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Appendix C

Acid Rock Drainage and Metal Leaching (ARD/ML) Assessment Report

Wanipigow Sand Extraction Project

Acid Rock Drainage and Metal Leaching (ARD/ML) Assessment

Canadian Premium Sands Inc.

Project number: 60640258

November 02, 2022

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1. Introduction

1.1 Initiation

The Wanipigow Sand Extraction Project (Project) is a proposed open-pit silica sand quarry located near Seymourville, Manitoba. Canadian Premium Sand Inc. (CPS) plans to develop this project to extract high quality silica sand from the sandstone unit of the Winnipeg Formation to produce glass. The development of the project will include the excavation of overburden to access the silica sand in the Lower Black Island subunit (LBI).

The Upper Black Island (UBI), LBI and Black Shale (BS) units of the Winnipeg Formation were deposited in a coastal marine environment and may contain pyrite and trace elements in concentrations more than a hundred times their average crustal abundance (Krauskopf, 1955). There is a concern that development works may produce acidic, metal-rich waters that could potentially impact the surrounding environment.

AECOM Canada Ltd. (AECOM) was retained by CPS to develop an Acid Rock Drainage (ARD) and Metal Leaching (ML) assessment for the Project to understand the potential of ARD/ML associated with the formations found at former proposed quarry site. A detailed work plan outlining the characterization plan was provided on November 21, 2018 and approved for implementation. That plan focused the ARD/ML characterization on the initial quarry site located in the western part of the property (i.e., pyritic black shale), and thus the majority of the samples analyzed were collected that that area. The mine plan has since been updated, and mining is now focused on an area of the property that does not contain Pyritic Black Shale based on exploration drilling results to date.

This report outlines the results of the geochemical characterization conducted in 2019 and provides a preliminary assessment of the potential ARD/ML risk in the glass sand resource area based on the very limited geochemical data (one sample) and geological and borehole information available.

1.2 Background

CPS is proposing to extract high quality silica sand from the Lake Winnipeg Formation, which is the on-shore extension of the Historical Black Island silica sand deposit. The Project is located on the east shore of Lake Winnipeg, approximately 160 km northeast of Winnipeg, Manitoba and approximately 67 km from the Town of Powerview-Pine Falls (**Figure 1)**. The proposed quarry site was moved from the initial proposed site (Black Shale area) to an area located further northeast (**Figure 2**).

An open-pit quarry operation will be developed, with progressive annual reclamation of quarry blocks where sand extraction has been completed. The average annual quarry area is approximately 5 hectares (ha), and the depth of the LBI in the quarry varies from 1 to 12 m with an average of 10.5 m. Annual reclamation of each quarry cell will occur as mining is completed in each block or cell. The Project will have a lifespan of approximately 35 years, with an estimated production of approximately 300,000 tonnes (t) of pure silica sand product per year.

Key components of the Project will include:

- An active open-pit sand quarry during each year of operation, including progressive annual site reclamation of spent quarries;
- Silica sand production processing, including a fully enclosed sand wash facility;
- Ancillary facilities, including portable office and storage buildings; and
- Access roads.

In 2018, APEX Geoscience (APEX) was retained by CPS to complete exploratory drilling activities to further define the site-specific locations, quantities and quality of the silica sand deposits within the CPS quarry lease areas. A total of 75 holes were drilled throughout the Project area. Black shales with observed pyritic nodules were identified in 12 drill cores located at the western boundary of the Project area, within the geographic boundaries of the Incorporated Community of Seymourville. Boreholes drilled in the current proposed quarry site in the northern part of the Project site did not intersect the black shale unit as the BS completely pinches out in this area (APEX, 2019). The boreholes drilled immediately west of the quarry area also did not intersect any black shale. The primary lithologies identified from reviewing the borehole logs within the sand resource area were the overburden glaciofluvial deposit and LBI sand.

1.3 Previous Geochemical Characterization

Although extensive geological exploration drilling has been conducted in the Project area, an ARD/ML geochemical characterization of the geological units that will be excavated or disturbed during the Project had not previously been completed.

The Winnipeg Formation in Manitoba contains some of the purest silica sands in North America. The high-purity silica sand of the Winnipeg Formation has many potential industrial uses. Historically, the sand has been quarried from Black Island to produce glass and processed in Winnipeg and later Selkirk. However, BS exposed in the former Selkirk Silica quarry on Black Island in Lake Winnipeg were classified as “metalliferous” BS, with elevated cobalt, lead, silver, and arsenic concentrations (Fedikow, 1995).

Fedikow (1995) conducted a geochemical study of the black shales and associated rocks at the former Selkirk Silica quarry. A total of five (5) samples including four (4) BS and one (1) limonitic sandstone were collected from the northeast corner of the quarry and submitted for whole rock and total metals analysis. The total metals analysis results indicated that the black shales on Black Island were enriched in heavy metals (i.e., arsenic, cobalt, copper, molybdenum and lead) and other trace elements. ARD/ML analysis such as Acid Base Accounting (ABA) or shake flask extraction (SFE) were not conducted.

1.4 Objectives

The objectives of this ARD/ML assessment are:

- Evaluate the potential for the material excavated or disturbed during the development and operation of the project to generate ARD/ML; and
- Collect sufficient geochemical data to support the development of operational management strategies and material handling options for potentially acid generating (PAG) or metal leaching (ML) materials.

1.5 Scope of Work

As outlined in AECOM’s March 2019 proposal, the ARD/ML assessment program at the Project area was designed to determine the potential for ARD/ML associated with geological formations in the pyritic shale area, and identify means to mitigate risks associated with ARD/ML by:

- Reviewing and evaluating background information and the results of previous exploration programs (i.e., drill core logs and reports) to identify parameters likely significant with respect to the ARD/ML;
- Conducting a site reconnaissance by a qualified AECOM geologist to visually examine the drill cores to confirm the lithological descriptions on the logs, and to select representative core samples for ARD/ML tests; and
- Compiling data and interpret laboratory results and characterize the geochemistry of the lithological units.

The methodology of assessment implemented herein is consistent with current industry standard and best practice including Price (1997, 2009) and INAP (2018).

2. Geology

2.1 Regional Geology

The Winnipeg Formation is an extensive formation in the Williston Basin, spanning across southern and central Manitoba, west into eastern and central Saskatchewan, and south into North Dakota, South Dakota, Montana and Wyoming (Ferguson et. al., 2007). The Winnipeg Formation was deposited during the Middle Ordovician, lies unconformably over Lower Ordovician-Cambrian sediments or Precambrian basement, and is conformably overlain by the carbonate rocks of the Red River Formation (Bitney, 1983). The Winnipeg Formation primarily consists of the upper black to dark grey shale and the basal sandstone, indicating a major marine transgressive cycle in the Williston Basin during the mid- to late-Ordovician (Vigrass, 1971).

The Winnipeg Formation is further subdivided into upper and lower units (Vigrass, 1971). During the early stage of the transgression, the lower unit was deposited in relatively shallow marine conditions, and thus is composed primarily of sandstone. The upper unit was deposited in deeper marine conditions, evident by the presence of sandstones to mudstones (Vigrass, 1971). Across the region, the Winnipeg Formation ranges in thickness up to 60m and in composition ranging from > 90% sand to >90% shale (Watson 1985).

2.2 Surficial Geology

The Winnipeg Formation is overlain by unconsolidated Pleistocene ground moraine that has a variable thickness and can be more than 10 m thick. The Project area has been subjected to pre-glacial and/or glacial erosion that has carved large depressions and hollows into the Winnipeg Formation. The resulting depressions and hollows have subsequently been filled by glacially derived overburden. The sediments include tills and glaciofluvial sediments deposited during the Wisconsinan Glaciation (Ferguson et. al., 2007).

2.3 Site Geology

The Project is located on the same silica sand exposed on Black Island in Lake Winnipeg. High proportions of sand are present in the formation in the Lake Winnipeg area. The Winnipeg Formation appears to be either flat-lying or gently dipping to the west in the Project area.

The Black Island silica sand quarry exhibits the best exposure of the Winnipeg Formation in Manitoba. Two major lithological units were encountered on Black Island and include a lower sandstone unit and upper pyritic black shale. The sandstone/interbedded shale lithology is part of the Black Island member of the Ordovician-age Winnipeg Formation. The sandstone is uncommonly calcareous, composed of well-rounded to rounded, equant, coarse to fine grained quartz grains (Lapenskie, 2016). The shale is generally bedded or laminated, and sulphide staining is visible below the contact between the lower sandstone and upper shale. In places, the shale is composed of up to 50% pyrite nodules, which are rounded, equant to elongate, concentrically layered, and 0.5 -1.0 millimetre (mm) in diameter (Lapenskie, 2016).

Based on the review of the exploration drill cores (APEX, 2019), a description of the main lithological units identified at the Project area is presented in **Table A.**

Table A: Description of Lithologies in Project Area

Geological Unit	Lithology	Description
Overburden	Surficial mixture of organic matter, sand, gravel and silt/clay	This unit is generally 0-3.5 m thick, and extends up to 6 m bgs; fine to medium sand mixed with up to 30-40% of clay/silt; occasional pebble clasts; light to dark grey color
Winnipeg Formation (sand: Upper Black Island)	Sandstone and/or loose fine sand	Brown grey to grey locally rust coloured with thickness up to 09 m and an approximate average of 4.6 m. Weakly cemented in spots but loose overall.
Winnipeg Formation (shale/silt)	Black shale	Laminated or layered shale varying in thickness from 0.5 m to 2.5 m; clay/silt layers alternating with fine sand layers, weak to well consolidated; dark grey to black color; pyrite nodules are observed at some locations. Occurs mainly in western part of the property.
Winnipeg Formation (sand: Lower Black Island)	Sandstone and/or loose fine sand	Weakly consolidated or unconsolidated fine to medium sand; thickness varies with location, from 6 m to 12 m; well-rounded to rounded; light grey to brown color; if black shale is present, yellow brown staining is observed in underlying sand unit, suspect iron-oxides
Pre-Cambrian Basement	Greenstone	Uniformly weathered/crystalline bright green coarse grained greenstone with patches of white-grey clay/kaolinite

3. Methodology

3.1 Sample Collection, Selection and Description

Sample selection was planned to be representative of the spatial distribution of the black shale found in the initially proposed quarry location. AECOM reviewed the borehole logs from 75 drill core locations completed in 2018 and selected samples with the potential to produce ARD/ML. Bedrock and overburden samples of approximately 2 kg each were collected from core boxes stored in Seymourville, MN. Rock samples were placed in labelled plastic bags and transported to SGS Canada Inc. in Burnaby, BC for geochemical analysis. The sample locations are presented in **Figure 3**.

A total of 12 bedrock and overburden samples were collected from for geochemical analysis. Although the BS unit associated with higher potential for sulphide mineralization was sampled in higher density, all geological units/lithology present in the area were sampled and characterized as part of the laboratory analytical program.

Six (6) samples were collected from the BS unit, 3 samples were collected from the sand unit underlying the BS unit and 3 from the sand outside of the BS unit. The BS typically had a characteristic black or dark grey color with isolated rounded pyrite nodules observed. One (1) of the six (6) shale samples (i.e., sample CPS18-004A_6-7.5m) was a grey shale composed of a mixture of sand and shale. Three (3) sand samples were also collected from the sand underlying the BS or overburden within the Pyritic Black Shale Zone. They generally exhibited light grey to brown and orange color, which was indicative of the staining from the overlying shale. The purpose of collecting sand samples underlying the BS was to characterize the impact of seepage from the BS into the underlying sand.

In addition, three (3) samples, including one sand sample from the current proposed site, were collected from the Winnipeg Sand where no BS was observed. One sample (i.e., CPS18-068_12.6-15m) was adjacent to the Pyritic Black Shale boundary, and other two samples were located distant from the Pyritic Black Shale Zone providing background sand composition. Only one sand sample (i.e., CPS18-024_7.5-9.0m) was collected from the sand resource. Detailed sample descriptions and classifications are presented in **Table 3-1**.

3.2 Laboratory Analysis

A total of 12 samples were submitted to SGS Inc. for ABA, elemental analysis, mineralogy by X-day diffraction (XRD) and SFE testing. These analytical methods are briefly described below.

3.2.1 Mineralogy and X-ray Diffraction

Qualitative x-ray powder diffraction was used to determine the mineralogical composition of the rock samples. Step-scan X-ray powder-diffraction data were collected over a range 3-80°2θ with one second step time using Co radiation, on a Bruker AXS D8 Advance diffractometer equipped with 0.02°divergence slit. The long fine-focus Co X-ray tube was operated at 35 kV and 40 mA.

The X-ray diffractograms were analyzed using the PDF2/PDF4 powder diffraction database published by the International Centre for Diffraction Data (ICDD) and Search-Match software DiffracPlus Eva and Topas software. The Rietveld analysis allows quantitative measurement of the abundance of mineral phases, and normalized mineral quantities to 100%. The mineral phase detection limits of the XRD ranged from 0.5% to 2%, which are strongly dependent on crystallinity, crystal structure and preferred orientation. It should be noted that the XRD cannot identify amorphous phases (i.e., iron oxyhydroxide), and therefore semi-crystalline and or secondary minerals may not be fully represented in the XRD results.

For values below the detection limit of 0.5%, they were derived from refinement calculations. Zero values indicate that the mineral was included in the refinement calculations, but the calculated concentration was less than 0.05%.

3.2.2 Total Recoverable Elemental Analysis

To determine “whole rock” concentrations of metals, samples were subjected to bulk geochemical analysis after digestion with *aqua regia* (HCl + HNO_3). This digestion is routinely used for analysis of trace metals to allow quantification of the reservoir of leachable metals. It also allows for comparison of concentrations of selected metals with average crustal abundance data (Price 1997) for similar rock types. The digestion does not completely dissolve resistant minerals such as quartz, spinels, zircon, rutile, ilmenite, chromite, or some silicates. Thus, the concentrations of certain major rock-forming constituents including aluminum, calcium, magnesium, potassium, sodium, and iron may be under-reported by this method. The same is true for more weathering-resistant forms of zirconium, chromium, uranium, thorium, and vanadium.

3.2.3 Acid Base Accounting

Acid-Base Accounting (ABA) is a series of laboratory tests designed to estimate a rock’s acidification potential (AP) and neutralization potential (NP). The AP of a rock is the total capacity of the rock to generate acid if all of its acid generating minerals react to completion during weathering. Similar to the definition of AP, the NP of a rock is its total capacity to neutralize acid if all its buffering minerals react to completion. Both AP and NP are expressed in units of kilogram of calcium carbonate equivalent per ton of material (kg $CaCO_3$/t) to allow direct comparisons. Corrections must be made when the respective minerals are not all pyrite or calcite. For this project, a correction for the presence of siderite ($FeCO_3$) was used. Hydrogen peroxide was added prior to the back titration step to ensure complete oxidation and hydrolysis of iron and manganese carbonates thereby reducing the likelihood of overestimating the NP.

The following tests were included in the ABA analysis:

3.2.3.1 Paste pH

A pulverized sample aliquot is mixed with reagent water and the pH of the resulting saturated paste is measured to assess the acid generating potential of the sample.

3.2.3.2 Neutralization Potential

A fizz test is employed to provide a guide to the amount of acid to be initially added to the test. NP is determined by treating a sample of known weight with an excess of hydrochloric acid at ambient temperatures for approximately 24 hours. Acid is added as required during the acid treatment stage to maintain sufficient acidity for reaction. After treatment, the unconsumed acid is titrated with a base to pH 8.3 to allow calculation of the calcium carbonate equivalent of the acid consumed.

3.2.3.3 Sulphate Sulphur (HCl Extractable)

Sulphate sulphur is extracted from the sample with dilute hydrochloric acid. The sulphate sulphur is determined using a Konelab Analyzer. Most sulphate containing minerals are soluble in hydrochloric acid (HCl), but pyritic and organic sulphur species are not. Also, most sulphate minerals including gypsum and anhydrite do not generate acid. However, other minerals such as melanterite ($FeSO_4 \cdot 7H_2O$) release acid upon dissolution. Mineralogical analysis is used to distinguish between acid generating and non-acid generating sulphate minerals.

3.2.3.4 Sulphide Sulphur (HNO_3 extractable)

The residue from the HCl extraction used to determine sulphate sulphur is subsequently extracted using nitric acid (HNO_3). This nitric acid extract is boiled to dryness and dissolved into HCl to arrive at an extract with the same matrix as the HCl extract (approximately 5% HCl).

3.2.3.5 Acidification Potential (AP)

To assess the samples acid generation capacity, its AP is determined from the calculated sulphide sulphur analysis, assuming (1) total conversion of sulphide to sulphate, and (2) production of 4 moles of H^+ per mole of pyrite oxidized. A conversion factor of 31.25 is used to convert percent contained sulphur to kg $CaCO_3$ equivalent per tonne of material (kg $CaCO_3$/t).

3.2.3.6 Carbonate Carbon Content

To estimate the reactive NP due to presence of carbonate minerals.

3.2.3.7 Neutralization Potential Ratio (NPR = NP/AP)

Most jurisdictions have an NPR criterion for classifying a sample as Non-PAG or PAG. Price (2009) recommends the classification shown in **Table B**:

Table B summarizes the acid generation potential criteria used in this assessment (Price, 2009). The criteria called neutralization potential ratio (NPR) is expressed as the ratio of neutralization potential (NP) and acid potential (AP) calculated using sulphide-sulphur content.

Table B: Acid Generation Potential Classification Criteria (Price, 2009)

Potential For ARD	Initial Screening Criteria	Comments
Likely	NPR <1	Likely acid generating, unless sulphide minerals are non-reactive (very low rates of sulphide oxidation)
Uncertain	1<NPR<2	Further assessment of geochemical data required to estimate maximum NPR value still capable of generating ARD.
Non-Acid Generating	NPR >2	Not potentially acid generating unless significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficiently reactive NP.

3.2.3.8 Net Neutralization Potential (NNP = NP – AP)

A sample is classified as PAG if its acid generation potential exceeds its acid neutralization capacity such that the NNP is a negative number. If a positive NNP value is less than +20 kg $CaCO_3$/t, a sample's AP is typically considered uncertain. Price (2009) does not recommend using NNP in characterizing a sample's acid producing potential. However, it can be useful in designing mitigation measures.

3.2.4 Shake Flask Extraction

The SFE is used to identify parameters potentially prone to leaching in the field by meteoric water. It provides an indication of readily soluble elements in the sample. Samples are combined with deionized water at a 3:1 water to solids ratio by weight and continuously shaken for 24 hours. Gentle agitation is provided to ensure continuous exposure of all surfaces and mixing of the rinse solution. Twenty-four hours is a nominal residence time. The leachate solution is extracted, filtrated and analyzed for general parameters (pH, acidity, alkalinity, electrical conductivity (EC), redox potential and sulphate) and dissolved metals by inductively coupled plasma mass spectrometry (ICP-MS). A distilled water blank is carried through the procedure and analyzed for pH and EC as a control sample.

3.2.5 Quality Assurance and Quality Control (QA/QC)

Laboratory results were evaluated for the following quality assurance/quality control (QA/QC) criteria to assess the reliability of the results:

- Sulphate-sulphur results are less than or equal to total sulphur results, within a 30 % margin.
- For each fizz rating, NP results do not exceed the maximum indicated by acid strength and volume guidelines presented in Price (2009).
- Negative NP values have paste pH values below 5.
- Duplicate sample values have relative percent difference (RPD) values less than 30% for metals for results more than five times of the detection limit.
- Each analysis batch includes control reference materials and results are within the tolerance ranges established by the laboratory.

4. Results and Discussion

The results of the laboratory testing were assessed to determine the types of minerals present in the samples (XRD), the concentrations of elements relative to average crustal abundance (Total Recoverable Elemental Analysis), and the potential for rock types to generate ARD (ABA) and ML under simulated field conditions (SFE). The results are discussed in the subsequent sections and laboratory reports are provided in **Appendix A**.

4.1 Mineralogy

Table 4-1 presents the results of the XRD analysis. The results represent the relative amounts of crystalline phases normalized to 100%. Key mineralogy results are summarized as follows:

- **Black Shale**: The most dominant minerals in the black shale samples were (from highest to lowest abundance): Quartz (54.1 % - 67.7 %, median 60 %), microcline (12.7 % - 23.3 %, median 17.1 %), pyrite (4.2 % - 18 %, median 8.1 %), albite (0.7 % - 9.1 %, median 2.8 %), muscovite (2 % - 3.6 %, median 2.3%), diopside (0.8 %- 1 %, median 0.9 %), chlorite (<0.05 % - 2.5 %, median 1 %), actinolite (<0.05 % - 3.7 %, median 3.2 %), kaolinite (<0.05 % - 2.5 %, median 2 %), calcite (<0.05 % - 0.5 %, median 0.4 %) and ankerite (<0.05 % - 0.6 %, median 0.3 %). Crystalline gypsum was identified in one of the samples (1.9 %).

  CPS18-004A_6-7.5m is a mixture of black shale and sand, and it exhibited a slightly different mineralogy compared to the other Black Shale samples. This sample is characterized by lower quartz (45.7 %) and pyrite (0.9 %) content, and higher microcline (39.6 %) content. Crystalline gypsum (0.9 %) was also identified in this sample.
- **Sand Underlying the Black Shale/Overburden**: The most dominant minerals in the sand samples underlying the black shale were, in order of abundance: Quartz (56.3 % - 92.2 %, median 86.9 %), microcline (2.3 % - 8.9 %, median 3.6 %), muscovite (2 % - 2.1 %, median 2.0 %), albite (1 % - 25.2 %, median 1.4 %), chlorite (0.9 % - 2.1 %, median 1.1 %), diopside (0.7 %- 2.1 %, median 0.7 %), pyrite (0.1 % - 0.7 %, median 0.5 %). Actinolite and calcite were not detected in these samples.
- **Sand without Black Shale Observed**: The most dominant minerals in the sand samples not associated with black shale were (from highest to lowest abundance): Quartz (35.4 % - 83.9 %, median 67.5 %), albite (0.9 % - 38.7 %, median 15.6 %), microcline (1.6 % - 12.8 %, median 6.3 %), muscovite (1.8 % - 3.3 %, median 2.3 %), kaolinite (<0.05 % - 6.6 %, median 4 %), diopside (1 %- 3.3 %, median 1.1 %), chlorite (0.8 % - 2.9 %, median 1.0 %), actinolite (<0.05 % - 3.2 %, median 2.6%), and calcite (<0.05 % - 1 %, median 0.8 %), pyrite (0.1 % - 0.4

%, median 0.2 %). Calcite content in this sample group was slightly higher than pyrite content. The sample collected from the sand resource consist predominantly of quartz (83.9 %) and aluminosilicates (14.8 %), with trace pyrite (0.1 %). Aside from the shale samples, gypsum was only detected in this sample, indicating ongoing or previous weathering. This sample did not contain any carbonates but contained the highest kaolinite level of all samples.

Overall, pyrite is the primary sulphide mineral and detected in all collected samples. BS samples generally had the highest amount of pyrite (i.e., 4.2 % - 18 %, median 8.1 %). Pyrite in the Winnipeg Sand underlying the Black Shale was also elevated, and ranged from 0.1% to 0.7%, with a mean value of 0.5%. The sand collected from outside the inferred BS Zone had the lowest pyrite concentrations (i.e., 0.1 % to 0.4 %) with the lowest being in sand from the sand resource area.

Carbonate minerals present in the samples generally provide readily available neutralization potential. Calcite was present in seven (7) out of 12 samples. However, the abundance of calcite was low, generally below the detection limit of 0.5 %. The highest abundance of calcite (i.e., 1 %) was observed in Winnipeg Sand CPS18-068_12.6-15m, which is located outside of the Pyritic Black Shale Zone. The low calcite content suggests low readily available neutralizing capacity. This indicates that reactive aluminosilicates such as chlorite, actinolite, lizardite and diopside will play a key role in controlling the potential for acid release. These minerals may contribute a significant fraction of the acid neutralization potential, albeit at a slower rate and to a lesser degree than calcite.

Ankerite ($CaFe(CO_3)_2$), a calcium and iron carbonate mineral, was the next most abundant carbonate mineral in six (6) out of 12 samples. The abundance of ankerite was between 0.2 % and 0.6 %. Ankerite contains iron, and therefore is net neutral with respect to NP (Morin and Hutt, 1997). The reason is that the oxidation of Fe (II) to Fe (III) and subsequent hydrolysis of Fe (III) generate the same amount of acidity that was consumed during the dissolution of the mineral (Jambor et al., 2003). Kutnahorite, a calcium and manganese carbonate, was also identified in two (2) out of 12 samples (0.7 % and 0.8 %, respectively). Dissolution of kutnahorite provides lower NP compared to calcite. As with iron carbonates, manganese carbonates are also considered net neutral with respect to NP under oxidizing neutral pH conditions. Under reducing conditions, reduced iron and manganese species are favored and ankerite and kutnahorite may contribute to the overall buffering capacity of the samples.

4.2 Total Recoverable Elemental Analysis

Table 4-2 presents the results of the total recoverable elemental analysis. The table shows the concentrations of a number of constituents from the *aqua regia* digestion as well as the average crustal abundances of those constituents in sandstone, shale, and black shale. The sandstone and shale compositions are from a compilation by Price (1997). The black shale compositions are from a compilation by Vine and Tourtelot (1970), which provides statistical data for black shales from 20 sets of samples collected from a wide variety of geological deposition environments. In most cases, the black shales were more enriched in heavy metals than shale and sandstone. To estimate element enrichment in the samples, a screening criterion was developed by multiplying the crustal abundance values by a factor of five. A summary of total metals analyses and crustal abundance exceedances is provided in **Table C.** Parameters presented in **Table** C were selected based on the range of total recoverable metal concentrations, and metals known to typically occur in association with the BS.

Table C: Summary of Whole Rock Trace Metal Analyses and Crustal Abundance Exceedances

Total Metal (ppm)		Pyritic Black Shale		Sand Underlying Black Shale/Overburden		Sand without Black Shale Observed	
	No.[1]	6		3		3	
	Unit	Range (Median)	n(Ex)[2]	Range (Median)	n(Ex)[2]	Range (Median)	n(Ex)[2]
Antimony	ppm	1.59-31.9 (11.3)	83%	0.3-0.79 (0.4)	100%	0.17-0.64 (0.4)	67%
Arsenic	ppm	4-73 (37)	17%	3-4 (3.5)	0%	2-3(2.5)	0%
Cadmium	ppm	0.11-0.27 (0.16)	17%	0.01-0.02 (0.015)	0%	0.02	0%
Chromium	ppm	105-181 (156)	0%	111-140 (124)	0%	48-125 (72)	0%
Cobalt	ppm	16-148 (59)	83%	5.8-10.6 (9.7)	100%	1.9-5 (4.3)	100%
Copper	ppm	46-316 (166)	33%	11.4-21.6 (17.5)	100%	14.9-17.7 (15.5)	100%
Iron	%	0.87-12 (5.1)	17%	0.58-1.43 (0.61)	0%	0.16-1.03 (0.92)	0%
Lead	ppm	11-153 (68)	33%	1.6-5.8 (5.3)	0%	2-7.4 (2.2)	0%
Manganese	ppm	20-133 (84)	0%	16-131 (52)	67%	11-108 (85)	67%
Mercury	ppm	0.17-1.1 (0.42)	17%	0.02-0.22 (0.07)	33%	0.1-0.15 (0.12)	0%
Molybdenum	ppm	2.3-6.8 (4.8)	17%	2.27-3.22 (2.95)	100%	0.57-2.78 (1.42)	67%
Nickel	ppm	26-322 (97)	50%	11-78 (17)	100%	8-42 (12)	67%
Selenium[3]	ppm	<1-2 (1.5)	0%	<1	0%	<1	0%
Silver	ppm	0.21-7.3 (2.1)	100%	0.06-0.14 (0.09)	100%	0.03-0.14 (0.03)	33%
Sulphur	%	0.84 - >5 (4.4%)	100%	0.03-0.52 (0.29)	67%	0.01 – 0.46 (0.01)	33%
Zinc	ppm	6-75 (9.5)	0%	4-15 (8)	0%	2-11 (9)	0%

***Notes**:*

1: Total number of samples

2: Percentage of samples with concentrations in excess of the screening criteria; Detection limits above the applicable criteria are not accounted for in the exceedances

3: The detection limit for selenium was above the crustal abundance criteria

As indicated in **Table C**, antimony, cobalt, molybdenum, nickel, silver, and sulphur concentrations were most elevated in the BS samples, exceeding the screening criteria by 50% or more. Arsenic, copper, iron, lead, manganese, mercury, and selenium concentrations were also elevated, but generally exceeded the screening criteria by less than 33%. Selenium concentrations were below their lower limit of detection in 11 out of 12 samples, although the detection limit was higher than the screening criteria. Cobalt and lead concentrations were elevated and exceeded the criteria from both Price (1997) and Vine and Tourtelot (1970) in two (2) BS samples (CPS18-012_9-10.5m and CPS18-074_8.5-9.9m). Sulphur contents in these two samples were both greater than 5%, indicating the increased metal concentrations in these two black shale samples are associated with sulphide minerals (i.e., pyrite).

Antimony, cobalt, copper, molybdenum, nickel, silver, and lead concentrations in the sand underlying the BS and overburden were generally one to two orders of magnitude lower than the concentrations in the BS. However, these metals were still higher than the sandstone screening criteria. The overburden sample (CPS18-012_0-1.5m) was more enriched in chromium, copper, manganese, and nickel than the sand samples.

Total recoverable metal concentrations in samples of Winnipeg Sand without Black Shale were generally lowest. However, antimony, cobalt, copper, manganese, molybdenum, nickel, silver, and sulphur concentrations were still above the sandstone screening criteria. Silver and sulphur concentrations were elevated only in the sand sample in close proximity to the Pyritic Black Shale Zone. Total recoverable metal concentrations in Winnipeg Sand from the sand resource was enriched in copper and marginally enriched in cobalt and molybdenum compared to the screening criteria described above (i.e., five times the crustal abundance values for sandstone). Visual observations of the overburden sample indicate potential evidence of ARD/ML.

Iron, aluminum, and manganese oxyhydroxides are known metastable phases, which can be formed as products of oxidation of pyrite. The sulphide-rich BS is especially prone to the formation of such phases. Aluminum oxyhydroxide is a weathering product formed on the surface of K-feldspar and other silicate minerals. The amorphous oxyhydroxides are usually formed first, then progressively transform into more crystalline forms under certain geochemical and physical conditions (i.e., pressure, pH, content of oxygen etc.). Amorphous oxyhydroxides generally have a higher affinity for metal adsorption and can sequester and co-precipitate metals. Also, organic matter is a common source or sink for trace elements because these elements can be immobilized by adsorption on organic matter, or metal-organic complexes. Organic carbon in the BS ranged from 0.17% to 0.42%, and was typically below 0.1 % in the Winnipeg Sand.

Correlations of constituent concentrations with iron, aluminum, manganese, and organic matter concentrations are provided in the last four columns of **Table 4-2**. The highly positive correlation between sulphur and iron (i.e., 0.94) also indicates that iron is primarily related to the sulphide minerals (i.e., pyrite). In addition, the high correlation (>0.75) of trace metals (i.e., antimony, arsenic, barium, bismuth, cadmium, cobalt, copper, lead, molybdenum, nickel, and sulphur) with organic carbon suggests that these metals may also be complexed or co-precipitated with organic matter. The organic matter is thought to have accumulated in BS during the sediment deposition process. Moreover, some trace elements, including mercury, niobium, selenium, terbium, thallium, thorium, tin, titanium and tungsten and uranium are strongly correlated with aluminum. These correlations suggest that iron and organic matter geochemistry may play a key role in controlling trace metal mobility.

4.3 Acid Base Accounting

Detailed ABA test results are summarized in **Table 4-3**. **Figure A** through **Figure** C graphically depict selected ABA results based on the sample classifications provided in **Table 3-1**.

The ABA test results indicated that the BS samples generally had acidic paste pH values (i.e., <4), elevated total sulphur contents (i.e., 0.78% to 14.70%), and low NP (-1.8 to 16.7 kg $CaCO_3$/t). However, two of the BS samples had paste pH values greater than 4 due to higher NP values. Samples of sand underlying the BS (CPS18-004A_7.5-9.0m and CPS18-042_4.5-4.7m) had slightly acidic paste pH values (i.e., 5 to 6), slightly elevated total sulphur (i.e., >0.2 %), and very low NP (3.2 to 5.6 kg $CaCO_3$/t). The overburden sample had circumneutral paste pH (i.e., 6.56) and low NP (10.1 kg $CaCO_3$/t). However, its low calcite content (0.3 %) indicates that the NP is derived from carbonate and reactive silicate minerals. Two (2) of the three sand samples not associated with the pyritic BS had circumneutral to slightly alkaline paste pH, very low sulphide-sulphur content (i.e., <0.01 %) and moderate NP. The sand sample collected from the sand resource area had low NP (4.9 kg $CaCO_3$/t), no carbonate NP (<0.8 kg $CaCO_3$/) and low total sulphur (0.01 %).

Overall, total sulphur concentrations ranged from 0.01 % to 14.7 %, with a median of 0.67%. Sulphide-sulphur concentrations ranged from 0.02 % to 12.9 %, indicating that sulphide-sulphur is the dominant sulphur species (Error! Reference source not found.). Sample points generally plot adjacent to the 1:1 equivalence line, indicating that the sulphur present is mostly derived from sulphide minerals. Sulphate-sulphur and non-extractable sulphur concentrations were generally much lower than sulphide-sulphur concentrations. Sulphate sulphur concentrations ranged from 0.01 % to 0.39 % (median 0.17 %) and non-extractable sulphur concentrations range from 0.04 % to 1.41 % (median 0.24 %).

Modified Sobek NP ranged from -1.8 to 18.9 kg $CaCO_3$/t in all samples. Carbonate equivalent neutralization potential (CaNP) ranged from <0.8 to 14.17 kg $CaCO_3$/t equivalent. **Figure B** presents the carbonate NP versus modified Sobek NP. The deviation from the 1:1 equivalence line indicates that some NP is derived from aluminosilicate minerals. The sand sample collected from the sand resource area had low NP (4.9 kg $CaCO_3$/t) entirely derived from aluminosilicate minerals since its CaNP was below the detection limit (<0.8 kg $CaCO_3$/t).

All six (6) BS samples were classified as PAG, had negative NNP values (i.e., -15.3 to -404.9 kg $CaCO_3$/t), and NPR <1 (**Figure C**). NPR values in BS samples ranged from -0.004 to 0.4, with a median of 0.16. The negative NP value indicate the samples were already generating acidity, as corroborated by the paste pH.

The two (2) sand samples underlying the BS were also classified as PAG, with NPR values of <1 (**Figure C**). The overburden sample and two (2) of the three (3) sand samples not associated with pyritic black shale (including the sample from the sand resource area) were classified as Non-PAG. One (1) sample was classified as having uncertain potential for acid generation (**Figure C**). The sand sample classified as having uncertain ARD potential (CPS18-068_12.6-15m) is located immediately adjacent to the Pyritic Black Shale Zone, contained the highest sulphur (i.e., 0.45 %) among the sand samples not associated with the pyritic black shale, and thus may have been impacted by adjacent shale.

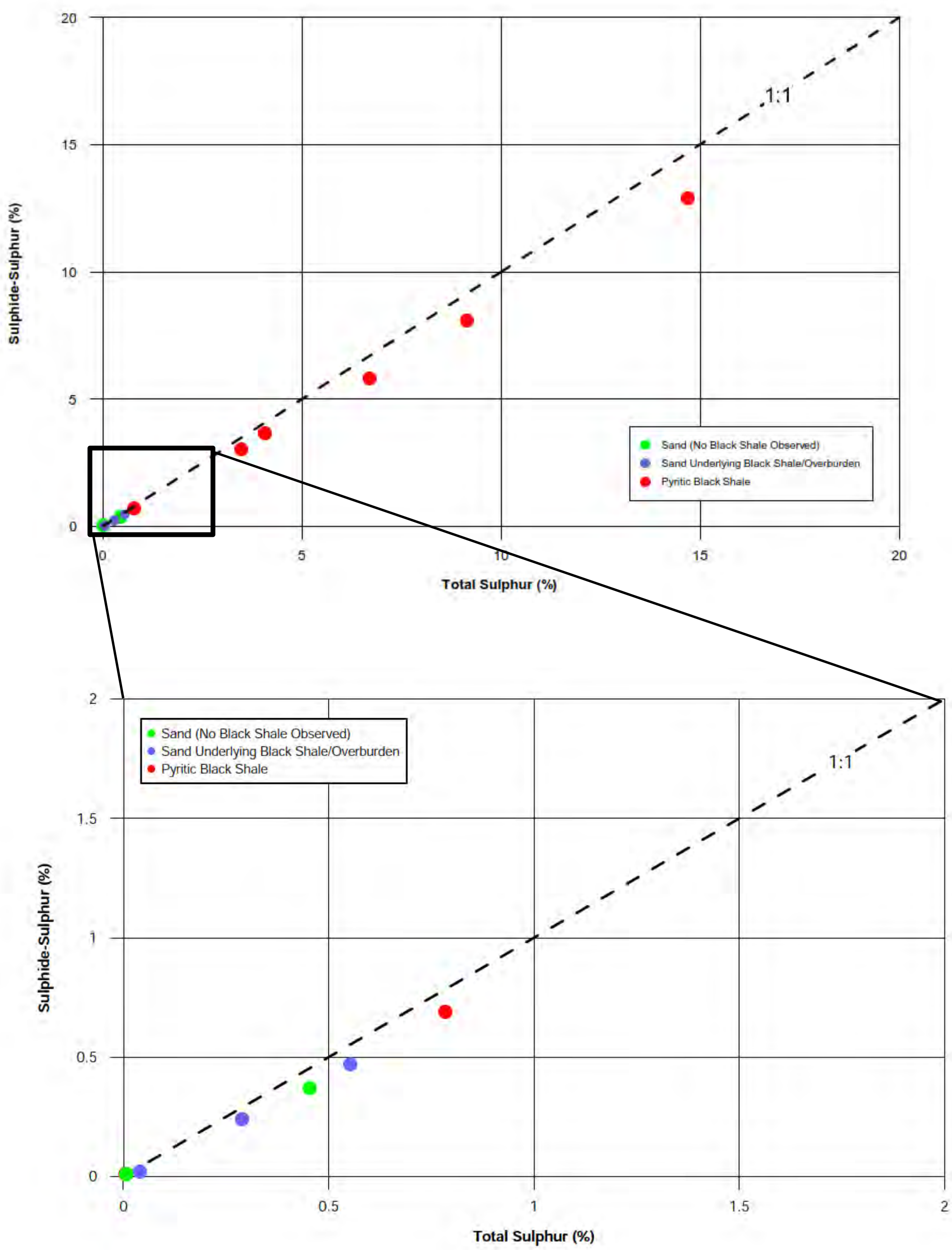


Figure A: Sulphide Sulphur vs. Total Sulphur

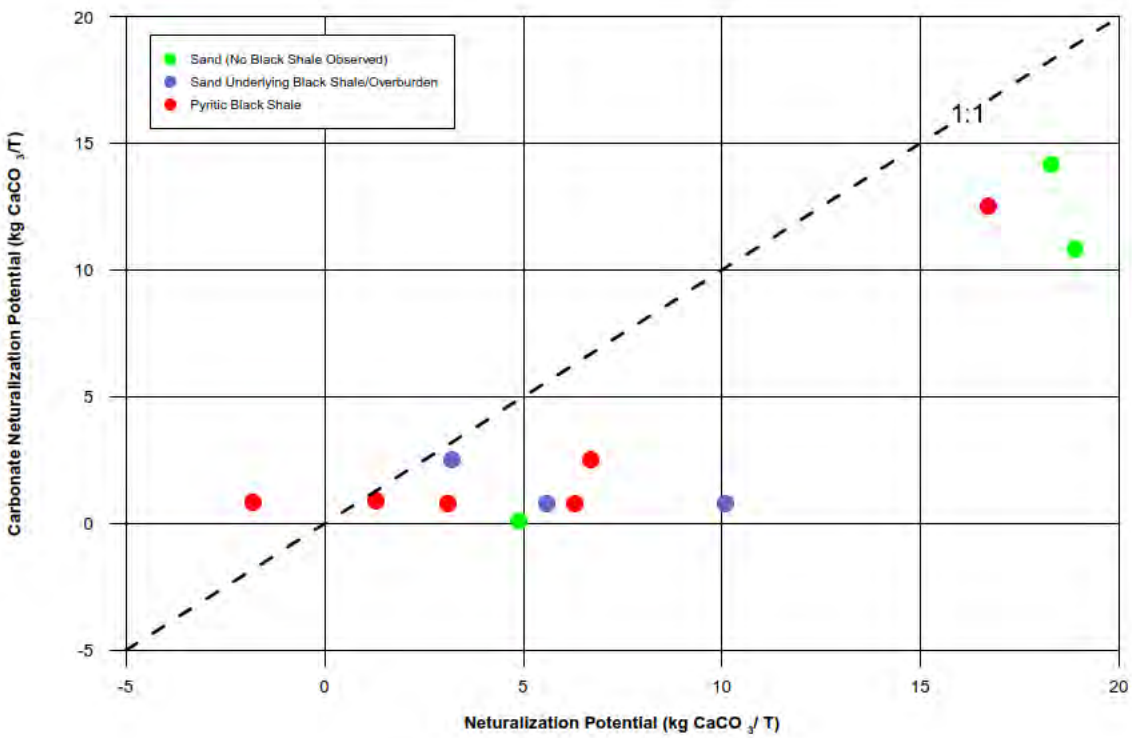


Figure B: Carbonate Neutralization Potential (CaNP) vs. Bulk Neutralization Potential (NP)

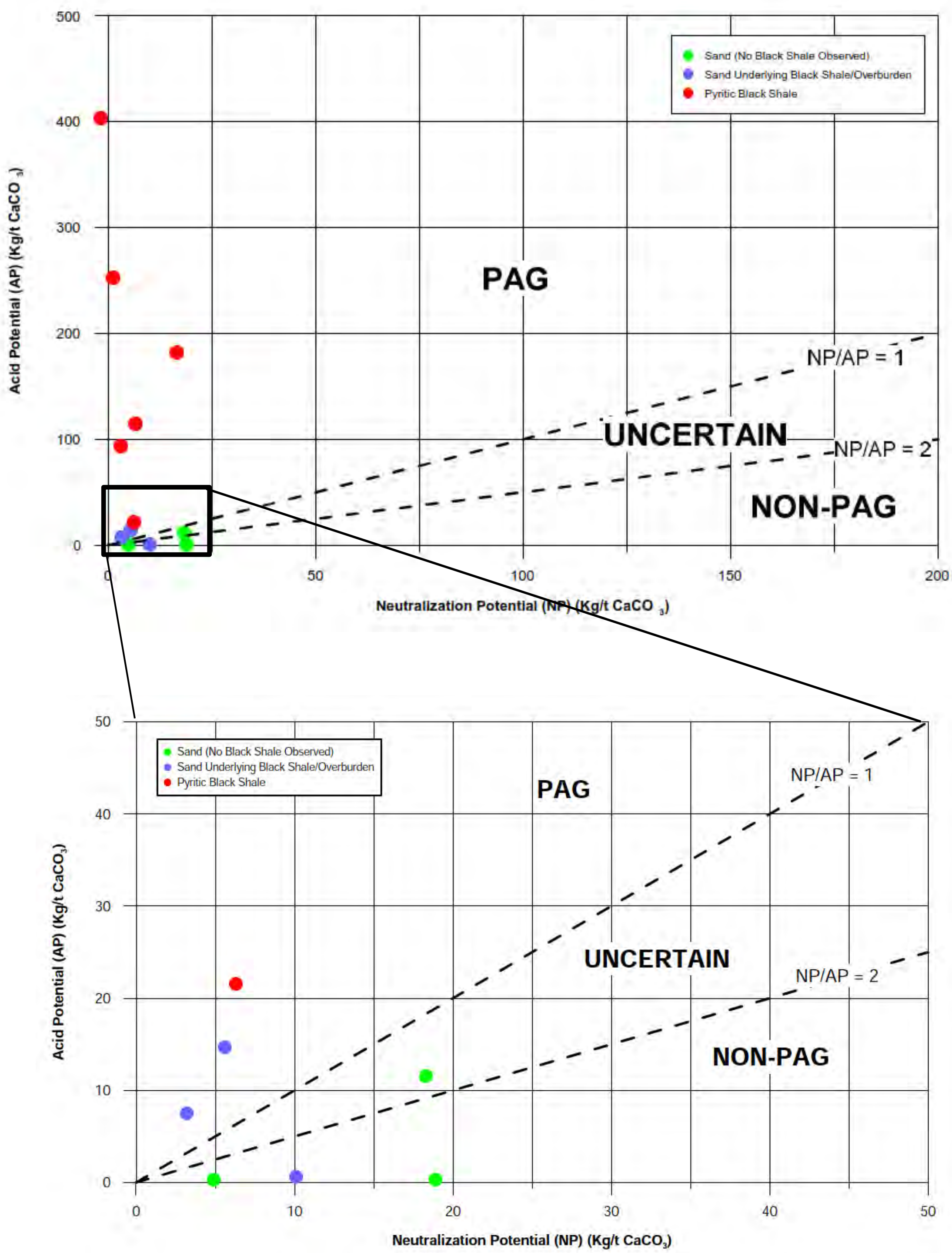


Figure C: Acid Generation Potential (AP) vs. Neutralization Potential (NP)

4.4 Shake Flask Extraction

The results of the SFE are presented in **Table 4-4**. The results were compared to the water quality guidelines and standards listed in **Table D** to screen for elevated leachable metal concentrations that may impact the aquifers and receiving water bodies in proximity to the proposed Project area. Although all standards and guidelines indicated have been applied as a screening tool for SFE water quality, the following rules were followed to determine which standard or guideline takes precedence per the Manitoba Contaminated Sites Remediation Regulation (CSRR):

- Rule 1: If a primary standard for a parameter in relation to the applicable site conditions was available, this standard was applied.
- Rule 2: If a primary standard was not available for a parameter or if none of the primary standards addressed the applicable site conditions, a secondary standard for the parameter and addressing the applicable site conditions.
- Rule 3: If a secondary standard for a parameter was not available or if the primary and secondary standards do not address the applicable site conditions, the tertiary standard was used if it addressed applicable site conditions.

Table D: Water Quality Standards and Guidelines

Standard / Guideline	Applied (Y/N)	Rationale
Primary Standards		
Canadian Council of Ministers of the Environment Water Quality Guidelines for the Protection of Aquatic Life	Y	Screening tool for potential freshwater receptors. Ontario proposed water quality objective for antimony was used because of the lack of CCME guideline.
Canadian Council of Ministers of the Environment, Water Quality Guidelines for the Protection of Agriculture	N	Site is not located on Agricultural Land.
Federal Interim Groundwater Quality Guidelines	N	Guidelines have not been finalized and referenced standards and guidelines from Ontario and Alberta have been applied to the Site.
Health Canada Guidelines for Canadian Drinking Water Quality	Y	Screening tool, as private water wells in the vicinity of the Project area may use the aquifer for drinking water.
Secondary Standards		
Ontario Ministry of the Environment, Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, 2011 - Table 1: Full Depth Background Site Condition Standards	Y	Screening tool to identify any parameters that may be outside normal background concentrations.
Tertiary Standards		
Alberta Tier 1 Guidelines, Natural Area Land Use, Coarse-Grained Soil	Y	Coarse-grained soil and “Natural Area” land use provides most conservative guidelines for screening purposes.

The BS SFE leachates generally exhibited acidic pH values (i.e., <6), low to non-detectable alkalinity, elevated conductivity (i.e., 876 - 3,225 microSiemens per centimeter [µS/cm]), and elevated sulphate (i.e., 385 - 1,857 mg/L) and dissolved metals. Black shale samples generally produced concentrations of dissolved constituents that were also present at high concentrations in the solid phase total recoverable metals analyses.

The overburden sample collected from the BS area and the sand samples underlying BS leachates were characterized by slightly acidic to pH values (i.e., 5 - 6.3), low alkalinity (i.e., <5 mg/L $CaCO_3$), and low to moderate conductivity (i.e., 32 - 494 µS/cm) and sulphate (i.e., 6 - 205 mg/L) concentrations. Metal concentrations were generally one to two orders of magnitude lower than those in the BS leachates. This is also consistent with the results of total recoverable metals analyses. Leachates from Winnipeg Sand not associated with BS generally had circumneutral pH values (7.3 - 7.9), low to moderate alkalinity (i.e., 7.5 - 50.2 mg/L $CaCO_3$), low to moderate conductivity (27 - 327 µS/cm) and low sulphate concentrations (3 - 106 mg/L). The sand sample taken from the sand resource area had the lowest alkalinity (7.5 mg/L $CaCO_3$) and sulphate (3 mg/L) consistent with a material containing low sulphur and carbonates.

Table E summarizes select SFE results for parameters that occur at concentrations in excess of the primary screening standards, including Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life(PAL) and Health Canada Guidelines for Canadian Drinking Water Quality (CDWQ). The purpose of this assessment is to qualitatively identify parameters that may leach from the Pyritic Black Shales, Sand underlying Black Shales and Sand without Black Shale Observed. If analytical results were below detection limits, the median was calculated by assuming the analytical value is equal to the detection limit.

Table E: Summary of Leach Testing and Water Quality Exceedances - Shake Flask Extraction

Parameter	Unit	Pyritic Black Shale		Sand Underlying Black Shale/ Overburden		Sand without Black Shale Observed	
		Range (median)	N (Ex)[2]	Range (median)	N (Ex)[2]	Range (median)	N (Ex)[2]
N[1]		6		3		3	
pH (Lab)	-	2.81-7.24 (4.02)	83%	5.5-6.4 (6)	100%	7.3-7.9 (7.8)	0%
Antimony	mg/L	0.003-0.2 (0.02)	83%	0.0017-0.002 (0.002)	0%	<0.0009-0.01 (0.0017)	33%
Arsenic	mg/L	7×10^{-4}-0.18 (0.01)	50%	3×10^{-4}-0.003 (3×10^{-4})	0%	0.002-0.004 (0.002)	0%
Cadmium	mg/L	4×10^{-4}-0.05 (0.02)	100%	3×10^{-5}-10^{-4} (6×10^{-5})	33%	3×10^{-6}-2×10^{-5} (5×10^{-6})	0%
Chromium	mg/L	9×10^{-5}-0.15 (0.11)	67%	0.01	0%	10^{-4}-0.004 (7×10^{-4})	0%
Cobalt[3]	mg/L	0.2 - 17.2 (7.8)	0%	0.003-0.29 (0.17)	0%	3×10^{-4}-0.0013 (0.001)	0%
Copper	mg/L	0.003-1.8 (0.67)	83%	0.001-0.03 (0.01)	67%	0.0035-0.01 (0.0057)	100%
Iron	mg/L	0.14-392 (57)	83%	0.07-1.9 (0.09)	33%	0.009-0.28 (0.13)	0%
Lead	mg/L	7×10^{-4}-0.4 (0.13)	50%	5.8×10^{-4}-0.00035 (6×10^{-4})	0%	6×10^{-5}-0.001 (10^{-4})	0%
Manganese	mg/L	0.4 - 1.56 (0.72)	100%	0.035-1.11 (0.32)	67%	0.011-0.028 (0.012)	0%
Mercury	mg/L	0.01-0.02 (0.01)	50%	<0.01-0.04 (0.01)	33%	<0.01	0%
Molybdenum	mg/L	7×10^{-5}-0.007 (4×10^{-4})	0%	< 4×10^{-4} -5×10^{-4} (3×10^{-4})	0%	0.007-0.009 (0.007)	0%
Nickel	mg/L	0.7-35 (6.9)	100%	0.06-0.49 (0.19)	100%	0.003-0.01 (0.004)	0%
Selenium	mg/L	0.0012-0.01 (0.003)	100%	3×10^{-4} -0.003 (0.002)	67%	7×10^{-5} -8×10^{-4} (10^{-4})	0%
Silver	mg/L	<5×10^{-5}	0%	<5×10^{-5}	0%	<5×10^{-5}	0%
Zinc	mg/L	0.02-3.2 (0.2)	83%	0.007-0.085 (0.093)	67%	<0.002-0.004 (0.002)	0%

***Notes**:*

1: Total number of samples

2: Percentage of samples with leachate concentrations in excess of the primary criteria; Detection limits above the applicable criteria are not accounted for in the exceedances

3: No primary criteria exist for cobalt. All black shale samples and two sand samples underlying black shale/overburden exceeded secondary cobalt criteria

Dissolved metals including antimony, cadmium, chromium, cobalt, copper, iron, manganese, mercury, nickel, lead, selenium, thallium, uranium, vanadium, and zinc exceeded at least one applicable screening guideline or standard. In general, the patterns of constituent concentrations in the BS SFE leachates were consistent with the total recoverable metals results, with the exception of selenium, silver, and zinc. Silver was above the crustal abundance criteria in most of the samples, but was not detected in the SFE leachates. Total recoverable selenium and zinc typically had low bulk concentrations but had elevated concentrations in the SFE leachates. The sand underlying the BS generally had a lower percentage of metals exceeding the guidelines, with metal concentrations in leachates generally one to two orders of magnitude lower than those in the BS. However, nickel concentrations also exceeded the CCME PAL guideline for aquatic life in all samples from this lithological unit. The overburden leachate generally exhibited lower metal concentrations than sand samples underlying black shales, except for antimony, arsenic, copper, lead, and iron. This is consistent with the visual examination of the overburden sample showing evidence of ARD/ML.

The Winnipeg Sand outside of the Pyritic Black Shale Zone had the lowest level of exceedances, with only copper marginally exceeding in all three samples. Aluminum exceedances were observed in two of the samples and antimony. However, copper concentrations in all Winnipeg Sand samples exceeded the CCME standard for aquatic life. The sample (i.e., CPS18-024_7.5-9.0m) collected from the sand resource quarry site had elevated leachable aluminum and copper and marginal lead and nickel concentrations relative to the CCME PAL guideline. Also, nickel and lead in that sample marginally exceeded the Alberta Tier 1 Guidelines for Natural Area Land Use for Coarse-Grained Soils. These data indicate limited potential for ML associated with the sand not associated with the BS. The elevated aluminum concentration in the sample is likely due to the elevated kaolinite content combined with crushing of the samples for the SFE experiment.

The SFE results suggest that the elevated potential for ML is associated with PAG samples, while the samples with low potential for acid generation also had limited potential for metal leaching.

AECOM’s (2019) hydrogeological investigation indicated that the potentiometric surface of the Winnipeg Formation aquifer is located within or slightly above the shallow high plasticity silt/clay layer, which is typically located between 1.0 and 3.5 metres below ground surface (mbgs). As such, the aquifer is considered to be confined, and there is potential for release of leached metals from the Black Shale unit to the underlying sand aquifer and possible discharge to the receiving environment (i.e., Winnipeg Lake).

A groundwater supply well developed near the sand resource area (i.e., CPR19-04) revealed that the aquifer in this area is also confined. A water quality sample taken from this well had arsenic and manganese concentrations higher than the CCME PAL long term guideline and nickel concentrations higher than the Ontario Ministry of the Environment, Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, 2011 - Table 1: Full Depth Background Site Condition Standards. Only nickel was elevated above the background level in the SFE and in groundwater indicating that aluminum, lead, and copper are not creating environmental impacts at the site and the water quality is naturally elevated in arsenic and manganese.

5. Conclusions

Based on the results of this ARD/ML assessment, the following conclusions are drawn:

1. Of twelve (12) samples, eight (8) samples were classified as PAG, including all BS and sand underlying BS samples. The Winnipeg Sand sample collected in close proximity to Pyritic Black Shale Zone was determined to have uncertain acid potential and is likely impacted by the BS. Winnipeg Sand distant from the Pyritic Black Shale Zone and overburden had low potential for acid generation.
2. Only one sample was collected from the sand resource quarry site and was classified as Non-PAG because it mainly consisted of geochemically inert sand with very low sulphur and carbonates contents. Based the estimates of overburden and sand excavated during development (i.e., an average of 350,000 t/year of overburden during the first 5 years, 550,000 t/year of sand silica mined and 300,000 t of pure silica sand produced) and on industry recommended minimum number of samples required to ensure an adequate characterization (Price 2009) and laboratory testing (1 sample per 1,000 t, 3 samples per 10,000 t minimum) , the geochemical behaviour of the materials within the sand quarry footprint has not been fully evaluated.
3. Pyrite was the primary sulphide mineral and was detected in all collected samples. BS generally had the highest amount of pyrite (i.e., 4.2 % - 18 %). Pyrite concentrations in sand underlying the BS were also elevated, ranging from 0.1 % to 0.7 %, with a mean of 0.5 %. The Winnipeg sand collected from outside the Pyritic Black Shale Zone had the lowest pyrite concentrations (i.e., 0.1 % to 0.4 %). The sand resource quarry sample and overburden had the lowest pyrite content (0.1 %).
4. Calcite was only present in low amounts (0.5 %) and mainly in BS samples, suggesting low readily available neutralizing capacity. Fast reactive aluminosilicate minerals such as chlorite, actinolite, lizardite and diopside will play a key role in controlling the potential for acid release.
5. Whole rock total recoverable metals analyses indicated that the BS were most enriched in heavy metals. Antimony, arsenic, cadmium, cobalt, copper, iron, lead, mercury, molybdenum, nickel, and silver were above the shale crustal abundance criteria. The sand underlying the BS unit had elevated but lower metal contents compared to the shale but higher metal contents than the sand samples outside of the Pyritic Black Shale Zone.
6. The correlation of trace metals antimony, arsenic, barium, bismuth, cadmium, cobalt, copper, lead, sulphur, molybdenum, nickel, and sulfur constituents with iron and organic matter suggests that these metals are present as sulphides or complexed or coprecipitated and/or adsorbed on organic matter.
7. The BS samples had elevated potential for metal leaching, as indicated by numerous exceedances of the applicable guidelines and standards. The sand underlying the BS had elevated but lower ML potential, with metal concentrations generally one to two orders of magnitude lower than those in BS. The overburden also showed potential for metal release as several metal exceeded the screening guidelines.
8. The Winnipeg sand outside of the Pyritic Black Shale Zone generally had the lowest ML potential. However, copper and aluminum exceeded the CCME guidelines for the Protection of Aquatic Life. Nickel and lead in the samples from the sand resource area also marginally exceeded the CCME and Alberta Tier 1 Guidelines. Although SFE leachate pH values are circumneutral for the Winnipeg sand sample collected from outside of the Pyritic Black Shale Zone, the low alkalinity (<60 mg/L $CaCO_3$) and low carbonate mineral contents suggests rocks have low buffering capacity and therefore are sensitive to acid input.
9. The results of the geochemical assessment based on very limited data indicate that the Winnipeg Sand in the sand resource at the site consists mainly of quartz and aluminosilicates with a trace amount of pyrite. There is a low potential for ARD and a limited potential for ML associated with this material. While the SFE showed that aluminum and copper were elements of concern, site groundwater quality indicated they are not presently impacting the environment. Only nickel may be elevated above background levels. Leachate testing has shown a potential for metal release from the overburden as suggested by the sample visual examination in the field. A review of geological data and borehole logs in the area shows that the current site consists mainly of overburden glaciofluvial material and LBI sand overlying the Precambrian basement. The Pyritic Black Shale Unit was not found in this area. This means that the sand in the resource area may have low potential for ARD and limited potential for ML if the sample tested is representative of the bulk composition of sand at the quarry site. However, spatial heterogeneity of composition may exist in the quarry leading to different ARD/ML risks levels.

6. Recommendations

Based on the results of this investigation, AECOM recommends the following:

1. **Characterization and Monitoring**: There are presently a very limited number of samples from within the proposed sand resource quarry area . Additional samples should be collected from all lithological units (i.e., overburden and sand) in the sand resource area and from the mine waste and analyzed to better understand their potential for ARD/ML. It will be important to confirm the absence of the Pyritic Black Shale within the proposed quarrying footprint. Additional samples should be collected from the Winnipeg sand and overburden from available drill core and tested to better understand the ARD/ML potential associated with the units in the glass sand resource area. Sampling and analysis would be most advantageous before development begins to allow for avoidance of pyritic shale during quarrying, if present, and optimization of the mine plan on the basis of study results. Groundwater quality samples should also be collected to assess current water quality conditions and develop a baseline water quality dataset for future use.
2. **Avoid Disturbance of Pyritic Black Shale**: Although Pyritic Black Shale is not presently expected to be present within the sand resource quarry footprint, disturbance of soil/rock within the encountered Pyritic Black Shale Zone should be avoided. If it is unexpectedly encountered, it should be managed as PAG, complete with appropriate storage and handling of to prevent ARD/ML from occurring. If encountered, the shale should be placed in an engineered lined and covered containment facility complete with diversion of surface water and groundwater to minimize oxidation If a storage facility is required, monitoring of groundwater and surface water upgradient and downgradient of the storage facility should be implemented to establish baseline conditions and verify the effectiveness of containment measures.
3. **Avoid Groundwater Supply Development Near Pyritic Shale**: Due to the leachability of metals from the BS and the underlying sand, no water supply wells should be installed in proximity to the Pyritic Black Zone. Water quality in these wells is likely to be naturally influenced by metal leaching from the overlying shale, and water would likely require treatment to meet drinking water quality criteria or allow for discharge to the environment.
4. **Implement the Acid Rock Drainage and Metal Leaching (ARD/ML) Assessment**: A preliminary management plan was developed based on the findings from this assessment to guide the management and mitigations of the material excavated and stripped to prevent and minimize potential impacts to the environment from construction and operations. This plan will be updated as more data and information become available.

7. References

AECOM Ltd Canada (2019). Wanipigow Sand Extraction Project – Water Supply Well Evaluation – Draft

APEX Geoscience. (2021). Inferred Resource Estimation on Canadian Premium Sand Inc.'s Wanipigow Silica Sand Glass Project In Manitoba, Canada. NI 43-101 Technical Report. October 14, 2021.

GARD Guide (2018). The Global Acid Rock Drainage Guide (GARD Guide): Prediction, Prevention, Management." INAP, http://www.gardguide.com/index.php?title=Main_Page.

Jambor, J.L., Dutrizac, J.E., Raudsepp, M., and Groat, L.A. (2003). Effect of peroxide on neutralization-potential values of siderite and other carbonate minerals. J. Environ. Qual. 32, 2373–2378.

Krauskopf, K.B.,(1955). Sedimentary Deposits of Rare Metals, Economic Geology 50th anniversary volume, 1905 – 1955, p. 411-463

Lapenskie, K. (2016). Preliminary investigations into the high-purity silica sand of the Winnipeg Formation, southern Manitoba; in Report of Activities 2016, Manitoba Growth, Enterprise and Trade, Manitoba Geological Survey, p. 176–180.

Bitney, Mary (1983). Winnipeg Formation (Middle Ordovician), Williston Basin, American Association of Petroleum Geologists. Volume 67, Pg1330

Morin, K.A., and Hutt, N.M. (1997). Environmental geochemistry of minesite drainage: practical theory and case studies (Vancouver, British Columbia: MDAG).

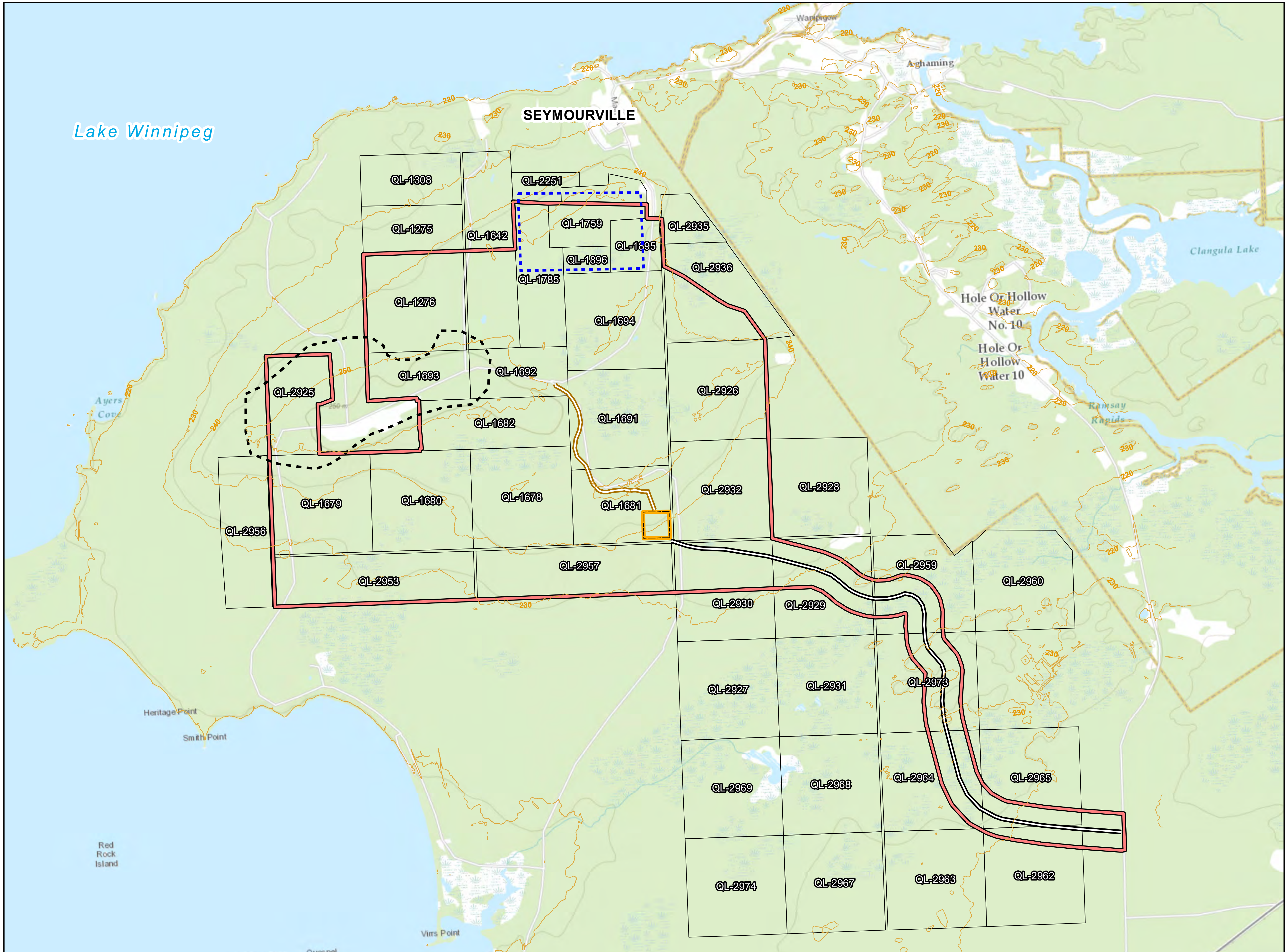
Price, W.A. (1997). Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia. MEND Report.Price, W.A. (2009). Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. MEND Report 1.20.1. Version CANMET – Mining and Mineral Sciences Laboratories, Smithers, BC.

Price, W.A. (2009), Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. MEND Report 1.20.1. Version CANMET – Mining and Mineral Sciences Laboratories, Smithers, BC.

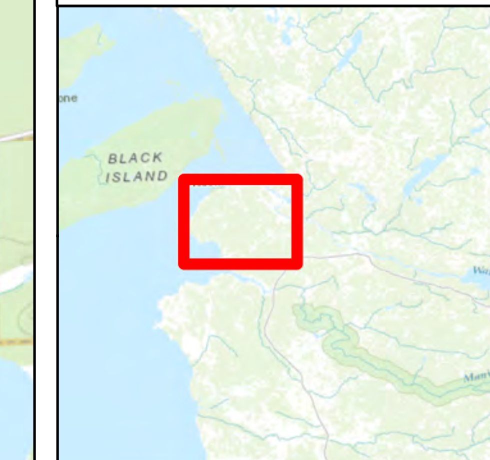
Vigrass, L.W. (1971). Depositional framework of the Winnipeg Formation in Manitoba and eastern Saskatchewan; in Geoscience Studies in Manitoba, A.C. Turnock (ed.), Geological Association of Canada, Special Paper 9, p. 225–234.

Watson, D.M. (1985). Silica in Manitoba; Manitoba Energy and Mines, Geological Services, Economic Geology Report ER84-2, 35 p.

Figures



PROJECT SITE LOCATION



Legend

- Proposed Sand Processing Facility Location
- Project Site Area Boundary
- Claim Post Quarry Lease Boundaries and ID
- Access Road for Project Construction and Emergency Use
- Main Access Road
- Contour Line (10m Interval)
- Estimated Boundary of Pyritic Black Shale (CPS,2019)
- Approximate Extent of Glass Sand Extraction Area

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Sources: ESRI

N

0 300 600 900 1,200
Meters

NAD 1983 UTM Zone 14N

60640258	07/28/2022	Figure 1

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Path: P:\60588114\900-CAD_GIS\920-929 (GIS-Graphics)\02_MXDs\ARD_ML Project\H001_Seymourville_ProjectSiteLocation.mxd **Reviewed By:** XX **Paper Size:** 11"x17" Scale is referenced to the specified paper size.
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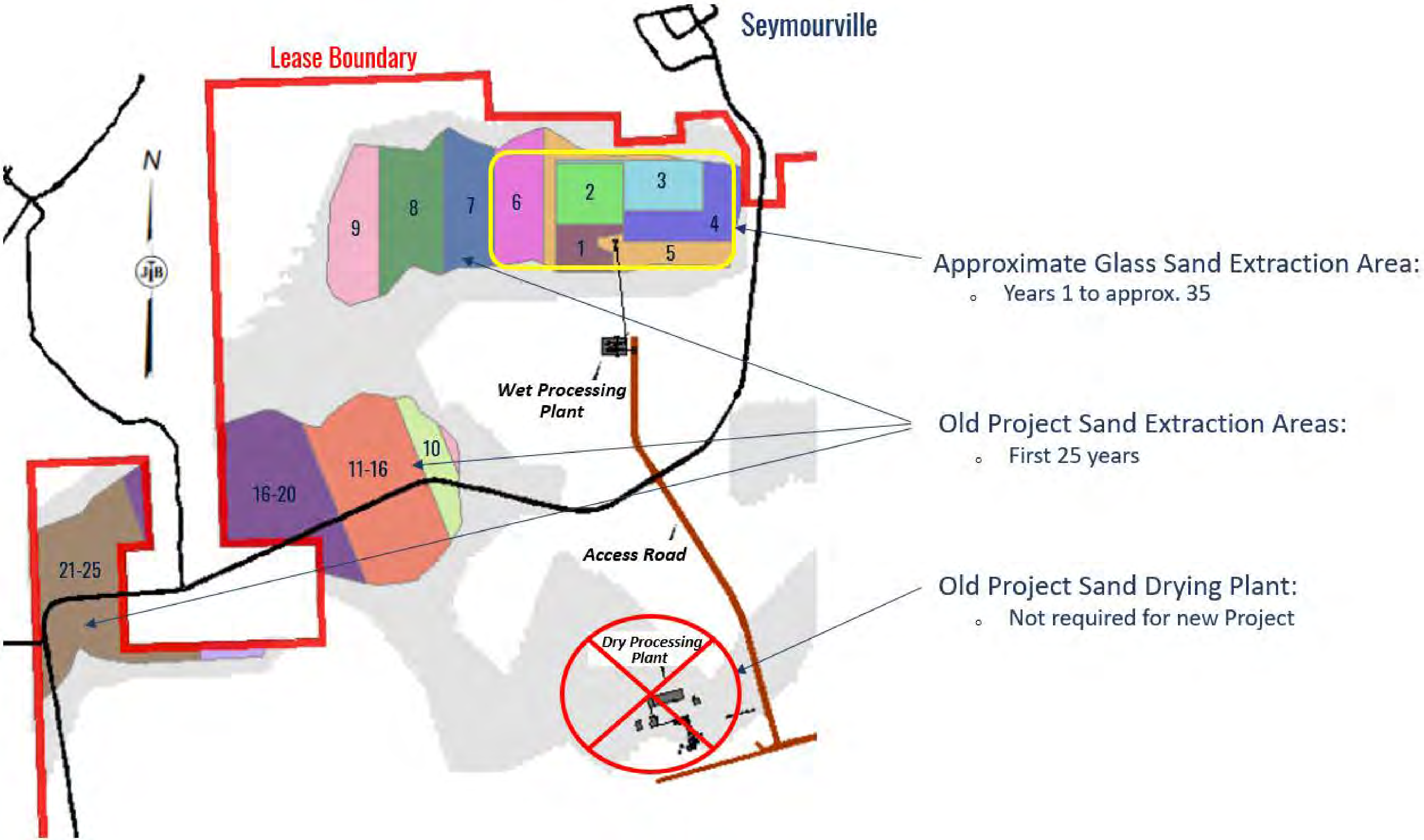
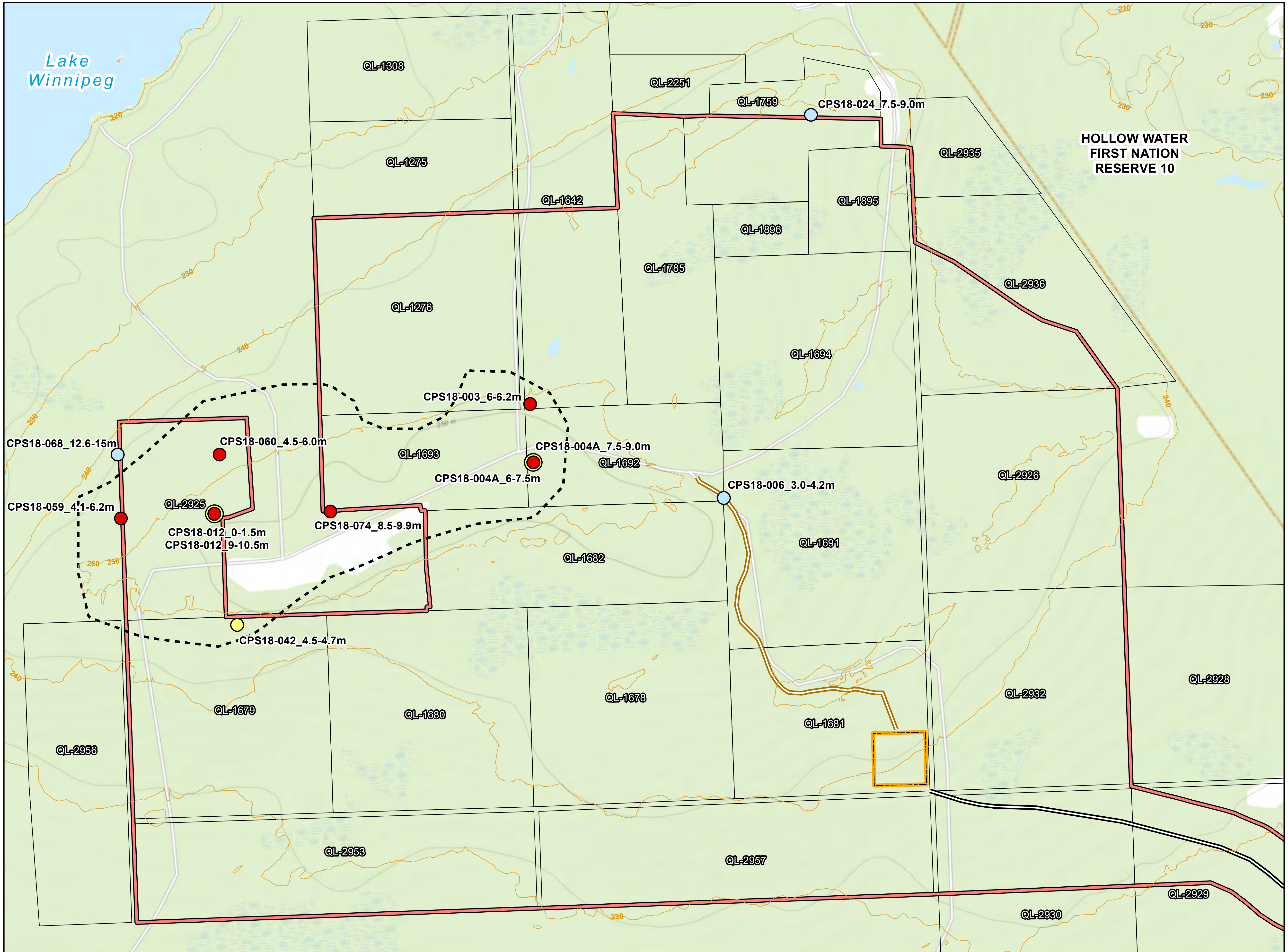
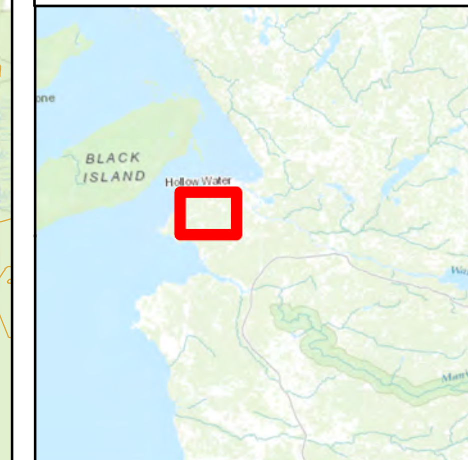


Figure 2: SAND EXTRACTION AREA



ARD/ML SAMPLING LOCATION



Legend

- Proposed Sand Processing Facility Location
- Project Site Area Boundary
- Claim Post Quarry Lease Boundaries and ID
- Access Road for Project Construction and Emergency Use
- Main Access Road
- Contour Line (10m Interval)
- Estimated Boundary of Pyritic Black Shale (CPS,2019)
- Black Shale
- Sand Underlying Black Shale/Overburden
- Sand without Black Shale Observed

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Sources: ESRI

N

0 150 300 450 600
Meters

NAD 1983 UTM Zone 14N

60640258	07/28/2022	Figure 3

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Tables

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Table 3-1. Description of Rock/Soil samples at Project Area

Area	Group Classification	Sample ID	Northing	Easting	Depth	Geological Unit	Lithology	Description/Comments
			m	m	m BGS			
Within Pyritic Black Shale Zone	Black Shale	CPS18-003_6-6.2 m	5672003	685687	6.0-6.2	Winnipeg Formation	Black shale	10-20 cm black shale lens, mixed with Orange sand and clay, Very carbonaceous
		CPS18-004A_6-7.5 m	5671764	685699	6.0-7.5	Winnipeg Formation	Shale/Sand	Shale and Sand interface; Grey Shale/ mudstone, layered texture, Hard, strongly cemented
		CPS18-012_9-10.5 m	5671555	684397	9.0-10.5	Winnipeg Formation	Black shale	Black shale, with concretions of silica sand and pyrite nodules
		CPS18-059_4.05-6.15 m	5671536	684016	4.05-6.15	Winnipeg Formation	Black shale	Black sandy clay; Stiff
		CPS18-060_4.5-6.0 m	5671796	684419	4.5-6.0	Winnipeg Formation	Black shale	Black to dark grey shale, with silty sand; Isolated rounded pyrite nodules were observed
		CPS18-074_8.5-9.9 m	5671564	684871	8.5-9.9	Winnipeg Formation	Black shale	Black to dark grey shale; Clay/silt layers alternating with fine sand layers, well consolidated
	Sand Underlying Black Shale/Overburden	CPS18-004A_7.5-9.0 m	5671764	685699	7.5-9.0	Winnipeg Formation	Sand	Black staining may come from the overlying shale interbed
		CPS18-012_0-1.5 m	5671555	684397	0.0-1.5	Overburden	Sand	Brown to orange color, loose medium sand, suspect potential ARD/ML minerals
		CPS18-042_4.5-4.7 m	5671101	684490	4.5-4.7	Winnipeg Formation	Sand	Grey to light brown color with orange staining; loose
Outside of Pyritic Black Shale Zone	Sand without Black Shale Observed	CPS18-068_12.6-15 m	5671796	684002	12.6-15.0	Winnipeg Formation	Silty sand	Grey fine sand; some rounded pyrite balls and abraided discs
		CPS18-006_3.0-4.2 m	5671620	686477	3.0-4.2	Winnipeg Formation	Sand	Light grey color, loose
		CPS18-024_7.5-9.0 m	5673183	686832	7.5-9.0	Winnipeg Formation	Sand	white silica sand, well sorted

Table 4-1. Results of Semi-quantitative Phase Analysis (wt.%) XRD-Rietveld - Seymourville Site

	Sample ID	CPS18-003_6-6.2m	CPS18-004A_6-7.5m	CPS18-004A_7.5-9.0 m	CPS18-006_3.0-4.2 m	CPS18-012_0-1.5 m	CPS18-012_9-10.5 m	CPS18-024_7.5-9.0 m	CPS18-042_4.5-4.7 m	CPS18-059_4.05-6.15 m	CPS18-060_4.5-6.0 m	CPS18-068_12.6-15 m	CPS18-074_8.5-9.9 m
	Depth (m.b.g.s)	6.0 - 6.2	6.0 - 7.5	7.5 - 9.0	3.0 - 4.2	0.0 - 1.5	9.0 - 10.5	7.5 - 9.0	4.5 - 4.7	4.05 - 6.15	4.5 - 6.0	12.6 - 15.0	8.5 - 9.9
	Geological Unit	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Overburden	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation
	Lithology Description	Black shale	Shale/Sand	Sand	Sand	Sand	Black shale	Sand	Sand	Black shale	Black shale	Silty sand	Black shale
	Acid Generating Status	PAG	PAG	PAG	Non-PAG	Non-PAG	PAG	Non-PAG	PAG	PAG	PAG	Uncertain	PAG
Mineral Composition (Formula)													
Quartz	SiO_2	60.0	45.7	86.9	35.4	56.3	64.9	83.9	92.2	59.2	67.7	67.5	54.1
Albite	$NaAlSi_3O_8$	9.1	1.2	1.0	38.7	25.2	0.7	0.9	1.4	2.8	5.6	15.6	1.5
Pyrite	FeS_2	4.2	0.9	0.7	0.2	0.1	11.2	0.1	0.5	4.6	8.1	0.4	18.0
Diopside	$CaMgSi_2O_6$	0.8	1.7	0.7	3.3	2.1	1.0	1.0	0.7	0.9	0.9	1.1	0.9
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$	3.6	4.0	2.1	3.3	2.0	2.0	1.8	2.0	3.6	2.3	2.3	2.3
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)$	1.0	1.9	1.1	1.0	2.1	0.3	2.9	0.9	2.5	-	0.8	-
Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	3.7	-	-	3.2	2.8	3.2	-	-	-	-	2.0	-
Calcite	$CaCO_3$	0.4	0.2	-	0.5	0.3	-	-	-	0.3	0.5	1.0	-
Ankerite	$CaFe(CO_3)_2$	0.2	0.2	-	0.4	-	-	-	-	0.3	0.6	0.6	-
Microcline	$KAlSi_3O_8$	17.1	39.6	3.6	12.8	8.9	16.7	1.6	2.3	23.3	12.7	6.3	21.4
Gypsum	$CaSO_4 \cdot 2H_2O$	-	0.9	-	-	-	-	1.2	-	-	-	-	1.9
Kaolinite	$Al_2Si_2O_5(OH)_4$	-	2.3	3.9	-	-	-	6.6	-	2.5	1.6	1.4	-
Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$	-	1.4	-	-	-	-	-	-	-	-	-	-
Lizardite	$Mg_3Si_2O_5(OH)_4$	-	-	-	0.3	0.3	-	-	-	-	-	-	-
Kutnahorite	$CaMn(CO_3)_2$	-	-	-	0.7	-	-	-	-	-	-	0.8	-
Magnetite	Fe_3O_4	-	-	-	-	-	-	-	-	-	-	0.3	-
	Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 4-2. Comparison of Total Recoverable Constituents to Crustal Abundance – Seymourville Site

Sample ID	Units	Detection Limit	Crustal Abundance in Rocks						CPS18-003_6-6.2 m	CPS18-004A_6-7.5 m	CPS18-004A_7.5-9.0 m	CPS18-006_3.0-4.2 m Parent	CPS18-006_3.0-4.2 Duplicate	RPD	CPS18-012_0-1.5 m	CPS18-012_9-10.5 m	CPS18-024_7.5-9.0 m	CPS18-042_4.5-4.7 m	CPS18-059_4.05-6.15 m	CPS18-060_4.5-6.0 m	CPS18-068_12.6-15 m	CPS18-074_8.5-9.9 m	Correlations between constituents and Three Major Oxy-hydroxides			Organic Carbon[a]
Depth (m.b.g.s)			Price (1997)[b]				Vine and Tourtelot (1970)[e]		6-6.2	6-7.5	7.5-9.0	3.0-4.2	3.0-4.2		0-1.5	9-10.5	7.5-9.0	4.5-4.7	4.05-6.15	4.5-6.0	12.6-15	8.5-9.9				
Lithology Description			Sandstone[c]	Sandstone X5[c]	Shale[c]	Shale X5[c]	Black Shale[e]	Black Shale X5	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation		Overburden	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation				
Geological Unit									Black Shale	Shale/Sand	Sand	Sandy Silt	Sandy Silt		Sand	Black Shale	Sand	Sand	Black Shale	Black Shale	Silty Sand	Black Shale	Aluminum	Iron	Manganese	
Acid Generating Status									PAG	PAG	PAG	Non-PAG	Non-PAG		Non-PAG	PAG	Non-PAG	PAG	PAG	PAG	Uncertain	PAG				
Parameters																										
Organic C[a]									0.169	0.268	0.027	0.011	0.011	-	0.138	0.284	0.005	0.024	0.315	0.229	0.033	0.420	-0.25	0.78	0.29	1.00
Aluminum (Al)	%	0.01	2.5	12.5	8	40	7	35	0.23	0.38	0.27	0.31	0.32	3.2	0.65	0.13	0.31	0.09	0.26	0.25	0.4	0.14	1.00	-0.18	-0.40	-0.24
Antimony (Sb)	ppm	0.05	0.01[d]	0.05[d]	1.5	7.5	-	-	6.79	**1.59**	**0.79**	<0.05	<0.05	-	**0.3**	**19.93**	**0.17**	**0.4**	**12.49**	**10.09**	**0.64**	**31.9**	-0.52	0.98	0.58	0.84
Arsenic (As)	ppm	1	1	5	13	65	-	-	22	4	4	<1	<1	-	3	53	2	<1	32	42	3	**73**	-0.71	0.99	0.61	0.84
Barium (Ba)	ppm	5	10[d]	50[d]	580	2900	300	1500	28	20	7	22	22	0.0	27	41	<5	<5	24	37	24	62	-0.57	0.86	0.74	0.80
Beryllium (Be)	ppm	0.1	0.1[d]	0.5[d]	3	15	1	5	<0.1	0.2	<0.1	<0.1	<0.1	-	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-1.00	-1.00	-1.00	0.24
Bismuth (Bi)	ppm	0.02	-	-	-	-	-	-	0.13	0.11	0.03	0.05	0.05	0.0	0.07	0.16	0.03	0.03	0.11	0.11	0.05	0.27	-0.40	0.91	0.51	0.91
Cadmium (Cd)	ppm	0.01	0.01[d]	0.05[d]	0.3	1.5	-	-	0.18	**0.11**	0.01	0.02	0.02	0.0	0.02	0.27	0.02	<0.01	0.13	0.12	0.02	0.19	-0.39	0.81	0.28	0.82
Caesium (Cs)	ppm	0.05	0.1[d]	0.5[d]	5	25	-	-	0.21	0.35	0.07	0.25	0.25	0.0	0.27	0.12	0.11	<0.05	0.18	0.17	0.28	0.15	-0.49	-0.23	0.39	0.15
Calcium (Ca)	%	0.01	3.91	19.55	2.21	11.05	1.5	7.5	0.05	0.04	0.05	0.54	0.54	0.0	0.14	0.02	0.02	0.02	0.14	0.47	0.56	0.15	-0.21	-0.09	0.57	-0.20
Cerium (Ce)	ppm	0.05	59	295	92	460	-	-	18.04	10.19	4.19	33.72	36.05	6.7	24.61	9.23	6.83	6.9	42.73	9.36	18.62	5.04	-0.16	-0.22	0.41	0.02
Chromium (Cr)	ppm	1	35	175	90	450	100	500	174	105	124	48	49	2.1	140	181	72	111	131	148	125	164	-0.63	0.59	0.38	0.64
Cobalt (Co)	ppm	0.1	0.3	1.5	19	95	10	50	**65.5**	**16**	**5.8**	**4.3**	**4.3**	0.0	**9.7**	**148**	**1.9**	**10.6**	**53**	47	**5**	**106**	-0.30	0.89	0.39	0.75
Copper (Cu)	ppm	0.5	1[d]	5[d]	45	225	70	350	91	**45.6**	**11.4**	**15.5**	**13.3**	15.3	**21.6**	183	**14.9**	**17.5**	177	155	**17.7**	**316**	-0.27	0.96	0.45	0.89
Gallium (Ga)	ppm	0.1	12	60	19	95	20	100	1.1	2.4	0.9	1.6	1.6	0.0	2.4	0.7	0.9	0.4	1.5	1.2	1.6	1	-0.39	-0.21	0.38	0.12
Germanium (Ge)	ppm	0.1	8	40	1.6	8	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	-	-	-	0.00
Hafnium (Hf)	ppm	0.05	3.9	19.5	2.8	14	-	-	0.16	0.49	0.28	0.17	0.19	11.1	0.12	0.17	0.33	0.13	0.3	0.19	0.25	0.16	0.98	-0.11	-0.45	0.06
Indium (In)	ppm	0.02	0.01[d]	0.05[d]	0.1	0.5	-	-	<0.02	<0.02	<0.02	<0.02	<0.02	-	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	-	-	-	0.63
Iron (Fe)	%	0.01	0.98	4.9	5	23.6	2	10	4.04	0.87	0.61	1.03	1.05	1.9	1.43	8.59	0.16	0.58	3.82	6.18	0.92	**12.4**	-0.18	1.00	0.50	0.82
Lanthenum (La)	ppm	0.1	30	150	92	460	30	150	7	5.3	2.2	17.5	18.6	6.1	14.3	3.5	3.7	2.7	12.9	4.5	9.5	2	0.01	-0.35	0.44	-0.18
Lead (Pb)	ppm	0.2	7	35	20	100	20	100	62.3	11.4	5.3	2	2.1	4.9	5.8	**101**	2.2	1.6	45.1	72.7	7.4	**153**	-0.26	0.99	0.46	0.82
Lithium (Li)	ppm	1	15	75	66	330	-	-	2	7	8	5	5	0.0	9	1	9	2	4	4	8	2	-0.31	-0.55	-0.06	-0.51
Lutetium (Lu)	ppm	0.01	1.2	6	0.7	3.5	-	-	0	0	<0.01	0.1	0.1	0.0	0	0	<0.01	0	0	0	0	0	-0.12	-0.32	0.32	-0.40
Magnesium (Mg)	%	0.01	0.7	3.5	1.5	7.5	0.7	3.5	0.1	0.06	0.02	0.51	0.52	1.9	0.57	0.02	0.02	0.02	0.1	0.29	0.23	0.02	0.95	-0.20	-0.17	-0.25
Manganese (Mn)	ppm	2	10[d]	50[d]	850	4250	150	750	54	20	16	**108**	**111**	2.7	**131**	99	11	**52**	68	106	**85**	133	-0.40	0.50	1.00	0.39
Mercury (Hg)	ppm	0.01	0.03	0.15	0.4	2	-	-	0.4	**0.17**	0.07	0.15	0.13	14.3	0.02	0.6	0.12	**0.22**	0.33	0.44	0.1	1.1	0.97	-0.02	-0.40	0.78
Molybdenum (Mo)	ppm	0.05	0.2	1	2.6	13	10	50	4.47	**2.33**	**2.95**	0.57	0.57	0.0	**2.27**	6.53	**1.42**	**3.22**	3.99	5.08	**2.78**	6.79	-0.50	0.84	0.38	0.76
Nickel (Ni)	ppm	0.5	2	10	68	340	50	250	76	**26**	**11**	**42**	**43**	2.4	**78**	**262**	8	**17**	87	107	**12**	**322**	-0.29	0.96	0.60	0.79
Niobium (Nb)	ppm	0.05	0.1[d]	0.5[d]	11	55	-	-	0.51	0.26	0.1	0.93	1.06	13.1	0.63	0.23	0.08	0.2	0.23	0.39	0.55	0.3	0.99	-0.11	-0.38	-0.19
Phosphorus (P)	%	0.01	0.017	0.085	0.07	0.35	-	-	<0.01	<0.01	<0.01	0.07	0.07	0.0	0.02	<0.01	<0.01	<0.01	<0.01	0.01	0.02	<0.01	-0.54	-0.46	0.50	-0.39
Potassium (K)	%	0.01	1.07	5.35	2.66	13.3	2	10	0.08	0.21	0.04	0.06	0.06	0.0	0.08	0.09	0.03	0.02	0.1	0.09	0.1	0.11	-0.39	0.26	0.21	0.63
Rubidium (Rb)	ppm	0.2	60	300	140	700	-	-	3	6.1	1.4	4.9	5	2.0	5.3	2	1.2	0.7	3	3.4	5.7	2.7	-0.09	-0.18	0.41	0.10
Scandium (Sc)	ppm	0.1	1	5	13	65	10	50	0.8	1.1	0.3	1.1	1.1	0.0	1.9	0.5	0.3	0.2	0.8	0.8	1	0.5	-0.29	-0.15	0.59	0.07
Selenium (Se)	ppm	1	0.05	0.25	0.6	3	-	-	<1	**<1**	**<1**	**<1**	**<1**	-	**<1**	1	**<1**	**<1**	<1	<1	**<1**	2	1.00	1.00	1.00	0.58
Silver (Ag)	ppm	0.01	0.01[d]	-	0.07	0.35	<1	-	**1.45**	**0.21**	**0.14**	0.03	0.02	40.0	**0.09**	**4.63**	0.03	**0.06**	**1.9**	**2.35**	**0.14**	**7.33**	0.95	0.11	-0.34	0.81
Sodium (Na)	%	0.01	0.33	1.65	0.96	4.8	0.7	3.5	0.01	<0.01	<0.01	0.02	0.02	0.0	0.02	0.01	<0.01	<0.01	0.01	0.02	0.03	0.02	-0.60	-0.10	0.73	-0.09
Strontium (Sr)	ppm	0.5	20	100	300	1500	200	1000	8.1	7	3.6	11.1	11.7	5.3	10.6	12	13.1	2.5	10.5	12.1	13.1	15.7	-0.30	0.51	0.64	0.39
Sulfur (S)	%	0.01	0.024	0.12	0.24	1.2	-	-	**3.25**	**0.84**	**0.52**	<0.01	<0.01	-	0.03	**>5.00**	<0.01	**0.29**	**3.84**	**>5.00**	**0.46**	**>5.00**	-0.35	0.94	-0.11	0.82
Tantalum (Ta)	ppm	0.05	0.01	0.05[d]	0.8	4	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	-	0.00
Tellurium (Te)	ppm	0.05	-	-	-	-	-	-	<0.05	<0.05	<0.05	0.05	<0.05	-	<0.05	0.06	<0.05	0.09	<0.05	0.07	<0.05	0.17	-0.47	0.65	0.39	0.52
Terbium (Tb)	ppm	0.02	1.6	8	1	5	-	-	0.13	0.09	0.03	0.21	0.22	4.7	0.15	0.08	0.03	0.08	0.29	0.07	0.11	0.03	0.99	-0.11	-0.41	0.08
Thallium (Tl)	ppm	0.02	0.82	4.1	1.4	7	-	-	0.85	0.18	0.17	0.06	0.06	0.0	0.09	2.24	0.03	0.1	0.89	0.75	0.1	1.13	-0.30	0.82	0.34	0.70
Thorium (Th)	ppm	0.01	1.7	8.5	12	60	-	-	2.7	3.1	1.1	4.2	4.7	11.2	3.1	1.8	1	0.5	3.8	1.6	2.3	1.3	0.90	-0.19	-0.23	0.14
Tin (Sn)	ppm	0.3	0.1[d]	0.5[d]	6	30	-	-	0.5	**0.6**	0.3	**0.7**	**0.6**	15.4	0.5	0.8	0.4	0.4	0.6	0.7	**0.6**	0.8	0.98	-0.07	-0.41	0.67
Titanium (Ti)	%	0.01	0.15	0.75	0.46	2.3	0.2	1	0.02	<0.01	<0.01	0.05	0.06	18.2	0.04	<0.01	<0.01	<0.01	<0.01	0.01	0.03	<0.01	0.99	-0.10	-0.83	-0.41
Tungsten (W)	ppm	0.1	1.6	8	1.8	9	-	-	0.6	2.5	5.2	0.2	0.2	0.0	0.2	2.2	1.5	2.2	1.6	3.6	0.5	2.5	-0.37	0.24	-0.21	0.16
Uranium (U)	ppm	0.05	0.45	2.25	3.7	18.5	-	-	1.16	1.3	0.28	0.68	0.74	8.5	0.55	0.75	0.19	0.17	2.22	0.41	0.54	0.55	0.95	-0.07	-0.43	0.53
Vanadium (V)	ppm	1	20	100	130	650	150	750	7	10	4	19	19	0.0	15	3	3	2	7	6	11	4	-0.26	-0.31	0.53	-0.22
Ytterbium (Yb)	ppm	0.1	4	20	2.6	13	-	-	0.2	0.2	<0.1	0.4	0.4	0.0	0.3	0.1	<0.1	<0.1	0.2	0.1	0.2	<0.1	-0.51	-0.52	0.58	-0.23
Yttrium (Y)	ppm	0.05	40	200	26	130	30	150	2.13	2.32	0.73	4.81	5.04	4.7	3.28	1.71	0.54	1.76	3.14	1.53	2.59	0.9	0.47	-0.33	0.20	-0.12
Zinc (Zn)	ppm	1	16	80	95	475	<300	-	7	75	8	11	11	0.0	15	9	2	4	6	13	9	10	-0.15	-0.12	-0.13	0.28
Zirconium (Zr)	ppm	0.5	-	-	-	-	70	350	5.2	14.3	7.8	5.3	5.6	5.5	5.3	6.5	8	5	7.8	6.3	7.6	6.4	-0.14	-0.16	-0.42	0.22

Notes:

[a] Organic Carbon is calculated from the difference between Total Carbon and Total inorganic Carbon (derived from ABA test, see Table 4-4)

[b] From Price (1997), Appendix 3

[c] Enrichment criteria based upon crustal abundance data multiplied by a factor of 5.

[d] Order of magnitude estimate from Price (1997) - most conservative value used

[e] From Vine and Tourtelot (1970), Table 2

- : Not Applicable

Exceeds Screening Criteria from one compilation.

ExceedsScreening Shale Criteria from both compilations

Lower limit of detection exceeds criteria from one or both compilations.

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Table 4-3. Acid Base Accounting (ABA) Results - Seymourville Site

Sample ID	Classification	Depth (m.bgs)	Lithology Description	Geological Unit	Fizz Test	Paste pH	Total C	Total Inorganic Carbon (TIC)	$CaCO_3$ Equiv.	Total S	HCl Extractable Sulphate Sulphur	HNO3 Extractable Sulphide Sulphur	Non Extractable Sulphur (by diff.)	Acid Generation Potential (AP)	Mod. ABA Neutralization Potential (NP)	Net Neutralization Potential NNP=NP-AP	Neutralization Potential Ratio NPR = NP/AP	Acid Generation Status
							wt%	wt%	Kg $CaCO_3$/T	wt%	wt%	wt%	wt%	Kg $CaCO_3$/T	Kg $CaCO_3$/T	Kg $CaCO_3$/T		
Detection Limit					-	0.20	0.005	0.01	-	0.005	0.01	0.01	-	-	0.50	-	-	-
CPS18-003_6-6.2m	Black Shale	6.0-6.2	Black shale	Winnipeg Formation	None	3.47	0.18	<0.01	<0.8	3.48	0.17	3.01	0.30	94.1	3.1	-91.0	0.03	PAG
CPS18-004A_6-7.5m		6.0-7.5	Shale/Sand	Winnipeg Formation	None	5.00	0.28	<0.01	<0.8	0.78	0.05	0.69	0.04	21.6	6.3	-15.3	0.3	PAG
CPS18-012_9-10.5 m		9.0-10.5	Black shale	Winnipeg Formation	None	3.31	0.29	<0.01	<0.8	9.14	0.18	8.09	0.87	252.8	1.3	-251.5	0.01	PAG
CPS18-059_4.05-6.15 m		4.05-6.15	Black shale	Winnipeg Formation	None	4.59	0.35	0.03	2.50	4.08	0.18	3.66	0.24	114.4	6.7	-107.7	0.1	PAG
CPS18-060_4.5-6.0 m		4.5-6.0	Black shale	Winnipeg Formation	None	6.32	0.38	0.15	12.50	6.70	0.25	5.82	0.63	181.9	16.7	-165.2	0.1	PAG
CPS18-074_8.5-9.9 m		8.5-9.9	Black shale	Winnipeg Formation	None	2.93	0.43	0.01	0.83	14.70	0.39	12.90	1.41	403.1	-1.8	-404.9	-0.004	PAG
CPS18-004A_7.5-9.0 m	Sand Underlying Black Shale/Overburden	7.5-9.0	Sand	Winnipeg Formation	None	6.34	0.04	<0.01	<0.8	0.55	0.04	0.47	0.04	14.7	5.6	-9.1	0.4	PAG
CPS18-012_0-1.5 m		0.0-1.5	Sand	Overburden	None	6.56	0.15	<0.01	<0.8	0.04	<0.01	0.02	<0.02	0.6	10.1	9.5	16.2	Non-PAG
CPS18-042_4.5-4.7 m		4.5-4.7	Sand	Winnipeg Formation	None	5.10	0.05	0.03	2.50	0.29	0.01	0.24	0.04	7.5	3.2	-4.3	0.4	PAG
CPS18-006_3.0-4.2 m	Sand without Black Shale Observed	3.0-4.2	Sand	Winnipeg Formation	None	8.86	0.14	0.13	10.83	0.01	<0.01	<0.01	<0.01	<0.3	18.9	> 18.6	> 63.0	Non-PAG
CPS18-068_12.6-15 m		12.6-15.0	Silty sand	Winnipeg Formation	None	7.58	0.20	0.17	14.17	0.45	0.03	0.37	0.05	11.6	18.3	6.7	1.6	Uncertain
CPS18-024_7.5-9.0 m		7.5-9.0	Sand	Winnipeg Formation	None	6.47	0.02	<0.01	<0.8	0.01	<0.01	<0.01	<0.01	<0.3	4.9	> 4.6	> 16.3	Non-PAG

Notes:

*AP = HNO_3 Extractable Sulphide Sulphur*31.25*

$CaCO_3$ Equivalency = Total Inorganic Carbon (TIC)(100/12)*10*

NNP = Modified NP-AP

Sulphate Sulphur determined by 25% HCl Leach with S by ICP.

Sulphide Sulphur determined by Sobek 1:7 Nitric Acid Leach with S by ICP Finish.

Insoluble S is acid insoluble S (Total S - (Sulphate S + Sulphide S)).

Mod. ABA Neutralization Potential - MEND Acid Rock Drainage Prediction Manual, MEND Project 1.16.1b (pages 6.2-11 to 17), March 1991.

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Table 4-4. MEND Shake Flask Extraction Results – Seymourville Site

Sample ID	Units	Alberta Tier 1 Guidelines, Natural Area, Coarse-Grained Soil	Ontario Table 1: Full Depth Background Site Condition Standards	Health Canada Canadian Drinking Water Quality	Canadian Water Quality Guidelines (CCME) for the Protection of Aquatic Life (AW, Freshwater), Short Term	Canadian Water Quality Guidelines (CCME) for the Protection of Aquatic Life (AW, Freshwater), Long Term	CPS18-003_6-6.2 m	CPS18-004A_6-7.5 m	CPS18-012_9-10.5 m	CPS18-059_4.05-6.15 m	CPS18-060_4.5-6.0 m	CPS18-074_8.5-9.9 m	CPS18-004A_7.5-9.0 m	CPS18-012_0-1.5 m)	CPS18-042_4.5-4.7 m	CPS18-006_3.0-4.2 m	CPS18-024_7.5-9.0 m	CPS18-068_12.6-15 m	Correlations between Trace Metals and Al, Fe and Mn		
Depth (m.b.g.s)							6-6.2	6-7.5	9-10.5	4.05-6.15	4.5-6.0	8.5-9.9	7.5-9.0	0-1.5	4.5-4.7	3.0-4.2	7.5-9.0	12.6-15			
Lithology Description							Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Overburden	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation	Winnipeg Formation			
Geological Unit							Black Shale	Shale / Sand	Black Shale	Black Shale	Black Sand	Black Shale	Sand	Sand	Sand	Sandy Silt	Sand	Silty Sand	Aluminum	Iron	Manganese
Classification							Black Shale						Sand Underlying Black Shale/Overburden			Sand Without Black Shale Observed					
Acid Generating Status							PAG	PAG	PAG	PAG	PAG	PAG	PAG	Non-PAG	PAG	Non-PAG	Non-PAG	Uncertain			
Inorganic																					
Hardness (as $CaCO_3$)	mg/L	n/g	n/s	n/g	n/g	n/g	247	231	109	804	943	578	205	11.8	56.1	36.4	8.5	156	-	-	-
pH (Lab)	-	6.5 - 8.5	n/s	7 - 10.5	n/g	6.5 - 9	3.03	4.99	3.05	5.97	7.24	2.81	6.37	5.95	5.53	7.92	7.29	7.79	-	-	-
Electrical Conductivity (Lab)	µS/cm	n/g	n/s	n/g	n/g	n/g	1566	876	1504	1499	1671	3225	494	32	164	86	27	373	-	-	-
Total Alkalinity	mg $CaCO_3$/L	n/g	n/s	n/g	n/g	n/g	-	0.2	-	2.8	59	-	4.1	2.7	1.3	43.3	7.5	50.2	-	-	-
Redox	mV	n/g	n/s	n/g	n/g	n/g	507	460	513	397	341	486	419	454	478	344.0	382	327	-	-	-
Acidity (to pH 4.5)	mg $CaCO_3$/L	n/g	n/s	n/g	n/g	n/g	123.7	-	153.8	-	-	298.1	-	-	-	-	-	-	-	-	-
Total Acidity (to pH 8.3)	mg $CaCO_3$/L	n/g	n/s	n/g	n/g	n/g	532.3	22.3	621	14.6	7.7	0	4.6	6.4	5.5	2.3	3	3	-	-	-
Sulphate (SO_4)	mg/L	128 - 429[b]	n/s	500 (Aesthetic Objective)	n/g	n/g	680	385	678	796	775	1857	205	6	64	3	3	106	-	-	-
Dissolved Metals																					
Aluminum (Al)	mg/L	0.007 - 0.1[a]	n/s	0.1	n/g	0.005 at pH < 6.5 0.1 at pH>6.5	20	0.974	28.2	0.055	0.01	42.2	0.007	0.888	0.047	0.152	2.96	0.037	1.00	0.94	0.56
Antimony (Sb)	mg/L	0.006	0.025	0.006	n/g	0.002*	0.0171	0.0029	0.154	0.0188	0.0255	0.2	0.0018	0.0017	< 0.0009	< 0.0009	0.0017	0.0104	0.92	0.87	0.76
Arsenic (As)	mg/L	0.005	0.013	0.01	n/g	0.005	0.0129	0.0007	0.132	0.0014	0.0028	0.177	0.0003	0.0028	0.0003	0.0021	0.0037	0.0017	0.94	0.89	0.62
Barium (Ba)	mg/L	1	0.61	1	n/g	n/g	0.029	0.0473	0.0276	0.0362	0.0479	0.0214	0.0525	0.00799	0.0331	0.00885	0.00386	0.0336	-0.18	-0.16	0.28
Beryllium (Be)	mg/L	n/g	0.0005	n/g	n/g	n/g	0.0018	0.00129	0.00527	0.000136	0.000007	0.00425	0.000012	0.000085	0.000677	0.000007	0.00007	< 0.000007	0.91	0.76	0.54
Bismuth (Bi)	mg/L	n/g	n/g	n/g	n/g	n/g	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	0.000022	< 0.000007	< 0.000007	0.000012	< 0.000007	-	-	-
Boron (B)	mg/L	1.5	1.7	5	29	1.5	0.017	0.461	0.072	0.106	0.048	0.055	0.057	0.032	0.059	0.022	0.091	0.045	-0.16	-0.15	0.05
Cadmium (Cd)	mg/L	0.00004 - 0.062[b]	0.5	5	0.001	0.00009	0.0387	0.00279	0.0526	0.0079	0.000384	0.0429	0.000095	0.000033	0.000055	0.000003	0.000023	0.000005	0.93	0.77	0.49
Calcium (Ca)	mg/L	n/g	n/s	n/g	n/g	n/g	55.9	49.2	19.2	221	321	221	61.7	1.23	13.3	6.82	1.47	46.7	0.18	0.31	0.55
Chromium (Cr)	mg/L	n/g	0.011	0.05	n/g	1b	0.107	0.00037	0.15	0.00009	< 0.00008	0.152	< 0.00008	0.00992	< 0.00008	0.00067	0.00364	0.00011	0.97	0.83	0.61
Cobalt (Co)	mg/L	n/g	0.0038	n/g	n/g	n/g	9.7	1.54	17.2	5.82	0.202	15.4	0.166	0.00304	0.287	0.000267	0.00128	0.00102	0.93	0.79	0.61
Copper (Cu)	mg/L	0.007	0.005	1	n/g	0.002 - 0.004[b]	1.13	0.309	1.04	0.0192	0.0025	1.75	0.0013	0.0309	0.0145	0.0035	0.0108	0.0057	0.98	0.93	0.54
Iron (Fe)	mg/L	0.3	n/s	0.3	n/g	0.3	117	0.836	112	1.41	0.141	392	0.07	1.9	0.085	0.128	0.279	0.009	0.94	1.00	0.62
Lead (Pb)	mg/L	0.001 - 0.007[b]	0.0019	0.01	n/g	0.001 - 0.007[b]	0.241	0.00929	0.43	0.0013	0.00064	0.254	0.00059	0.00353	0.00058	0.00012	0.00145	0.00006	0.88	0.68	0.40
Lithium (Li)	mg/L	n/g	n/s	n/g	n/g	n/g	0.0433	0.158	0.0411	0.0484	0.0246	0.0392	0.0322	0.0038	0.0417	0.0048	0.0179	0.0253	0.01	0.00	0.24
Magnesium (Mg)	mg/L	n/g	n/s	n/g	n/g	n/g	26.1	26.4	14.9	61.5	34.7	6.49	12.3	2.11	5.57	4.7	1.18	9.65	-0.14	-0.15	0.35
Manganese (Mn)	mg/L	0.05	n/s	0.05	n/g	n/g	0.359	0.481	0.828	1.15	0.604	1.56	0.317	0.0354	1.11	0.0126	0.0109	0.0281	0.56	0.62	1.00
Mercury (Hg)	mg/L	0.000005	0.0001	0.001	n/g	0.000026	0.01	< 0.01	< 0.01	< 0.01	0.02	0.01	< 0.01	0.04	< 0.01	< 0.01	< 0.01	< 0.01	-	-	-
Molybdenum (Mo)	mg/L	n/g	0.023	n/g	n/g	0.073	0.00017	0.00032	0.00038	0.00009	0.00746	0.00065	0.00046	0.00019	< 0.00004	0.00709	0.00729	0.00883	-0.40	-0.35	-0.49
Nickel (Ni)	mg/L	0.004 - 1.52[b]	0.014	n/g	n/g	0.025 - 0.15[b]	8.02	1.87	26.3	5.72	0.734	35	0.193	0.0615	0.489	0.0033	0.005	0.0035	0.96	0.91	0.68
Phosphorus (P)	mg/L	n/g	n/s	n/g	n/g	n/g	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	0.024	< 0.003	0.02	< 0.003	0.024	0.012	< 0.003	0.42	0.47	0.47
Potassium (K)	mg/L	n/g	n/s	n/g	n/g	n/g	1.59	95.5	23.9	23.2	19.2	14.2	10.1	0.563	3.96	1.42	1.41	7	-0.05	-0.06	0.17
Selenium (Se)	mg/L	0.002	0.005	0.05	n/g	0.001	0.00196	0.00788	0.00506	0.00313	0.00164	0.00117	0.00297	0.00029	0.00216	0.00012	0.00007	0.00077	-	-	-
Silicon (Si)	mg/L	n/g	n/s	n/g	n/g	n/g	8.59	12.2	5.39	4.55	2.51	6.39	3.02	8.97	3.47	6.31	9	3.87	0.11	0.07	-0.27
Silver (Ag)	mg/L	0.0001	0.0003	n/g	n/g	0.00025	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.0001	-	-	-
Sodium (Na)	mg/L	200	n/s	200	n/g	n/g	1.52	2.9	1.86	2.18	3.76	1.47	1	1.7	0.79	2.49	1.62	3.36	-0.29	-0.27	-0.27
Strontium (Sr)	mg/L	n/g	n/s	n/g	n/g	n/g	0.0898	0.183	0.195	0.248	0.295	0.237	0.0692	0.0104	0.0488	0.0205	0.0129	0.153	0.32	0.35	0.61
Sulphur (S)	mg/L	n/g	n/s	n/g	n/g	n/g	227	133	211	299	395	603	79.2	2.7	23.3	< 0.3	1.1	58	0.66	0.76	0.71
Thallium (Tl)	mg/L	n/g	0.0005	n/g	n/g	0.0008	0.0049	0.00174	0.0133	0.00218	0.000647	0.0086	0.000579	0.000024	0.000499	< 0.000005	0.000016	0.000046	0.87	0.69	0.51
Tin (Sn)	mg/L	n/g	n/s	n/g	n/g	n/g	0.00015	0.00022	0.00016	0.00014	0.00017	0.00017	0.00015	0.00237	0.00023	0.00025	0.00157	0.00015	-0.21	-0.21	-0.45
Titanium (Ti)	mg/L	n/g	n/s	n/g	n/g	n/g	0.00211	0.00026	0.00256	< 0.00005	0.0002	0.00597	0.00011	0.06065	< 0.00005	0.00822	0.135	0.00115	-0.21	-0.21	-0.39
Uranium (U)	mg/L	0.015	0.0089	0.02	0.033	0.015	0.12	0.00299	0.0596	0.00125	0.00282	0.057	0.000938	0.00177	0.00006	0.000363	0.000313	0.00236	0.75	0.62	0.23
Vanadium (V)	mg/L	n/g	0.0039	n/g	n/g	n/g	0.0162	0.00004	0.0314	0.00002	0.00005	0.0656	0.00003	0.0036	0.00001	0.00276	0.00307	0.00066	0.97	0.98	0.60
Zinc (Zn)	mg/L	0.03	0.16	5	0.008 - 0.381[a,b,c]	0.001 - 2.639[b,c]	0.204	3.17	0.307	0.023	< 0.002	0.099	0.093	0.007	0.085	< 0.002	0.004	< 0.002	-0.17	-0.17	-0.10
Zirconium (Zr)	mg/L	n/g	n/s	n/g	n/g	n/g	0.004	< 0.002	0.004	< 0.002	< 0.002	0.005	< 0.002	0.017	< 0.002	< 0.002	0.019	< 0.002	-0.86	-0.66	-0.72

Notes:
[a] Guideline/standard varies with pH
[b] Guideline/standard varies with hardness
[c] Guideline/standard varies with dissolved organic carbon (DOC)
**Proposed Water Quality Objective for Ontario*
n/g = No Guideline
n/s = No Standard
**Proposed Water Quality Objective for Ontario*

Value	*Exceeds CCME AW (Short Term)*
Value	*Exceeds CCME AW (Long Term)*
Value	*Exceeds Health Canada Canadian Drinking Water Quality Guideline*
Value	*Exceeds Both Health Canada Canadian Drinking Water Quality and CCME AW (Short Term)*
Value	*Exceeds Ontario Full Depth Background Site Conditions*
Value	*Exceeds Alberta Tier 1 Guidelines, Natural Area, Coarse-Grained Soil*

Appendix A

Laboratory Reports

CLIENT : **AECOM**
PROJECT : **Seymourville Sands**
SGS Project # : **1911**
Test : **Modified Acid Base Accounting with Siderite Correction**
Date : **April 26, 2019**

Sample ID	**Paste pH**	**TIC %**	**CaCO3 NP**	**C(T) %**	**S(T) %**	**S(SO4) %**	**S(S-2) %**	**Insoluble S %**	**AP**	**Modified NP w/ Siderite Correction**	**Net Modified NP**
Method Code	Sobek	CSB02V	Calc.	CSA06V	CSA06V	CSA07V	CSA08D	Calc.	Calc.	Modified/Siderite Corr.	Calc.
LOD	0.20	0.01	#N/A	0.005	0.005	0.01	0.01	#N/A	#N/A	0.5	#N/A
CPS18-003 (6-6.2 m)	3.47	<0.01	<0.8	0.179	3.48	0.17	3.01	0.30	94.1	3.1	-91.0
CPS18-004A (6-7.5 m)	5.00	<0.01	<0.8	0.278	0.784	0.05	0.69	0.04	21.6	6.3	-15.3
CPS18-004A (7.5-9.0 m)	6.34	<0.01	<0.8	0.037	0.553	0.04	0.47	0.04	14.7	5.6	-9.1
CPS18-006 (3.0-4.2 m)	8.86	0.13	10.8	0.141	0.007	<0.01	<0.01	<0.01	<0.3	18.9	18.9
CPS18-012 (0-1.5 m)	6.56	<0.01	<0.8	0.148	0.04	<0.01	0.02	0.02	0.6	10.1	9.5
CPS18-012 (9-10.5 m)	3.31	<0.01	<0.8	0.294	9.14	0.18	8.09	0.87	252.8	1.3	-251.5
CPS18-024 (7.5-9.0 m)	6.47	<0.01	<0.8	0.015	0.007	<0.01	<0.01	<0.01	<0.3	4.9	4.9
CPS18-042 (4.5-4.7 m)	5.10	0.03	2.5	0.054	0.289	0.01	0.24	0.04	7.5	3.2	-4.3
CPS18-059 (4.05-6.15 m)	4.59	0.03	2.5	0.345	4.08	0.18	3.66	0.24	114.4	6.7	-107.7
CPS18-060 (4.5-6.0 m)	6.32	0.15	12.5	0.379	6.7	0.25	5.82	0.63	181.9	16.7	-165.2
CPS18-068 (12.6-15 m)	7.58	0.17	14.2	0.203	0.454	0.03	0.37	0.05	11.6	18.3	6.7
CPS18-074 (8.5-9.9 m)	2.93	0.01	0.8	0.43	14.7	0.39	12.9	1.41	403.1	-1.8	-404.9
Duplicates											
CPS18-004A (7.5-9.0m)						0.04	0.47				
CPS18-006 (3.0-4.2)				0.141	0.008						
CPS18-024 (7.5-9.0m)		<0.01									
CPS18-042 (4.5-4.7m)										4.0	
QC											
GTS-2A				1.94	0.328						
RTS-3A						0.99	2.32				
SY4		0.92									
NBM-1										49.9	
Expected Value		0.91		2.01	0.341	0.98	2.46			49.6	
Tolerance +/-		0.07		0.11	0.030	0.12	0.25			4.5	

Note:

CLIENT : **AECOM**
PROJECT : **Seymourville Sands**
SGS Project # : **1911**
Test : **Metals by Aqua Regia Digestion with ICP-MS Finish**
Date : **April 22, 2019**

Sample ID	**Ag ppm**	**Al %**	**Ba ppm**	**Ca %**	**Cr ppm**	**Cu ppm**	**Fe %**	**K %**	**Li ppm**	**Mg %**
Method Code	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
LOD	0.01	0.01	5	0.01	1	0.5	0.01	0.01	1	0.01
CPS18-003 (6-6.2 m)	1.45	0.23	28	0.05	174	91	4.04	0.08	2	0.1
CPS18-004A (6-7.5 m)	0.21	0.38	20	0.04	105	45.6	0.87	0.21	7	0.06
CPS18-004A (7.5-9.0 m)	0.14	0.27	7	0.05	124	11.4	0.61	0.04	8	0.02
CPS18-006 (3.0-4.2 m)	0.03	0.31	22	0.54	48	15.5	1.03	0.06	5	0.51
CPS18-012 (0-1.5 m)	0.09	0.65	27	0.14	140	21.6	1.43	0.08	9	0.57
CPS18-012 (9-10.5 m)	4.63	0.13	41	0.02	181	183	8.59	0.09	1	0.02
CPS18-024 (7.5-9.0 m)	0.03	0.31	<5	0.02	72	14.9	0.16	0.03	9	0.02
CPS18-042 (4.5-4.7 m)	0.06	0.09	<5	0.02	111	17.5	0.58	0.02	2	0.02
CPS18-059 (4.05-6.15 m)	1.9	0.26	24	0.14	131	177	3.82	0.1	4	0.1
CPS18-060 (4.5-6.0 m)	2.35	0.25	37	0.47	148	155	6.18	0.09	4	0.29
CPS18-068 (12.6-15 m)	0.14	0.4	24	0.56	125	17.7	0.92	0.1	8	0.23
CPS18-074 (8.5-9.9 m)	7.33	0.14	62	0.15	164	316	12.4	0.11	2	0.02
Duplicate										
CPS18-006 (3.0-4.2)	0.02	0.32	22	0.54	49	13.3	1.05	0.06	5	0.52
QC										
OREAS 260	0.16	1.3	149	0.87	50	46.7	3.68	0.26	20	0.57
Certified Values	0.146	1.33	151	0.885	49.2	46.5	3.73	0.285	21.5	0.593
Tolerance (%)	30.77	12.80	20.12	14.46	16.31	13.55	11.33	23.08	24.25	14.55

CLIENT
PROJECT
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Test
Date

Sample ID	**Mn** ppm	**Na** %	**Ni** ppm	**P** %	**S** %	**Sr** ppm	**Ti** %	**V** ppm	**Zn** ppm	**Zr** ppm
Method Code	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
LOD	2	0.01	0.5	0.01	0.01	0.5	0.01	1	1	0.5
CPS18-003 (6-6.2 m)	54	0.01	76	<0.01	3.25	8.1	0.02	7	7	5.2
CPS18-004A (6-7.5 m)	20	<0.01	26	<0.01	0.84	7	<0.01	10	75	14.3
CPS18-004A (7.5-9.0 m)	16	<0.01	11	<0.01	0.52	3.6	<0.01	4	8	7.8
CPS18-006 (3.0-4.2 m)	108	0.02	42	0.07	<0.01	11.1	0.05	19	11	5.3
CPS18-012 (0-1.5 m)	131	0.02	78	0.02	0.03	10.6	0.04	15	15	5.3
CPS18-012 (9-10.5 m)	99	0.01	262	<0.01	>5.00	12	<0.01	3	9	6.5
CPS18-024 (7.5-9.0 m)	11	<0.01	8	<0.01	<0.01	13.1	<0.01	3	2	8
CPS18-042 (4.5-4.7 m)	52	<0.01	17	<0.01	0.29	2.5	<0.01	2	4	5
CPS18-059 (4.05-6.15 m)	68	0.01	87	<0.01	3.84	10.5	<0.01	7	6	7.8
CPS18-060 (4.5-6.0 m)	106	0.02	107	0.01	>5.00	12.1	0.01	6	13	6.3
CPS18-068 (12.6-15 m)	85	0.03	12	0.02	0.46	13.1	0.03	11	9	7.6
CPS18-074 (8.5-9.9 m)	133	0.02	322	<0.01	>5.00	15.7	<0.01	4	10	6.4
Duplicate										
CPS18-006 (3.0-4.2)	111	0.02	43	0.07	<0.01	11.7	0.06	19	11	5.6
QC										
OREAS 260	455	0.08	72	0.04	0.07	14.3	<0.01	19	119	14
Certified Values	450	0.082	75	0.04	0.077	14.8	BDL	22.0	125	12.6
Tolerance (%)	11.76	46.15	14.29	66.67	66.67	20.32	BDL	23.9	12.77	#N/A

CLIENT
PROJECT
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Sample ID	**As ppm**	**Be ppm**	**Bi ppm**	**Cd ppm**	**Ce ppm**	**Co ppm**	**Cs ppm**	**Ga ppm**	**Ge ppm**	**Hf ppm**
Method Code	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
LOD	1	0.1	0.02	0.01	0.05	0.1	0.05	0.1	0.1	0.05
CPS18-003 (6-6.2 m)	22	<0.1	0.13	0.18	18.04	65.5	0.21	1.1	<0.1	0.16
CPS18-004A (6-7.5 m)	4	0.2	0.11	0.11	10.19	16	0.35	2.4	<0.1	0.49
CPS18-004A (7.5-9.0 m)	4	<0.1	0.03	0.01	4.19	5.8	0.07	0.9	<0.1	0.28
CPS18-006 (3.0-4.2 m)	<1	<0.1	0.05	0.02	33.72	4.3	0.25	1.6	<0.1	0.17
CPS18-012 (0-1.5 m)	3	0.1	0.07	0.02	24.61	9.7	0.27	2.4	<0.1	0.12
CPS18-012 (9-10.5 m)	53	<0.1	0.16	0.27	9.23	148	0.12	0.7	<0.1	0.17
CPS18-024 (7.5-9.0 m)	2	<0.1	0.03	0.02	6.83	1.9	0.11	0.9	<0.1	0.33
CPS18-042 (4.5-4.7 m)	<1	<0.1	0.03	<0.01	6.9	10.6	<0.05	0.4	<0.1	0.13
CPS18-059 (4.05-6.15 m)	32	<0.1	0.11	0.13	42.73	53	0.18	1.5	<0.1	0.3
CPS18-060 (4.5-6.0 m)	42	<0.1	0.11	0.12	9.36	47	0.17	1.2	<0.1	0.19
CPS18-068 (12.6-15 m)	3	<0.1	0.05	0.02	18.62	5	0.28	1.6	<0.1	0.25
CPS18-074 (8.5-9.9 m)	73	<0.1	0.27	0.19	5.04	106	0.15	1	<0.1	0.16
Duplicate										
CPS18-006 (3.0-4.2)	<1	<0.1	0.05	0.02	36.05	4.3	0.25	1.6	<0.1	0.19
QC										
OREAS 260	12	1.1	0.54	0.22	62.42	31.7	2.99	4.6	<0.1	0.41
Certified Values	12.5	1.24	0.54	0.21	55	32.10	3.12	5.05	BDL	0.33
Tolerance (%)	35.29	35.07	20.41	27.03	#N/A	11.39	#N/A	16.04	BDL	#N/A

CLIENT
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Sample ID	**Hg ppm**	**In ppm**	**La ppm**	**Lu ppm**	**Mo ppm**	**Nb ppm**	**Pb ppm**	**Rb ppm**	**Sb ppm**	**Sc ppm**
Method Code	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
LOD	0.01	0.02	0.1	0.01	0.05	0.05	0.2	0.2	0.05	0.1
CPS18-003 (6-6.2 m)	0.4	<0.02	7	0.02	4.47	0.51	62.3	3	6.79	0.8
CPS18-004A (6-7.5 m)	0.17	<0.02	5.3	0.03	2.33	0.26	11.4	6.1	1.59	1.1
CPS18-004A (7.5-9.0 m)	0.07	<0.02	2.2	<0.01	2.95	0.1	5.3	1.4	0.79	0.3
CPS18-006 (3.0-4.2 m)	0.15	<0.02	17.5	0.06	0.57	0.93	2	4.9	<0.05	1.1
CPS18-012 (0-1.5 m)	0.02	<0.02	14.3	0.04	2.27	0.63	5.8	5.3	0.3	1.9
CPS18-012 (9-10.5 m)	0.6	0.03	3.5	0.02	6.53	0.23	101	2	19.93	0.5
CPS18-024 (7.5-9.0 m)	0.12	<0.02	3.7	<0.01	1.42	0.08	2.2	1.2	0.17	0.3
CPS18-042 (4.5-4.7 m)	0.22	<0.02	2.7	0.01	3.22	0.2	1.6	0.7	0.4	0.2
CPS18-059 (4.05-6.15 m)	0.33	<0.02	12.9	0.03	3.99	0.23	45.1	3	12.49	0.8
CPS18-060 (4.5-6.0 m)	0.44	<0.02	4.5	0.02	5.08	0.39	72.7	3.4	10.09	0.8
CPS18-068 (12.6-15 m)	0.1	<0.02	9.5	0.03	2.78	0.55	7.4	5.7	0.64	1
CPS18-074 (8.5-9.9 m)	1.1	0.03	2	0.01	6.79	0.3	153	2.7	31.9	0.5
Duplicate										
CPS18-006 (3.0-4.2)	0.13	<0.02	18.6	0.06	0.57	1.06	2.1	5	<0.05	1.1
QC										
OREAS 260	0.05	0.02	32.2	0.13	0.35	0.06	29.4	19	1.39	3
Certified Values	0.047	0.027	28.1	0.140	0.43	BDL	30.7	21.2	1.32	3.39
Tolerance (%)	#N/A	90.91	#N/A	33.33	49.28	BDL	12.35	#N/A	21.85	19.06

CLIENT
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Test
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Sample ID	**Se ppm**	**Sn ppm**	**Ta ppm**	**Tb ppm**	**Te ppm**	**Th ppm**	**Tl ppm**	**U ppm**	**W ppm**	**Y ppm**
Method Code	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B	ICM14B
LOD	1	0.3	0.05	0.02	0.05	0.1	0.02	0.05	0.1	0.05
CPS18-003 (6-6.2 m)	<1	0.5	<0.05	0.13	<0.05	2.7	0.85	1.16	0.6	2.13
CPS18-004A (6-7.5 m)	<1	0.6	<0.05	0.09	<0.05	3.1	0.18	1.3	2.5	2.32
CPS18-004A (7.5-9.0 m)	<1	0.3	<0.05	0.03	<0.05	1.1	0.17	0.28	5.2	0.73
CPS18-006 (3.0-4.2 m)	<1	0.7	<0.05	0.21	0.05	4.2	0.06	0.68	0.2	4.81
CPS18-012 (0-1.5 m)	<1	0.5	<0.05	0.15	<0.05	3.1	0.09	0.55	0.2	3.28
CPS18-012 (9-10.5 m)	1	0.8	<0.05	0.08	0.06	1.8	2.24	0.75	2.2	1.71
CPS18-024 (7.5-9.0 m)	<1	0.4	<0.05	0.03	<0.05	1	0.03	0.19	1.5	0.54
CPS18-042 (4.5-4.7 m)	<1	0.4	<0.05	0.08	0.09	0.5	0.1	0.17	2.2	1.76
CPS18-059 (4.05-6.15 m)	<1	0.6	<0.05	0.29	<0.05	3.8	0.89	2.22	1.6	3.14
CPS18-060 (4.5-6.0 m)	<1	0.7	<0.05	0.07	0.07	1.6	0.75	0.41	3.6	1.53
CPS18-068 (12.6-15 m)	<1	0.6	<0.05	0.11	<0.05	2.3	0.1	0.54	0.5	2.59
CPS18-074 (8.5-9.9 m)	2	0.8	<0.05	0.03	0.17	1.3	1.13	0.55	2.5	0.9
Duplicate										
CPS18-006 (3.0-4.2)	<1	0.6	<0.05	0.22	<0.05	4.7	0.06	0.74	0.2	5.04
QC										
OREAS 260	<1	0.9	<0.05	0.54	<0.05	10.9	0.22	1.28	<0.1	11.6
Certified Values	BDL	0.62	BDL	0.52	0.081	11.30	0.22	1.29	BDL	11.7
Tolerance (%)	BDL	#N/A	BDL	21.28	89.66	13.01	37.84	21.46	BDL	11.76

CLIENT
PROJECT
SGS Project #
Test
Date

Sample ID	Yb ppm
Method Code	ICM14B
LOD	0.1
CPS18-003 (6-6.2 m)	0.2
CPS18-004A (6-7.5 m)	0.2
CPS18-004A (7.5-9.0 m)	<0.1
CPS18-006 (3.0-4.2 m)	0.4
CPS18-012 (0-1.5 m)	0.3
CPS18-012 (9-10.5 m)	0.1
CPS18-024 (7.5-9.0 m)	<0.1
CPS18-042 (4.5-4.7 m)	<0.1
CPS18-059 (4.05-6.15 m)	0.2
CPS18-060 (4.5-6.0 m)	0.1
CPS18-068 (12.6-15 m)	0.2
CPS18-074 (8.5-9.9 m)	<0.1
Duplicate	
CPS18-006 (3.0-4.2)	0.4
QC	
OREAS 260	0.9
Certified Values	0.99
Tolerance (%)	42.94

CLIENT : **AECOM**
PROJECT : **Seymourville Sands**
SGS Project # : **1911**
Test : **24 Hour Nanopure Water Leach Extraction Test at 3:1 Liquid to Solid Ratio**
Date : **April 22, 2019**

Leachate Analysis

Sample ID			**CPS18-003 (6-6.2m)**	**CPS18-004A (6-7.5m)**	**CPS18-004A (7.6-9.0m)**	**CPS18-006 (3.0-4.2m)**	**CPS18-012 (0-1.5m)**	**CPS18-012 (9-10.5m)**	**CPS18-024 (7.5-9.0m)**	**CPS18-042 (4.5-4.7m)**	**CPS18-059 (4.05-6.15m)**	**CPS18-060 (4.5-6.0m)**	**CPS18-068 (12.6-15m)**	**CPS18-074 (8.5-9.9m)**	**Blank**
Parameter	**Method**	**Units**													
Volume Nanopure Water		mL	750	750	750	750	750	750	750	750	750	750	750	750	750
Sample Weight		g	250	250	250	250	250	250	250	250	250	250	250	250	-
pH	meter		3.03	4.99	6.37	7.92	5.95	3.05	7.29	5.53	5.97	7.24	7.79	2.81	6.01
Redox	meter	mV	507	460	419	344	454	513	382	478	397	341	327	486	-
Conductivity	meter	uS/cm	1566	876	494	86	32	1504	27	164	1499	1671	373	3225	2
Acidity (to pH 4.5)	titration	mg CaCO3/L	123.7	#N/A	#N/A	#N/A	#N/A	153.8	#N/A	#N/A	#N/A	#N/A	#N/A	298.1	-
Total Acidity (to pH 8.3)	titration	mg CaCO3/L	532.3	22.3	4.6	2.3	6.4	621.0	3.0	5.5	14.6	7.7	3.0	0.0	-
Alkalinity	titration	mg CaCO3/L	#N/A	0.2	4.1	43.3	2.7	#N/A	7.5	1.3	2.8	59.0	50.2	#N/A	-
Sulphate	Turbidity	mg/L	680	385	205	3	6	678	3	64	796	775	106	1857	-
Ion Balance															
Major Anions	Calc	meq/L	14.17	8.03	4.35	0.93	0.18	14.13	0.21	1.36	16.64	17.32	3.21	38.69	#N/A
Major Cations	Calc	meq/L	15.15	7.75	4.42	0.90	0.52	14.49	0.62	1.32	17.32	19.60	3.45	41.14	#N/A
Difference	Calc	meq/L	-0.99	0.28	-0.07	0.03	-0.34	-0.36	-0.41	0.03	-0.68	-2.27	-0.24	-2.46	#N/A
Balance (%)	Calc	%	-3.4%	1.8%	-0.8%	1.8%	-48.7%	-1.3%	-49.1%	1.3%	-2.0%	-6.2%	-3.6%	-3.1%	#N/A
Dissolved Metals															
Hardness CaCO3		mg/L	247	231	205	36.4	11.8	109	8.5	56.1	804	943	156	578	-
Aluminum Al	ICP-MS	mg/L	20.0	0.974	0.007	0.152	0.888	28.2	2.96	0.047	0.055	0.010	0.037	42.2	-
Antimony Sb	ICP-MS	mg/L	0.0171	0.0029	0.0018	< 0.0009	0.0017	0.154	0.0017	< 0.0009	0.0188	0.0255	0.0104	0.200	-
Arsenic As	ICP-MS	mg/L	0.0129	0.0007	0.0003	0.0021	0.0028	0.132	0.0037	0.0003	0.0014	0.0028	0.0017	0.177	-
Barium Ba	ICP-MS	mg/L	0.0290	0.0473	0.0525	0.00885	0.00799	0.0276	0.00386	0.0331	0.0362	0.0479	0.0336	0.0214	-
Beryllium Be	ICP-MS	mg/L	0.00180	0.00129	0.000012	0.000007	0.000085	0.00527	0.000070	0.000677	0.000136	0.000007	< 0.000007	0.00425	-
Bismuth Bi	ICP-MS	mg/L	< 0.000007	< 0.000007	< 0.000007	< 0.000007	0.000022	< 0.000007	0.000012	< 0.000007	< 0.000007	< 0.000007	< 0.000007	< 0.000007	-
Boron B	ICP-MS	mg/L	0.017	0.461	0.057	0.022	0.032	0.072	0.091	0.059	0.106	0.048	0.045	0.055	-
Cadmium Cd	ICP-MS	mg/L	0.0387	0.00279	0.000095	0.000003	0.000033	0.0526	0.000023	0.000055	0.00790	0.000384	0.000005	0.0429	-
Calcium Ca	ICP-MS	mg/L	55.9	49.2	61.7	6.82	1.23	19.2	1.47	13.3	221	321	46.7	221	-
Chromium Cr	ICP-MS	mg/L	0.107	0.00037	< 0.00008	0.00067	0.00992	0.150	0.00364	< 0.00008	0.00009	< 0.00008	0.00011	0.152	-
Cobalt Co	ICP-MS	mg/L	9.70	1.54	0.166	0.000267	0.00304	17.2	0.00128	0.287	5.82	0.202	0.00102	15.4	-
Copper Cu	ICP-MS	mg/L	1.13	0.309	0.0013	0.0035	0.0309	1.04	0.0108	0.0145	0.0192	0.0025	0.0057	1.75	-
Iron Fe	ICP-MS	mg/L	117	0.836	0.070	0.128	1.90	112	0.279	0.085	1.41	0.141	0.009	392	-
Lead Pb	ICP-MS	mg/L	0.241	0.00929	0.00059	0.00012	0.00353	0.430	0.00145	0.00058	0.00130	0.00064	0.00006	0.254	-
Lithium Li	ICP-MS	mg/L	0.0433	0.158	0.0322	0.0048	0.0038	0.0411	0.0179	0.0417	0.0484	0.0246	0.0253	0.0392	-
Magnesium Mg	ICP-MS	mg/L	26.1	26.4	12.3	4.70	2.11	14.9	1.18	5.57	61.5	34.7	9.65	6.49	-
Manganese Mn	ICP-MS	mg/L	0.359	0.481	0.317	0.0126	0.0354	0.828	0.0109	1.11	1.15	0.604	0.0281	1.56	-
Mercury Hg	ICP-MS	ug/L	0.01	< 0.01	< 0.01	< 0.01	0.04	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	0.01	-
Molybdenum Mo	ICP-MS	mg/L	0.00017	0.00032	0.00046	0.00709	0.00019	0.00038	0.00729	< 0.00004	0.00009	0.00746	0.00883	0.00065	-
Nickel Ni	ICP-MS	mg/L	8.02	1.87	0.193	0.0033	0.0615	26.3	0.0050	0.489	5.72	0.734	0.0035	35.0	-
Phosphorus P	ICP-MS	mg/L	< 0.003	< 0.003	< 0.003	0.024	0.020	< 0.003	0.012	< 0.003	< 0.003	< 0.003	< 0.003	0.024	-
Potassium K	ICP-MS	mg/L	1.59	95.5	10.1	1.42	0.563	23.9	1.41	3.96	23.2	19.2	7.00	14.2	-
Selenium Se	ICP-MS	mg/L	0.00196	0.00788	0.00297	0.00012	0.00029	0.00506	0.00007	0.00216	0.00313	0.00164	0.00077	0.00117	-
Silicon Si	ICP-MS	mg/L	8.59	12.2	3.02	6.31	8.97	5.39	9.00	3.47	4.55	2.51	3.87	6.39	-
Silver Ag	ICP-MS	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00005	0.00010	< 0.00005	-
Sodium Na	ICP-MS	mg/L	1.52	2.90	1.00	2.49	1.70	1.86	1.62	0.79	2.18	3.76	3.36	1.47	-
Strontium Sr	ICP-MS	mg/L	0.0898	0.183	0.0692	0.0205	0.0104	0.195	0.0129	0.0488	0.248	0.295	0.153	0.237	-
Sulphur (S)	ICP-MS	mg/L	227	133	79.2	< 0.3	2.7	211	1.1	23.3	299	395	58.0	603	-
Thallium Tl	ICP-MS	mg/L	0.00490	0.00174	0.000579	< 0.000005	0.000024	0.0133	0.000016	0.000499	0.00218	0.000647	0.000046	0.00860	-
Tin Sn	ICP-MS	mg/L	0.00015	0.00022	0.00015	0.00025	0.00237	0.00016	0.00157	0.00023	0.00014	0.00017	0.00015	0.00017	-
Titanium Ti	ICP-MS	mg/L	0.00211	0.00026	0.00011	0.00822	0.06065	0.00256	0.135	< 0.00005	< 0.00005	0.00020	0.00115	0.00597	-
Uranium U	ICP-MS	mg/L	0.120	0.00299	0.000938	0.000363	0.00177	0.0596	0.000313	0.000060	0.00125	0.00282	0.00236	0.0570	-
Vanadium V	ICP-MS	mg/L	0.0162	0.00004	0.00003	0.00276	0.00360	0.0314	0.00307	0.00001	0.00002	0.00005	0.00066	0.0656	-
Zinc Zn	ICP-MS	mg/L	0.204	3.17	0.093	< 0.002	0.007	0.307	0.004	0.085	0.023	< 0.002	< 0.002	0.099	-
Zirconium Zr	ICP-MS	mg/L	0.004	< 0.002	< 0.002	< 0.002	0.017	0.004	0.019	< 0.002	< 0.002	< 0.002	< 0.002	0.005	-

Quantitative X-Ray Diffraction by Rietveld Refinement

Report Prepared for:	*SGS Canada Inc*
Project Number/ LIMS No.	*14094-01B/MI4509-APR19*
Batch No.	*1911 Seymourvill Sand*
Sample Receipt:	*April 16, 2019*
Sample Analysis:	*April 26, 2019*
Reporting Date:	*May 1, 2019*

Instrument:	BRUKER AXS D8 Advance Diffractometer
Test Conditions:	Co radiation, 40 kV, 35 mA Regular Scanning: Step: 0.02°, Step time: 1s, 2θ range: 3-80°
Interpretations :	PDF2/PDF4 powder diffraction databases issued by the International Center for Diffraction Data (ICDD). DiffracPlus Eva and Topas software.
Detection Limit :	0.5-2%. Strongly dependent on crystallinity.

Contents:

[redacted]

Kim Gibbs, H.B.Sc., P.Geo.
Senior Mineralogist

[redacted]

Huyun Zhou, Ph.D., P.Geo.
Senior Mineralogist

ACCREDITATION: SGS Minerals Services Lakefield is accredited to the requirements of ISO/IEC 17025 for specific tests as listed on our scope of accreditation, including geochemical, mineralogical and trade mineral tests. To view a list of the accredited methods, please visit the following website and search SGS Canada - Minerals Services - Lakefield: http://palcan.scc.ca/SpecsSearch/GLSearchForm.do.

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Method Summary

The Rietveld Method of Mineral Identification by XRD (ME-LR-MIN-MET-MN-D05) method used by SGS Minerals Services is accredited to the requirements of ISO/IEC 17025.

Mineral Identification and Interpretation:

Mineral identification and interpretation involves matching the diffraction pattern of an unknown material to patterns of single-phase reference materials. The reference patterns are compiled by the Joint Committee on Powder Diffraction Standards - International Center for Diffraction Data (JCPDS-ICDD) database and released on software as Powder Diffraction Files (PDF).

Interpretations do not reflect the presence of non-crystalline and/or amorphous compounds, except when internal standards have been added by request. Mineral proportions may be strongly influenced by crystallinity, crystal structure and preferred orientations. Mineral or compound identification and quantitative analysis results should be accompanied by supporting chemical assay data or other additional tests.

Quantitative Rietveld Analysis:

Quantitative Rietveld Analysis is performed by using Topas 4.2 (Bruker AXS), a graphics based profile analysis program built around a non-linear least squares fitting system, to determine the amount of different phases present in a multicomponent sample. Whole pattern analyses are predicated by the fact that the X-ray diffraction pattern is a total sum of both instrumental and specimen factors. Unlike other peak intensity-based methods, the Rietveld method uses a least squares approach to refine a theoretical line profile until it matches the obtained experimental patterns.

Rietveld refinement is completed with a set of minerals specifically identified for the sample. Zero values indicate that the mineral was included in the refinement calculations, but the calculated concentration was less than 0.05wt%. Minerals not identified by the analyst are not included in refinement calculations for specific samples and are indicated with a dash.

Summary of Rietveld Quantitative Analysis X-Ray Diffraction Results

Mineral/Compound	CPS18-003 (6-6.2m) APR4509-01 (wt %)	CPS18-004A (6-7.5m) APR4509-02 (wt %)	CPS18-004A (7.5-9.0m) APR4509-03 (wt %)	CPS18-006 (3.0-4.2m) APR4509-04 (wt %)	CPS18-012 (0-1.5m) APR4509-05 (wt %)	CPS18-012 (9-10.5m) APR4509-06 (wt %)
Quartz	60.0	45.7	86.9	35.4	56.3	64.9
Albite	9.1	1.2	1.0	38.7	25.2	0.7
Pyrite	4.2	0.9	0.7	0.2	0.1	11.2
Diopside	0.8	1.7	0.7	3.3	2.1	1.0
Muscovite	3.6	4.0	2.1	3.3	2.0	2.0
Chlorite	1.0	1.9	1.1	1.0	2.1	0.3
Actinolite	3.7	-	-	3.2	2.8	3.2
Calcite	0.4	0.2	-	0.5	0.3	-
Ankerite	0.2	0.2	-	0.4	-	-
Microcline	17.1	39.6	3.6	12.8	8.9	16.7
Gypsum	-	0.9	-	-	-	-
Kaolinite	-	2.3	3.9	-	-	-
Biotite	-	1.4	-	-	-	-
Lizardite	-	-	-	0.3	0.3	-
Kutnahorite	-	-	-	0.7	-	-
Magnetite	-	-	-	-	-	-
TOTAL	100	100	100	100	100	100

Zero values indicate that the mineral was included in the refinement, but the calculated concentration is below a measurable value.

Dashes indicate that the mineral was not identifed by the analyst and not included in the refinement calculation for the sample.

The weight percent quantities indicated have been normalized to a sum of 100%. The quantity of amorphous material has not been determined

Mineral/Compound	Formula
Quartz	SiO_2
Albite	$NaAlSi_3O_8$
Pyrite	FeS_2
Diopside	$CaMgSi_2O_6$
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$
Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$
Calcite	$CaCO_3$
Ankerite	$CaFe(CO_3)_2$
Microcline	$KAlSi_3O_8$
Gypsum	$CaSO_4 \cdot 2H_2O$
Kaolinite	$Al_2Si_2O_5(OH)_4$
Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$
Lizardite	$Mg_3Si_2O_5(OH)_4$
Kutnahorite	$CaMn(CO_3)_2$
Magnetite	Fe_3O_4

Summary of Rietveld Quantitative Analysis X-Ray Diffraction Results

Mineral/Compound	CPS18-024 (7.5-9.0m) APR4509-07 (wt %)	CPS18-042 (4.5-4.7m) APR4509-08 (wt %)	CPS18-059 (4.05-6.15m) APR4509-09 (wt %)	CPS18-060 (4.5-6.0m) APR4509-10 (wt %)	CPS18-068 (12.6-15m) APR4509-11 (wt %)	CPS18-074 (8.5-9.9m) APR4509-12 (wt %)
Quartz	83.9	92.2	59.2	67.7	67.5	54.1
Albite	0.9	1.4	2.8	5.6	15.6	1.5
Pyrite	0.1	0.5	4.6	8.1	0.4	18.0
Diopside	1.0	0.7	0.9	0.9	1.1	0.9
Muscovite	1.8	2.0	3.6	2.3	2.3	2.3
Chlorite	2.9	0.9	2.5	-	0.8	-
Actinolite	-	-	-	-	2.0	-
Calcite	-	-	0.3	0.5	1.0	-
Ankerite	-	-	0.3	0.6	0.6	-
Microcline	1.6	2.3	23.3	12.7	6.3	21.4
Gypsum	1.2	-	-	-	-	1.9
Kaolinite	6.6	-	2.5	1.6	1.4	-
Biotite	-	-	-	-	-	-
Lizardite	-	-	-	-	-	-
Kutnahorite	-	-	-	-	0.8	-
Magnetite	-	-	-	-	0.3	-
TOTAL	100	100	100	100	100	100

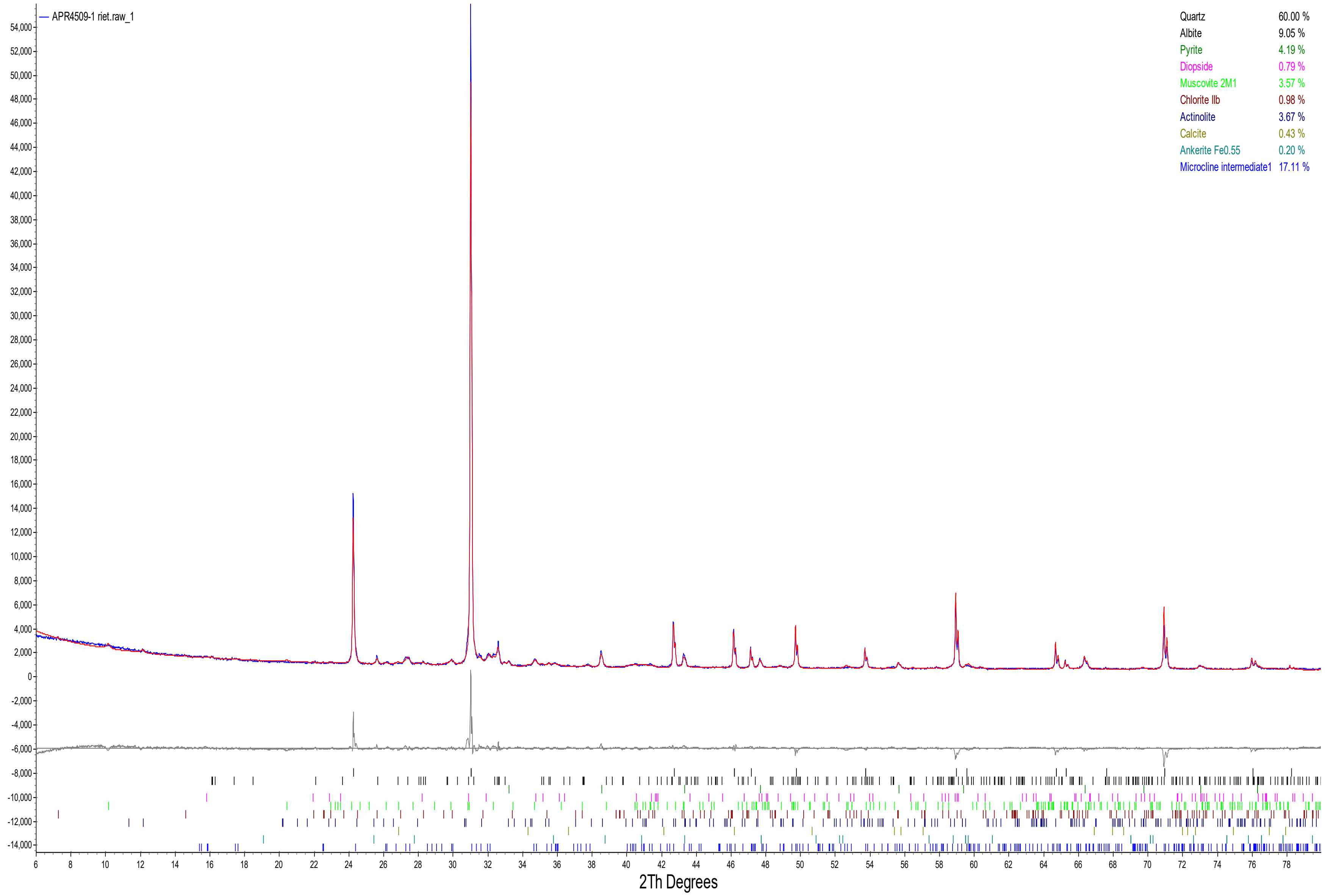
Zero values indicate that the mineral was included in the refinement, but the calculated concentration is below a measurable value.

Dashes indicate that the mineral was not identifed by the analyst and not included in the refinement calculation for the sample.

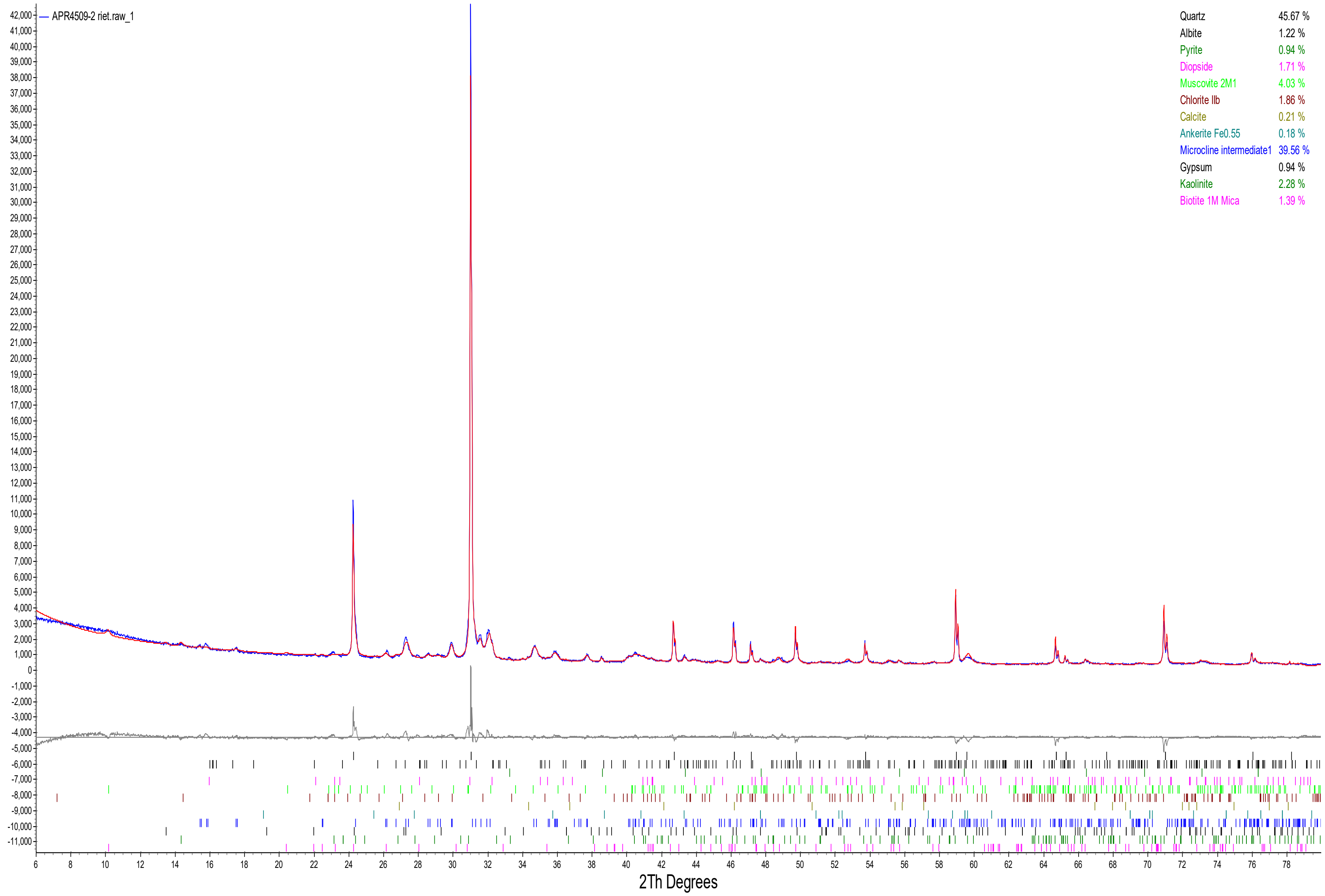
The weight percent quantities indicated have been normalized to a sum of 100%. The quantity of amorphous material has not been determined.

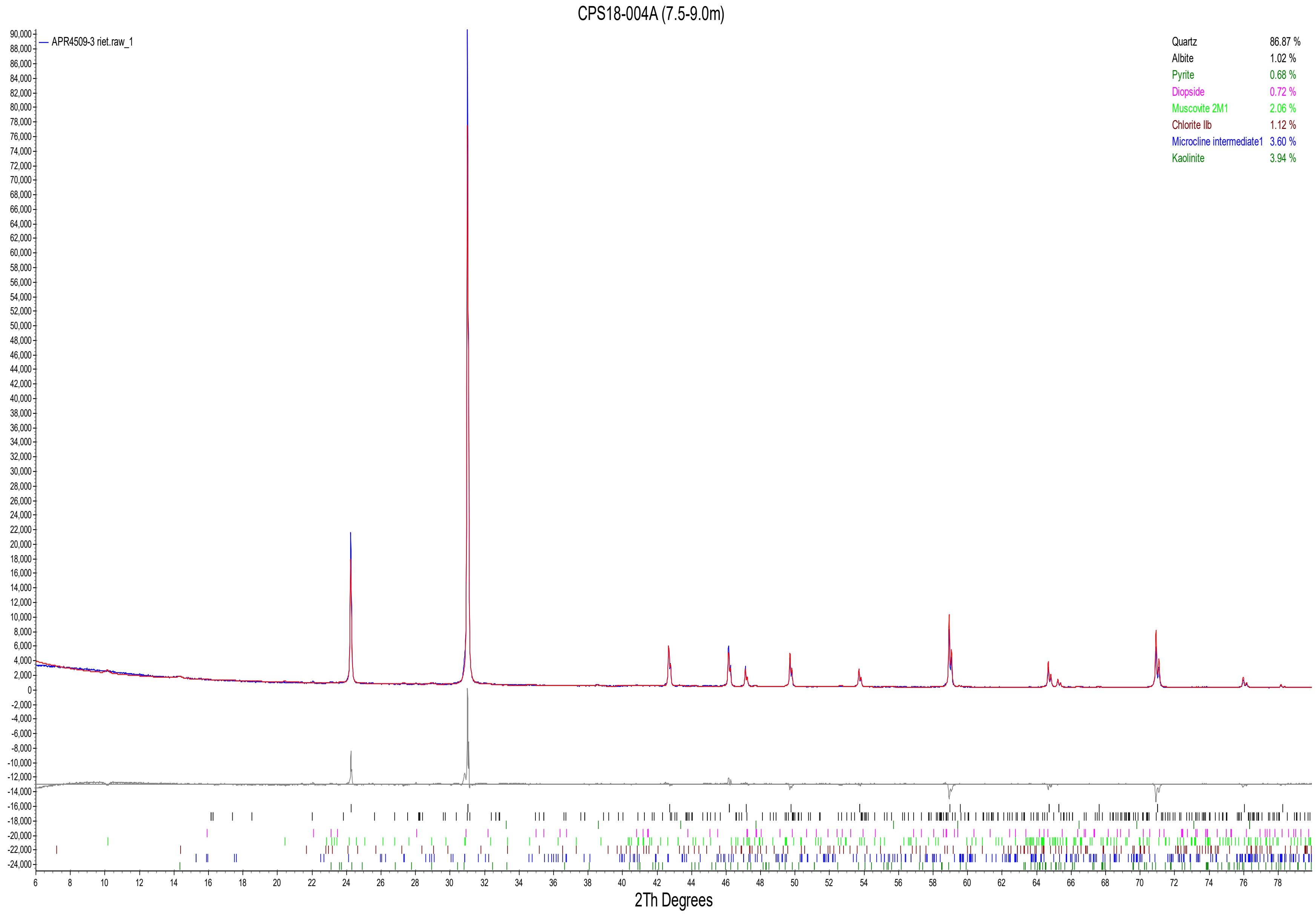
Mineral/Compound	Formula
Quartz	SiO_2
Albite	$NaAlSi_3O_8$
Pyrite	FeS_2
Diopside	$CaMgSi_2O_6$
Muscovite	$KAl_2(AlSi_3O_{10})(OH)_2$
Chlorite	$(Fe,(Mg,Mn)_5,Al)(Si_3Al)O_{10}(OH)_8$
Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$
Calcite	$CaCO_3$
Ankerite	$CaFe(CO_3)_2$
Microcline	$KAlSi_3O_8$
Gypsum	$CaSO_4 \cdot 2H_2O$
Kaolinite	$Al_2Si_2O_5(OH)_4$
Biotite	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$
Lizardite	$Mg_3Si_2O_5(OH)_4$
Kutnahorite	$CaMn(CO_3)_2$
Magnetite	Fe_3O_4

CPS18-003 (6-6.2m)

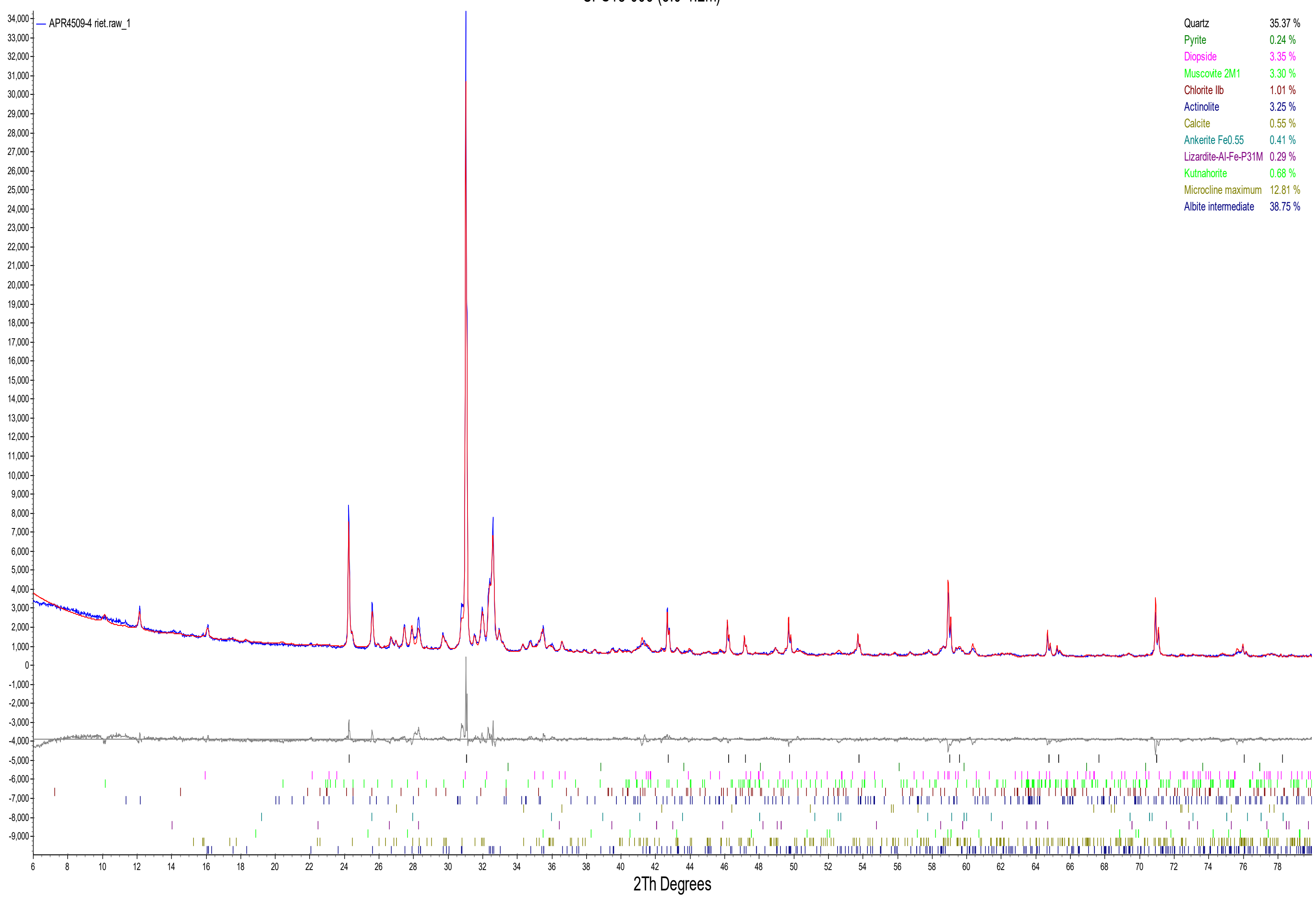


CPS18-004A (6-7.5m)

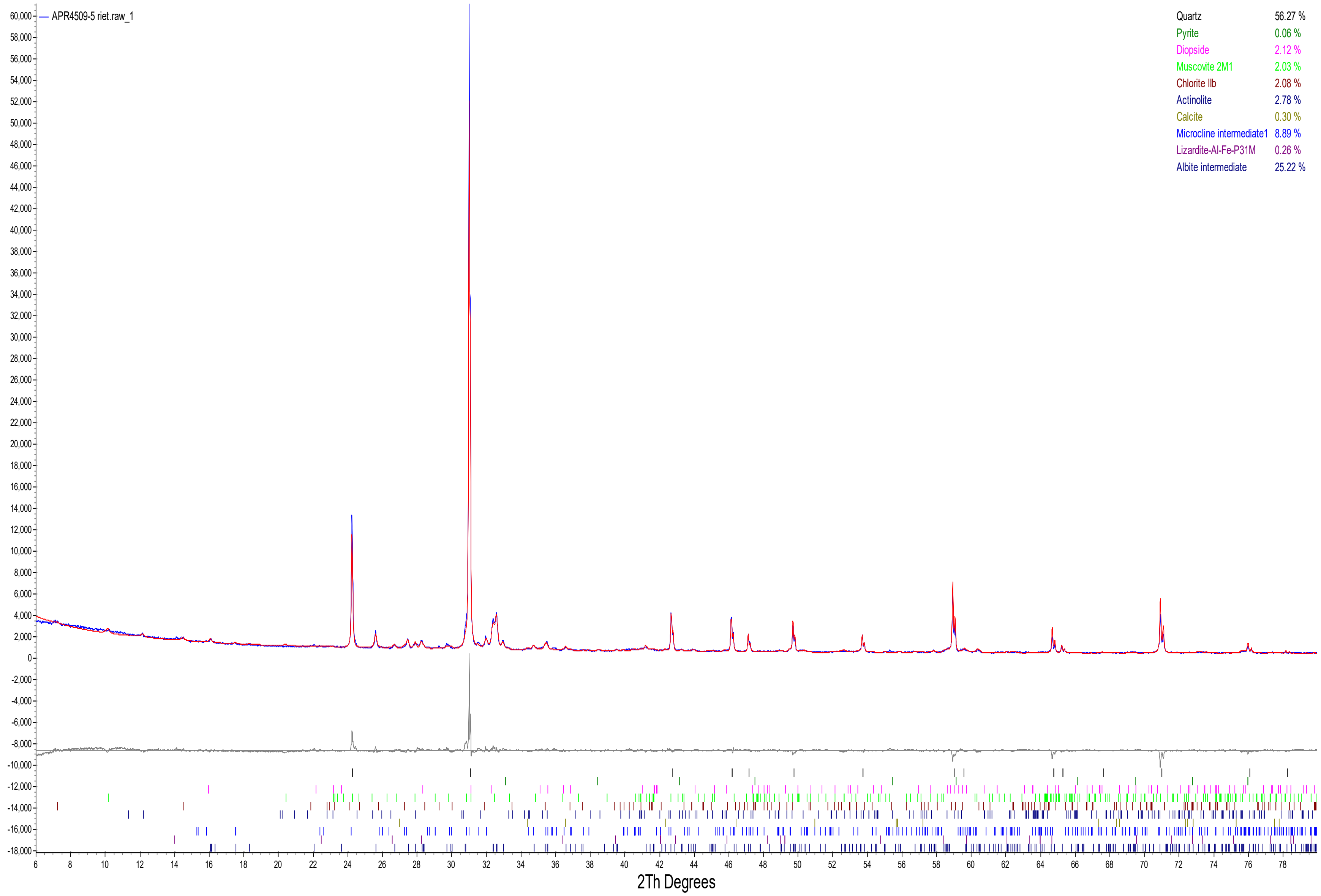



CPS18-004A (7.5-9.0m)
APR4509-3 riet.raw_1
Quartz 86.87 %
Albite 1.02 %
Pyrite 0.68 %
Diopside 0.72 %
Muscovite 2M1 2.06 %
Chlorite IIb 1.12 %
Microcline intermediate1 3.60 %
Kaolinite 3.94 %
2Th Degrees

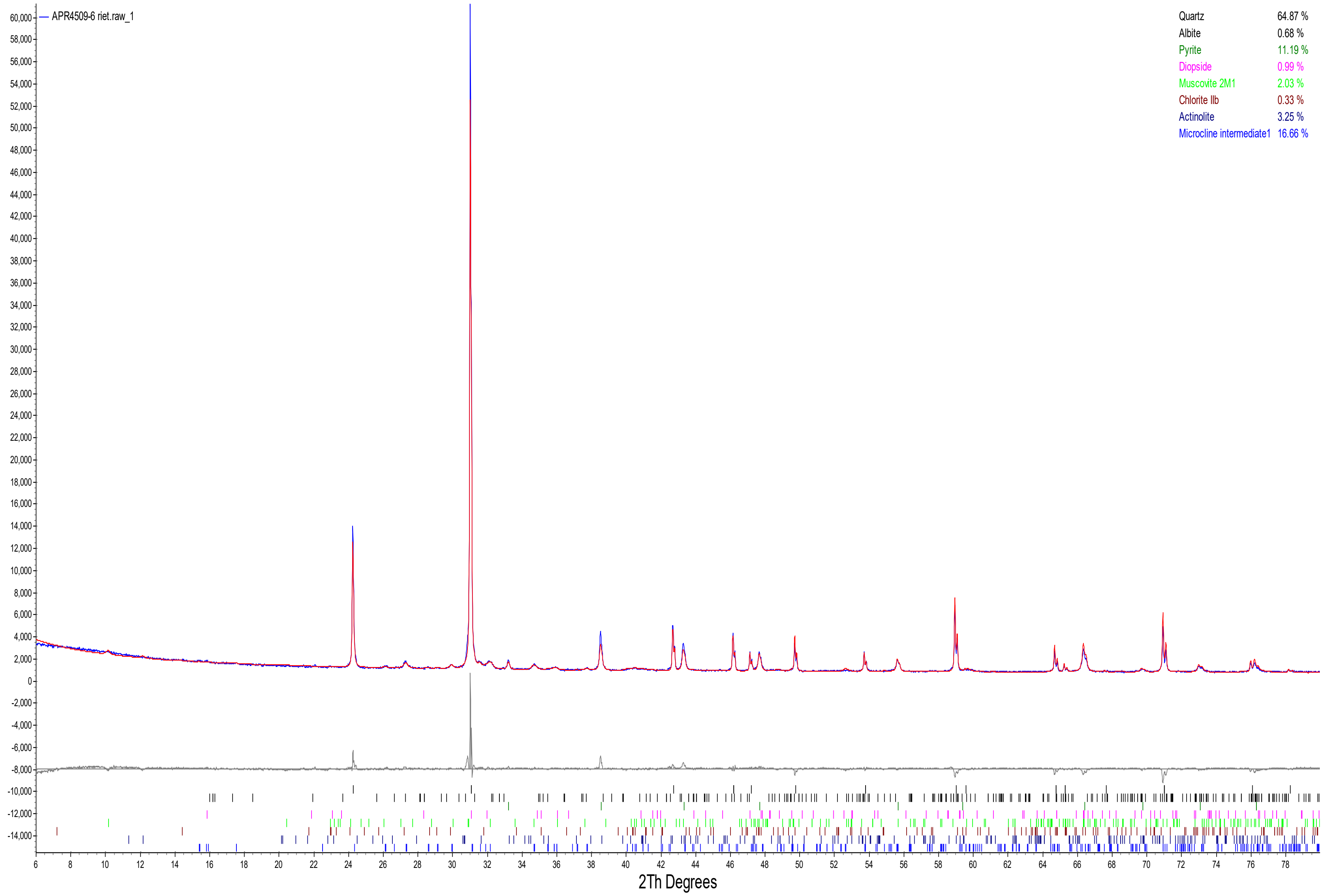
CPS18-006 (3.0-4.2m)



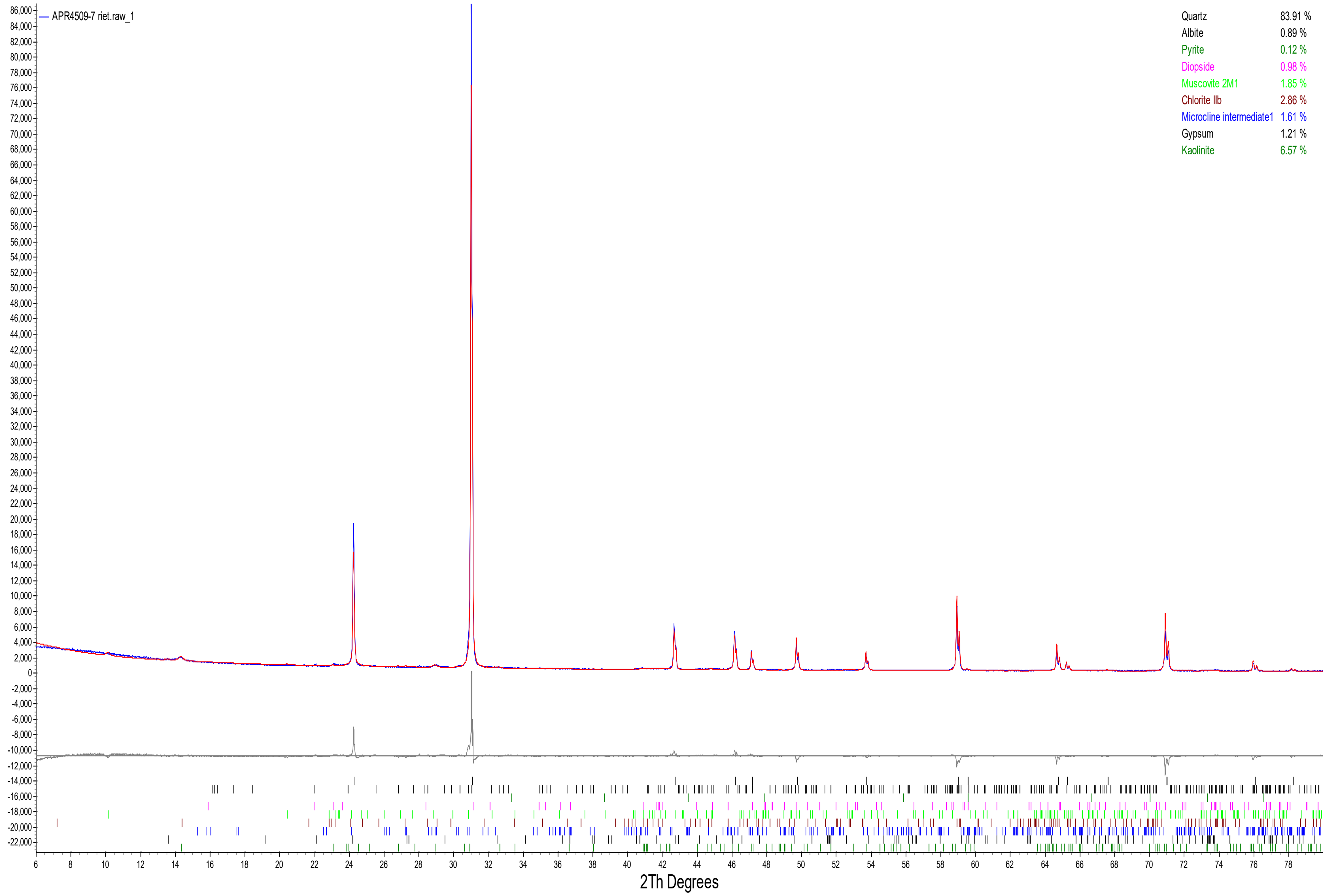
CPS18-012 (0-1.5m)



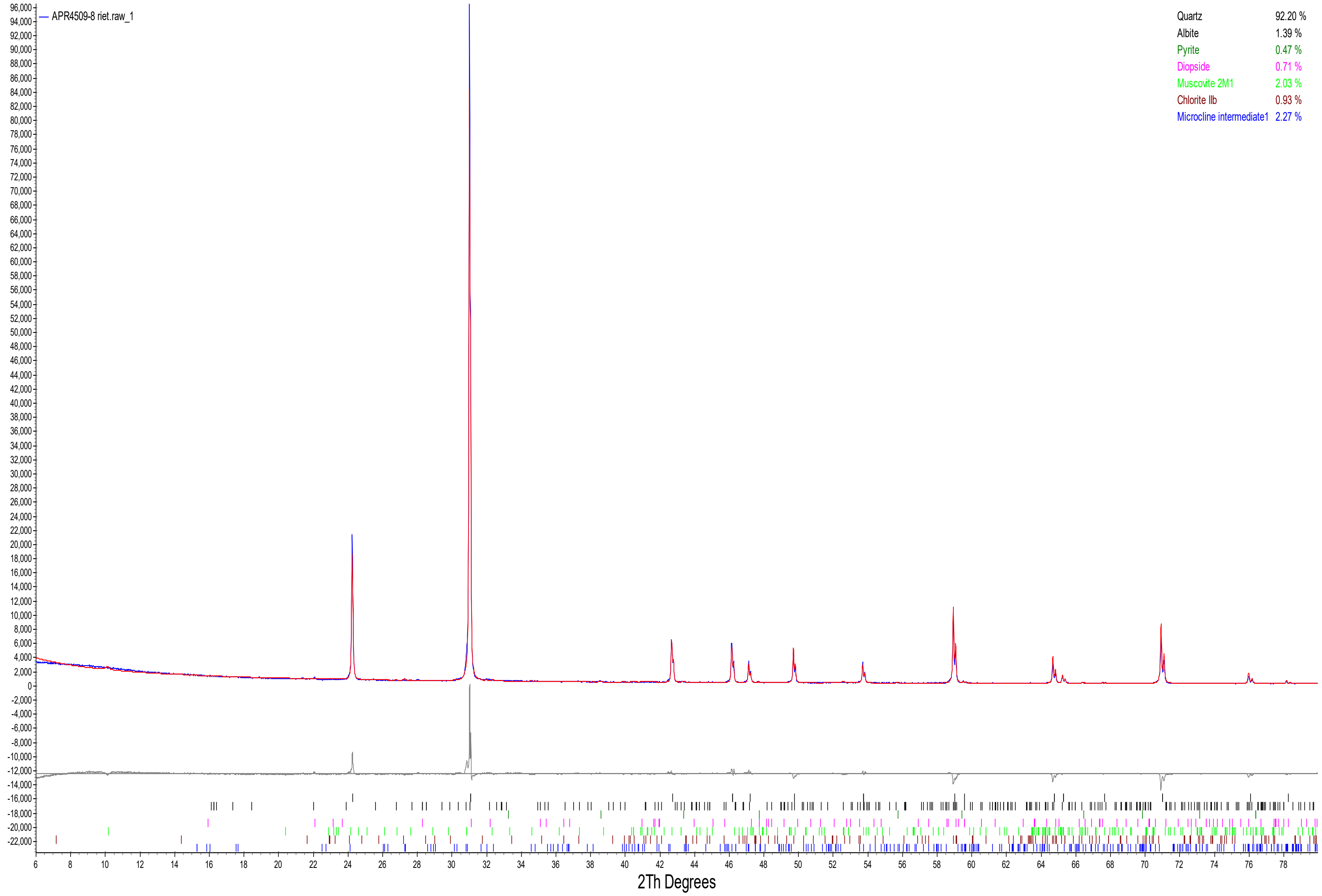
CPS18-012 (9-10.5m)

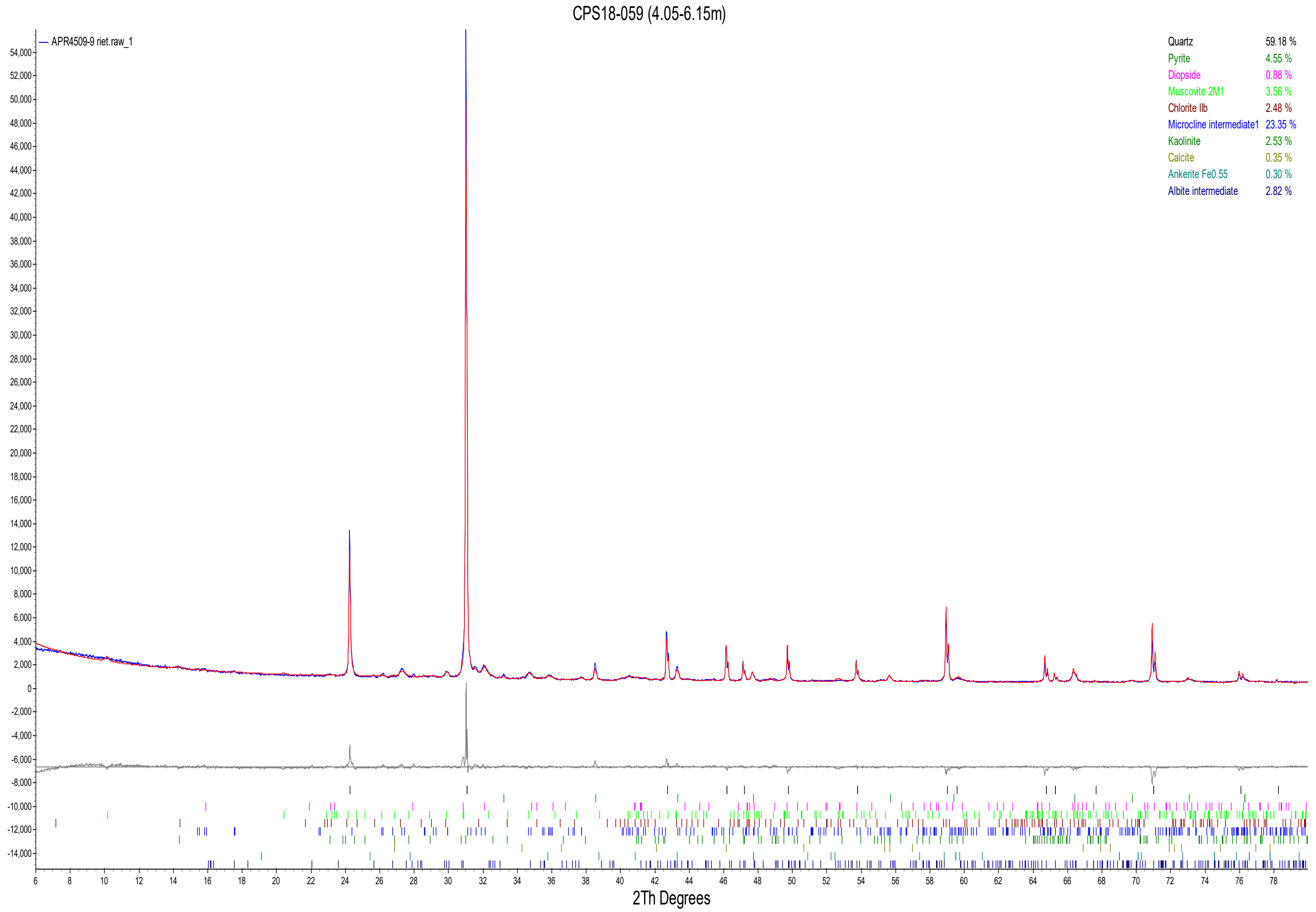


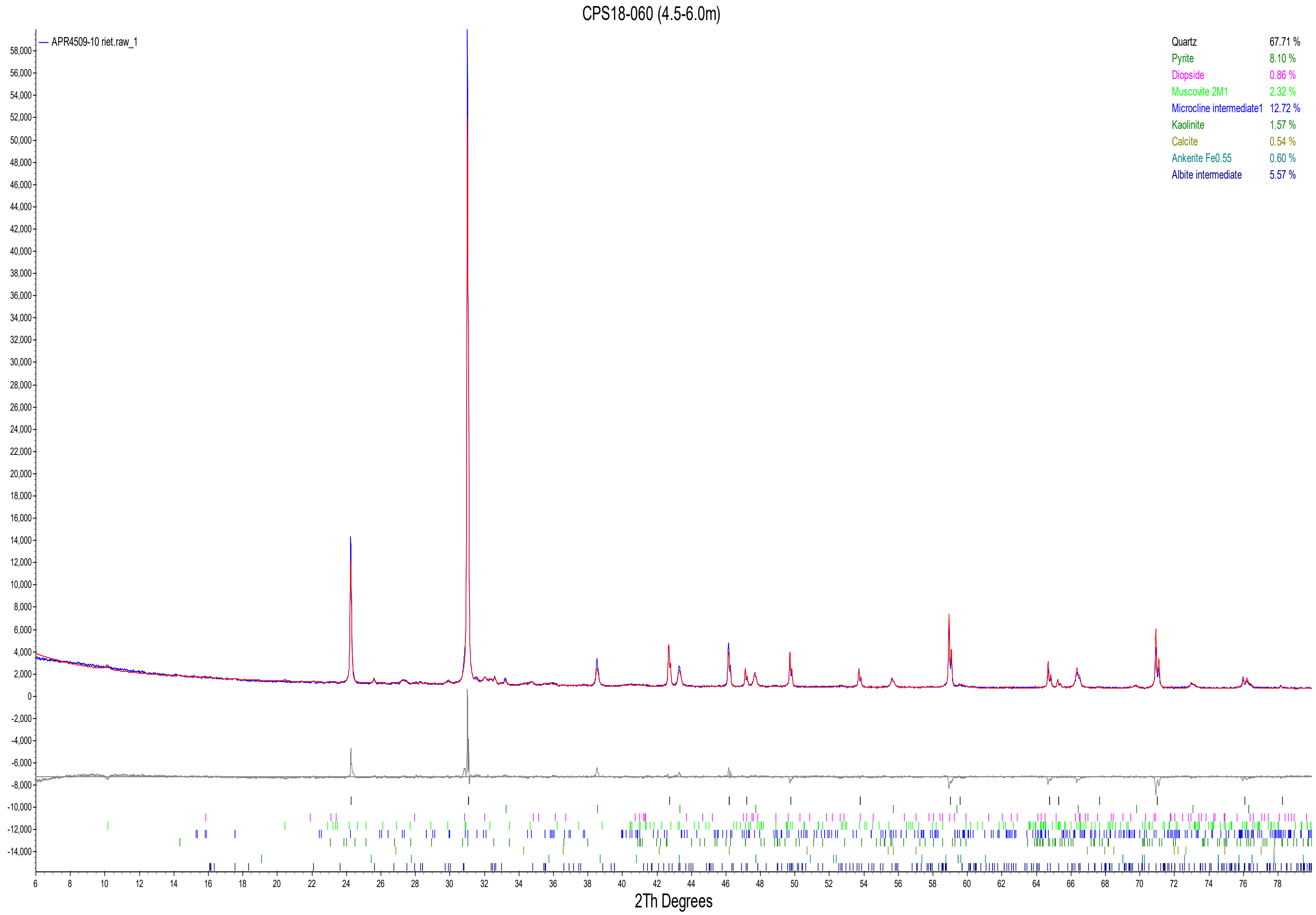
CPS18-024 (7.5-9.0m)



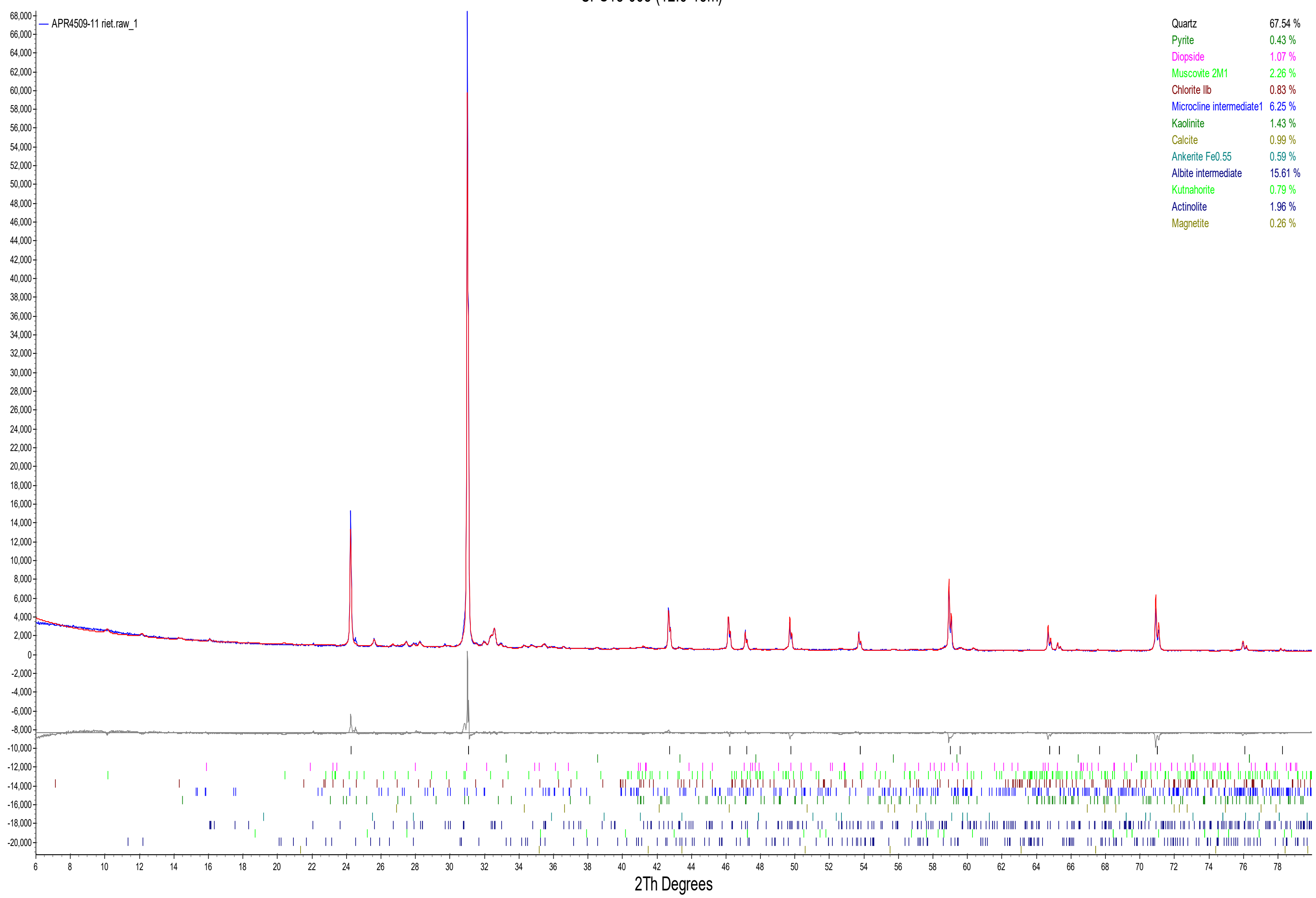
CPS18-042 (4.5-4.7m)

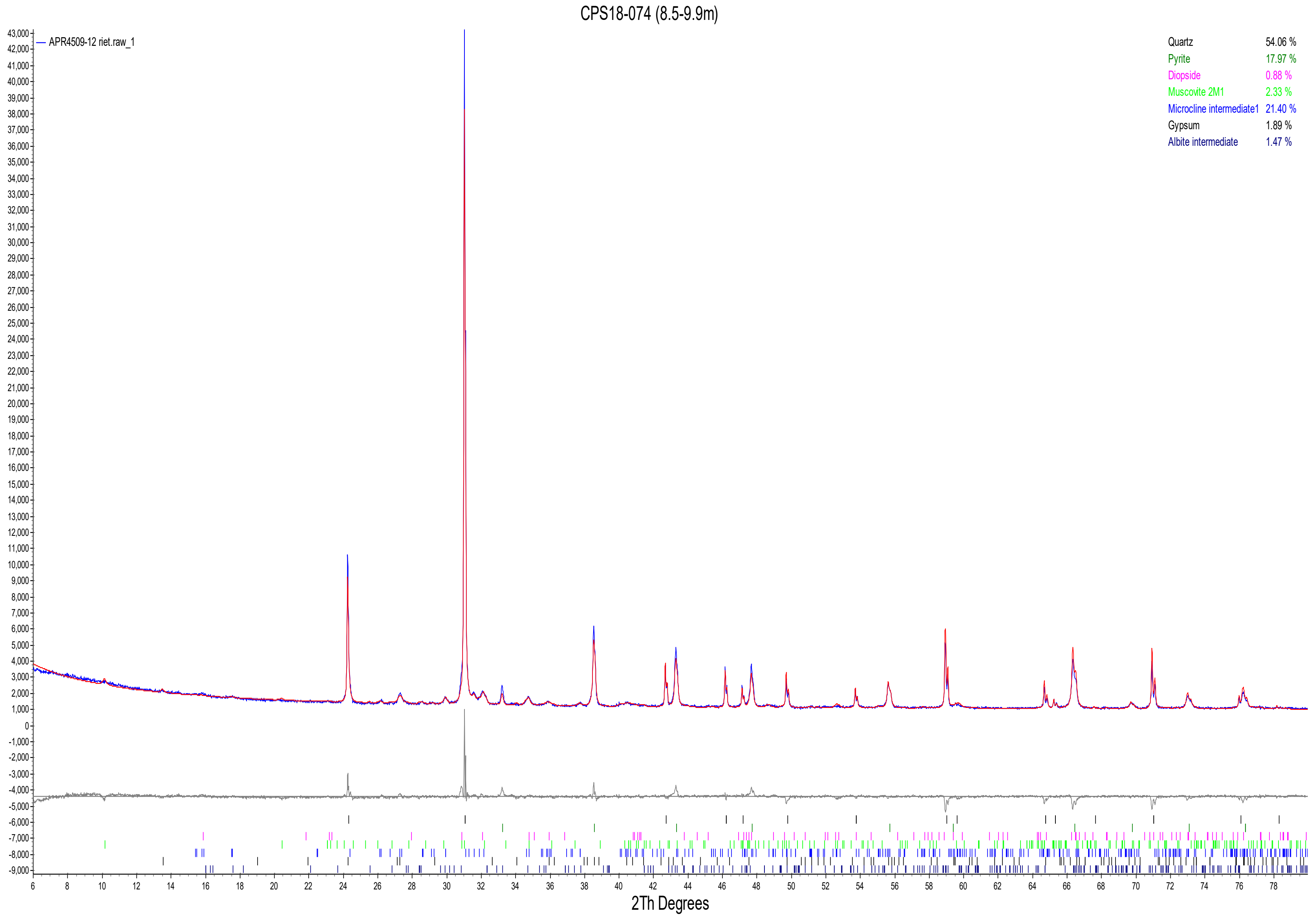



CPS18-059 (4.05-6.15m)
APR4509-9 riet.raw_1
Quartz 59.18 %
Pyrite 4.55 %
Diopside 0.88 %
Muscovite 2M1 3.56 %
Chlorite IIb 2.48 %
Microcline intermediate1 23.35 %
Kaolinite 2.53 %
Calcite 0.35 %
Ankerite Fe0.55 0.30 %
Albite intermediate 2.82 %
2Th Degrees


CPS18-060 (4.5-6.0m)
APR4509-10 riet.raw_1
Quartz 67.71 %
Pyrite 8.10 %
Diopside 0.86 %
Muscovite 2M1 2.32 %
Microcline intermediate1 12.72 %
Kaolinite 1.57 %
Calcite 0.54 %
Ankerite Fe0.55 0.60 %
Albite intermediate 5.57 %
2Th Degrees

CPS18-068 (12.6-15m)




CPS18-074 (8.5-9.9m)
APR4509-12 riet.raw_1
Quartz 54.06 %
Pyrite 17.97 %
Diopside 0.88 %
Muscovite 2M1 2.33 %
Microcline intermediate1 21.40 %
Gypsum 1.89 %
Albite intermediate 1.47 %
2Th Degrees

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