total movement after 9 months of monitoring is only 1 mm and is limited to the weathered bedrock. No lateral movement was measured within the intact bedrock, which would be the greater hazard.

The longitudinal tension cracks below the road indicate a high likelihood of fillslope failures. The fill may simply be a sliver fill supporting the outer shoulder, in which case, failures should only affect the outside shoulder, but could still affect road user safety.

No additional fill can be supported on this slope and road widening will require excavating into the talus slope instead, which could cause long-term raveling. The talus is relatively free-draining and the bedrock subgrade is not susceptible to softening; therefore, the ditch can be reduced in order to reduce the cut. Still, cutslope raveling will warrant additional maintenance along this section to clear both the road and ditch of rolling talus.

13.4 Recommendations

If the road is to be widened, it must be excavated into the talus slope, as shown on the current cross-sections. The excavator must ramp up to reach the crest of the talus slope so that the entire talus slope can be flattened to 1.5H:1V or back to the bedrock.

The ditch depth and width can be reduced along this road segment for drainage, but a wider ditch may be needed for rockfall catchment.

Further investigation should include test pit excavations along the outside edge during road construction to determine how much of the road prism is affected by the fillslope hazard.

14 Sta. 14+030 to 14+220

14.1 Surface Conditions

Once beyond the tension cracks near Sta. 14+030, the road gently curves to the west. The adit portal and tibble were located upslope of roughly Sta. 14+050, with the tibble visible on the 1959 airphotos. Although the adit was not located, a bench was found that likely accessed the adit (visible on Photo 14). This bench crosses a 70 to 85% slope comprised of fine rubbly colluvium overlying sedimentary bedrock. Some isolated sections are as steep as 100%, probably created by the excavation for either the road or the access trail to the adit. These steeper pitches generally expose bedrock.

The road fillslope is 2 to 5 m high from Sta. 14+040 to 14+180, and leads down to gentle, irregular to benchy terrain sloping at 20% or less. This broad bowl lacks obvious signs of slope movement, but is forested entirely with deciduous trees (see Photo 14), indicating wide-spread disturbance.

From approximately Sta. 14+180 to 14+220, the road curves to the northeast and begins to climb in grade. The cutslope to the west shortens and the fillslope to the east increases. The cutslope exposes sand, likely part of a glaciofluvial blanket. Tension cracks were noted on both sides of the road, as well as visible subsidence on the surface, indicating settlement of the road fill.



Photo 14: Aerial view of Sta. 14+030 to 14+220.

14.2 Subsurface Conditions

Borehole T19-30S was drilled just north of the tension cracks near Sta. 14+030. The borehole found 15.2 m of fill directly overlying siltstone bedrock. The fill is a variable mixture of gravel, sand, silt and clay and appears to be mine waste. Most of the upper 3.7 m of fill is silt or sandy silt, although a loose coal seam was noted between 2.0 and 2.4 m depth. From 3.7 m to 11.6 m depth, the fill contains more gravel and clay, and displays some plasticity. Some chunks of clay in the drill core were hard but the drill rods penetrated without any applied force from 4.6 m to 7.6 m depth and from 9.1 to 10.7 m depth, indicating that the fill is very loose and uncompacted.

From 11.6 to 13.7 m depth, the fill is gap-graded silt and gravel with some clay. The bottom layer of fill from 13.7 to 15.2 m depth is very soft clayey silt with some stiffer chunks of clay. Again, the drill rods penetrated without any applied force from 14.0 to 15.2 m depth.

Boreholes T19-28S and T19-28S-1 were drilled near Sta. 14+145, in the centre of this broad bowl-shaped feature. Borehole T19-28S was drilled in a level area just inside of the road (marked on Photo 14) and found 8.4 m of fill overlying a thin blanket of till and then bedrock. The upper 5.5 m of fill is mostly loose gravelly silt and sand with some denser chunks and cobbles. This fill appears to be weathered waste material comprised of mostly siltstone. The fill transitions to firm clayey silt near 5.5 m depth and appears to be weathered waste material derived from shale.

Borehole T19-28S-1 was drilled towards the outside shoulder of the road and encountered similar conditions. The upper fill is mostly silty sand and gravel, overlying clayey silt at 2.7 m depth. The deeper fill ranges from very soft to firm with some hard chunks, and is 87% silt and clay, suggesting a possible shale source. Till was found at 7.9 m depth and then bedrock at 8.8 m depth.

Boreholes T19-28S and T19-28S-1 found the underlying till and bedrock to be at roughly the same elevation despite being 11 m apart, which suggests a gentle natural slope beneath the fill. This large bowl-shaped landform appears to have been used as a waste dump during the adjacent mine operation.

14.3 Assessment

This fill throughout this large bowl ranges from less than 8 m to more than 15 m thick, and covers a wide area that extends far downslope of the road. The fill is very loose, possibly with voids, highly prone to settlement and would have settled significantly under its own weight. The fill has been in place for more than 70 years, but the tension cracks in the road indicates that the fill is still actively settling. Some of the recent settlement may also be caused by weathered rock/soil infiltrating into voids within the original deposit of waste rock.

The gentle terrain downslope of the road and the gentle natural grade beneath the fill throughout this wide bowl is not expected to pose a significant slope hazard. The SI in Borehole T19-28S, located on the uphill side of the road, measured minor movement fluctuating between -0.5 to 1 mm

(i.e. uphill movement) to +0.5 to 1 mm (downhill movement). The movement is occurring down to 17 m depth, but bedrock is at 10 m depth. Once again, the use of three different SI probes seems to have affected the accuracy of the measurements with the April 19 reading be the main anomaly. The readings from May to November 2019, using the same probe consistently, shows virtually no movement. Continued monitoring is warranted but global stability of the fillslope does not appear to be a hazard in the middle of broad bowl.

The south end of this zone, near Sta. 14+030, has steeper terrain downslope of the road and the SI in Borehole T19-30S has measured definitive movement in the downhill (positive A) direction. The movement was most notable between May and September 2019; however, some of the movement was subsequently reversed between September and November 2019. The same probe was used for all three readings from May to November; therefore, the movement and reversal seems to be real but cannot be explained. The movement has occurred within a wide zone between 3 and 17 m depth, indicating that instead of a definitive slip plane, the movement is occurring at several depths within the fill. The movement is probably limited to the south end of this section of road and caused by the steep fillslope and natural terrain to the southeast. This transition near Sta. 14+030 could be problematic for long-term performance of the road and warrants further monitoring.

14.4 Recommendations

DWB's cross-sections do not show any road widening prior to Sta. 14+200. However, if needed, most of this road segment can be widened on either side of the existing road. The existing cutslope is relatively short beyond Sta. 14+070, requiring minor excavation to widen into the cutslope. If the road is widened on the fillslope side, the toe of the widened fill must be well supported on the gentle terrain below. The height of the fillslope should be limited to less than 5 m and constructed no steeper than 2H:1V. Prior to placing any fill, all organics should be stripped within the fill area and a series of narrow benches excavated into existing fillslope to key the fill in. Even with the above recommendations, the added load on the existing fill/spoil will likely cause settlement and require additional regrading.

Placement of additional fill on the steep slope below Borehole T19-30S (Sta. 14+030) should be avoided. Even raising the grade by 1.5 m, as currently planned, could cause additional settlement and slope movement. If possible, the existing road grade should be maintained until past Sta. 14+040. Otherwise, the SI in Borehole T19-30S should be frequently monitored immediately after placing the fill.

Considering the movement measured to date and the variability in measurements, the SIs should continue to be monitored every 2 to 3 months and the data re-assessed prior to detailed design. The consistent use of the same SI probe should remove some of this variability.

15 Bridge Site

15.1 Subsurface Conditions

The stratigraphy at the prefeasibility design bridge crossing at Borehole T18-16S consists of silty sand and sandy silt with cobbles. The upper 0.8 m was identified as fill overlying colluvium with a similar gradation. Weathered, moderately strong siltstone was encountered at 3.0 m depth, transitioning into fresh, very strong siltstone at 10.1 m.

The fill is classified as compact to dense based on the DCPT results; however, the blow counts are greatly affected by cobbles in the fill. Blow counts between 10 and 20 are probably more realistic. The underlying silty sand also contains some cobbles and small boulders. Although DCPT blow counts are greater than 40, the deposit is probably compact rather than dense.

The prefeasibility design bridge site was subsequently moved approximately 120 m downstream, where Borehole T19-33S was drilled on the west side of the creek. This borehole encountered 3.4 m of sand and gravel with some cobbles and a trace of silt. The deposit also appears to contain boulders but none were sampled while drilling. A DCPT was not performed but the deposit is inferred to be loose. The fluvial deposit overlies approximately 0.3 m of weathered siltstone and then unweathered siltstone.

15.2 Bridge Structure

The bridge has yet to be re-designed for the revised location. The prefeasibility design bridge design³ by DWB was for a 30.5 m long structure with steel girders and a timber deck, supported on a total of eight steel pipe piles 406 mm in diameter. The abutments are supported by treated timber ballast walls and are to be heavily armoured with riprap.

The design drawings provided did not include any bearing loads for the piles; however, load calculations provided by DWB indicate that the deadload of the bridge will be approximately 1,900 kN. The design coal hauling truck is approximately 26 m long, with a fully loaded weight of 110,000 kg or 1,078 kN. Adding 30% dynamic load allowance increases the estimated design load to 1,400 kN. Since only one truck can fit on the bridge at one time, the total design load for the bridge is assumed to be approximately 3,300 kN.

Lateral loads on the bridge abutments were not provided.

³ DWB Drawings 16364-426-20 to 24, Rev E, "Telkwa Coal Limited, Goathorn Creek Crossing", dated 23/05/2017.

15.3 Assessment

With bedrock at 3.4 m depth in Borehole T19-33S and 3.0 m depth in Borehole T18-16S, the depth to bedrock seems to be relatively shallow and consistent along the contemporary valley bottom. However, with only two boreholes, the shallow depth could be coincidental and the actual bedrock surface could be variable.

The approximately 3 m of loose sand and gravel cannot support the axial pile loads from the bridge and could be prone to settlement; however, piles socketed into bedrock could easily support the bridge loads. Steel pipe piles 406 mm in diameter, socketed into unweathered siltstone bedrock, should achieve at least 1,500 kN axial resistance (ULS) per pile, which is much greater than needed based on the current design of 4 piles per abutment. The piles still need to be analyzed for lateral resistance but a minimum socket length of 2 m is recommended for pile fixity (note that lateral pile analysis could result in an increased minimum socket length). Still, piles socketed into bedrock should be a feasible means of supporting the bridge loads.

The bridge abutments could also be supported on spread footings bearing directly on bedrock. The weathered siltstone should provide at least 1,000 kPa bearing resistance (ULS), which exceeds the bridge requirements. If additional lateral resistance is needed, the footings could be anchored to bedrock using rock anchors.

15.4 Foundation Recommendations

The bridge abutments should bear directly on bedrock, either through spread footings or piles socketed into bedrock. For feasibility design, a minimum footing width of 1 m is recommended for the footing option, while a minimum 2 m bedrock socket is recommended for the pile option.

16 Haul Road Design

16.1 Laboratory Test Results

16.1.1 Gradation

The general results of the grain size analyses from the test pit investigation and those borehole samples located within 2 m of the road surface are summarized in Table 5, and represent the apparent road subgrade conditions.

Table 5
Summary of Grain Size Analyses

Road Station	Test Pit/ Borehole	Sample	Gradation				Classification
			% Cobbles	% Gravel	% Sand	% Fines	
8+975	TP18-29	1	15	15	26	44	CL
9+350	TP18-30	1	0	18	30	52	CL
9+860	TP18-31	1	0	18	30	52	CL
10+340	TP18-32	1	0	8	30	62	ML-CL
10+340	TP18-32	2	0	17	28	55	CL
11+200	TP18-33	1	0	2	21	77	CL
11+790	TP18-35	1	0	32	47	21	SM-SC
11+790	TP18-35	2	0	22	59	19	SM-SC
12+100	TP18-37	1	0	10	73	17	SM-SC
12+450	TP18-36	1	0	62	34	4	GW
13+260	T19-33S	1	0	47	44	9	GW-GM
13+915	T19-31S	1	0	21	28	51	ML-SM
14+145	T19-28S	1	0	29	35	36	SM-SC

16.1.2 California Bearing Ratio

The California Bearing Ratio (CBR) test is a simple strength test that compares the bearing capacity of a material with that of a well-graded crushed stone. A high quality crushed stone material should have a CBR of 100%. The test results do not indicate a pass or fail but merely provide a relative strength of the tested soils under the conditions tested.

The results depend on the level of compaction and moisture conditions. The four samples tested were each heavily compacted at close to optimal moisture content and close to 100% of SPMDD. Actual levels of compaction ranged from 100 to 102% of SPMDD. The samples were then tested under saturated conditions.

The samples tested were from test pits along the road alignment, as well as two test pits excavated within the gravel pit off of Caribou FSR01. The results are summarized on Table 6.

Table 6
Summary of California Bearing Ratio Test Results

Test Pit	Road Station	Sample Depth (m)	CBR Value Range (%)
TP18-29	8+975	0.7 to 1.2	3
TP18-31	9+860	0.75 to 1.25	3
TP18-35	11+790	0.2 to 0.4	6 - 9
TP18-36	12+450	0.3 to 0.7	39 - 64
TP18-38	Gravel Pit	1.9 to 2.2	48 - 56
TP18-39	Gravel Pit	1.2 to 1.5	60 - 64

16.1.3 Standard Proctor Density Tests

As part of the CBR testing, standard Proctor density tests were conducted on the same CBR samples from the test pits along the road alignment and from both of the test pits in the gravel pit. The results are summarized on Table 7.

Table 7
Summary of Standard Proctor Test Results

Test Pit	Sample Depth (m)	Maximum Dry Density (kg/m ³)	Optimum Moisture Content (%)
TP18-29	0.7 to 1.2	2090	9.7
TP18-31	0.75 to 1.25	1972	12.5
TP18-35	0.2 to 0.4	2127	9.2
TP18-36	0.3 to 0.7	2329	5.6
TP18-38	1.9 to 2.2	2181	7.3
TP18-39	1.2 to 1.5	2202	7.8

16.1.4 Soundness Testing

The samples from the two test pits excavated in the gravel pit were tested for soundness. Both samples were tested using the Micro-Deval tests (ASTM D6928 for coarse aggregate and ASTM D7428 for fine aggregate) and the results are summarized on Table 8. BC MOTI's acceptable limit is 20% on the coarse aggregate and 25% on the fine aggregate. Both samples meet this standard.

The sample from TP18-38 was also tested using the L.A. Abrasion test and the result is summarized on Table 9. BC MOTI does not use this procedure, but the maximum loss permissible by various transportation agencies throughout the United States generally ranges from 25% to 45%, depending on the material's proposed use. The test result on the sample from TP18-38 meets these general standards.

Table 8
Summary of Micro-Deval Test Results

Test Pit	Sample Depth (m)	Loss Coarse (%)	Loss Fines (%)
TP18-38	1.9 to 2.2	14.9	13.4
TP18-39	1.2 to 1.5	15.5	14.3

Table 9
Summary of LA Abrasion Test Results

Test Pit	Sample Depth (m)	Loss After 500 Revolutions (%)
TP18-38	1.9 to 2.2	19.2

16.2 In-Situ Test Results

The laboratory CBR results were dependent on specified soil sample conditions, such as degree of compaction and moisture content. Given these conditions are variable in the subgrade soils along the alignment, LWD testing was carried out to estimate *in-situ* CBR values. This field test measures E_{vd} rather than CBR directly; however, several correlations between these parameters are described in scientific literature^{4,5}.

The LWD measures E_{vd} which is related to the stiffness of the subgrade under a dynamic load. E_{vd} was used to estimate the *in-situ* modulus of subgrade reaction (k) and CBR. The estimated CBR of the subgrade soils generally ranged between 4% and 6%, with the exception of TP18-37, where the CBR was 15%. The results are summarized in Table 10.

Table 10
Summary of LWD Test Results

Test Pit	Test Depth (m)	Measured E_{vd} (MPa)	Estimated k (Mpa)	Estimated CBR (%)
TP18-29	0.6	20.49	32	4
TP18-30	0.5	24.70	39	6
TP18-31	0.5	25.04	40	6
TP18-32	0.75	20.07	32	4
TP18-34	0.75	8.76	13	4
TP18-35	0.02	12.85	19	6
TP18-37	0.02	10.66	17	15
TP18-36	0.02	27.35	42	5

⁴ Barounis, N., Costello, C., & Smith, T. Characterisation of in situ soils based on the resilient soil modulus obtained using Light Weight Deflectometer (LWD).

⁵ Estates, D. (2011). A guide to airfield pavement design and evaluation. Design & Maintenance Guide, 27.

16.3 Summary of Subgrade Conditions

Table 11 summarizes the apparent subgrade conditions based on the test pit investigation, laboratory testing, and in-situ testing. This table shows the laboratory CBR test results as well as the in-situ CBR results correlated from the LWD testing. Note that the laboratory CBR tests were conducted with the samples compacted to approximately 100% SPMDD. As such, the laboratory CBR value is considered to be the maximum achievable by compaction for that particularly soil type. Heavy compaction will be required during construction to achieve such values.

Table 11
Summary of Subgrade CBR Conditions

Test Pit/ Borehole	Station	Subgrade	Lab CBR	CBR from LWD	Design CBR
TP18-29	8+975	sandy SILT (CL)	3	4	3
TP18-30	9+350	sandy SILT (CL)		6	3
TP18-31	9+860	silty, gravelly SAND (SP) Over SILT (CL)	3	6	3
TP18-32	10+340	silty SAND (SP) Over silty CLAY (CL-ML) Over SILT (CL)		4	3
TP18-33	11+200	SILT, clay, some sand			3
TP18-34	11+390	SAND (SP)		4	3
TP18-35	11+790	silty SAND FILL (SM) Over silty SAND (SM)	6-9	6	3
TP18-37	12+100	SAND (SM) Over gravelly SAND		5	3
TP18-36	12+450	sandy GRAVEL	39-64	15	6
19-33S	13+260	SAND & GRAVEL (GP-GM)			6
19-32S	13+630	SILT FILL (ML)			3
19-31S	13+915	Gravelly, sandy SILT FILL (ML)			3
19-29S-1	13+980	SILT FILL (ML) Over Siltstone BEDROCK			>30
19-29S	14+010	Siltstone			>30
19-30S	14+030	Sandy SILT FILL (ML)			3
19-28S-1	14+145	Silty SAND & GRAVEL FILL (SM/GM)			3

16.4 Road Base Design

16.4.1 Traffic Loads

The design vehicle and traffic loads were provided in DWB's report dated December 10, 2018⁶. The design vehicle is a B train with 70 tonne payload. The vehicle traffic assumes 750,000 tonnes of coal is hauled per year, or 31 loads per day over 350 days per year for a total of approximately 10,850 truckloads per year. Truckloads are assumed to be evenly distributed throughout the year.

The design truck has a gross vehicle weight of 110,000 kg distributed through a maximum steering axle load of 91 kN, two tridem axle loads up to 369 kN, and a dual axle load up to 228 kN.

The load distribution depends on tire pressures, which were assumed to be 830 kPa (120 psi) during seasonally favourable conditions, and 550 kPa (80 psi) during the spring thaw season.

Back-haul trucks are assumed to be empty, and additional two-way vehicle traffic is expected to be low volume and comprised of on-highway trucks and light trucks. Such vehicle traffic was ignored in the road structure design.

16.4.2 Climatic Considerations

Tables 11A & 11B present climatic information for Smithers, BC from the 2018 BC Building Code and Climate BC, used to estimate the equivalent AASHTO climatic region.

Tables 11A & 11B
Summary of Design Climate Data

Project Location	Design Temperatures		Design Precipitation		Equivalent AASHTO Climatic Region
	January 2.5% °C	January 1% °C	Annual Rain (mm)	Annual Precipitation (mm)	
Smithers (El. 522m)	-29	-31	325	500	Region VI (Dry, hard freeze, spring thaw)

Climate Station Location	MODBERG Climatic Information		
	Mean Annual Air Temp. (C)	Mean Freezing Index (deg C-day)	Design Length of Freezing Season (days)
Smithers (El. 522m)	4.2	737.6	167

⁶ DWB report "Feasibility Road Design Phase 2 – Design Basis Memorandum, Revision 4" to Allegiance Coal Limited, dated December 20, 2018.

Based on the climate data, a 5 month winter season (frozen subgrade and pavement layers), a 5 month summer season (drained subgrade and pavement layers), and a 2 month spring thaw season (wet subgrade and pavement layers) were assumed for design purposes.

Using the Modified Berggren equation and the climate data for Smithers, the maximum depth of frost penetration is estimated to be 1.55 m. Subgrade soils within 1.55 m of the ground surface could be susceptible to frost heave and softening during spring thaw.

16.4.3 Preliminary Design Thicknesses

The test pits and LWD analysis covered only selected sections of the proposed and existing haul roads; large sections of the road subgrade were not assessed, particularly from Sta. 0+000 to 9+000 but also on the west side of the bridge crossing. The subgrade support provided by the loose fill from approximately Sta. 13+620 to 14+220 was not evaluated and could be particularly poor. Heavy compaction of the subgrade will be required prior to placing the subbase in order to create more uniform bearing support with a minimum CBR of 3 during spring thaw conditions.

The subgrade along the section of road along the valley bottom, from approximately Sta. 12+400 to 13+300 is assumed to be relatively good based on the sole LWD test in TP18-36; however, the road likely has soft zones where surficial sands overlie the compact gravel, or where buried decaying wood debris underlies the gravel. Further investigation and testing is needed during detailed design and construction.

The subgrade conditions will also be affected by final road grades, construction procedures, fill materials used, the level of compaction achieved, and both construction and maintenance of road drainage measures. The design thicknesses summarized on Table 12 are preliminary and intended solely for feasibility design.

Table 12
Preliminary Road Structure Design Thicknesses

Design Section	Assumed Subgrade		Subbase Thickness	Base Coarse Thickness	Surfacing Thickness
	Assumed Condition	CBR			
Sta. 0+000 to 0+850	Unknown	3	600 mm	200 mm	150 mm
Sta. 0+850 to 12+050	Sandy SILT	3	600 mm	200 mm	150 mm
Sta. 12+050 to 13+500	Silty SAND & GRAVEL	6	350 mm	200 mm	150 mm
Sta. 13+500 to 13+930	Sandy SILT or SILT FILL	3	600 mm	200 mm	150 mm
Sta. 13+930 to 14+030	Thin FILL over BEDROCK	>30	0 to 300 mm	200 mm	150 mm
Sta. 14+030 to 14+220	SILT FILL	3	600 mm	200 mm	150 mm
Sta. 14+220 to 15+920	Unknown	3	600 mm	200 mm	150 mm

The subbase thickness could be reduced by at least 300 mm by adding a triaxial geogrid layer (i.e. Tensar's Triax TX7). However, the main benefits of geogrid occur where the subgrade CBR is less than 3. Such areas may be identified during detailed design or construction. A disadvantage of geogrid is that by reducing the total thickness of the road structure, frost can penetrate farther into the subgrade, causing greater softening during spring-thaw.

Placement of a woven geotextile as a separator layer between the stripped subgrade and the subbase fill is recommended either as part of the standard design for the entire road or, as a minimum, from Sta. 0+000 to 12+050, Sta. 13+500 to 13+390, and Sta. 14+030 to 14+220. The subgrade should be scarified and then heavily compacted prior to placing the geotextile and subbase fill.

Additional fill required to reach the final subgrade elevation should be placed in maximum 0.3 m thick lifts with each lift compacted to at least 95% SPMDD or 92% modified Proctor maximum dry density (MPMDD). Subgrade fill material may consist of local material, provided it is free of organics and other deleterious materials and is not too wet to be suitably compacted. The type of subgrade fill will, however, affect the subgrade CBR; therefore, the subbase thickness may need to be adjusted.

The final subgrade should be proof-rolled using a fully loaded rock truck to delineate softened areas. Areas showing excess elastic deflection should be investigated and improved. Such areas may have disturbed wet soils that should be subexcavated and backfilled with competent fill. Other areas may require a thicker subbase.

The subbase fill should be well-graded sandy gravel pitrun. BC Ministry of Transportation & Infrastructure's (BCMOTI) gradation specification for select granular subbase (SGSB) is too broad, and allows for use of a sandy product that may not provide a suitable CBR. Potential sources should be evaluated during detailed design; however, the nearby gravel pit investigated by TP18-37 and TP18-38 has been tested and should provide a suitable product that meets the design requirements. The subbase should be placed in maximum 0.3 m thick lifts and compacted to a minimum 98% SPMDD or 95% MPMDD.

Both the base course gravel and high-fines surfacing aggregate (HFSA) should be 25 mm minus crushed gravel with a minimum 50% fractured faces. BCMOTI's gradation specification for 25 mm well-graded or open-graded base, and HFSA, should be adequate. Both layers should be compacted to a minimum 98% SPMDD or 95% MPMDD.

DWB's structural road design includes 200 mm of HFSA, 250 mm of base course, two layers of triaxial geogrid, and a layer of geotextile. Using Tensar's design procedures, the total structural number for the design section is equivalent or exceeds the road structures in Table 12. A cost analysis should determine the more cost-effective structure, depending on the proximity of suitable gravel pits.

16.4.4 Road Drainage

Drainage of the full road structure is imperative to achieve the design strengths and to minimize rutting. Both the subgrade surface and the final road surface should be sloped or crowned at least 2% to divert surface water away.

The minimum ditch depth should extend at least 200 mm below the subgrade elevation to prevent the ditch from draining into the road structure, particularly where the ditch gradient is minimal. Since most of the road should have a total road structure thickness of 900 mm, the adjacent ditch should exceed 1 m deep and be graded to prevent water from ponding.

Culverts should be installed at every natural drainage and low area along the road, to prevent water from pooling in the ditch. Where natural drainages are not found, the maximum spacing between culverts should, in general, be 300 m where the road and ditch grade are up to 3%, 250 m for grades between 3 and 6%, and 150 m where the grade exceeds 6%. In general, DWB's road profile appears to meet these recommended spacings.

16.4.5 Maintenance

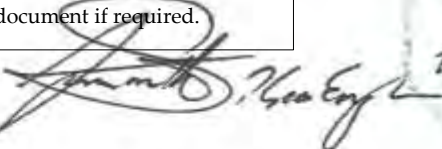
Gravel haul roads require regular maintenance, including grading to remove rutting, washboarding, normal material loss, and cleaning of ditches to maintain drainage. Additional work is often identified during the initial stage of hauling, such as additional drainage measures or areas where the subgrade is too soft. A higher level of maintenance and some construction improvements should be anticipated in the first year of operations, particularly after the first spring thaw. Ultimately, the maintenance plan will depend on the quality of construction and performance expectations.

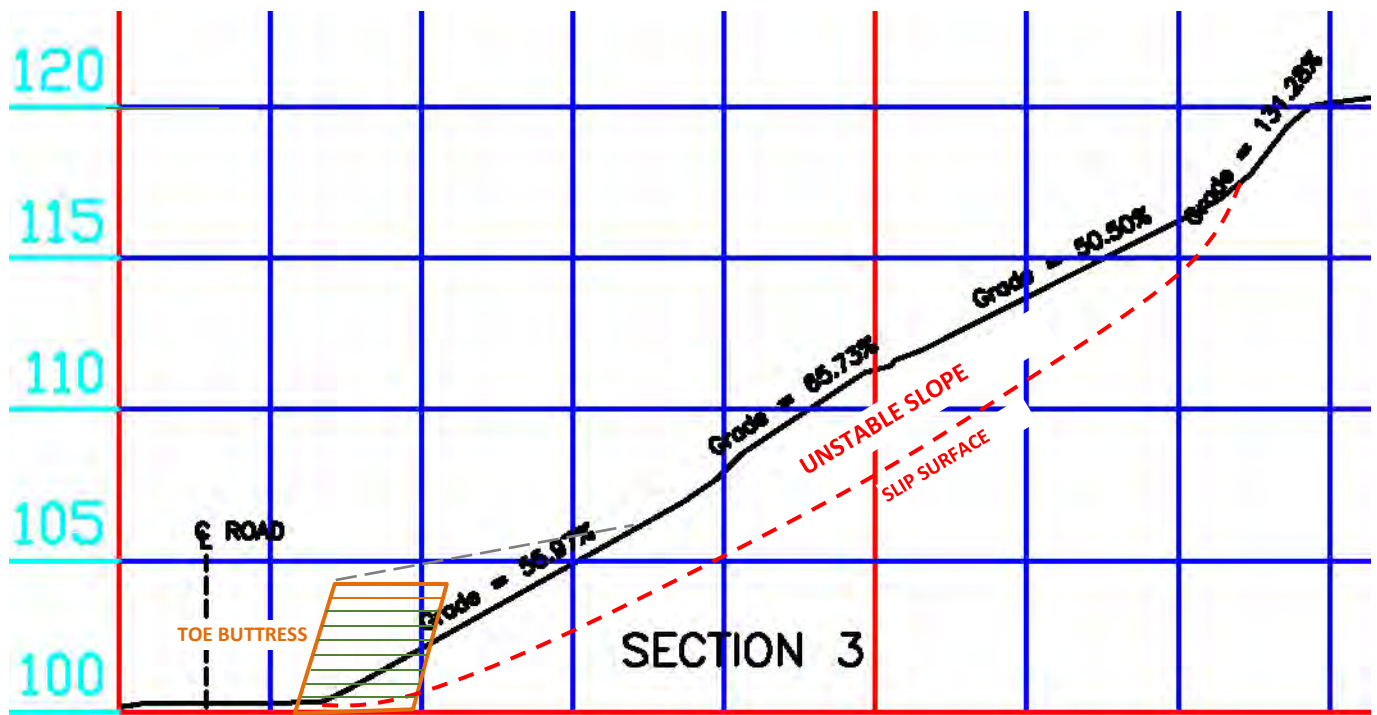
17 Closure

This report has been prepared for Telkwa Coal Ltd. by the following:

This is an electronic replica of the original signed and sealed report and has been provided for convenience. Westrek has retained the original signed / sealed report on file and can provide an authenticated document if required.

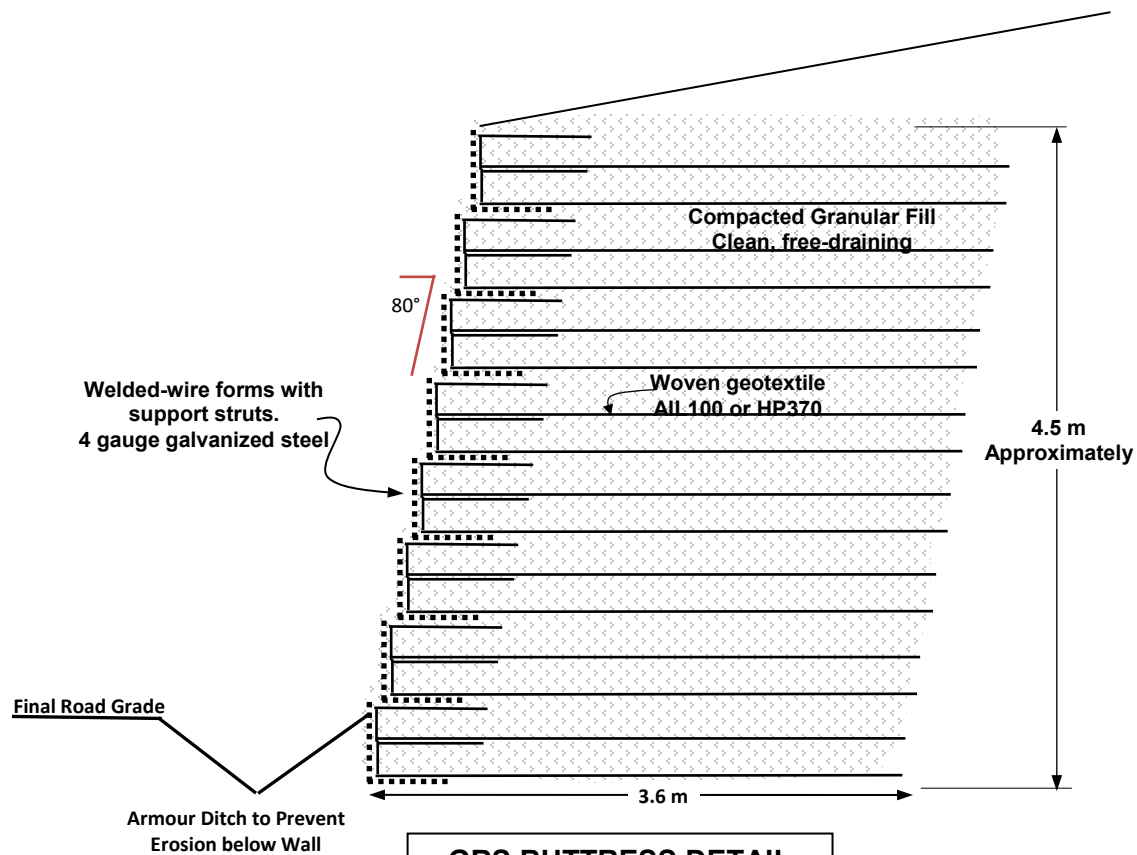

E. J. McQUARRIE
February 14, 2020
B.C. PROFESSIONAL ENGINEERS
B.C. GEOLOGISTS
Senior Geotechnical Engineer


Timothy Smith, P.Geo., Eng.L.
Principal and Senior Engineering Geologist
2020/02/14



TYPICAL CROSS-SECTION

Scale 1:250



GRS BUTTRESS DETAIL

Scale 1:50



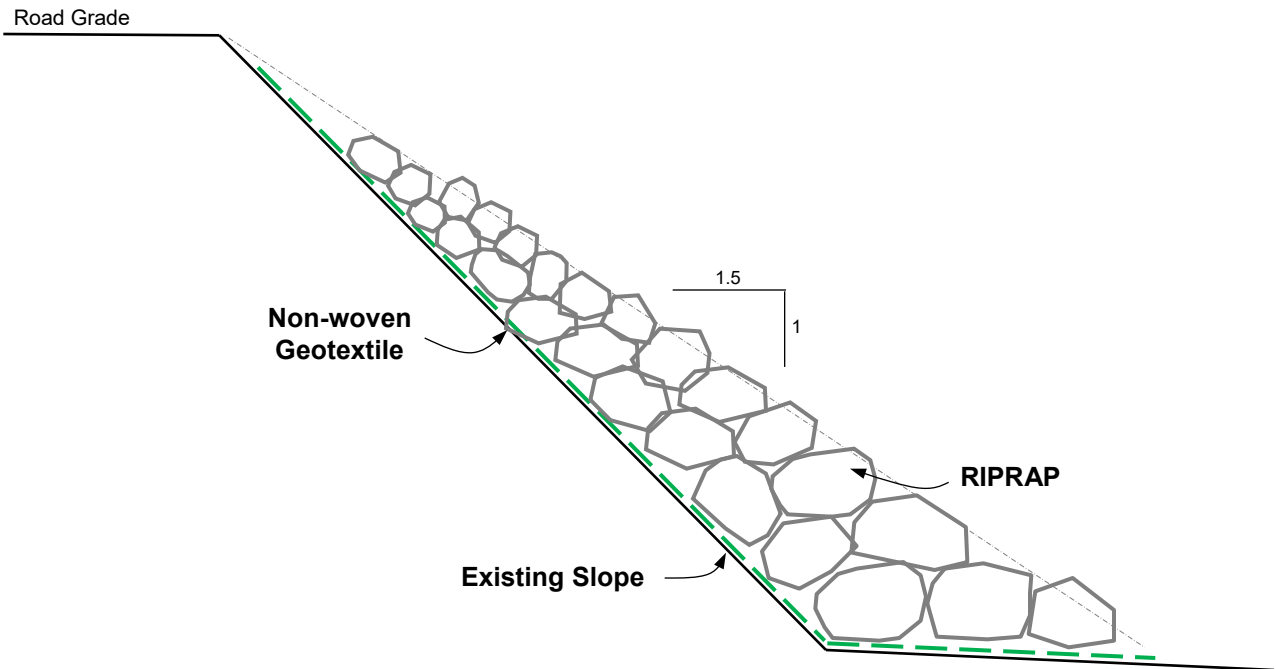
TOE BUTTRESS
STA. 11+778 to 11+845

Tenas Haul Road

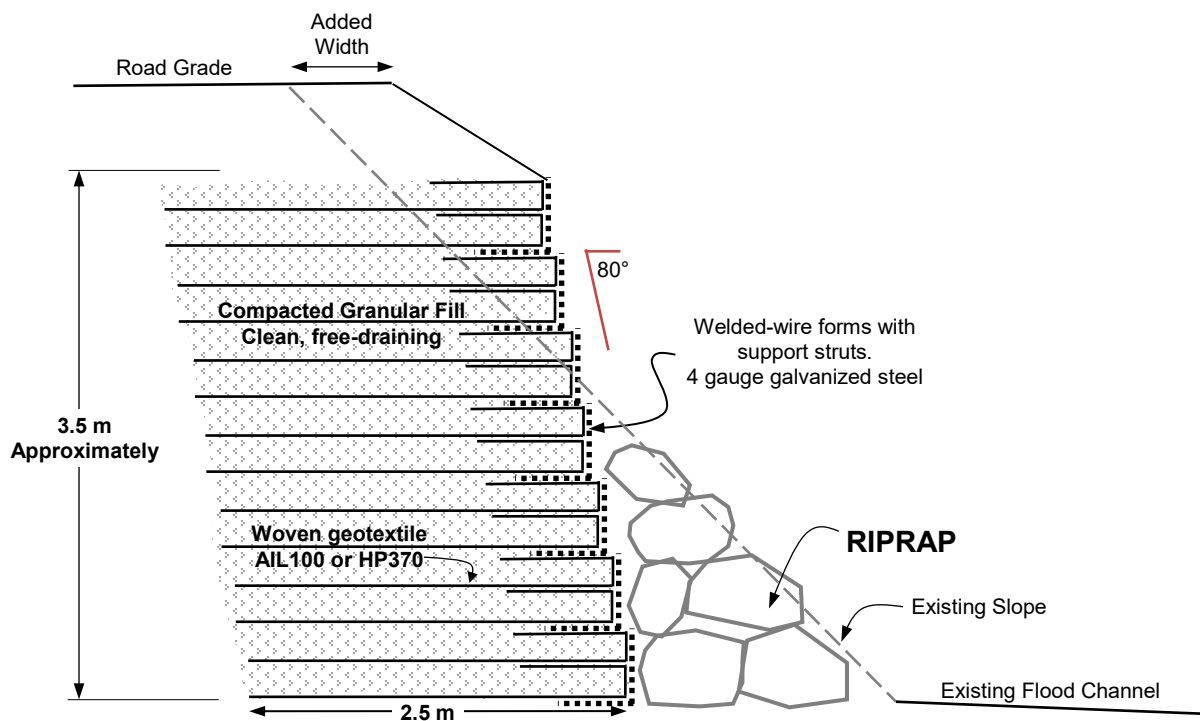
Scale: as noted

Project: 017-318

FIGURE 1



**OPTION 1
RIPRAP EXISTING FILLSLOPE**



**OPTION 2
RECONSTRUCTED GRS FILLSLOPE**



**ROAD STABILIZATION
STA. 13+040**

Tenas Haul Creek Road

Scale: 1:50

Project: 017-318

FIGURE 2

Appendix A

Interpretation and Use of Study and Report
and Limitations of Liability

Appendix A

Interpretation and Use of Study and Report and Limitations

1. STANDARD OF CARE.

This study and Report have been prepared in accordance with generally accepted engineering and geoscience practices. No other warranty, expressed or implied, is made. Geological and geotechnical studies and reports do not include environmental consulting unless specifically stated in the report.

2. COMPLETE REPORT.

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

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

3. BASIS OF THE REPORT.

The Report has been prepared for the specific site, development, design objectives and purpose that were described to us by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the document are only valid to the extent that there has been no material alteration to or variation from any of the said descriptions provided to us unless we are specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT.

The information and opinions expressed in the Report, or any document forming the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT OUR WRITTEN CONSENT. WE WILL CONSENT TO ANY REASONABLE REQUEST BY THE CLIENT TO APPROVE THE USE OF THIS REPORT BY OTHER PARTIES AS "APPROVED USERS". The contents of the Report remain our copyright property and we authorise only the Client and Approved Users to make copies of the Report only in such quantities as are reasonably necessary for the use of the Report by those parties. The Client and Approved Users may not give, lend, sell or otherwise make the Report or any portion thereof, available to any party without our written permission. Any uses, which a third party makes of the Report, or any portion of the Report, are the sole responsibility of such third parties. Westrek accepts no responsibility for damages suffered by any third party resulting from unauthorised use of the Report.

5. INTERPRETATION OF THE REPORT.

- (i) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, and engineering estimates have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations utilising the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarising such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions are subject to change over time and those making use of the Report

should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

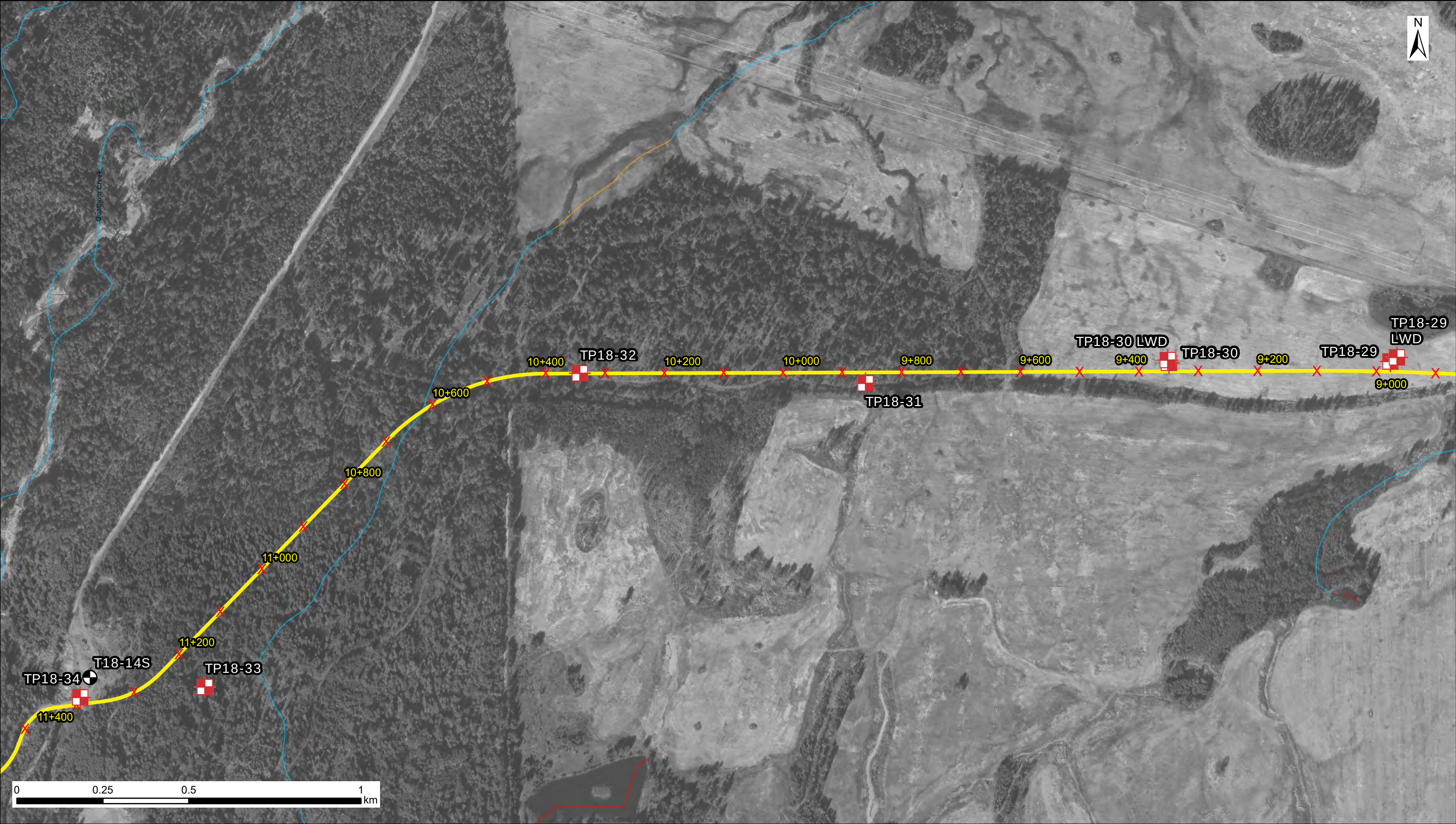
- (ii) Reliance on Provided information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to us. We have relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, we cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the report as a result of misstatements, omissions, misrepresentations or fraudulent acts of persons provided information.
- (iii) To avoid misunderstandings, Westrek should be retained to work with the other design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to engineering issues. Further, Westrek should be retained to provide field reviews during the construction, consistent with generally accepted practices.

6. LIMITATIONS OF LIABILITY.

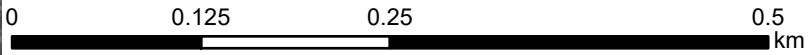
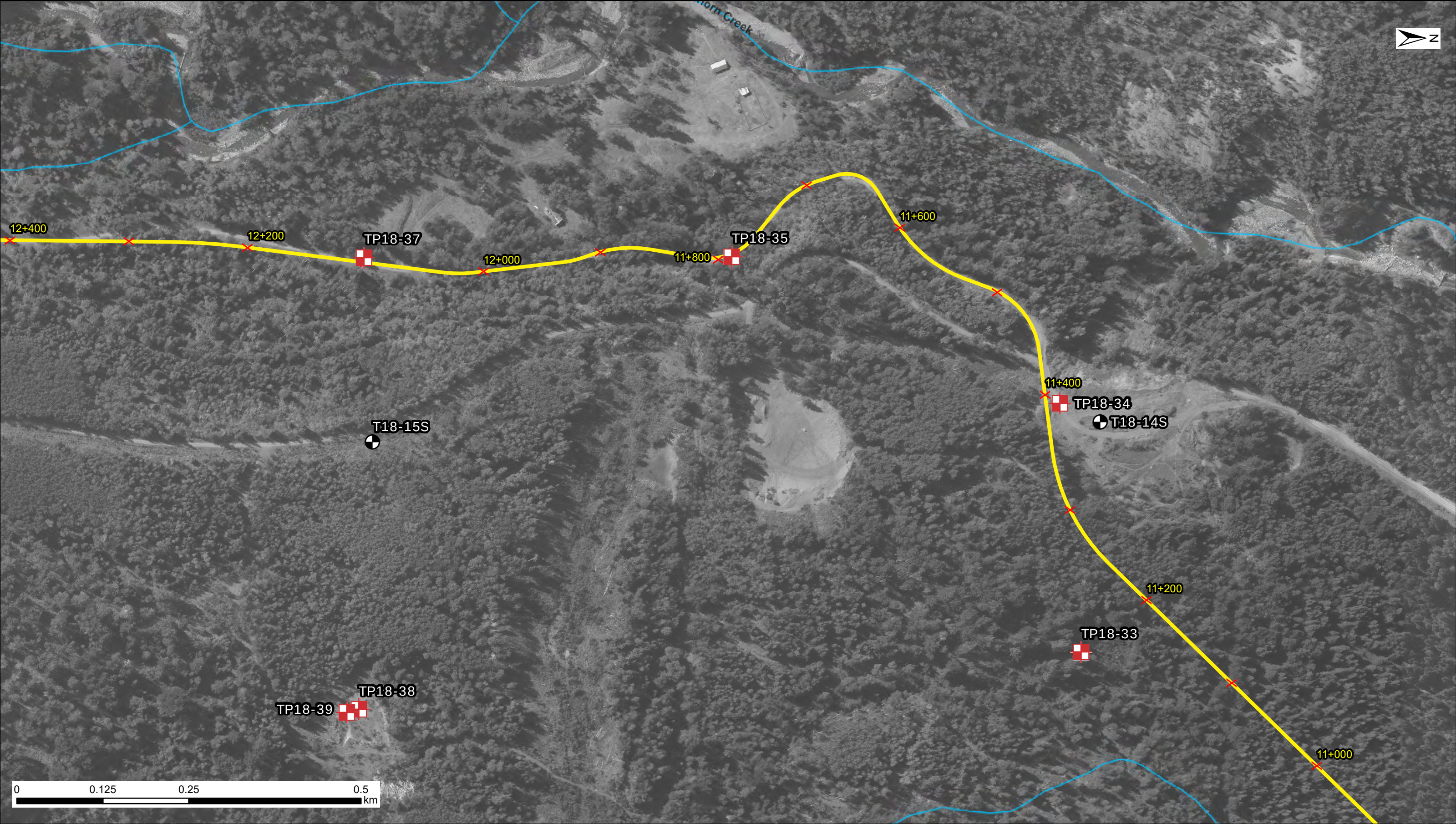
- (i) In recognition of the relative risks and benefits of the study and report to be provided to the Client by Westrek, the risks have been allocated such that the Client agrees, to the fullest extent permitted by law, to limit the liability of Westrek, its officers, directors, partners, employees, shareholders, owners, sub-consultants and principals for any and all claims, losses, costs, damages of any nature whatsoever or claims expenses from any cause or causes, whether arising in contract or tort, including legal fees and costs and disbursements, so that the total aggregate liability of Westrek, its officers, directors, partners, employees, shareholders, owners, sub-consultants and principals shall not exceed the limits of Westrek's insurance for services rendered for this matter. It is intended that this limitation will apply to any and all liability or cause of action however alleged or arising, unless otherwise prohibited by law. Notwithstanding the foregoing, it is expressly agreed that there shall be no claim whatsoever against Westrek, its officers, directors, partners, employees, shareholders, owners, sub-consultants and principals for loss of income, profit or other consequential damages howsoever arising.
- (ii) Westrek is not responsible for any errors, omissions, mistakes or inaccuracies contained in information provided by the Client, including but not limited to the location of underground or buried services, and with respect to such information, Westrek may rely on it without having to verify or test that information. Further, Westrek is not responsible for any errors or omissions committed by persons, consultants or specialists retained directly by the Client and with respect to any information, documents or opinions provided by such persons, consultants or specialists, Westrek may rely on such information, documents or opinions without having to verify or test the same.
- (iii) Notwithstanding the provisions of the *Limitations Act*, R.S.B.C. 1996 c. 266, Westrek's liability for any and all claims of the Client shall absolutely cease to exist after a period of two (2) years following the date of:
 - (a) Substantial performance of the services,
 - (b) suspension or abandonment of the agreement to provide the services to be provided under this agreement, or
 - (c) termination of Westrek's services under the agreement,whichever shall occur first, and following such period, the Client shall have no claim whatsoever against Westrek.

Appendix B

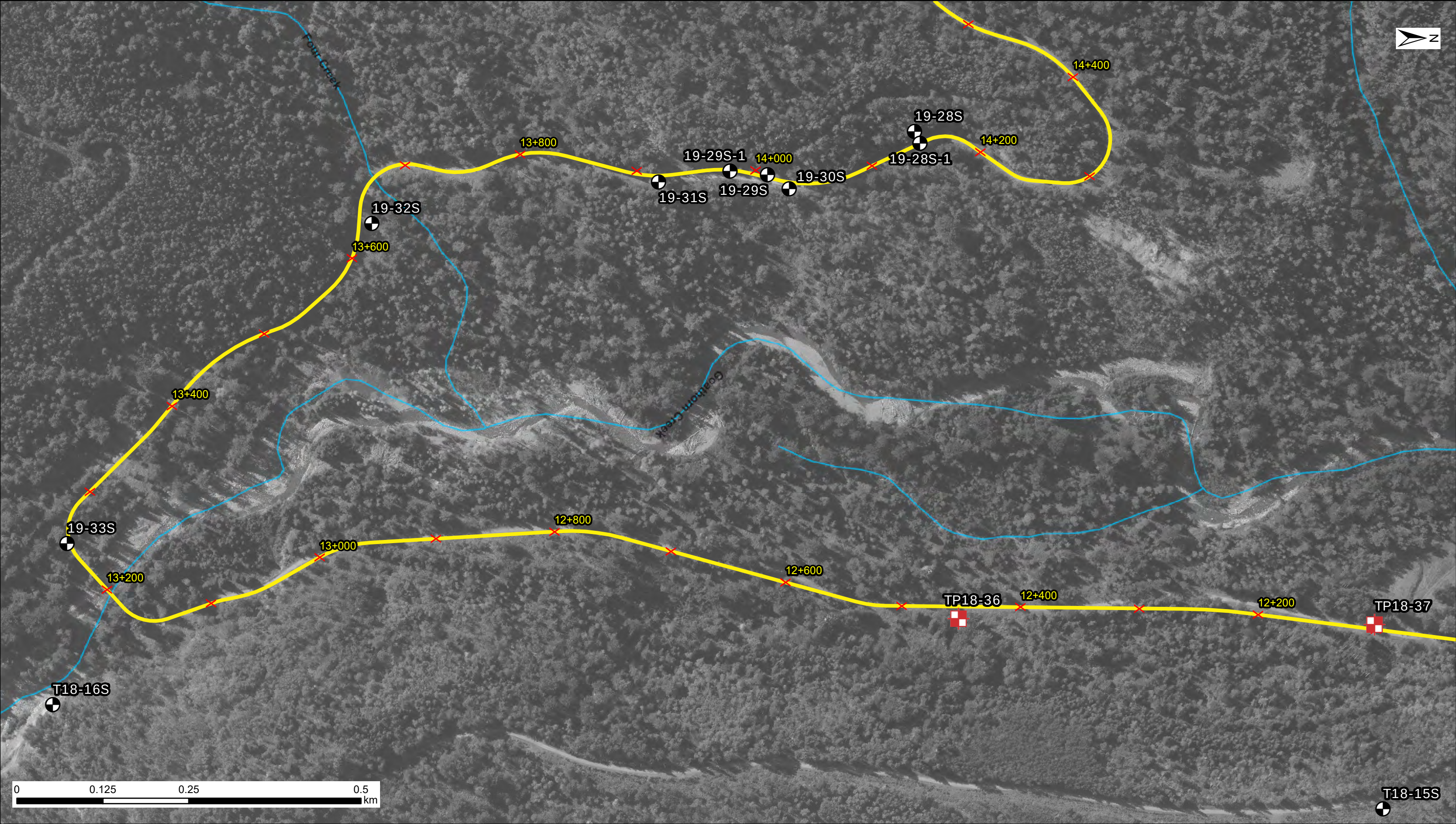
Drawings



	1:10000	TENAS HAUL ROAD - BOREHOLE AND TEST PIT LOCATION PLAN TELKWA, BC TELKWA COAL LTD.	DRAWING 01
	April 3, 2019		
	Project: 017-318		



 westrek geotechnical services ltd. 100-1383 McGill Road, Kamloops, BC V2C 6K7	1: 5000	TENAS HAUL ROAD - BOREHOLE AND TEST PIT LOCATION PLAN TELKWA, BC TELKWA COAL LTD.	DRAWING 02
	April 3, 2019		
	Project: 017-318		



 100-1383 McGill Road, Kamloops, BC V2C 6K7	1: 5000	TENAS HAUL ROAD - BOREHOLE AND TEST PIT LOCATION PLAN TELKWA, BC TELKWA COAL LTD.	DRAWING 03
	April 3, 2019		
	Project: 017-318		

Appendix C

Borehole & Test Pit Logs



BOREHOLE T18-14S

Telkwa Coal

Main road, site of landslide.

Date Drilled: Sep 24 - 25/2018

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620514E 6055570N

Elevation: 683.0 m

SAMPLE TYPE

☒ SPT SAMPLE

☐ GRAB SAMPLE

☐ SHELBY TUBE

☐ CORE SAMPLE

☐ NO RECOVERY

INSTALLATION

☒ GROUT

☐ BENTONITE

☐ SAND

☐ DRILL CUTTINGS

☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] [DCPT]
20 40 60 80
VANE SHEAR (kPa) [Rig] [Pocket]
40 80 120 160

OTHER DATA

Elevation (m)
Water Level

0 (SP) SAND
fine- to coarse-grained, trace to some fines, trace gravel,
subrounded; dark brown; moist, loose to compact, FILL.

1
2 - below ~1.8 m, includes chunks of SILT, trace fine gravel, trace coal
pods; rusty to maroon brown; w~PL, inferred stiff

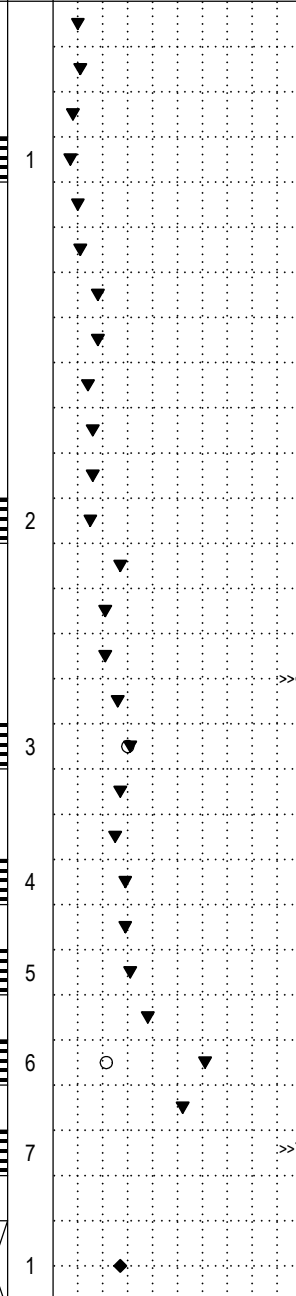
3
4 (ML) sandy SILT
trace clay, trace gravel, trace coal; rusty to maroon brown, with
localized fine- to coarse-grained sand interbeds; moist, dense.

5
6 ...becomes some sand; medium grey.

7 (SM/GM) silty SAND and SILTY GRAVEL
fine-grained to coarse-grained sand, fine to coarse gravel,
subrounded to subangular; medium brown, with pods of fines; wet,
dense to very dense.

8 (CI) SILT
some clay, trace sand, trace gravel, with occasional cobbles; medium
grey, behaves more like a clay than a silt; w<PL, hard (TILL).

9
10



Cvane @ 4.6 m = 319 kPa
W_n = 15.0%
W_n = 10.7%
Cpen @ 7.9 m = 160 kPa
N = 27
Recovery = 80%

WESTREK BOREHOLE LOG TELKWA COAL BOREHOLES GPJ WCS SOIL LOG.GDT 19-4-23

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SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN
ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 1 of 4



BOREHOLE T18-14S

Telkwa Coal

Main road, site of landslide.

Date Drilled: Sep 24 - 25/2018

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620514E 6055570N

Elevation: 683.0 m

SAMPLE TYPE

☒ SPT SAMPLE

☐ GRAB SAMPLE

☐ SHELBY TUBE

☐ CORE SAMPLE

☐ NO RECOVERY

INSTALLATION

☒ GROUT

☐ BENTONITE

☐ SAND

☐ DRILL CUTTINGS

☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL DESCRIPTION

SOIL SYMBOL

DEPTH (m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] [DCPT]
20 40 60 80
VANE SHEAR (kPa) [Rig] [Pocket]
40 80 120 160

OTHER DATA

SLOTTED
PIEZOMETER

Elevation (m)
Water Level

10
11
12
13
14
15
16
17
18
19
20

Sonic

(ML) SILT
some sand, fine-grained, some clay, trace gravel; maroon-brown; dry to moist, very dense (TILL).

- from 16.8 m - 17.4 m, silt seam (GLACIOLACUSTRINE).

- gravel content increases below.

2

8

9

10

11

Open @ 10.7 m > 220 kPa
N = 72
W_n = 9.5%
Recovery = 62.5%
Cvane @ 11.0 m = 441 kPa

W_n = 10.9% PL = 14.1%
LL = 32.7%

W_n = 14.6%
Sieve Analysis (17.2 m):
Gravel = 3% Sand = 13%
Silt = 73% Clay = 11%

672

671

670

669

668

667

666

665

664

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LOGGED: hkw

DRAWN: hkw

Page 2 of 4

**BOREHOLE T18-14S**

Telkwa Coal

Main road, site of landslide.

Date Drilled: Sep 24 - 25/2018

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620514E 6055570N

Elevation: 683.0 m

SAMPLE TYPE

☒ SPT SAMPLE☐ GRAB SAMPLE☐ SHELBY TUBE☐ CORE SAMPLE☐ NO RECOVERY

INSTALLATION

☒ GROUT☐ BENTONITE☐ SAND☒ DRILL CUTTINGS☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL DESCRIPTION

DEPTH
(m)
(ELEV.)SAMPLE TYPE
SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] ◆ [DCPT] ▼
20 40 60 80
VANE SHEAR (kPa) [Rig] ✕ [Pocket] ⊗
40 80 120 160

OTHER DATA

SLOTTED
PIEZOMETERElevation (m)
Water Level

20

- from 20.4 m - 20.7 m, becomes maroon and more gravelly.

20.4
662.5

21

22

- becomes more clayey.

22.5
660.5

23

(CI) SILT, clayey
trace sand, trace gravel, with trace cobbles; medium grey to medium brown, laminated, behaves more like a clay than a silt; w<PL to w~PL, hard (TILL).23.2
659.8

24

25

Sonic

26

- becomes massive, trace to some gravel.

25.9
657.1

27

28

29

(ML) SILT
trace gravel; maroon-brown; dry, very dense (TILL).29.3
653.7

30

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 3 of 4

WESTREK BOREHOLE LOG TELKWA COAL BOREHOLES GPJ WGS SOIL LOG.GDT 19-4-23

**BOREHOLE T18-14S**

Telkwa Coal

Main road, site of landslide.

Date Drilled: Sep 24 - 25/2018

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620514E 6055570N

Elevation: 683.0 m

SAMPLE TYPE ☒ SPT SAMPLE ☐ GRAB SAMPLE ☐ SHELBY TUBE ☐ CORE SAMPLE ☐ NO RECOVERY
INSTALLATION ☒ GROUT ☐ BENTONITE ☐ SAND ☒ DRILL CUTTINGS ☐ SCREEN

Depth (m)	DRILLING METHOD	SOIL DESCRIPTION	SOIL SYMBOL	DEPTH (m) (ELEV.)	SAMPLE TYPE	SAMPLE NO	PLASTIC	M.C.	LIQUID	OTHER DATA	SLOTTED PIEZOMETER	Elevation (m) Water Level
							10	20	30			
							BLOW COUNT [SPT] ◆ [DCPT] ▼					
							20	40	60	80		
							VANE SHEAR (kPa) [Rig] ✕ [Pocket] ⊗					
							40	80	120	160		
30	Sonic	End of hole at 30.5 m (652.5 m) Notes: Water level at 5.4 m below ground surface on April 18, 2019.		30.5								
				652.5								
31												652
32												651
33												650
34												649
35												648
36												647
37												646
38												645
39												644
40												

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 4 of 4

**BOREHOLE T18-15S**Telkwa Coal
Secondary road.

Date Drilled: Sep 26 - 27/2018

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620563E 6054948N

Elevation: 716.7 m

SAMPLE TYPE

☒ SPT SAMPLE☐ GRAB SAMPLE☐ SHELBY TUBE☐ CORE SAMPLE☐ NO RECOVERY

INSTALLATION

☒ GROUT☐ BENTONITE☐ SAND☐ DRILL CUTTINGS☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL
DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] [DCPT] ▼
20 40 60 80
VANE SHEAR (kPa) [Rig] [Pocket] ⊗
40 80 120 160

OTHER
DATAElevation (m)
Water Level

(SW/GW) SAND and GRAVEL
fine- to coarse-grained sand, fine to coarse gravel, subrounded to subangular, trace to some fines, trace cobbles; dark to medium brown, medium-bedded, with interbedded units of SAND and GRAVEL; moist, compact.
- becomes some cobbles; dry.

- contains thinly-bedded fine-grained sand

- from 4.4 m to 4.6 m, becomes rusty red-brown

- increased cobbles

- becomes trace cobbles; moist to dry, dense.

- interbedded sand and gravel
from ground surface to 12.8 m

- DCPT results skewed by
cobbles

- DCPT refused on large
cobble
 $W_n = 3.7\%$
Sieve Analysis (5.3 m):
Gravel = 44% Sand = 47%
Fines = 9%

N = 36
Recovery = 42%

WESTREK BOREHOLE LOG TELKWACOAL_BOREHOLES.GPJ WGS SOIL LOG.GDT 19-4-23

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N - Blow Count
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Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 1 of 4



BOREHOLE T18-15S

Telkwa Coal
Secondary road.

Date Drilled: Sep 26 - 27/2018

Drill Type: Sonic

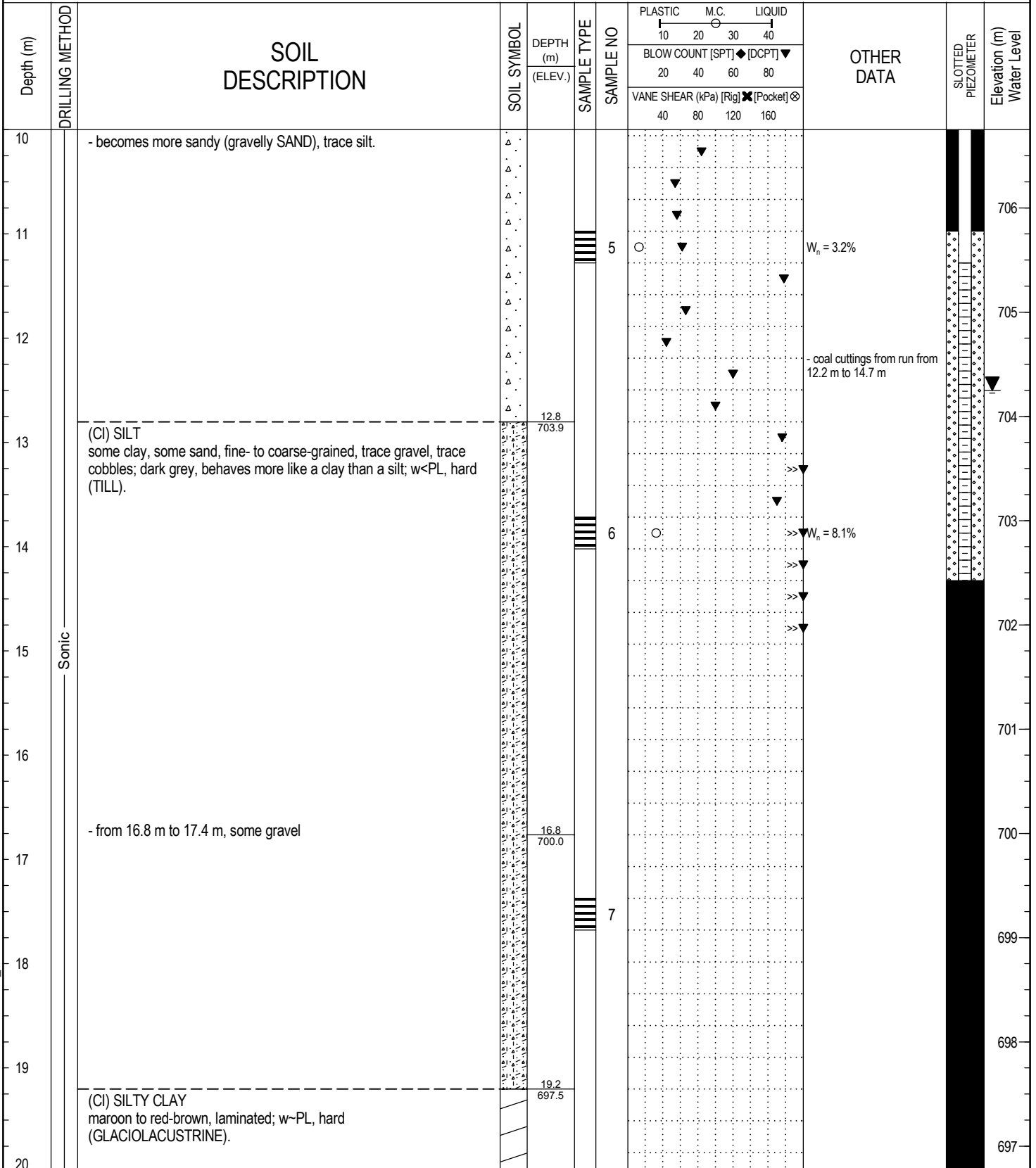
Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620563E 6054948N

Elevation: 716.7 m

SAMPLE TYPE ☒ SPT SAMPLE ☐ GRAB SAMPLE ☐ SHELBY TUBE ☐ CORE SAMPLE ☐ NO RECOVERY
INSTALLATION ☒ GROUT ☐ BENTONITE ☐ SAND ☒ DRILL CUTTINGS ☐ SCREEN



WESTREK BOREHOLE LOG TELKWACOAL_BOREHOLES.GPJ WGS SOIL LOG.GDT 19-4-23

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 2 of 4

**BOREHOLE T18-15S**Telkwa Coal
Secondary road.

Date Drilled: Sep 26 - 27/2018

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620563E 6054948N

Elevation: 716.7 m

SAMPLE TYPE

☒ SPT SAMPLE☐ GRAB SAMPLE☐ SHELBY TUBE☐ CORE SAMPLE☐ NO RECOVERY

INSTALLATION

☒ GROUT☐ BENTONITE☐ SAND☒ DRILL CUTTINGS☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] ◆ [DCPT] ▼
20 40 60 80
VANE SHEAR (kPa) [Rig] ✕ [Pocket] ⊗
40 80 120 160

OTHER DATA

SLOTTED
PIEZOMETERElevation (m)
Water Level

20

21

22

23

24

25

26

27

28

29

30

- with cobbles.

(ML) SILT
some clay, trace sand, trace gravel; dark grey and maroon-brown,
laminated; dry, very dense (GLACIOLACUSTRINE).
- becomes with cobbles; non-laminated.

(CI) SILTY CLAY
trace gravel; maroon; w<PL, hard (GLACIOLACUSTRINE).

(SP) SAND
fine-grained, trace gravel; maroon; dry, very dense
(GLACIOLACUSTRINE).

(CI) SILTY CLAY
maroon; w<PL, hard (GLACIOLACUSTRINE).

8

9

10

11

12

13

W_n = 22.5% PL = 18.1%
LL = 39.9%

W_n = 19.3%

696

695

694

693

692

691

690

689

688

687

WESTREK BOREHOLE LOG TELKWA COAL BOREHOLES GPJ WGS SOIL LOG.GDT 19-4-23

THIS LOG IS FOR GEOTECHNICAL PURPOSES ONLY.
THIS LOG IS THE SOLE PROPERTY OF WESTREK GEOTECHNICAL
SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN
ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 3 of 4

**BOREHOLE T18-15S**Telkwa Coal
Secondary road.

Date Drilled: Sep 26 - 27/2018

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620563E 6054948N

Elevation: 716.7 m

SAMPLE TYPE

☒ SPT SAMPLE☐ GRAB SAMPLE☐ SHELBY TUBE☐ CORE SAMPLE☐ NO RECOVERY

INSTALLATION

☒ GROUT☐ BENTONITE☐ SAND☐ DRILL CUTTINGS☐ SCREEN

Depth (m)

Sonic

Sonic

SOIL
DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] ◆ [DCPT] ▼
20 40 60 80
VANE SHEAR (kPa) [Rig] ✕ [Pocket] ⊗
40 80 120 160

OTHER
DATASLOTTED
PIEZOMETERElevation (m)
Water Level

30

31

32

33

34

35

36

37

38

39

40

End of hole at 30.5 m (686.3 m)
Notes: Water level at 12.5 m below ground surface on April 18, 2019.30.5
686.3

686

685

684

683

682

681

680

679

678

677

WESTREK BOREHOLE LOG TELKWACOAL_BOREHOLES.GPJ WGS SOIL LOG.GDT 19-4-23

THIS LOG IS FOR GEOTECHNICAL PURPOSES ONLY.
THIS LOG IS THE SOLE PROPERTY OF WESTREK GEOTECHNICAL
SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN
ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 4 of 4



BOREHOLE T18-16S

Telkwa Coal

Bridge.

Date Drilled: Sep 27-2018

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620517E 6053836N

Elevation: 685.8 m

SAMPLE TYPE

☒ SPT SAMPLE

☐ GRAB SAMPLE

☐ SHELBY TUBE

☐ CORE SAMPLE

☐ NO RECOVERY

INSTALLATION

☒ GROUT

☐ BENTONITE

☐ SAND

☐ DRILL CUTTINGS

☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] [DCPT]
20 40 60 80
VANE SHEAR (kPa) [Rig] [Pocket]
40 80 120 160

OTHER DATA

Elevation (m)

(SM) SILTY SAND
fine- to coarse-grained, some gravel, subangular to subrounded, with cobbles; medium brown; dry to moist, compact (possible FILL).

(SM) SILTY SAND
some gravel to gravelly, subrounded to subangular, some cobbles; medium brown, bedded; dry, dense (COLLUVIUM).

(ML) sandy SILT
some gravel, subrounded to angular, some cobbles; dark brown and black, with coal; dry, dense.

(ML) sandy SILT
trace to some gravel, some cobbles; red-brown; moist to dry, stiff to hard (WEATHERED COLLUVIUM).

SILTSTONE
weathered, dark grey, uniform, moderately fractured, moderately strong (R3).

1

1

2

3

4

3

N = 68
Recovery = 54%

N = 150
Recovery = 37.5%

N = 150
Recovery = 25%

N = 150
Recovery = 0%

- core samples retrieved below 9.1 m was drilled with water, resulting in better core condition for the given material.

WESTREK BOREHOLE LOG TELKWA COAL BOREHOLES GPJ WGS SOIL LOG.GDT 19-4-23

THIS LOG IS FOR GEOTECHNICAL PURPOSES ONLY.
THIS LOG IS THE SOLE PROPERTY OF WESTREK GEOTECHNICAL SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 1 of 2



BOREHOLE T18-16S

Telkwa Coal

Bridge.

Date Drilled: Sep 27-2018

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620517E 6053836N

Elevation: 685.8 m

SAMPLE TYPE

☒ SPT SAMPLE

☐ GRAB SAMPLE

☐ SHELBY TUBE

☐ CORE SAMPLE

☐ NO RECOVERY

INSTALLATION

☐ GROUT

☐ BENTONITE

☐ SAND

☐ DRILL CUTTINGS

☐ SCREEN

Depth (m)

DRILLING METHOD

Sonic

SOIL DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] ◆ [DCPT] ▼
20 40 60 80
VANE SHEAR (kPa) [Rig] ✕ [Pocket] ⊗
40 80 120 160

OTHER DATA

Elevation (m)

SILTSTONE
fresh, dark grey, uniform, very strong (R5).

End of hole at 12.2 m (673.6 m)

- core sample at around 10.7 m broken by drilling.

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 2 of 2



BOREHOLE 19-28S

Telkwa Coal
Road shoulder.

Date Drilled: Feb 16 - 17/2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620005.1E 6054560.5N

Elevation: 710.4 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE

☐ GRAB SAMPLE

☐ SHELBY TUBE

☐ CORE SAMPLE

☐ NO RECOVERY

INSTALLATION

☒ GROUT

☐ BENTONITE

☐ SAND

☐ DRILL CUTTINGS

☐ SCREEN

Depth (m)

DRILLING METHOD
Sonic

SOIL DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] [DCPT]
20 40 60 80
VANE SHEAR (kPa) [Rig] [Pocket]
40 80 120 160

OTHER DATA

Elevation (m)

(SM-GM) SILT and SAND
gravelly, trace clay, trace organics, with occasional cobbles; light grey
with orange-brown mottling, blocky; moist, loose to compact with very
dense blocks (FILL).

1

$W_n = 15.0\%$
Sieve Analysis (1.4 m):
Gravel = 29% Sand = 35%
Fines = 36%
Cpen @ 1.5 m (block) > 220
kPa
N = 80
Recovery = 0%
- SPT hit cobble/boulder.

2

$W_n = 14.8\%$

2

N = 17
Recovery = 67%

(ML) clayey SILT
trace sand, light grey with orange-brown mottling, blocky; moist, firm
to stiff with hard blocks (FILL).

3

$W_n = 13.2\%$
Sieve Analysis (5.9 m):
Gravel = 1% Sand = 6%
Silt = 61% Clay = 33%
Cpen @ 6.1 m (block) > 220
kPa

3

Cpen @ 7.6 m (block) > 220
kPa
N = 10
Recovery = 21%

(ML) SILT
trace sand, trace gravel; maroon; moist, very dense (WEATHERED
TILL).

4

Cpen @ 8.5 m > 220 kPa
 $W_n = 9.3\%$

(ML) SILT
trace to some sand, trace clay; light grey with maroon mottling, with
localized silty sand interbeds; moist, very dense (TILL).

4

- VWP (VW56321) installed @
9.1 m.
N = 200
Recovery = 21%

WEATHERED SILTSTONE
moderately fractured, medium grey, moderately strong (R3).

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SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN
ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 1 of 2

**BOREHOLE 19-28S**Telkwa Coal
Road shoulder.

Date Drilled: Feb 16 - 17/2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620005.1E 6054560.5N

Elevation: 710.4 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE☐ GRAB SAMPLE☐ SHELBY TUBE☐ CORE SAMPLE☐ NO RECOVERY

INSTALLATION

☒ GROUT☐ BENTONITE☐ SAND☐ DRILL CUTTINGS☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL
DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] ◆ [DCPT] ▼
20 40 60 80
VANE SHEAR (kPa) [Rig] ✕ [Pocket] ⊗
40 80 120 160

OTHER
DATASLOPE
INCLINOMETER

Elevation (m)

SILTSTONE

fresh, moderately fractured, medium to dark grey, very strong (R5).

10.4
700.0

Open @ 10.7 m > 220 kPa

700

699

698

697

696

695

694

16.8
693.6

End of hole at 16.8 m (693.6 m)

Notes: Road box well protector, top of pipe is 0.9 m above ground surface. Surveyed elevation is of ground surface.

693

692

691

THIS LOG IS FOR GEOTECHNICAL PURPOSES ONLY.
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SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN
ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 2 of 2

WESTREK BOREHOLE LOG TELKWA_FEB2019_BOREHOLES.GPJ WGS SOIL LOG.GDT 19-4-1

**BOREHOLE 19-28S-1**Telkwa Coal
Road.

Date Drilled: Feb 18-2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620010.8E 6054565.4N

Elevation: 710.2 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE☐ GRAB SAMPLE☐ SHELBY TUBE☐ CORE SAMPLE☐ NO RECOVERY

INSTALLATION

☒ GROUT☐ BENTONITE☐ SAND☐ DRILL CUTTINGS☐ SCREEN

Depth (m)

DRILLING METHOD

Sonic

SOIL
DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] ◆ [DCPT] ▼
20 40 60 80
VANE SHEAR (kPa) [Rig] ✕ [Pocket] ⊗
40 80 120 160

OTHER
DATAElevation (m)
Water Level

(SM/GM) SILTY SAND and GRAVEL
trace organics; medium brown; damp, loose (FILL).

(ML) clayey SILT
trace sand, trace gravel, with rare cobbles; medium grey with rusty
orange mottling, blocky; damp, very soft to firm with hard blocks
(FILL).

- becomes w~PL to w>PL.

(ML) SILT
trace to some clay, trace sand, trace gravel; medium grey with
orange-brown mottling; w<PL, hard (TILL).

WEATHERED SILTSTONE
moderately fractured, light maroon, moderately strong (R3).

1

2

1

3

4

2

5

6

7

 $W_n = 18.4\%$

Cpen @ 2.7 m (block) > 220
kPa

N = 19
Recovery = 38%

$W_n = 13.2\%$
Sieve Analysis (4.1 m):
Gravel = 4% Sand = 9%
Silt = 57% Clay = 30%
Cpen @ 1.2 m (block) > 220
kPa

Cpen @ 5.8 m (block) = 220
kPa

N = 3
Recovery = 25%
- gravel lodged in SPT spoon.

Cpen @ 7.3 m (block) = 190
kPa
 $W_n = 18.5\%$

Cpen @ 8.2 m = 230 kPa

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THIS LOG IS THE SOLE PROPERTY OF WESTREK GEOTECHNICAL
SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN
ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 1 of 2

WESTREK BOREHOLE LOG TELKWA_FEB2019_BOREHOLES GPJ WGS SOIL LOG.GDT 19-4-1



BOREHOLE 19-28S-1

Telkwa Coal
Road.

Date Drilled: Feb 18-2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620010.8E 6054565.4N

Elevation: 710.2 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE

☐ GRAB SAMPLE

☐ SHELBY TUBE

☐ CORE SAMPLE

☐ NO RECOVERY

INSTALLATION

☐ GROUT

☐ BENTONITE

☐ SAND

☐ DRILL CUTTINGS

☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL
DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] ◆ [DCPT] ▼
20 40 60 80
VANE SHEAR (kPa) [Rig] ✕ [Pocket] ⊗
40 80 120 160

OTHER
DATA

Elevation (m)
Water Level

10

Sonic

- becomes rusty brown.

10.4
699.8

10.7
699.5

End of hole at 10.7 m (699.5 m)

11

12

13

14

15

16

17

18

19

20

700

699

698

697

696

695

694

693

692

691

WESTREK BOREHOLE LOG TELKWA_FEB2019_BOREHOLES GPJ WGS SOIL LOG.GDT 19-4-1

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SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN
ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 2 of 2



BOREHOLE 19-29S

Telkwa Coal
Road.

Date Drilled: Feb 18-2019

Drill Type: Sonic

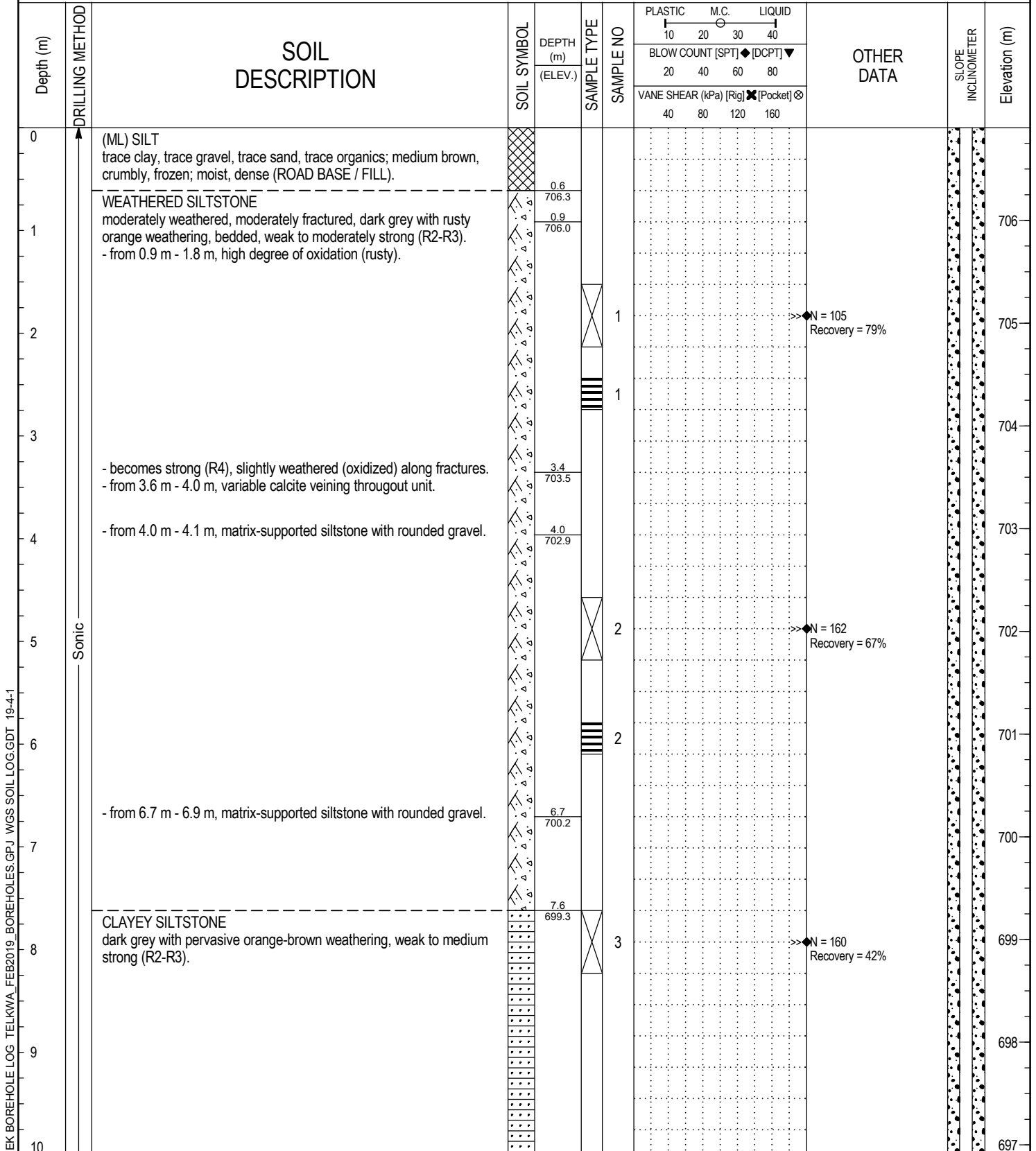
Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620040.8E 6054403.2N

Elevation: 706.9 m [surveyed]

SAMPLE TYPE ☒ SPT SAMPLE ☐ GRAB SAMPLE ☐ SHELBY TUBE ☐ CORE SAMPLE ☐ NO RECOVERY
INSTALLATION ☒ GROUT ☐ BENTONITE ☐ SAND ☒ DRILL CUTTINGS ☐ SCREEN



WESTREK BOREHOLE LOG TELKWA FEB2019_BOREHOLES GPJ WCS SOIL LOG.GDT 19-4-1

THIS LOG IS FOR GEOTECHNICAL PURPOSES ONLY.
THIS LOG IS THE SOLE PROPERTY OF WESTREK GEOTECHNICAL SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw
DRAWN: hkw
Page 1 of 2



BOREHOLE 19-29S

Telkwa Coal

Road.

Date Drilled: Feb 18-2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620040.8E 6054403.2N

Elevation: 706.9 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE

☐ GRAB SAMPLE

☐ SHELBY TUBE

☐ CORE SAMPLE

☐ NO RECOVERY

INSTALLATION

☐ GROUT

☐ BENTONITE

☐ SAND

☐ DRILL CUTTINGS

☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] [DCPT]
20 40 60 80
VANE SHEAR (kPa) [Rig] [Pocket]
40 80 120 160

OTHER DATA

SLOPE
INCLINOMETER

Elevation (m)

10

11

12

13

14

15

16

17

18

19

20

Sonic

End of hole at 10.7 m (696.2 m)
Notes: Flush mount well protector installed 0.45 m below ground surface, covered with road base.

10.7
696.2

3

696

695

694

693

692

691

690

689

688

687

WESTREK BOREHOLE LOG TELKWA_FEB2019_BOREHOLES GPJ WGS SOIL LOG.GDT 19-4-1

THIS LOG IS FOR GEOTECHNICAL PURPOSES ONLY.
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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 2 of 2



BOREHOLE 19-29S-1

Telkwa Coal
Road.

Date Drilled: Feb 20-2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620044.8E 6054435.6N

Elevation: 707.5 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE

☐ GRAB SAMPLE

☐ SHELBY TUBE

☐ CORE SAMPLE

☐ NO RECOVERY

INSTALLATION

☐ GROUT

☐ BENTONITE

☐ SAND

☐ DRILL CUTTINGS

☐ SCREEN

Depth (m)

DRILLING METHOD
Sonic

SOIL DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] ◆ [DCPT] ▼
20 40 60 80
VANE SHEAR (kPa) [Rig] ✕ [Pocket] ⊗
40 80 120 160

OTHER DATA

Elevation (m)

0
1
2
3
4
5
6
7
8
9
10

(ML) SILT
trace clay, trace gravel, trace sand, trace organics; medium brown,
crumbly, frozen; moist, dense (ROAD BASE / FILL).

WEATHERED SILTSTONE
moderately weathered, moderately fractured, dark grey with rusty
orange weathering, bedded, weak to moderately strong (R2-R3).

End of hole at 3.0 m (704.5 m)

0.8
706.7
3.0
704.5

1

- from 0 m - 0.76 m, frozen.

707
706
705
704
703
702
701
700
699
698

WESTREK BOREHOLE LOG TELKWA_FEB2019_BOREHOLES GPJ WGS SOIL LOG.GDT 19-4-1

THIS LOG IS FOR GEOTECHNICAL PURPOSES ONLY.
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SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN
ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 1 of 1



BOREHOLE 19-30S

Telkwa Coal
Road shoulder.

Date Drilled: Feb 19-2019

Drill Type: Sonic

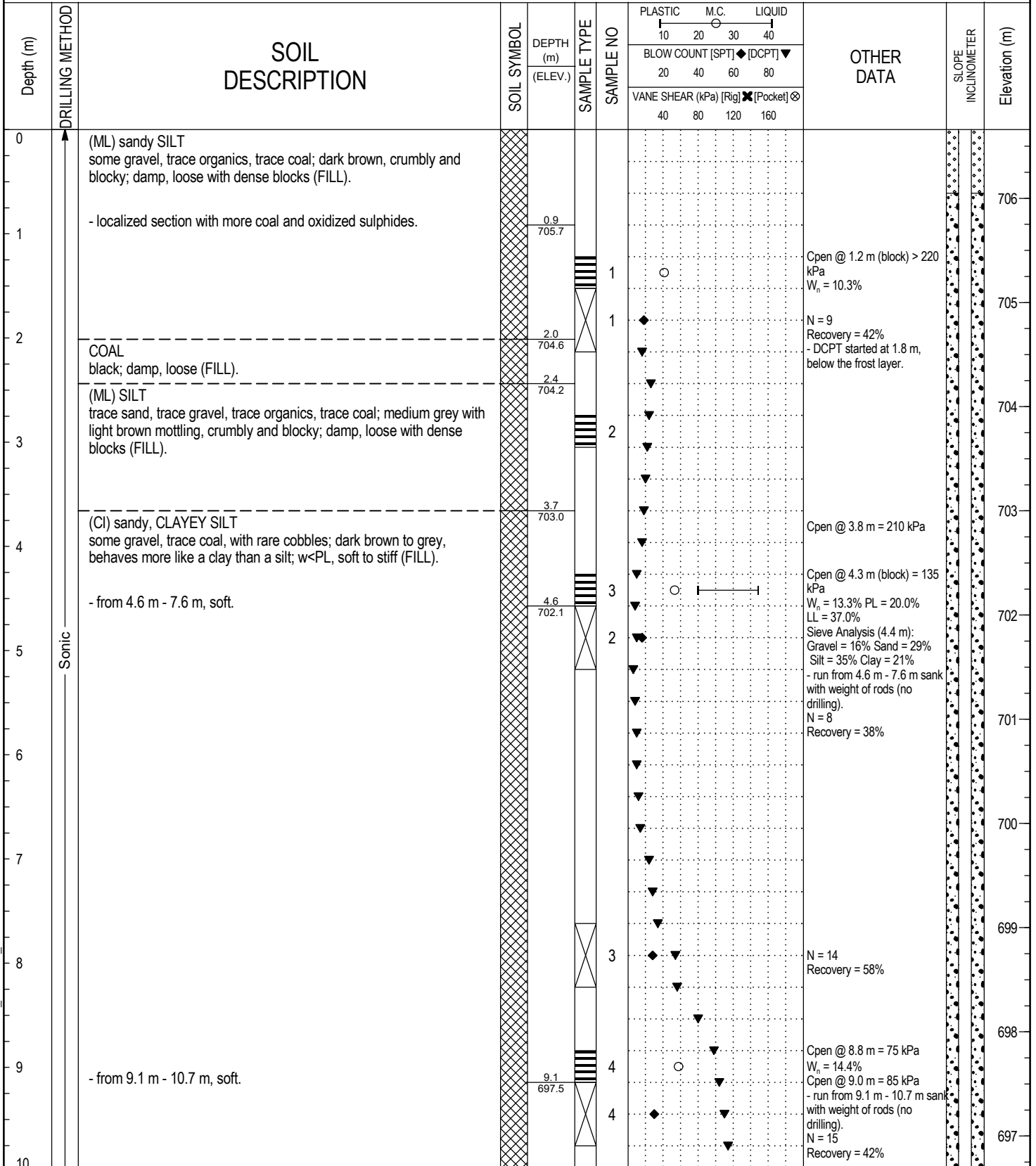
Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620049.7E 6054456.2N

Elevation: 706.7 m [surveyed]

SAMPLE TYPE ☒ SPT SAMPLE ☒ GRAB SAMPLE ☐ SHELBY TUBE ☐ CORE SAMPLE ☐ NO RECOVERY
INSTALLATION ☒ GROUT ☒ BENTONITE ☒ SAND ☒ DRILL CUTTINGS ☐ SCREEN



WESTREK BOREHOLE LOG TELKWA FEB2019_BOREHOLES GPJ WGS SOIL LOG.GDT 19-4-1

THIS LOG IS FOR GEOTECHNICAL PURPOSES ONLY.
THIS LOG IS THE SOLE PROPERTY OF WESTREK GEOTECHNICAL SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 1 of 2



BOREHOLE 19-30S

Telkwa Coal
Road shoulder.

Date Drilled: Feb 19-2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620049.7E 6054456.2N

Elevation: 706.7 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE

☐ GRAB SAMPLE

☐ SHELBY TUBE

☐ CORE SAMPLE

☐ NO RECOVERY

INSTALLATION

☒ GROUT

☐ BENTONITE

☐ SAND

☐ DRILL CUTTINGS

☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] [DCPT]
20 40 60 80
VANE SHEAR (kPa) [Rig] [Pocket]
40 80 120 160

OTHER DATA

SLOPE
INCLINOMETER

Elevation (m)

- from 11.0 m - 11.8 m, stiff, coal seams with brown-red oxidation.

(ML) SILT and GRAVEL

trace to some clay, trace sand, with cobbles; dark brown to grey with orange-brown mottling; damp, compact (FILL).

- from 12.2 m to 12.8 m, becomes grey with rusty brown weathering, calcified.

(ML) CLAYEY SILT

some gravel, trace sand, with cobbles; dark brown to grey; w~PL to w<PL, very soft to stiff (FILL).

- from 14.0 m - 15.2 m, soft and wet.

SILTSTONE

fresh, medium grey, very strong (R5).

End of hole at 18.3 m (688.4 m)

Notes: Flush mount well protector at surface. DCPT completed on road, approx. 2 m west of sonic borehole.

Cpen @ 11.0 m = 85 kPa

W_n = 10.5%
Sieve Analysis (12.0 m):
Gravel = 37% Sand = 8%
Silt = 44% Clay = 11%
N = 24
Recovery = 63%

Cpen @ 13.4 m > 220 kPa

Cpen @ 13.7 m = 195 kPa
W_n = 12.8%
Sieve Analysis (13.9 m):
Gravel = 22% Sand = 10%
Silt = 48% Clay = 20%
- run from 14.0 m - 15.2 m
sank with weight of rods (no drilling).

- VWP (VW56320) installed @ 14.9 m.

N = 200
Recovery = 0%

WESTREK BOREHOLE LOG TELKWA_FEB2019_BOREHOLES.GPJ WGS SOIL LOG.GDT 19-4-1

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 2 of 2

**BOREHOLE 19-31S**Telkwa Coal
Road shoulder.

Date Drilled: Feb 20 - 21/2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620048.2E 6054334.2N

Elevation: 704.9 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE☐ GRAB SAMPLE☐ SHELBY TUBE☐ CORE SAMPLE☐ NO RECOVERY

INSTALLATION

☒ GROUT☐ BENTONITE☐ SAND☐ DRILL CUTTINGS☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL
DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] [DCPT]
20 40 60 80
VANE SHEAR (kPa) [Rig] [Pocket]
40 80 120 160

OTHER
DATA

Elevation (m)

(ML) gravelly, sandy SILT
trace coal, with cobbles; medium grey with orange-brown and
red-brown mottling; moist, very loose to loose (ROAD BASE / FILL).

(GM) gravelly SILT
some sand; medium grey to medium brown, orange-brown
weathering; moist, loose to compact (FILL).

Sonic

4.0
700.9

C_{pen} @ 1.2 m = 85 kPa
W_n = 13.3%
Sieve Analysis (1.4 m):
Gravel = 22% Sand = 28%
Fines = 51%
N = 4
Recovery = 42%

N = 7
Recovery = 42%

W_n = 9.2%

N = 21
Recovery = 38%

N = 12
Recovery = 38%

C_{pen} @ 7.3 m = 110 kPa
VWP (VW56319) installed at
7.6 m.
N = 18
Recovery = 63%

W_n = 21.0%
Sieve Analysis (8.4 m):
Gravel = 40% Sand = 12%
Fines = 49%

N = 22
Recovery = 58%

WESTREK BOREHOLE LOG TELKWA FEB2019_BOREHOLES GPJ WGS SOIL LOG.GDT 19-4-1

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 1 of 3



BOREHOLE 19-31S

Telkwa Coal
Road shoulder.

Date Drilled: Feb 20 - 21/2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620048.2E 6054334.2N

Elevation: 704.9 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE

☐ GRAB SAMPLE

☐ SHELBY TUBE

☐ CORE SAMPLE

☐ NO RECOVERY

INSTALLATION

☐ GROUT

☐ BENTONITE

☐ SAND

☐ DRILL CUTTINGS

☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL
DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

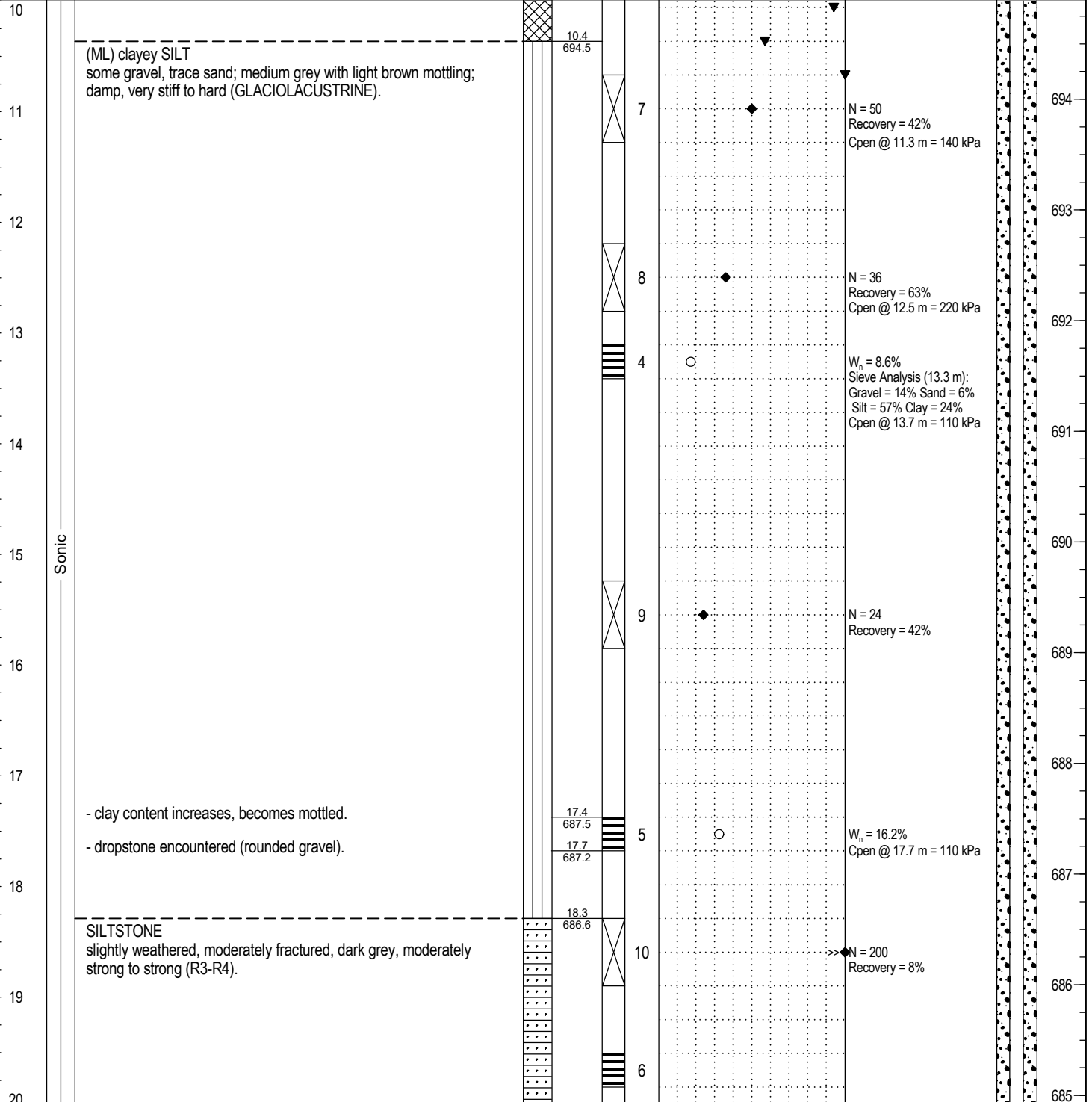
SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] [DCPT]
20 40 60 80
VANE SHEAR (kPa) [Rig] [Pocket]
40 80 120 160

OTHER
DATA

SLOPE
INCLINOMETER

Elevation (m)





BOREHOLE 19-31S

Telkwa Coal
Road shoulder.

Date Drilled: Feb 20 - 21/2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620048.2E 6054334.2N

Elevation: 704.9 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE

☐ GRAB SAMPLE

☐ SHELBY TUBE

☐ CORE SAMPLE

☐ NO RECOVERY

INSTALLATION

☐ GROUT

☐ BENTONITE

☐ SAND

☐ DRILL CUTTINGS

☐ SCREEN

PLASTIC M.C. LIQUID

10 20 30 40

BLOW COUNT [SPT] ☒ [DCPT] ☒

20 40 60 80

VANE SHEAR (kPa) [Rig] ☒ [Pocket] ☒

40 80 120 160

OTHER
DATA

SLOPE
INCLINOMETER

Elevation (m)

Depth (m)

DRILLING METHOD

SOIL
DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

7

24.4
680.5

End of hole at 24.4 m (680.5 m)
Notes: Road box well protector, top of pipe is 0.9 m above ground
surface. Surveyed elevation is of ground surface.

Sonic

684

683

682

681

680

679

678

677

676

675

WESTREK BOREHOLE LOG TELKWA_FEB2019_BOREHOLES GPJ WGS SOIL LOG.GDT 19-4-1

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 3 of 3

**BOREHOLE 19-32S**Telkwa Coal
Road shoulder.

Date Drilled: Feb 22-2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620093.2E 6054105.7N

Elevation: 691.0 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE☐ GRAB SAMPLE☐ SHELBY TUBE☐ CORE SAMPLE☐ NO RECOVERY

INSTALLATION

☒ GROUT☐ BENTONITE☐ SAND☐ DRILL CUTTINGS☐ SCREEN

Depth (m)

DRILLING METHOD

Sonic

SOIL
DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] [DCPT] ▼
20 40 60 80
VANE SHEAR (kPa) [Rig] ✕ [Pocket] ⊗
40 80 120 160

OTHER
DATA

Elevation (m)

0 (ML) SILT
trace sand, trace gravel, trace organics; medium brown, blocky;
moist, loose (bulk) to dense (blocks) (FILL).

0.9
690.1

1 (SM) SILTY SAND
some gravel, trace organics; dark brown; moist, loose (FILL).

2.4
688.6

2 (CI) CLAYEY SILT
some sand, trace gravel; medium brown, behaves more like a clay
than a silt; moist, firm to stiff (FILL).

1

1

CPen @ 0.9 m = 150 kPa

CPen @ 2.7 m = 160 kPa

N = 10
Recovery = 38%

CPen @ 4.3 m = 100 kPa

W_n = 21.8% PL = 18.0%
LL = 33.0%
Sieve Analysis (5.0 m):
Gravel = 4% Sand = 15%
Silt = 49% Clay = 32%
Cvane @ 5.2 m = 54 kPa
Cvane @ 5.8 m = 34 kPa

N = 8
Recovery = 79%
Cvane @ 6.4 m = 29 kPa

7.8
683.2 (SM) SILTY SAND
fine-grained, trace coal; medium brown; wet, compact.

3

W_n = 27.2%

8.8
682.2 (CI) CLAYEY SILT
trace sand, with rare cobbles; medium grey, behaves more like a clay
than a silt; w~PL to w<PL, very stiff to hard (GLACIOLACUSTRINE).

3

N = 19
Recovery = 33%

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 1 of 2

WESTREK BOREHOLE LOG TELKWA_FEB2019_BOREHOLES GPJ WGS SOIL LOG.GDT 19-4-1



BOREHOLE 19-32S

Telkwa Coal
Road shoulder.

Date Drilled: Feb 22-2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620093.2E 6054105.7N

Elevation: 691.0 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE

☐ GRAB SAMPLE

☐ SHELBY TUBE

☐ CORE SAMPLE

☐ NO RECOVERY

INSTALLATION

☐ GROUT

☐ BENTONITE

☐ SAND

☐ DRILL CUTTINGS

☐ SCREEN

Depth (m)

DRILLING METHOD

SOIL
DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] ◆ [DCPT] ▼
20 40 60 80
VANE SHEAR (kPa) [Rig] ✕ [Pocket] ⊗
40 80 120 160

OTHER
DATA

Elevation (m)

10
11
12
13
14
15
16
17
18
19
20

Sonic

- dropstone encountered (rounded gravel).

SILTSTONE
fresh, dark grey, thinly bedded, moderately to very strong (R3-R5).

End of hole at 17.4 m (673.6 m)

15.2
675.8

15.5
675.5

17.4
673.6

4

4

5

CPen @ 10.4 m = 175 kPa
 $W_p = 17.1\%$ PL = 18.0%
LL = 40.0%
Sieve Analysis (10.5 m):
Gravel = 0% Sand = 2%
Silt = 64% Clay = 34%

N = 16
Recovery = 38%

CPen @ 13.4 m = 175 kPa

CPen @ 14.9 m > 220 kPa

N = 110
Recovery = 42%

680

679

678

677

676

675

674

673

672

WESTREK BOREHOLE LOG TELKWA_FEB2019_BOREHOLES.GPJ WGS SOIL LOG.GDT 19-4-1

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N - Blow Count
Standard Penetration Test [SPT]: ASTM D1586
Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 2 of 2

**BOREHOLE 19-33S**

Telkwa Coal

Bridge site.

Date Drilled: Feb 24-2019

Drill Type: Sonic

Driller: Boart Longyear

Project No. 017-318

Co-ordinate: 9U 620371.2E 6053856.6N

Elevation: 682.5 m [surveyed]

SAMPLE TYPE

☒ SPT SAMPLE☐ GRAB SAMPLE☐ SHELBY TUBE☐ CORE SAMPLE☐ NO RECOVERY

INSTALLATION

☒ GROUT☐ BENTONITE☐ SAND☐ DRILL CUTTINGS☐ SCREEN

Depth (m)

DRILLING METHOD
Sonic

SOIL DESCRIPTION

SOIL SYMBOL

DEPTH
(m)
(ELEV.)

SAMPLE TYPE

SAMPLE NO

PLASTIC M.C. LIQUID
10 20 30 40
BLOW COUNT [SPT] ◆ [DCPT] ▼
20 40 60 80
VANE SHEAR (kPa) [Rig] ✕ [Pocket] ⊗
40 80 120 160

OTHER DATA

Elevation (m)

0
1
2
3
4
5
6
7
8
9
10

TOPSOIL

(GP-GM) GRAVEL and SAND
subangular to subrounded, trace silt, with occasional cobbles;
medium brown; damp, loose.0.3
682.2

1

1

WEATHERED SILTSTONE

moderately fractured, medium grey, moderately strong (R3).

SILTSTONE

fresh, medium to dark grey, strong (R4).

3.4
679.13.7
678.8

W_n = 3.7%
Sieve Analysis (1.4 m):
Gravel = 47% Sand = 44%
Fines = 9%

N = 31
Recovery = 38%
- drilling method skewed rock
strength.

End of hole at 6.1 m (676.4 m)

6.1
676.4682
681
680
679
678
677
676
675
674
673

WESTREK BOREHOLE LOG TELKWA_FEB2019_BOREHOLES GPJ WGS SOIL LOG.GDT 19-4-1

THIS LOG IS FOR GEOTECHNICAL PURPOSES ONLY.
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SERVICES LTD. AND CANNOT BE USED OR DUPLICATED IN
ANYWAY WITHOUT EXPRESS WRITTEN PERMISSION.

N - Blow Count

Standard Penetration Test [SPT]: ASTM D1586

Dynamic Cone Penetration Test [DCPT]: Number of blows using SPT energy to
produce 300 mm of penetration of a 50 mm diameter cone.

LOGGED: hkw

DRAWN: hkw

Page 1 of 1

RECORD OF TEST PIT TP18-29 Telkwa Coal

Site Conditions: Agriculture field

Date Excavated: 2018-Nov-01

Equipment: Excavator

Project No.: 017-318

Co-ordinate: 9U 622721E 6056179N

Elevation: No elevation

Depth (m)	DEPTH (m) (ELEV.)	SOIL DESCRIPTION	SOIL SYMBOL	SAMPLE NO	PLASTIC 20 40 60 80 M.C. 20 40 60 80 LIQUID 20 40 60 80	OTHER DATA	Elevation (m)
0	0.2	TOPSOIL (ML) SILT sandy; trace organics; brown. (CL) SILTY CLAY sandy, some gravel, trace cobbles and boulders (rounded to sub-rounded); low plastic; stiff; w<PL; light brown.			DCPT RESISTANCE [PORTABLE] POCKET PEN. UCS (kPa) TORVANE UCS (kPa)	LWD @ 0.6m depth: EVD = 20.5 MN/m2 W _n = 8.6% PL = 16% LL = 29% Sieve Analysis : Gravel = 18.2% Sand = 30% Fines = 51.7% SA-01 additional lab testing: Standard Proctor, CBR. Refer to report for results.	
1				1			
1.6		End of test pit at 1.6 m Notes: No seepage. Sampling depth is approximate.					
2							
3							
4							

PHOTOGRAPHS



Photo 1: Test pit excavation.



Photo 2: Excavated material.

RECORD OF TEST PIT TP18-30 Telkwa Coal

Site Conditions: Agriculture field

Date Excavated: 2018-Nov-01

Equipment: Excavator

Project No.: 017-318

Co-ordinate: 9U 622330E 6056174N

Elevation: No elevation

Depth (m)	DEPTH (m) (ELEV.)	SOIL DESCRIPTION	SOIL SYMBOL	SAMPLE	SAMPLE NO	PLASTIC	M.C.	LIQUID	OTHER DATA	Elevation (m)
						20	40	60		
						DCPT RESISTANCE [PORTABLE]				
						20	40	60		
						POCKET PEN. UCS (kPa)				
						50	100	150		
						TORVANE UCS (kPa)				
						50	100	150		
0	0.1	TOPSOIL (CI) SILTY CLAY sandy, some organics; low plastic; soft; w<PL; dark brown.								
	0.5	(CI) SILTY CLAY sandy, some gravel (rounded to sub-rounded clasts); low plastic; stiff; w<PL; grey. -becomes brown; stiff to very stiff.								
1	1.1	End of test pit at 1.1 m Notes: No seepage. Sampling depth is approximate.			1				LWD @ 0.5m depth: EVD = 24.7 MN/m2 W _n = 13.2% PL = 18% LL = 32% Sieve Analysis : Gravel = 18.6% Sand = 29.5% Fines = 51.9%	
2										
3										
4										

PHOTOGRAPHS



Photo 1: Test pit excavation.



Photo 2: Excavated material.

RECORD OF TEST PIT TP18-31 Telkwa Coal

Site Conditions: ~2m north of old road shoulder

Date Excavated: 2018-Nov-01

Equipment: Excavator

Project No.: 017-318

Co-ordinate: 9U 621822E 6056106N

Elevation: No elevation

Depth (m)	DEPTH (m) (ELEV.)	SOIL DESCRIPTION	SOIL SYMBOL	SAMPLE NO	PLASTIC 20 40 60 80 M.C. 20 40 60 80 LIQUID 20 40 60 80	OTHER DATA	Elevation (m)
0	0.2	TOPSOIL (SP) SAND silty, some organics; loose; moist; dark brown.		1	DCPT RESISTANCE [PORTABLE] POCKET PEN. UCS (kPa) TORVANE UCS (kPa)	LWD @ 0.5m depth: EVD = 25.0 MN/m2 W_n = 12.2% PL = 16% LL = 33% Sieve Analysis : Gravel = 18.2% Sand = 29.6% Fines = 52.2% SA-01 additional lab testing: Standard Proctor, CBR. Refer to report for results.	
	0.6	(SP) SAND silty, gravelly (rounded to sub-rounded clasts), trace cobbles; loose; moist; light brown.					
	1.4	(CI) SILTY CLAY sandy, some gravel; low plastic; stiff; w<PL; brown.					
	1.4	End of test pit at 1.4 m Notes: No seepage. Sampling depth is approximate.					

PHOTOGRAPHS



Photo 1: Test pit excavation.



Photo 2: Excavated material.

RECORD OF TEST PIT TP18-32 Telkwa Coal

Site Conditions: ~2m north of old road

Date Excavated: 2018-Nov-01

Equipment: Excavator

Project No.: 017-318

Co-ordinate: 9U 621336E 6056116N

Elevation: No elevation

Depth (m)	DEPTH (m)	SOIL DESCRIPTION	SOIL SYMBOL	SAMPLE	SAMPLE NO	PLASTIC M.C. LIQUID		OTHER DATA	Elevation (m)
	(ELEV.)					20 40 60 80	20 40 60 80		
						■ DCPT RESISTANCE [PORTABLE] ■			
						◆ POCKET PEN. UCS (kPa) ◆ ⊗ TORVANE UCS (kPa) ⊗			
						50 100 150 200			
0	0.2	TOPSOIL							
	0.4	(ML) SILT sandy; some organics; moist; dark brown.							
		(SP) SAND silty; loose; moist; brown.				1			
		(CL-ML) SILTY CLAY - CLAYEY SILT sandy, trace gravel, (sub-rounded to sub-angular clasts); low plastic; stiff; w<PL; brown..							
1	1.3					2			
	1.5	(CI) SILTY CLAY sandy, some gravel, trace cobbles (rounded); stiff; w<PL; brown.							
		End of test pit at 1.5 m Notes: No seepage. Sampling depth is approximate.							
2									
3									
4									

$W_n = 10.4\%$ $PL = 19\%$
 $LL = 24\%$
 Sieve Analysis :
 Gravel = 8.4% Sand = 29.6% Fines = 62%
 $LWD @ 0.75m \text{ depth: } EVD = 20.7 \text{ MN/m}^2$
 $W_n = 10.6\%$ $PL = 17\%$
 $LL = 36\%$
 Sieve Analysis :
 Gravel = 16.9% Sand = 27.8% Fines = 55.3%

PHOTOGRAPHS



Photo 1: Test pit excavation.



Photo 2: Excavated material.

RECORD OF TEST PIT TP18-33 Telkwa Coal

Date Excavated: 2018-Nov-01

Equipment: Excavator

Project No.: 017-318

Site Conditions: ~75 m SW of proposed alignment; no access.

Co-ordinate: 9U 620717E 6055562N

Elevation: No elevation

Depth (m)	DEPTH (m) (ELEV.)	SOIL DESCRIPTION	SOIL SYMBOL	SAMPLE	SAMPLE NO	PLASTIC	M.C.	LIQUID	OTHER DATA	Elevation (m)
						20	40	60		
						DCPT RESISTANCE [PORTABLE]				
						20	40	60		
						POCKET PEN. UCS (kPa)				
						50	100	150		
						TORVANE UCS (kPa)				
						50	100	150		
0	0.1	TOPSOIL (SP) SAND silty; some organics; loose; moist; brown. (ML) SILT sandy, trace gravel, trace clay; loose; moist; brown; some oxidation in upper 0.5 m.								
1	1.4	- becomes wet.			1				W _n = 21.5% Sieve Analysis : Gravel = 1.8% Sand = 21.1% Fines = 77.1%	
2	1.7	End of test pit at 1.7 m Notes: Seepage at bottom. Sampling depth is approximate.								
3										
4										

PHOTOGRAPHS



Photo 1: Test pit excavation.



Photo 2: Excavated material.

RECORD OF TEST PIT TP18-34 Telkwa Coal

Site Conditions: ~ 2 m west of existing road.

Date Excavated: 2018-Nov-01

Equipment: Excavator

Project No.: 017-318

Co-ordinate: 9U 620512E 6055547N

Elevation: No elevation

Depth (m)	DEPTH (m) (ELEV.)	SOIL DESCRIPTION	SOIL SYMBOL	SAMPLE	SAMPLE NO	PLASTIC	M.C.	LIQUID	OTHER DATA	Elevation (m)
						20	40	60		
						DCPT RESISTANCE [PORTABLE]				
						20	40	60		
						POCKET PEN. UCS (kPa)				
						50	100	150		
						TORVANE UCS (kPa)				
						50	100	150		
0		(SP) SAND (fine to medium grained), trace silt; loose; moist; brown.								
0.8		End of test pit at 0.8 m Notes: No seepage.							LWD @ 0.75m depth: EVD = 8.76 MN/m2	
1										
2										
3										
4										

PHOTOGRAPHS



Photo 1: Test pit excavation.



Photo 2: Excavated material.

RECORD OF TEST PIT TP18-35 Telkwa Coal

Site Conditions: Inside shoulder of existing road.

Date Excavated: 2018-Nov-01

Equipment: Excavator

Project No.: 017-318

Co-ordinate: 9U 620390E 6055250N

Elevation: No elevation

Depth (m)	DEPTH (m) (ELEV.)	SOIL DESCRIPTION	SOIL SYMBOL	SAMPLE NO	PLASTIC	M.C.	LIQUID	OTHER DATA	Elevation (m)
					20	40	60		
					DCPT RESISTANCE [PORTABLE]				
					20	40	60		
					POCKET PEN. UCS (kPa)				
					50	100	150		
					TORVANE UCS (kPa)				
					50	100	150		
0		FILL (SM) SAND gravelly, some silt; compact; moist; trace rootlets; brown.		2				LWD @ road surface : EVD = 12.9 MN/m2	
0.5								W _n = 12.2% Sieve Analysis : Gravel = 22% Sand = 58.8% Fines = 19.5%	
0.6		TOPSOIL, dark brown.							
		(SM) SAND silty, gravelly; compact; moist; grey.		1				W _n = 12.5% Sieve Analysis : Gravel = 32.5% Sand = 46.9% Fines = 20.6% SA-01 & SA-02 additional lab testing: Standard Proctor, CBR. Refer to report for results.	
1.6		End of test pit at 1.6 m Notes: No seepage. Sampling depth is approximate.							
2									
3									
4									

PHOTOGRAPHS

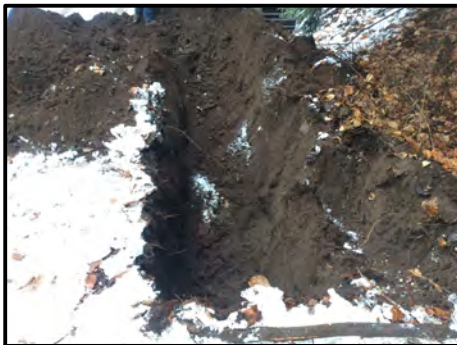


Photo 1: Test pit excavation.



Photo 2: Excavated material.

RECORD OF TEST PIT TP18-36 Telkwa Coal

Site Conditions: Inside shoulder of existing road.

Date Excavated: 2018-Nov-01

Equipment: Excavator

Project No.: 017-318

Co-ordinate: 9U 620404E 6054635N

Elevation: No elevation

Depth (m)	DEPTH (m) (ELEV.)	SOIL DESCRIPTION	SOIL SYMBOL	SAMPLE	SAMPLE NO	PLASTIC	M.C.	LIQUID	OTHER DATA	Elevation (m)
						20	40	60		
						DCPT RESISTANCE [PORTABLE]				
						20	40	60		
						POCKET PEN. UCS (kPa)				
						50	100	150		
						TORVANE UCS (kPa)				
						50	100	150		
0		(GW) GRAVEL sandy, trace silt, some cobbles and boulders (up to 300 mm diameter); compact; moist.			1				LWD @ road surface: EVD = 27.4 MN/m2	
1	1	End of test pit at 1.0 m Notes: No seepage.							W _n = 4% Sieve Analysis : Gravel = 61.1% Sand = 33.9% Fines = 4.4% SA-01 additional lab testing: Standard Proctor, CBR. Refer to report for results.	
2										
3										
4										

PHOTOGRAPHS



Photo 1: Test pit excavation.



Photo 2: Excavated material.

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DRAWN: MS

Page 1 of 1

RECORD OF TEST PIT TP18-37 Telkwa Coal

Site Conditions: Inside shoulder of existing road.

Date Excavated: 2018-Nov-01

Equipment: Excavator

Project No.: 017-318

Co-ordinate: 9U 620411E 6054956N

Elevation: No elevation

Depth (m)	DEPTH (m) (ELEV.)	SOIL DESCRIPTION	SOIL SYMBOL	SAMPLE	SAMPLE NO	PLASTIC	M.C.	LIQUID	OTHER DATA	Elevation (m)
						20	40	60		
						DCPT RESISTANCE [PORTABLE]				
						20	40	60		
						POCKET PEN. UCS (kPa)				
						50	100	150		
						TORVANE UCS (kPa)				
						50	100	150		
0		(SM) SAND some gravel, some silt; loose; moist.			1				LWD @ road surface: EVD = 10.7 MN/m2 W _n = 6.7% Sieve Analysis : Gravel = 10% Sand = 72.6% Fines = 17.3%	
0.6		(SP) Gravelly SAND to (GP) sandy GRAVEL, some cobbles, trace boulders (up to 200 mm diameter), trace silt, loose to compact, well drained.								
1										
1.6										
2		End of test pit at 1.6 m Notes: No seepage. Sample locations approximate.								
3										
4										



RECORD OF TEST PIT TP18-38 Telkwa Coal

Site Conditions: Base of existing gravel pit.

Date Excavated: 2018-Nov-02

Equipment: Excavator

Project No.: 017-318

Co-ordinate: 9U 620786E 6054964N

Elevation: No elevation

Depth (m)	DEPTH (m)	SOIL DESCRIPTION	SOIL SYMBOL	SAMPLE	SAMPLE NO	PLASTIC	M.C.	LIQUID	OTHER DATA	Elevation (m)	
	(ELEV.)					20	40	60			80
						■ DCPT RESISTANCE [PORTABLE] ■					
						◆ POCKET PEN. UCS (kPa) ◆					
						⊗ TORVANE UCS (kPa) ⊗					
						50	100	150	200		
0		(SP) SAND and GRAVEL trace silt, trace cobbles (up to 100 mm diameter); compact; moist; brown.	Δ Δ								

PHOTOGRAPHS

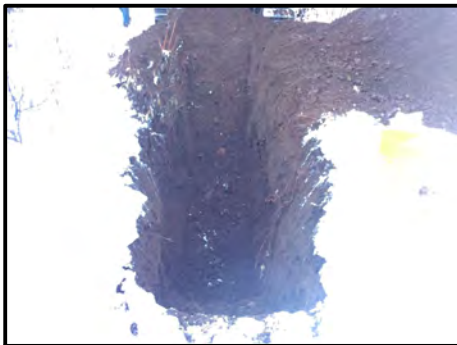


Photo 1: Test pit excavation.



Photo 2: Excavated material.



RECORD OF TEST PIT TP18-39 Telkwa Coal

Site Conditions: Side slope of existing gravel pit.

Date Excavated: 2018-Nov-02

Equipment: Excavator

Project No.: 017-318

Co-ordinate: 9U 620789E 6054954N

Elevation: No elevation

Depth (m)	DEPTH (m) (ELEV.)	SOIL DESCRIPTION	SOIL SYMBOL	SAMPLE	SAMPLE NO	PLASTIC	M.C.	LIQUID	OTHER DATA	Elevation (m)
						20	40	60		
						DCPT RESISTANCE [PORTABLE]				
						20	40	60		
						POCKET PEN. UCS (kPa)				
						50	100	150		
						TORVANE UCS (kPa)				
						50	100	150		
0		(GP) GRAVEL and SAND trace silt, trace cobbles; loose; moist; brown.								
1										
1.5		End of test pit at 1.5 m Notes: No seepage.			1				SA-01 additional lab testing: Standard Proctor, CBR, abrasion & impact, relative density and absorption. Refer to report for results. Sieve Analysis : Gravel = 53% Sand = 45% Fines = 2%	
2										
3										
4										

PHOTOGRAPHS



Photo 1: Test pit excavation.

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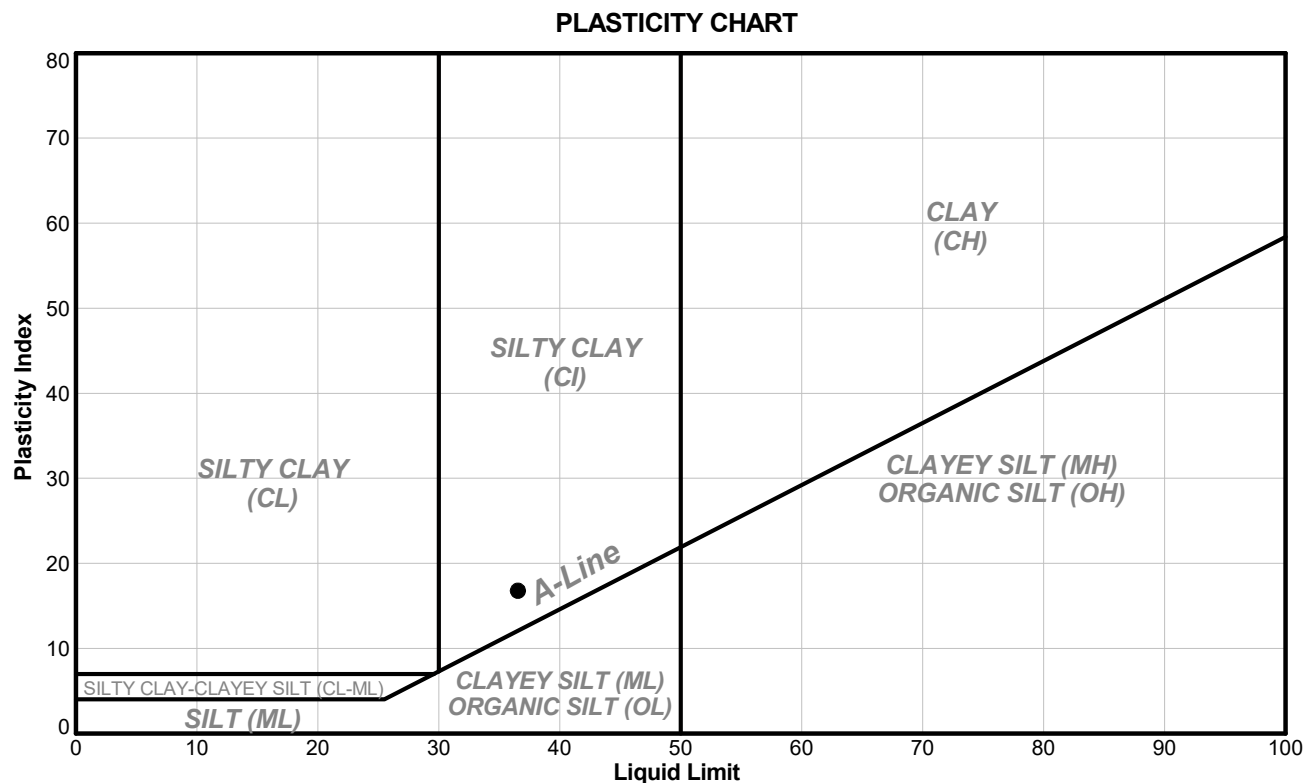
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Page 1 of 1

Appendix D

Laboratory Test Results

Client:	Telkwa Coal Ltd.	ID:	19-30S
Project:	Ref #017-318	Sample No.:	SA-03
Location:		Depth Interval (m):	4.30 to 4.60
Project No.:	18109666 Phase: 1000	Lab Schedule No.:	
Other Remarks:	N/A		
Test Method:	A-Multi Point	Preparation Method:	Air Dried



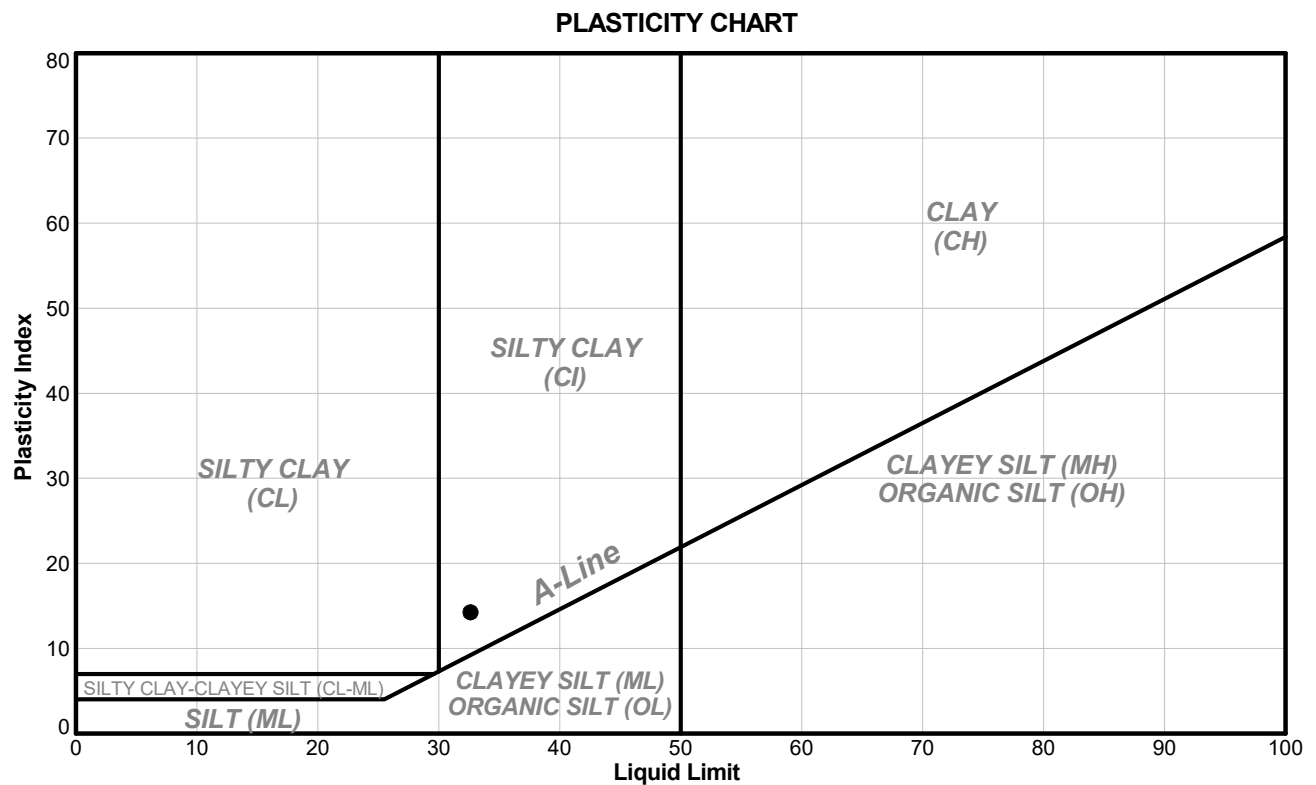
Sym.	Sample Location	Sample / Specimen Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	19-30S	SA-03	4.30	4.60	67	37	20	17.0	13.3	-0.4

NP - NON-PLASTIC RESULT ND - NOT DETERMINED

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

RG	3/7/2019	LP	3/15/2019
Tech	Date	Checked	Date

Client:	Telkwa Coal Ltd.	ID:	19-32S
Project:	Ref #017-318	Sample No.:	SA-02
Location:		Depth Interval (m):	4.90 to 5.20
Project No.:	18109666 Phase: 1000	Lab Schedule No.:	
Other Remarks:	N/A		
Test Method:	A-Multi Point	Preparation Method:	Air Dried



Sym.	Sample Location	Sample / Specimen Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	19-32S	SA-02	4.90	5.20	92	33	18	15.0	21.8	0.3

NP - NON-PLASTIC RESULT ND - NOT DETERMINED

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

FF	3/7/2019	LP	3/15/2019
Tech	Date	Checked	Date

Client: Telkwa Coal Ltd.
 Project: Ref #017-318
 Location:
 Project No.: 18109666 Phase: 1000

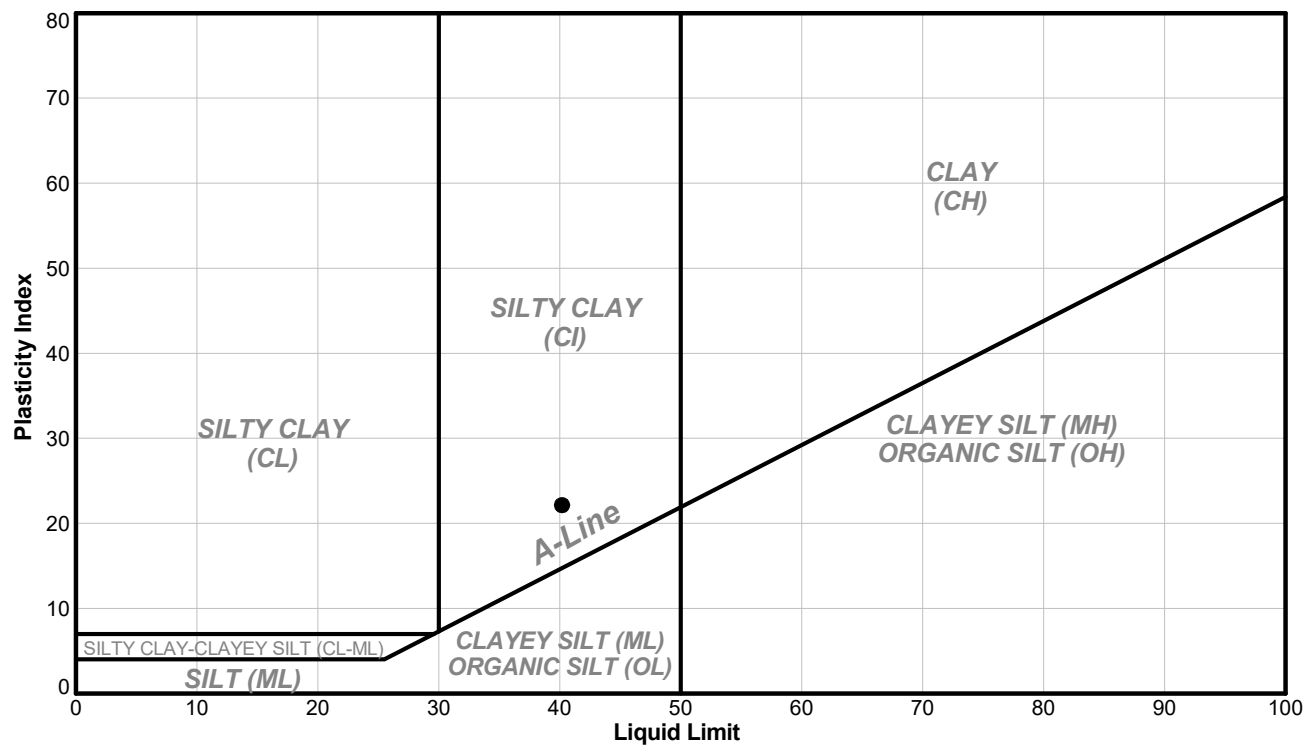
ID: 19-32S
 Sample No.: SA-04
 Depth Interval (m): 10.40 to 10.70
 Lab Schedule No.:

Other Remarks: N/A

Test Method: A-Multi Point

Preparation Method: Air Dried

PLASTICITY CHART



Sym.	Sample Location	Sample / Specimen Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	19-32S	SA-04	10.40	10.70	99	40	18	22.0	17.1	0.0

NP - NON-PLASTIC RESULT ND - NOT DETERMINED

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

FF	3/5/2019	LP	3/15/2019
Tech	Date	Checked	Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

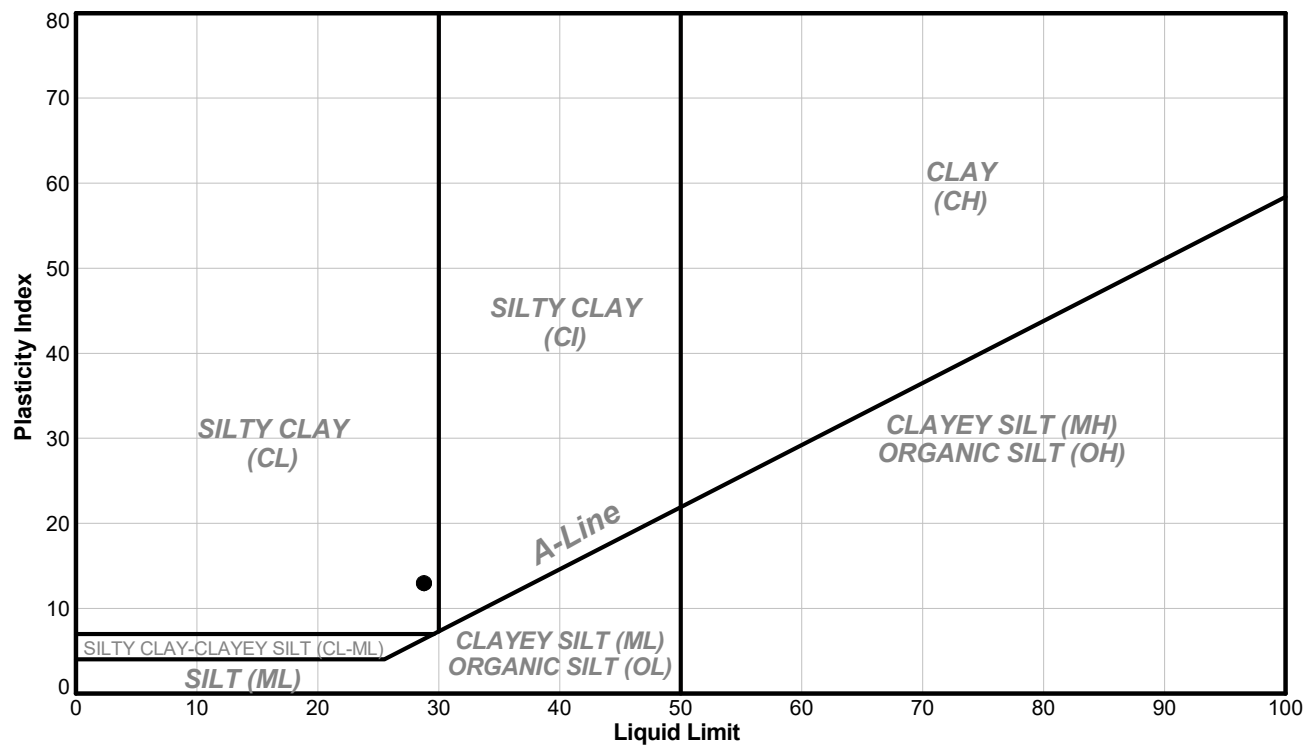
ID: TP18-29
Sample No.: 1
Depth (m): N/A
Lab Schedule No.:

Other Remarks: N/A

Test Method: A-Multi Point

Preparation Method: Air Dried

PLASTICITY CHART



Sym.	Sample Location	Sample / Specimen Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	TP18-29	1	0.00	0.00	56	29	16	13.0	8.6	-0.6

NP - NON-PLASTIC RESULT ND - NOT DETERMINED

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

FF	12/14/2018	LH	1/3/2019
Tech	Date	Checked	Date

Client: Telkwa Coal Ltd.
 Project: Ref #017-318
 Location:
 Project No.: 18109666 Phase: 1000

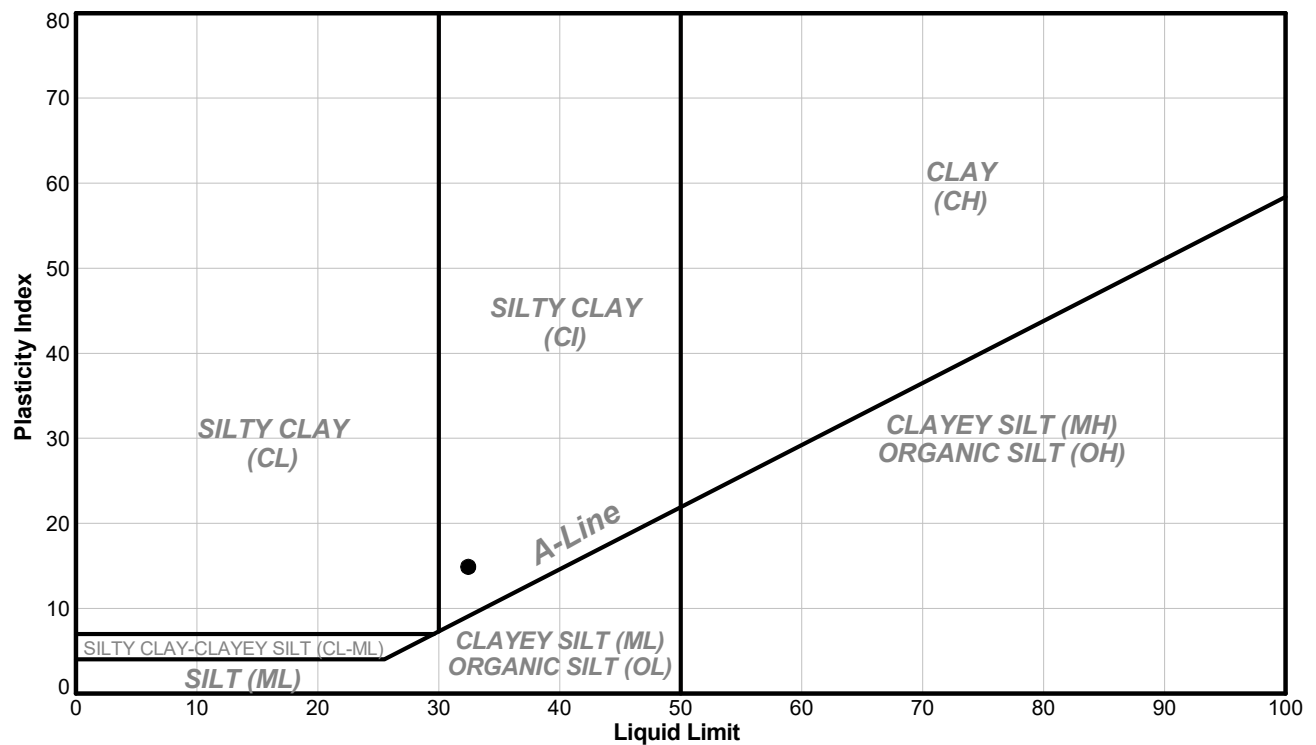
ID: TP18-30
 Sample No.: 1
 Depth (m): N/A
 Lab Schedule No.:

Other Remarks: N/A

Test Method: A-Multi Point

Preparation Method: Air Dried

PLASTICITY CHART



Sym.	Sample Location	Sample / Specimen Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	TP18-30	1	0.00	0.00	67	32	18	14.0	13.2	-0.3

NP - NON-PLASTIC RESULT ND - NOT DETERMINED

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

RZ	12/17/2018	LH	1/3/2019
Tech	Date	Checked	Date

Client: Telkwa Coal Ltd.
 Project: Ref #017-318
 Location:
 Project No.: 18109666 Phase: 1000

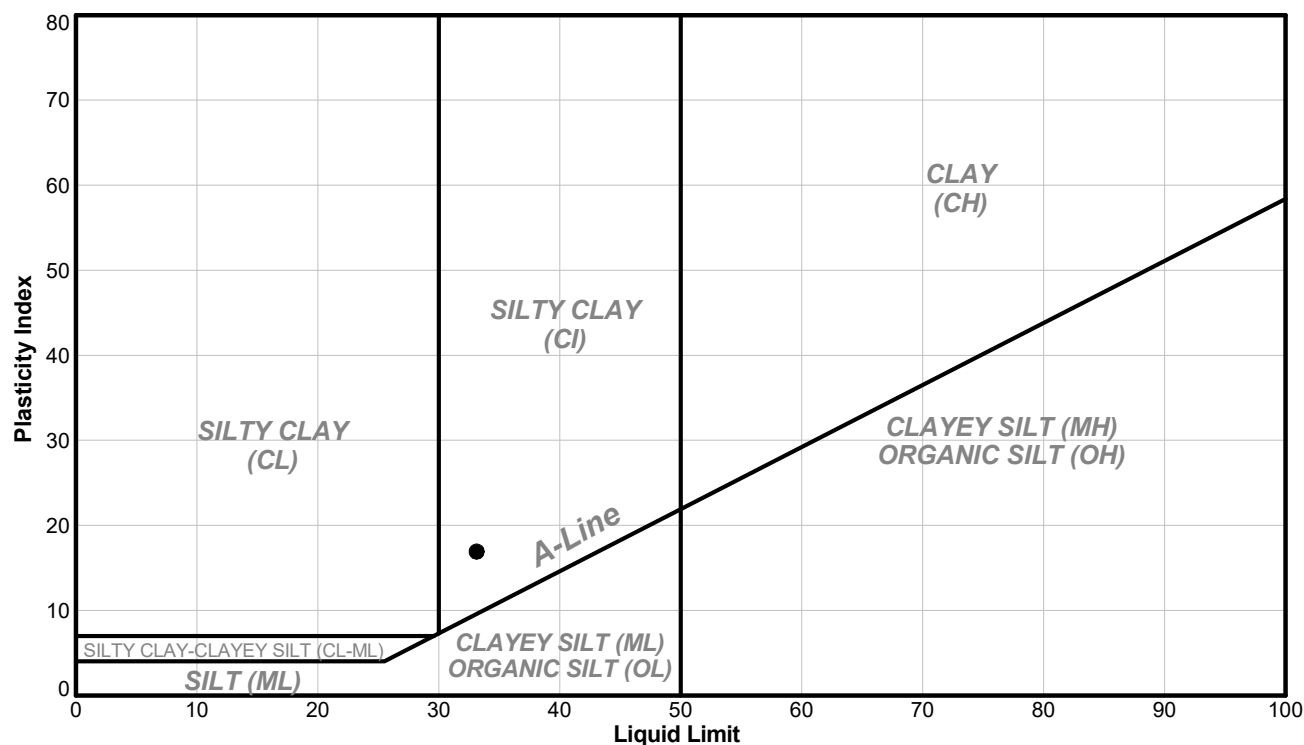
ID: TP18-31
 Sample No.: 1
 Depth (m): N/A
 Lab Schedule No.:

Other Remarks: N/A

Test Method: A-Multi Point

Preparation Method: Air Dried

PLASTICITY CHART



Sym.	Sample Location	Sample / Specimen Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	TP18-31	1	0.00	0.00	66	33	16	17.0	12.2	-0.2

NP - NON-PLASTIC RESULT ND - NOT DETERMINED

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

RZ	12/14/2018	LH	1/3/2019
Tech	Date	Checked	Date

Client: Telkwa Coal Ltd.
 Project: Ref #017-318
 Location:
 Project No.: 18109666 Phase: 1000

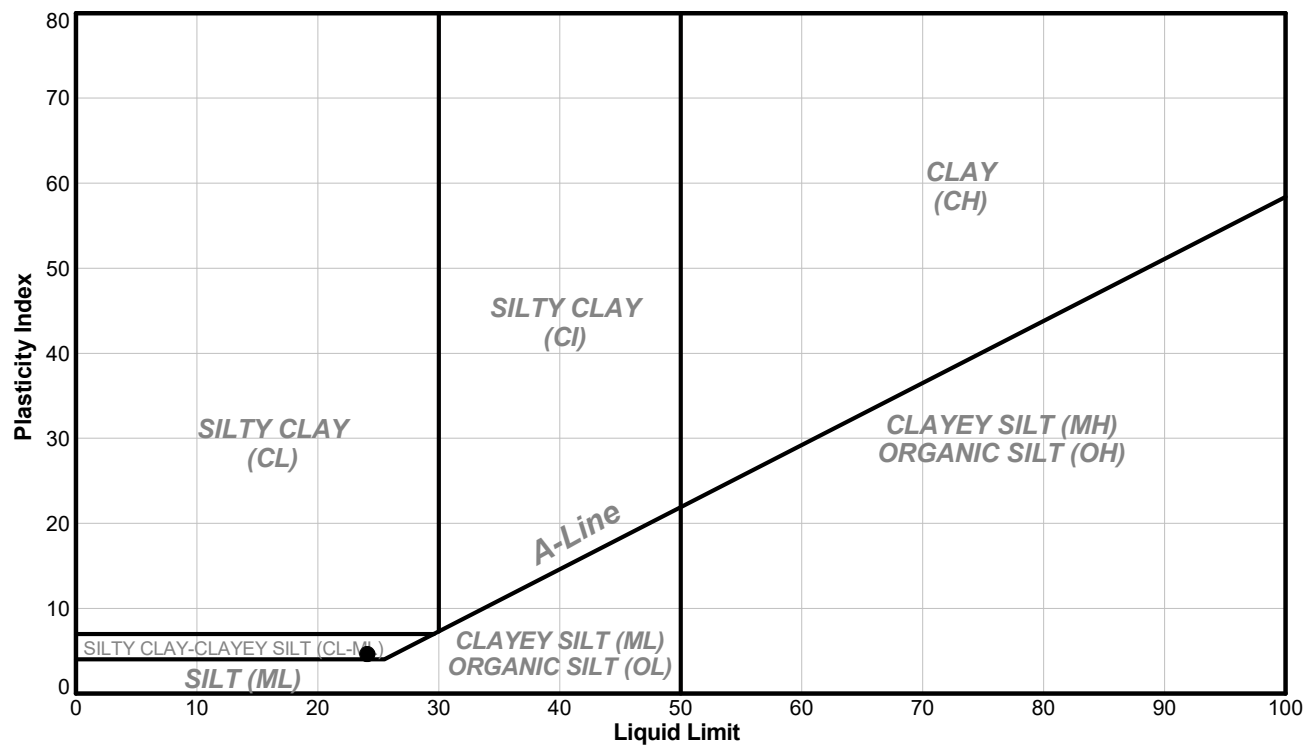
ID: TP18-32
 Sample No.: 1
 Depth (m): N/A
 Lab Schedule No.:

Other Remarks: N/A

Test Method: A-Multi Point

Preparation Method: Air Dried

PLASTICITY CHART



Sym.	Sample Location	Sample / Specimen Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	TP18-32	1	0.00	0.00	77	24	19	5.0	10.4	-1.7

NP - NON-PLASTIC RESULT ND - NOT DETERMINED

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

RZ	12/17/2018	LH	1/3/2019
Tech	Date	Checked	Date

Client: Telkwa Coal Ltd.
 Project: Ref #017-318
 Location:
 Project No.: 18109666 Phase: 1000

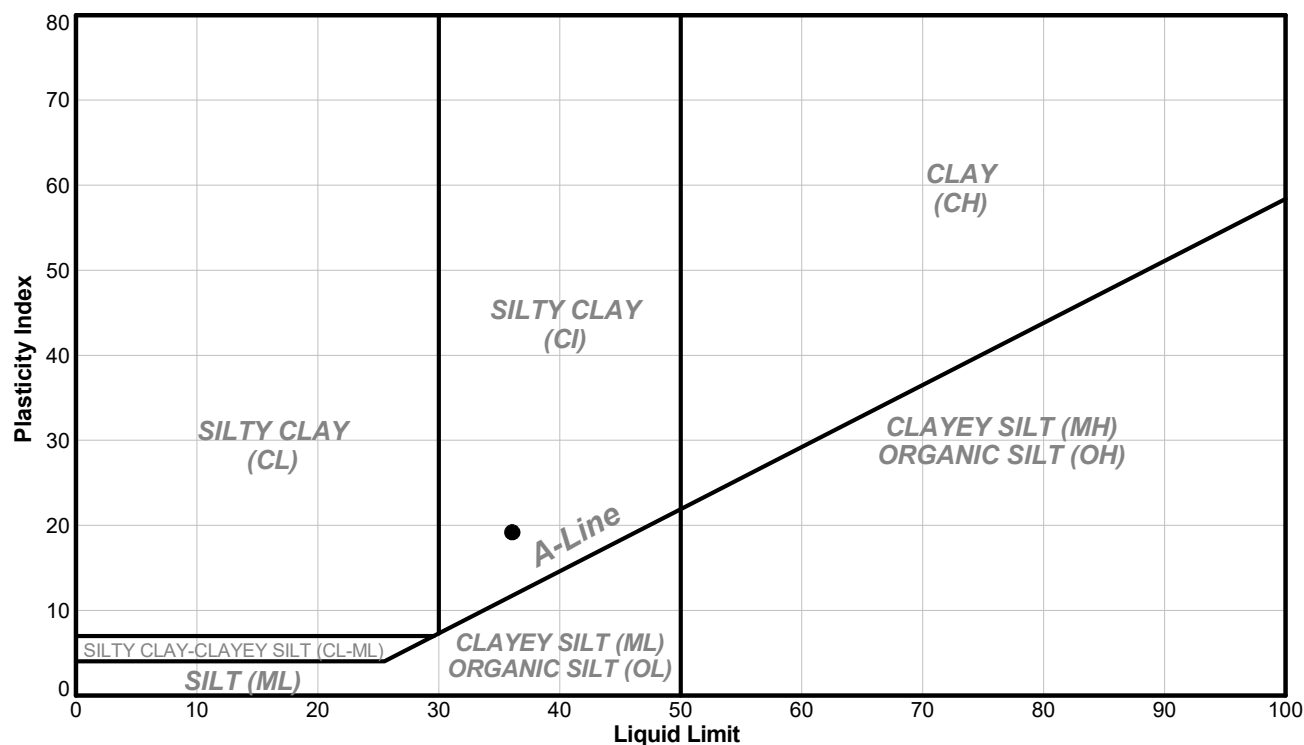
ID: TP18-32
 Sample No.: 2
 Depth (m): N/A
 Lab Schedule No.:

Other Remarks: N/A

Test Method: A-Multi Point

Preparation Method: Air Dried

PLASTICITY CHART



Sym.	Sample Location	Sample / Specimen Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	TP18-32	2	0.00	0.00	70	36	17	19.0	10.6	-0.3

NP - NON-PLASTIC RESULT ND - NOT DETERMINED

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

RZ	12/17/2018	LH	1/3/2019
Tech	Date	Checked	Date



Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D1883

Project No.:	18109666-1000	Borehole:	TP18-29
Project:	Ref #017-318	Sample:	N/A
Location:	N/A	Depth (m):	N/A
Client:	Telkwa Coal Ltd.	Lab ID No:	356

Sample Description:	SANDY SILT; some clay; trace gravel, brown		
Remarks:			
Classification:	N/A	Oversize Material (%):	21.2

Initial Sample Properties

Sample Diameter (cm):	15.24
Sample Height (cm):	11.61
Area (cm²):	182.5
Volume (cm³):	2118.6
Wet Weight (g):	4767.9
Dry Weight (g):	4256.7
Water Content (%):	12.0
Dry Density (kg/m³):	2009

Final Water Contents

Top 1.0 inch (%):	15.8
Bottom of Sample (%):	12.5
Average Sample (%):	13.0

Equipment

Machine:	3
Load Cell:	305670
Axial DCDT:	LP-828

Test Properties

Target Dry Density (%):	100 % of Standard Proctor
Target Dry Density (kg/m³):	1970
Soaking:	Yes
Immersion Period (hours):	144
Swelling:	-0.97
Penetration Rate (mm/min):	1.27
Surcharge Weight (kg):	9.1
Piston Diameter (cm):	5.00

Test Comments:	Sample was compacted to 100% of standard Proctor.
-----------------------	---

Test Results

Penetration (mm):	2.54	5.08
Standard Stress (kPa):	6900	10300
Penetration Stress (kPa):	193	358
CBR Value (%):	3	3

TM	January 25, 2019	LH	February 8, 2019
TESTED BY	DATE	CHECKED BY	DATE

Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D1883

Project No.: 18109666-1000

Borehole: TP18-29

Project: Ref #017-318

Sample: N/A

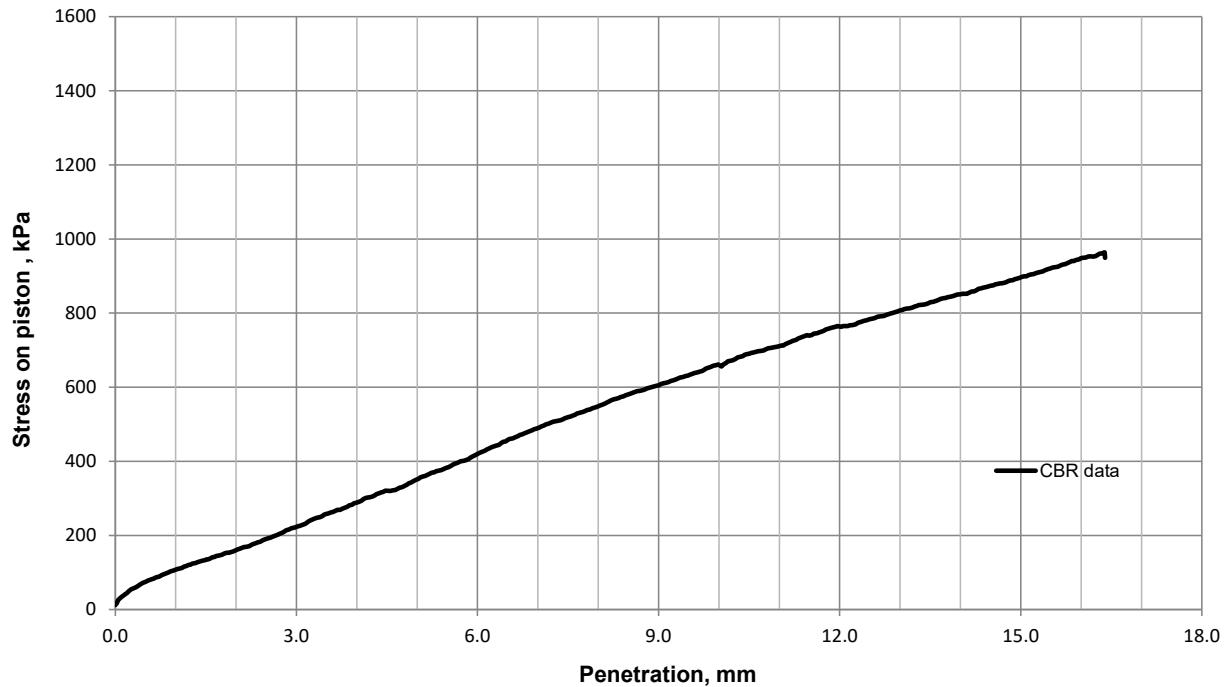
Location: N/A

Depth (m): N/A

Client: Telkwa Coal Ltd.

Lab ID No: 356

CBR Data



Test Results

Penetration	Penetration Stress	CBR Value
2.54 mm	193 kPa	3 %
5.08 mm	358 kPa	3 %

TM
TESTED BY

January 25, 2019
DATE

LH
CHECKED BY

February 8, 2019
DATE



Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D1883

Project No.:	18109666-1000	Borehole:	TP18-31
Project:	Ref #017-318	Sample:	N/A
Location:	N/A	Depth (m):	N/A
Client:	Telkwa Coal Ltd.	Lab ID No:	356

Sample Description:	SANDY SILT; some clay; some gravel, brown		
Remarks:			
Classification:	N/A	Oversize Material (%):	10.7

Initial Sample Properties

Sample Diameter (cm):	15.24
Sample Height (cm):	11.61
Area (cm²):	182.5
Volume (cm³):	2118.6
Wet Weight (g):	4629.1
Dry Weight (g):	4057.2
Water Content (%):	14.1
Dry Density (kg/m³):	1915

Final Water Contents

Top 1.0 inch (%):	17.2
Bottom of Sample (%):	14.4
Average Sample (%):	14.9

Equipment

Machine:	8
Load Cell:	305670
Axial DCDT:	LP-828

Test Properties

Target Dry Density (%):	100 % of Standard Proctor
Target Dry Density (kg/m³):	1910
Soaking:	Yes
Immersion Period (hours):	144
Swelling:	0.06
Penetration Rate (mm/min):	1.27
Surcharge Weight (kg):	9.1
Piston Diameter (cm):	5.00

Test Comments:	Sample was compacted to 100% of standard Proctor.
-----------------------	---

Test Results

Penetration (mm):	2.54	5.08
Standard Stress (kPa):	6900	10300
Penetration Stress (kPa):	207	350
CBR Value (%):	3	3

TM	February 4, 2019	LH	February 8, 2019
TESTED BY	DATE	CHECKED BY	DATE

Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D1883

Project No.: 18109666-1000

Borehole: TP18-31

Project: Ref #017-318

Sample: N/A

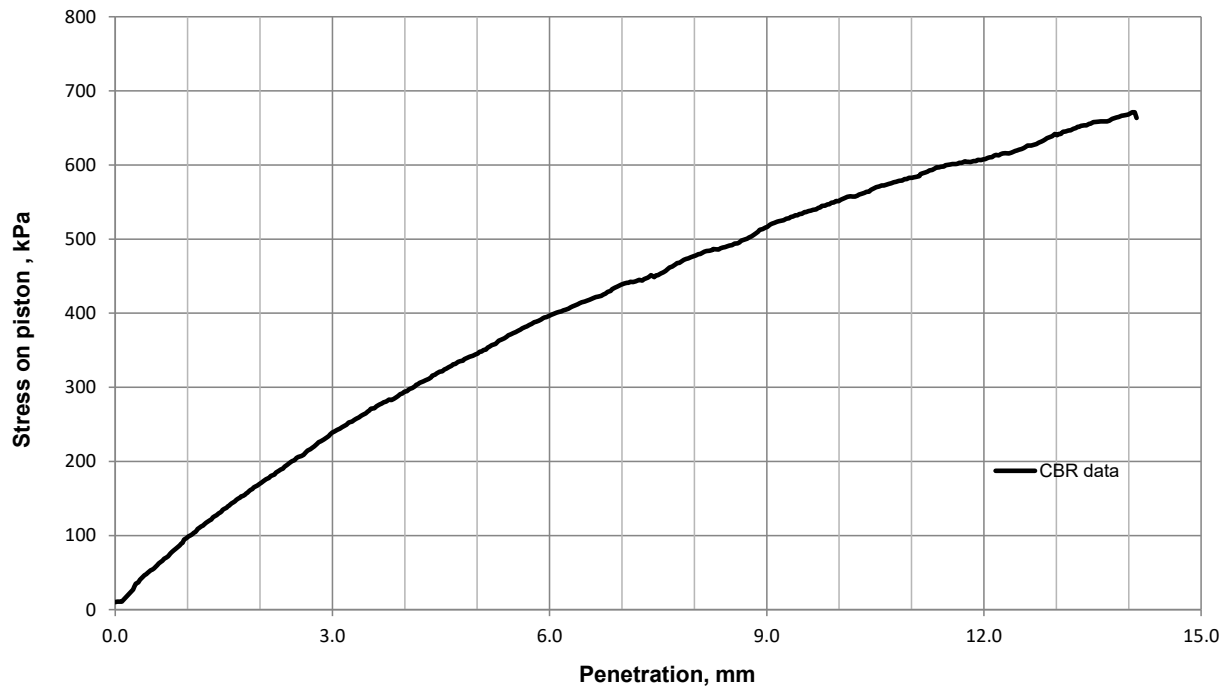
Location: N/A

Depth (m): N/A

Client: Telkwa Coal Ltd.

Lab ID No: 356

CBR Data



Test Results

Penetration	Penetration Stress	CBR Value
2.54 mm	207 kPa	3 %
5.08 mm	350 kPa	3 %

TM
TESTED BY

February 4, 2019
DATE

LH
CHECKED BY

February 8, 2019
DATE



Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D1883

Project No.:	18109666-1000	Borehole:	TP18-35
Project:	Ref #017-318	Sample:	N/A
Location:	N/A	Depth (m):	N/A
Client:	Telkwa Coal Ltd.	Lab ID No:	356

Sample Description:	SAND; some gravel; some silt; trace clay, brown		
Remarks:			
Classification:	N/A	Oversize Material (%):	15.1

Initial Sample Properties	
Sample Diameter (cm):	15.24
Sample Height (cm):	11.58
Area (cm²):	182.3
Volume (cm³):	2111.2
Wet Weight (g):	4833.1
Dry Weight (g):	4436.0
Water Content (%):	9.0
Dry Density (kg/m³):	2101

Final Water Contents	
Top 1.0 inch (%):	12.6
Bottom of Sample (%):	9.4
Average Sample (%):	9.9

Equipment	
Machine:	8
Load Cell:	305670
Axial DCDT:	LP-828

Test Properties	
Target Dry Density (%):	100 % of Standard Proctor
Target Dry Density (kg/m³):	2049
Soaking:	Yes
Immersion Period (hours):	144
Swelling:	-0.27
Penetration Rate (mm/min):	1.27
Surcharge Weight (kg):	9.1
Piston Diameter (cm):	5.00

Test Comments:	Sample was compacted to 100% of standard Proctor.
-----------------------	---

Test Results		
Penetration (mm):	2.54	5.08
Standard Stress (kPa):	6900	10300
Penetration Stress (kPa):	418	887
CBR Value (%):	6	9

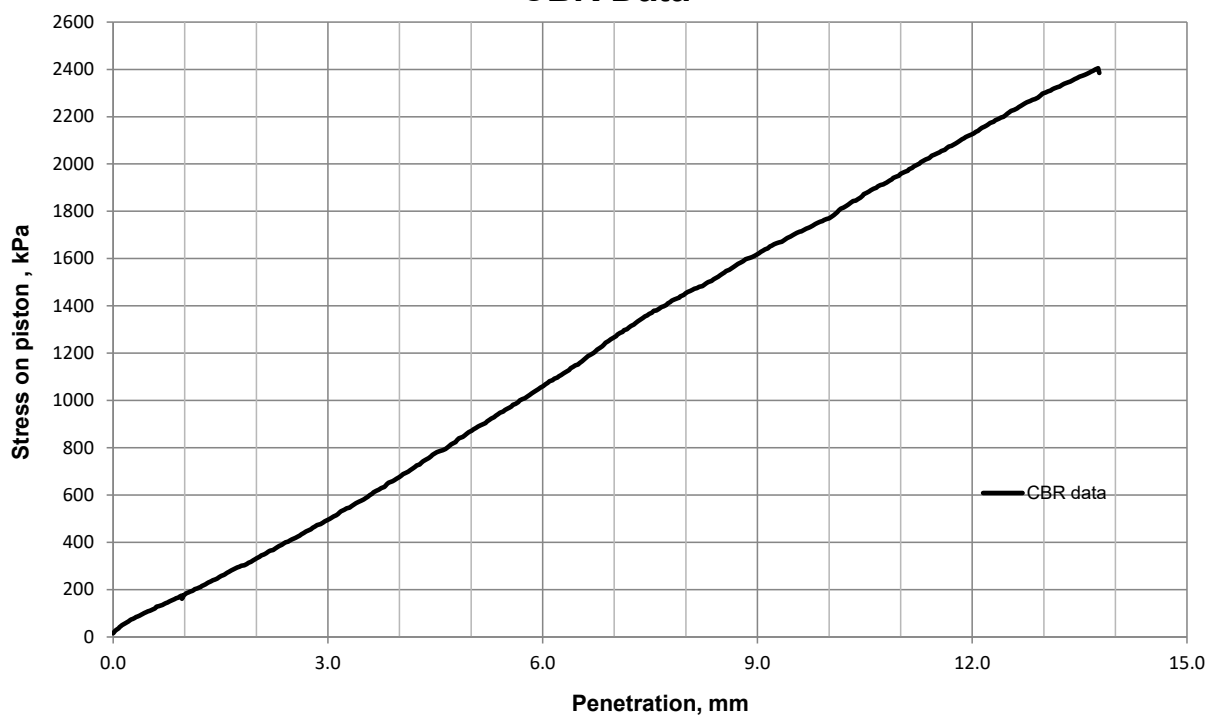
TM	February 4, 2019	LH	February 8, 2019
TESTED BY	DATE	CHECKED BY	DATE

Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D1883

Project No.:	18109666-1000	Borehole:	TP18-35
Project:	Ref #017-318	Sample:	N/A
Location:	N/A	Depth (m):	N/A
Client:	Telkwa Coal Ltd.	Lab ID No:	356

CBR Data



Test Results

Penetration	Penetration Stress	CBR Value
2.54 mm	418 kPa	6 %
5.08 mm	887 kPa	9 %

TM
TESTED BY

February 4, 2019
DATE

LH
CHECKED BY

February 8, 2019
DATE



Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D1883

Project No.:	18109666-1000	Borehole:	TP18-36
Project:	Ref #017-318	Sample:	1
Location:	Not Given	Depth (m):	N/A
Client:	Telkwa Coal Ltd.	Lab ID No:	356

Sample Description:	SANDY GRAVEL, trace silt		
Remarks:	-		
Classification:	N/A	Oversize Material (%):	36.5

Initial Sample Properties	
Sample Diameter (cm):	15.24
Sample Height (cm):	11.58
Area (cm²):	182.3
Volume (cm³):	2111.2
Wet Weight (g):	4815.0
Dry Weight (g):	4581.4
Water Content (%):	5.1
Dry Density (kg/m³):	2170

Final Water Contents	
Top 1.0 inch (%):	8.1
Bottom of Sample (%):	9.2
Average Sample (%):	8.9

Equipment	
Machine:	8
Load Cell:	305670
Axial DCDT:	LP-828

Test Properties	
Target Dry Density (%):	100 % of Standard Proctor
Target Dry Density (kg/m³):	2159
Soaking:	Yes
Immersion Period (hours):	144
Swelling:	-0.28
Penetration Rate (mm/min):	1.27
Surcharge Weight (kg):	4.5
Piston Diameter (cm):	5.00

Test Comments:	Sample was compacted to 100% Proctor.
-----------------------	---------------------------------------

Test Results		
Penetration (mm), corrected:	4.07	6.61
Standard Stress (kPa):	6900	10300
Penetration Stress (kPa), corrected:	2725	6577
CBR Value (%), corrected:	39	64

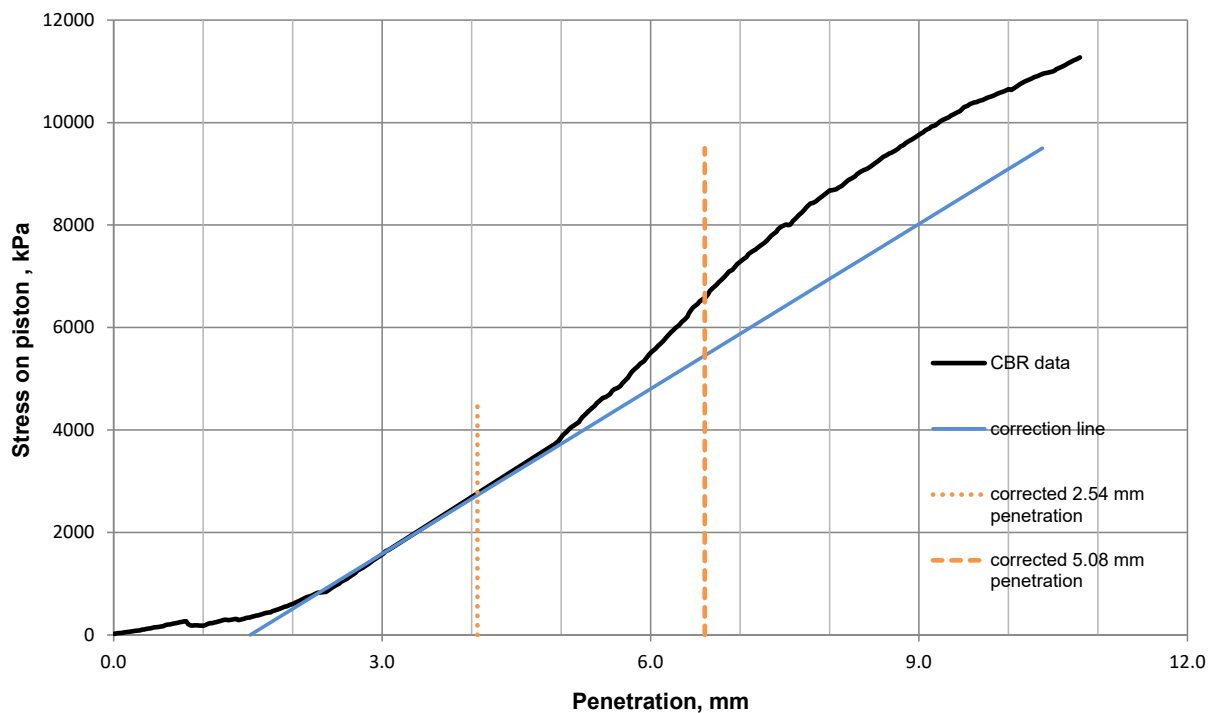
TM	January 9, 2018	LH	February 28, 2019
TESTED BY	DATE	CHECKED BY	DATE

Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D1883

Project No.:	18109666-1000	Borehole:	TP18-36
Project:	Ref #017-318	Sample:	1
Location:	Not Given	Depth (m):	N/A
Client:	Telkwa Coal Ltd.	Lab ID No:	356

CBR Data



Test Results (corrected)

Penetration	Penetration Stress	CBR Value
4.07 mm	2725 kPa	39 %
6.61 mm	6577 kPa	64 %

 TM
TESTED BY

 January 9, 2018
DATE

 LH
CHECKED BY

 February 28, 2019
DATE



Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D1883

Project No.:	18109666-1000	Borehole:	TP18-38
Project:	Ref #017-318	Sample:	1
Location:	N/A	Depth (m):	N/A
Client:	Telkwa Coal Ltd.	Lab ID No:	356

Sample Description:	SAND and GRAVEL		
Remarks:	0		
Classification:	N/A	Oversize Material (%):	22.7

Initial Sample Properties	
Sample Diameter (cm):	15.24
Sample Height (cm):	11.58
Area (cm²):	182.3
Volume (cm³):	2111.4
Wet Weight (g):	4598.9
Dry Weight (g):	4368.6
Water Content (%):	5.3
Dry Density (kg/m³):	2069

Final Water Contents	
Top 1.0 inch (%):	8.7
Bottom of Sample (%):	8.9
Average Sample (%):	8.9

Equipment	
Machine:	3
Load Cell:	305670
Axial DCDT:	LP-828

Test Properties	
Target Dry Density (%):	100 % of Standard Proctor
Target Dry Density (kg/m³):	2065
Soaking:	Yes
Immersion Period (hours):	144
Swelling:	0.02
Penetration Rate (mm/min):	1.27
Surcharge Weight (kg):	9.1
Piston Diameter (cm):	5.00

Test Comments:	Sample was compacted to 100% of standard Proctor. Free water drained during the test
-----------------------	---

Test Results		
Penetration (mm), corrected:	3.45	5.99
Standard Stress (kPa):	6900	10300
Penetration Stress (kPa), corrected:	3323	5722
CBR Value (%), corrected:	48	56

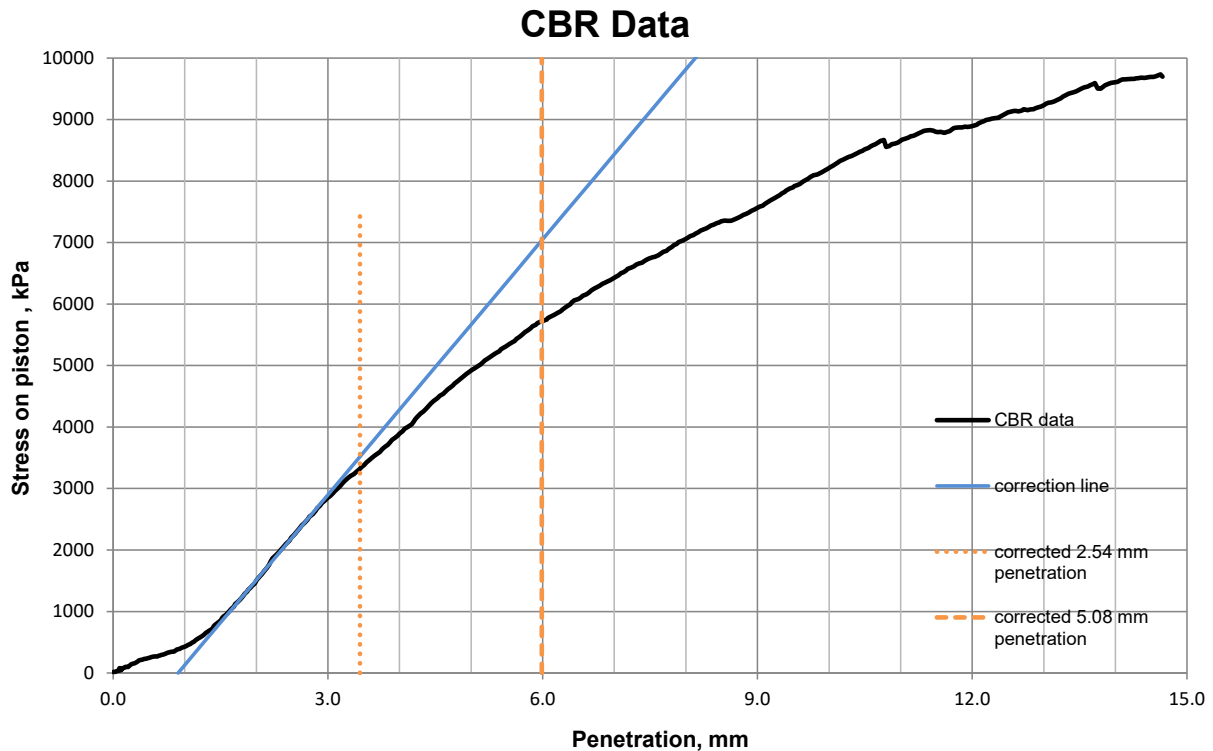
TM	January 21, 2019	LH	February 8, 2019
TESTED BY	DATE	CHECKED BY	DATE

Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D1883

Project No.: 18109666-1000
Project: Ref #017-318
Location: N/A
Client: Telkwa Coal Ltd.

Borehole: TP18-38
Sample: 1
Depth (m): N/A
Lab ID No: 356



Test Results (corrected)

Penetration	Penetration Stress	CBR Value
3.45 mm	3323 kPa	48 %
5.99 mm	5722 kPa	56 %

TM
TESTED BY

January 21, 2019
DATE

LH
CHECKED BY

February 8, 2019
DATE



Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D1883

Project No.:	18109666-1000	Borehole:	TP18-39
Project:	Ref #017-318	Sample:	1
Location:	N/A	Depth (m):	N/A
Client:	Telkwa Coal Ltd.	Lab ID No:	356

Sample Description:	SAND and GRAVEL		
Remarks:	0		
Classification:	N/A	Oversize Material (%):	21.5

Initial Sample Properties	
Sample Diameter (cm):	15.24
Sample Height (cm):	11.61
Area (cm²):	182.5
Volume (cm³):	2118.6
Wet Weight (g):	4665.3
Dry Weight (g):	4448.2
Water Content (%):	4.9
Dry Density (kg/m³):	2100

Final Water Contents	
Top 1.0 inch (%):	7.9
Bottom of Sample (%):	10.5
Average Sample (%):	9.9

Equipment	
Machine:	3
Load Cell:	305670
Axial DCDT:	LP-828

Test Properties	
Target Dry Density (%):	100 % of Standard Proctor
Target Dry Density (kg/m³):	2096
Soaking:	Yes
Immersion Period (hours):	144
Swelling:	0.22
Penetration Rate (mm/min):	1.27
Surcharge Weight (kg):	9.1
Piston Diameter (cm):	5.00

Test Comments:	Sample was compacted to 100% of standard Proctor. Free water drained during the test
-----------------------	---

Test Results		
Penetration (mm), corrected:	3.40	5.94
Standard Stress (kPa):	6900	10300
Penetration Stress (kPa), corrected:	4167	6627
CBR Value (%), corrected:	60	64

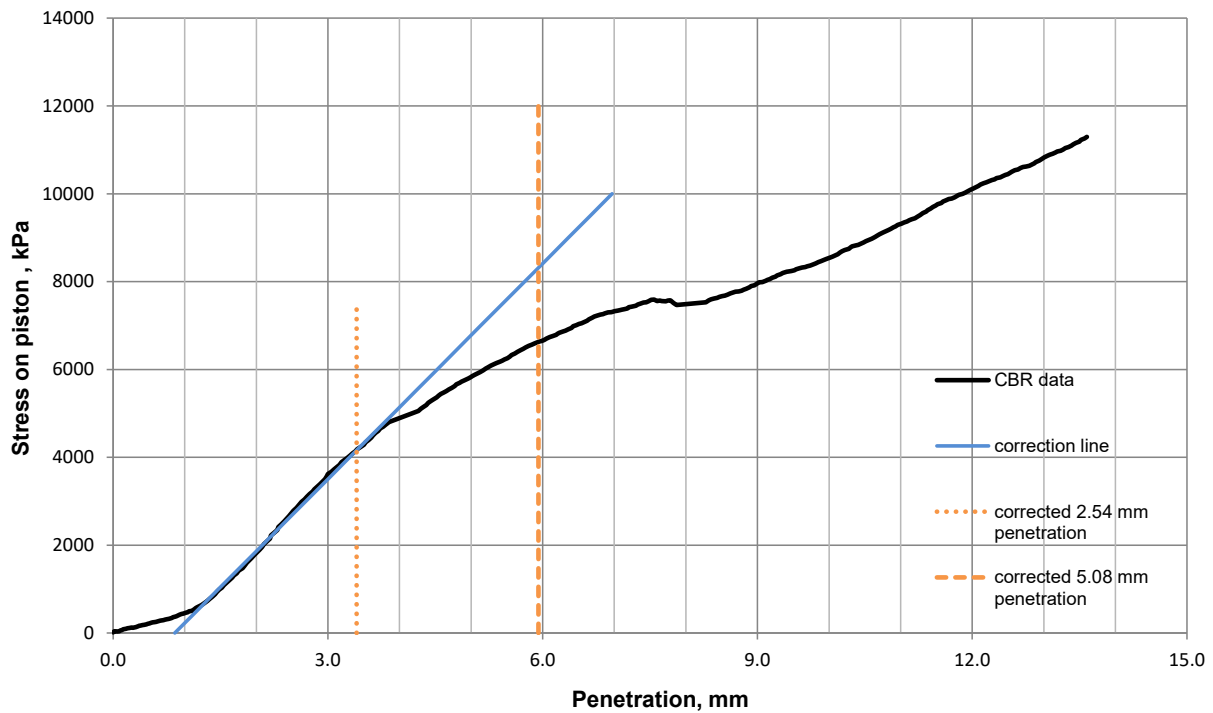
TM	January 21, 2019	LH	February 8, 2019
TESTED BY	DATE	CHECKED BY	DATE

Standard Test Method for California Bearing Ratio (CBR) of Laboratory-Compacted Soils

ASTM D1883

Project No.:	18109666-1000	Borehole:	TP18-39
Project:	Ref #017-318	Sample:	1
Location:	N/A	Depth (m):	N/A
Client:	Telkwa Coal Ltd.	Lab ID No:	356

CBR Data



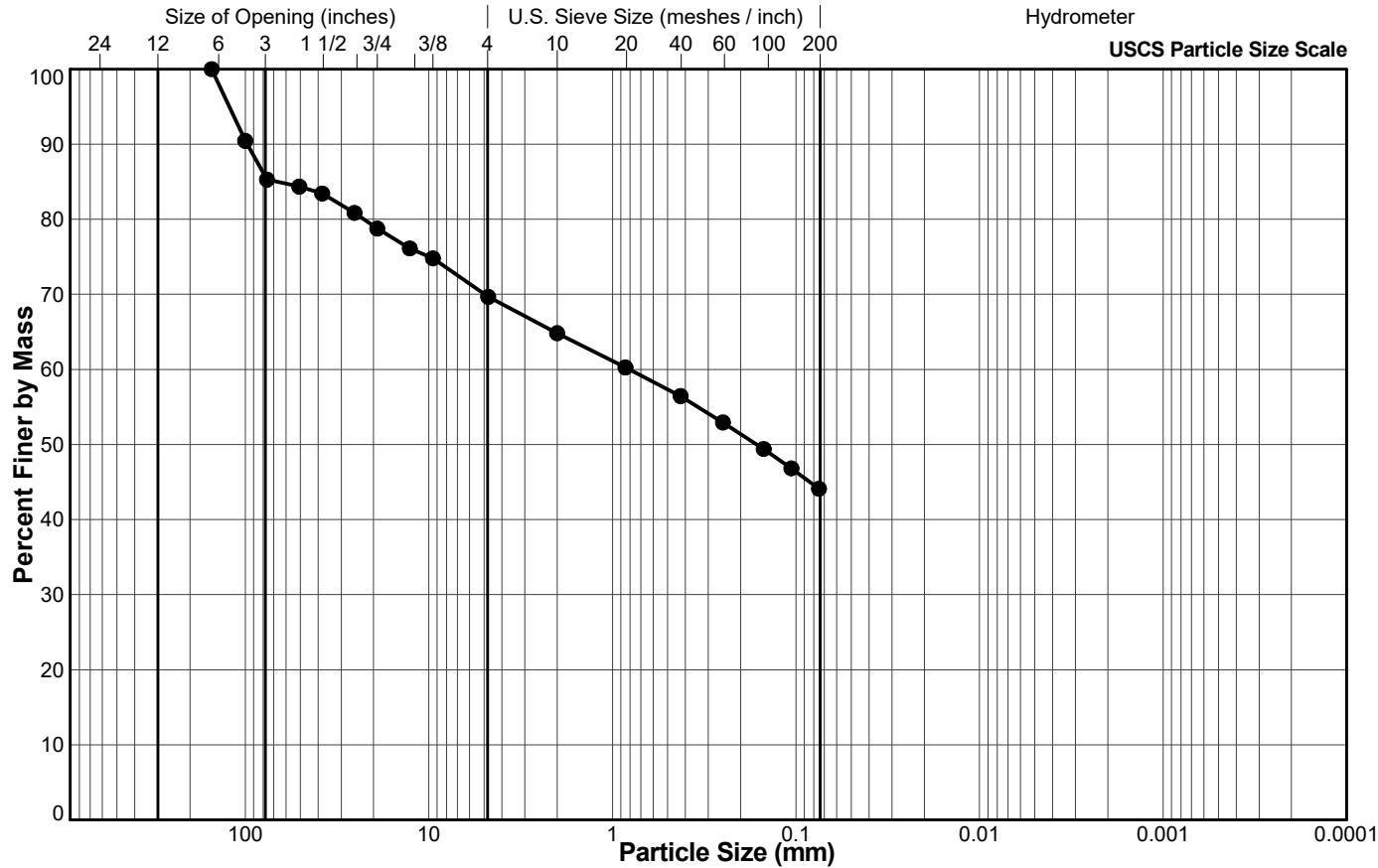
Test Results (corrected)

Penetration	Penetration Stress	CBR Value
3.40 mm	4167 kPa	60 %
5.94 mm	6627 kPa	64 %

TM	January 21, 2019	LH	February 8, 2019
TESTED BY	DATE	CHECKED BY	DATE

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: TP18-29
Sample No.: 1
Depth (m): N/A
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
4"	100	90.5
3"	76.2	85.3
2"	50.8	84.4
1 1/2"	38.1	83.4
1"	25.4	80.9
3/4"	19.1	78.8
1/2"	12.7	76.1
3/8"	9.5	74.8
#4 US MESH	4.75	69.7
#10 US MESH	2	64.8
#20 US MESH	0.85	60.3
#40 US MESH	0.425	56.4
#60 US MESH	0.25	52.9
#100 US MESH	0.15	49.4
#140 US MESH	0.106	46.8
#200 US MESH	0.075	44.1

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

VN

12/12/2018

LH

1/3/2019

Tech

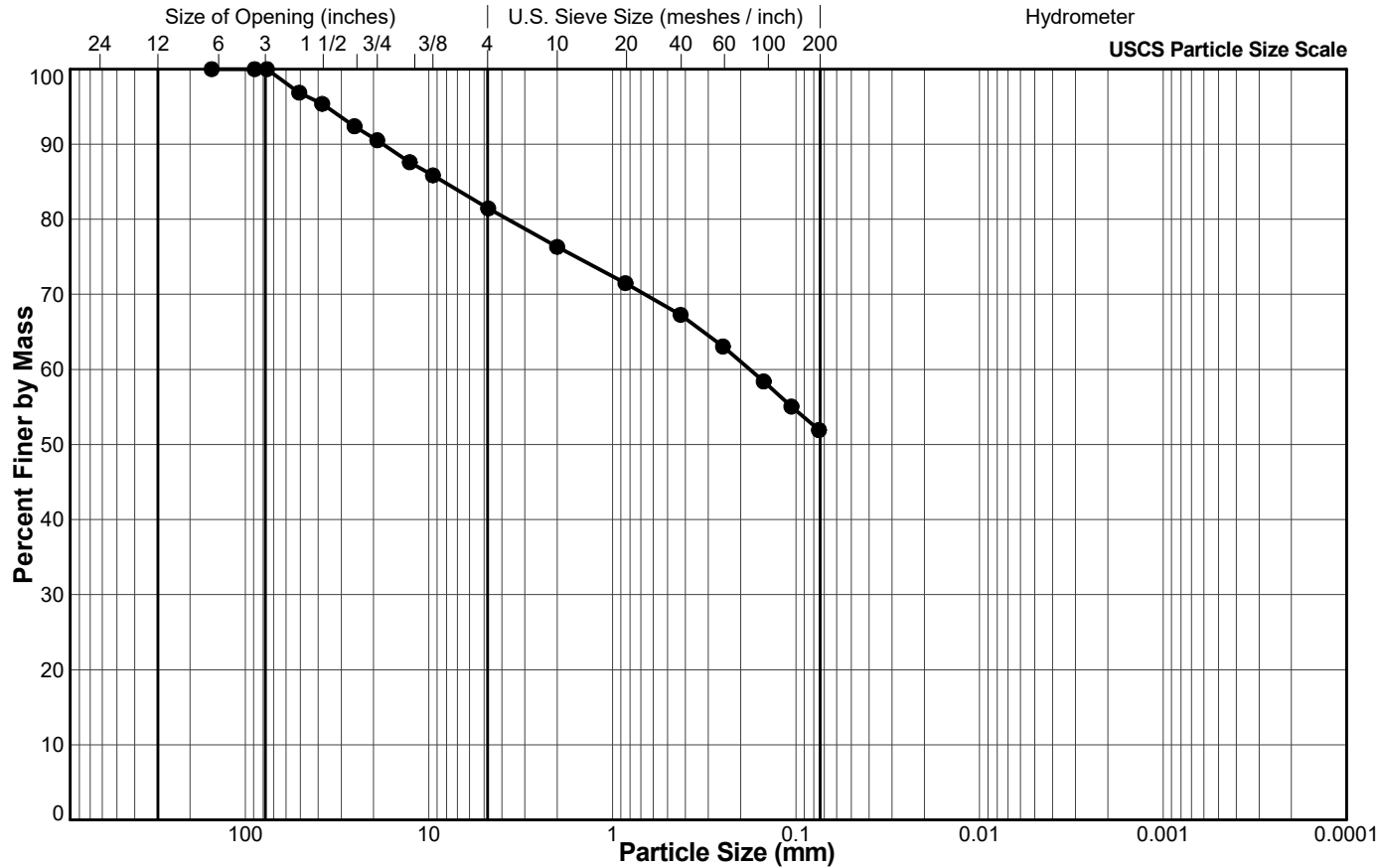
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: TP18-30
Sample No.: 1
Depth (m): N/A
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	96.9
1 1/2"	38.1	95.4
1"	25.4	92.4
3/4"	19.1	90.5
1/2"	12.7	87.6
3/8"	9.5	85.8
#4 US MESH	4.75	81.4
#10 US MESH	2	76.3
#20 US MESH	0.85	71.5
#40 US MESH	0.425	67.3
#60 US MESH	0.25	63.1
#100 US MESH	0.15	58.4
#140 US MESH	0.106	55.1
#200 US MESH	0.075	51.9

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

VN

12/16/2018

LH

1/3/2019

Tech

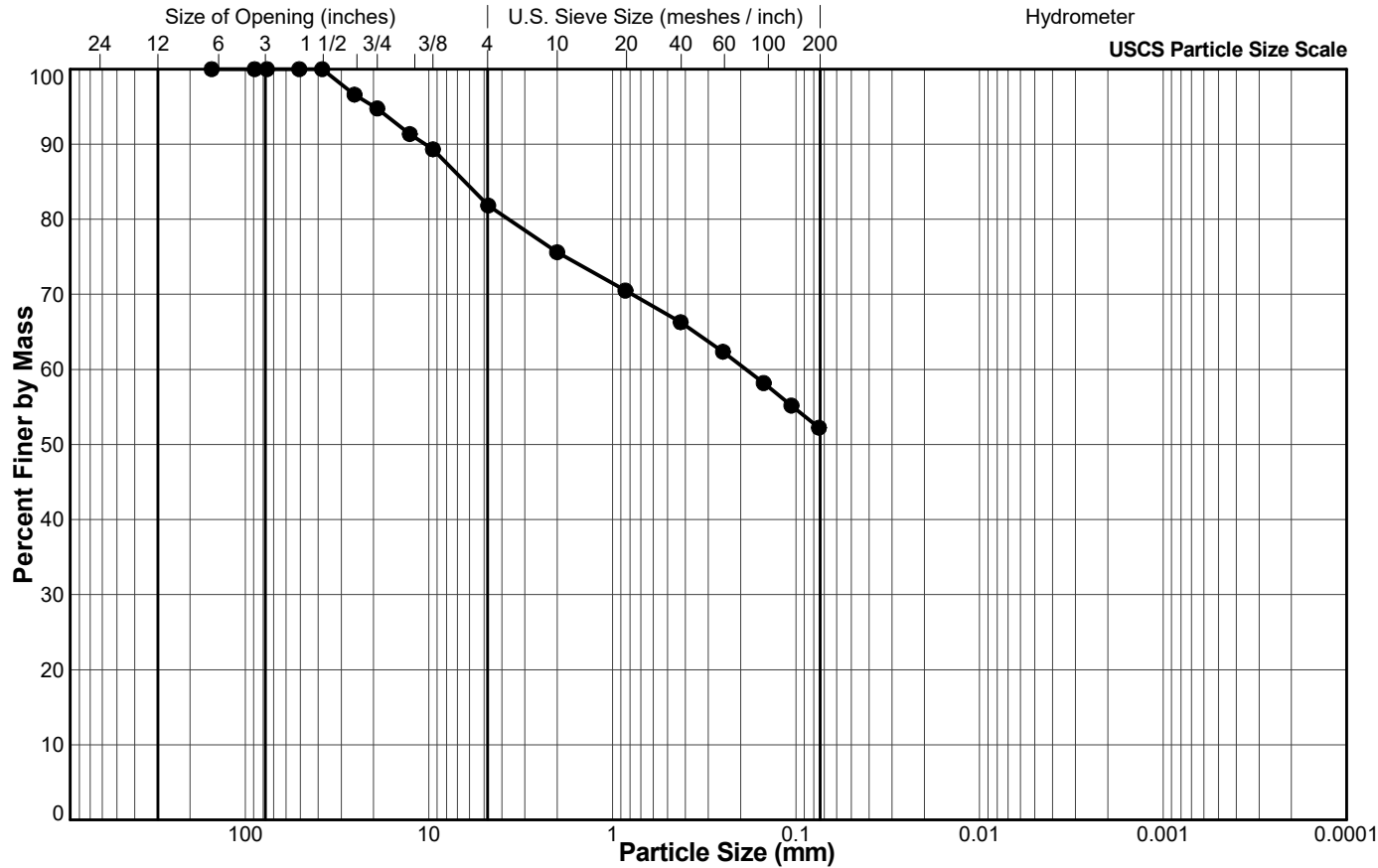
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: TP18-31
Sample No.: 1
Depth (m): N/A
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	100.0
1"	25.4	96.6
3/4"	19.1	94.8
1/2"	12.7	91.4
3/8"	9.5	89.3
#4 US MESH	4.75	81.8
#10 US MESH	2	75.6
#20 US MESH	0.85	70.5
#40 US MESH	0.425	66.3
#60 US MESH	0.25	62.4
#100 US MESH	0.15	58.2
#140 US MESH	0.106	55.2
#200 US MESH	0.075	52.2

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

VN

12/12/2018

LH

1/3/2019

Tech

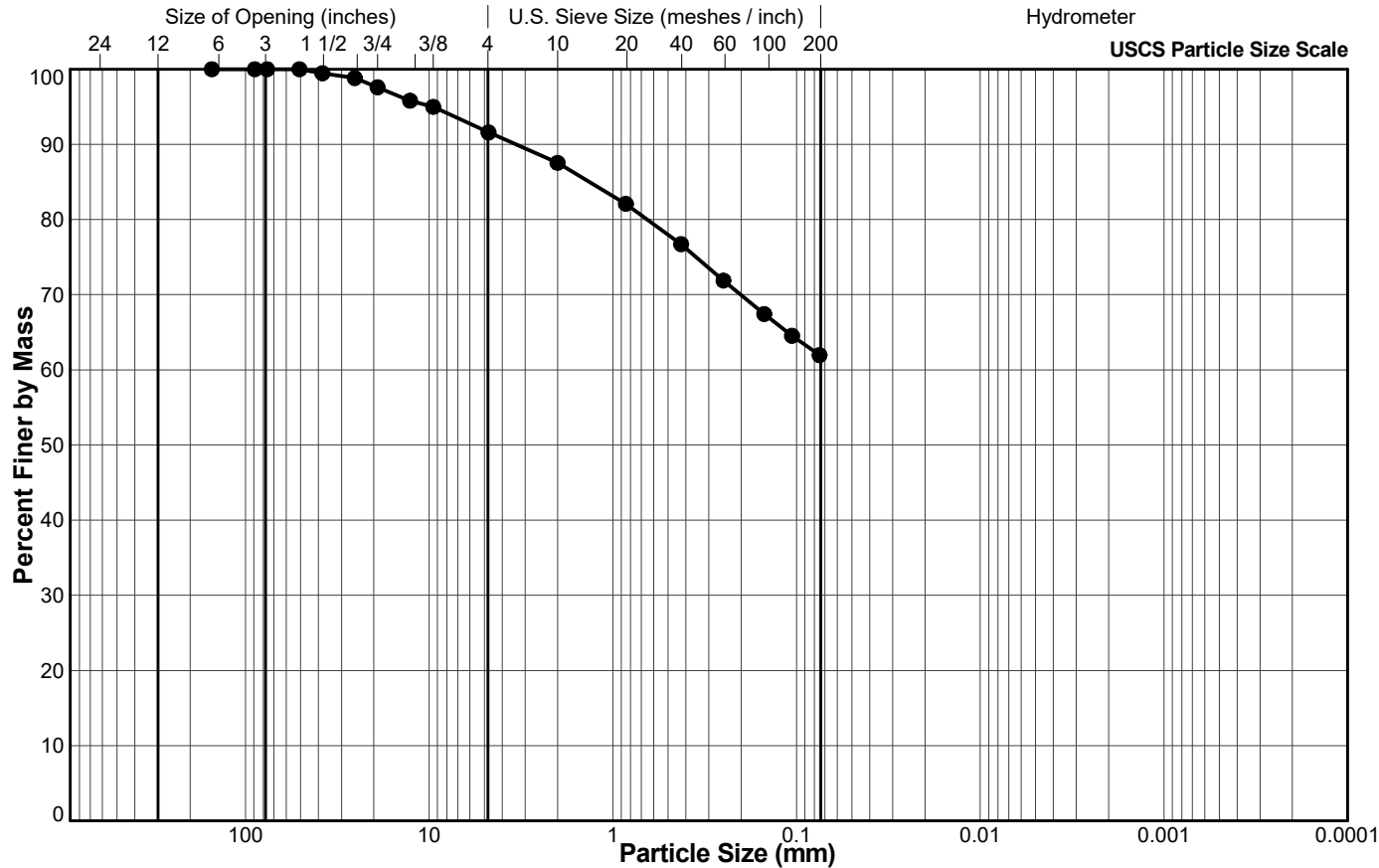
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: TP18-32
Sample No.: 1
Depth (m): N/A
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	99.5
1"	25.4	98.8
3/4"	19.1	97.6
1/2"	12.7	95.8
3/8"	9.5	95.0
#4 US MESH	4.75	91.6
#10 US MESH	2	87.5
#20 US MESH	0.85	82.1
#40 US MESH	0.425	76.7
#60 US MESH	0.25	71.9
#100 US MESH	0.15	67.4
#140 US MESH	0.106	64.5
#200 US MESH	0.075	62.0

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

VN

12/14/2018

LH

1/3/2019

Tech

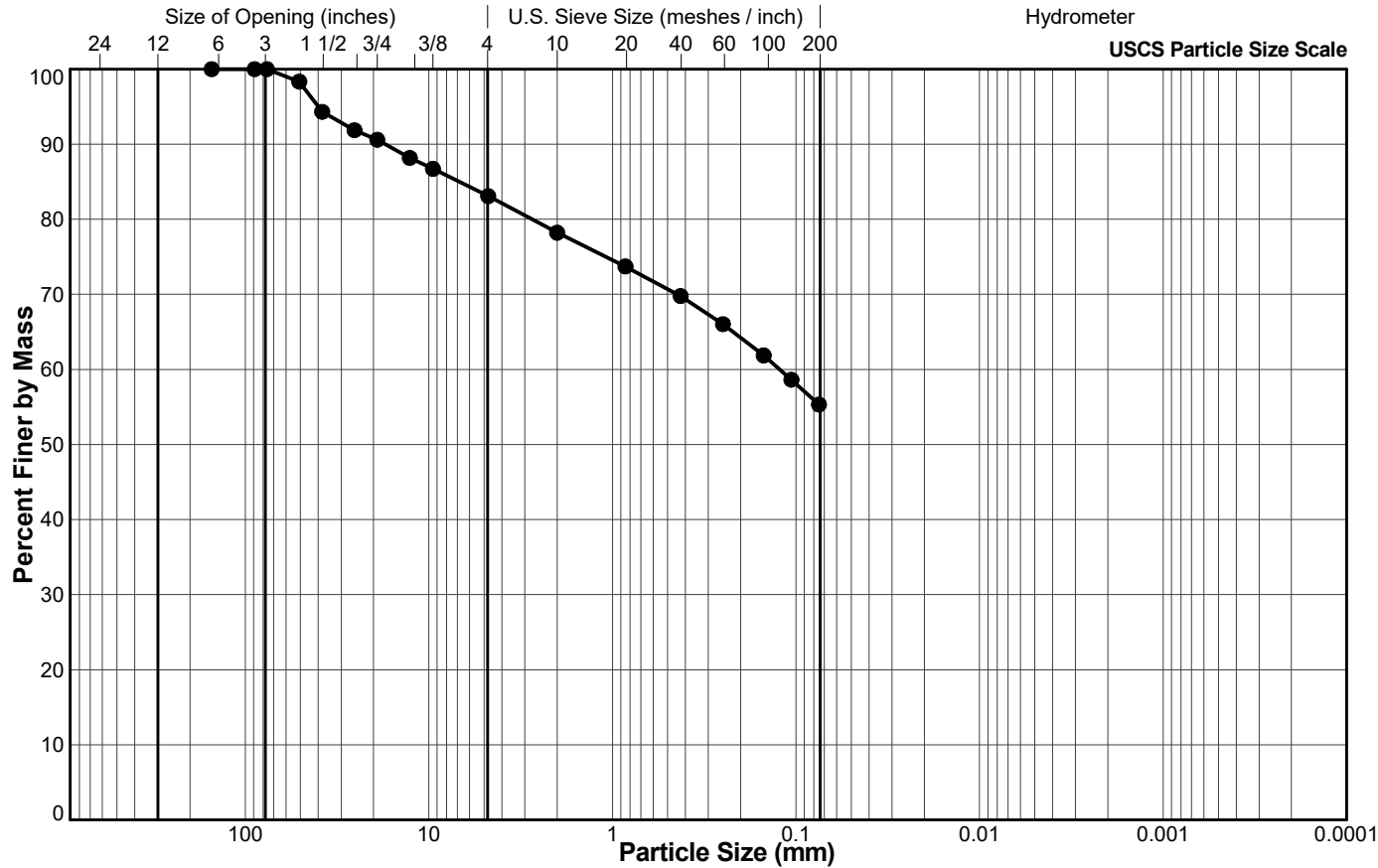
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: TP18-32
Sample No.: 2
Depth (m): N/A
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	98.3
1 1/2"	38.1	94.3
1"	25.4	91.9
3/4"	19.1	90.6
1/2"	12.7	88.2
3/8"	9.5	86.7
#4 US MESH	4.75	83.1
#10 US MESH	2	78.2
#20 US MESH	0.85	73.7
#40 US MESH	0.425	69.8
#60 US MESH	0.25	66.0
#100 US MESH	0.15	61.9
#140 US MESH	0.106	58.6
#200 US MESH	0.075	55.3

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

VN

12/13/2018

LH

1/3/2019

Tech

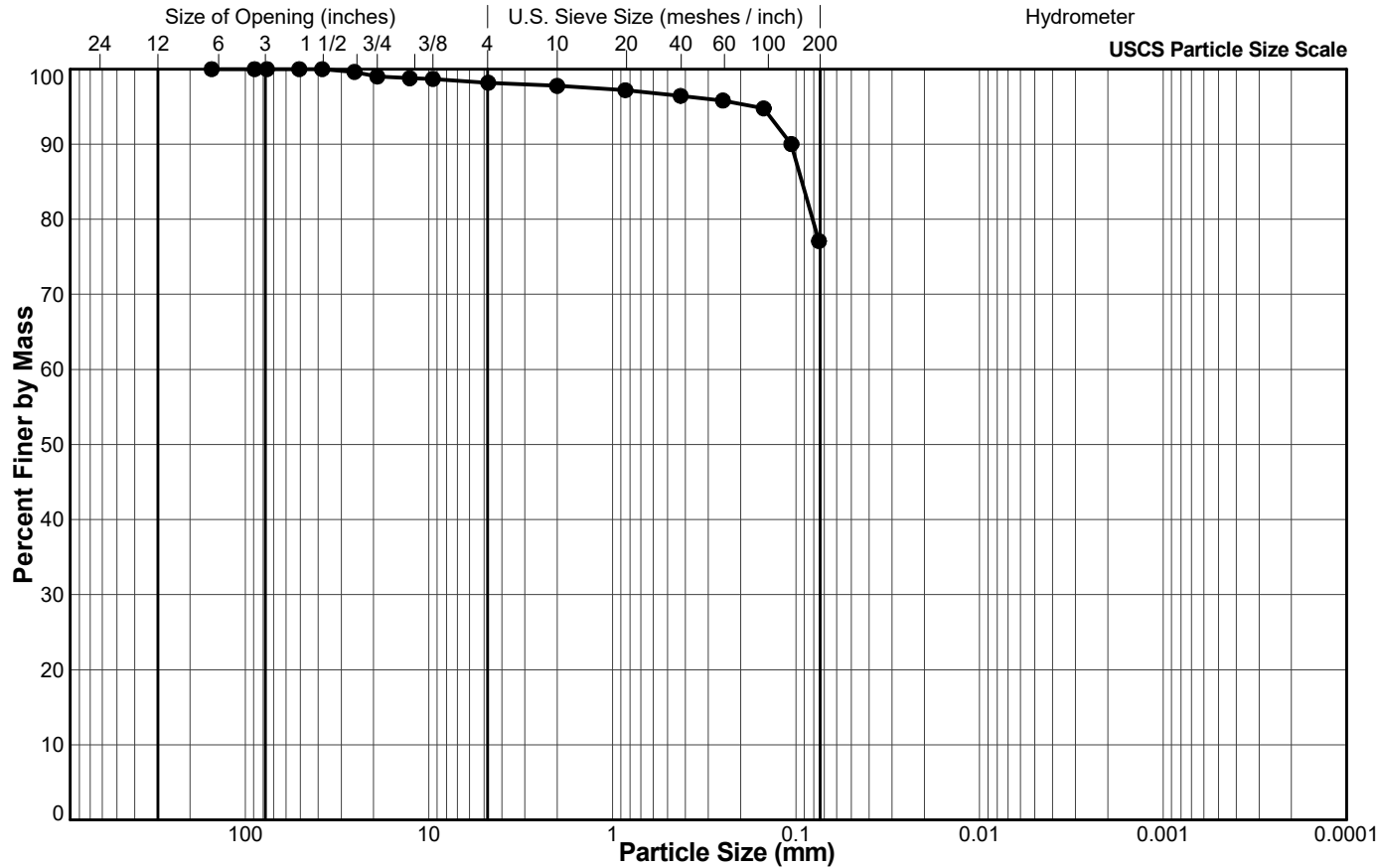
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: TP18-33
Sample No.: 1
Depth (m): N/A
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	100.0
1"	25.4	99.6
3/4"	19.1	99.0
1/2"	12.7	98.8
3/8"	9.5	98.7
#4 US MESH	4.75	98.2
#10 US MESH	2	97.8
#20 US MESH	0.85	97.2
#40 US MESH	0.425	96.4
#60 US MESH	0.25	95.8
#100 US MESH	0.15	94.8
#140 US MESH	0.106	90.0
#200 US MESH	0.075	77.1

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

VN

12/14/2018

LH

1/3/2019

Tech

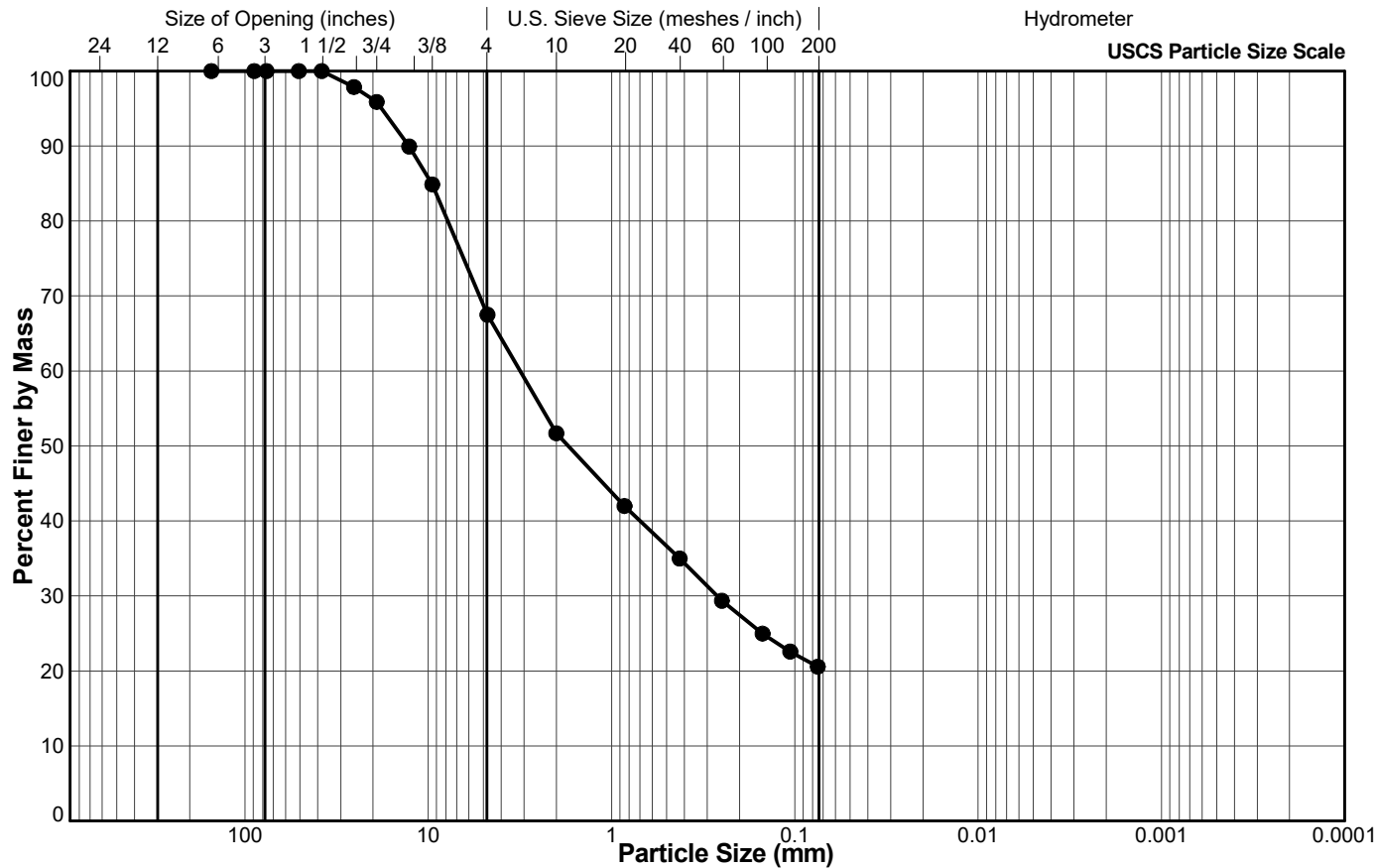
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: TP18-35
Sample No.: 1
Depth (m): N/A
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	100.0
1"	25.4	97.9
3/4"	19.1	95.9
1/2"	12.7	89.9
3/8"	9.5	84.9
#4 US MESH	4.75	67.5
#10 US MESH	2	51.7
#20 US MESH	0.85	42.0
#40 US MESH	0.425	35.0
#60 US MESH	0.25	29.4
#100 US MESH	0.15	25.0
#140 US MESH	0.106	22.6
#200 US MESH	0.075	20.6

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

VN

12/13/2018

LH

1/3/2019

Tech

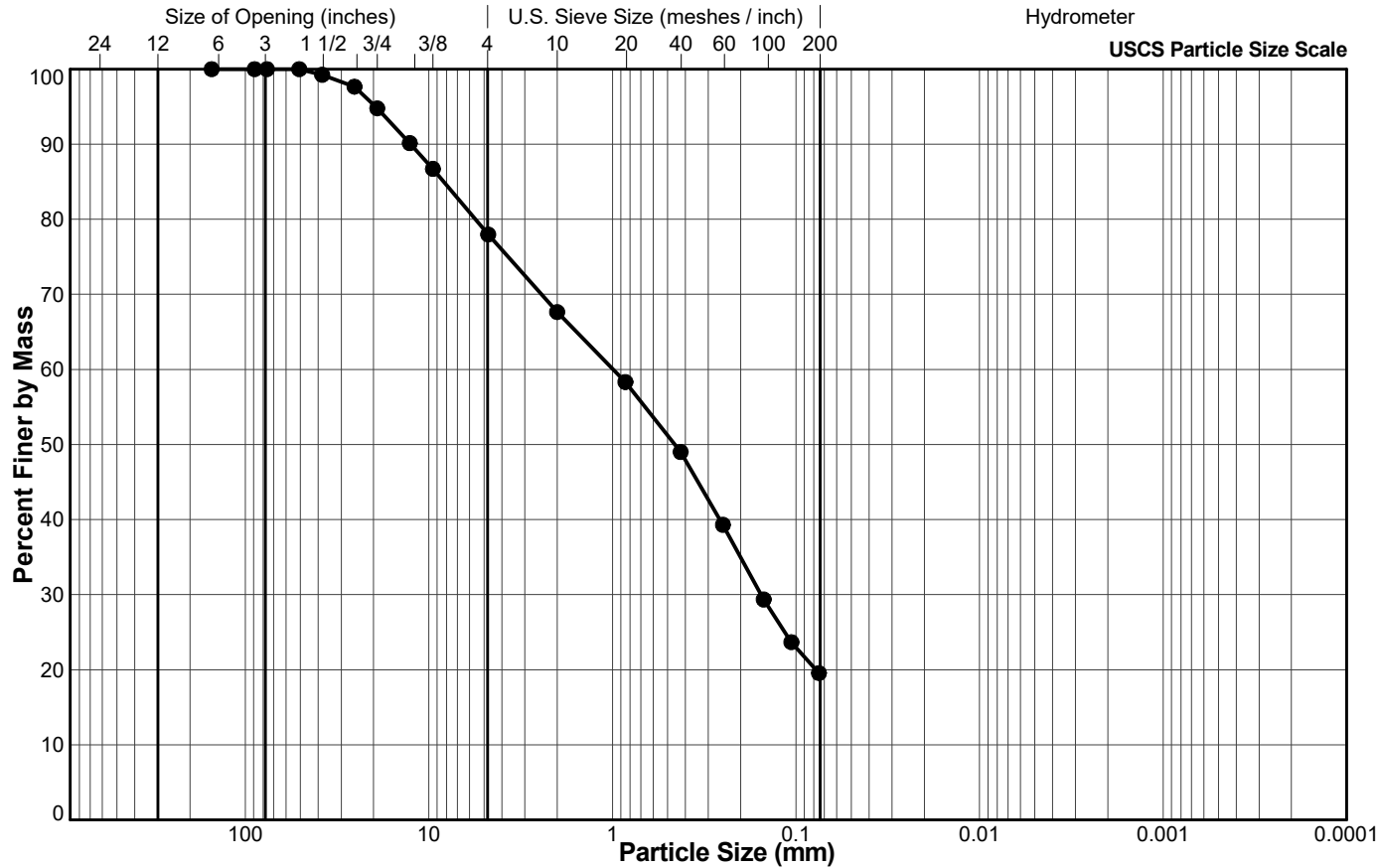
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: TP18-35
Sample No.: 2
Depth (m): N/A
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	99.2
1"	25.4	97.7
3/4"	19.1	94.8
1/2"	12.7	90.1
3/8"	9.5	86.7
#4 US MESH	4.75	78.0
#10 US MESH	2	67.6
#20 US MESH	0.85	58.3
#40 US MESH	0.425	49.0
#60 US MESH	0.25	39.3
#100 US MESH	0.15	29.4
#140 US MESH	0.106	23.7
#200 US MESH	0.075	19.5

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

VN

12/14/2018

LH

1/3/2019

Tech

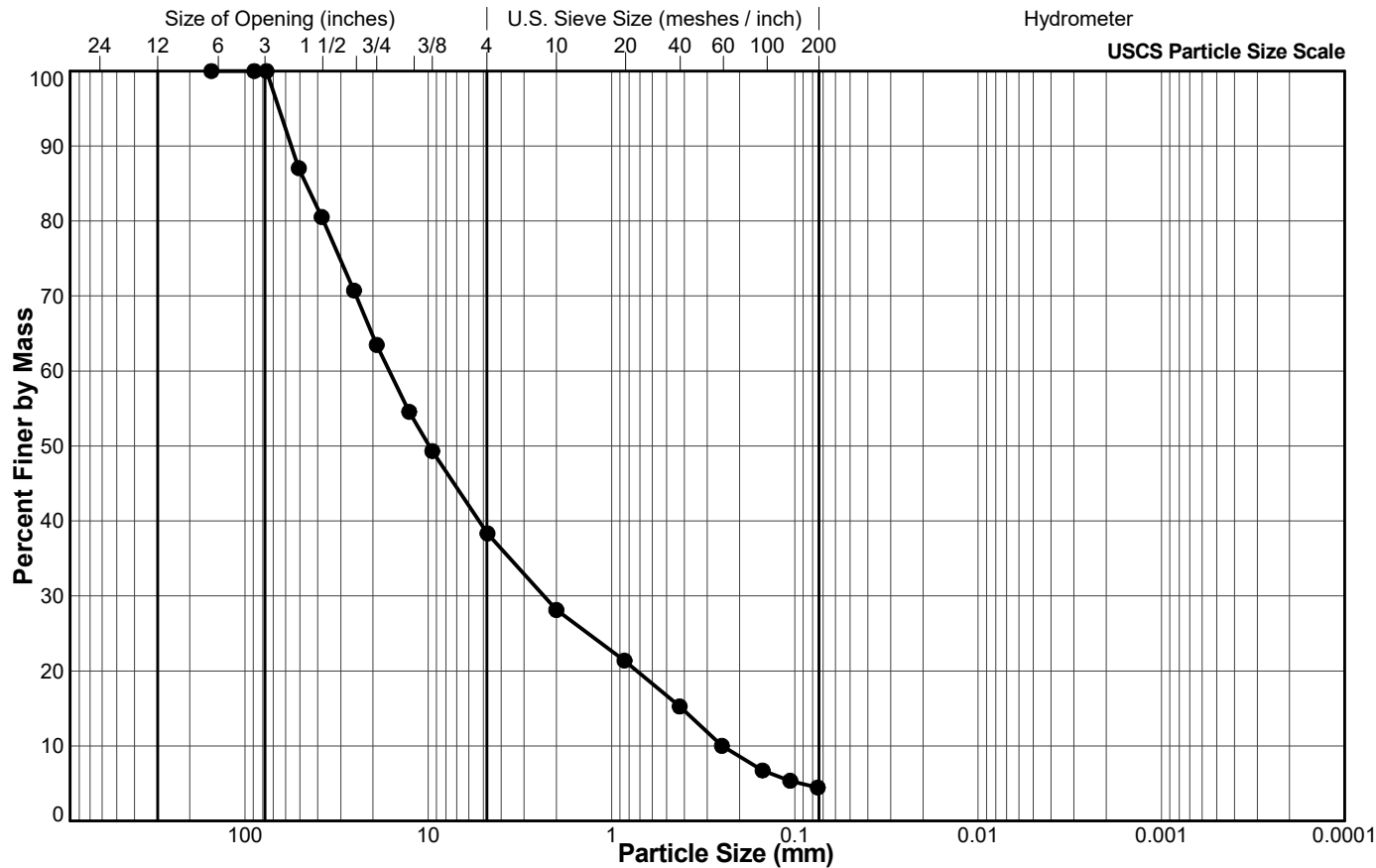
Date

Checked

Date

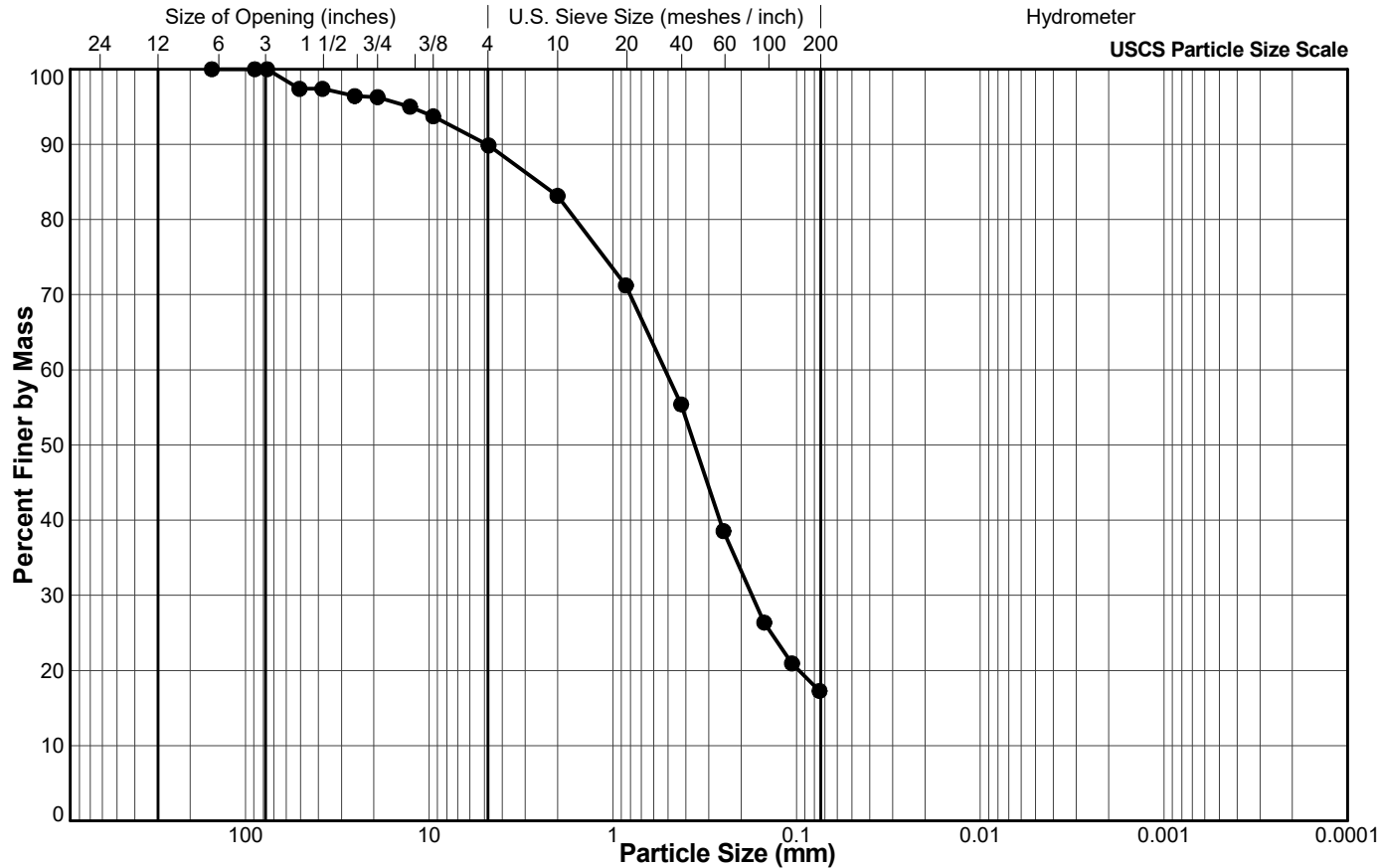
Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: TP18-36
Sample No.: 1
Depth (m): N/A
Lab Schedule No.:



Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: TP18-37
Sample No.: 1
Depth (m): N/A
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	97.4
1 1/2"	38.1	97.4
1"	25.4	96.4
3/4"	19.1	96.3
1/2"	12.7	95.0
3/8"	9.5	93.7
#4 US MESH	4.75	89.9
#10 US MESH	2	83.2
#20 US MESH	0.85	71.2
#40 US MESH	0.425	55.4
#60 US MESH	0.25	38.5
#100 US MESH	0.15	26.4
#140 US MESH	0.106	20.9
#200 US MESH	0.075	17.3

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

VN

12/14/2018

LH

1/3/2019

Tech

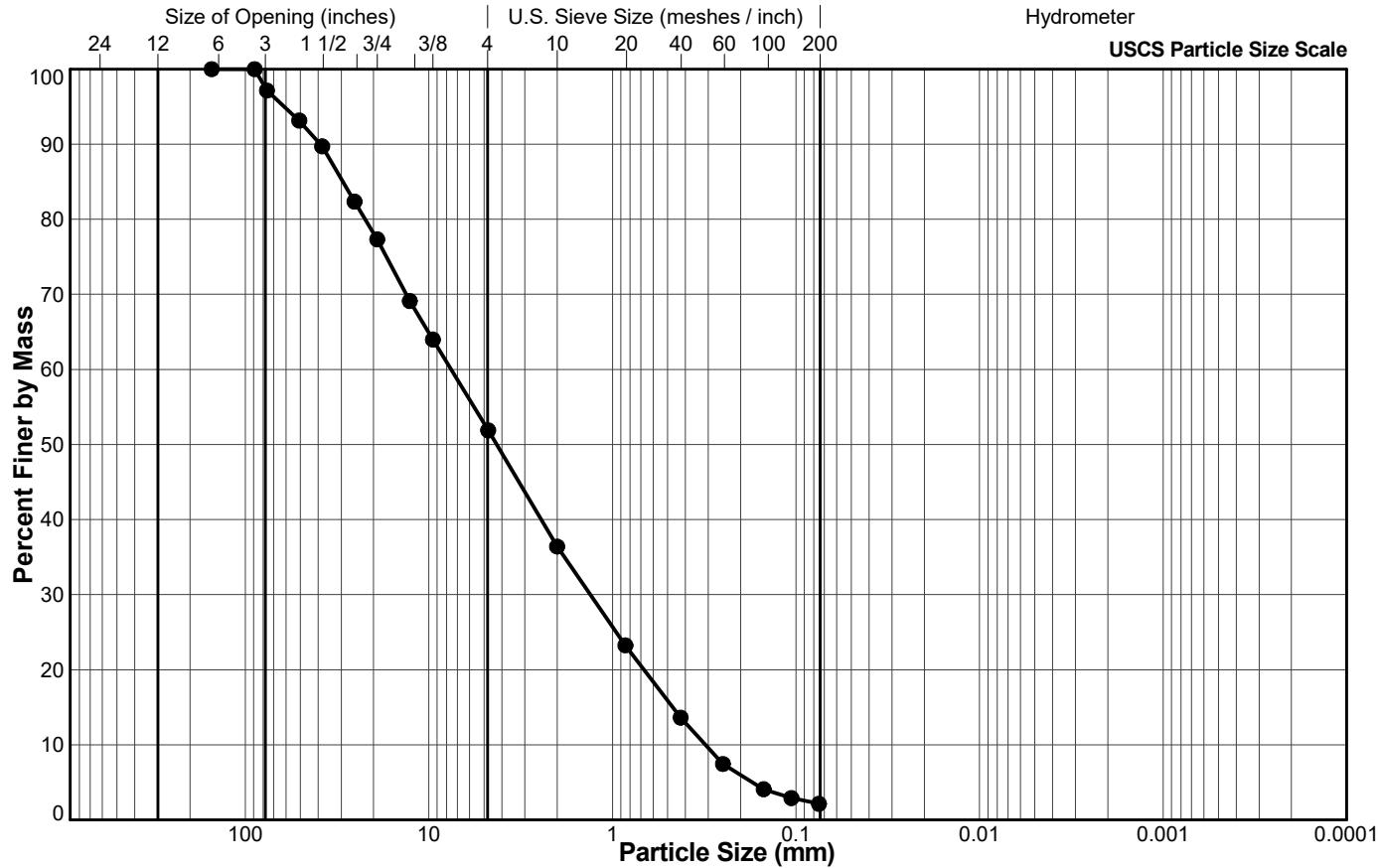
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: TP18-38
Sample No.: 1
Depth (m): N/A
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	97.1
2"	50.8	93.2
1 1/2"	38.1	89.7
1"	25.4	82.4
3/4"	19.1	77.3
1/2"	12.7	69.1
3/8"	9.5	64.0
#4 US MESH	4.75	51.9
#10 US MESH	2	36.4
#20 US MESH	0.85	23.2
#40 US MESH	0.425	13.6
#60 US MESH	0.25	7.4
#100 US MESH	0.15	4.1
#140 US MESH	0.106	2.9
#200 US MESH	0.075	2.1

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

VN

12/24/2018

LH

1/9/2019

Tech

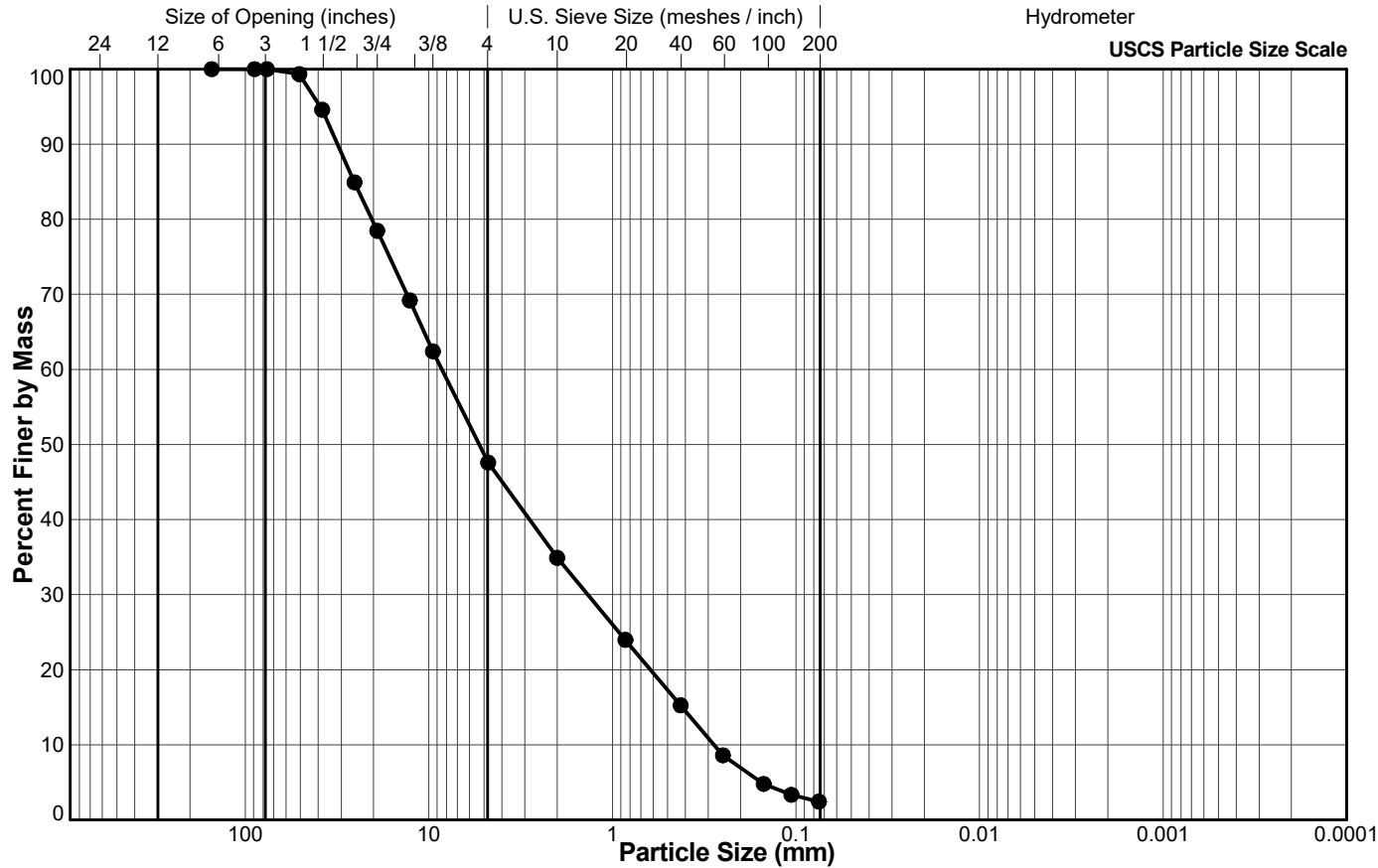
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: TP18-39
Sample No.: 1
Depth (m): N/A
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	99.3
1 1/2"	38.1	94.6
1"	25.4	84.9
3/4"	19.1	78.5
1/2"	12.7	69.2
3/8"	9.5	62.4
#4 US MESH	4.75	47.6
#10 US MESH	2	34.9
#20 US MESH	0.85	24.0
#40 US MESH	0.425	15.3
#60 US MESH	0.25	8.6
#100 US MESH	0.15	4.8
#140 US MESH	0.106	3.3
#200 US MESH	0.075	2.4

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

VN

12/26/2018

LH

1/9/2019

Tech

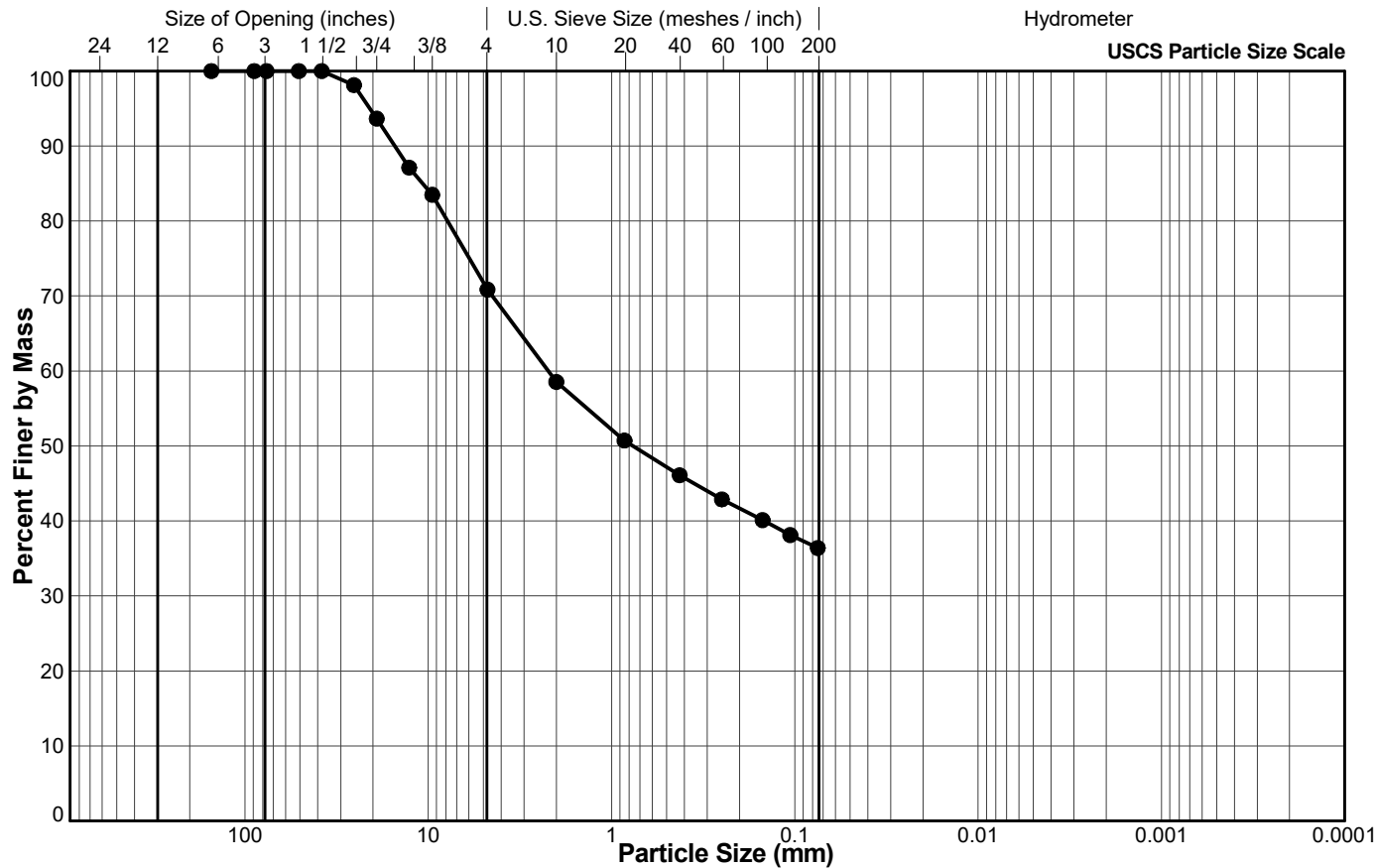
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: 19-28S
Sample No.: SA-01
Depth Interval (m): 1.20 to 1.50
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	100.0
1"	25.4	98.1
3/4"	19.1	93.7
1/2"	12.7	87.1
3/8"	9.5	83.5
#4 US MESH	4.75	70.9
#10 US MESH	2	58.5
#20 US MESH	0.85	50.7
#40 US MESH	0.425	46.1
#60 US MESH	0.25	42.9
#100 US MESH	0.15	40.1
#140 US MESH	0.106	38.1
#200 US MESH	0.075	36.4

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

FF/RG

3/7/2019

LP

3/15/2019

Tech

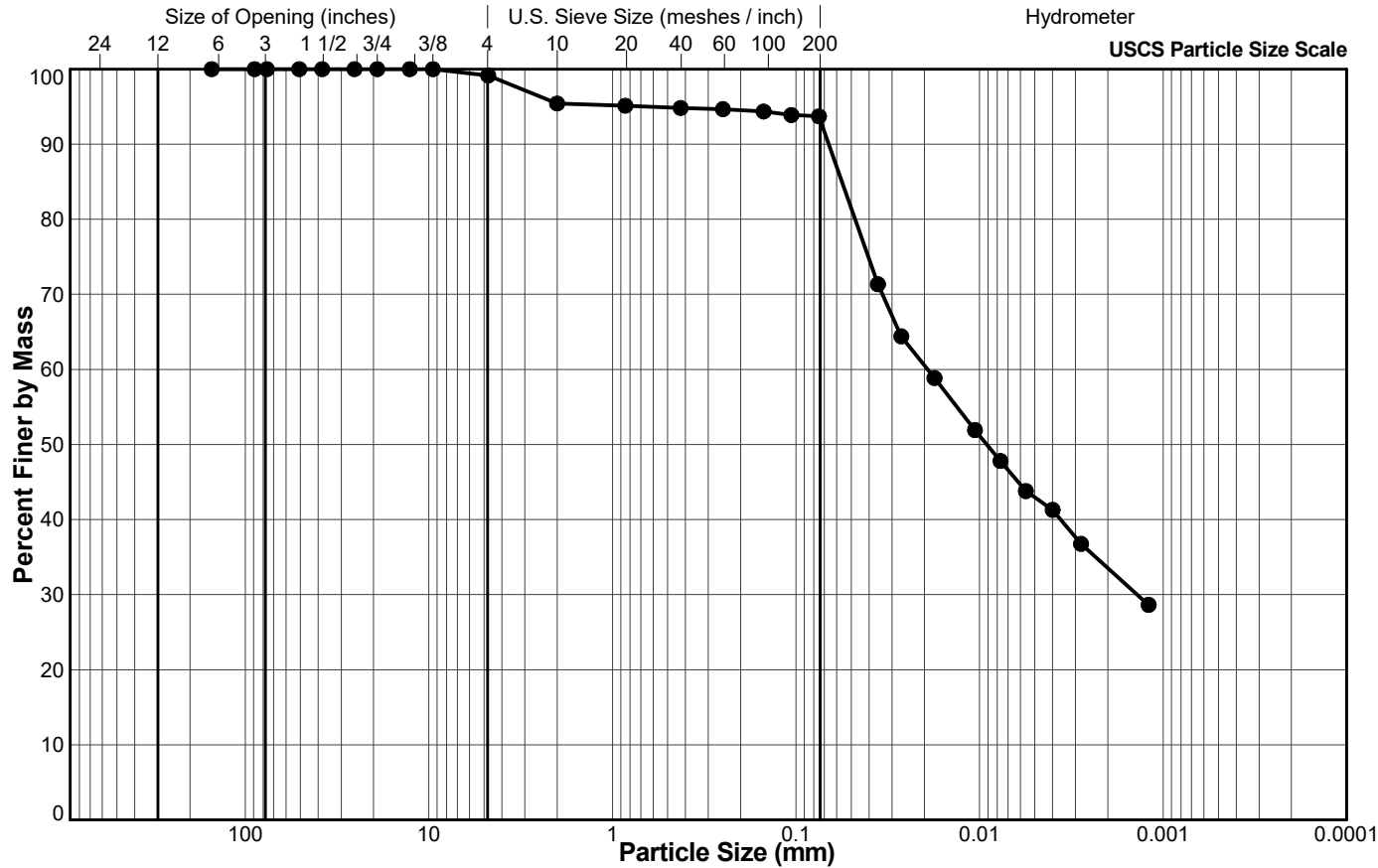
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: 19-28S
Sample No.: SA-03
Depth Interval (m): 5.80 to 6.10
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	100.0
1"	25.4	100.0
3/4"	19.1	100.0
1/2"	12.7	100.0
3/8"	9.5	100.0
#4 US MESH	4.75	99.2
#10 US MESH	2	95.4
#20 US MESH	0.85	95.1
#40 US MESH	0.425	94.8
#60 US MESH	0.25	94.7
#100 US MESH	0.15	94.4
#140 US MESH	0.106	93.9
#200 US MESH	0.075	93.7
	0.0358	71.3
	0.0267	64.4
	0.0176	58.9
	0.0106	51.9
	0.0077	47.8
	0.0056	43.8
	0.0040	41.3
	0.0028	36.8
	0.0012	28.6

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

DC/FF

3/7/2019

LP

3/15/2019

Tech

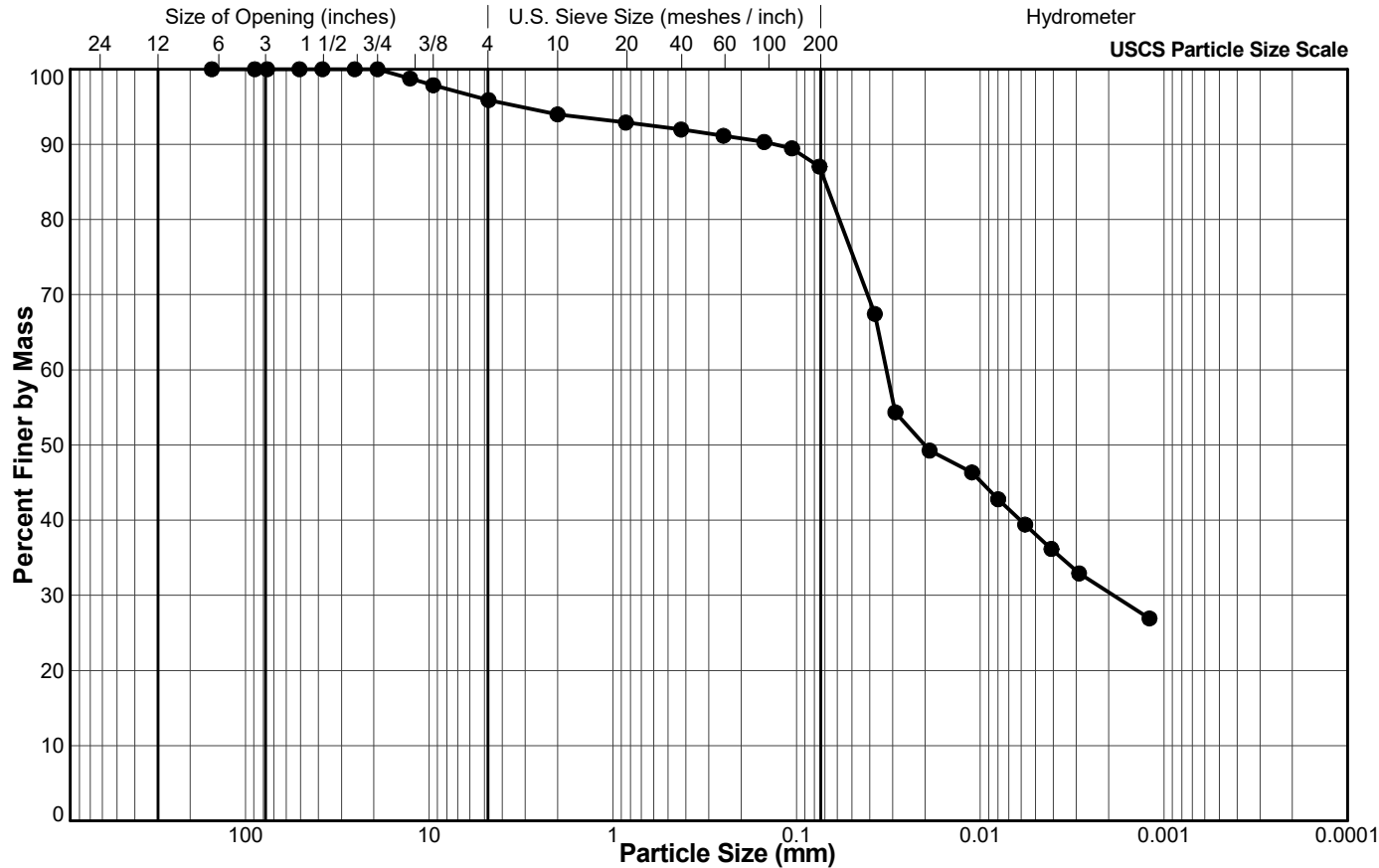
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: 19-28S-1
Sample No.: SA-03
Depth Interval (m): 4.00 to 4.30
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	100.0
1"	25.4	100.0
3/4"	19.1	100.0
1/2"	12.7	98.8
3/8"	9.5	97.9
#4 US MESH	4.75	95.9
#10 US MESH	2	94.0
#20 US MESH	0.85	92.9
#40 US MESH	0.425	92.0
#60 US MESH	0.25	91.1
#100 US MESH	0.15	90.3
#140 US MESH	0.106	89.5
#200 US MESH	0.075	87.0
	0.0375	67.4
	0.0290	54.4
	0.0189	49.3
	0.0111	46.4
	0.0080	42.8
	0.0057	39.4
	0.0041	36.2
	0.0029	32.9
	0.0012	26.9

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

DC/FF

3/7/2019

LP

3/15/2019

Tech

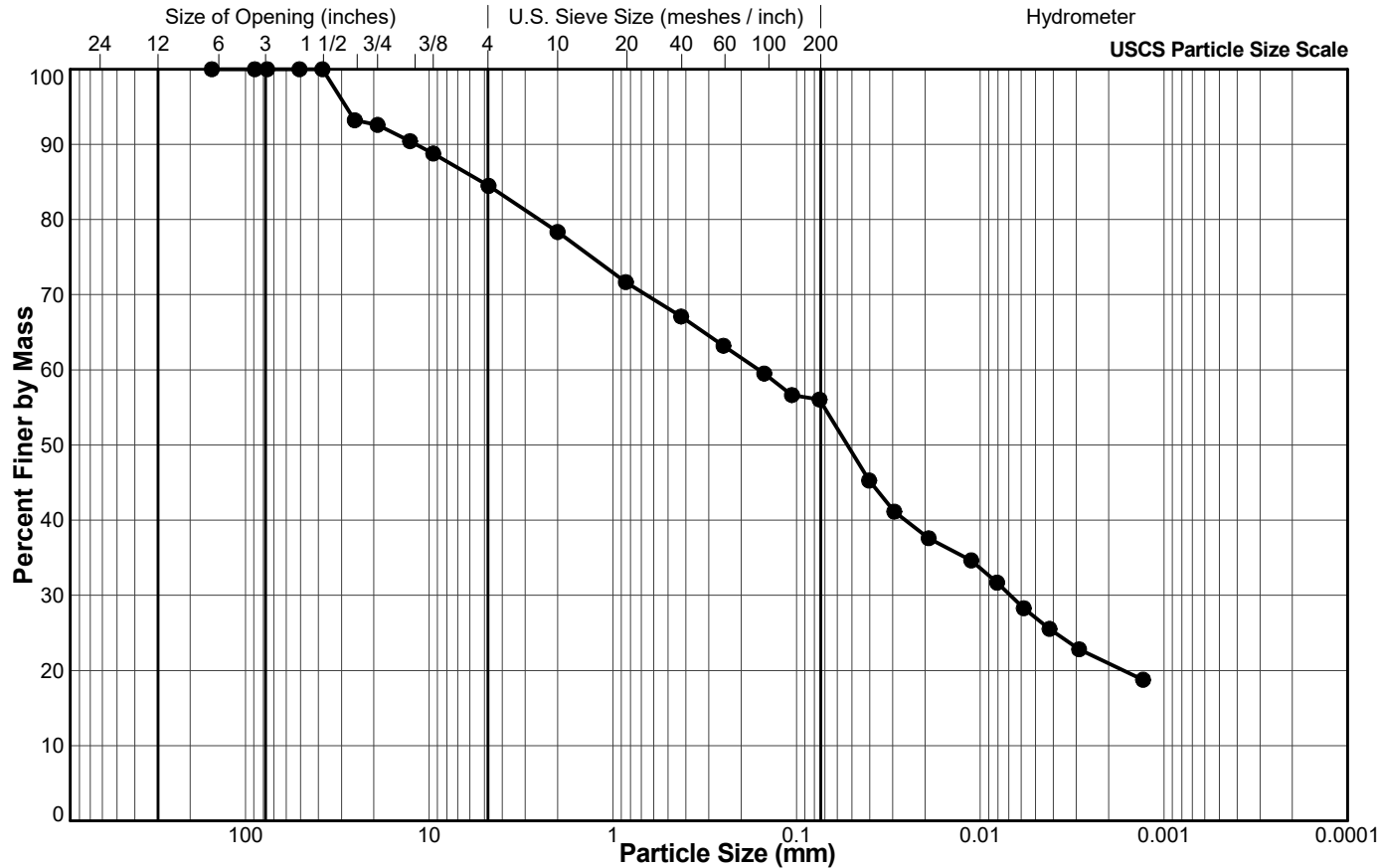
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: 19-30S
Sample No.: SA-03
Depth Interval (m): 4.30 to 4.60
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	100.0
1"	25.4	93.2
3/4"	19.1	92.6
1/2"	12.7	90.4
3/8"	9.5	88.8
#4 US MESH	4.75	84.5
#10 US MESH	2	78.3
#20 US MESH	0.85	71.7
#40 US MESH	0.425	67.1
#60 US MESH	0.25	63.2
#100 US MESH	0.15	59.5
#140 US MESH	0.106	56.6
#200 US MESH	0.075	56.0
	0.0403	45.3
	0.0294	41.1
	0.0191	37.6
	0.0112	34.6
	0.0081	31.7
	0.0058	28.3
	0.0042	25.5
	0.0029	22.8
	0.0013	18.8

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

DC/FF

3/7/2019

LP

3/15/2019

Tech

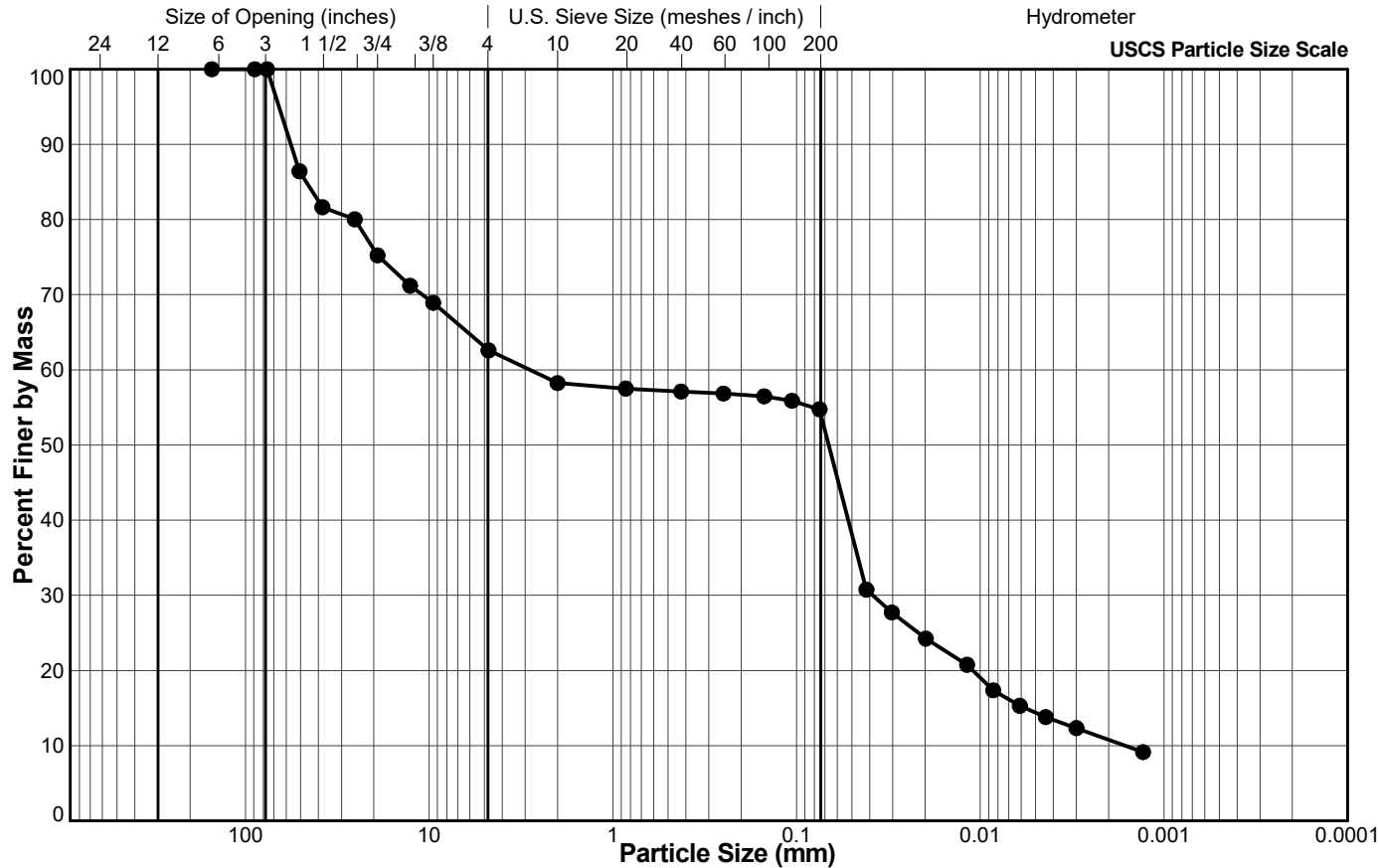
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: 19-30S
Sample No.: SA-06
Depth Interval (m): 11.90 to 12.20
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	86.4
1 1/2"	38.1	81.6
1"	25.4	80.0
3/4"	19.1	75.2
1/2"	12.7	71.2
3/8"	9.5	68.9
#4 US MESH	4.75	62.6
#10 US MESH	2	58.2
#20 US MESH	0.85	57.5
#40 US MESH	0.425	57.1
#60 US MESH	0.25	56.8
#100 US MESH	0.15	56.5
#140 US MESH	0.106	55.9
#200 US MESH	0.075	54.8
	0.0417	30.8
	0.0303	27.7
	0.0198	24.2
	0.0118	20.8
	0.0085	17.4
	0.0061	15.3
	0.0044	13.8
	0.0030	12.3
	0.0013	9.1

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

DC/FF

3/7/2019

LP

3/15/2019

Tech

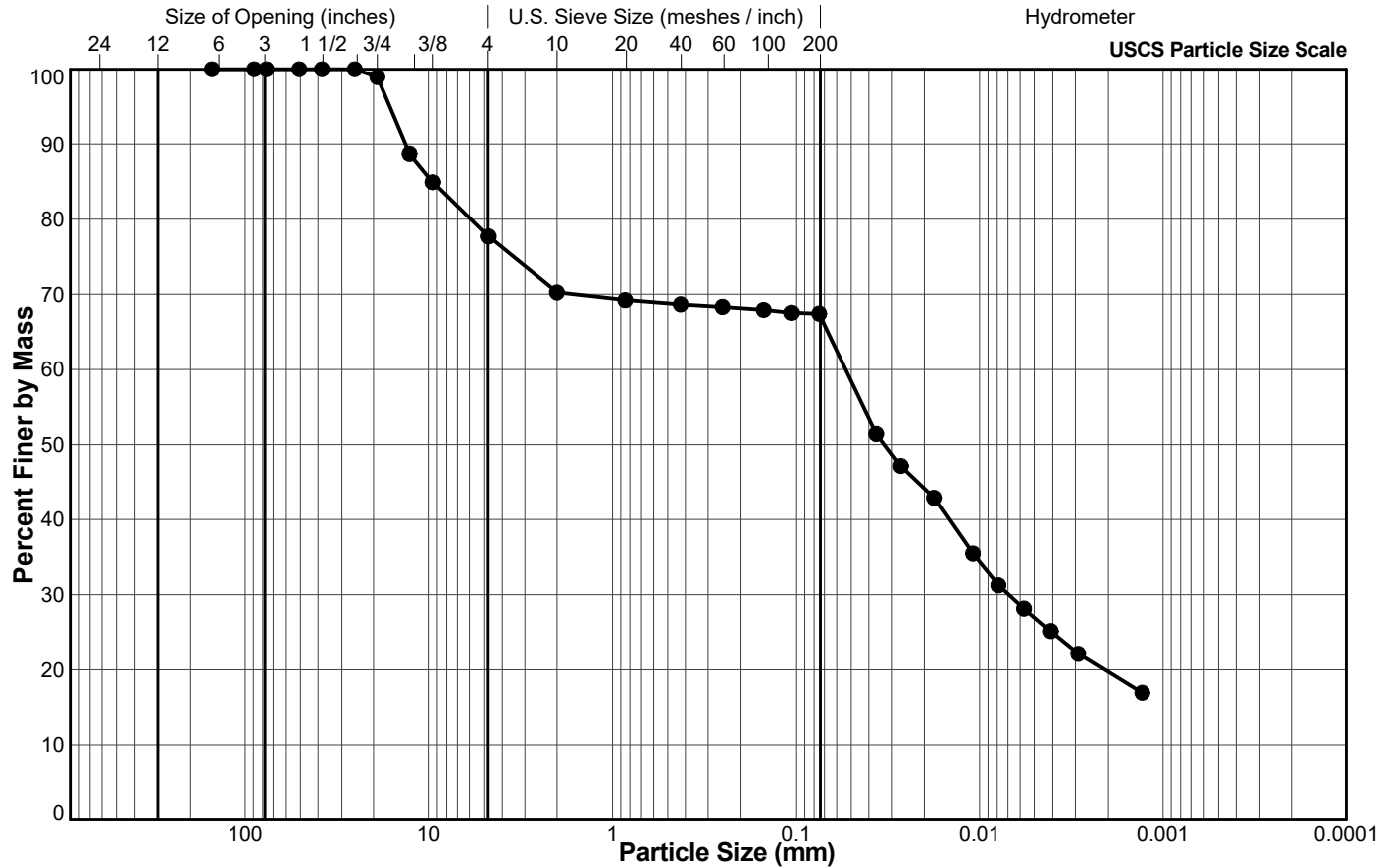
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: 19-30S
Sample No.: SA-09
Depth Interval (m): 13.70 to 14.00
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	100.0
1"	25.4	100.0
3/4"	19.1	98.9
1/2"	12.7	88.7
3/8"	9.5	85.0
#4 US MESH	4.75	77.7
#10 US MESH	2	70.3
#20 US MESH	0.85	69.2
#40 US MESH	0.425	68.7
#60 US MESH	0.25	68.3
#100 US MESH	0.15	67.9
#140 US MESH	0.106	67.6
#200 US MESH	0.075	67.5
	0.0364	51.4
	0.0269	47.2
	0.0177	42.9
	0.0109	35.5
	0.0079	31.3
	0.0057	28.2
	0.0041	25.2
	0.0029	22.1
	0.0013	16.9

BOULDER	COBBLE	GRAVEL	SAND	FINES (Silt, Clay)
		Coarse	Coarse	
		Fine	Medium	
			Fine	

DC/FF

3/7/2019

LP

3/15/2019

Tech

Date

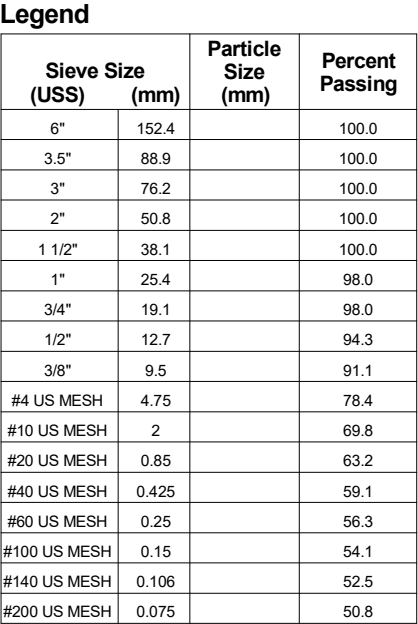
Checked

Date



Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: 19-31S
Sample No.: SA-01
Depth Interval (m): 1.20 to 1.50
Lab Schedule No.:

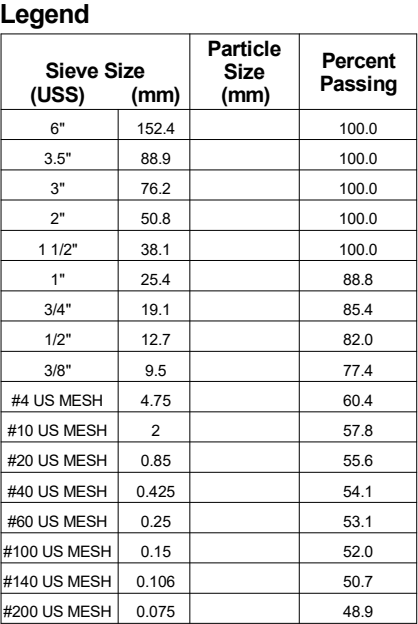


FF/RG	3/7/2019	LP	3/15/2019
Tech	Date	Checked	Date



Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

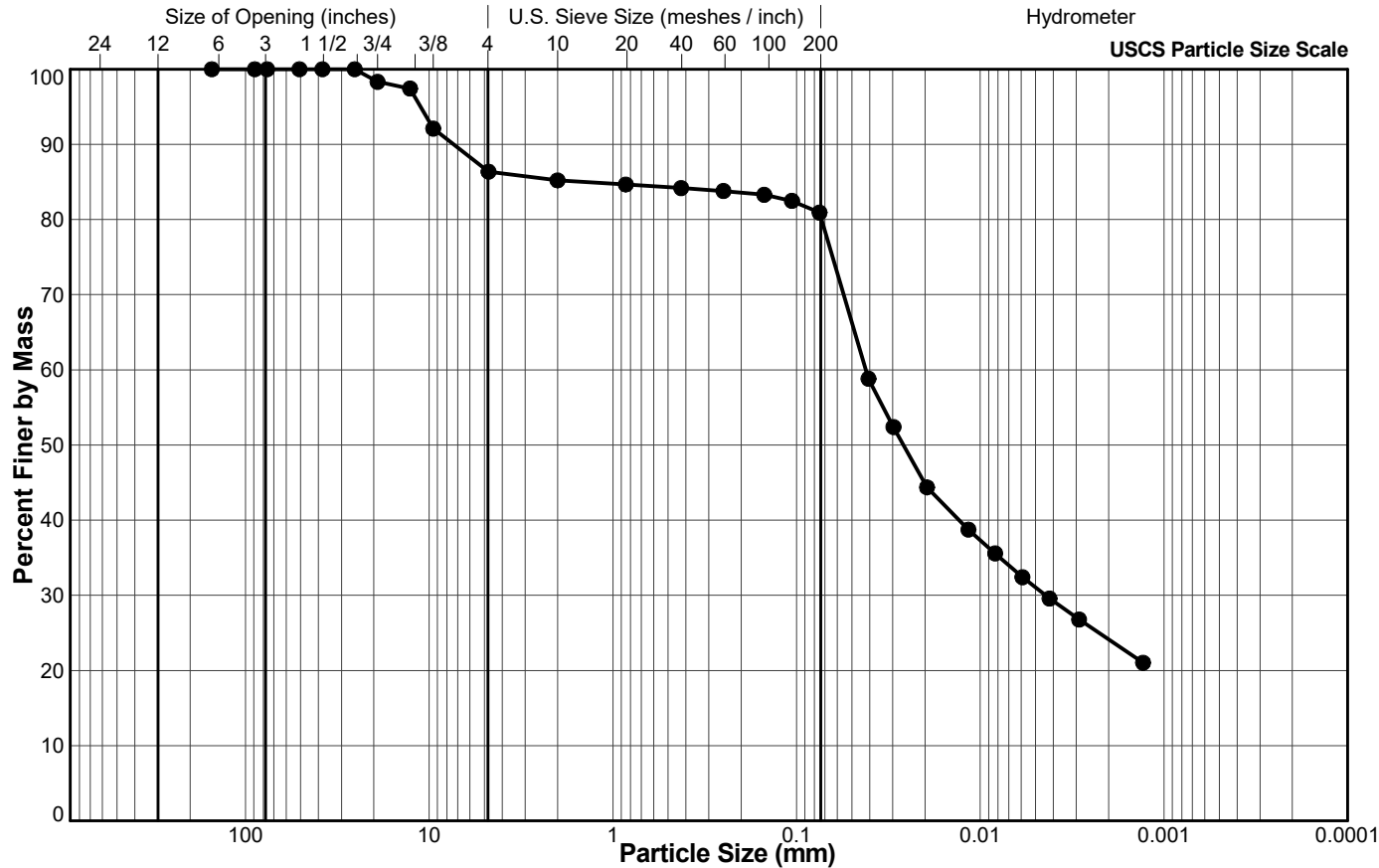
Sample Location: 19-31S
Sample No.: SA-03
Depth Interval (m): 8.20 to 8.50
Lab Schedule No.:



FF/RG	3/7/2019	LP	3/15/2019
Tech	Date	Checked	Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: 19-31S
Sample No.: SA-04
Depth Interval (m): 13.10 to 13.40
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	100.0
1"	25.4	100.0
3/4"	19.1	98.3
1/2"	12.7	97.4
3/8"	9.5	92.1
#4 US MESH	4.75	86.4
#10 US MESH	2	85.2
#20 US MESH	0.85	84.7
#40 US MESH	0.425	84.2
#60 US MESH	0.25	83.8
#100 US MESH	0.15	83.3
#140 US MESH	0.106	82.5
#200 US MESH	0.075	80.9
	0.0406	58.8
	0.0297	52.4
	0.0195	44.4
	0.0116	38.7
	0.0083	35.6
	0.0059	32.4
	0.0042	29.6
	0.0029	26.8
	0.0013	21.0

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

DC/KS

3/26/2019

LH

3/28/2019

Tech

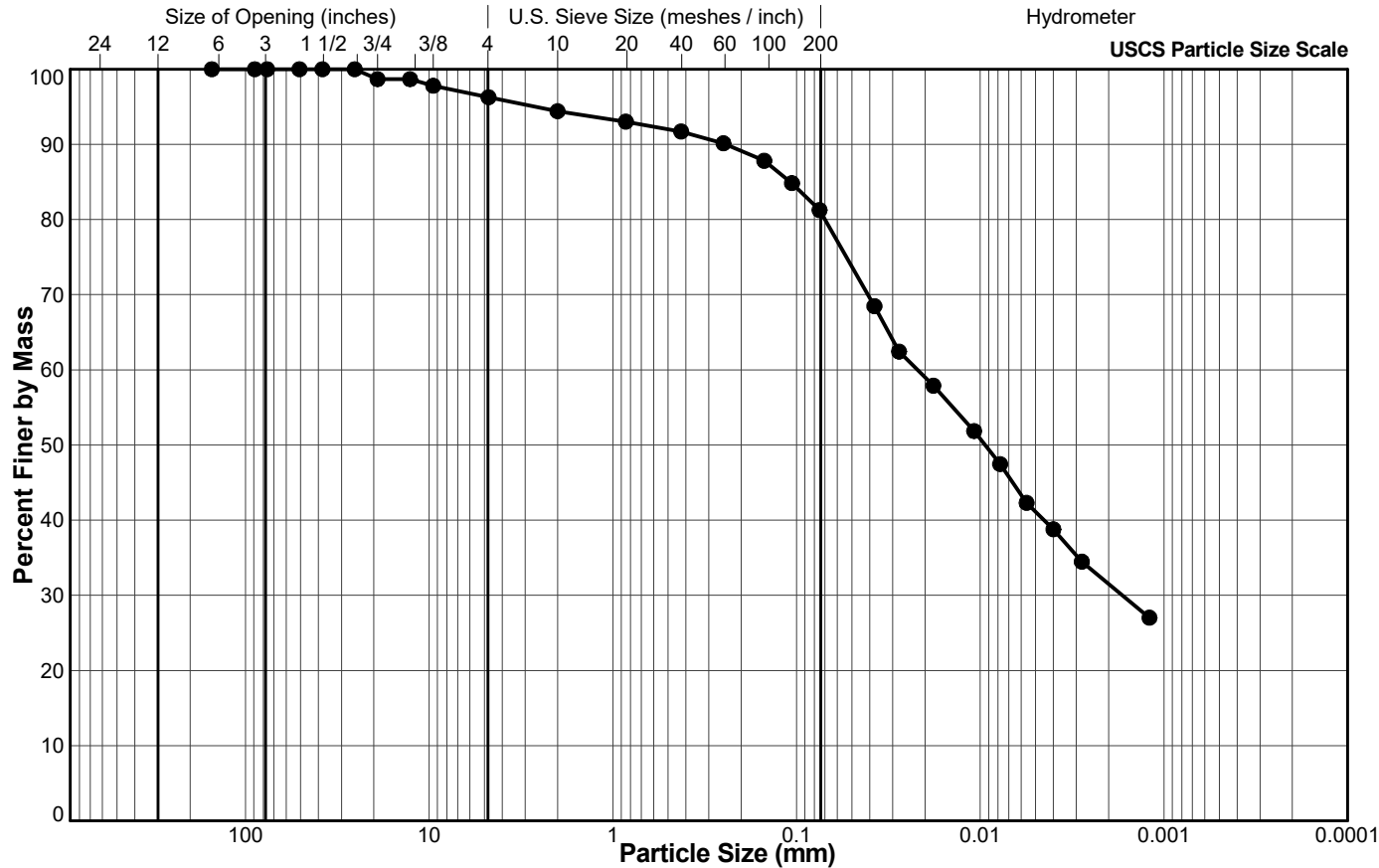
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: 19-32S
Sample No.: SA-02
Depth Interval (m): 4.90 to 5.20
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	100.0
1"	25.4	100.0
3/4"	19.1	98.7
1/2"	12.7	98.7
3/8"	9.5	97.8
#4 US MESH	4.75	96.3
#10 US MESH	2	94.4
#20 US MESH	0.85	93.0
#40 US MESH	0.425	91.7
#60 US MESH	0.25	90.1
#100 US MESH	0.15	87.8
#140 US MESH	0.106	84.8
#200 US MESH	0.075	81.3
	0.0377	68.5
	0.0277	62.4
	0.0180	57.9
	0.0108	51.9
	0.0078	47.5
	0.0056	42.3
	0.0040	38.8
	0.0028	34.5
	0.0012	27.0

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

DC/FF

3/7/2019

LP

3/15/2019

Tech

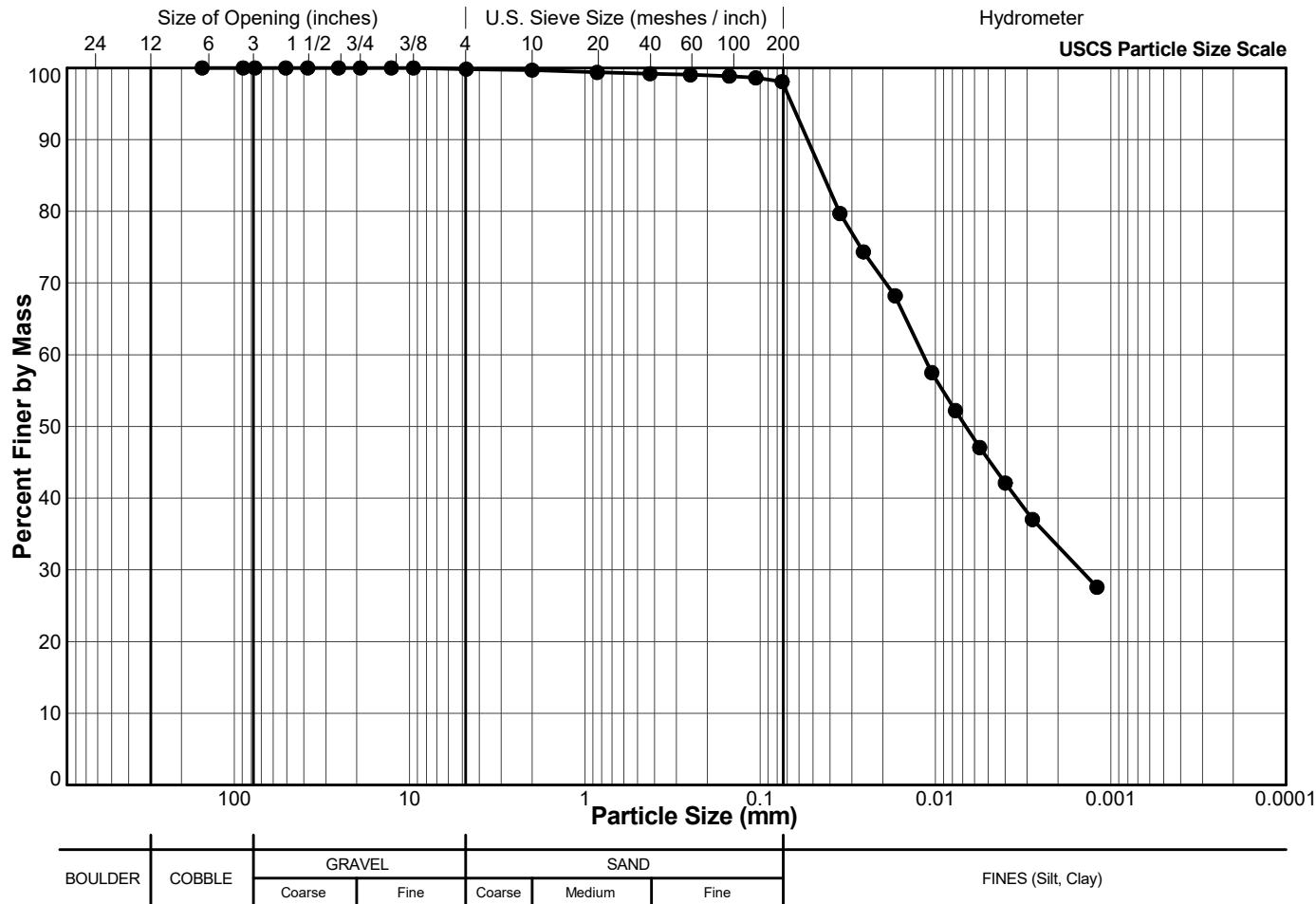
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: 19-32S
Sample No.: SA-04
Depth Interval (m): 10.40 to 10.70
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	100.0
1"	25.4	100.0
3/4"	19.1	100.0
1/2"	12.7	100.0
3/8"	9.5	100.0
#4 US MESH	4.75	99.8
#10 US MESH	2	99.7
#20 US MESH	0.85	99.4
#40 US MESH	0.425	99.2
#60 US MESH	0.25	99.0
#100 US MESH	0.15	98.9
#140 US MESH	0.106	98.6
#200 US MESH	0.075	98.1
	0.0351	79.7
	0.0258	74.3
	0.0170	68.2
	0.0105	57.5
	0.0077	52.2
	0.0056	47.1
	0.0040	42.1
	0.0028	37.0
	0.0012	27.6

DC/FF

3/7/2019

LP

3/15/2019

Tech

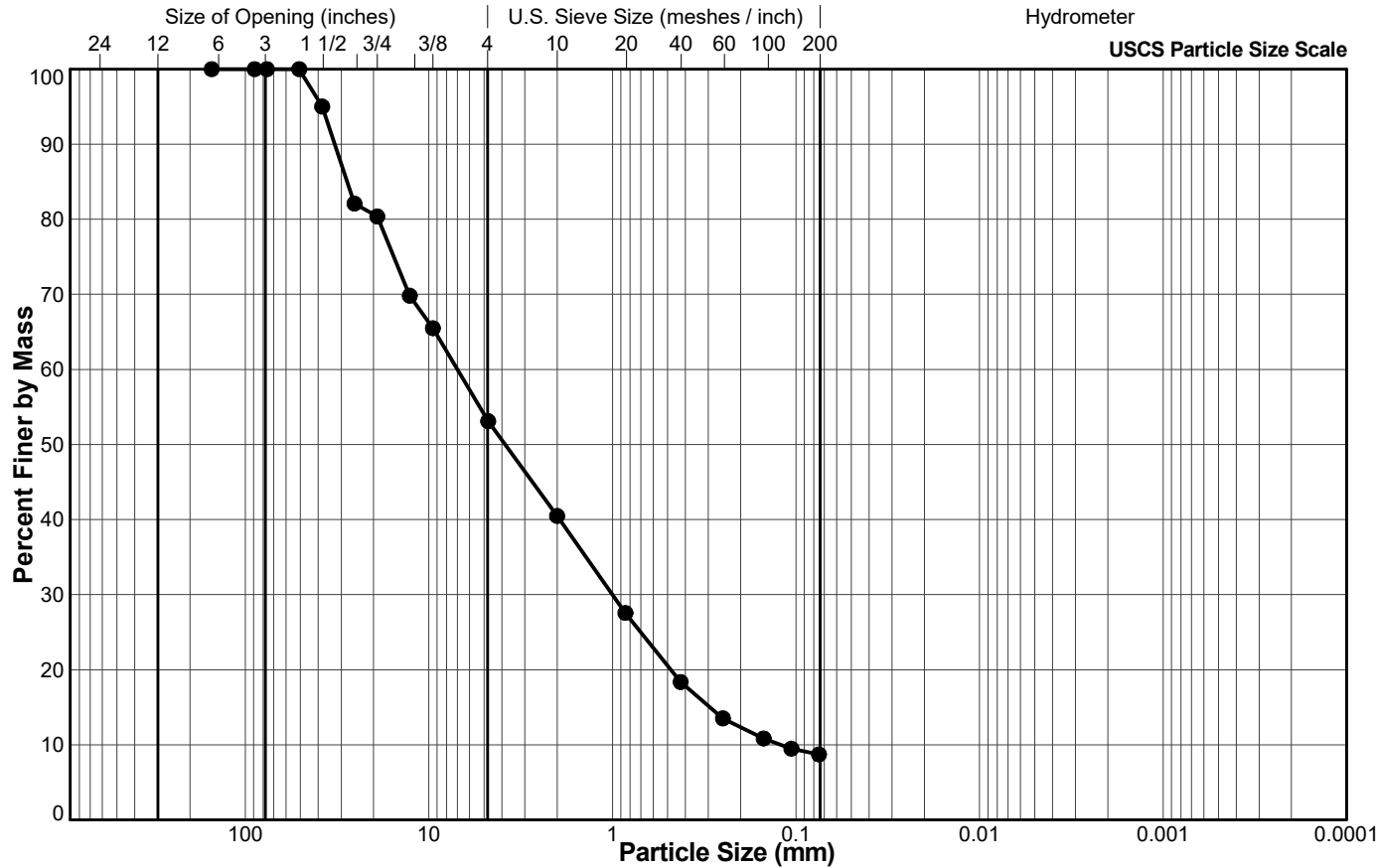
Date

Checked

Date

Client: Telkwa Coal Ltd.
Project: Ref #017-318
Location:
Project No.: 18109666 **Phase:** 1000

Sample Location: 19-33S
Sample No.: SA-01
Depth Interval (m): 1.20 to 1.50
Lab Schedule No.:



Legend

Sieve Size (USS)	Particle Size (mm)	Percent Passing
6"	152.4	100.0
3.5"	88.9	100.0
3"	76.2	100.0
2"	50.8	100.0
1 1/2"	38.1	95.0
1"	25.4	82.1
3/4"	19.1	80.4
1/2"	12.7	69.8
3/8"	9.5	65.5
#4 US MESH	4.75	53.1
#10 US MESH	2	40.5
#20 US MESH	0.85	27.6
#40 US MESH	0.425	18.4
#60 US MESH	0.25	13.5
#100 US MESH	0.15	10.8
#140 US MESH	0.106	9.5
#200 US MESH	0.075	8.7

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

FF/RG

3/7/2019

LP

3/15/2019

Tech

Date

Checked

Date

GRAIN SIZE DISTRIBUTION



Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

Project No: KX13690
Date: October 25, 2018

Attn: Hazel Wong / Kevin Turner

Project Name: Telkwa Coal - Telkwa, BC.

Test No.: 18 - 145-1

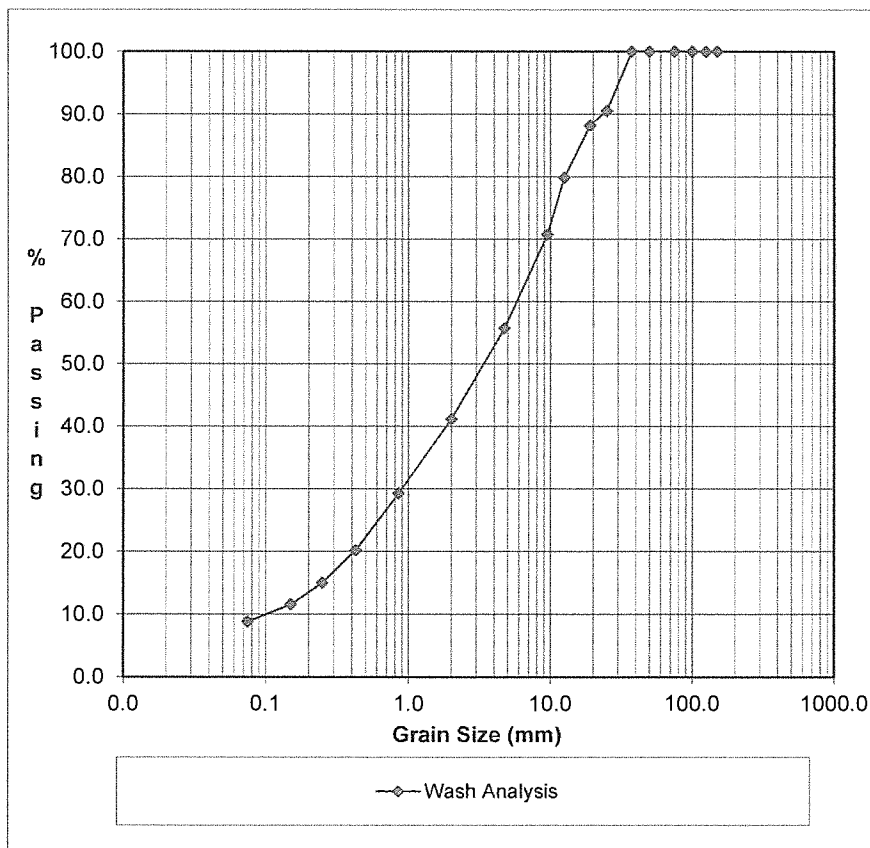
Source: TH 18 - 15S @ 5.2 - 5.5m
Sample #03

Sample Type: Grab sample

Date Sampled: Sept 26, 2018

By: Client

Date Tested: October 22, 2018



Wash Sieve Analysis

Wash Sieve Analysis				
Sieve Size(mm)	Percent Retained	Percent Passing	Limits	
			Upper	Lower
150.0	0.0	100.0		
125.0	0.0	100.0		
100.0	0.0	100.0		
75.0	0.0	100.0		
50.0	0.0	100.0		
37.5	0.0	100.0		
25.0	9.5	90.5		
19.0	2.3	88.2		
12.5	8.3	79.9		
9.5	9.2	70.7		
4.75	15.0	55.7		
2.000	14.5	41.2		
0.850	11.9	29.3		
0.425	9.1	20.2		
0.250	5.2	15.0		
0.150	3.4	11.6		
0.075	2.8	8.8		
PAN	8.8			

Sieve Mass (g): 1637.8

Gravel	44.3 %
Sand	46.9 %
Fines	8.8 %

COMMENTS

Wood Environment & Infrastructure Solutions

Per: B. Shearer

Reporting of these test results constitutes a testing service only.
Engineering interpretation or evaluation of the test results is provided only on written request.

GRAIN SIZE DISTRIBUTION

wood.

Westrek Geotechnical Services Ltd
101- 1383 McGill Road
Kamloops, BC
V2C 6K7

OFFICE: Kamloops, BC
PROJECT: KX13690
DATE: October 25, 2018

Attn: Hazel Wong / Kevin Turner

Project Name: Telkwa Coal - Telkwa BC.

TEST NO: 18-145-1

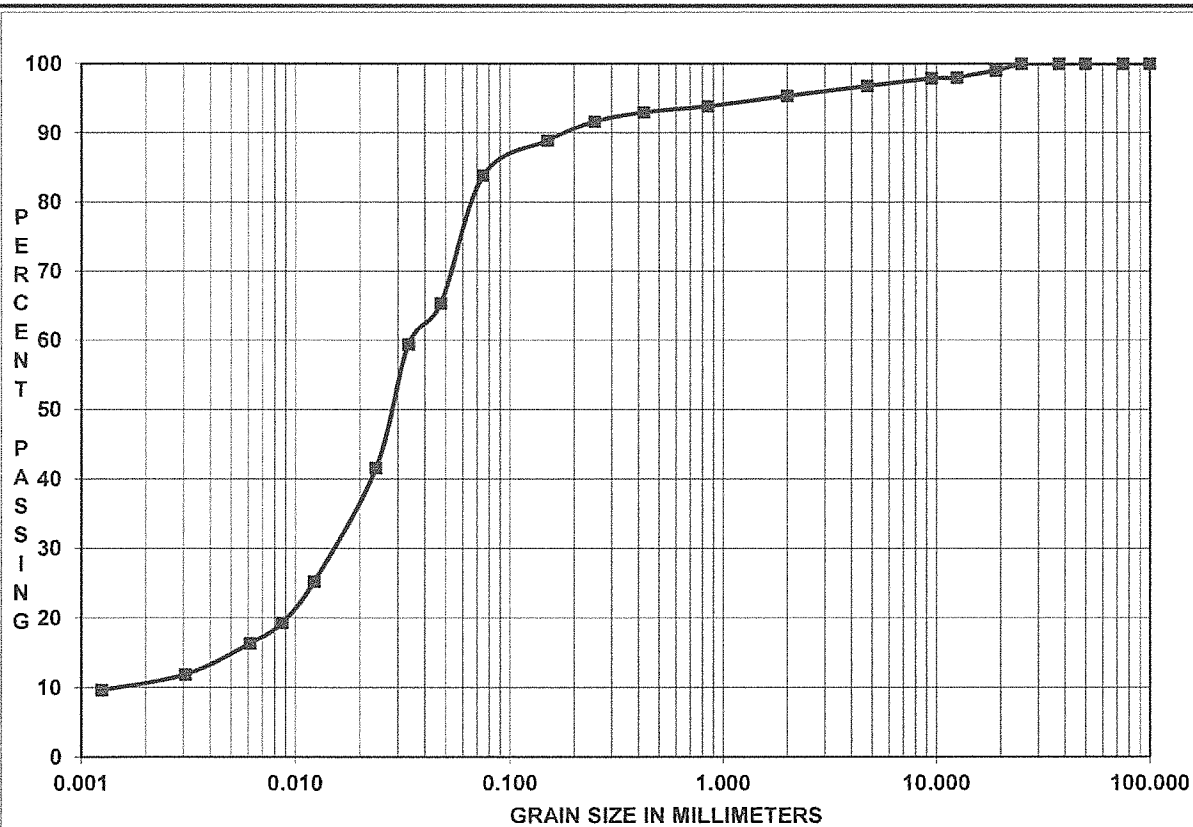
SAMPLED BY: Client

DATE Sampled: Sept 24, 2018

SOURCE: TH 18 -14S @ 17.1 - 17.4m Sa# 10

DATE TESTED: Oct 24, 2018

SAMPLE TYPE:



SUMMARY

Grain size (mm)	Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	99.0
12.5	98.0
9.5	97.9
4.75	96.8
2.00	95.4
0.850	93.9
0.425	93.0
0.250	91.6
0.150	88.9
0.075	83.8
0.0476	65.3
0.0336	59.4
0.0238	41.6
0.0123	25.2
0.0087	19.3
0.0061	16.3
0.0031	11.9
0.0012	9.7

REMARKS:

GRAVEL 3.2%
SAND 13.0%
SILT 73.2%
CLAY 10.6%

TECHNICIAN: B. Shearer

Reporting of these test results constitutes a testing service only.
Engineering interpretation or evaluation of the test results is provided only on written request.

ATTERBERG LIMITS



PROJECT : Westrek Geotechnical Services Ltd.

Project Number: KX13690

Lab : 18-145-1

Date: October 25, 2018

Sample ID: Telkwa Coal - TH 18-14S @ 12.8 - 13.1m - Sa# 08

Technician: B. Shearer

Liquid Limit

Trial No.	1	2	3	
No. of Blows	33	26	22	
Tare ID:	1	2	3	
Mass Wet + Tare	91.18	91.62	93.29	
Mass Dry + Tare	81.81	82.14	83.55	
Mass Tare:	52.23	53.05	54.04	
Mass of Water:	9.37	9.48	9.74	
Dry Soil Mass:	29.58	29.09	29.51	
Moisture Content:	31.7%	32.6%	33.0%	
Liquid Limit:	32.9%	32.8%	32.5%	

Average Liquid Limit: 32.7%

Plastic Limit

Trial No.	4	5	6	
Tare ID:	1	2	3	
Mass Wet + Tare	62.03	62.02	61.70	
Mass Dry + Tare	61.04	61.03	60.70	
Mass Tare:	53.95	54.03	53.64	
Mass of Water:	0.99	0.99	1.00	
Dry Soil Mass:	7.09	7.00	7.06	
Moisture Content:	14.0%	14.1%	14.2%	

Average Plastic Limit: 14.1%

Plasticity Index: 18.6

ATTERBERG LIMITS



PROJECT : Westrek Geotechnical Services Ltd.

Project Number: KX13690

Lab : 18-145-2

Date: October 25, 2018

Sample ID: Telkwa Coal - TH 18-15S @ 20.7- 21.0m - Sa# 08

Technician: B. Shearer

Liquid Limit

Trial No.	1	2	3	
No. of Blows	31	25	20	
Tare ID:	1	2	3	
Mass Wet + Tare	87.53	91.28	91.84	
Mass Dry + Tare	77.93	80.76	80.94	
Mass Tare:	53.55	54.24	54.20	
Mass of Water:	9.60	10.52	10.90	
Dry Soil Mass:	24.38	26.52	26.74	
Moisture Content:	39.4%	39.7%	40.8%	
Liquid Limit:	40.5%	39.7%	39.6%	

Average Liquid Limit: 39.9%

Plastic Limit

Trial No.	4	5	6	
Tare ID:	1	2	3	
Mass Wet + Tare	60.00	62.36	61.45	
Mass Dry + Tare	58.85	61.03	60.29	
Mass Tare:	52.40	53.68	53.93	
Mass of Water:	1.15	1.33	1.16	
Dry Soil Mass:	6.45	7.35	6.36	
Moisture Content:	17.8%	18.1%	18.2%	

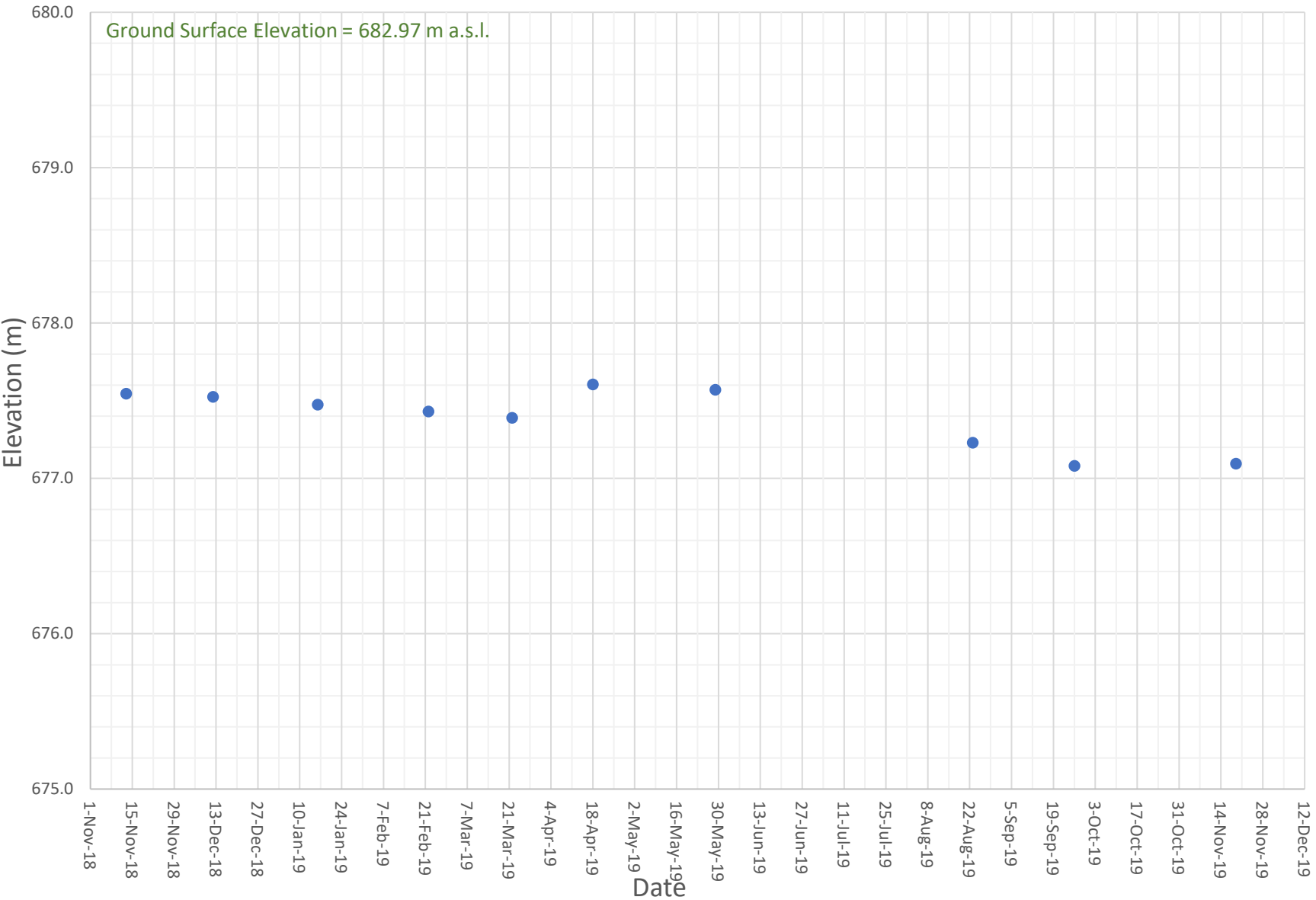
Average Plastic Limit: 18.1%

Plasticity Index: 21.9

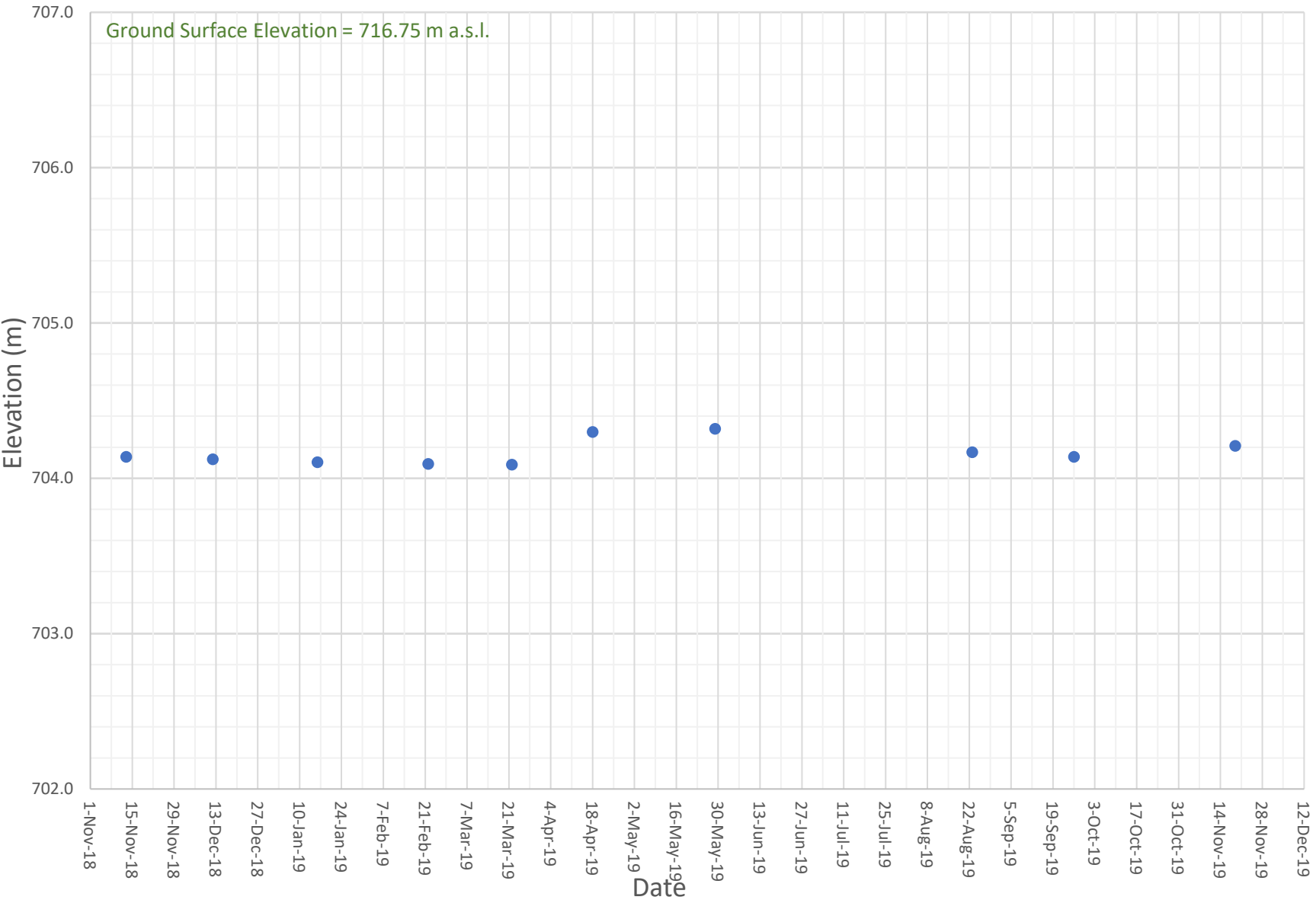
Appendix E

Slope Inclinometer and Piezometer Monitoring

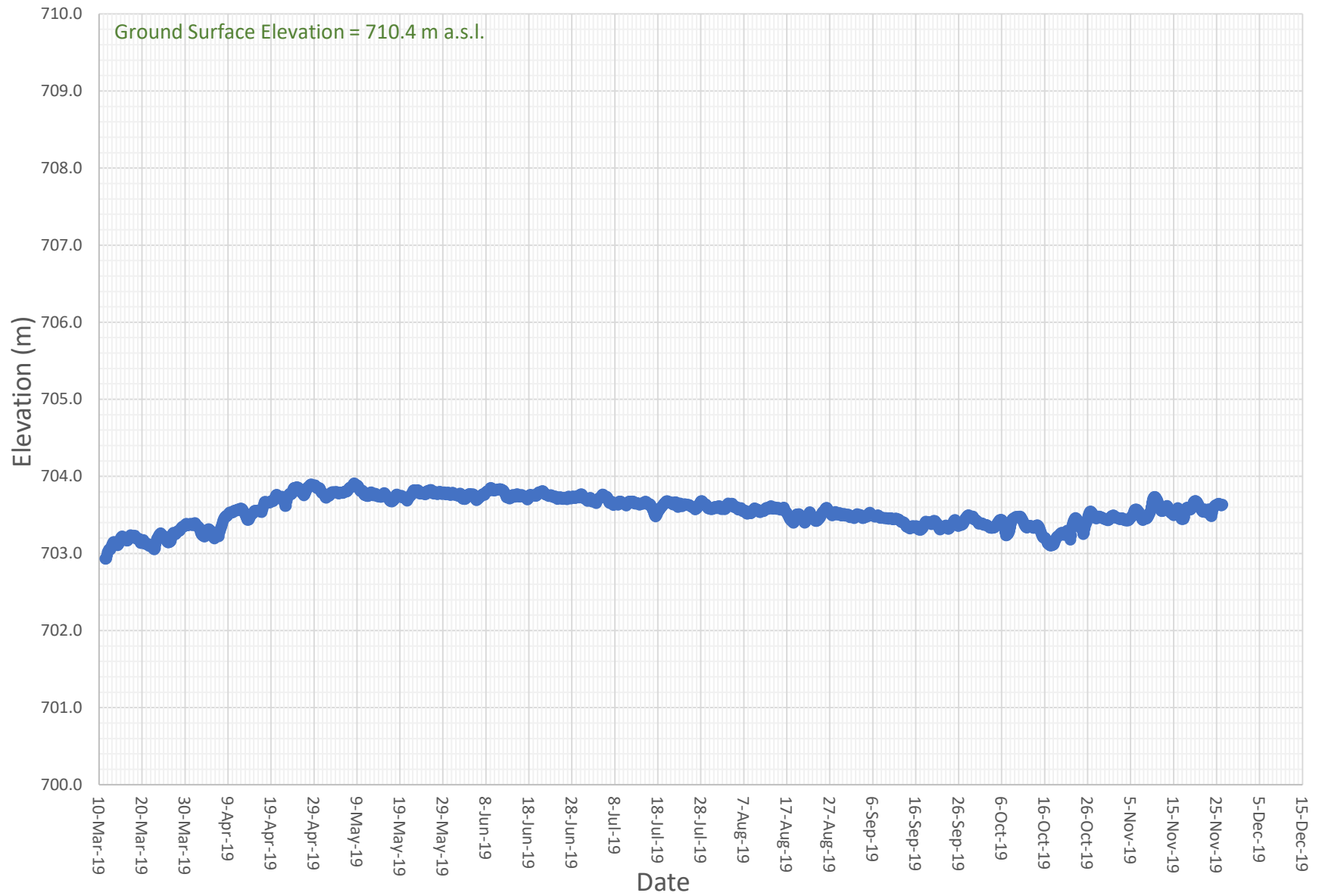
T18-14S Standpipe (Piezometer Elevation = 673.7 - 675.2 m)



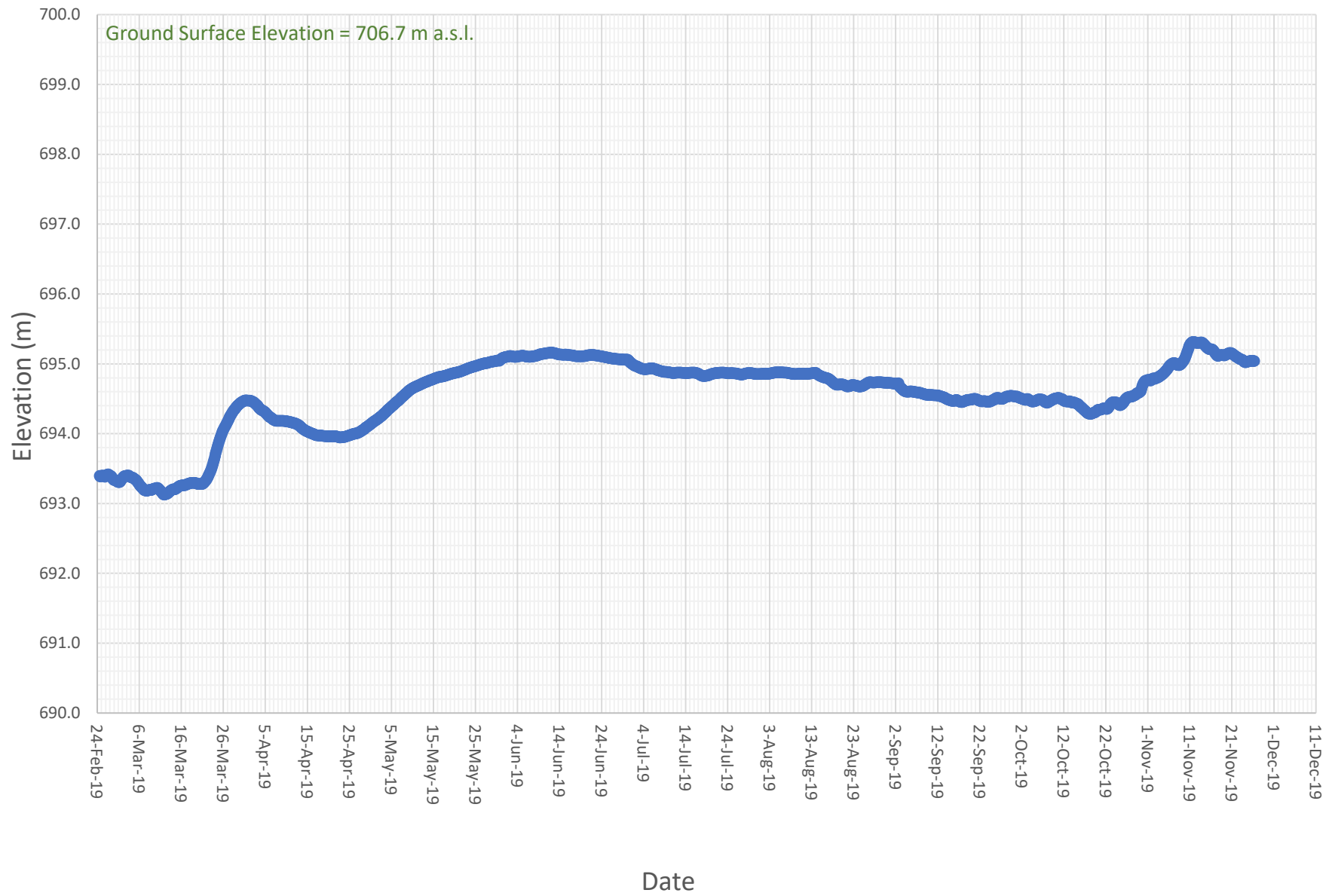
T18-15S Standpipe (Piezometer Elevation = 702.1 - 705.1 m)



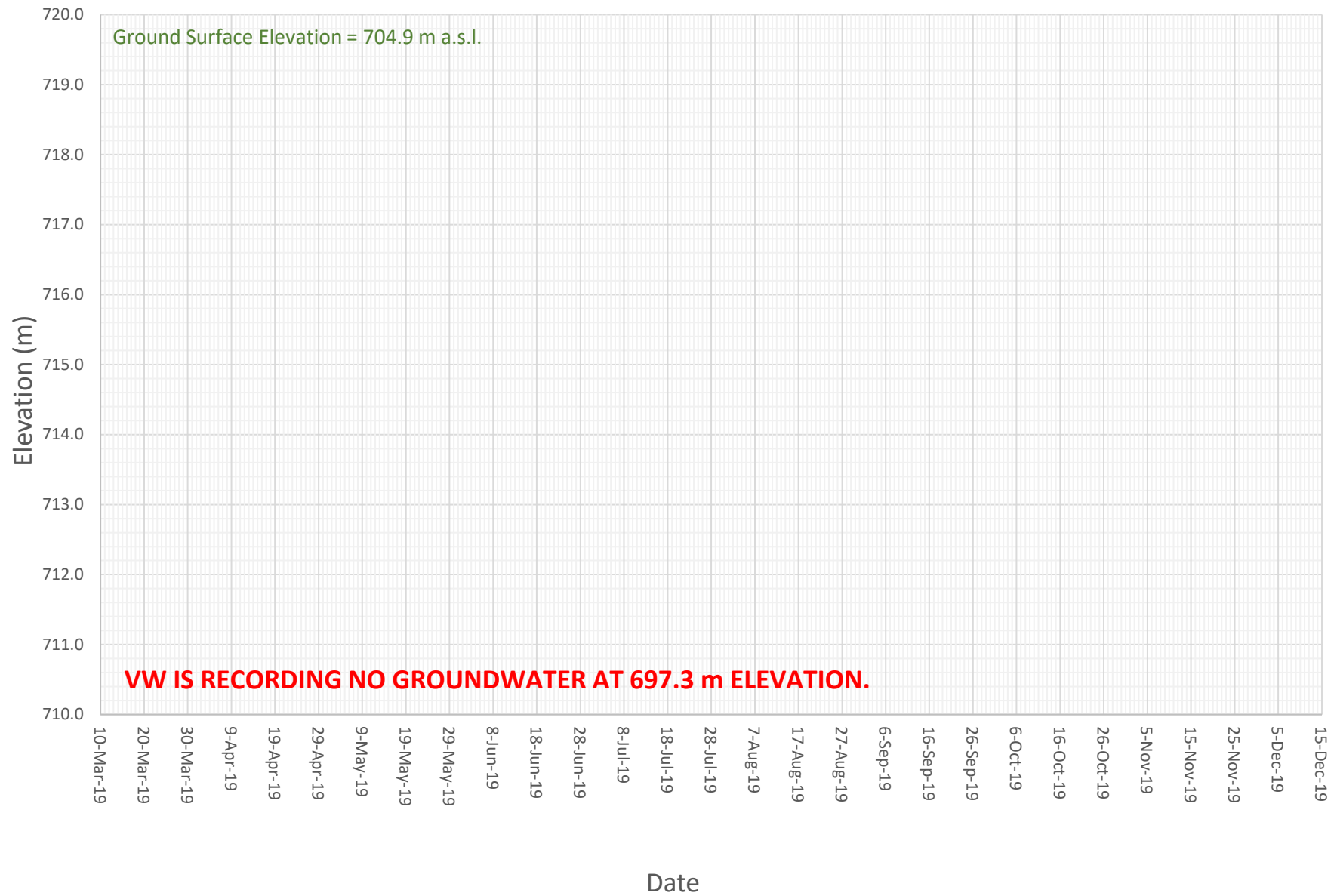
T19-28S Piezometric Surface (VW elevation = 701.3 m a.s.l.)



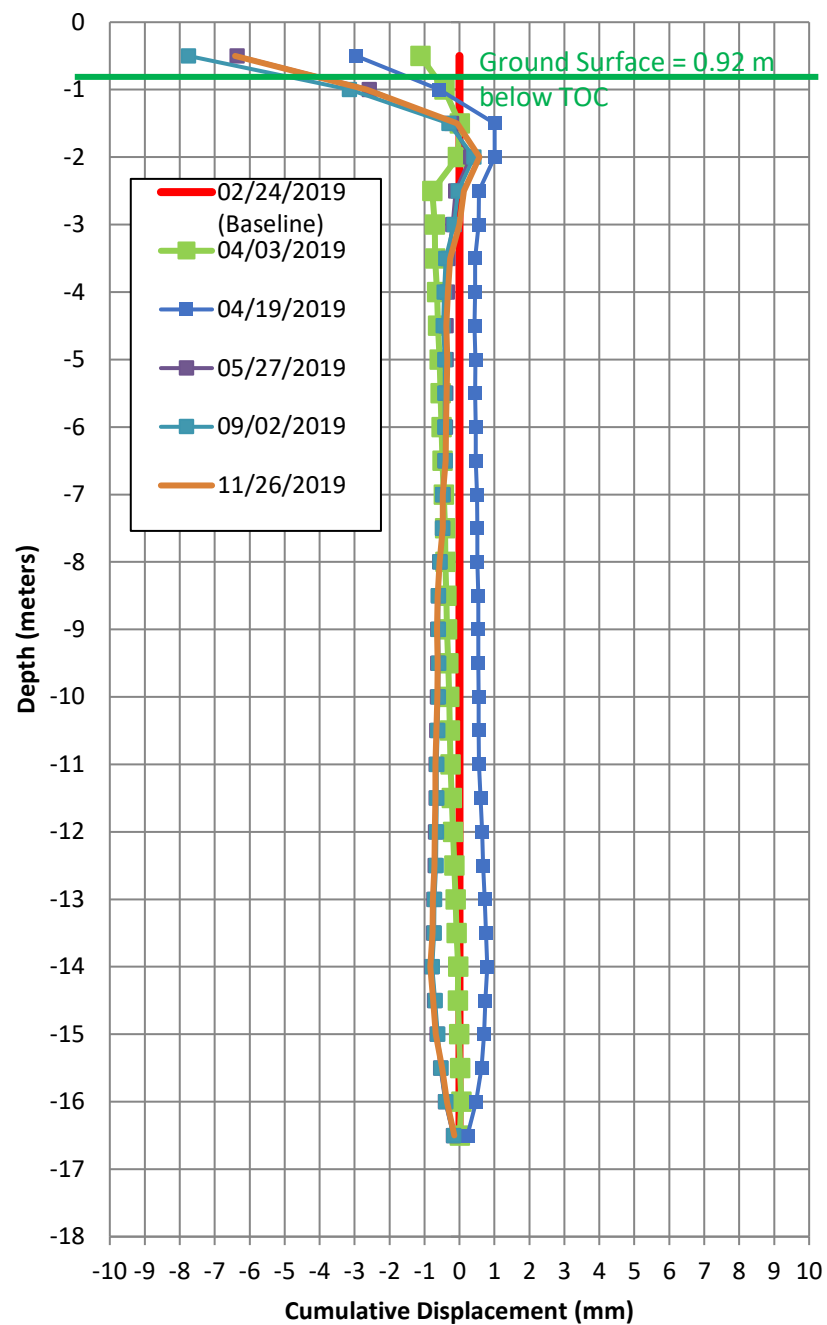
T19-30S Piezometric Surface (VW elevation = 691.8 m a.s.l.)



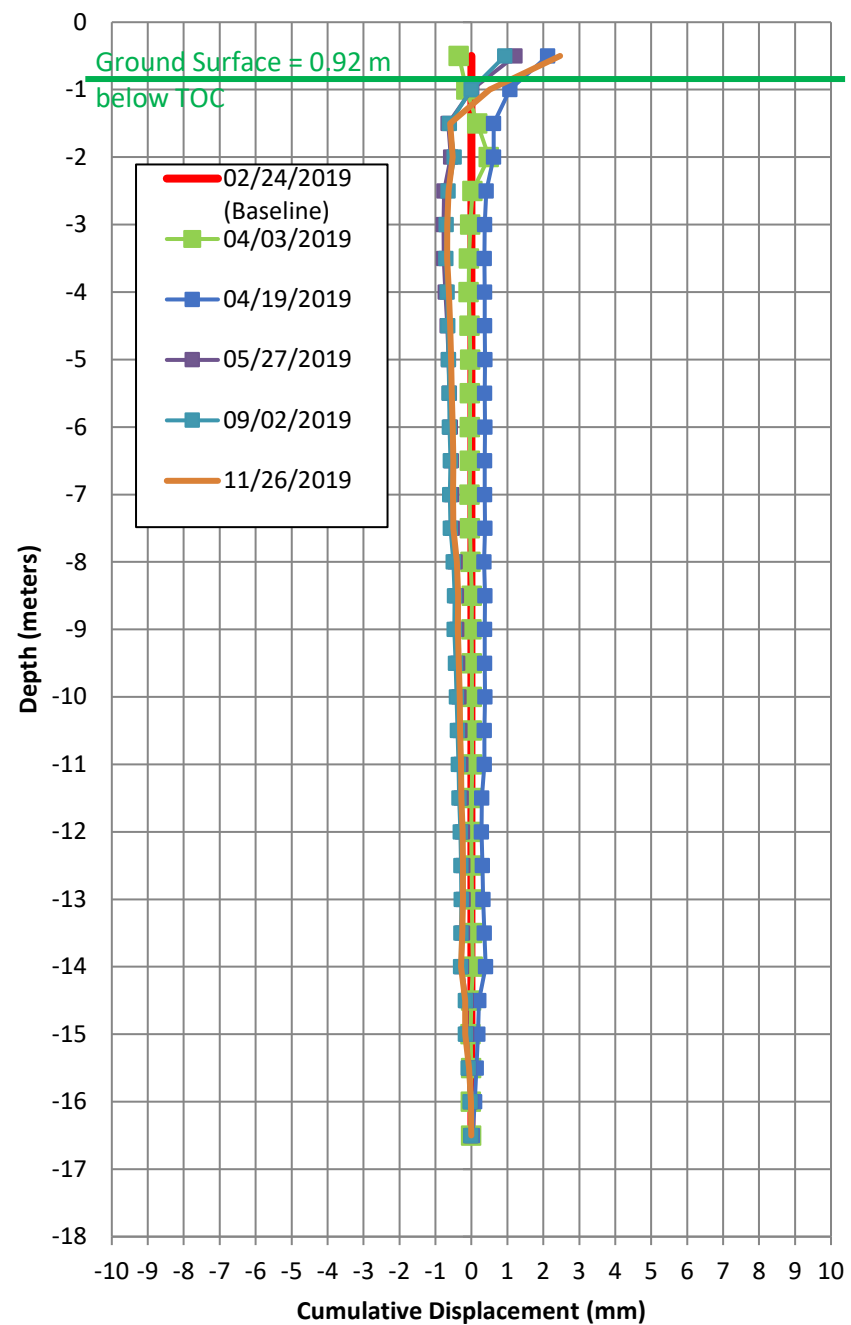
T19-31S Piezometric Elevation (VW elevation = 697.3 m a.s.l.)



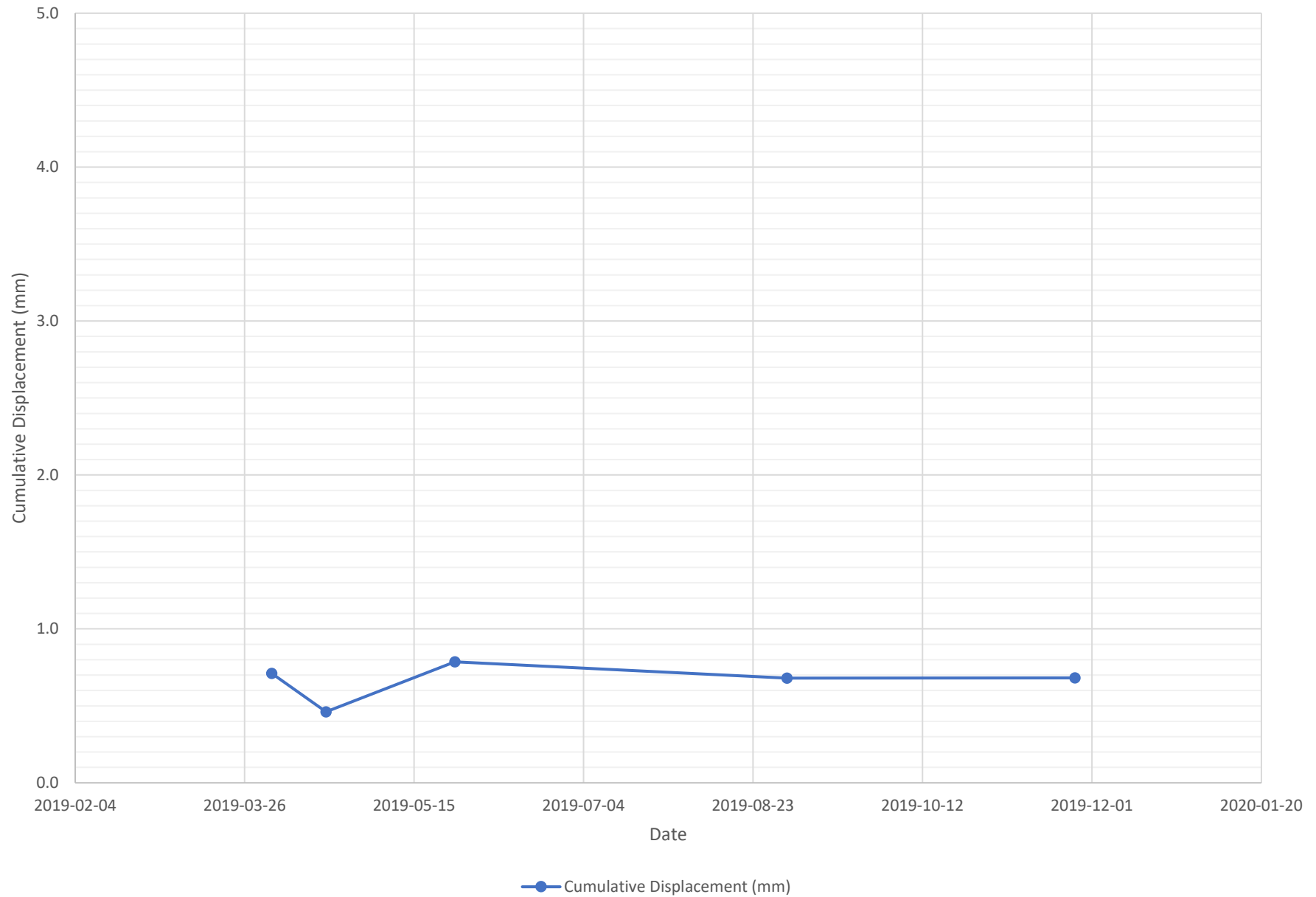
T19-28S Axis A



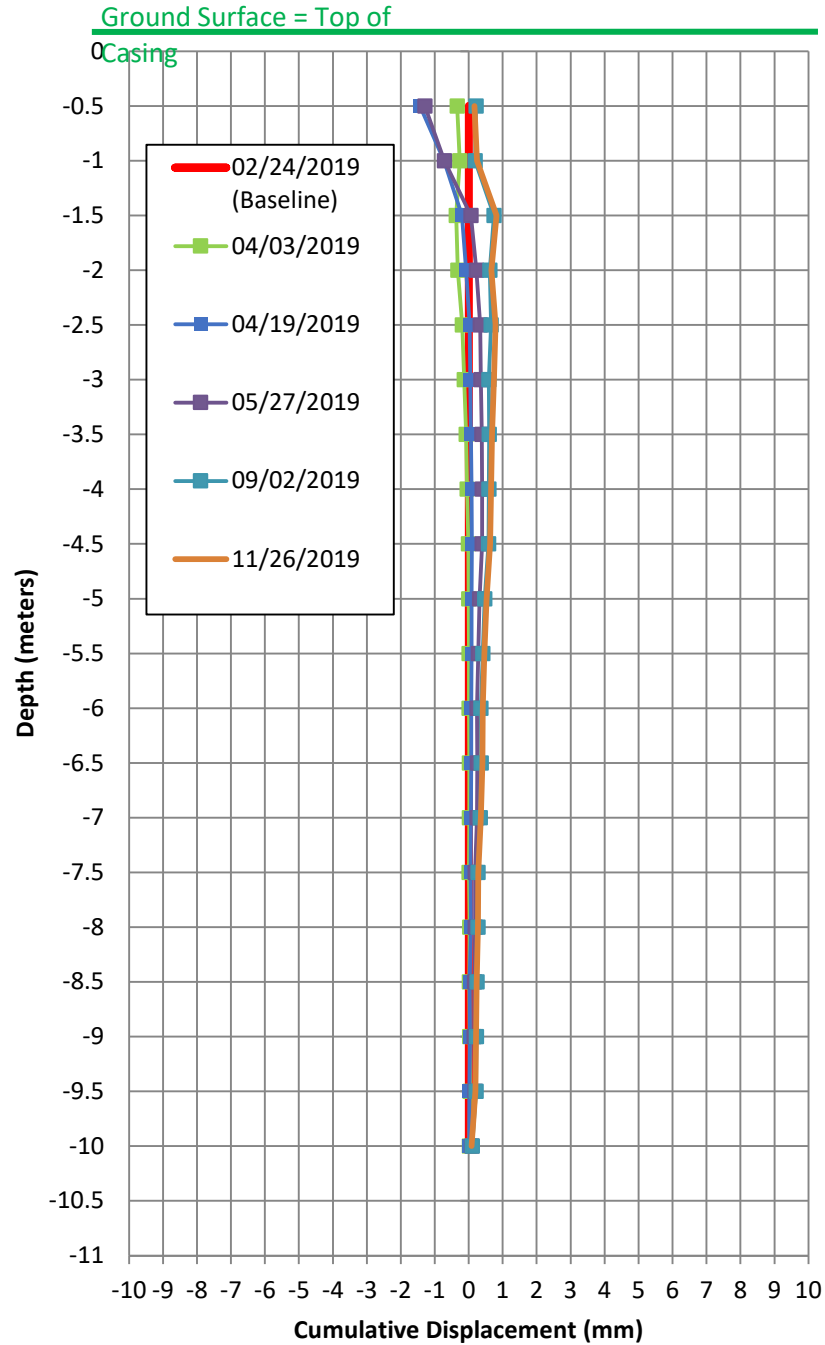
T19-28S Axis B



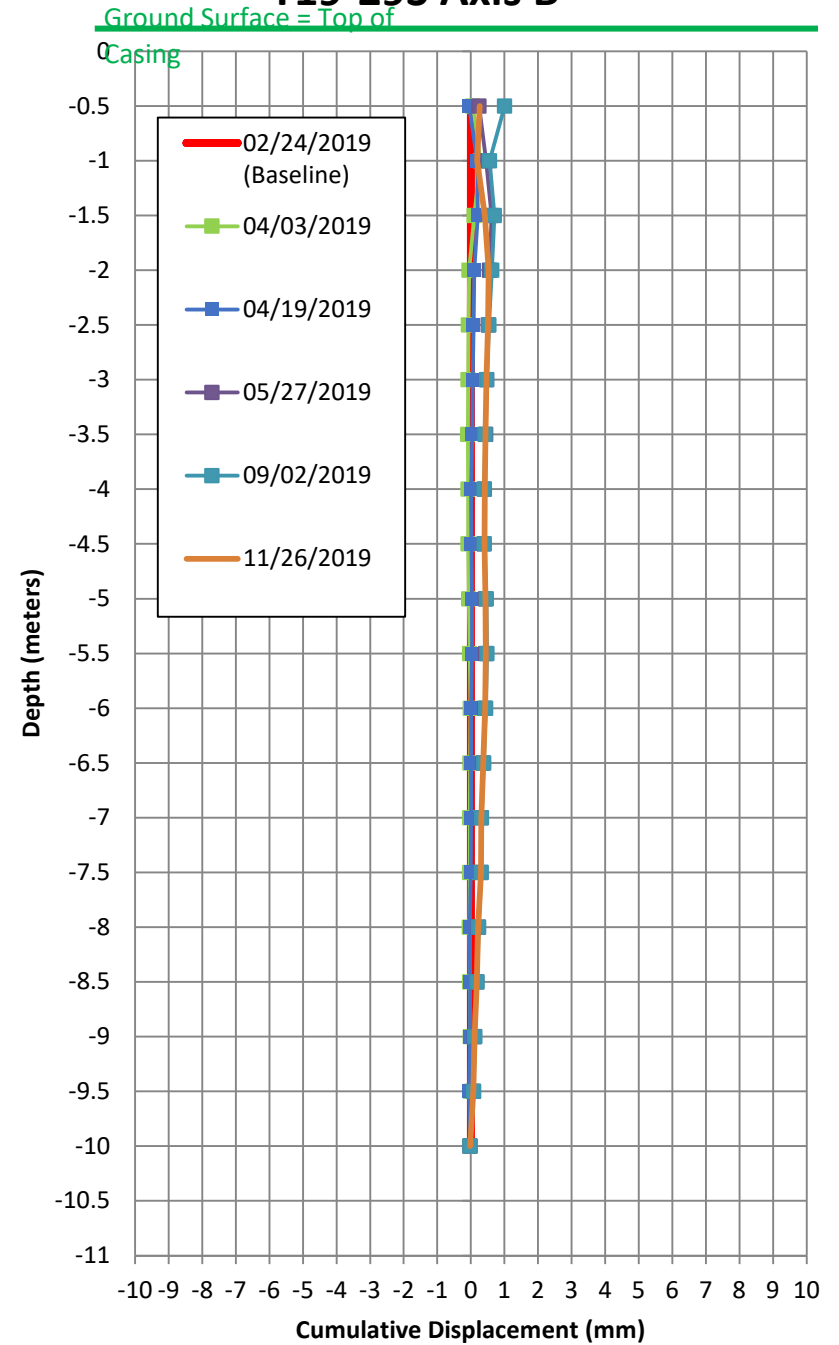
T19-28S Cumulative Movement from 3.0 m to 16.5 m below top of pipe



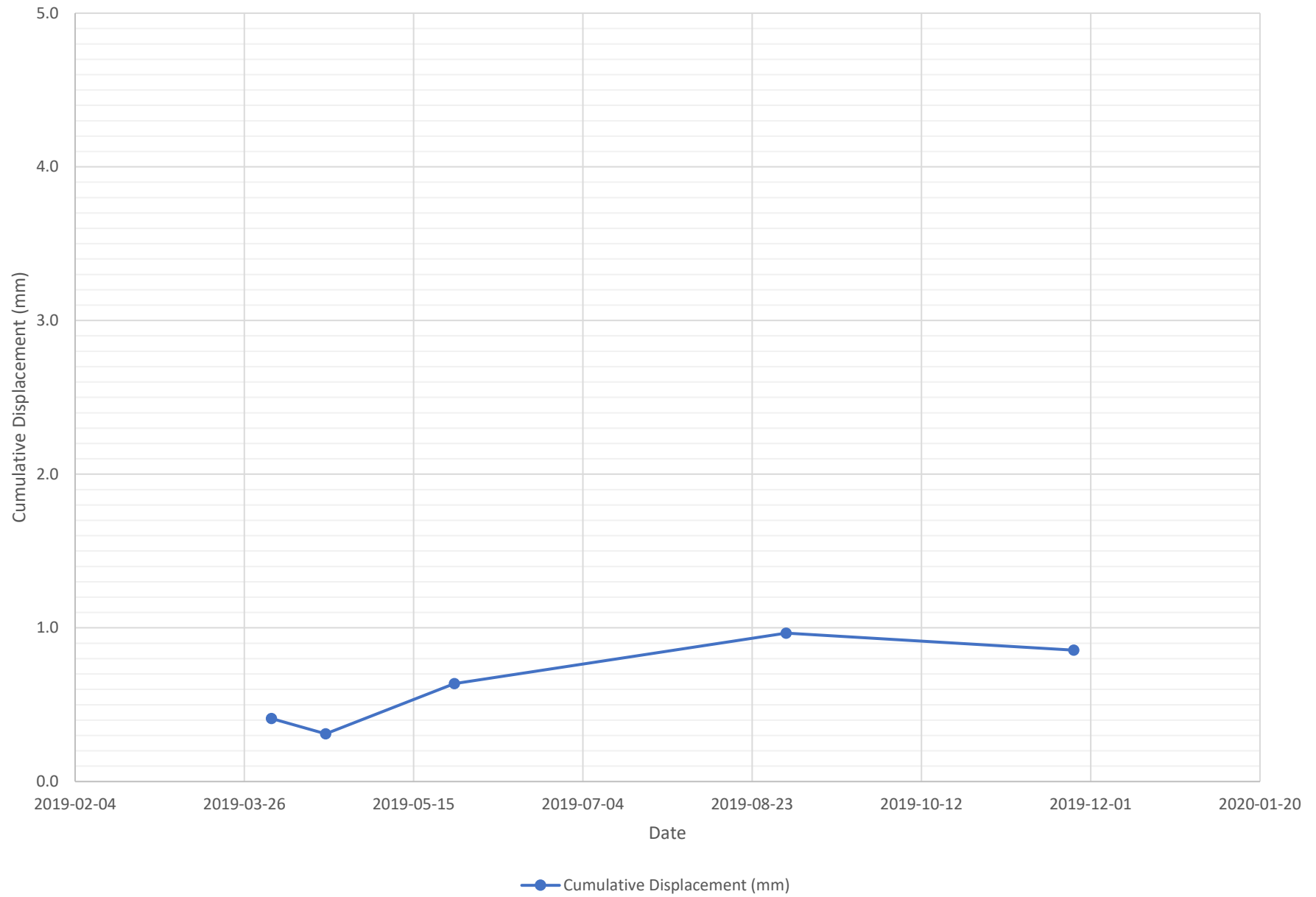
T19-29S Axis A



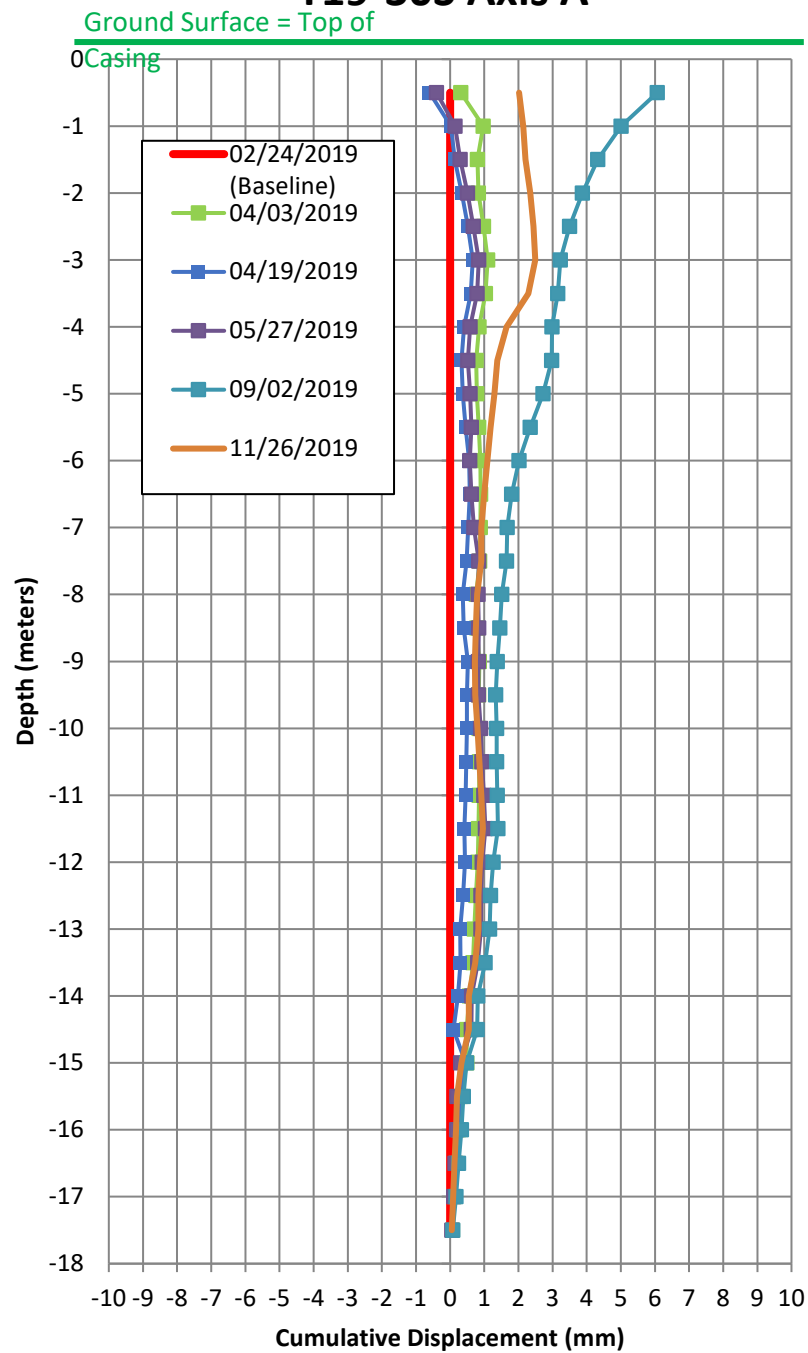
T19-29S Axis B



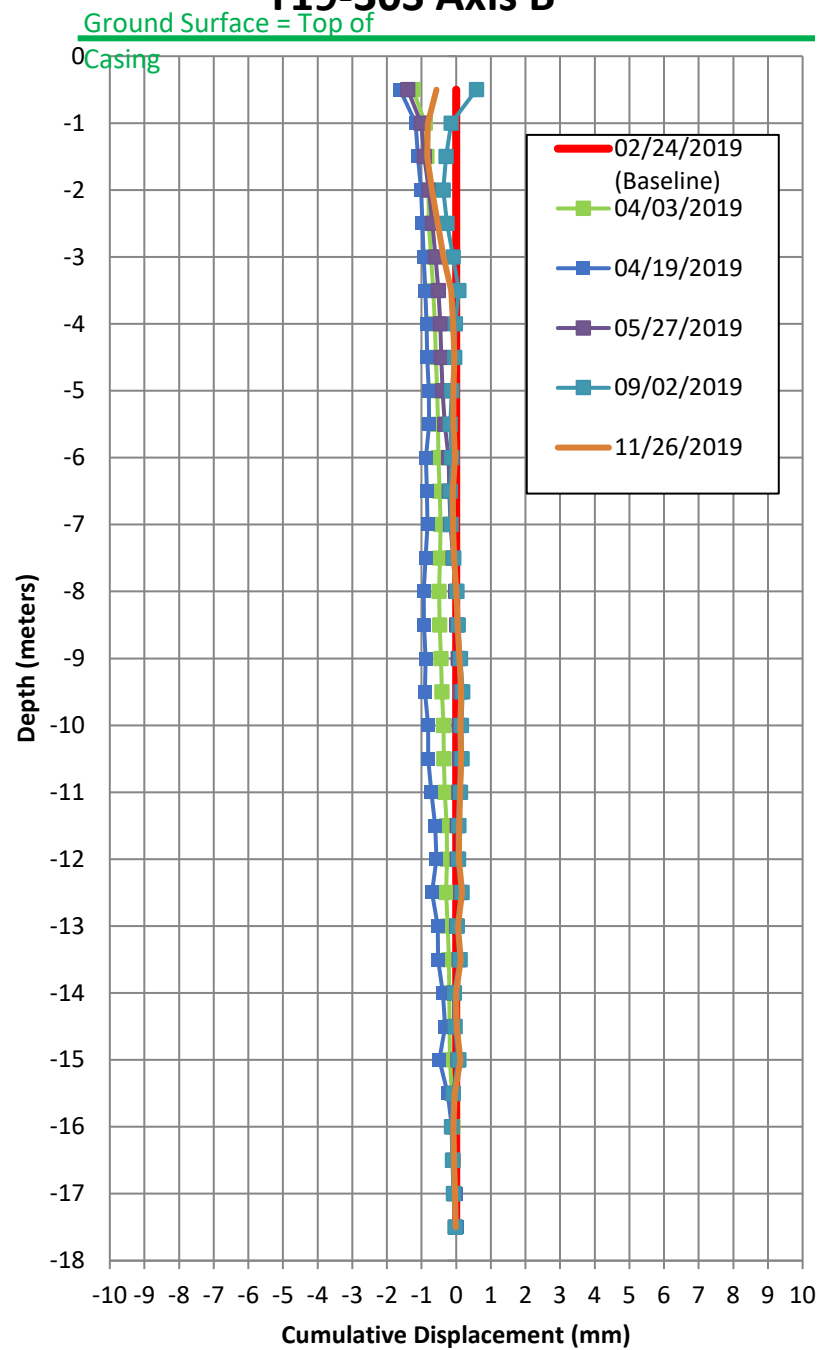
T19-29S Cumulative Movement from 1.5 m to 10.0 m below top of pipe



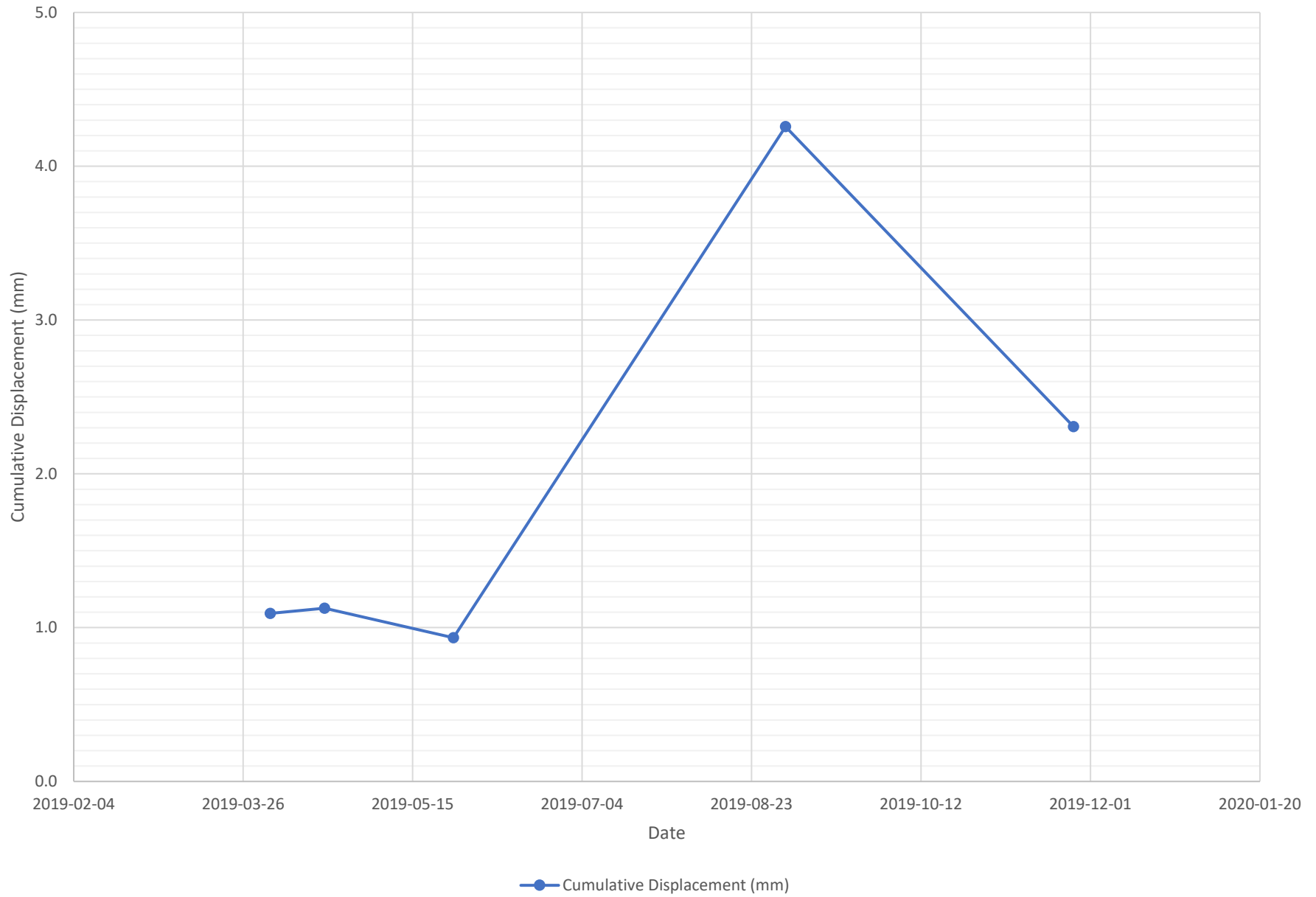
T19-30S Axis A



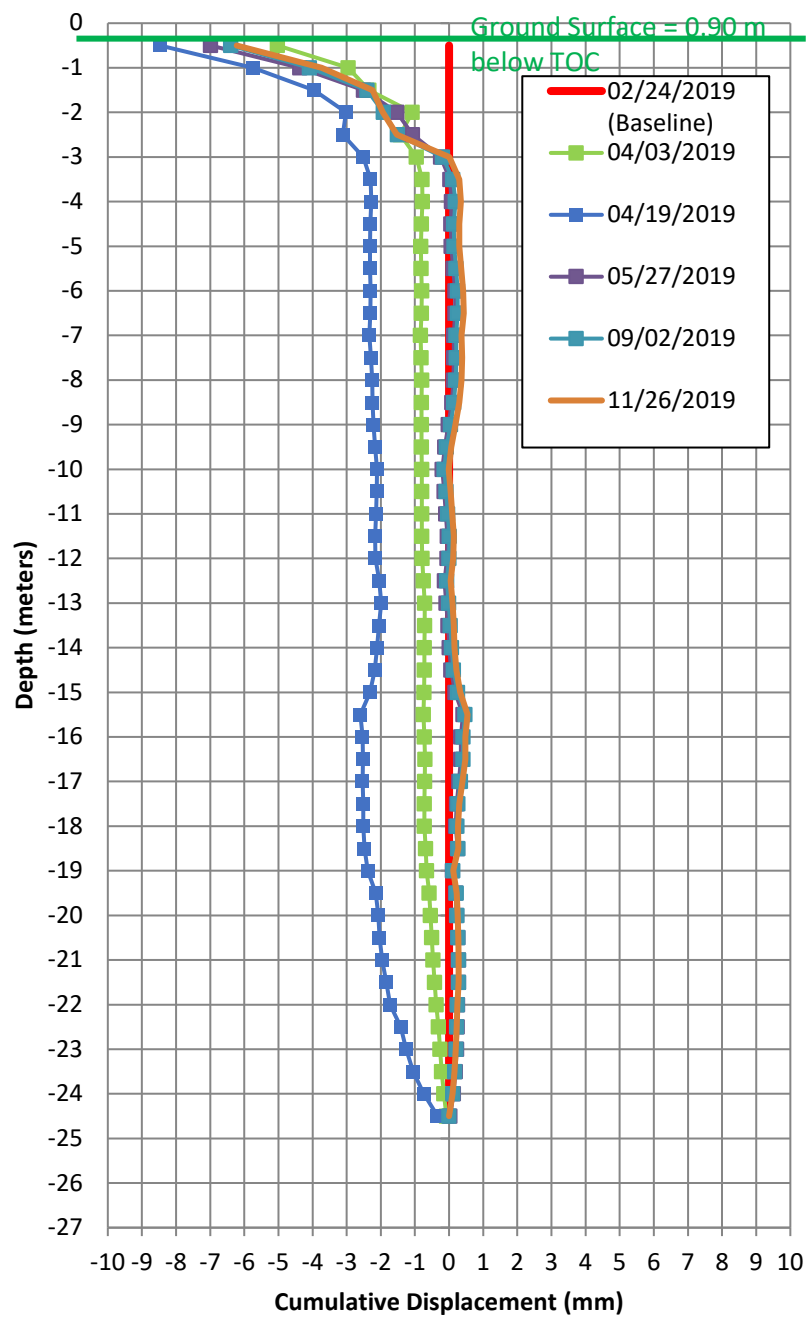
T19-30S Axis B



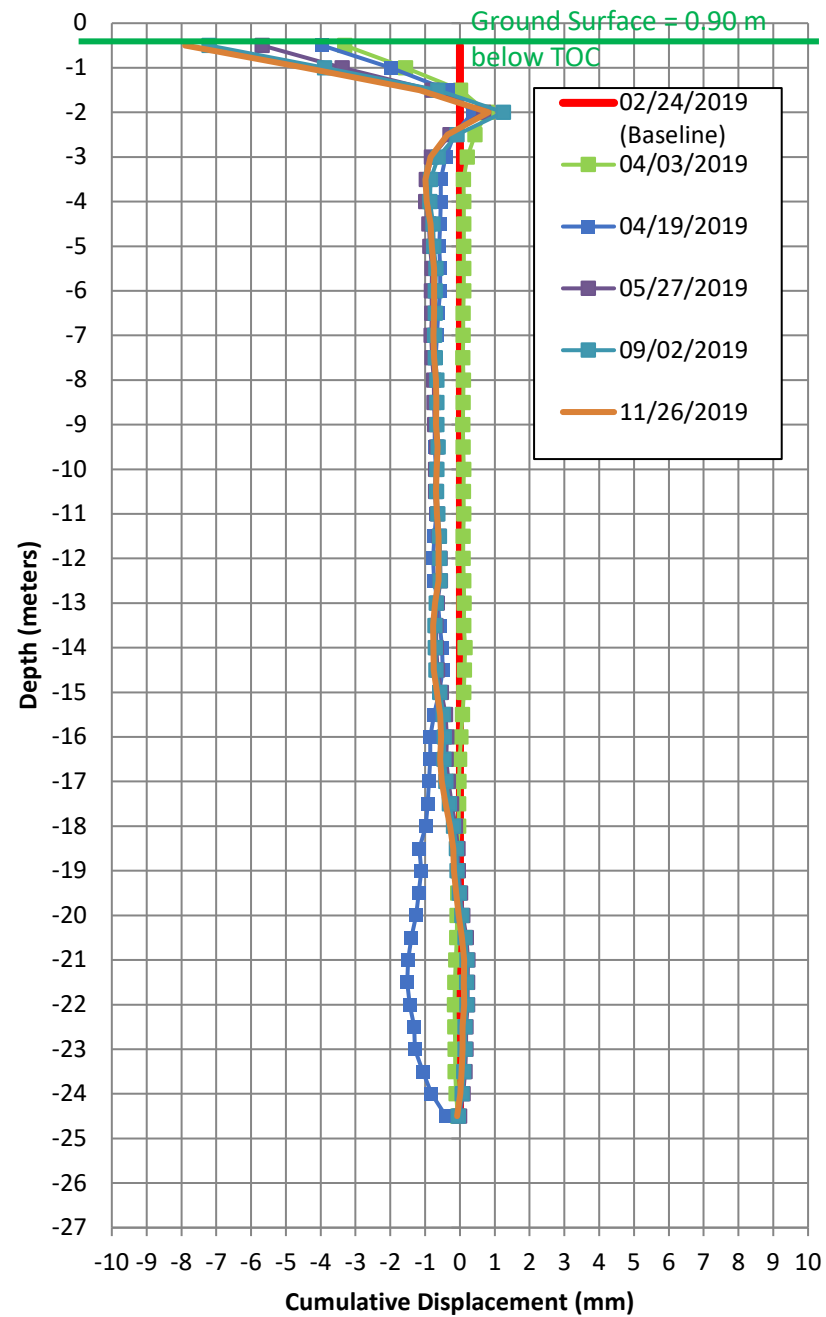
T19-30S Cumulative Movement from 1.5 m to 17.5 m below top of pipe



T19-31S Axis A



T19-31S Axis B



T19-31S Cumulative Movement from 3.0 m to 24.5 m below top of pipe

