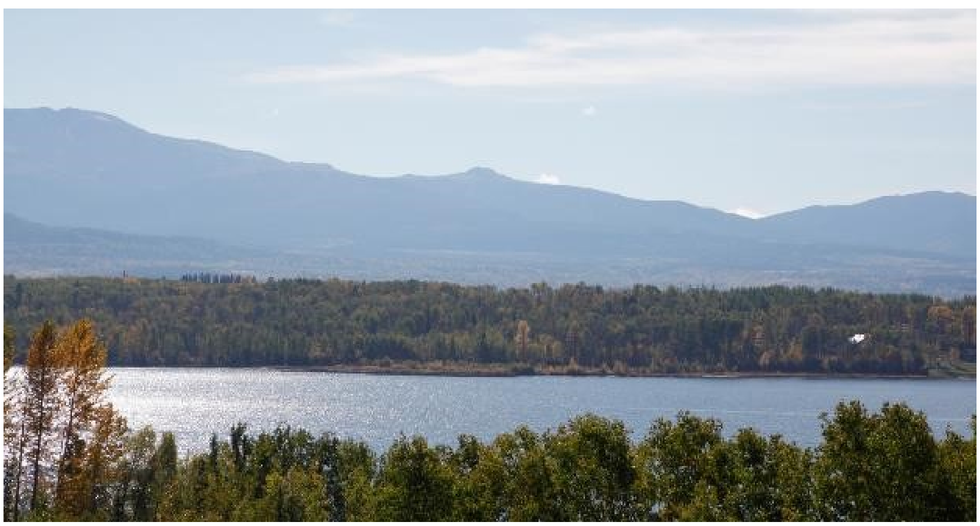
Tenas Project – Factual Data Report for 2019 Field Investigation

Prepared for

Telkwa Coal Ltd.



Prepared by

SRK Consulting (Canada) Inc.
2CT025.006
July 2019

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Prepared for

Telkwa Coal Ltd.
1415 Hankin Avenue
Telkwa, BC V0J 2X0

Tel: +1 778 643 2843
Web: www.allegiancecoal.com.au

Prepared by

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2
Canada

Tel: +1 604 681 4196
Web: www.srk.com

Project No: 2CT025.006

File Name: Tenas 2019 Field Data Report_2CT025.006_20190704.docx

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1 Introduction

SRK Consulting (Canada) Inc. (SRK) is pleased to provide Telkwa Coal Ltd. (Telkwa) with this factual data report for the 2019 Field Investigations undertaken at the Tenas Coal Project, British Columbia. Soil investigations were carried out to examine foundation materials below proposed management ponds, waste rock dumps and sediment ponds, infrastructure pads and rock geotechnical investigations for proposed pit slopes. This work was carried out in accordance with the SRK proposal, referenced 2CS000.P29, and dated October 5, 2018.

Data from the 2018 geotechnical investigation has also been presented for completeness of the Tenas datasets and for comparison purposes with the 2019 findings.

This report provides a description of the geotechnical field investigations, and the results of the factual data collected in February 2019. In addition, downhole televiewer survey and laboratory testing performed by others are included as they support the geotechnical data presented in this report.

2 Scope of Work

2.1 Supervision of Geotechnical Field Investigations

The geotechnical field investigation supervision included the following activities:

- Geotechnical logging, sampling and point load testing of rock core recovered from diamond drillholes;
- Supervision, geotechnical logging, consistency testing and sampling of soil from sonic drillholes and test pit excavations; and
- Supervision of standpipe piezometers around the perimeter of the proposed management ponds.

2.2 Data Analyses and Factual Reporting

This task included data processing and preparation of this factual report based on the data collected during the field investigation. The following activities were carried out, and are included in this report:

- QA/QC of geotechnical core and soil logs;
- Descriptions of the materials encountered in the sonic drillholes and test pits and determined from the results of the laboratory testing;
- Rock mass classification using Bieniawski's Rock Mass Rating (RMR_{89}) system;
- Preparation of downhole plots using the logged geotechnical parameters;

- Preparation of stereographic projections showing the structural data collected from televiewer surveys; and
- Compilation of the laboratory testing results.

3 Site Conditions

3.1 Site Location

The Tenas Project is located in central British Columbia approximately 15 km south of Smithers and 2 km southwest of Telkwa, as shown on Figure 3-1. The project site is located south of the Telkwa River.

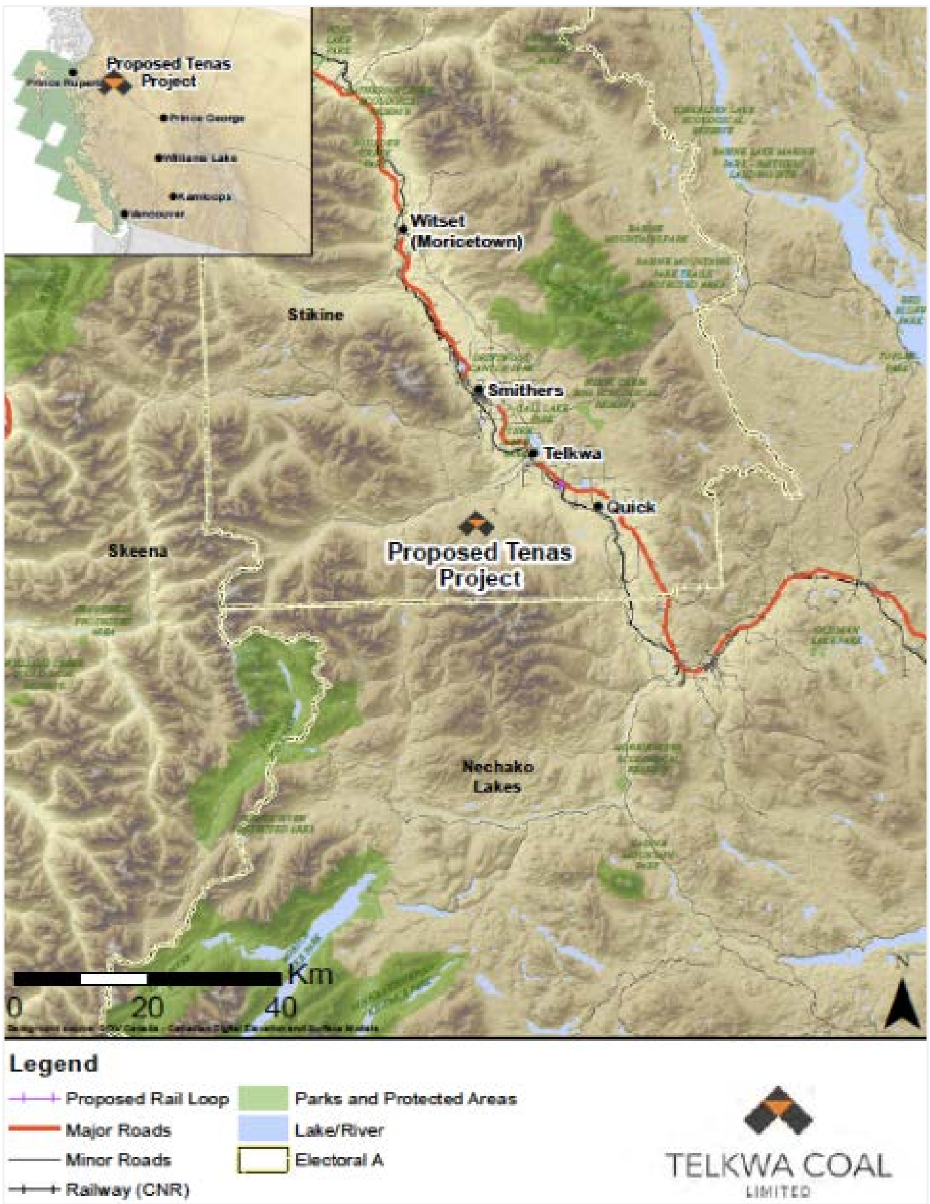


Figure 3-1: Tenas project location plan

3.2 Geomorphology and Surficial Soils

The Tenas site is located within the foothills of British Columbia, between the Bulkley Mountain Range to the north and west, and the low-lying gently sloping relief of the Nechako Plateau. Bedrock is typically covered by Quaternary soils, except for rocky outcrops along deeply eroded sections in adjacent river and stream valleys. Elevation across the site ranges generally from 600 to 900 m, with maximum elevations along the east side of the property (Levson et al, 1997).

The regional surficial soils have been studied by Levson et al, 1997. Two soil units are characterized regionally, and include:

- A widespread, massive unit, interpreted as a till, is located at or near the ground surface elevation. The till is described as diamicton, with particle sizes ranging from clay to boulders within a fine grained or sandy matrix. No thickness information was provided by Levson et al.
- In some areas, the till is underlain by both glaciofluvial stratified sands and gravels, and horizontally bedded sand, silt and clay sequences interpreted to be advanced-phase glacio-lacustrine sediments.

The results of the soil geotechnical investigations are summarised in Section 6. In 2019, an objective of the geotechnical drilling was to improve the characterization of on a glacial paleo-channel located in the north of the project site. The 2019 investigations intercepted finer grained till, more commonly described as a sandy lean clay (CL), as well as coarser-grained soils within the paleo-channel described as a clayey silty sands or gravels. At greater depths within the paleo-channel (i.e. below above 30 m) these two broader material types are interfingered. Both of these materials are comparable to the till units described by Levson et al. In 2018, the surficial soils intercepted were mostly sandy clean clays.

Similar to 2018, the 2019 results indicate that the silts and clays are commonly stiff to hard in consistency, and the sands and gravels are dense to very dense.

3.3 Bedrock Geology

The coal that is to be mined from the Tenas Pit is located within the sedimentary sequences of the early Cretaceous-aged Skeena Group. The Skeena Group consists of mudstones, siltstones, sandstones and conglomerates with inter-bedded, bituminous coal seams. The Skeena Group has been historically divided into four units (Palsgrove, 1991), of which two units are economically coal-bearing (Figure 3-2).

Of relevance to this study at Tenas is Unit 1 described by Palsgrove. A geological map of the Tenas Pit area with the Unit 1 outcrops is shown in Figure 3-3. Unit 1 comprises a 50 to 120 m thick sedimentary sequence interbedded with Coal Seam 1 (Seams 1A to 1F). The individual coal seams vary from less than 1 m to 3 m in thickness, and can be laterally discontinuous (Palsgrove, 1991).

The Skeena Group unconformably overlies the Hazelton Volcanic Group rocks. Additionally, the project geology map indicates the intrusive unit is in contact with the Skeena Group in all directions outside of the proposed pit footprint (Figure 3-3). However, the Hazelton Volcanic Group was not intercepted in vertical diamond drillholes that extended below the lower-most coal plys at Tenas or the inclined diamond drillholes that were drilled though the east-limb of the Tenas syncline (i.e. proposed east wall) along the east side of the deposit.

As discussed, the Skeena Group rock have been folded into a syncline at Tenas. On the west side the rocks are shallow, west dipping and gently folded along a west-limb. Toward the east, the bedding dips increase at the axis of the fold, and the rocks are moderately dipping to the east along the east-limb.

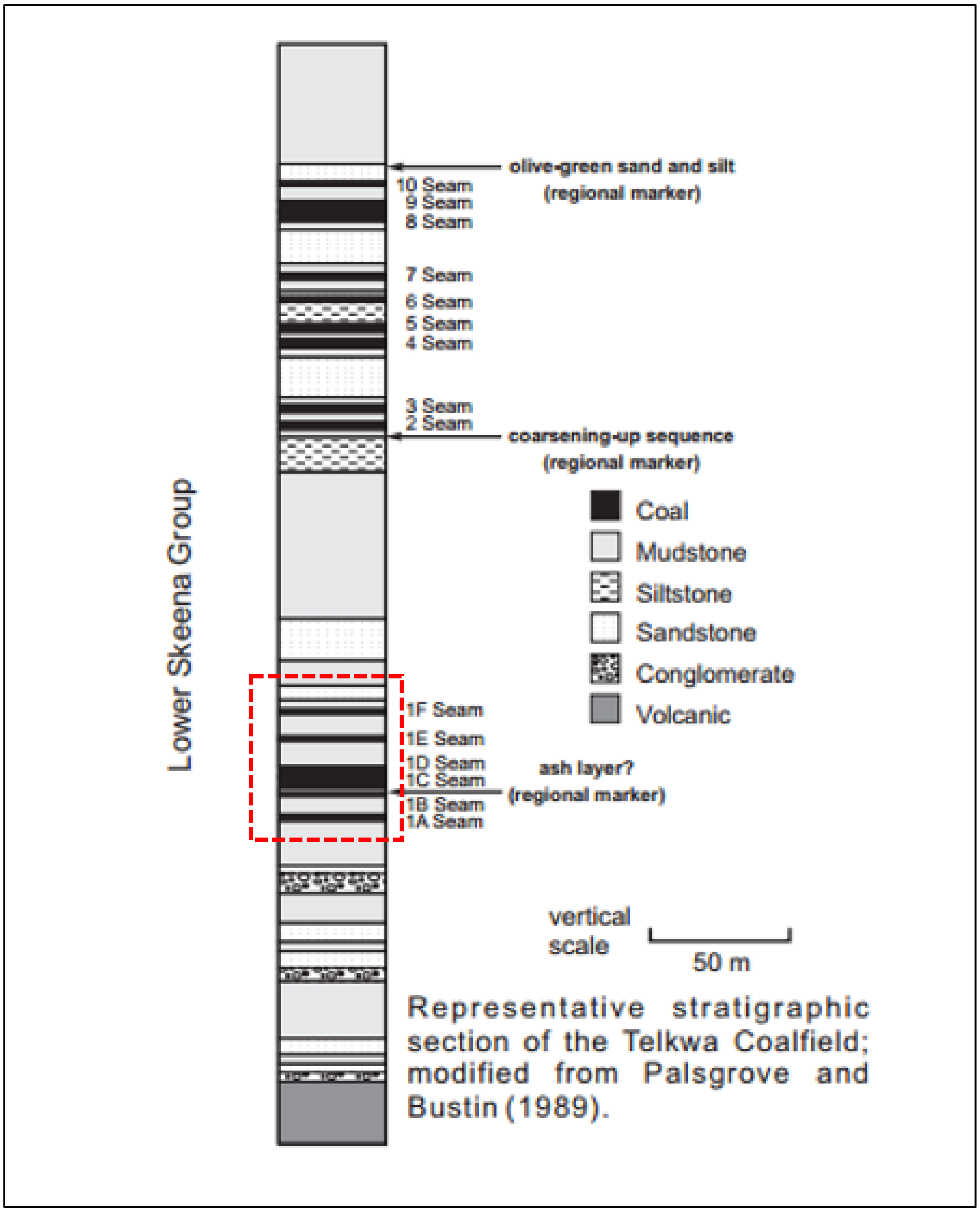


Figure 3-2: Representative Stratigraphy of the Skeena Group (Palsgrove, 1991). Unit 1 shown in Red Dashed Box

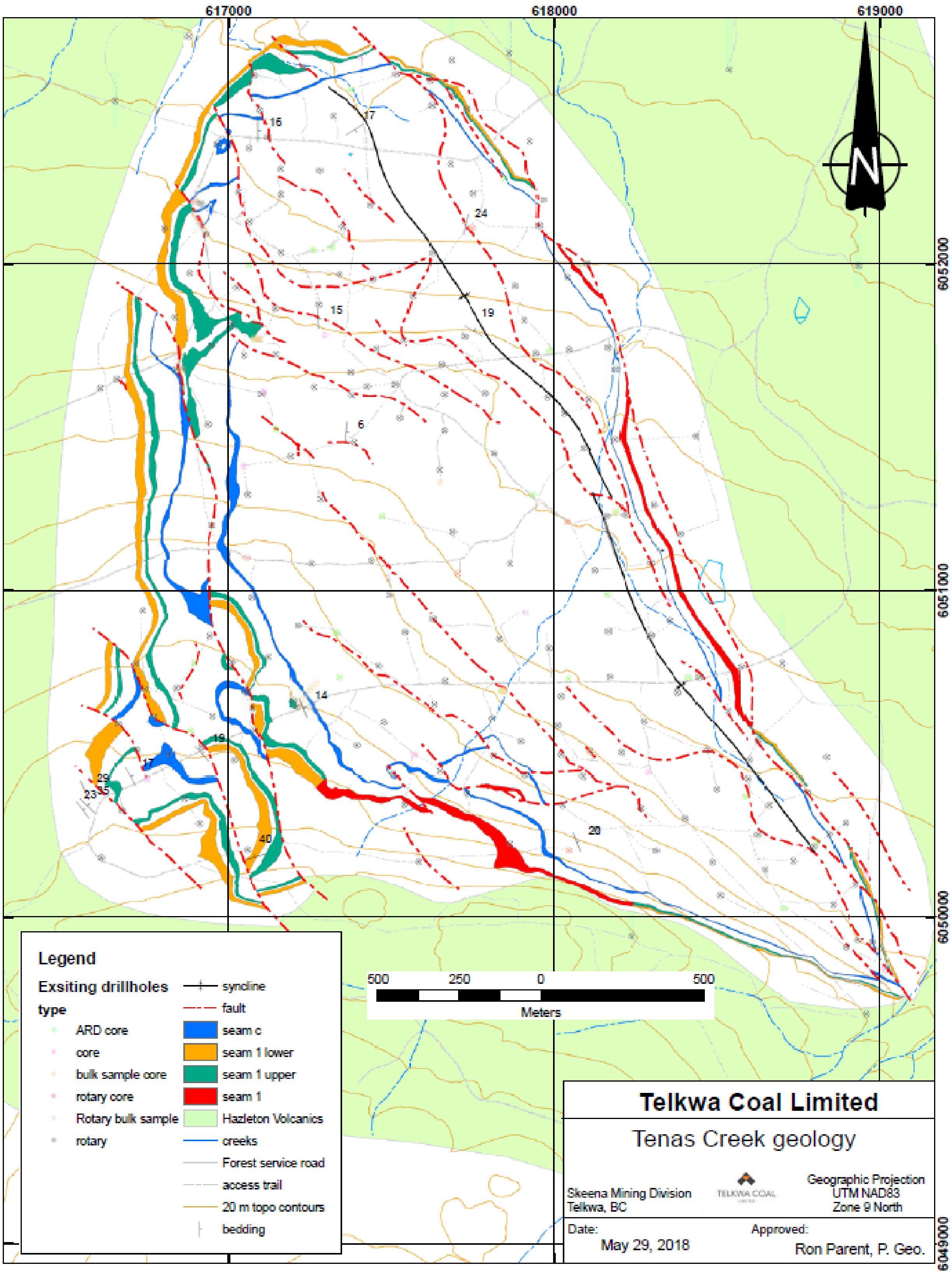


Figure 3-3: Tenas Geology Map (Telkwa, 2018)

3.4 Seismicity

The 2015 National Building Code Seismic Hazard Map (NRC, 2015) indicates that the Telkwa Coal project site is located in a relatively stable seismic area. The peak ground acceleration (PGA) for a two percent probability of exceedance in a 50-year period, i.e. once in 2,475 years, is 0.049 g.

4 Previous Geotechnical and Hydrogeological Investigations

Five previous geotechnical and hydrogeological investigation programs have been completed in the Telkwa area, as summarised in Table 4-1. These include investigations for the Tenas, Goathorn and Telkwa North deposits. The 1997 Piteau Engineering Ltd. (Piteau) report is most relevant to the 2018 and 2019 geotechnical investigations, and the data from these historical investigations has been compiled and compared in this current report.

Table 4-1: Summary of Previous Geotechnical and Hydrogeological Investigations in the Telkwa Area

Consultant	Report Title	Year of Report	Pit Area
Klohn Leonoff	Stage II Geotechnical, Hydrological, and Hydrogeological Design report.	1985	Goathorn
Piteau Engineering Ltd.	Engineering Geology and Geotechnical Assessment for the Pit 7 and Pit 8 Areas.	1994	Telkwa North
Piteau Engineering Ltd.	Water Management of Tailings Pond and Pits 7 and 8.	1994	Telkwa North
Piteau Engineering Ltd.	Engineering Geology and Geotechnical Assessment for the Tenas Pit and Waste Dumps.	1997	Tenas
Piteau Engineering Ltd.	Geotechnical Assessment for the Coal Haul Roads, Tailings Pond and Plant Site.	1998	All pits
SRK Consulting (Canada) Ltd.	Tenas Project – Factual Data for 2018 Geotechnical Investigation	2018	Tenas

5 2019 Field Investigations

The 2019 field investigations have been divided into soil (sonic drilling and testing pitting) and rock (diamond drilling and televiewer surveying) components. Laboratory testing was conducted on both soil and rock samples collected during the investigations. The summary of the program is presented in the following subsections. A map of the geotechnical investigation area, with all sonic drillholes and test pits is shown in Figure 5-1 and the diamond drillholes shown in Figure 5-2. The 2018 and historical Piteau investigations are included in both figures.

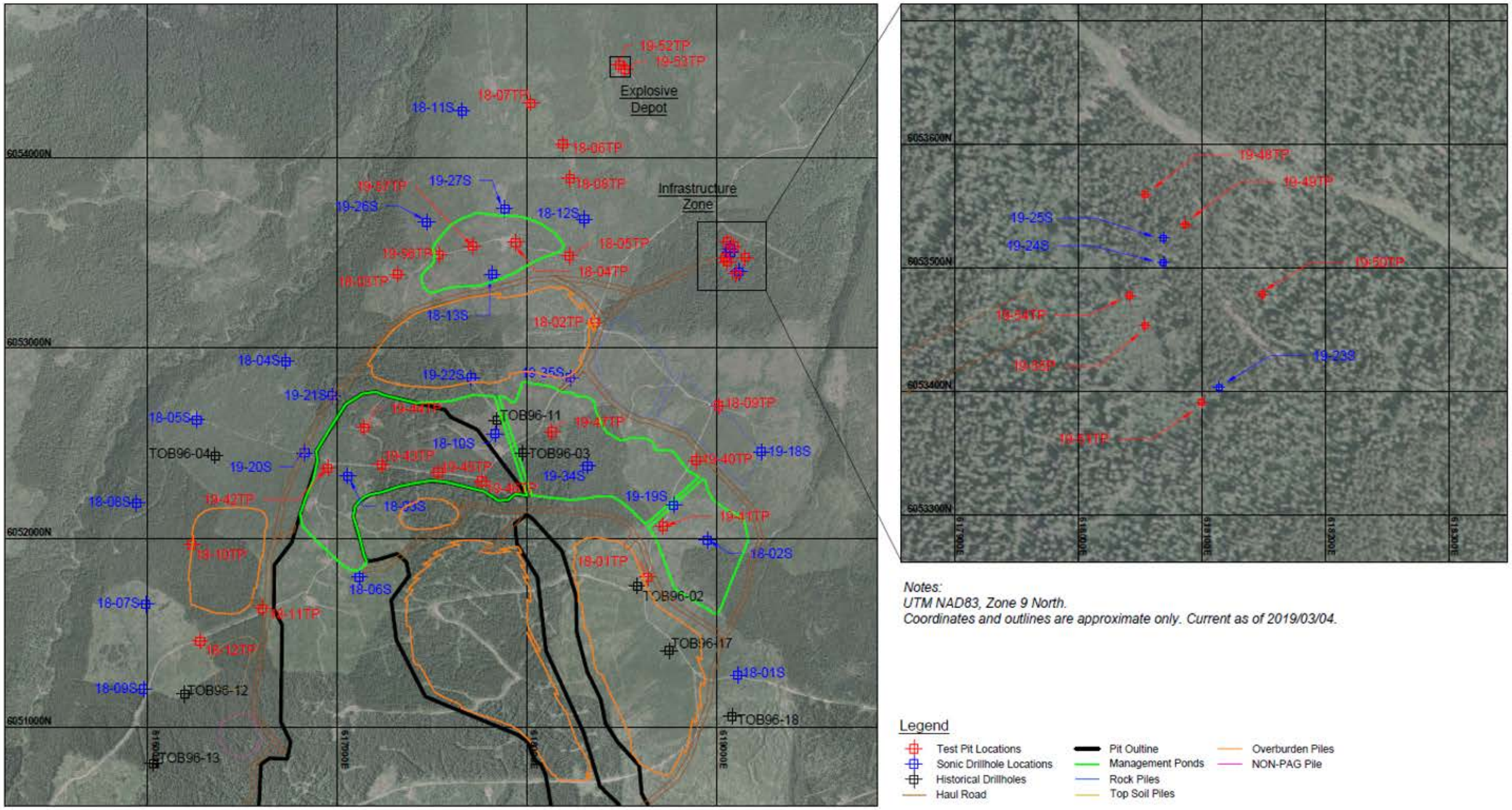


Figure 5-1: Location plan showing 2018, 2019 and historic sonic drillholes and test pit investigations

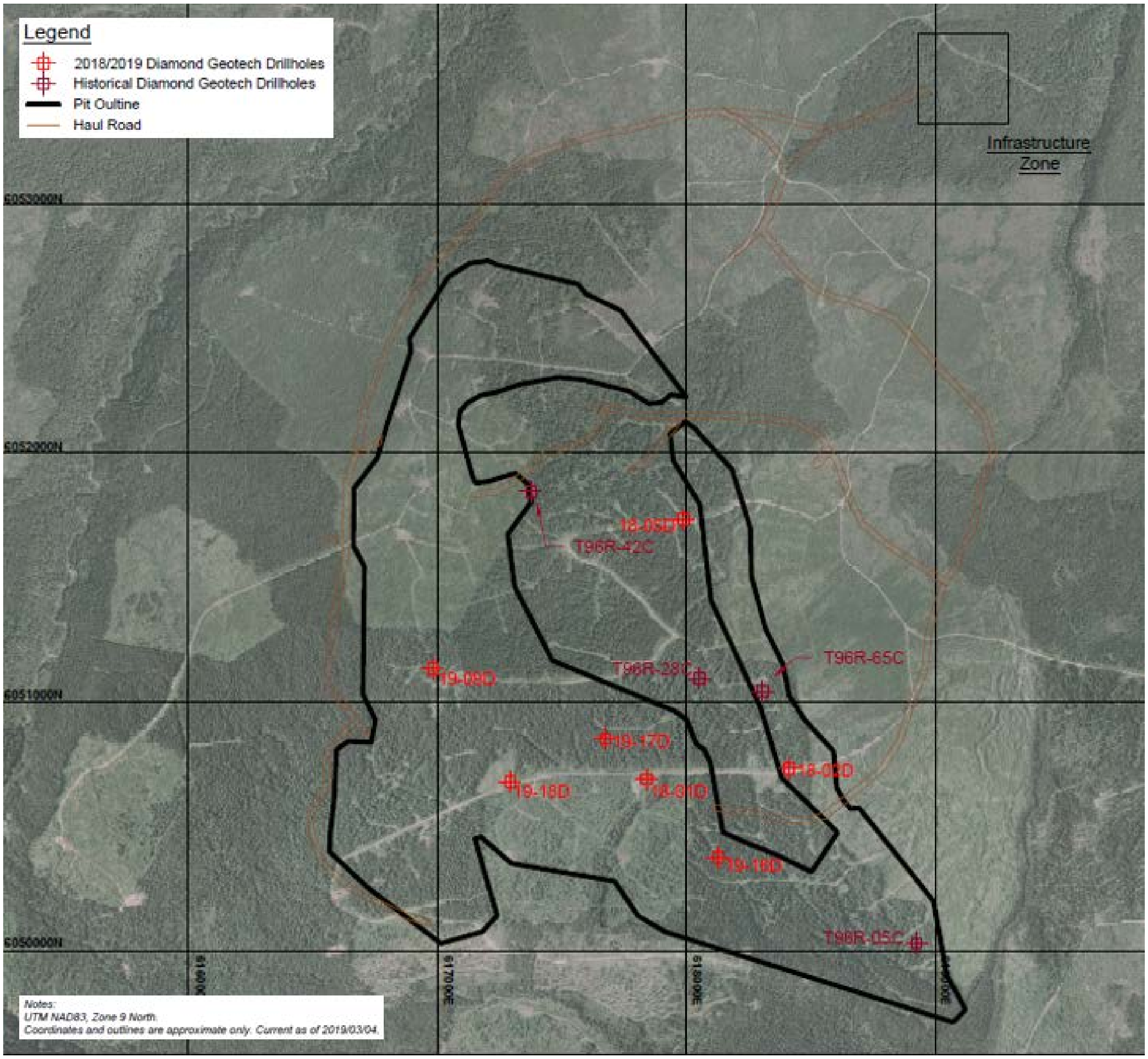


Figure 5-2: Location plan showing 2019 and 2018, and historical diamond drillholes that were used for geotechnical data collection

5.1 Sonic Drilling

The sonic drill program was completed using a LS250 Minisonic rig by Boart Longyear. The 2019 program consisted of 12 geotechnical sonic drillholes as detailed in Table 5-1. The geotechnical sonic holes investigated soil foundations below management ponds, sediment ponds, external soil/rock piles and infrastructure pad. The drillholes were drilled vertically and were terminated at depths between 10.7 m and 67.1 m upon reaching bedrock. One of the primary objectives for the 2019 field investigation was to confirm the depth to bedrock. A total of 12 standpipe piezometers were installed in the drillholes for shallow groundwater monitoring.

A total 12 sonic drillholes were completed in 2018 (SRK, 2018) and eight drillholes as part of the 1997 Piteau investigations. The sonic drillholes details are summarised in Table 5-1.

Table 5-1: Summary of 2018, 2019 and historic sonic drilling details

Field Program	Drillhole ID	Termination Depth (m)	Easting (m)[1]	Northing (m)[1]	Elevation (m)[1]	Depth to Bedrock	Depth to Groundwater	Standpipe Well Installation	Primary Investigation Purpose
SRK 2019	19-18S	47.2	619237	6052454	817	43.4	27.4	34.1-35.6	Management Ponds
	19-19S	47.2	618775	6052171	840	44.9	45.8	43.5-45.0	Management Ponds
	19-20S	44.2	616824	6052440	859	43.0	31.0	28.7-30.2	Management Ponds/Pit Slope
	19-21S	59.4	616976	6052746	834	56.1	24.9	56.7-58.2	Management Ponds/Pit Slope
	19-22S	29.7	617705	6052847	826	28.0	16.7	27.8-29.3	Management Ponds
	19-23S	11.3	619117	6053405	798	Not intercepted	Not encountered[1]	-	Plant Infrastructure Pad
	19-24S	20.4	619070	6053505	797	Not intercepted	Not encountered[1]	-	Plant Infrastructure Pad
	19-25S	10.7	619072	6053523	798	Not intercepted	Not encountered[1]	-	Plant Infrastructure Pad
	19-26S	67.1	617469	6053665	807	Not intercepted	33.1	50.8-52.3	Management Ponds
	19-27S	67.1	617883	6053726	808	Not intercepted	40.1	43.0-44.5	Management Ponds
	19-34S	38.1	618256	6052399	837	33.5	14.1	35.1-36.6	Management Ponds/Pit Slope
	19-35S	30.5	618228	6052834	829	Not intercepted	20.3	28.3-29.8	Management Ponds
SRK 2018	T18-01S	9.0	619132	6051278	863	Not intercepted	14.5	-	Overburden Piles
	T18-02S	19.5	618921	6051995	836	Not intercepted	Not encountered[1]	11.0-14.0	Overburden Piles
	T18-03S	15.0	617071	6052362	852	Not intercepted	Not encountered[1]	-	Management Ponds/Pit Slope
	T18-04S	20.0	616709	6052775	834	Not intercepted	Not encountered[1]	-	Overburden Piles
	T18-05S	14.0	616249	6052648	852	Not intercepted	Not encountered[1]	-	Overburden Piles
	T18-07S	27.9	616004	6051665	908	26.5	Not encountered[1]	-	Overburden Piles
	T18-08S	15.5	616018	6052169	885	Not intercepted	Not encountered[1]	-	Overburden Piles
	T18-09S	13.5	615957	6051117	939	13.9	Not encountered[1]	10.1-13.1	Overburden Piles
	T18-10S	14.0	617817	6052528	838	Not intercepted	Not encountered[1]	-	Overburden Piles
	T18-11S	19.5	617697	6054253	791	Not intercepted	Dry	7.5-10.5	Overburden Piles
	T18-12S	30.8	618296	6053689	801	Not intercepted	Not encountered[1]	-	Overburden Piles
	T18-13S	18.4	617809	6053408	815	Not intercepted	Dry	14.9-17.9	Overburden Piles
Piteau 1997	TOB-96-02	33.50	6051748	618580	853	Not intercepted	Not encountered[1]	17.0-20.0	Overburden Piles
	TOB-96-03	24.0	6052446	617976	836	22.9	Not encountered[1]	-	Overburden Piles/Pit Slope
	TOB-96-04	123.0	6052433	616356	853	117.0	77.0	-	Overburden Piles
	TOB-96-11	20.2	6052619	617839	827	Not intercepted	Not encountered[1]	18.2-20.2	Overburden Piles/Pit Slope
	TOB-96-12	4.60	6051178	616197	926	3.75	Not encountered[1]	1.7-4.0	Overburden Piles/Pit Slope
	TOB-96-13	20.0	6050812	616031	943	11.0	3.0	-	Overburden Piles
	TOB-96-17	14.0	6051407	618747	860	11.5	3.0	-	Overburden Piles
	TOB-96-18	17/0	6051061	619079	873	15.0	Not encountered[1]	-	Overburden Piles

Note: ¹: Datum: UTM NAD83, Zone 9 North. Coordinates and elevation surveyed after completion of program and provided by Telkwa. Values rounded to nearest metre.

Geotechnical soil logs describing the encountered materials and associated split photos are presented in Appendix A. The logs include the following:

- Soil layer descriptions, including Unified Soil Classification System (USCS) classification/soil type, particle size and shape, plasticity, color and odor, fabric and structure, moisture, consistency or relative density, and inferred soil unit;
- Samples and pocket penetrometer testing;
- Standard penetration test (SPT) results; and
- Drill performance indicators of subsurface condition (i.e., drilling resistance).

5.2 Test Pit Investigations

In 2019, a total of 18 test pits were excavated to investigate shallow foundation materials below the proposed management ponds, sediment ponds, explosives depot pad, infrastructure pad and external soil piles. The test pits were excavated to maximum depth between 2.5 and 4.6 m using a tracked John Deer 230LC Hydraulic Excavator fitted with a toothed bucket. The test pits were terminated at practical bucket refusal or the maximum reach of the excavator.

The test pits were located along existing trails or within previously disturbed ground associated with trail and drill pad construction. The test pit ID numbers, dates completed, and surveyed locations are summarized in Table 5-2. Geotechnical soil logs based on these test pits are presented in Appendix A. Bulk disturbed samples from the test pits were generally collected every 1.5 m. The logs include the following:

- Soil layer description, including Unified Soil Classification System (USCS) classification/soil type, particle size and shape, plasticity, color and odor, fabric and structure, moisture, consistency or relative density, and inferred soil unit;
- pocket penetrometer test locations and results;
- Sample locations; and
- Photos of the excavation.

Additional relevant information noted during the excavation, including water inflow, sloughing and excavator resistance, have also been added to the geotechnical logs.

Table 5-2: Summary of 2018 and 2019 test pit details

Field Program	Test Pit ID	Final Depth (m)	Easting (m) [1]	Northing (m) [1]	Elevation (m) [1]	Primary Investigation Purpose
SRK 2019	19-40TP	3.3	618891	6052407	834	Management Ponds
	19-41TP	4.0	618716	6052062	842	Management Ponds
	19-42TP	3.7	616949	6052368	860	Management Ponds
	19-43TP	4.6	617233	6052385	841	Management Ponds
	19-44TP	3.7	617142	6052582	836	Management Ponds
	19-45TP	2.5	617531	6052346	838	Management Ponds
	19-46TP	4.0	617762	6052299	840	Management Ponds
	19-47TP	3.8	618131	6052559	835	Management Ponds
	19-48TP	4.3	619054	6053559	801	Plant Infrastructure Pad
	19-49TP	4.3	619087	6053535	801	Plant Infrastructure Pad
	19-50TP	4.2	619149	6053478	801	Plant Infrastructure Pad
	19-51TP	4.1	619100	6053391	803	Plant Infrastructure Pad
	19-52TP	3.3	618485	6054492	781	Explosives Depot Area
	19-53TP	3.1	618516	6054468	782	Explosives Depot Area
	19-54TP	4.2	619042	6053477	802	Plant Infrastructure Pad
	19-55TP	4.1	619054	6053453	827	Plant Infrastructure Pad
	19-56TP	3.9	617534	6053491	818	Management Ponds
	19-57TP	3.6	617712	6053538	813	Management Ponds
SRK 2018	T18-01TP	3.2	618635	6051793	848	Overburden Piles
	T18-02TP	4.0	618354	6053134	818	Overburden Piles
	T18-03TP	3.1	617316[2]	6053388[2]	808[2]	Management Ponds
	T18-04TP	3.6	617939	6053557	811	Management Ponds
	T18-05TP	3.0	618222	6053485	813	Overburden Piles
	T18-06TP	3.3	618188	6054074	788	Management Ponds
	T18-07TP	2.7	618019	6054291	785	Management Ponds
	T18-08TP	3.2	618226	6053894	797	Management Ponds
	T18-09TP	3.2	619008[2]	6052695[2]	821[2]	Overburden Piles
	T18-10TP	3.6	616234[2]	6051965[2]	897[2]	Overburden Piles
	T18-11TP	3.0	616607	6051628	923	Overburden Piles/Pit Slope
	T18-12TP	2.9	616277	6051458	930	Overburden Piles/Pit Slope

Note: [1]: Datum: UTM NAD83, Zone 9 North. Coordinates and elevation surveyed after completion of program and provided by Telkwa. Values rounded to nearest metre, [2]: Test pit not surveyed. Coordinates estimated using topographic map provided by Telkwa.

5.3 Geotechnical Core Data Collection

SRK utilized diamond core drilling in 2019 for geotechnical data collection. The primary purpose of the drillholes was to collect core for geochemistry sampling and testing, however, the drillholes provided an increased dataset for the pit slope study work. In total, two inclined and six vertical diamond drillholes have been utilized in 2018 and 2019 for geotechnical data collection. The inclined drillholes (2018) were positioned in the steeper East Footwall to investigate the rock mass that is to be mined and the ultimate footwall rocks. The vertical drillholes spread throughout the deposit to investigate general rock mass conditions, including the footwall rocks in shallower dipping sequences. Televiewer surveys were conducted in eight locations. The location of the drillholes is presented in Figure 5-2. The diamond drillholes were geotechnically logged, sampled, field tested and supported with laboratory testing. Details of the drilling program are provided in Table 5-3.

In addition, the geotechnical logging data from four vertical diamond drillholes conducted for the historical 1997 Piteau field investigations were reviewed. For the purposes of this study, this data is considered qualitative and provides general rock mass information.

Table 5-3: Diamond drilling program summary

Field Program	Drillhole ID	Length[1] (mah)	Dip (°)	Azimuth (°)	Easting[2] (m)	Northing[2] (m)	Elevation[2] (masl)	Geotechnical Logging	Televiewer Survey (m)
SRK 2009	T19-09D	50.4	-90	000	616982	6051132	982	Yes	4.0 – 49.4
	T19-16D	73.2	-90	000	618128	6050374	973	Yes	4.0 – 71.9
	T19-17D	59.9	-90	000	617674	6050852	953	Yes	7.0 - 58.6
	T19-18D	35.5	-90	000	617292	6050679	997	Yes	0.0 - 34.7
SRK 2018	T18-01D	78.7	-90	000	617841	6050689	958	Yes	16.5 – 78.7
	T18-02D	124.9	-60	042	618412	6050732	928	Yes	12.0 – 124.9[3]
	T18-03D	102.6	-90	000	617080	6051772	904	No	10.5 – 102.6
	T18-05D	180.4	-70	064	617988	6051733	893	Yes	No[4]
	T18-07D	213.7	-90	000	617318	6052051	864	No	7.5 – 213.7
Piteau 1997	T96R-05C	105.8	-90	000	618923	6050031	948	Yes	No[5]
	T96R-28C	120.7	-90	000	618052	6051092	919	Yes	No[5]
	T96R-42C	151.6	-90	000	617377	6051844	868	Yes	No[5]
	T96R-65C	141.0	-90	000	618305	6051041	915	Yes	No[5]

[1]: mah = metres along hole, relative to ground surface.

[2]: Datum: UTM NAD83, Zone 9 North. Coordinates and elevation surveyed after completion of program and provided by Telkwa. Values rounded to nearest metre.

[3]: Televiewer survey has poor image quality.

[4]: Televiewer survey not attempted because of drillhole instability.

[5]: Televiewer survey not conducted as part of geotechnical program

5.3.1 Geotechnical Logging

The recovered rock core from the geotechnical drillholes was logged, sampled, tested, boxed and photographed on-site. Geotechnical data was collected in accordance with SRK standard logging procedures. The descriptive terms and standards used by SRK to describe the geotechnical characteristics of the rock core are consistent with terminology recommended by the International Society for Rock Mechanics (ISRM).

Downhole plots of the following geological and geotechnical parameters that were logged are presented in Appendix B and include:

- Rock type and major structural features;
- Total Core Recovery;
- Rock Quality Designation (RQD);
- Fracture Spacing;
- ISRM Field Rock Strength Estimates;
- Point Load Test results ($Is_{(50)}$);
- Interval Joint Condition Rating (JCR); and
- Rock Mass Rating System (RMR_{89}) (Bieniawski, 1989).

5.3.2 Point Load Testing

Point Load Strength Index testing was carried out following logging and photographs. The testing was carried out on representative rock types, generally at 3 to 4 m depth intervals.

5.4 Downhole Geophysics

Downhole geophysical surveys were conducted by Century Wireline Services (Century). Century carried out the following downhole geophysical logging surveys:

- Borehole deviation (azimuth and tilt);
- Caliper;
- Gamma;
- Neutron density; and
- Acoustic televiewer (ATV) surveys in selected drillholes.

The televiewer surveys provide images of the borehole wall that can be used to determine the orientations and depths of structural geological features. The raw televiewer images were processed by Century and reoriented to true north. Century reportedly used a rotation of +18.2° to correct the data for local magnetic declination. The processed logs were provided to SRK along with orientation data from Century’s structural picks and are presented in Appendix DC.

5.5 Laboratory Testing

Representative soil and rock samples were collected after the core was logged and photographed. Samples were sent to the Golder Associates (Golder) laboratory in Burnaby, British Columbia for testing. The laboratory tests are summarised in Table 5-4. Soil laboratory test results are presented in Appendix D and rock laboratory test results in Appendix E.

Table 5-4: Summary of Laboratory Strength Testing

Test	ASTM	No. tests in 2018	No. tests in 2019	Material Type
Particle Size Distribution Tests with Hydrometer	ASTM D422	19	73	Soil
Atterberg Limits (Plasticity	ASTM D4318-10	18	35	Soil
Proctor Soil Compaction Tests	ASTM D698	4	-	Soil
Hydraulic Conductivity	ASTM D5084-10 Method C	3	-	Soil
Direct Sear Tests of Soil (Consolidated/Drained)	ASTM D3080	3	10	Soil
Soil Resistivity	ASTM G187	10	-	Soil
Soil pH	ASTM D4972	10	-	Soil
Water Content	ASTM D2216	35	-	Soil
Uniaxial Compressive Strength of Intact Rock	ASTM D7012 Method C	6	8	Rock
Uniaxial Compressive Strength of Intact Rock with Elastic Moduli	ASTM D7012 Method D	3	-	Rock
Direct Shear Tests on Rock Discontinuities	ASTM D5607	3	4	Rock

6 Results of the Soil Geotechnical Investigations

6.1 Material Observations

The surficial geology summary for the Tenas project area is based on the results of SRK's 2018 and 2019 field investigations.

The overburden of the Tenas project area ranges from a thickness of approximately 4 m to over 100 m, as indicated by the most recent 3D Geology Model developed by Telkwa.

Most of the overburden materials above bedrock consists of a well graded till. In general, the till is a sandy lean clay (CL) with silt and fine sand and some gravel. Cobbles and boulders were encountered during the drilling, and these are estimated to comprise less than 5% of the materials intercepted. The till is commonly stiff to hard in consistency with low to medium plasticity. The colour ranges from medium-brown to very dark-brown or dark-grey. Sand, silt and gravel lenses were commonly encountered within the till at depth. These materials are generally comparable to the massive diamicton unit described by Levson et al (1997).

The 2019 investigations were more focused around the paleo-channel that is situated within the management pond footprint. Eight of the 12 sonic locations were advanced through the paleo-channel to bedrock. The coarser materials located below the finer-grained till was generally described as clayey silty sands (SM or SC) or gravels (GM or GC). These materials are dense to very dense, well graded. The fines component can be low to medium plasticity

Both materials are generally comparable to the till unit described by Levson et al. Full descriptions of the materials logged are presented in the soil logs in Appendix A.

It should be noted that the finer-grained till materials are generally consistent with the results of the Piteau and Klohn Leonoff investigations carried our previously. In the northwest area of the project site, the Piteau investigations (Piteau, 1997) noted a very thick soil profile in historical drillhole TOB96-04. This thick unit was described as sand and gravel sized outwash deposits (Piteau, 1997). The diamond cored drilling method utilized to advance TOB96-04 likely washed out the silt and clay component with a remaining over-representation of the sand and gravel materials. It is likely that the materials in TOB96-04 are similar in composition to the coarse materials intercepted in the 2019 drillholes located within the management pond footprint (at depths generally greater than about 30 m).

6.2 Standard Penetration Testing Results

Standard Penetration Tests (SPT's) were conducted at regular intervals as the sonic drillholes where advanced. The uncorrected SPT 'N' blows versus depth is plotted in Figure 6-1. There is reasonable correlation between the blows and depth. The data indicates that the uncorrected N blows were generally above 20 (i.e. very stiff soil) at 1.5 m below ground surface level and increased with depth.

SPT N blows for the sandy lean clay till (CL) varied between 15 to >50 correlating to a very-stiff to hard fine-grained material. SPT N values for intervals of clayey sand (SC) or silty sand (SM) or clayey gravel (GC or GM) varied from 30 to >50 correlating to a dense to very dense coarse-grained material. SPT N blows correlated with full material descriptions are presented in the soil logs in Appendix A.

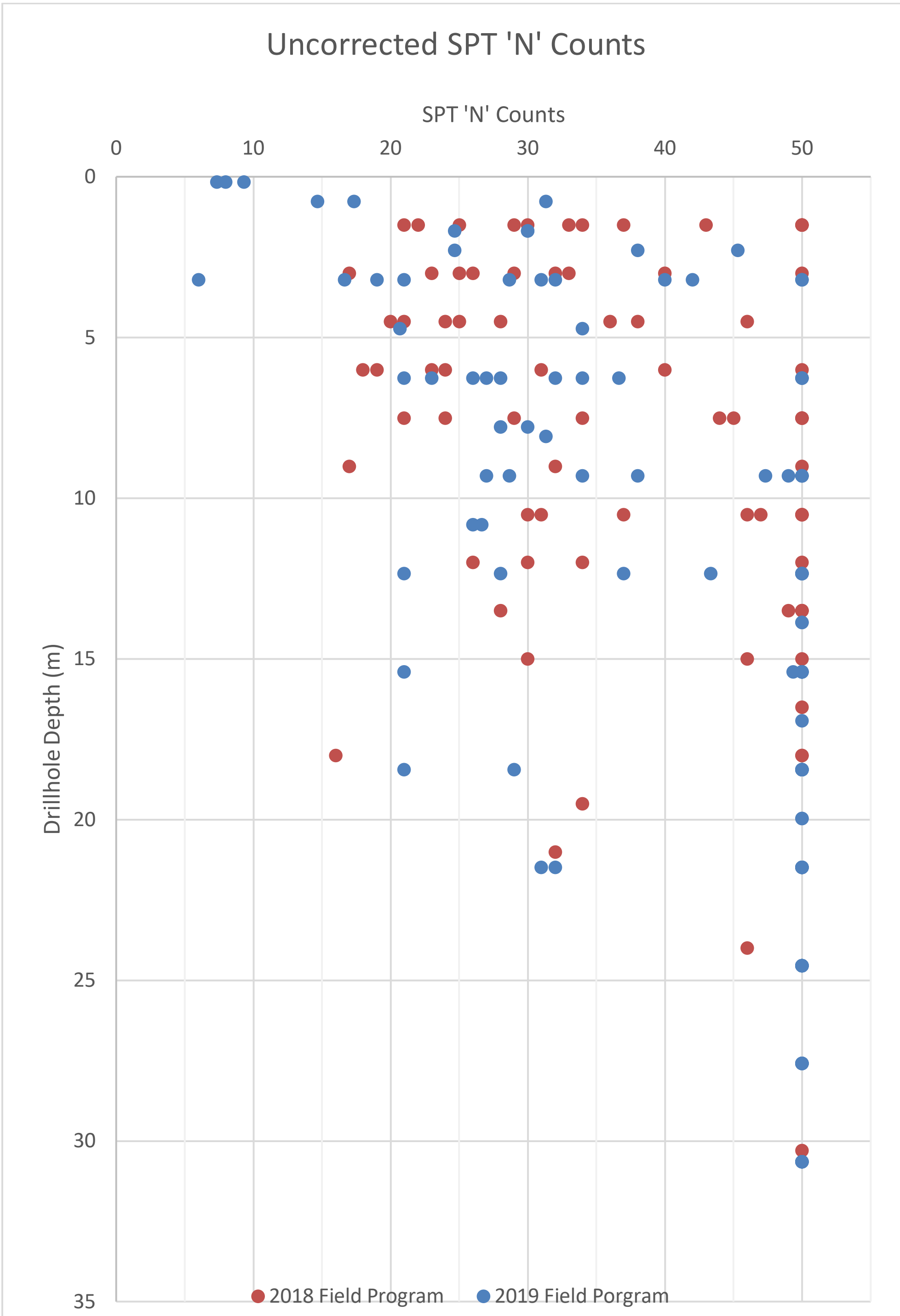


Figure 6-1: SPT N Blows vs. Depth for 2018 and 2019 sonic drilling

The historical SPT data from the Piteau investigations is presented in Figure 6-2. The data indicates a similar increasing SPT ‘N’ blow trend with depth.

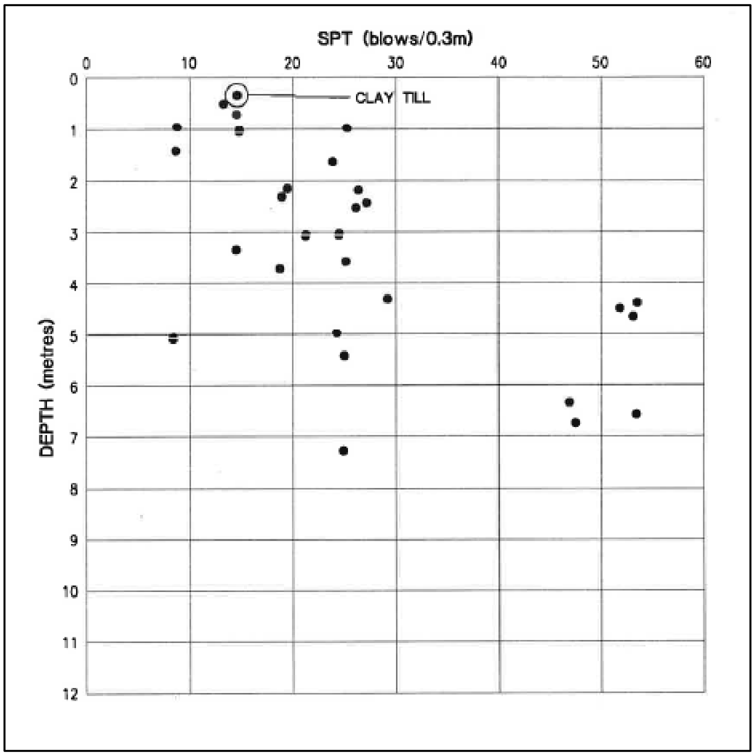


Figure 6-2: Historical SPT N Blows vs. Depth (Piteau, 1997)

6.3 Groundwater

Piezometric information and water table estimates were based on a review of monitoring well reading data and saturated soil observations during the sonic drilling. Where intercepted in monitoring wells completed as part of the 2018/2019 investigation, the shallowest groundwater levels were approximately 14 m, however, most of the recorded levels where between 20 m and 40 m. Table 5-1 provides a summary of the depth to groundwater measures in the standpipe installations. No groundwater inflows were recorded during the sonic drilling work.

In 2019, groundwater inflow was observed in one test pit at 3.5 m which corresponds to a gravelly clay underlying a clay layer with less gravel.

In 2018, groundwater inflow was observed in four test pits during excavation. The groundwater inflow occurred in the first 1 m of the test pit within the looser gravelly till directly beneath the top soil and above the stiffer underling till materials. Higher water inflow was recorded at test pit T18-08TP at a depth of 0.2 m which corresponded to the base of gravelly fill from a historic access trail.

6.4 Soil Lab Testing Results

The following sections provide a summary of the results of the soil samples that were sent to Golder. The full laboratory test reports are presented in Appendix E.

6.4.1 Particle Size Distribution Tests

Particle Size Distribution (PSD) tests with hydrometer (ASTM D422) were completed. The percentages of gravel, sand and fines for each sample are presented in Table 6-1 and combined PSD curves of all the samples presented in Figure 6-3 and Figure 6-4. The results show that the samples generally have a fines content greater than 50% with a typical sand content of 20% - 40% and a gravel content of 0 % - 20%. The shape of the PSD curves indicates that most samples are well graded, or gap graded.

It should be noted that some samples may underestimate the percentage of gravel or boulders that were observed in the in-situ soil. This is because large cobbles and boulders that were too large to sample in the field and cannot be practically included in the tests.

Table 6-1: Summary of PSD Test Results for 2018 and 2019

Field Investigation	Location	Sample ID	Sample Mid-Point Depth (m)	% Gravel	% Sand	% Silt/Clay
2018	T18-01S	SPT-04	6.2	19.7	27.2	53.1
	T18-02S	BLK-05	11.9	0.0	38.9	61.1
	T18-02S	BLK-02	12.8	0.2	30.8	69.0
	T18-02TP	BLK-01	1.0	17.7	30.9	51.4
	T18-03S	BLK-02	9.2	17.9	67.5	14.6
	T18-03TP	BLK-02	2.8	25.4	21.3	53.3
	T18-04S	BLK-02	8.7	0.6	7.5	91.9
	T18-05S	BLK-02	10.3	9.8	17.9	72.3
	T18-07TP	BLK-02	2.0	28.3	29.5	42.2
	T18-08S	SPT-05	9.2	8.8	33.3	57.9
	T18-08TP	BLK-01	2.0	19.1	27.3	53.6
	T18-09TP	BLK-02	3.0	10.0	20.7	69.3
	T18-10S	BLK-01	3.9	10.0	27.9	62.1
	T18-11S	BLK-01	0.3	26.9	35.5	37.6
	T18-12S	BLK-04	24.3	28.7	37.7	33.6
	T18-13S	SPT-01	1.7	6.4	30.9	62.7
	T18-13S	BLK-01	12.7	0.6	4.3	95.1
	T18-08D	W3-13	12.8	1.0	62.2	36.8
	T18-07S	BLK-02 & BLK-03	14.7 & 21.7	26.6	27.7	45.7
2019	19-18S	35077	6.4	7.5	25.3	67.2
	19-18S	35080	15.6	7.5	28.8	63.6
	19-18S	35084	29.3	2.5	77.2	20.3
	19-18S	35085	35.05	14.4	61.1	24.5
	19-18S	35086	42.45	10.1	23.0	66.9
	19-19S	35087	3.25	19.6	30.6	49.9
	19-19S	35089	11.9	0.0	5.0	95.0
	19-19S	35090	14.6	0.0	44.4	55.6
	19-19S	35091	18.5	0.0	72.6	27.4
	19-19S	35093	21.55	1.1	12.2	86.7
	19-19S	35094	26.2	0.1	56.3	43.6
	19-19S	35095	30.2	0.0	50.5	49.5
	19-19S	35096	34.75	13.0	24.8	62.2
	19-19S	35097	42.1	18.4	30.3	51.3
	19-19S	35098	44.25	15.0	48.3	36.7
	19-20S	35052	5.85	35.9	38.0	26.1
	19-20S	35053	8.8	46.3	38.4	15.2
	19-20S	35054	11.9	50.7	39.8	9.5
	19-20S	35055	14.6	26.5	56.5	17.0
	19-20S	35056	17.1	23.0	60.4	16.7

Field Investigation	Location	Sample ID	Sample Mid-Point Depth (m)	% Gravel	% Sand	% Silt/Clay
	19-20S	35057	20.1	16.3	25.1	58.7
	19-20S	35059	24.7	1.3	48.1	50.5
	19-20S	35060	27.7	2.5	16.1	81.5
	19-20S	35061	32.9	46.5	34.1	19.3
	19-20S	35062	36	22.0	45.3	32.6
	19-20S	35063	42.4	49.3	25.8	24.8
	19-21S	35032	2.7	9.3	66.7	24.0
	19-21S	35033	6.4	0.9	65.9	33.2
	19-21S	35034	11	0.8	8.8	90.3
	19-21S	35035	15.5	10.8	10.7	78.4
	19-21S	35039	23.95	30.4	35.1	34.5
	19-21S	35040	26.8	12.9	39.5	47.6
	19-21S	35041	30.25	8.8	21.7	69.5
	19-21S	35042	31.7	48.2	33.2	18.6
	19-21S	35043	39	14.7	24.2	61.1
	19-21S	35045	50.45	26.3	27.4	46.3
	19-22S	29661	3.35	15.6	27.4	57.0
	19-22S	29663	11	0.1	22.2	77.8
	19-22S	29665	16.5	19.6	27.2	53.2
	19-22S	29666	19.2	8.7	63.7	27.6
	19-22S	29668	26.5	0.2	4.7	95.1
	19-23S	29676	1.3	18.3	30.9	50.8
	19-24S	29682	7.3	19.9	27.9	52.2
	19-24S	29685	16.5	7.1	38.8	54.2
	19-25S	29689	8.5	13.1	35.1	51.9
	19-26S	29591	51.5	0.1	80.4	19.5
	19-27S	29603	29.9	0.0	66.3	33.7
	19-27S	29604	33.2	45.7	42.0	12.3
	19-27S	29605	36	17.1	59.0	23.8
	19-27S	29606	41.8	0.7	59.8	39.5
	19-34S	29612	4.3	23.4	21.8	54.8
	19-34S	29613	8.9	12.7	16.6	70.6
	19-34S	29615	13.7	0.5	85.2	14.3
	19-34S	29616	14.9	3.7	61.5	34.8
	19-34S	29617	17.7	5.9	30.9	63.3
	19-34S	29618	20.1	0.0	63.5	36.5
	19-34S	29619	24.1	0.1	28.5	71.4
	19-34S	29620	26.2	1.4	57.6	41.0
	19-34S	29622	33.2	9.3	27.1	63.6
	19-35S	29624	5.8	11.6	25.4	63.0

Field Investigation	Location	Sample ID	Sample Mid-Point Depth (m)	% Gravel	% Sand	% Silt/Clay
	19-35S	35139	14.9	0.9	7.2	91.9
	19-35S	35140	17.1	0.0	77.1	22.9
	19-35S	35141	18.15	0.0	73.1	26.9
	19-35S	35142	19.5	0.0	58.1	41.9
	19-35S	35143	22.6	11.6	26.5	61.9
	19-48TP	29669	0.6	29.4	38.6	32.0
	19-49TP	29672	0.1	12.2	50.2	37.6
	19-49TP	29674	3	12.5	30.2	57.3
	19-52TP	29690	1.2	23.3	34.2	42.5
	19-53TP	29692	0.6	18.2	43.0	38.7
	19-53TP	29693	1.8	25.3	25.6	49.1
	19-55TP	29697	1.2	30.8	28.8	40.3
	19-57TP	35023	1.2	19.4	36.2	44.3

Historical PSD tests results are presented in Table 6-2. The 2018 results are generally similar to the historical results in terms of gravel, sand and fines content. Full PSD curves for the historical data were not available.

Table 6-2: Historical PSD Tests (Piteau, 1997)

Location	Sample Mid-Point Depth (m)	% Gravel	% Sand	% Fines
TOB96-11	3.1	20	37	43
TOB96-11	5.5	12	28	60
TOB96-11	10.3	13	24	63
TOB96-13	3.2	13	31	56
TOB96-17	3.2	15	31	54
TOB96-18	3.2	17	29	54

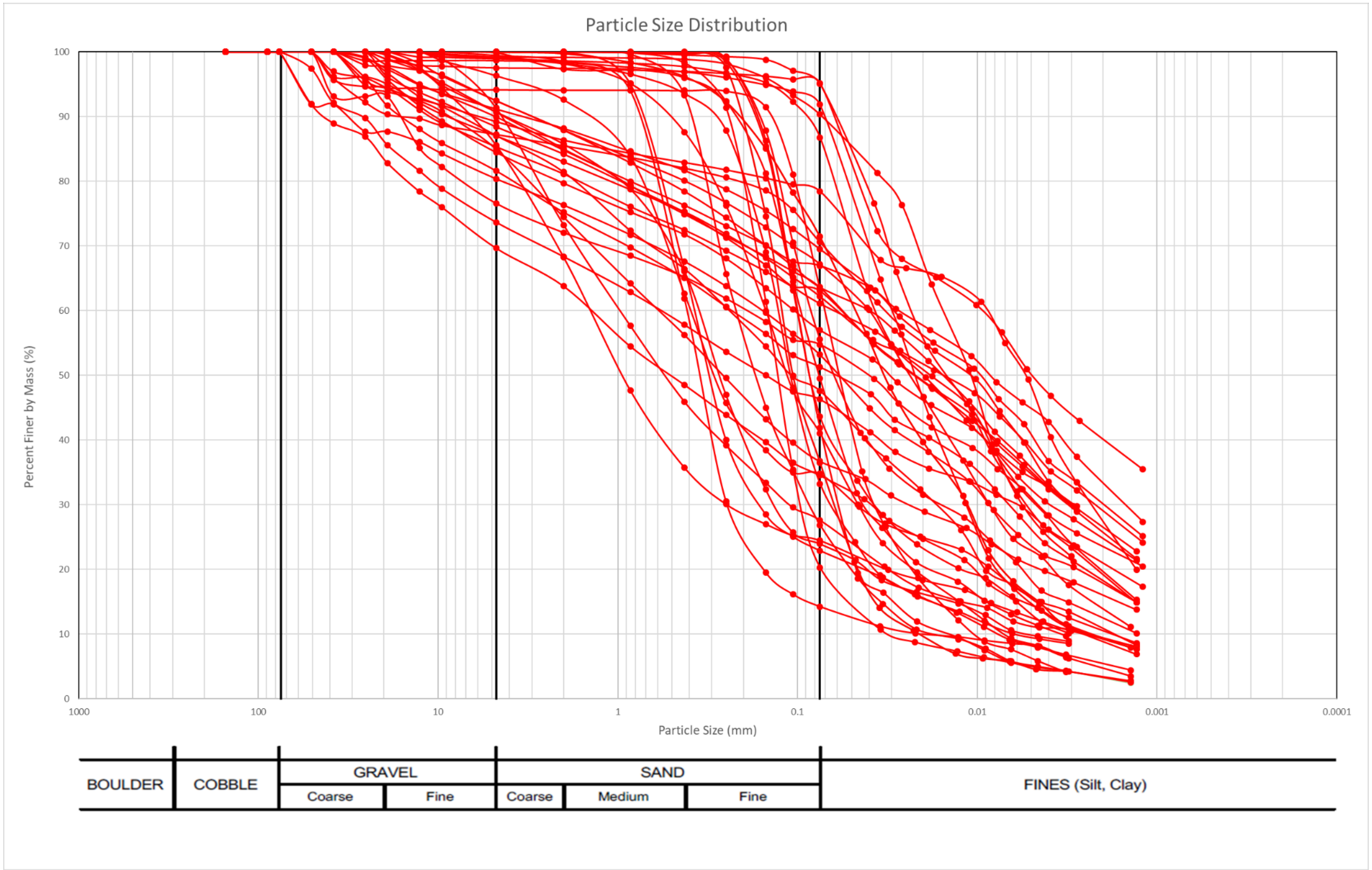


Figure 6-3: PSD Curves for 2019 Tested Samples

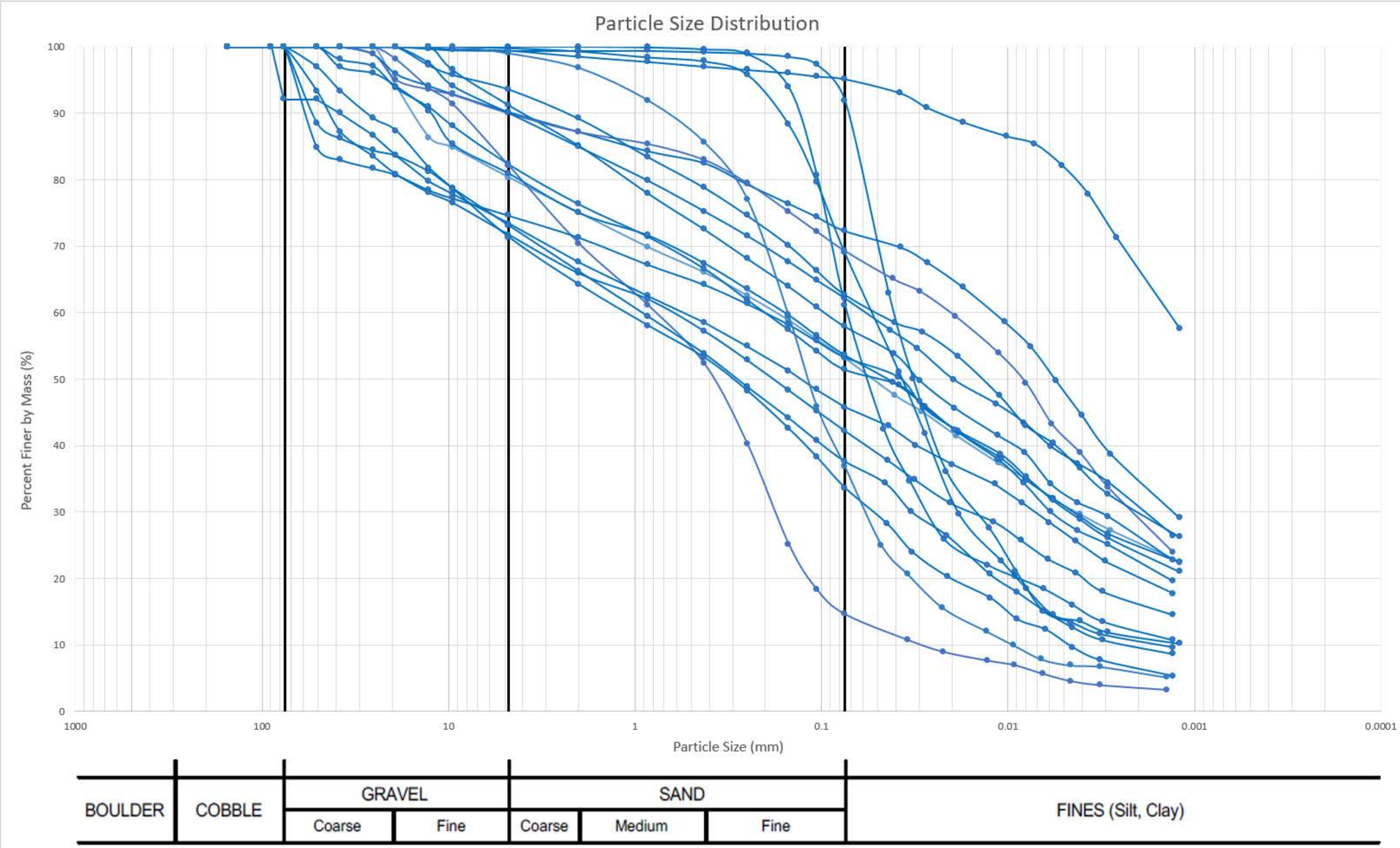


Figure 6-4: PSD Curves for 2018 Tested Samples

6.4.2 Atterberg Limits (Plasticity)

A total of nineteen Atterberg Limit tests (ASTM D4318-10) were completed for soil classification in 2019. A summary of the 2018, 2019 and historical test results is summarized in Table 6-3 and plotted on a plasticity chart in

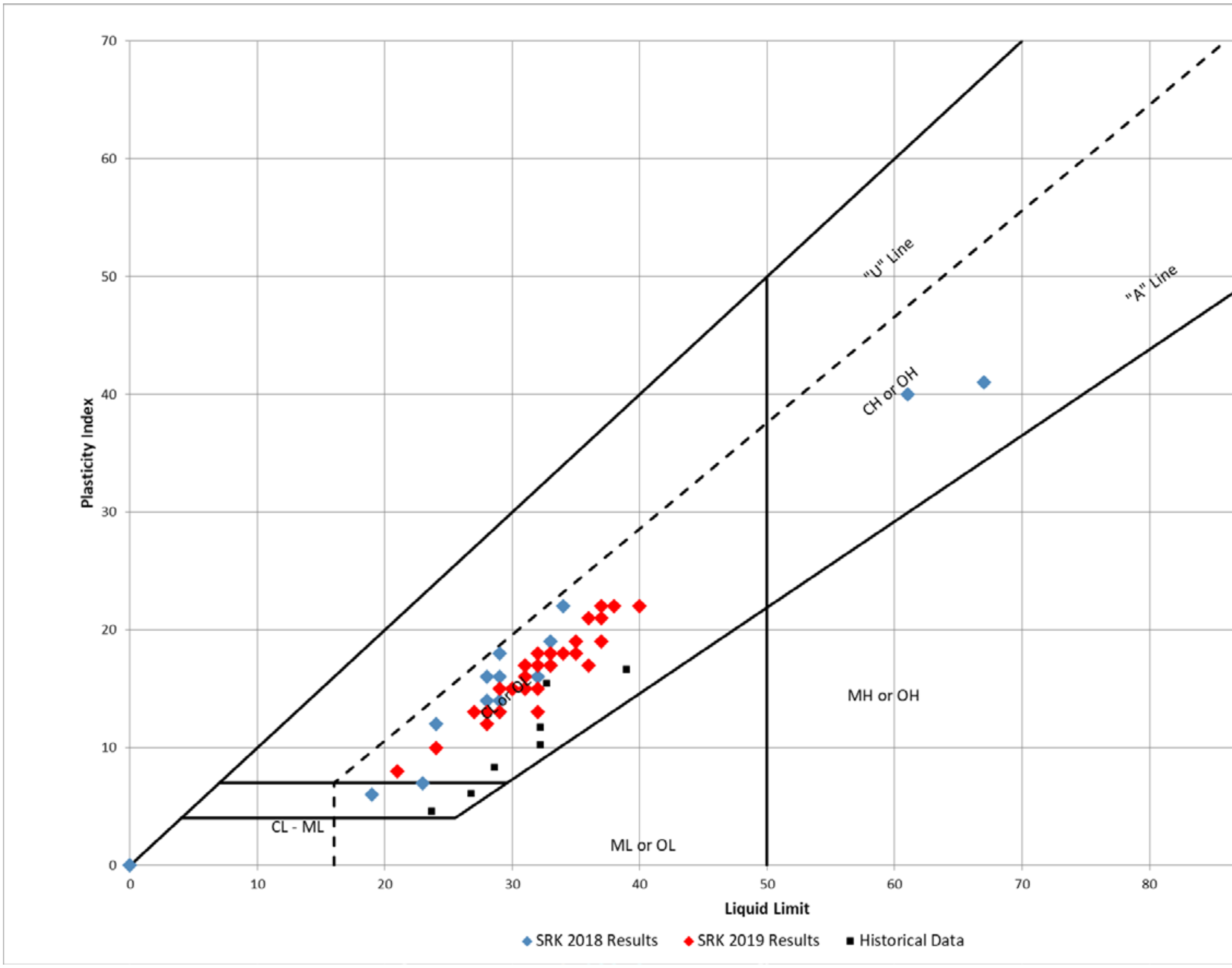


Figure 6-5. In summary, the results indicate that the majority of the samples are a lean-clay (CL) with low to medium plasticity. Two samples were in the high plasticity range.

The 2018 and 2019 results are generally similar to the historical results as most of the tested samples are within the lean-clay (CL) category as shown in

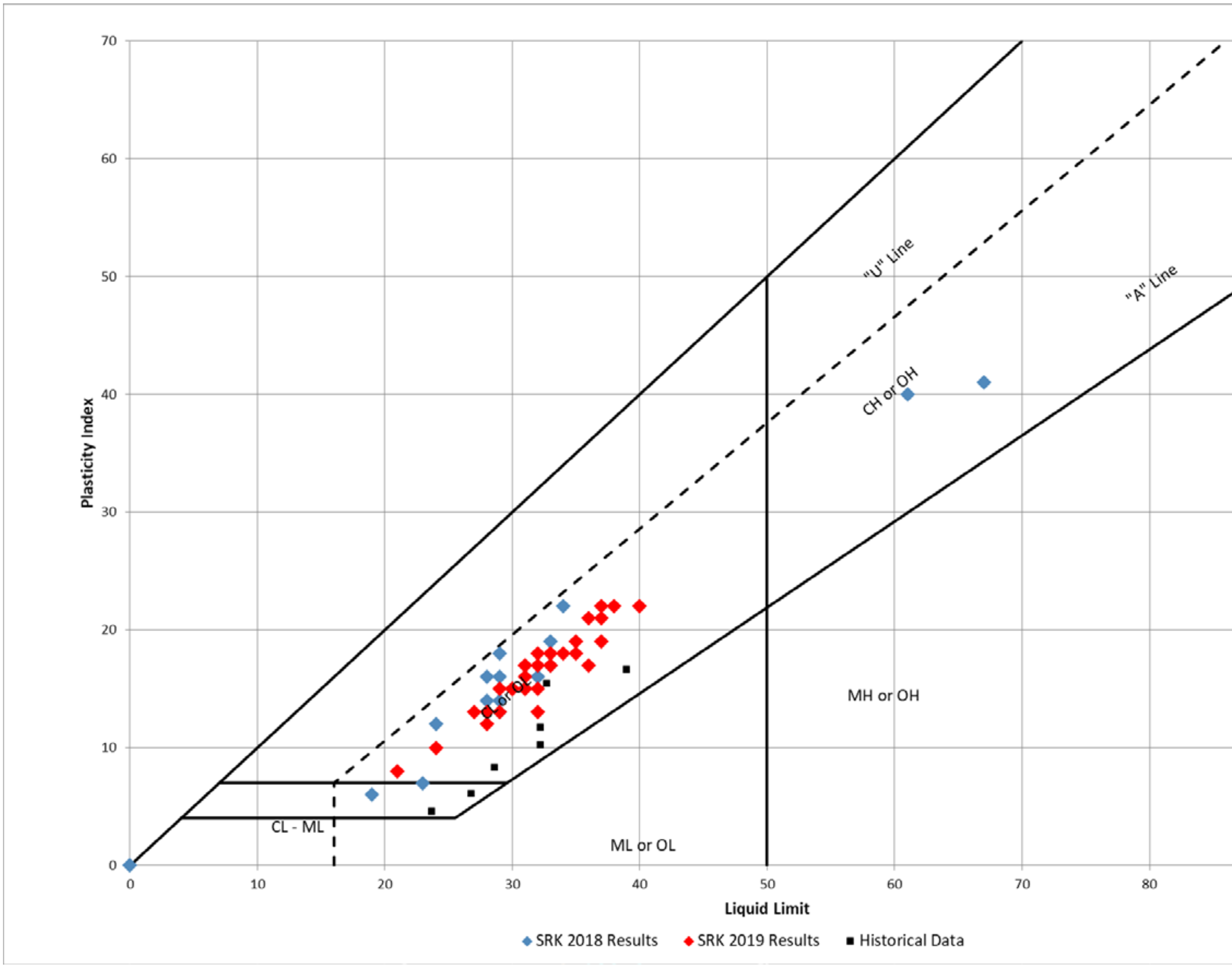


Figure 6-5. Although the historical testing is limited, the results do indicate a slightly lower plasticity index.

Table 6-3: Summary of Atterberg Limit Test Results

SRK Field Program	Location	Sample ID	Sample Mid-Point Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index	Water Content (%)	Liquidity Index	USCS Soil Type
2018	T18-01S	SPT-02	3.2	34	12	22	13.7	0.1	CL
	T18-01S	BLK-02	7.2	29	11	18	12.0	0.1	CL
	T18-02S	SPT-06	9.2	33	16	17	16.6	0.0	CL
	T18-02S	BLK-05	11.9	23	16	7	25.3	1.3	CL
	T18-02S	BLK-02	12.8	NP	NP	NP	12.6	NP	ML
	T18-04S	BLK-02	8.7	NP	NP	NP	22.7	NP	ML
	T18-04S	SPT-05	10.7	32	16	16	20.8	0.3	CL
	T18-05S	SPT-01	1.7	19	13	6	12.6	-0.1	CL-ML
	T18-05S	BLK-02	10.3	33	14	19	16.4	0.1	CL
	T18-07S	BLK-02 & BLK-03	14.7 & 21.7	28	14	14	10.6	-0.2	CL
	T18-07TP	BLK-02	2.0	29	15	14	10.3	-0.3	CL
	T18-08S	SPT-07	15.2	29	16	13	13.4	-0.2	CL
	T18-08TP	BLK-01	2.0	29	13	16	13.9	0.1	CL
	T18-09S	BLK-01	7.3	24	12	12	9.3	-0.2	CL
	T18-11S	BLK-02	6.7	32	16	16	19.4	0.2	CL
	T18-12S	BLK-03	17.8	61	21	40	25.2	0.1	CH
	T18-13S	SHL-01	6.3	28	12	16	13.9	0.1	CL
	T18-13S	BLK-01	12.7	67	26	41	29.2	0.1	CH
2019	19-18S	35077	6.4	30	15	15	13.9	-0.1	CL
	19-18S	35080	15.6	30	15	15	13.3	-0.1	CL
	19-18S	35086	42.5	40	18	22	14.2	-0.2	CI
	19-19S	35087	3.3	30	15	15	8.7	-0.4	CL
	19-19S	35096	34.8	28	15	13	11	-0.3	CL
	19-19S	35097	42.1	27	14	13	8.1	-0.5	CL
	19-20S	35057	20.1	31	16	15	12.8	-0.2	CL
	19-20S	35059	24.7	21	13	8	16.9	0.5	CL
	19-20S	35063	42.4	28	16	12	12.5	-0.3	CL
	19-21S	35034	11	32	19	13	22.1	0.2	CI
	19-21S	35035	15.5	36	19	17	20.8	0.1	CI
	19-21S	35041	30.3	35	16	19	14.9	-0.1	CI
	19-21S	35043	39	33	16	17	10.5	-0.3	CI
	19-21S	35045	50.5	29	14	15	6.4	-0.5	CL
	19-22S	29661	3.4	33	16	17	12.2	-0.2	CI
	19-22S	29665	16.5	24	14	10	8.8	-0.5	CL
	19-22S	29668	26.5	32	17	15	11.7	-0.4	CI
	19-23S	29676	1.3	32	15	17	12.5	-0.1	CL
	19-24S	29682	7.3	32	14	18	12.5	-0.1	CL
	19-24S	29685	16.5	31	14	17	11.3	-0.2	CL
	19-25S	29689	8.5	33	15	18	11.7	-0.2	CL
	19-34S	29612	4.3	31	15	16	12.1	-0.2	CI
	19-34S	29613	8.9	29	16	13	11.4	-0.4	CL
	19-34S	29622	33.2	38	16	22	10.4	-0.3	CI

SRK Field Program	Location	Sample ID	Sample Mid-Point Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index	Water Content (%)	Liquidity Index	USCS Soil Type
	19-35S	29624	5.8	31	14	17	12.4	-0.1	CI
	19-35S	35143	22.6	33	15	18	10.2	-0.3	CI
	19-49TP	29674	3	37	16	21	12.6	-0.2	CI
	19-50TP	35047	3.6	37	15	22	11.4	-0.2	CI
	19-51TP	35049	2.4	36	15	21	10.3	-0.2	CI
	19-52TP	29690	1.2	30	15	15	12.6	-0.2	CI
	19-53TP	29692	0.6	34	16	18	10.1	-0.3	CI
	19-53TP	29693	1.8	35	17	18	14.1	-0.2	CI
	19-55TP	29696	0.1	180	128	52	157.3	0.6	OH
	19-55TP	29697	1.2	37	18	19	15.6	-0.1	CI
	19-57TP	35023	1.2	31	16	15	11.5	-0.3	CI

NP: Non-Plastic

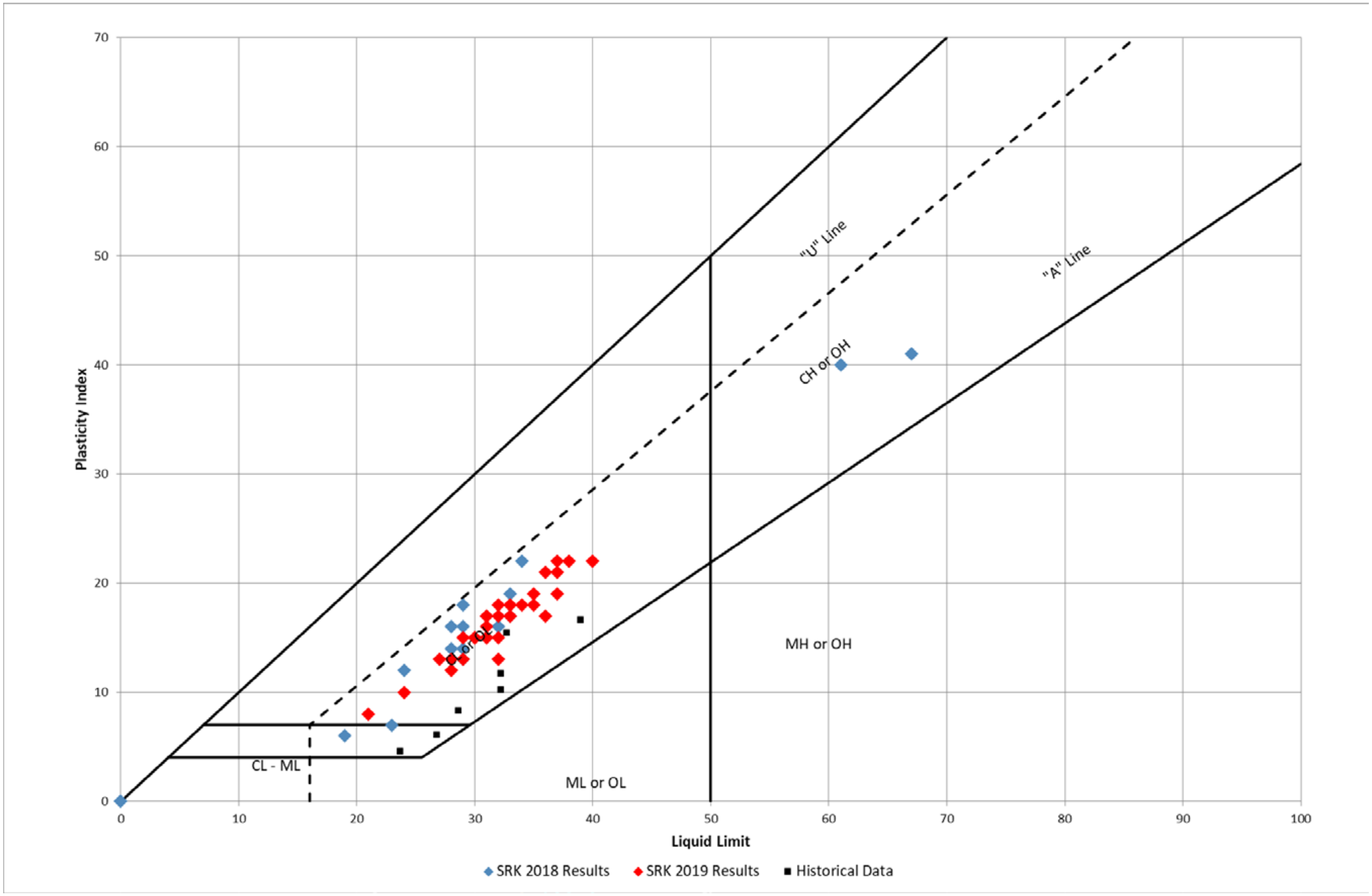


Figure 6-5: Atterberg Limits for 2018 and 2019 Test Results and Historical Data

Table 6-4: Historical Atterberg Limit Tests (Piteau, 1997)

Drillhole	Sample Mid-Point Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index	Water Content (%)	USCS Soil Type
TOB96-11	3.1	29	20	8	11.3	CL
TOB96-11	5.5	32	22	10	11.0	CL
TOB96-11	10.3	24	19	5	15.7	CL-ML
TOB96-13	3.2	39	22	17	12.5	CL
TOB96-13	7.2	27	21	6	10.0	CL-ML
TOB96-17	3.2	33	17	15	14.1	CL
TOB96-18	3.2	32	21	12	13.0	CL

6.4.3 Remolded Soil Direct Shear Tests

Ten soil direct shear tests (ASTM D3080) were performed on remolded and disturbed soil samples. The testing was conducted on finer-grained portions of the samples collected during the investigations. A summary of the test results is presented in Table 6-5.

Table 6-5: Summary of Remolded Soil Direct Shear Results

SRK Field Program	Location	Sample ID	Sample Mid-Point Depth (m)	Peak Normal Stress (kPa)	Peak Shear Stress (kPa)	Residual Normal Stress (kPa)	Residual Shear Stress (kPa)
2018	T18-02S	SPT-05	7.7	500	290	500	225
				1000	460	1000	438
				2000	930	2000	780
	T18-12S	SPT-07	18.2	500	230	500	170
				1000	360	1000	400
				2000	710	2000	840
	T18-10S	BLK-01	3.8	500	170	500	95
				1000	420	1000	165
				2000	900	2000	460
2019	19-19S	35096	34.8	1000	690	1000	684
				1500	1098	1500	1059
				2000	1426	2000	1254
	19-21S	35035	15.5	500	262	500	229
				1000	535	1000	510
				1500	795	1500	557
	19-22S	29661	3.4	300	196	300	200
				800	461	800	468
				1500	873	1500	881
	19-22S	29665	16.5	500	341	500	338
				1000	664	1000	651
				1500	1000	1500	965
	19-34S	29622	31.7	1000	467	1000	440
				1500	719	1500	616
				2000	892	2000	815
	19-35S	29624	5.8	300	181	300	176
				800	467	800	465
				1500	846	1500	841
	19-35S	35143	22.6	500	341	500	363
				1000	672	1000	696
				1500	922	1500	962

7 Results of Rock Geotechnical Investigations

7.1 Rock Types

Rock types encountered in the geotechnical drilling program generally comprised Skeena Group mudstone, siltstone, sandstone and coal. The typical appearance of representative rock types is presented in Figure 7-1, through Figure 7-4.

Engineering geological descriptions for each rock type are detailed below.

Coal (C):

Fine grained, bedded and cleated texture, dark grey and black, assessed fresh to extremely weathered, generally estimated extremely weak to very weak intact rock strength (R0 to R1).

Figure 7-1: Example Core of Coal Rock Type

Mudstone (MDST):

Fine grained, bedded, grey and dark grey, assessed fresh to highly weathered, generally estimated very weak to medium strong intact rock strength (R1 to R3). The mudstone is often interbedded with small coal seams and breaks on graphitic coated joints near major coal seams.

Figure 7-2: Example Core of Mudstone Rock Type

Siltstone (SLST):

Fine grained, bedded and laminated texture, dark grey, assessed fresh to moderately weathered, generally estimated very weak to medium strong intact rock strength (R2 to R3). The siltstone can be interbedded with small coal seams and breaks on graphitic coated joints near major coal seams.

Figure 7-3: Example Core of Siltstone Rock Type

Sandstone (SST):

Fine to medium grained, bedded and massive texture, light to dark grey, assessed fresh to moderately weathered, generally estimated moderate to strong intact rock strength (R3 to R4). Sandstone represents 5% of what was logged.

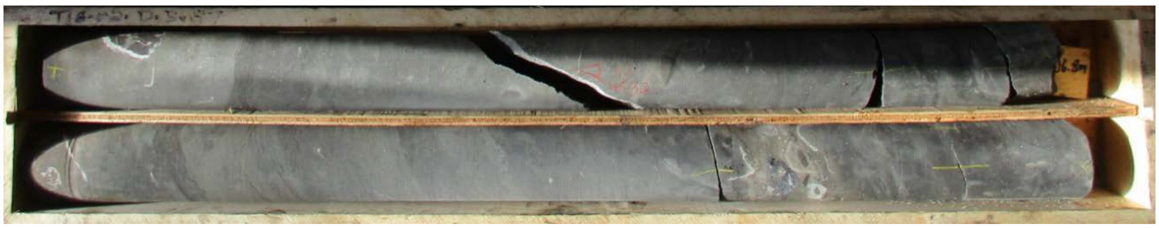


Figure 7-4: Example Core of Sandstone Rock Type

<u>Hazelton Volcanics (HV):</u>

Fine to medium grained, massive and porphyritic texture, pink to dark red, assessed fresh to slightly weathered. The volcanics were only intercepted in one deeper cored exploration drillhole and are expected to be a significant distance from most of the final pit slopes.

Figure 7-5: Example core of Hazelton Volcanics rock type

The logged lithology is plotted on the geotechnical logs in Appendix B and the general coal geology model is shown on the geological sections in Appendix F.

7.2 Rock Strength

7.2.1 Estimated Strengths

Field estimates of intact rock strength were carried out during core logging. The field estimates of intact rock strength are based on the ISRM suggested methods summarized in Table 7-1.

Table 7-1: Summary of ISRM Intact Rock Strength Estimates (Brown, 1982)

Grade	Description	Field Identification	Approx. Range of Unconfined Compressive Strength (MPa)
R0	Extremely Weak Rock	Indented by thumbnail.	0.25 - 1.0
R1	Very Weak Rock	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.	1.0 - 5.0
R2	Weak Rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.	5.0 – 25
R3	Medium Strong Rock	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer.	25 – 50
R4	Strong Rock	Specimen requires more than one blow of geological hammer to fracture it.	50 – 100
R5	Very Strong Rock	Specimen requires many blows of geological hammer to fracture it.	100 - 250
R6	Extremely Strong Rock	Specimen can only be chipped with geological hammer.	>250

Logged field estimates of intact rock strength for MDST, SLST and SST are presented in Figure 7-6. For the MDST, SLST and SST rock types, the strength of the rock was noted to be weaker parallell to bedding. The field estimates of intact rock strength for each geotechnical interval are shown in the downhole plots for each drillhole in Appendix B.

The following observations are made:

- Mudstone (MDST) had an estimated logged strength ranging between 5 and 50 MPa (R2 to R3 rock strength classification)
- Siltstone (SLST) had an estimated logged strength ranging between 5 and 50 MPa (R2 to R3);
- Sandstone (SST) had an estimated logged strength mostly in the 25 to 50 MPa range (R3).

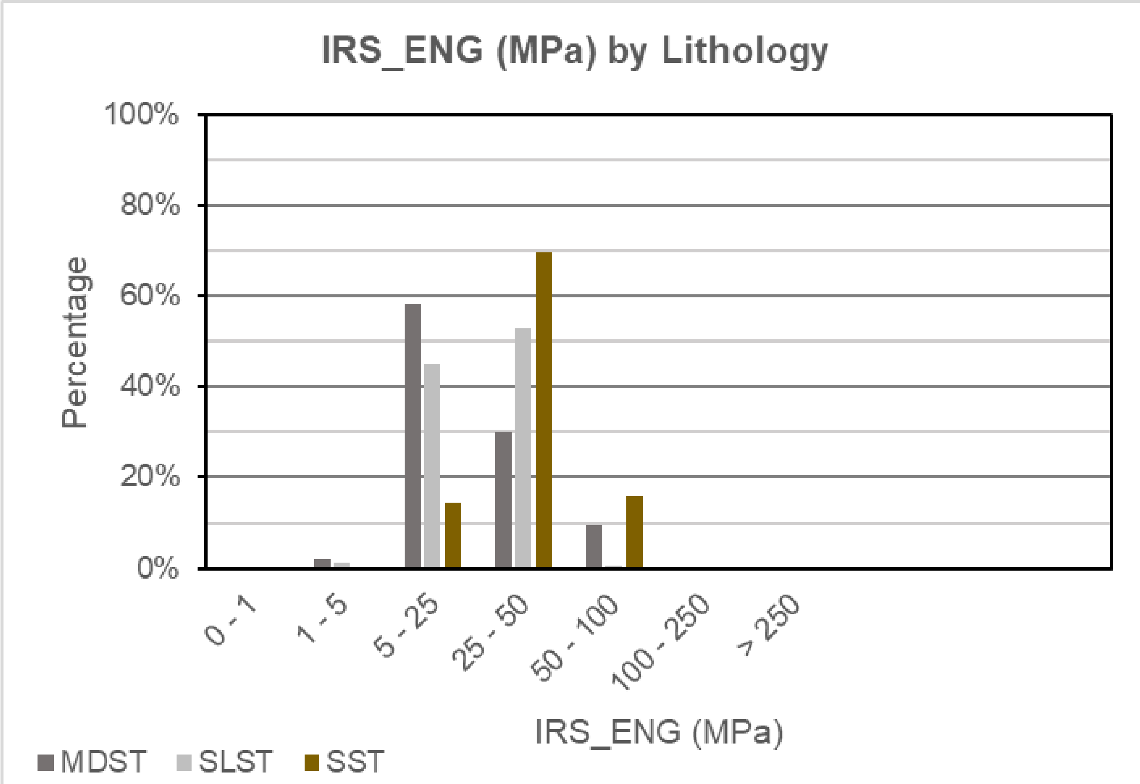


Figure 7-6: Field Estimates of Intact Rock Strength by Rock Type

7.2.2 Point Load Strength Index Testing

Point load strength index test results are summarised in Table 7-2. The results of the point load strength index testing are presented in the geotechnical logging in Appendix C. All diametral tests were conducted parallel to bedding and all axial tests were conducted perpendicular to bedding.

Table 7-2: Summary of Point Load Strength Testing Results

Lithology	Test Type	No. of Valid Tests	Range ($Is_{(50)}$ MPa)		Mean ($Is_{(50)}$ MPa)	Median ($Is_{(50)}$ MPa)	Standard Deviation ($Is_{(50)}$ MPa)
			Min	Max			
MDST	Diametral	30	0.11	1.56	0.55	0.51	0.34
	Axial	19	0.05	2.16	1.17	1.08	0.53
SLST	Diametral	47	0.07	3.74	0.67	0.51	0.60
	Axial	41	0.13	3.51	1.15	1.13	0.72
SST	Diametral	6	0.11	4.29	1.39	0.67	1.52
	Axial	0[1]	-	-	-	-	-

[1]: No appropriate axial samples were available for testing

For the MDST, SLST and SST rock types, the strength of the rock was noted to be weaker parallel to bedding (diametral tests).

7.2.3 UCS Testing

A total of nine Unconfined Compression Strength (UCS) tests were performed on rock core samples collected during the field program. Three samples were selected for additional measurement of Young's Modulus and Poisson's Ratio. Most samples were tested perpendicular to bedding. All rock types were observed to be weaker parallel to bedding. Laboratory tests results are provided in Appendix E and summarised in Table 7-3.

Table 7-3: Summary of 2018 and 2019 UCS Test Results

Drillhole	Depth From (mah)[1]	Depth To (mah)[1]	Rock Type[2]	Dry Density (kg/m^3)	UCS (MPa)	$UCS_{(50)}$ (MPa)[4]	Young's Modulus (GPa)	Poisson's Ratio	Valid Test
T18-02D	122.06	122.42	SLST	2486	25.2	28.8	-	-	Yes
T18-05D	127.5	127.86	MDST	2541	25.8	28.4	-	-	Yes
T18-05D	153.89	154.29	MDST	2614	42.3	46.4	-	-	Yes
T18-05D	172.5	172.95	SLST	2365	~~6.8~~	~~7.5~~	-	-	No[3]
T18-02D	59.97	60.63	MDST	2471	31.1	34.1	3.2	0.06	Yes
T18-05D	54.4	54.81	MDST	2549	52.5	57.7	4.9	0.08	Yes
T18-05D	112.5	112.8	SST	2253	23.5	25.7	2.3	0.21	Yes
T18-02D	66	66.36	MDST	2503	43.9	48.4	-	-	Yes
T18-02D	116.7	117.0	SST	2711	68.3	75.5	-	-	Yes
19-09D	31.2	31.4	SLST	2560	17.9	19.8	-	-	Yes
19-16D	48.7	48.9	SST	2656	48.8	50.1	-	-	Yes
19-16D	57.6	57.9	SLST	2587	27.0	29.6	-	-	Yes
19-16D	61.9	62.1	MDST	2519	40.6	43.8	-	-	Yes
19-17D	72.2	73.2	SLST	2583	~~10.6~~	~~11.7~~	-	-	No[3]
19-17D	45.1	45.4	SST	2609	34.7	38.5	-	-	Yes
19-18D	51.3	51.5	SLST	2778	15.5	16.2	-	-	Yes
19-18D	24.3	24.5	SLST	2593	27.5	30.5	-	-	Yes

[1]: mah = metres along hole, relative to ground surface.

[2]: Rock type logged by Telkwa during sample collection.

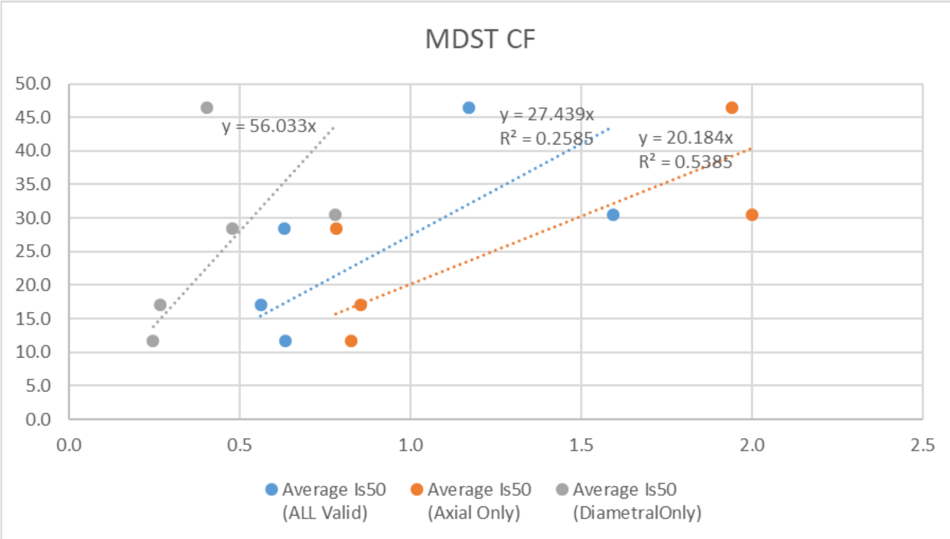
[3]: Lab comments and photos indicate sample had a desiccation crack prior to testing, likely compromising integrity of the sample.

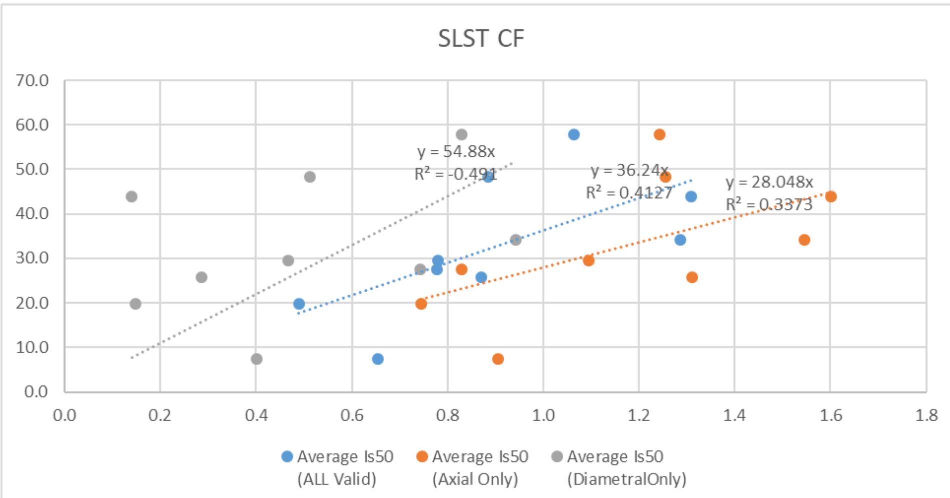
[4]. UCS equivalent for 50 mm specimen calculated using Turk 1986 method

7.2.4 PLT Conversion Factor

The point load test (PLT) data was compared with the UCS testing by means of a conversion factor (CF). The CF was generated by plotting $Is_{(50)}$ values against the tested UCS sample (located within +/- 5 m). The average of the valid axial $Is_{(50)}$ values within 5 m of the UCS test was used to estimate a CF. A linear regression line was fitted for the data, as shown in Figure 7-7. Typically, CF ranges between 20 and 30 and is a site-specific relationship.

As Figure 7-6 shows the UCS and $Is_{(50)}$ correlation for MDST is variable but indicates an overall CF of 27 as an appropriate value. There is not enough UCS tests to make a valid correlation between the PLT and UCS data for the SLSLT and SST rock types. However, the data that was collected indicates the CF is similar to that of the MDST.





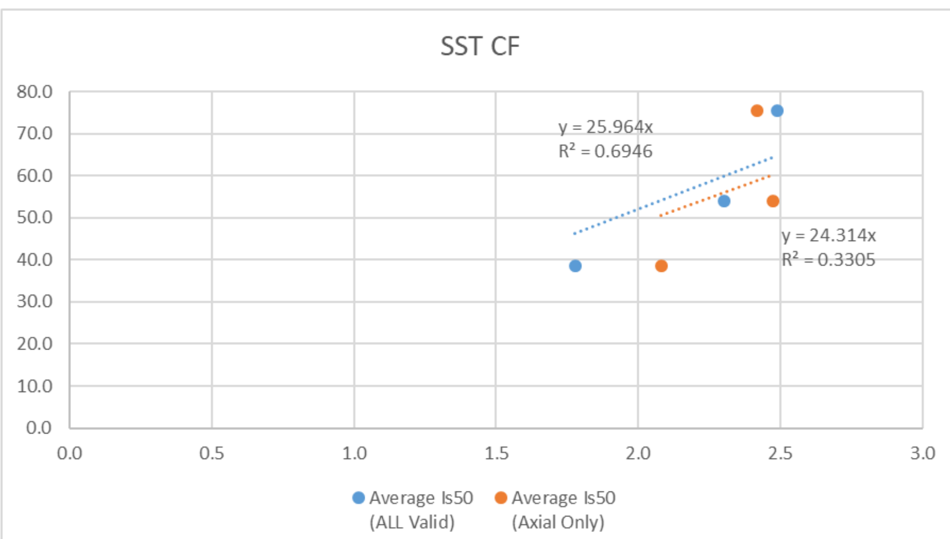


Figure 7-7: $Is_{(50)}$ vs UCS

7.3 Discontinuity Strength

7.3.1 Joint Condition Rating

The joint condition rating (JCR) is used in the RMR_{89} rock mass classification system (Bieniawski, 1989) to describe the small-scale surface characteristics of open discontinuities. A rating is assigned based on the observed discontinuity surface roughness and wall rock alteration, as presented in Table 7-4. The following observations are made:

- Mudstone surface roughness was generally in the 10 to 20 range (slickensided to slightly rough);
- Siltstone surface roughness was generally in the 10 to 20 range (slickensided to slightly rough); and
- Sandstone surface roughness was generally described as slightly rough (20 rating).

Table 7-4: Rating Guide for Joint Condition Rating (Bieniawski, 1989).

Condition of Joints	Rating
Soft gouge >5 mm thick, or joints open >5 mm; continuous joints	0
Slickensided surfaces, or gouge <5 mm thick, or joints open 1–5 mm; continuous joints	10
Slightly rough surfaces, separation <1 mm, soft joint wall rock	20
Rough surfaces, separation <1 mm, hard joint wall rock	25
Very rough surfaces, not continuous, no separation, hard joint wall rock	30

Logged JCR values for MDST, SLST, and SST are presented in Figure 7-8.

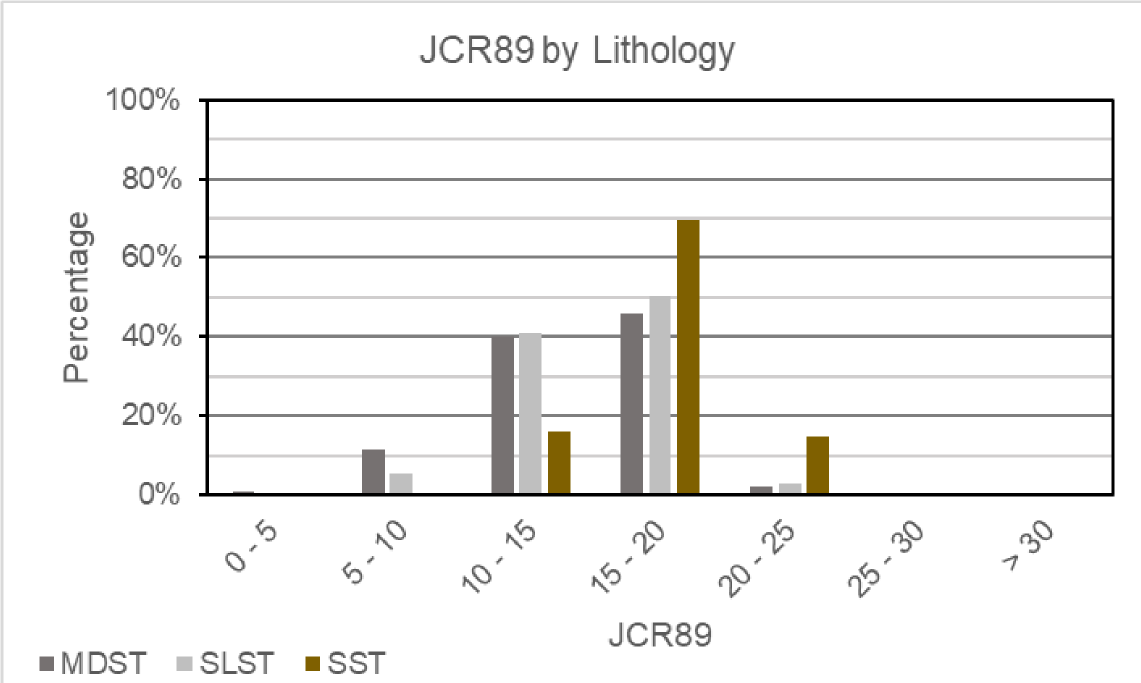


Figure 7-8: Logged JCR by Rock Type

The JCR for each geotechnical interval is shown in the downhole plots for each drillhole in Appendix B.

7.3.2 Direct Shear Testing Results

A total of seven direct shear tests were performed on rock core samples collected during the field program. Laboratory tests results are provided in Appendix E and summarised in Table 7-5. Based upon the logged JCR values, the direct shear test results appear to be on the upper bound side of the roughness range.

Table 7-5: Direct Shear Test Results – Rock

Drillhole	Sample #	Depth From (mah)1	Depth To (mah)1	Rock Type²	Feature type	Logged JCR	Peak Cohesionless		Residual	
							Peak Friction Angle (°)	Peak Cohesion (kPa)	Residual Friction Angle (°)	Residual Apparent Cohesion (kPa)
T18-05D	DSS-129	128.55	128.95	MDST	Joint		31	0	15	0
T18-05D	DSS-153	153.35	153.65	MDST	Joint		31	0	15	67
T18-05D	DSS-156	155.45	155.65	SLST	Bedding		34	0	23	62
T19-09D	35004	33.0	33.3	SST	Bedding		36	0	20	54
T19-16D	35011	67.8	68.0	MDST	Bedding		30	0	32	0
T19-17D	35013	42.8	43.0	SLST	Joint		45	0	38	120
T19-17D	35015	45.4	45.7	SST	Bedding		34	0	33	17

¹: mah = metres along hole, relative to ground surface.

²: Rock type logged by Telkwa during sample collection.

7.4 Rock Mass Classification

A rock mass quality assessment using RMR_{89} rock mass classification system (Bieniawski, 1989) has been prepared for the rocks logged in each drillhole. RMR_{89} values were calculated on a geotechnical interval basis, with each interval assessed based on the actual conditions encountered during the geotechnical logging. Geotechnical logging intervals were selected based on variations in strength, fracture frequency and/or lithology.

The RMR_{89} classification system ranks rock mass quality based on the following five geotechnical parameters:

- *R1* = rating for the strength of intact rock material (rating = 0 to 15);
- *R2* = rating for drill core quality, RQD (rating = 3 to 20);
- *R3* = rating for spacing of joints (rating = 5 to 20);
- *R4* = rating for JCR (rating = 0 to 30); and
- *R5* = rating for groundwater (Jw) (rating = 0 to 15).

The overall rock mass quality is determined by summing the individual rankings as follows.

$$\boldsymbol{RMR_{89}} = R1 + R2 + R3 + R4 + R5$$

The rock mass class as a function of rock mass rating as summarized in Table 7-6.

Table 7-6: Summary of Rock Mass Rating System (Bieniawski, 1989)

Parameter	**Range of Values**						
UCS (MPa) Rating	>250 (15)	100-250 (12)	50-100 (7)	25-50 (4)	5-25 (2)	1-5 (1)	<1 (0)
RQD Rating	90-100% (20)	75-90% (17)	50-75% (13)	25-50% (8)	<25% (3)		
Joint Spacing Rating	>2 m (20)	0.6-2 m (15)	200-600 mm (10)	60-200 mm (8)	<60 mm (5)		
Joint Condition Rating, (JCR)	Very rough No separation Hard wall rock (30)	Slightly rough Separation <1 mm Hard wall rock (25)	Slightly rough Separation<1 mm Soft wall rock (20)	Slickensides, Separation or gouge <5 mm (10)	Soft gouge or Separation >5 mm (0)		
Groundwater (Jw) Rating	Completely Dry (15)	Damp (10)	Moist (7)	Mod. Pressure (4)	Severe (0)		
Total RMR_{89} Value (Sum of Ratings for 5 Items) =							
Rating	100 – 81	80 – 61	60 – 41	40 - 21	20 – 0		
Category	5 – Very Good	4 – Good	3 – Fair	2 - Poor	1 - Very Poor		

Notes: MPa = megapascals; Rating values are shown in parentheses.

The five geotechnical parameters logged and the resulting RMR_{89} for each geotechnical interval are shown in the downhole plots for each drillhole in Appendix B. A histogram of the geotechnical interval RMR_{89} distribution for the 2018 drilling program is shown in Table 7-7.

Table 7-7: Weight Average RMR_{89} Values by Lithology

Lithology	TCR (%)	RQD (%)	IRS_ENG (MPa)	FF/m	JCR_{89}	RMR_{89}	Total Logged Length
MDST	95	80	28	5.5	14	56	226
SLST	98	89	28	3.5	15	58	211
SST	98	97	42	1.0	17	69	38

7.5 Structural Orientation

7.5.1 Televiewer Stereographic Data

Stereographic projections of the orientated core data for the 2019 televiewer surveys were plotted using the Rocscience software DIPS™ (Version 6.0). The lower hemisphere, equal area projection is referenced to true north. In addition, the stereographic projections T18-01D, T18-02D, T18-03D, and T18-05D from the 2018 program are presented from Figure 7-9 to Figure 7-16 for comparison purposes. Downhole geophysical logs prepared by Century are provided in Appendix C.

2019 Drillholes

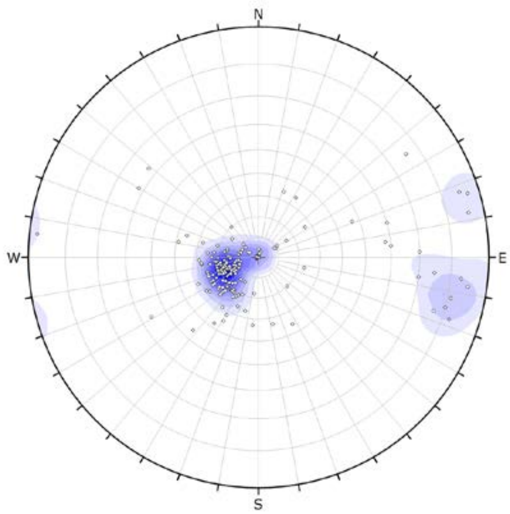


Figure 7-9: Stereographic Projection of ATV data of T19-09D. (Left: All Data; Right: bedding Poles removed to show any other joint concentrations)

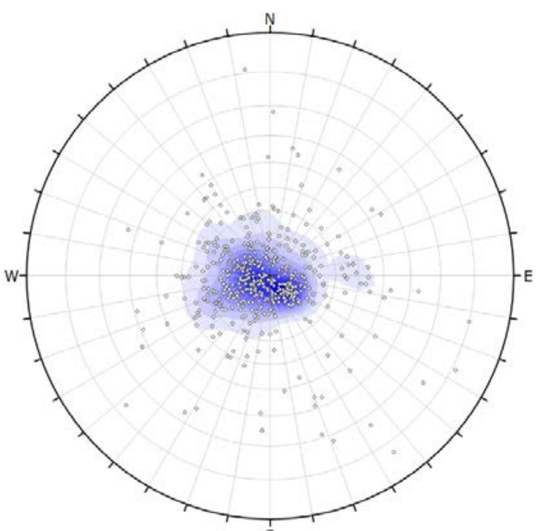


Figure 7-10: Stereographic Projection of ATV data of T19-16D. (Left: All Data; Right: bedding Poles removed to show any other joint concentrations)

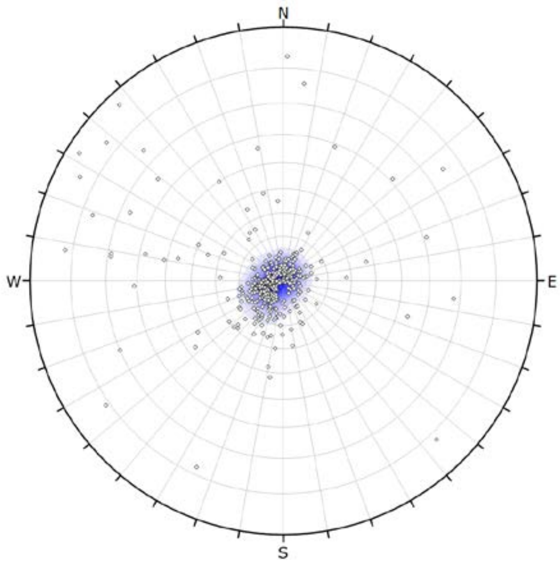


Figure 7-11: Stereographic Projection of ATV data of T19-17. (Left: All Data; Right: bedding Poles removed to show any other joint concentrations)

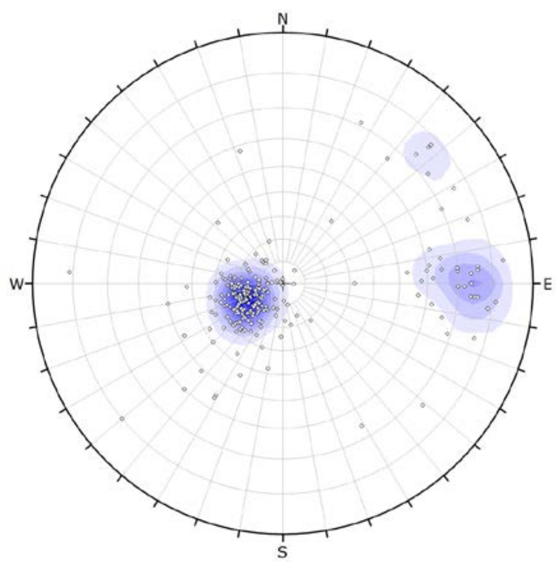


Figure 7-12: Stereographic Projection of ATV data of T19-18D. (Left: All Data; Right: bedding Poles removed to show any other joint concentrations)

2018 Drillholes

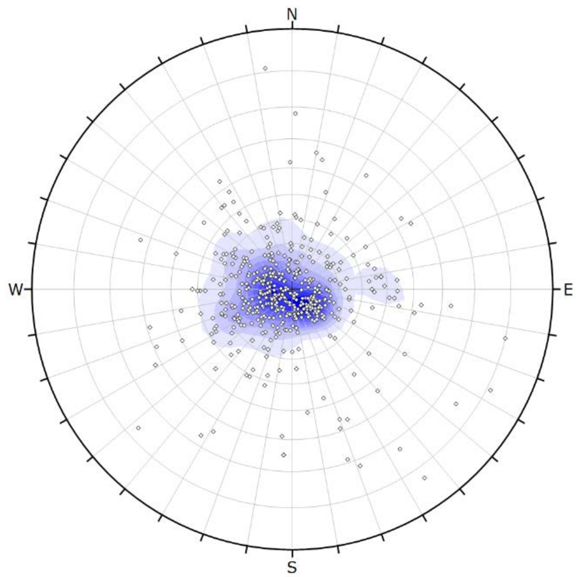


Figure 7-13: Stereographic Projection of ATV data of T18-01D. (Left: All Data; Right: bedding Poles removed to show any other joint concentrations)

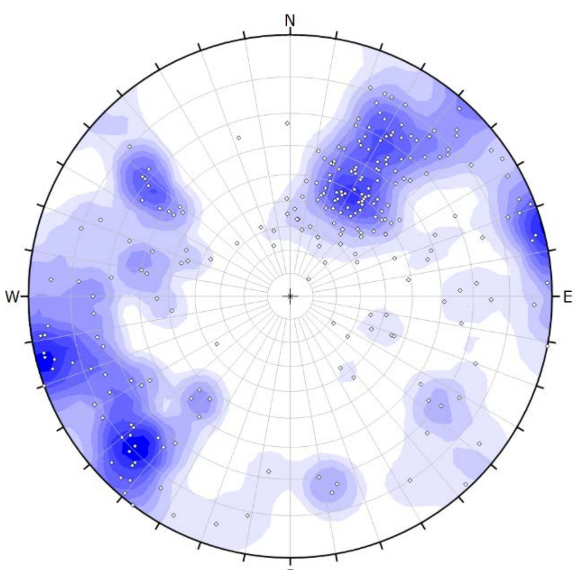


Figure 7-14: Stereographic Projection of ATV data of T18-02D. (Left: All Data; Right: Bedding Poles Removed to show any other joint concentrations)

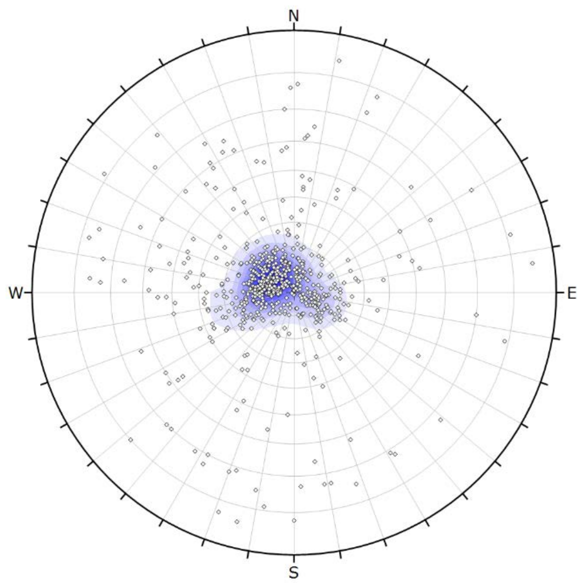


Figure 7-15: Stereographic Projection of ATV data of T18-03D. (Left: All Data; Right: Bedding Poles Removed to show any other joint concentrations)

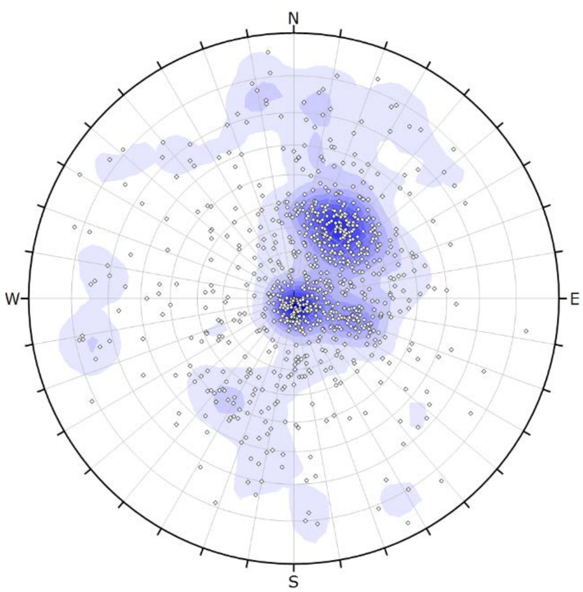


Figure 7-16: Stereographic Projection of ATV data of T18-07D. (Left: All Data; Right: Bedding Poles Removed to show any other joint concentrations)

The following observations can be made from the ATV results:

- Drillholes T19-09, T19-17D, T19-18D, T19-19D, T18-01D, T18-03D:
  – Bedding is typically shallow dipping and corresponds with the west-limb of the deposit.
  – Joint orientations are highly scattered; however, two main orthogonal joint sets can be observed. This includes a steeply, dipping joint striking NNE-SSW and a steeply dipping joint set striking E-W. The verticality of these drillholes results in under sampling of the steep joint sets.
- Drillhole T18-02D and T18-07D:
  – Bedding is moderately dipping at angles between 40 and 60 degrees to the southwest.
  – Two joint sets can be observed, including includes a steeply, dipping joint striking NNW-SSE and a steeply dipping joint set striking E-W. This indicates some rotation of the joint orientations along the east-limb of the deposit.

7.5.2 Major Structures

Major structures that were logged, such as faults or crushed coal/rock, are presented in the downhole plots in Appendix B. The fracture frequency and RMR of logged intervals with major structures reflect their impact on the quality of the rock mass, and the presence of potential major structures. The major structure data from this program should be considered in the development of the 3D structural geology models of the deposit.

8 Conclusions

Based on the results of the 2019 geotechnical soil and rock investigations, the following conclusions can be made:

Soil Investigation:

- The surficial soil materials intercepted in the sonic drillholes and test pit excavations are consistent with the regional interpretation that includes the presence of a wide-spread diamicton till material (Levson et al, 1997).
- The majority of the surficial soils intercepted were described as:
  - A sandy lean clay till (CL). The clay till typically contains silt and fine sand with some gravel. The clayey till was low to medium plasticity and generally stiff to hard. This unit was intercepted in all drillholes and test pits; and
  - A unit within the paleo-channel that is characterized as clayey silty sands (SM or SC) or gravels (GM or GC). These materials are dense to very dense, well graded. The fines component has low to medium plasticity.
- The 2019 soil laboratory test results provide a reasonable characterization of the till and paleo-channel materials and are generally consistent with the 2018 and historical test results.
- The strength testing indicates the fine grain materials are generally very stiff to hard, and the coarse material intercepted was dense to very dense.
- Groundwater was not intercepted during the drilling. Groundwater inflow was observed in one test pit and was related to be a shallow perched system. Standpipe piezometers indicate that the shallow piezometric table is located between 20 m and 40 m within the overburden soils.

Rock Investigation:

- The lithology intercepted in the drilling program correlates with the Skeena group and consisted of mudstones, siltstones, and sandstones with inter-bedded, bituminous coal seams. The Hazelton volcanic group was not intercepted in the diamond drillholes.
- The assessed strengths were generally R3 for the sandstones, R2 to R3 for the siltstones, and R2 to R3 for the mudstones. All rock types were observed to be weaker parallel to bedding. Laboratory intact rock testing work supported the field strength estimates from geotechnical logging.
- RMR_{89} average is 56 for the mudstones, 58 for the siltstones and 69 for the sandstones. An RMR_{89} was not assigned to the coal and automatically assigned a 20 as the classification use is limited for very weak rocks. .
- Discontinuities captured by the acoustic televiewer surveys indicate that bedding orientations are similar to the 3D Tenas geological model (Telkwa, 2018). Shallow east-dipping bedding exists on the west side of the deposit, and moderately to steeply west dipping on the east side. Two major steeply dipping joints sets have also been identified.

- Major structures, such as faults or crushed coal/rock were encountered during the drilling program. The major structure data from this program should be incorporated into the Tenas deposit 3D structural geology model.

8.1 Recommendations

The collection of geotechnical and orientation data from the diamond drillholes indicated the presence of major structures. The orientation and character of these faults should be compared with the existing 3D fault model developed by Telkwa. The fault model should be regularly updated with new drilling information and mapping data from the exposed bench faces during excavation. The interaction of the faults on the stability of the pit slopes will be a critical aspect to the ongoing monitoring and review of expected stability conditions. Similarly, the joint data should be continually mapped during excavation to confirm or refine the orientations used in design work.

The results of the soil geotechnical investigations should be reviewed on an ongoing basis as the detailed design work is conducted. These reviews should identify the requirements for any additional data to be collected to reduce uncertainty in design and/or geotechnical risks during operations.

9 Closure

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Staff Consultant - Mining Rock Mechanics

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Senior Consultant – Mining Rock Mechanics

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